LPX-160 Constant Potential

Industrial X-Ray System

T.O. 33B3-3-31-11

MAN-00375

Revision 003

Service Support:

USA: 203-790-1188

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! WARNING !

The operator of this X-ray unit, or any person in the immediate vicinity, is subject to receiving some X-ray radiation during the time that the X-ray unit is producing X-rays. Since X-rays may cause harmful effects to the human body, unnecessary exposure should always be avoided, and all exposures held to an absolute minimum compatible with practical requirements.

! WARNING !

The operator of this unit must be trained and certified in the use of industrial X-ray equipment. Operation by unqualified persons can result in serious injury or death to themselves or others in the vicinity. Observe all recommended practices of the National Council on Radiation Protection (NCRP).

! WARNING !

All cables must be attached to their appropriate connectors on the control unit, cooling unit, and Tube Head before applying power to the system.

Table of Contents

CHAPTER ONE: INTRODUCTION

1.1 GENERAL UNIT DESCRIPTION

This manual describes the LORAD LPX-160 Portable Industrial X-ray Unit, and contains the information necessary to properly operate and maintain the entire system. This unit is designed to meet the needs of the commercial NDT user. The system consists of three main assemblies; a digital Control Unit, a constant potential Tube Head, and a recirculating liquid Cooling Unit. These assemblies are described in detail below.

The LPX-160 has been devised for inspection of materials for discontinuances including inclusions, cracks, corrosion, porosity, etc. X-ray potential up to 160 kilovolts (kV), and tube current up to 5 milliamperes (mA) can be generated by this apparatus.

1.1.1 Control Unit Description

The Control Unit houses all system operating controls, and the circuitry needed to provide the appropriate drive power to the Tube Head and Cooling Unit. It also contains the Low Voltage Power Supply circuitry to power its own internal circuits. The MAIN system circuit breaker is located on the front panel of the Control Unit, and automatically shuts down the system when excessive current is drawn during operation.

The Control Unit is used by the radiographer to set the radiographic exposure parameters, and to activate/deactivate X-ray emissions from the Tube Head. One hundred feet of cable is supplied with the unit enabling the Tube Head to be placed a safe distance from the Control Unit and operator.

The Control Unit is enclosed in a metal container with a removable cover. A collapsible handle is attached to the cover as a means of transporting the unit when the cover is attached to the Control.

1.1.2 Tube Head Description

The Tube Head is a cylindrical aluminum shelled assembly sheltering the X-ray tube, the High Voltage Power Supply, and the Filament Supply. It is insulated with sulfur hexafluoride gas, pressurized to 50 psi @70°F. The X-ray tube is of the end grounded configuration, with a beryllium window located approximately 2 inches from the end. Built in handles are located at each end of the Tube Head, providing a means of carrying the apparatus.

A shielded cable connects the Tube Head to the Control Unit, and a length of twin hose attaches the Tube Head to the Cooling unit.

1.1.3 Cooling Unit Description

The Cooling Unit dissipates heat generated at the anode of the X-ray tube. Liquid coolant from a self contained reservoir is pumped through one side of a twin hose assembly, into the Tube Head. In the Tube Head, the coolant flows through a cooling manifold, into the anode, then back to the Cooling Unit through the second half of the Twin Hose assembly.

Once in the Cooling Unit, coolant passes through a flow switch, that is interlocked with the Control Unit, then to a filter that screens out contaminants. From the filter, coolant flows through a forced air radiator, where conducted heat is dissipated, then back into the reservoir.

An electrical motor driven fan and pump assembly circulates coolant, and creates airflow through the radiator. Power is supplied via an interconnecting cable from the Control Unit. When properly connected to the system, the Cooling Unit is automatically activated by a switching circuit within the Control Unit.

1.2 USING THE SERVICE MANUAL

! WARNING !

Before any work is performed on the LPX-160, the troubleshooter MUST have a thorough understanding of x-ray machinery, X-ray generation, x-ray potential, and x-ray control. The troubleshooter MUST understand all hazards associated with x-ray generation. The "Safety Summary" in this chapter MUST be read completely, and thoroughly understood. The numerous safety warnings, cautions, and notes throughout this manual MUST be read prior to commencing any maintenance procedures.

1.2.1 Manual Outline

This manual is written to provide qualified radiographers and technicians a means to logically inspect, operate, troubleshoot, and repair the LORAD LPX-160 Portable X-ray Unit. The following paragraphs profile the arrangement of this manual, and the information each chapter provides the user.

Chapter One:

This chapter provides operators and technicians with general information about the LPX-160. Included is the unit description, basic specifications, and a safety summary.

Chapter Two:

This chapter lists the required tools and equipment.

Chapter Three:

This chapter covers unpacking and reshipment instructions, required pre-operational checks, Power Up instructions, and setup procedures. An equipment checklist is also provided.

Chapter Four:

This chapter gives a brief overview of unit controls and switches. Also discussed are the proper "Warm Up" and Operating procedures.

Chapter Five:

This chapter encompasses mechanical maintenance and repair procedures. Included are disassembly, assembly, and parts replacement procedures. Also included are detailed troubleshooting, test, and calibration procedures for each assembly of the x-ray unit.

Chapter Six:

Contains all pertinent system illustrations.

Chapter Seven:

Contains the LPX-160 Illustrated Parts Breakdown (IPB).

Chapter Eight:

Discusses the Laser Pointer device.

1.3 SAFETY SUMMARY

When properly installed, maintained, and operated, x-ray equipment can be used effectively and safely. If any portion of this unit is incorrectly installed and/or operated by unqualified personnel, or if the maintenance schedule is neglected, it is a potentially dangerous apparatus. All operators and technicians must read and understand the "X-RAY PROTECTION WARNING" published at the front of this manual. This manual must be read in its entirety and the procedures completely understood before operating the unit. Also, the numerous NOTES, CAUTIONS, and WARNINGS must be read and thoroughly understood before beginning operation or maintenance procedures.

The following summary should be used as a checklist to assure comprehension.

! NOTE BOX !

An essential operating procedure, condition, or statement, which is necessary in proper operation of the system.

! CAUTION BOX !

An operating or maintenance procedure, practice, condition, or statement, which, if not strictly observed, could result in damage to, or destruction of equipment.

! WARNING BOX !

An operating or maintenance procedure, practice, condition, or statement, which, if not strictly observed, could result in injury to or death of personnel.

1.3.1 Radiation Hazard

This equipment generates X-radiation at levels that can be lethal. Operation of this unit must be performed by certified, experienced industrial x-ray personnel who understand the characteristics of radiation and the associated dangers of exposure to primary, secondary, and residual sources of radiation.

1.3.2 Lethal Voltages

High power radiation sources depend upon the generation of extremely high, yet well protected voltages. Under no circumstances should the operator access the interior of the Control Unit or the Tube Head. The only permissible operator-maintenance procedures are the ones contained in Chapter Three of this manual.

1.3.3 Badges

All personnel who work around x-ray equipment must wear a functional exposure dosage indicator.

1.3.4 Radiation Protection

X-ray equipment must be operated within properly designated protective barriers. Otherwise, personnel must not approach closer than 100 feet from the Tube Head, and in no cases cross the direct path of the primary beam.

1.3.5 Radiation Monitoring

After installation, re-installation, transporting, performing maintenance and during all radiographic operations not within a radiation enclosure, a radiation survey should be performed.

1.3.6 Warm-Up Procedures

Explicit procedures are outlined for "running-up" high voltage with new equipment, equipment with a new tube, equipment that has been inactive for a period of time, and equipment in daily use. These procedures must be strictly followed at all times.

1.3.7 Operation

Equipment must be operated at correct source voltage and frequency, and must never be left running unattended. The gas pressure in the Tube Head must be checked to ensure it is within allowable limits before operating the unit. Never operate this apparatus if output voltage/current is unstable.

1.3.8 Cooling Unit Operation

Regularly check to ensure the coolant level is within specification, is circulating, and does not leak. Always allow the Cooling unit to run approximately 5 minutes after completion of x-ray generation.

1.3.9 Care in Handling

Extreme care must be taken when handling the apparatus. Exercise caution while packing, unpacking, shipping, and during maintenance. Remember, the x-ray tube is durable but breakable, and should be stored and shipped in the upright position.

1.4 LOCATION OF WARNING LABELS AND CONTROL NUMBERS

Each assembly of the LPX-160 Portable X-ray System is equipped with control tags providing particular data about the unit. This data includes the unit's serial number, the unit's description, and the unit's part number.

Attached to the Control Unit and Tube Head are warning labels. Figure 1-1 illustrates the location of the control tags and warning labels for each assembly of the LPX-160.

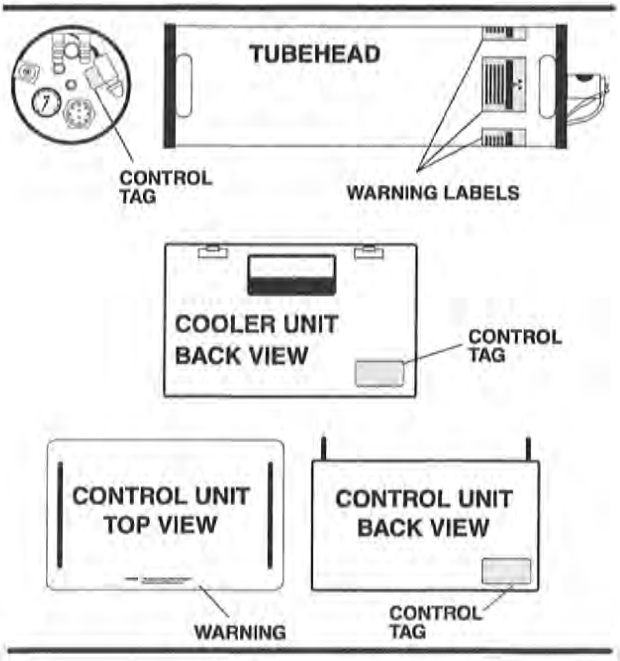


FIGURE 1-1:
LOCATION OF CONTROL TAGS & WARNING LABELS

1.5 BASIC SPECIFICATIONS

The following Tables illustrate the physical, operational, and environmental specifications for each component of the LPX-160 Portable X-ray Unit. Conformance with these specifications will ensure maximum system performance, and reduce the chances of mechanical breakdown and personnel hazard.

1.5.1 General System Specifications

Table 1-1 illustrates the general operating and environmental limits of the entire LPX-160 Portable X-ray Unit.

Table 1-1: General Unit Specifications

Line Voltage*	100 - 130 VAC 200 - 250 VAC	50/60 Hz; 16 amps max. 50/60 Hz; 8 amps max.
Operating Temperature Range	(Ambient)	-4°F to 120°F -20°C to 49°C
Humidity	0 - 100%	Relative Humidity
Stabilization	kV and mA remain within ±3%	Line Voltage varied from 100 - 130/200 - 250 VAC
Storage Temperature Range	-65°F to 160°F	-54°C to 49°C

* Line Voltage selection is automatic. The system operates from either line without any switch or jumper configuration.

1.5.2 General Tube Head Specifications

Table 1-2 (below) illustrates the general operating specifications of the Tube Head Assembly.

Table 1-2: GENERAL TUBE HEAD SPECIFICATIONS

Physical Specifications Cooling System	7.25 inch diameter 28 inch length Liquid Coolant Solution	Weight: 30 pounds (approximate)
Operating Potential	10 - 160kV	@ 0.1 - 5.0 mA
Output	230 R/minute	@ 160kV, 5mA, 50cm, unfiltered
Leakage Radiation	Less than 1.0 R/hour	@ 1 meter from target
Tube Pressure Sense	Monitors Tube Head Gas Pressure	Shuts Down Unit when pressure falls below 25psi
X-ray Tube Anode Thermal Sense	Monitors Temperature of X-ray Tube Anode	Shuts Down Unit if Anode Temp. rises above 180°F
Pressure Relief Valve	Automatically releases Tube Pressure	Activated if Tube Pressure exceeds 80 p.s.i.
Pressure Gauge	Displays Tube Pressure	Used for visual inspection

1.5.3 Optional Tube Head Specifications

Table 1-3 depicts the options available for the Tube Head Assembly. Figure 1-2 illustrates the direction of the x-ray beam for both the 40° cone and the 360° panoramic.

Table 1-3: TUBE HEAD OPTION SPECIFICATIONS

Tube Head 40° Cone	Liquid Cooling System	1.5mm or 0.5mm available Focal Spot	0.063 or 0.020 Beryllium Window
Tube Head 360° Panoramic	Liquid Cooling System only	1.5mm Focal Spot only	0.6mm Nickel Window Tube

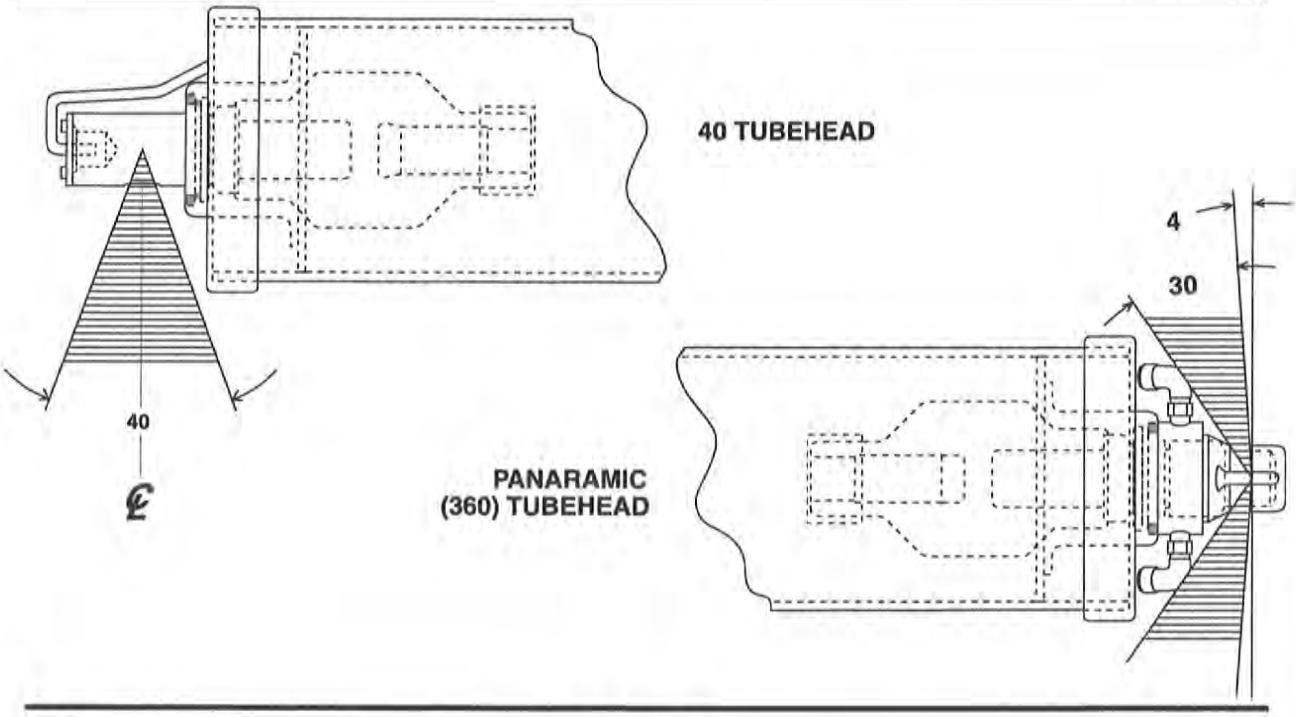


FIGURE 1-2:
X-RAY BEAM DIRECTION

1.5.4 Control Unit Specifications

Table 1-4 illustrates the physical and operating specifications of the Control Unit.

Outlined are the physical dimensions, indicators, and operating controls of the unit. The controls are explained in detail in Chapter Four of this manual.

Table 1-4: CONTROL UNIT SPECIFICATIONS

kV Control	Push buttons to set desired kV level	0kV to 160kV (1kV increments)
kV Indicator	LCD readout on upper display	Displays current kV level
mA Control	Push buttons to set desired mA level	0.1mA to 5mA (0.1mA increments)
mA Indicator	LCD readout on upper display	Displays current mA level
X-Ray ON Switch	Pushbutton switch with x-ray symbol	Activates x-ray generation
X-Ray OFF Switch	Red mushroom-type switch	Terminates x-ray operation
Key Lock Safety Switch	Keyswitch that enables X-RAY ON	External Interlocks must be closed
Exposure Timer	LCD readout on upper display	Count-down or count-up timing options
Weight	35 pounds	Approximate
Dimensions	12" x 18" x 12"	
Power ON Indicator	Green LED array front panel	Lights upon power up
X-ray ON Indicator	Red LED array on front panel	Lights during x-ray emission

1.5.5 Cooling Unit Specifications

Table 1-5 illustrates the operating and physical specifications of the Cooling Unit. These conditions are detailed in Chapter Two of this manual.

Table 1-5: COOLING UNIT SPECIFICATIONS

Physical Specifications	12" high x 15" wide 14" depth	with cover attached
Weight	55 lbs. approximate	with cover attached
Liquid Coolant Solution	14 parts methyl alcohol, 7 parts water 1 part "TEXACO" Soluble "D" oil	(not supplied)
Coolant Flow	.5 gallons per minute	@ 50 foot head
Cooling Unit Connections	Quick Disconnects	Self Sealing

CHAPTER TWO: SPECIAL TOOLS AND TEST EQUIPMENT

2.1 SPECIAL TOOLS AND TEST EQUIPMENT

The LORAD LPX-160 Portable X-ray Unit is a self-contained apparatus. Under normal operating conditions, the unit requires no special equipment other than standard radiographic supplies such as film, film holders, etc.

Table 2-1 illustrates the tools and equipment required to perform the general maintenance and repair procedures contained in this manual

Table 2-1: Required Tools and Equipment

DESCRIPTION	MINIMUM SPEC.	P/N, MODEL
Dual Trace Oscilloscope with H.V. Probe	35 MHz Bandwidth (min.)	"Tektronix 2215" or equiv.
Volt/Ohm Meter	Standard rating	"Simpson 260" or equiv.
Four Digital Multimeters	Standard rating	"Fluke 77" or equiv.
Variable Power Transformer	0 - 130 volts; 10 Amps	
SF_6 Gas Supply	Dry, @pressure exceeding 50 p.s.i. @ 70°F.	NSN # 6830-00-817-2342
Vacuum Pump/Regulator ass'y w/hoses.	Recharge Kit	9-200A-0102
Tube Head Simulator	Available	9-200A-0101
Victoreen Ratemeter		Model 660 with 660-3 probe
Shielded Radiation Cabinet	To meet applicable safety requirements	
Tube Wrench	Available	9-060A-0055
Silicone Grease	#55	"Dow-Corning"
Standard Hand Tools		
Dry Cleaning Solvent		P-S-661
Isopropyl Alcohol		TT-1-735
Full Face Shield & Gloves	To meet applicable safety requirements	
kV Board Extender Cable	Available	"SK3741"
mA Board Extender Cable	Available	"SK3740"
Mother Board Test Fixture	Available	"SK3784"
Temperature Probe		"Fluke 80T-15OU" or equiv.
Resistor	3 ohm, 50 watt	1-103A-0061
Resistor	10 ohm, 50 watt	1-103A-0062
Resistor	30 ohm, 25 watt	1-103A-0063
Signal Generator	33kHz, 10V amplitude	"Beckmann Circuitmate FG2"
Transformer	Available	P/N: 1-451A-0026
Leak Detector	Halogen	"MACTOOLS AC5500"
Two Oscilloscope Probes		"Tektronix P6121"
High Voltage Probe		"Fluke 80K-40" or equiv.
Oscilloscope High Voltage Probe		"Tektronix P6015" or equiv.
Tubehead Load Simulator	Available	"SK3690"
Calibration Test Set	Available	"SK3691"
Cooling Unit Test Fixture	Available	"SK3743"
Power Supply	10 V.D.C., 100mA	H.P. 6212C - 6216C
Paint	Indust. Green 20° Gloss	"Sherwin Williams F63VXG 2361"

CHAPTER THREE: PREPARATION FOR USE AND SHIPMENT

3.1 EQUIPMENT CHECKLIST

The following checklists outline the standard and optional equipment common to the LPX-160 Portable X-ray Unit

(P/N: 3-000-0723, NSN: 6635-01-417-1830).

After unpacking the unit, and completing a thorough visual inspection, each item should be compared with this list to assure completeness.

Note that the Tube Head assembly is a standard item, but several models are available. Verify the Tube Head shipped with your unit matches the model that was originally ordered.

3.1.1 Standard Equipment Checklist

☐	Assembly, Tube Head Liquid Cooled; 1.5 mm Focal Spot 0.063" Beryllium Window	3-000A-0736
☐	Control Unit (1)	3-000A-0738
☐	Cooling Unit Assembly (1) (Liquid Cooled Units Only)	3-000A-0737
☐	Power Cable Assembly (1) (3 Pin Connector, 100ft)	1-040A-0380
☐	Control Cable Assembly (1) (10 Pin Connector, 100ft.)	1-040A-0342
☐	Cooler Power Cable (1) (8 Pin Connector, 50ft.)	1-040A-0343
☐	Interlock Mating Connector (1)	1-600-3074
☐	Safety Switch Key (3)	2-610A-0001
☐	50 Foot Cooling Hose (1)	3-000A-0742
☐	Laser Pointer Device NSN: 5860-01-378-6472	3-000A-0792
☐	Tube Head Transit Case (1)	2-630-0025
☐	Control Unit Transit Case (1)	2-630-0026
☐	Cooling Unit Transit Case (1)	2-630-0027
☐	Cable Transit Case (1)	2-630-0028

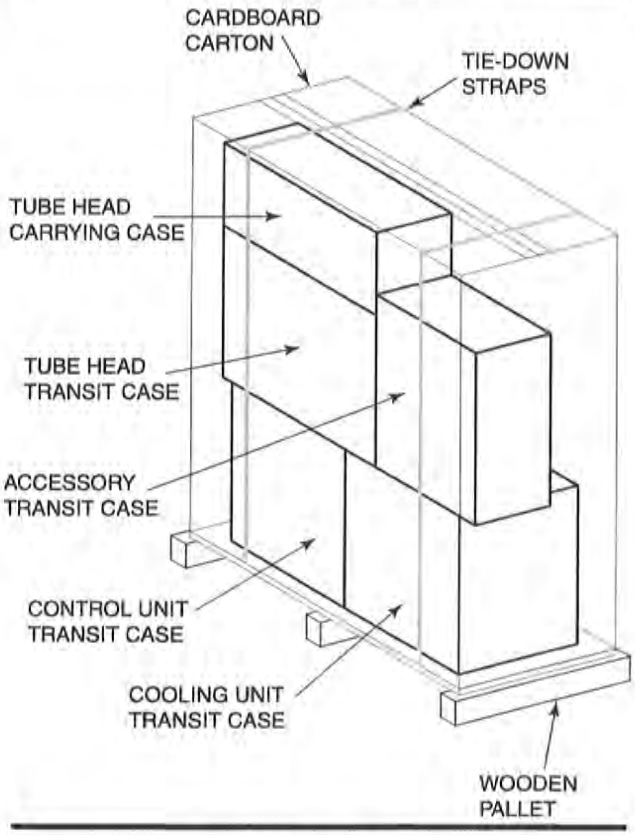


FIGURE 3-1:
X-RAY UNIT SHIPPING CRATE & TRANSIT CASES

3.1.2 Available Optional Equipment

☐	X-Ray Tube Head Stand NSN: 6635-01-329-6457	3-000A-0754
☐	Tube Head Simulator	9-200A-0101
☐	Kit, Tube Head Re-charge	9-200A-0102
☐	Tool, Tube Wrench	9-060A-0055
☐	Assembly, Tube Head Liquid Cooled; 360° Cone 1.5 mm Focal Spot 0.6 mm Nickel Window Tube	3-000A-0772

3.2 UNPACKING AND RESHIPMENT

3.2.1 Unpacking Instructions

The LPX-160 Portable X-ray Unit is shipped in a single container comprised of a wooden pallet and a cardboard carton. All components of the x-ray unit are housed in four foam-lined transit cases, which are secured within the shipping container. To gain access to the transit cases, first cut the shipping straps that secure the cardboard carton to the pallet, then lift the carton up and off the pallet.

Carefully remove all the packaging material (i.e., straps, cushions, plastic wrap, etc.) from the transit cases, then lift each transit case from the pallet. Perform a complete and thorough visual inspection of all contents using the checklist below:

Transit Case #	Contents
1 of 4	Controller & Twin Hose Assembly
2 of 4	Tubehead Assembly
3 of 4	Cooler Unit
4 of 4	Accessories (i.e., cables, laser pointer, etc.)

If damage to any component has occurred, immediately contact the carrier. All damaged containers must be retained until an inspection by the carrier has been completed. If it is necessary to repackage and ship the unit, follow the instructions outlined under "Reshipment Instructions" (section 3.2.2).

Note that the twin cooling hose assembly is shipped from the factory in the Control Unit transit case. Upon receipt, remove the twin cooling hose assembly from the Control Unit transit case and store it permanently in the Accessory transit case (with all other accessory items).

! NOTE !

Store the transit cases in a safe location. The transit cases will be used as shipping containers if it becomes necessary to re-pack the x-ray system for deployment or to return the system for servicing.

3.2.2 Reshipment Instructions

If, for any reason, the LPX-160 Industrial X-ray Unit must be transported or shipped, the original transit cases must be used to prevent damage (see Figure 3-2).

! ATTENTION !

"Sulfur Hexafluoride, Non-flammable gas is present in limited quantities in one or more cases of this shipment. This is to certify that the above mentioned materials are properly classified, described, packaged, marked, and labeled, and are in proper condition for transportation according to "Department of Transportation" regulation number U.N1080.

! WARNING !

All coolant solution must be completely drained from the reservoir before packing and shipping the Cooling Unit. Coolant is a flammable material and must be removed.

! NOTE !

When shipping the Control Unit, DO NOT include the twin cooling hose assembly in the Control Unit transit case. The twin cooling hose is permanently stored in the Accessory transit case.

! NOTE !

ALWAYS pack the individual components in their respective transit case.

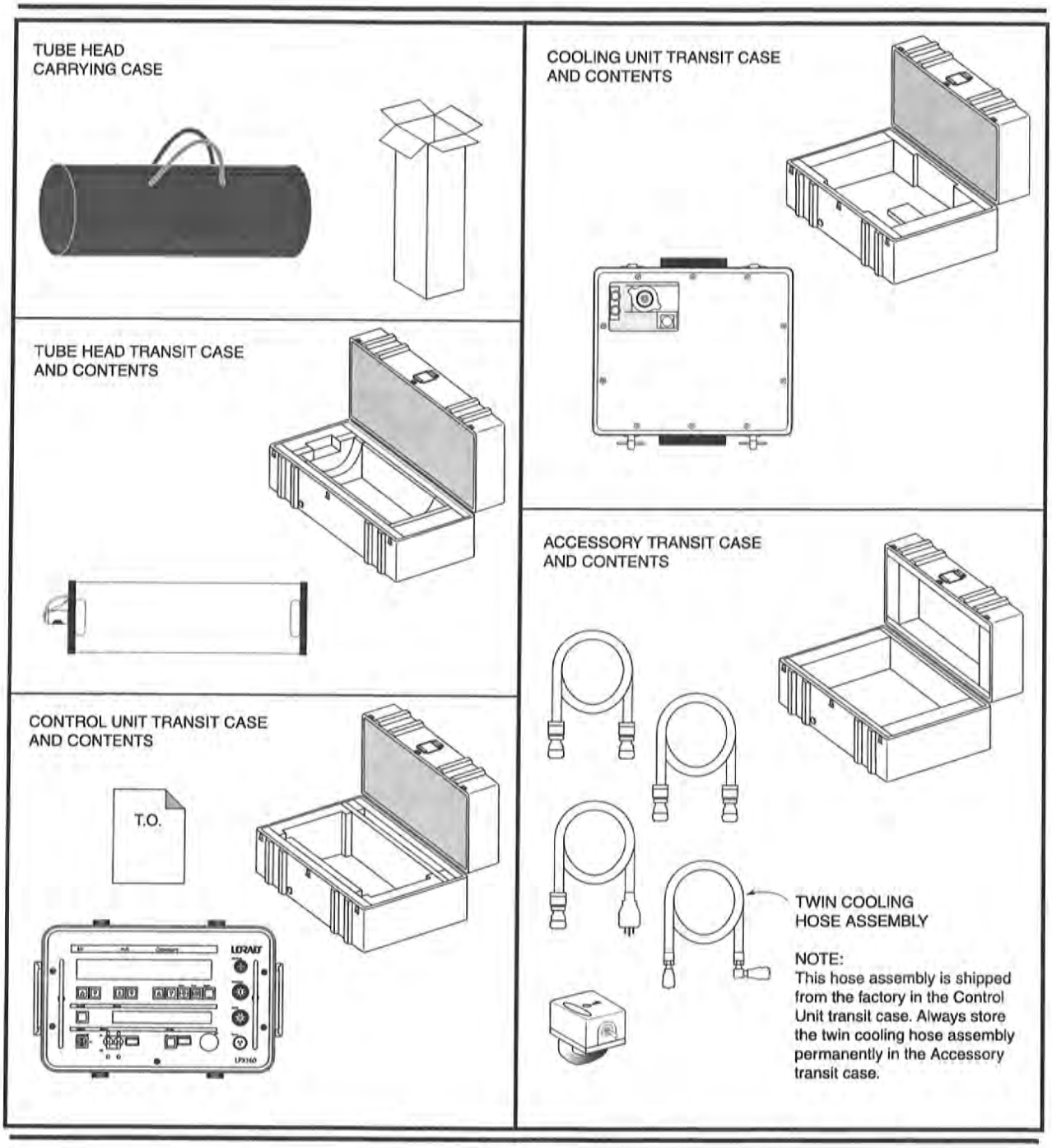


FIGURE 3-2:

TRANSIT CASES AND CONTENTS

3.3 PRE-OPERATIONAL CHECKS AND CONNECTIONS

The following paragraphs outline the steps to properly inspect and set up the LPX-160 Portable X-ray Unit. Whenever the system is assembled, these procedures must be completed, before x-rays are generated. Refer to Figure 3-3 and Figure 3-4 while performing these procedures.

Step #1

Check the Tube Head gas pressure gauge and verify that the unit is adequately pressurized. If the gauge indicates Tube Head pressure below 50 psi (pounds per square inch) at 70°F, perform the procedures for "Pressurizing the Tube Head". These procedures are outlined in Chapter Five of this manual.

Step #2

If Tube Head gas pressure is below 50 psi at 70°F, ensure the reading on the gauge is above 5 psi. If Tube Head gas pressure is below 5 psi at 70°F, the Tube Head must be purged of all remaining gas, then refilled before operating the unit. The procedures for "Refilling the Tube Head" are outlined in Chapter Five of this manual.

! CAUTION !

DO NOT operate this unit if Tube Head Pressure is below 50 psi @ 70°F or damage to the Tube Head may occur.

! NOTE !

Tube Head gas pressure normally varies ± psi for every 7°F increase or decrease in Tube Head temperature.

Step #3

Inspect the Cooling Unit's Twin Hose assembly, and hose connections for damage. The connector couplings must be firmly attached to the hose, and the hose must be free of punctures, fraying, or dry rot.

Step #4

Remove the Radiator cap on the Cooling Unit and ensure the coolant level is within 1/2" from the top of the reservoir. If the coolant level is below normal, add coolant solution (as outlined in Chapter Five of this manual).

Step #5

For liquid cooled units, connect the two angled couplings on the Twin Hose assembly to the fittings on the back of the Tube Head. Then, connect the opposite ends of the Twin Hose to the female fittings on the Cooling Unit

! NOTE !

There is no designated left or right side to the Twin Hose assembly. If each connector is properly seated, coolant flow through the Tube Head will be achieved.

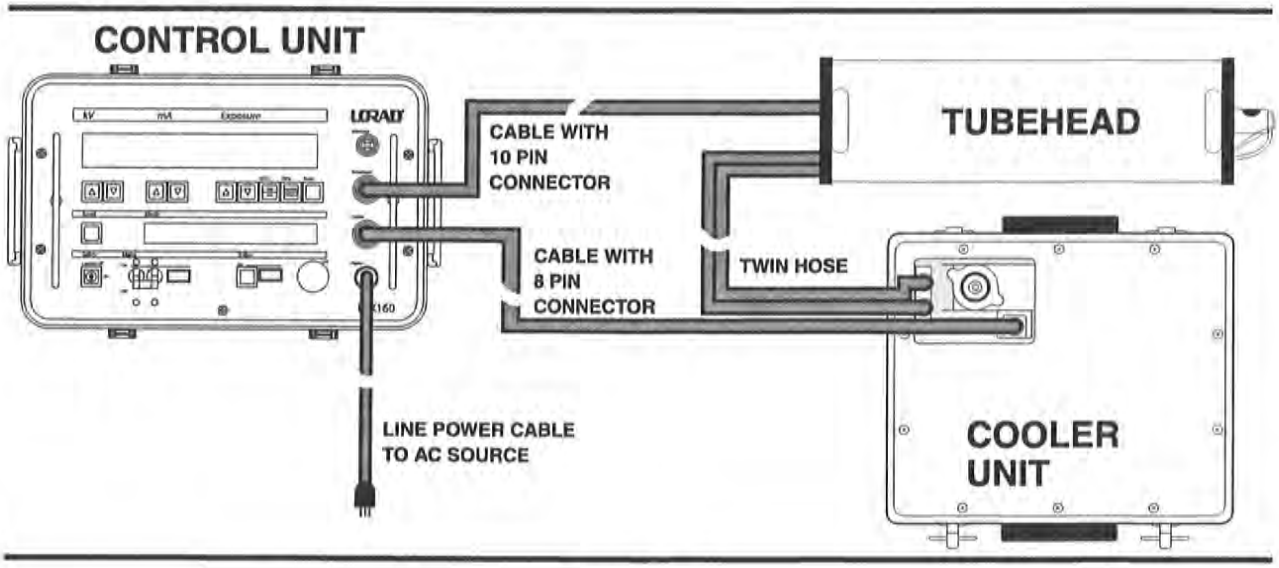


FIGURE 3-3:

LPX-160 SETUP

Step #6

Remove the Control Unit's top cover. Note the four connectors along the right side of the front panel. Check each connector, verifying there is no foreign material lodged inside. Visually inspect the entire Control Unit for missing or broken knobs and switches. Also, check the overall integrity of the entire unit.

Step #7

Install the cable (8 pin connectors) between the Control Unit and the Cooling Unit. Insert the male connector into the Control Unit, and the female connector into the Cooling Unit.

Step #8

Install the cable (10 pin connectors) between the Control Unit, and the Tube Head. Insert the male connector in the Control Unit, and female connector in the back of the Tube Head.

Step #9

Install the Line Power cable between the Control Unit and an AC Power Outlet. The female connector is inserted in the Control Unit, and the male end in the AC Outlet.

! NOTE !

The wall outlet must be rated either 120 VAC, 20 amps, 50/60 Hz or 230 VAC, 10 amps, 50/60Hz. Line voltage selection is automatic. For 220V input application, the male plug on the supplied power cord must be removed and replaced with one that fits the local AC receptacle, or an adapter cable can be locally manufactured. See Figure 3-4 for the correct plug termination.

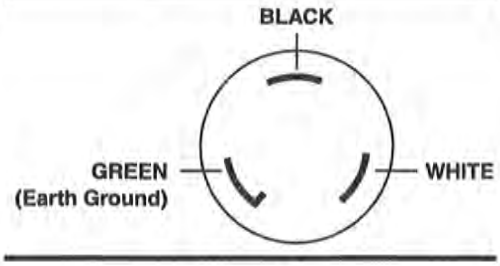


FIGURE 3-4:

220 VOLT PLUG TERMINATION

3.4 EXTERNAL INTERLOCK CONNECTIONS

The INTERLOCK connector on the front panel of the Control Unit allows x-ray enclosure doors and/or external warning devices to be interconnected with the internal safety interlock circuitry of the system.

! NOTE !

Pins "A" and "B" of the INTERLOCK connector must form a closed circuit in order to operate the x-ray unit. If no external switch interlocks are incorporated, a jumper (provided) must be installed across pins "A" and "B" to form this closed circuit.

Figure 3-5 illustrates the two circuits provided for this purpose. Pins "A" and "B" are used to connect enclosure door switches. When properly attached, x-rays can only be generated when the enclosure doors housing the Tube Head are shut. Pins "C" and "D" provide a switch closure to operate warning devices such as lights, sirens, or other types of external warning signals. These signals warn all personnel that x-rays are being generated.

! WARNING !

Voltage is present at pins "A" and "B" of the INTERLOCK when the unit is powered up. Ensure power is OFF before making any external connections or while installing the jumper.

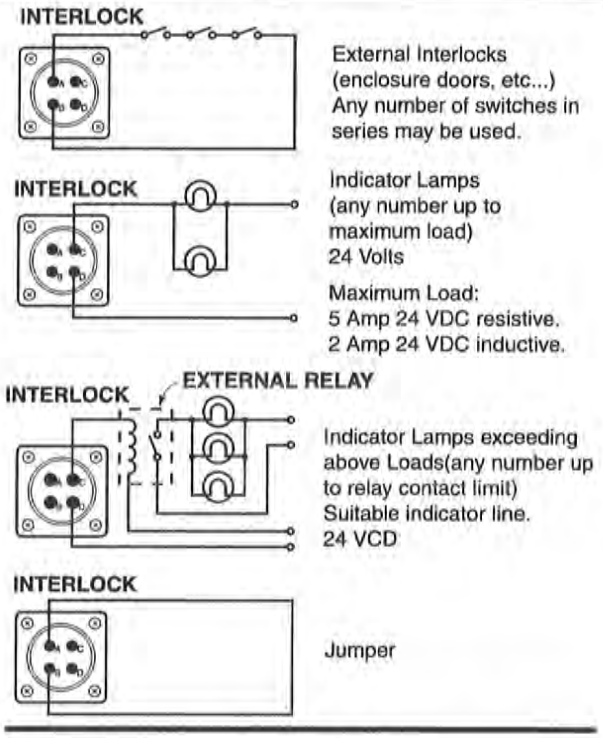


FIGURE 3-5:

EXTERNAL INTERLOCK CONNECTIONS

CHAPTER FOUR: OPERATION INSTRUCTIONS

4.1 PRE-OPERATIONAL CHECKS & SYSTEM SETUP

The procedures for setting up and inspecting the x-ray unit are described in Chapter Three.

4.2 OPERATION

The following paragraphs describe the controls and switches on the control panel of the LPX-160 Control Unit. The functions and use of these controls must be thoroughly understood before operating the x-ray unit.

4.3 CONTROL UNIT OVERVIEW

The control panel on the digital Control Unit contains the switches and indicators necessary to operate and monitor the x-ray apparatus. The control panel comprises two liquid crystal display (LCD) screens, exposure control pushbutton switches, a MAIN POWER circuit breaker, and LED indicators. Connectors along the right side of the panel provide connections for the input power cord and the system's interconnecting control cables.

4.3.1 The Top LCD (Figure 4-1)

The top LCD screen (large screen) displays two rows of exposure parameters. The top row displays the exposure parameters set by the operator using the front panel controls. The exposure kV is displayed on the left side of the screen, the mA is displayed near the center, and the exposure duration (TIME) is displayed on the right. The selectable exposure duration can be displayed in minutes and seconds, or in mAs.

The bottom row displays the actual operating levels during x-ray emission. The operating kV level is displayed on the left, directly below the set kV level. Tube current is displayed in the center of the screen, directly below the set mA level. At the right side of the screen, directly below the set exposure duration, is the time or mAs remaining or elapsed.

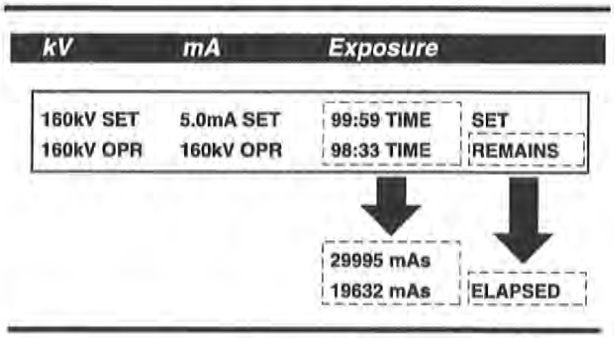


FIGURE 4-1:
TOP LCD DISPLAY

4.3.2 The Bottom LCD (Figure 4-2)

The bottom LCD screen (small screen) displays the system's operating mode, operator prompts, and any system (fault) messages. The upper left side of the screen indicates the system operation mode or one of the available automatic warm up modes. The lower left side of the screen indicates the selected warm up mode, or any system fault messages.

The right hand side of the screen indicates the current operating status of the system, or if a fault was detected, a description of the fault condition.

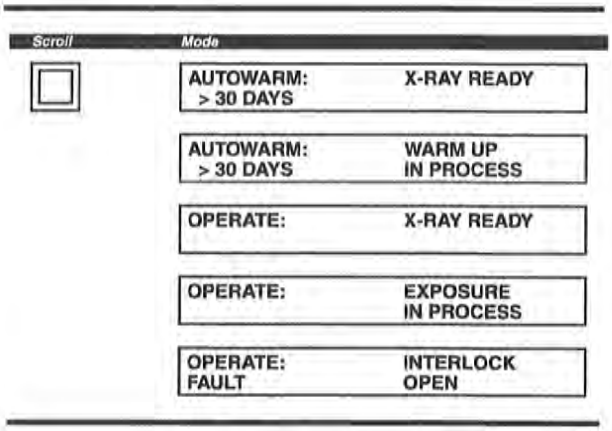


FIGURE 4-2:
BOTTOM LCD DISPLAY

4.4 FRONT PANEL CONTROLS AND INDICATORS

Refer to Figure 4-3 for the location of each control and indicator while reading this section.

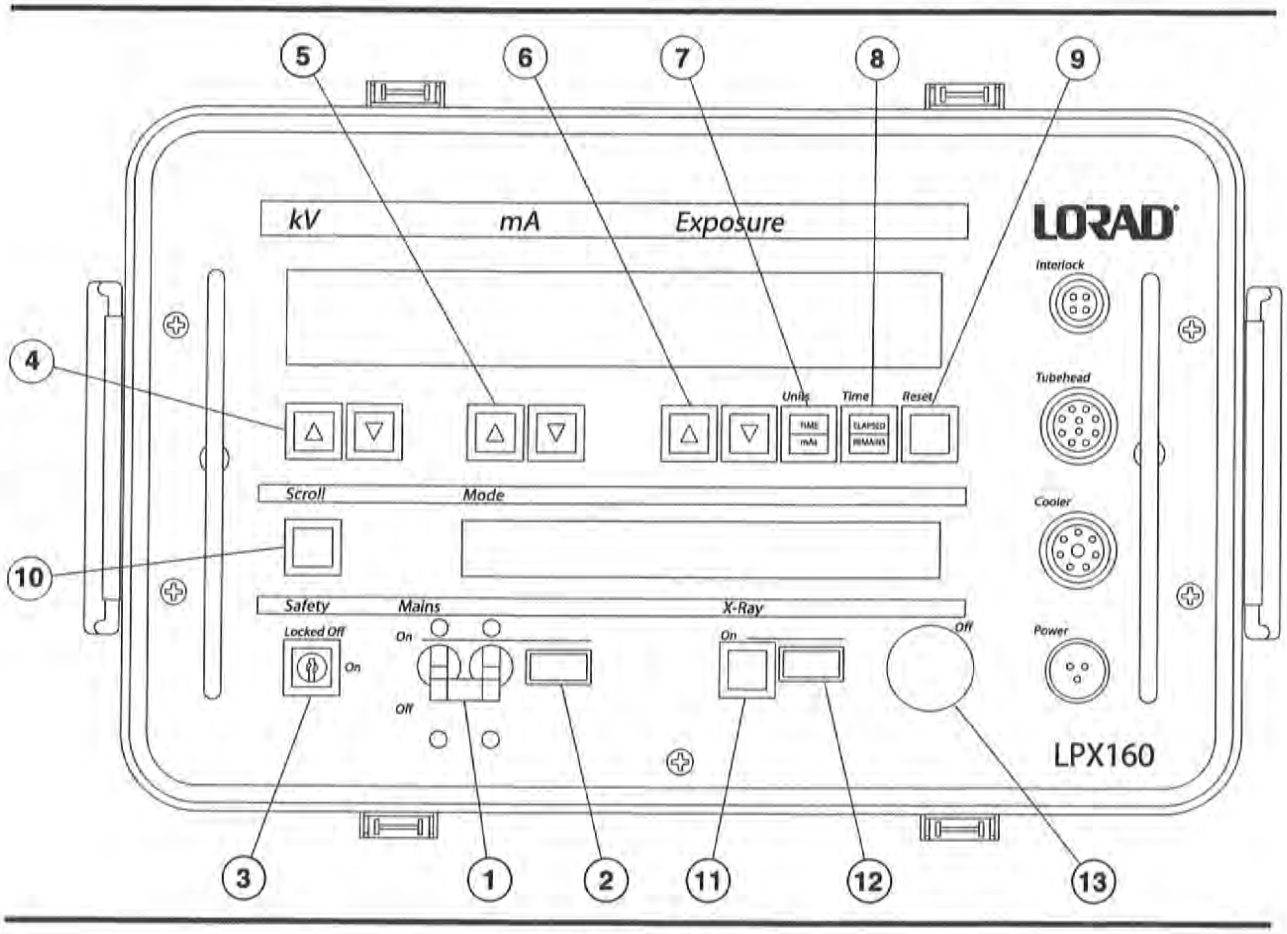


FIGURE 4-3:

CONTROLS AND INDICATORS

4.4.1 MAINS ON/OFF Switch (1)

The MAINS ON/OFF switch is a two position circuit breaker that applies power to the Control Unit. Placing the MAINS switch in the ON position causes line power to be applied to the Control Unit after a delay of approximately 2 seconds. During this delay the input power detection circuitry determines whether line voltage is 110 or 220 volts, and selects the proper line circuitry. Placing the MAINS switch in the OFF position causes line power to be immediately disconnected from the system. The MAINS switch also acts as the system circuit breaker and will automatically trip off if excessive current is drawn.

4.4.2 MAINS ON Indicator (2)

The MAINS ON indicator is a light emitting diode (LED) array located next to the MAINS ON/OFF switch. This LED glows green when line power is applied to the system.

4.4.3 SAFETY Switch (3)

The SAFETY switch, a two position key switch, prevents unauthorized use of the X-Ray Unit. Before x-rays can be generated, the key must be inserted into the switch and rotated to the ON position. The SAFETY switch does not activate x-ray generation, but permits use of the x-ray apparatus. The Tube Head must never be approached with power applied without the SAFETY switch in the LOCKED OFF position and the keys in the possession of the operator.

4.4.4 kV UP/DOWN Control (4)

The kV UP/DOWN pushbutton controls are located near the upper left side of the control panel, below the upper LCD display. These switches, identified by arrow labels, are used to set the desired exposure kV level. Pressing the UP button (D) causes the set kV in the upper portion of the LCD window to increment by 1 kV steps, toward 160 kV. Pressing the DOWN button (-) causes the set kV in the upper portion of the LCD window to decrement by 1 kV steps, toward 0 kV. For rapid change, press and hold the UP or DOWN button. For slow change, press and release the buttons.

These switches are active upon initial system power up, during an exposure in the OPERATE mode, and prior to an exposure provided the Exposure Counter has been reset.

4.4.5 mA UP/DOWN Control (5)

The mA UP/DOWN pushbutton controls are located near the center of the control panel, below the upper LCD display. These switches, identified by arrow labels, are used to set the desired exposure mA level. Pressing the UP button (D) causes the set mA in the upper portion of the LCD window to increment by 0.1 mA steps, toward 5.0 mA. Pressing the DOWN button (-) causes the set mA in the upper portion of the LCD window to decrement by 1 mA steps, toward 0 mA. For rapid change, press and hold the UP or DOWN button. For slow change, press and release the buttons.

These switches are active upon initial system power up, during an exposure in the OPERATE mode, and prior to an exposure provided the Exposure Counter has been reset.

4.4.6 EXPOSURE UP/DOWN Control (6)

The EXPOSURE UP/DOWN pushbutton controls are located near the upper right side of the control panel, directly below the upper LCD display. These switches, identified by the directional arrow labels, are used to set the desired exposure time or mAs value. Pressing the UP button (D) causes the exposure duration in the upper portion of the LCD window to rise toward the maximum exposure time of 99 minutes and 59 seconds (in the Time mode), or toward 29995 mAs (in the mAs mode). Pressing the DOWN button (-) causes the set exposure time or mAs value to decrease. For rapid change, press and hold the UP or DOWN button. For slow change, press and release the buttons.

These switches are active upon initial system power up and prior to an exposure provided the exposure timer has been reset.

4.4.7 UNITS (Time/mAs) Control (7)

The UNITS pushbutton control, located below the upper LCD display (next to the EXPOSURE UP/DOWN controls), switches between the two exposure duration modes (Time or mAs). When power is applied to the system, the exposure duration mode defaults to TIME. Pressing the UNITS button once switches the mode to mAs, and pressing it yet again switches it back to TIME.

In the TIME mode, the maximum exposure duration is 99 minutes and 59 seconds. In the mAs mode, the Control Unit monitors the operating mA and automatically controls the exposure duration to fulfill the selected number of mAs. No operator time calculations are required. This switch is active upon initial system power up, after an exposure is complete or has been interrupted, or if the exposure timer has been reset.

4.4.8 TIME (Elapsed/Remains) Control (8)

The TIME pushbutton control, located below the upper LCD display (next to the UNITS control), switches the selected exposure duration mode between Count Up (Elapsed) or Count Down (Remains) mode. Selecting the Elapsed mode causes the lower line of the exposure display to begin at zero and count upward until the set exposure time or mAs value is reached. Selecting the Remains mode causes the lower line of the exposure display to begin at the set exposure time or mAs value and count down until reaching zero.

The displayed units will be in minutes/seconds or mAs depending on the mode selected. This switch is active at all times when power is applied to the system.

4.4.9 RESET Control (9)

The RESET pushbutton control, located next to the TIME control, resets the exposure timer. When depressed, the exposure duration (lower row) will either return to the duration set by the operator (Remains mode), or to zero (Elapsed mode). This switch is only active after the exposure has been terminated, either by reaching the set time (or mAs), or having been interrupted by pressing the STOP Button.

4.4.10 SCROLL Control (10)

The SCROLL control, used in conjunction with the MODE display (lower LCD), switches between the OPERATE mode and the five AUTOWARM (warm-up) modes. The OPERATE mode is selected to make radiographs after completing the proper warm up sequence (if warm up is required). One of the five AUTOWARM modes are selected to run up to the required kV level at a fixed rate when the equipment has not been used for a period of time (see "Warm Up Sequence").

4.4.11 X-RAY ON Control (11)

The X-RAY ON control, identified by the radiation symbol, starts x-ray generation. The SAFETY KEY SWITCH must be turned to the ON position for this switch to activate.

4.4.12 X-RAY ON Indicator (12)

The X-RAY ON indicator is a light emitting diode (LED) array located next to the X-RAY ON control. This LED glows red when x-rays are being generated.

4.4.13 X-RAY OFF Control (13)

The X-RAY OFF control (large, red pushbutton switch), near the bottom of the control panel, terminates (interrupts) the x-ray exposure. This switch can be depressed anytime during the exposure, at which time power to the x-ray tube is discontinued, the exposure counter stops, and the red X-RAY ON LED array extinguishes. The timer will continue to display the exposure time (elapsed or remaining), or the mAs value until the START button is again depressed to resume the interrupted exposure, or the RESET control is pressed to set the time for a new exposure.

4.5 X-RAY TUBE WARM UP

The X-ray tube provided with this system has been pre-aged by the original manufacturer, and further tested and aged by Hologic. It is necessary, however, that the voltage be run up to the required kV level at a fixed rate when the equipment has not been used for a period of time. The LPX-160 (Digital) has an AUTOWARM feature, which allows the operator to select and initiate one of five automatic warm-up sequences.

4.5.1 Pre-Operational Safety Precautions

While performing the warm-up sequence, or during x-ray generation, the following safety precautions must be strictly observed before the x-ray tube is energized.

! WARNING !

To avoid radiation hazards under unshielded, outdoor operating conditions, the Control Unit must be placed a considerable distance from the Tube Head. A sufficient length of cable is provided, and must be used to help protect the operator and others in the immediate vicinity. Refer to NCRP (National Council on Radiation Protection) recommended practices. In NO case should personnel be in the path of the main x-ray beam, even at extended distances.

! WARNING !

The operator of this apparatus must ensure all personnel are clear of the hazardous X-ray area before generating X-rays. Flashing beacons and/or audible alarms should be utilized during exposures, warning personnel of the radiation hazards. Personal radiation monitoring devices shall be worn by all personnel in the immediate vicinity. Radiation warning signs shall be posted where necessary.

! WARNING !

The operator of this X-ray unit, or any person in the immediate vicinity, may be subject to receiving some exposure to X-radiation during the time that the X-ray unit is generating X-rays. Since X-rays can cause harmful effects to the human body, unnecessary exposure should be avoided, and all exposure held to an absolute minimum compatible with practical requirements and current safety regulations. An X-ray survey meter, placed in the vicinity of the Control Unit and operator, is recommended.

! WARNING !

All cables MUST be connected to their appropriate connectors on the Control Unit, Cooling Unit, and Tube Head before applying power to the System.

4.5.2 Using the Autowarm Feature

This procedure is required whenever the tube is operated above 100 kV, and four hours have elapsed since the x-ray tube was operated at the level required for the next exposure, or when operating with a new tube having less than ten hours of operation. The AUTOWARM modes automatically set the run-up level to 160 kV, but it is only necessary to run the tube to the kV level required for the next exposure. Tubes having been previously operated, but not run over 100 kV for 30 days or longer, must be treated as new tubes.

The following procedures outline the steps to properly complete the x-ray tube warm up sequence. Table 1 relates the tube's inactive time to the required AUTOWARM mode.

Step #1

Rotate the lead shield on the anode of the Tube Head until the window is completely blocked to reduce the amount of x-rays emitted during the warm up sequence

! WARNING !

Although the window is blocked, the Tube Head MUST NOT be approached during the warm up process. The area must be surveyed to assure adequate radiation limits. All applicable safety precautions must be observed.

Step #2

Check that all interlock connections are closed, or the jumper is installed across pins "A" and "B" of the INTERLOCK connector.

Step #3

Place the MAINS circuit breaker ON. Select the appropriate AUTOWARM mode from the table below. To do so, depress the SCROLL pushbutton until the lower LCD displays the appropriate AUTOWARM mode.

! WARNING !

The system is now capable of generating x-rays. All unauthorized personnel must be clear of the area, and all warning devices must be activated.

Step #4

Turn the SAFETY switch ON, then press the X-RAY ON button to start the AUTOWARM sequence. Allow the selected AUTOWARM sequence to operate through the kV level required for the ensuing exposure. For example, if the x-ray unit is to be operated at 130 kV, allow the system to autowarm past the 130 kV level (the next highest increment).

Table 4-1: AUTOWARM MODES

> 30 DAYS	This mode is used when the Tube Head has not been operated at the 160 kV level within the last 30 days. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 2 minutes at that level, the kV automatically rises 5 kV. These steps are automatically repeated every 2 minutes until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.
7 - 30 DAYS	This mode is used when the Tube Head has not been operated at the 160 kV level for at least 7 days but not more than 30 days. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 1 minute at that level, the kV automatically rises 5 kV. These steps are automatically repeated every 1 minute until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY
16 HRS. - 7 DAYS	This mode is used when the Tube Head has not been operated at the 160 kV level for at least 16 hours but not more than 7 days. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 1 minute at that level, the kV automatically rises 10 kV. These steps are automatically repeated every 1 minute until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.
8 - 16 HOURS	This mode is used when the Tube Head has not been operated at the 160 kV level for at least 8 hours but not more than 16 hours. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 1 minute at that level, the kV automatically rises 20 kV. These steps are automatically repeated every 1 minute until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.
4 - 8 HOURS	This mode is used when the Tube Head has not been operated at the 160 kV level for at least 4 hours but not more than 8 hours. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 1 minute at that level, the kV automatically rises 30 kV. These steps are automatically repeated every 1 minute until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.

Step #5

When the system is properly warmed up, press the STOP button. The Mode Display will indicate:

WARM-UP INTERRUPTED

Step #6

Press the RESET button, then press the scroll button until the Mode display indicates:

OPERATE: X-RAY READY

If the ensuing exposure is to be operated at 160 kV, simply let the AUTOWARM mode continue (do not press the STOP button). When the sequence completes the warm-up at 160 kV, the lower LCD screen automatically displays the above message.

Step #7

Turn the SAFETY SWITCH to the LOCKED OFF position and remove the key. Rotate the lead shield on the Tube Head's anode to expose the window. X-ray exposures at the kV level warmed up to can now be safely made.

! NOTE !

It is normal in a new x-ray tube for tube seasoning reactions to occur. These reactions are a necessary part of the glass metallization process in the tube, and can be expected to occur until the tube has been operated for at least 30 hours, or if the tube has been dormant for extended periods of time. Also, seasoning reactions may occur during the Autowarm sequence.

! NOTE !

During Autowarm, if seasoning reactions occur, x-ray generation is automatically stopped, and the Mode window displays the message: ARC DETECTED - RESTART. Re-activate x-ray generation by pressing the X-RAY ON switch. The kV level will rise to 20 kV below where the reaction occurred and operate for 2 minutes. After, the kV level rises to the next highest incremental kV level on the selected warmup schedule. The Autowarm sequence will then proceed normally.

! NOTE !

If the automatic reduction of kV reduces the kV level below 100 kV, the Mode window displays the message: ARC SERVICE. When this occurs, switch the MAINS power switch OFF, then back ON to restart the Autowarm sequence.

! NOTE !

Occasionally with a new tube (or with a tube that has been dormant), reactions occur at kV levels below 100 kV. This causes the kV level to not rise to 100 kV, and the ARC message to show immediately after pressing the x-ray button. When this occurs, scroll to the OPERATE: XRAY READY mode, set the unit for 5.0 mA, and 0 kV. Press the X-RAY button and increase the kV level—one kV per second—for 30 seconds (30 kV). The mA should rise to 5.0 mA. After 30 seconds, advance the kV level in 10 kV steps every 30 seconds to 100 kV. Switch the MAINS OFF, then back ON. Use the Autowarm sequence to warm-up the tube to the desired level.

4.6 LPX-160 OPERATING PROCEDURES

When the system is properly assembled, the warm-up sequence complete, and all safety precautions/practices taken, x-ray exposures can be made by following the steps below.

All NOTES, CAUTIONS, and WARNINGS outlined in this section must be strictly observed to avoid damaging equipment, or injuring personnel.

Step #1

If the operator has not read the "SAFETY SUMMARY" in Chapter 1 of the original document, and the WARNINGS outlined under "Pre-Operational Safety Precautions" of this document, do so before proceeding.

Step #2

Perform all pre-operational checks and inspections before operating this unit. Also, confirm that all external interlock connections are closed, or that the jumper is installed in the INTERLOCK connector.

> **! WARNING !**
>
> All cables MUST be connected to their appropriate connectors on the Control Unit, Cooling Unit, and Tube Head before power is applied to the System.

Step #3

Make sure the SAFETY KEYSWITCH is in the LOCKED OFF position, then remove the key. Turn the MAINS switch ON. After approximately 2 seconds, the green MAINS LED indicator will illuminate, the Cooling Unit will start, the Control Unit's cooling fan will start, and information will appear in the upper and lower LCD screens.

Step #4

If the LPX-160 is to be operated above 100 kV and it has been more than four hours since it was last operated at that level, or if operating with a new x-ray tube, it is necessary to perform the appropriate warm-up procedure (outlined earlier in this document). If the warm-up procedure is unnecessary, proceed to Step #5.

Step #5

Press the SCROLL pushbutton until the lower LCD display indicates "OPERATE: X-RAY READY". Set the desired kV and mA levels using the appropriate UP/DOWN controls. Set the desired exposure duration using the EXPOSURE UP/DOWN controls.

Step #6

Position the film holder and Tube Head for the ensuing exposure. Make sure all personnel are clear of the area, and that all external warning devices are working properly. Insert the key into the SAFETY KEYSWITCH and turn it to the ON position. The LPX-160 is now ready to make an exposure. Press the X-RAY ON switch to begin the exposure.

> **! WARNING !**
>
> NEVER allow the x-ray unit to run unattended. NEVER approach the x-ray Tube Head when power is applied, or if the key is in the SAFETY LOCK.

> **! CAUTION !**
>
> Tube current (mA) can be run up to the maximum value it can produce at the set kV level, up to 5 mA. At no time, however, should the tube be permitted to operate above 5 mA. Lower kV settings (settings below 25 kV) will not permit the tube to generate the full 5 mA.

Step #7

The exposure will continue for the duration set by the operator, after which time the unit will automatically shut off. During the exposure, x-ray emission can be interrupted anytime by pressing the red X-RAY OFF pushbutton. To restart an interrupted exposure, press the X-RAY ON switch.

Step #8

At the end of the exposure, turn the key in the SAFETY KEYSWITCH to the LOCKED OFF position. Remove the key while making any positioning adjustments to the Tube Head or replacing film holders. Press the RESET button. To repeat the exposure, re-insert the key and turn it to the ON position and press the X-RAY ON button. If the next exposure requires new parameters, press the appropriate UP/DOWN switches at this time to set in the new factors, then turn the key to the ON position and press the X-RAY ON switch.

Step #9

If further operation is not necessary, turn the key to the LOCKED OFF position and remove it. Allow the Cooling Unit to operate for an additional five minutes.

> **! NOTE !**
>
> The Cooling Unit must be allowed to operate for five minutes after the exposure before turning the unit OFF. During this time, heat generated at the anode during operation is dissipated.

Step #10

After the five minute cool down period, place the MAINS circuit breaker OFF. Remove the power cord from its source, disconnect all cables and hoses, and replace all covers. Place the key in a safe, controlled area to prevent unauthorized use of the unit. Store the x-ray unit in a cool, dry location that provides secure storage.

4.7 LPX-160 FAULT MESSAGES

During operation, if a fault condition occurs, x-ray generation is automatically terminated and FAULT messages will appear in the MODE display (lower LCD). The following is a list of the fault messages that may appear and instructions on how to remedy the fault.

INTERLOCK

The connection between pins "A" and "B" of the INTERLOCK connector has been interrupted. Check that the interlocked enclosure door switches are operable and closed, or that the jumper is properly installed.

INTLCK-FLOW

Coolant flow from the Cooling Unit to the Tube Head has been interrupted. Check that the Cooling Unit is functioning, or that the twin coolant hose is properly attached.

TEMPERATURE/PRESSURE

The Tube Head has overheated or the gas pressure has dropped below 20 psi. Make sure the Cooling Unit is working properly. Check the gas pressure within the Tube Head. If the pressure is below 50 psi @ 70°F, perform the Re-pressurization/Re-Filling procedures outlined in Chapter 5 of the original document.

ARC DETECTED

This fault condition is usually due to instability from a new tube or from an inadequate warm up sequence. Re-start the system and perform an additional warm up sequence. If the ARC DETECTED fault occurs repeatedly on restart, service is necessary.

EXCESS kV

This condition occurs if the drive voltage to the high voltage inverter (in the Control Unit) exceeds a factory set level. If this message occurs repeatedly, service is necessary.

X-RAY SW. ERROR

Upon power up, the computer checks the X-RAY ON button for a short circuit and displays this message if a short is detected. X-ray generation cannot be initiated in this condition. Service is necessary.

CHAPTER FIVE: MAINTENANCE INSTRUCTIONS

5.1 ROUTINE UPKEEP AND CARE

The LPX-160 Portable X-ray Unit is a reliable, easily maintained, industrial x-ray device. With modest amounts of upkeep and care, this system will provide the user years of trouble free operation. Section 5.1 "Routine Upkeep and Care", provides an inspection guideline, that if followed, reduces the possibility of equipment breakdown, and optimizes the unit's reliability.

This section outlines the minor periodic upkeep practices to perform regularly. Overhaul and major maintenance procedures are covered in section 5.3, section 5.4, and section 5.5. Some of the routine practices are conducted in accordance to a pre-arranged schedule (inspections and cleaning), while others need attention only when the need arises (re-pressurizing or re-filling the tube head).

Other minor upkeep procedures, such as coolant mixture procedures, are detailed here. If these minor care practices are followed, discrepancies are detected and repaired earlier, reducing "down" time and the need for major overhaul.

5.1.1 Inspection Checklist

To minimize the possibility of equipment breakdown, and assist in early detection of potential problems, the following "Inspection Checklist" should be followed. Discrepancies discovered during these inspections must be noted, and immediately corrected to avoid major malfunctions of the x-ray unit.

These inspections must be performed before each use, except where noted. The schedule for semi-annual inspections should be established based on the conditions under which it is used. The following pages contain checklists outlining specific areas on each assembly that should be checked during each inspection cycle.

! NOTE !

When operating in harsh environments, the following inspection checklist must be performed sooner than normally scheduled due to the higher concentration of dust and debris accumulating within each assembly.

CHECK THE FOLLOWING BEFORE EACH USE

TABLE 5-1: TUBE HEAD CHECKLIST

Pressure Gauge	Gauge in good condition; Gas pressure 50 - 55 psi @ 70°F.
Gas Valve Cap	Securely fastened to charging valve.
Twin Hose Connectors	Check for dents, nicks, or corrosion; Hose couplings seat properly.
Cable Connector	Ensure all pins are straight; Check for corrosion or debris; Check condition of threads.
Tube Head Handles	Check for cracks or breaks.
Lead Shield	Check for cracks or dents; Ensure shield rotates freely.
Tube Head Housing	Paint finish in good condition; Check for dents and visible damage.

Table 5-2: Control Unit Checklist

Cabinet and Cover	Paint finish in good condition; check for dents and visible damage; check for loose hardware
Cable Connectors	Firmly seated on front panel; check for bent or broken pins; check for corrosion or debris; check for cracked receptacles check thread condition.
Control Switches	Pushbuttons spring back when depressed; check for cracked or broken switches; identification labeling readable.
Indicator Lamps/LEDs	Illuminate when activated.
LCD Displays Screens	Check for cracks or damage; backdrop lights upon power up; RESET button operates.
Fan	Operates when power is applied.

Table 5-3: Cooling Unit Checklist

Coolant Level	Radiator Cap is easily removed; Fluid level within 1/2" from top.
Radiator *+	Check for cleanliness; Check for dents, cracks or damage.
Drive Belt *+	Check for cracks or frayed areas; Check for proper belt tension.
Air Filter *+	Check for cracks or visible damage; Check for cleanliness.
Pump Assembly *+	Rotates freely; Check for signs of leakage.
Motor and Fan *+	Rotates freely; Check for dents or cracks.

*Equipment Covers must be removed to perform inspection.
+ Should be checked semi-annually or more frequently as conditions dictate.

Table 5-4: Interconnecting Cables and Hose Checklist

Military Connectors	Secured firmly to cable; Check for corrosion or debris Check for bent or broken pins; Check for cracked or broken housing.
Cable Insulation	Check for cracks, holes or frays; Check for signs of wear or dry rot.
Hose Couplings	Couplings secured firmly to hose; Check for corrosion or blockage.
Hoses	Check hoses for cracks or punctures; Check for visible signs of leakage.

5.1.2 Cleaning the LPX-160

An essential element to keeping the LPX-160 working in peak condition is cleanliness. During prolonged periods of use, especially in harsh environmental operating conditions, it becomes necessary to clean each assembly of the system. Maintaining a standard cleaning schedule is a significant part of any preventative maintenance program. Unit cleanliness helps optimize performance, and minimizes equipment failure during use.

The following paragraphs outline the materials needed, and the steps to perform, to clean the LPX-160. Cleaning should be performed every 90 days, or more often if an obvious need arises.

5.1.2.1 Required Cleaning Materials

1. Clean lint free cloths;
2. Mild detergent;
3. 1" Soft bristled paint brush;
4. Electronic Cleaning Solution;
5. Acid brushes;
6. Low pressure air station, hose and nozzle set. (pressure not to exceed 25 p.s.i.)

5.1.2.2 Cleaning the X-Ray Unit

! WARNING !

Power to the unit MUST be OFF and the unit MUST be disconnected from the power source when cleaning is in progress.

Step #1

Dampen a clean lint free cloth in a solution of warm water and mild detergent. Wring any excess water from the cloth to prevent dripping. Remove dirt, dust, or debris from the Top Cover of the Control Unit. Clean the outer casing of the Tube Head, Control Unit, and Cooling Unit using this same method.

Step #2

Remove dirt, dust, or debris from the Front Panel of the Control Unit using a 1" soft bristled paint brush. Dirt that is not easily dislodged can be removed with a lint free cloth dampened in a warm water and mild detergent solution.

! CAUTION !

DO NOT allow any water to enter the cable jackets or connectors when cleaning the equipment. Always wring out any excess water from the cloth.

Step #3

Remove the Control and Cooling Units from their respective cases by first removing the bolts from the bottom of the case, then removing the screws from the top panel. Carefully lift the entire unit out of the case. Using a LP (low pressure) air and nozzle system, blow any dirt, dust, or debris out of the unit.

Step #4

Inspect the connectors on each cable assembly. Remove any dirt, dust, debris, or foreign material from the pins/sockets with Electronic Cleaning Solution and an acid brush. DO NOT use water. Check for corrosion on the pins or connectors and remove if necessary.

Step #5

The Air Filter within the Cooling Unit is washable and should be cleaned periodically. Refer to the procedures outlined under "Cooling Unit Upkeep" (section 5.1.4).

5.1.3 Tube Head Upkeep

The following paragraphs describe the general maintenance procedures to be completed periodically on the Tube Head Assembly. Outlined below are the steps for "Re-pressurizing", and "Re-filling" the Tube Head with Sulfur Hexafluoride gas, and the conditions under which each are performed. A "Temperature Compensation" chart is provided for use as a reference while conducting these tasks (Figure 5-2).

5.1.3.1 Re-Pressurizing the Tube Head Assembly

This x-ray unit can be safely operated at Tube Head pressures as low as 50 psi @ 70°F. Should the Tube Head pressure fall below this value (as indicated on the pressure gauge), the Tube Head will need re-pressurizing. Following the procedures outlined below, the Tube Head can be re-pressurized between 50 and 55 psi with dry Sulfur Hexafluoride gas at 70°F through the charging valve (automobile tire type) located on the back of the Tube Head assembly. Use a hose incorporated with a relief valve or pressure regulator, and a gauge having an accuracy of at least ±4 psi. Figure 5-1 and Figure 5-2 can be used as references while performing these procedures.

! CAUTION !

DO NOT re-pressurize if Tube Head pressure has fallen below 5 psi @ 70°F. Such low pressures may have caused contaminants to enter the Tube Head chamber, and can cause damage from high voltage arcing. If pressure is below 5 psi, the Tube Head must be purged of all gas, then re-filled. Note the differences between "re-pressurizing" and "re-filling" the Tube Head.

! NOTE !

A Charger and Maintenance Kit for the Tube Head is available, (see section 3.1.2 of this manual).

TUBE HEAD PRESSURIZATION SETUP

Step #1

Remove the protective cover from the SF_6 (Sulfur Hexafluoride) cylinder (2). Remove the plug from the cylinder valve (3) with a 3/8" Allen Wrench. The cylinder valve outlet is left-hand threaded.

! CAUTION !

Extreme care must be exercised while handling the cylinder so as not to drop it after the protective cover has been removed.

Step #2

Connect the SF_6 charging regulator assembly (6), or equivalent, to the SF_6 cylinder valve.

! NOTE !

The pressure regulator supplied with the optional recharge kit is factory set to 50- 55psi @ 70°F, and locked with a hex nut on the adjustment knob. However, due to spring tension aging, and/or various ambient temperatures, this setting may need to be updated.

Step #3

Connect the Tube Head (1) to the Regulator assembly (6) using the hose (8), as shown in Figure 5-1. Leave the SF_6 cylinder closed at this time. For this procedure, hose (9), and pump (10) are not required.

Step #4

Open the Vacuum Line Valve (7) slightly, to purge the hose (8) of standing air. Open the SF_6 gas cylinder slightly to purge the regulator of any standing air. Now close the Vacuum Line Valve (7), and open the SF_6 cylinder valve (3) to its fully open position (when reaching its physical stop).

Step #5

The Tube Head will begin filling with SF_6. When the Tube Head gauge indicates the correct pressure, close the SF_6 cylinder valve (3). To determine the correct pressure, refer to the "Pressure vs. Temperature" chart (Figure 5-2).

Step #6

Remove the charging hose connection at the Tube Head. Secure the gas cylinder by removing the connections and replacing the protective cover. Recheck the pressure and inspect the Tube Head for leakage.

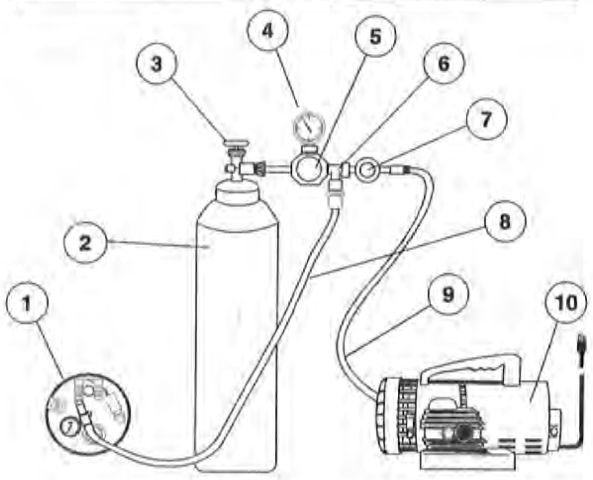


FIGURE 5-1:

TUBE HEAD PRESSURIZATION SETUP

5.1.3.2 Re-Filling the Tube Head Assembly

This procedure is used when gas pressure within the Tube Head has dropped below 5 psi @ 70°F, or after major maintenance on the Tube Head has occurred. To re-fill the Tube Head, follow the procedures outlined below while referring to Figure 5-1 and Figure 5-2.

Step #1

Remove the protective cover from the SF_6 (Sulfur Hexafluoride) cylinder (2). Remove the plug from the cylinder valve (3) with a 3/8" Allen Wrench. The cylinder valve outlet is left-hand threaded.

! WARNING !

Extreme care must be exercised while handling the cylinder so as not to drop it after the protective cover has been removed.

Step #2

Connect the SF_6 charging regulator assembly (6), or equivalent, to the SF_6 cylinder valve.

! NOTE !

The pressure regulator supplied with the optional recharge kit is factory set to 50-55psi @ 70°F, and locked with a hex nut on the adjustment knob. However, due to spring tension aging, and/or various ambient temperatures, this setting may need to be updated.

Step #3

Connect the Vacuum Pump (10) and the Tube Head (1) to the Regulator Assembly (6), using the hoses (8) and (9) as shown in Figure 5-1.

Step #4

Leaving the SF_6 gas cylinder valve (3) closed, open the Vacuum Line (7) counter-clockwise.

Step #5

Start the Vacuum Pump and allow it to run for at least 20 minutes. The final vacuum indicated on the regulator gauge should be at least 25" Hg.

Step #6

Close the Vacuum Line Valve (7) and turn the Vacuum Pump off. Open the SF_6 cylinder valve (3) to its fully open position (until reaching its physical stop). Fill the Tube Head until the gauge indicates 25 psi, then close the cylinder valve.

Step #7

Open the Vacuum Valve and run the pump an additional 10 minutes. Close the Vacuum Line and stop the pump. Open the SF_6 cylinder valve again and fill the Tube Head to the pressure indicated on the "Pressure vs. Temperature" chart (Figure 5-2). When the Tube Head is at the correct pressure, close the SF_6 cylinder Valve.

Step #8

Remove the charging hose connection at the Tube Head, secure the gas cylinder, and replace the protective cover. Re-check the pressure and inspect the Tube Head for leaks.

5.1.3.3 Temperature Compensation

As shown in Figure 5-2, temperature changes cause SF_6 gas to expand or contract at the rate of 1 psi for every 7°F increase/decrease in ambient air temperature. Allowances for these changes must be made when checking the Tube Head gas pressure, or while re-pressurizing/re-filling the Tube Head. The following graph illustrates the maximum and minimum pressure limitation of the Tube Head at various temperature ranges. This chart is to be used whenever the Tube Head is inspected, re-pressurized, or re-filled.

! NOTE !

It is standard practice to allow both the gas supply and the Tube Head to achieve room temperature before attempting to re-pressurize. This eliminates errors resulting from differences between the gas supply and the Tube Head temperatures.

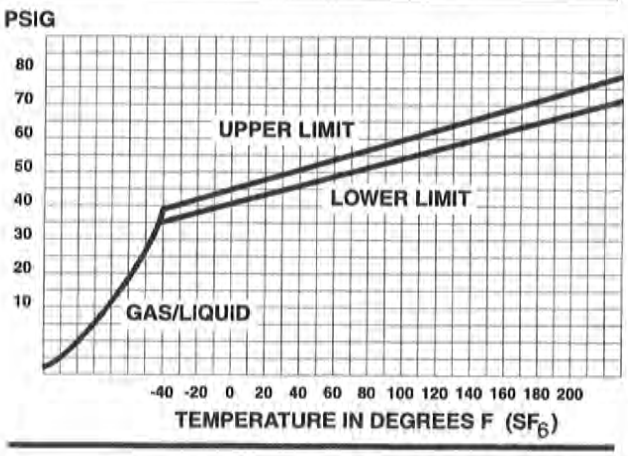


FIGURE 5-2:

PRESSURE VS. TEMPERATURE CHART

5.1.4 Cooling Unit Upkeep

The following paragraphs describe the general maintenance procedures to be completed periodically on the Cooling Unit Assembly. These tasks include mixing and adding of coolant solution, cleaning the Air Filter, and cleaning the Coolant Filter. These procedures should be completed in accordance with the pre-arranged inspection cycle, and should be modified accordingly during times of heavy use or while operating under severe environmental conditions.

5.1.4.1 Mixing and Adding Coolant Solution

There are times, after prolonged use (due to evaporation), or after performing maintenance on the Cooling Unit, that coolant solution will have to be added to the reservoir. The following procedures outline the methods used to properly formulate, and add coolant solution to the Cooling Unit.

Step #1

A plastic container is needed to mix and store the coolant solution. The container should be appropriately sized to accommodate easy handling, have a method of pouring the solution, and a means of capping it off for storage.

Step #2

In this container mix 14 parts of methyl alcohol, with 7 parts distilled water, and 1 part "TEXACO" Soluble "D" oil. Gently agitate the container to help blend the solution.

Step #3

Remove the top cover from the Cooling Unit, then remove the radiator cap. If the coolant level is more than 1/2" from the top of the reservoir, coolant solution must be added.

Step #4

Add enough coolant solution to the reservoir so that the level is approximately 1/2" from the top, then replace the radiator cap.

Step #5

Install the Twin Hose assembly between the Cooling Unit and the Tube Head. Connect the Control Unit to the Cooling Unit and apply power. Allow the coolant to circulate through the system for approximately three minutes.

Step #6

Remove power, then remove the radiator cap. Inspect the coolant level and ensure it is within 1/2" from the top of the reservoir. Add more coolant solution if necessary, and repeat step #5.

! WARNING !

The coolant container must be stored in a cool, dry area with the cap on. The container must be clearly marked, so the contents are easily identified.

5.1.4.2 Cooling Unit Maintenance Cleaning

The wire mesh air filter within the Cooling Unit must be cleaned periodically to remove dust, dirt, or debris collected during use. Large accumulations of dirt can impede the flow of air through the radiator assembly, resulting in restricted or limited cooling of the anode. The following procedures outline the steps to remove and clean the Cooling Unit's Air Filter.

Step #1

Remove the top cover from the Cooling Unit. Extract the Cooling Unit from the protective case by removing the ten screws from the top plate, then remove the four bolts from the bottom of the case. Lift the entire Cooling Unit from the protective case.

Step #2

Remove the four screws (with nuts) securing the grille and filter to the inner side of the protective case.

Step #3

Remove dirt, dust, or debris from the filter by washing it in a solution of mild detergent and warm water. When complete, rinse the filter thoroughly with clean, warm water. DO NOT use gasoline or other solvents to clean the filter. Allow the filter to dry completely, or blow off any remaining moisture with compressed air.

Step #4

Re-install the filter and grille assembly to the protective case. DO NOT over tighten the mounting hardware or distortion to the filter frame may occur.

Step #5

The Cooling Unit contains a screen type filter housed within an in-line strainer assembly. This assembly is attached to the Cooling Unit chassis. The filter must be removed, inspected, and cleaned periodically to prevent restricted coolant flow and over heating of the anode. To remove and clean the filter assembly, follow the procedures outlined below.

Step #6

Unscrew and remove the cap nut from the strainer assembly (coolant solution can be expected to seep out while the cap is removed). Lift the Filter/Strainer out of the assembly, and quickly replace the cap nut to stem the flow of coolant solution.

Step #7

Remove contaminants from the filter with a solution of warm water and mild detergent. The screen is made of delicate material and can be deformed quite easily. Care must be taken while handling the filter.

Step #8

Rinse the filter in clean, warm water to remove excess detergent. Remove the cap nut and install the filter. Replace the cap nut and tighten.

Step #9

Add coolant solution to the reservoir, to compensate for spillage that occurred during cleaning. Clean any coolant solution from the chassis that leaked out during this procedure. Install the chassis into the protective case. Re-install top plate and cooling unit cover.

! NOTE !

Attach the Twin Hose assembly between the Cooling Unit and the Tube Head, and the Control Unit to the Cooling Unit. Apply power, and allow coolant to circulate for three minutes. Re-check the coolant level to ensure it is 1/2" from the top. Add coolant solution as needed.

5.2 SYSTEM DESCRIPTION

This section contains the Theory of Operation and Circuit Descriptions for each assembly of the LPX-160 Industrial x-ray unit. This information will provide experienced electronic technicians with a sufficient amount of knowledge to logically understand the circuitry and troubleshoot the equipment. The contents of this section must be read in their entirety and thoroughly understood before attempting any troubleshooting procedures.

The LPX-160 consists of three major assemblies: the Control Unit, the Cooling Unit, and the Tube Head. Detailed first is the Theory of Operation for these assemblies. The theory describes the sequence of operation and general system information that can be referenced to the Block Diagram provided (Figure 5-3). This Block Diagram logically illustrates the arrangement of the three assemblies and should be used when troubleshooting. The Circuit Description outlines, in greater detail, the circuitry within each assembly of the LPX-160. When troubleshooting the system, refer to the appropriate schematic in section six of this manual.

5.2.1 Theory of Operation

The following paragraphs describe the Theory of Operation of the LPX-160 Industrial x-ray unit. Refer to Figure 5-3, "System Block Diagram".

5.2.1.1 Theory of Operation Overview

The LPX-160 Industrial x-ray unit is a digitally controlled system consisting of three major assemblies:

1. X-ray Tube Head;
2. Control Unit;
3. Cooling Unit.

The Tube Head assembly houses the x-ray tube, the High Voltage D.C. Power Supply, and the Filament Transformer. The x-ray tube emits x-rays during system operation. The High Voltage D.C. Power Supply provides the necessary voltage needed to generate x-rays within the tube. The Filament Transformer within the Tube Head provides current to the x-ray tube, that heats the tube's filament.

The Control Unit houses the necessary circuitry to convert input line power to the voltages needed to drive, and regulate, the kV and filament circuits within the Tube Head and the cooling unit.

The Cooling Unit recirculates liquid coolant to the x-ray tube anode. This self contained cooling system dissipates heat generated at the anode, and keeps the tube's anode temperature within acceptable levels.

5.2.1.2 Control Unit Theory of Operation

The Digital Control Unit is made up of a computer controlled Front Panel Assembly and a power supply Chassis Assembly. The power supply Chassis Assembly generates all the power needed to drive the high voltage and filament circuits in the Tube Head. kV is produced from 0 to 160 and is proportional to a 0 to 10 volt analog control signal supplied by the Front Panel Assembly. mA from 0 to 5 is produced and is proportional to a 0 to 5 volt analog control signal also from the Front Panel Assembly. The Chassis Assembly provides to the Front Panel Assembly a 0 to 10 volt analog sense signal proportional to the actual measured Tube Head kV, and a 0 to 5 volt analog sense signal proportional to the measured mA. The Front Panel Assembly generates the analog control voltages by digital means and converts the analog sense voltages to digital information and displays the measured kV and mA digitally on the front panel.

The exposure parameters (kV, mA, and time) are set by two different modes (AUTOWARM and OPERATE). In AUTOWARM mode, the microcontroller sets the parameters according to five operator selectable, factory programmed warm-up schedules. In OPERATE mode, the operator instructs the microcontroller what exposure parameters to set through the use of incrementing and decrementing pushbutton type switches. The microcontroller displays the set parameters by digital means on the front panel.

When the operator initiates an exposure by pressing the X-RAY ON switch, the microcontroller senses the switch closing, activates the kV and mA Boards, sets the kV and mA Board output levels, times the exposure, and then terminates the exposure after the set time has elapsed.

The microcontroller monitors the Cooling Unit flow switch, the Tube Head temperature and pressure sensors, the INTERLOCK connection, the kV Board arc detector, and the high kV detector outputs. If a fault condition occurs at any of these points, the microcontroller terminates x-ray generation and displays a message informing the operator which fault occurred.

The Control Unit contains two (2) principal power sections, the kV Drive and the mA Drive. The kV Drive provides power to the Tube Head circuitry, that develops the high x-ray potentials. The mA Drive provides power to heat the x-ray tube filament. X-ray tube current (mA) is determined by controlling the temperature of the filament with the Filament Drive circuitry. This controls the number of electrons "boiled off" the filament, thus providing tube current flow.

Line Power is supplied to the Line Rectifier circuitry, that converts the 50/60 Hz line power to a regulated D.C. voltage. When operating from a 230 volt line source, the rectifier provides a D.C. potential equal to the approximate peak value of the line voltage. When operating from a 115 volt line source, the rectifier serves as a voltage doubler. The unregulated D.C. voltage is equal to twice the approximate

peak value of the line voltage. This unregulated D.C. power is applied to the kV and mA supply circuitry.

The kV Supply circuitry within the Control Unit consists of a Buck Regulator that converts the unregulated D.C. voltage from the Rectifier to a regulated D.C. voltage. The value of the regulated D.C. voltage is determined by the kV Control setting on the Control Unit's front panel. The regulated D.C. voltage from the Buck Regulator is applied to the kV Inverter, and converted to a square wave A.C. voltage for application to the Tube Head. A small portion of the kV generated in the Tube Head is fed back to the kV Buck Regulator, and continually compared to the setting on the kV Control. The Buck Regulator constantly adjusts the regulated output as necessary to maintain the kV level initially set on the kV Control.

The mA Supply circuitry within the Control Unit works similar to the kV Supply circuitry. Unregulated D.C. power from the Rectifier is applied to the mA Buck Regulator. The Buck Regulator converts the unregulated D.C. voltage to a regulated D.C. voltage. The value of the regulated D.C. voltage is determined by the mA Control setting on the Control Unit's front panel. This regulated D.C. voltage is applied to the mA Inverter, and converted into a square wave A.C. voltage for application to the Tube Head Filament Transformer. The x-ray tube current from the Tube Head is fed back to the mA Buck Regulator, and continually compared to the setting on the mA Control. The Buck Regulator constantly adjusts the regulated output as necessary to maintain the tube current initially set on the mA Control.

The Control Unit also houses the Low Voltage Power Supplies used to furnish biasing voltages to the internal circuitry within the Control Unit.

5.2.1.3 Tube Head Theory of Operation

The square wave from the kV Drive Inverter within the Control Unit is applied to the High Voltage Step-Up Transformer within the Tube Head. The Step-Up Transformer increases the amplitude to approximately 32,000 volts (maximum for 160 kV). This high voltage A.C. is applied to the High Voltage Rectifier/Multiplier. The Rectifier/Multiplier converts the A.C. signal to D.C., and increases the level to 160 kV. The D.C. is then applied to the x-ray tube cathode.

The square wave from the mA Drive Inverter within the Control Unit is applied to the Filament Transformer. The Filament Transformer decreases the square wave, approximately nine (9) times, to a level appropriate for the x-ray tube filament. Since the x-ray tube filament is at the 160 kV level, the Filament Transformer also provides enough isolation to withstand the high voltage differential between its input and its output.

The Tube Head is pressurized to approximately 50 psi with sulfur hexafluoride gas, providing insulation for the high potentials.

5.2.1.4 Cooling Unit Theory of Operation

The Cooling Unit recirculates liquid coolant through the x-ray tube anode, keeping its temperature consistent with proper operation. The Cooling Unit consists of an electric motor driven pump, a coolant reservoir, a fan, a radiator, and a twin hose assembly.

Coolant flows from the reservoir, through the fan cooled radiator, and into the motor driven pump. The pump propels the coolant through one side of a twin hose assembly, into the Tube Head. The coolant is internally routed to the x-ray tube anode, where it dissipates the heat, then flows through the second side of the twin hose assembly, back into the reservoir.

5.2.2 Circuit Description

The following paragraphs contain descriptions of each circuit within the LPX-160 Industrial X-ray unit. Refer to the appropriate schematic or assembly drawing in section six of this manual while reading each circuit description.

5.2.2.1 Automatic Line Voltage Configuration

This circuit, on the Mother Board, samples the supplied line voltage, determines if it is between 100 - 135 volts or 200 - 250 volts, and configures the appropriate circuitry within the Control Unit to operate from the applied line voltage. The following paragraphs describes the process of the LPX-160's "Automatic Line Voltage Selection" circuitry. Refer to Mother Board Drawings (Chapter 6) while reading this section.

When the Circuit Breaker on the Control Unit's front panel is switched "ON", line voltage is applied to E6 and E8. From E6 and E8 it advances to diodes D4, D5, D6, D8, and D1, resistor R3, R4, capacitor C1, and the Time Delay Relay K201. The Time Delay Relay K201 prevents line voltage from being applied to the rest of the Control Unit's circuitry for approximately 2 seconds (time determined by the value of R203.

Diode D1, resistors R3, R4, R1, and capacitor C1 convert line voltage to D.C. at a level sufficient to cause the Time Delay Relay K201 to start its timing interval. Diodes D4, D5, D6, and D8 collectively create a Full Wave Rectifier, and, with Filter C2, converts line voltage to a D.C. equal to the approximate peak value of the A.C. voltage. This D.C. voltage is divided by R11 and R12, and compared in Transistor Q1 to a reference voltage set by D7.

If line voltage is less than the set reference voltage 100 - 135 volts, additional circuit configuration is not necessary, and the Control Unit remains configured for the lower line voltage. The Time Delay Relay K201 "times out" and applies the line voltage to the rest of the Control circuitry. If the line voltage is 200 - 250 volts, the compared voltage is greater than the set reference voltage. Q1 turns on, causing Q2 to pull in relays K1 and K2. K1 and K2 configure the Cooling Unit, the Low Voltage Power Supply Transformer, and the Main Rectifier Doubler FW Bridge D201, C201, C202, R201, R202, to operate from the higher line voltage. The Time Delay Relay K201 "times out", and line voltage is applied to the remaining circuits.

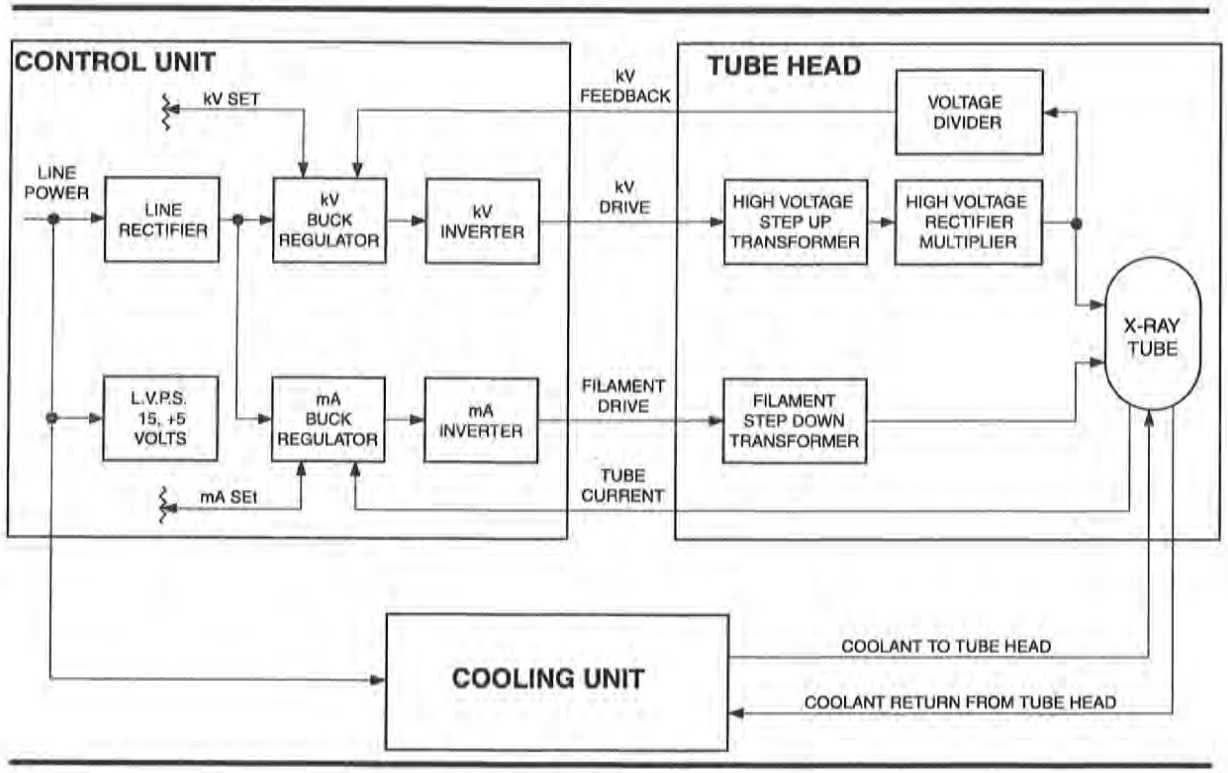


FIGURE 5-3:

SYSTEM BLOCK DIAGRAM

5.2.2.2 Main Power Rectifier/Doubler

The Main Power Rectifier/Doubler converts A.C. Line Power to D.C. at a level equal to the peak value of the A.C. voltage. The following paragraphs describe the process of the LPX-160's "Main Power Rectifier/Doubler" circuitry. Refer to Mother Board Drawings (Chapter 6) while reading this section.

Line power is applied to the Diode Bridge D201. When Relay K1 is de-energized, the circuit operates as a half wave voltage doubler. On the positive half of the line voltage cycle, C201 charges to the peak of the line voltage. On the negative half of the line voltage cycle, C202 charges to the peak of the line voltage. The resultant sum voltage across C201 and C202 is twice the peak of the line voltage.

When K1 is energized (line voltage between 200 and 250 volts), D201 performs as a Full Wave Bridge, charging C201 and C202 in series. The D.C. voltage developed across C201 and C202 is fed to the kV and mA Boards.

5.2.2.3 mA Board Circuit Description

The mA Board converts rectified and filtered line voltage to a 33 kHz square wave that drives the Tube Head mounted Filament Transformer. The following paragraphs describe the LPX-160's mA Board circuitry. Refer to mA Board Drawings (Chapter 6) while reading this section.

A 0 to +5 volt D.C. control voltage from the Front Panel Processor Board enters the board at pin M of P1. This control voltage is then applied to the Buffer U2. Also connected to the input of the Buffer U2 is a "rate of rise" ramp voltage. This voltage is generated on the kV Board and enters the mA Board on pin L. When the Front Panel's "X-Ray ON" Switch is depressed, K1-A is energized, removing the ground from pin 3 of the Buffer U2. The ramp voltage, from the kV Board, simultaneously starts from zero, and slowly ramps up toward 15 volts. If the ramp voltage is less than the control voltage, Buffer U2 sees the ramp voltage. Once the ramp voltage becomes greater than the control voltage, diode D12 is reversed biased, and Buffer U2 sees only the control voltage. The output of the Buffer U2 is fed to the non-inverting input of the Error Amplifier U3. The x-ray tube current enters the board at pin P of connector P1. This current has a range of 0 to 5 mA. The tube current generates a proportional 0V to 5V voltage across R38. This voltage is applied to the inverting input of the Error Amplifier U3. The difference between the tube current analog and the mA set control voltage is amplified by the Error Amplifier U3 and fed to pin 2 of Pulse Width Modulator U5. The tube current analog is buffered by U4 and connected to pin R of P1.

Unregulated D.C. from the Main Power Rectifier enters the board at pins D and F, and is applied to the Buck Switching Rectifier. The Buck Switching Rectifier is comprised of Q1, Q2, D1, L1, and C8. Pulse Width Modulator U5 provides pulses to T2, the widths of which are proportional to the error voltage from the Error Amplifier U3. The duty cycle controlled pulses from the secondaries are 180° out of phase, which causes Q1 and Q2 to turn on alternately. The pulses of current from Q1 and Q2 are smoothed by L1, D1, and C8, providing a smooth D.C. voltage across C8. The amplitude of C8 is required to maintain x-ray tube current at the level set on the Control Panel.

U1, Q5, Q6, Q7, and their associated components comprise a voltage sensing/voltage limiting circuit. This circuit prevents excessive voltage (that which may damage the x-ray tube filament from being developed across C8 when feedback current is not present. When the voltage across C8 reaches a predetermined level, enough current flows through the photodiode in U1, causing current to flow through R13, R16, R15, and R8. R15 is normally set so that Q7 is switched on when the voltage at C8 reaches approximately 150 volts. When Q7 turns on, current flows through R38, causing the Buck Regulator to regulate at the 150 volt level. Q5 and Q6 are set using R16 to turn on when the voltage at C8 reaches approximately 158 volts. When Q5 and Q6 are turned on, they reduce the voltage on pin 8 of the Pulse Width Modulator U5, limiting its duty cycle, and preventing the voltage on C8 from going higher. This secondary voltage limiting circuit prevents high tube current when feed control is coming into regulation.

The D.C. voltage developed at C8 is fed to the Half Wave Inverter Q3 and Q4. U6 acts as an Oscillator, outputting a 33 kHz square wave to the primary of T3. The secondaries of T3 are phased 180° apart to alternately turn on Q3 and Q4. A square wave is thus developed between P1, pin B and P1, pin A. T4 senses the current out of the inverter. Voltage is developed at pin 9, which is the pulse-by-pulse current limit input of U6. This is proportional to the current in the primary of T4. When enough voltage (approximately 1 volt) is developed at pin 9 of U6 to reach the current limit threshold, the pulse from U6 is terminated, limiting the current.

5.2.2.4 4 kV Board Circuit Description

The kV Board converts rectified and filtered line voltage into a 25kHz square wave to drive the Tube Head's High Voltage Transformer. The following paragraphs describe the LPX-160's kV Board circuitry. Refer to kV Board Drawings (Chapter 6) while reading this section.

A 0 to +10 volt D.C. control voltage from the Front Panel Processor Board is applied to the kV Board at pin n. This voltage is proportional to the selected kV. Pin n is connected through R49 to buffer U4-3. When x-ray generation is OFF, U4-3 is held at ground by Relay K1A. Relay K1B keeps capacitor C10 discharged. When x-ray generation is activated, Relays K1A and K1B pull in, and the grounds are removed. Capacitor C10 is charged linearly by Constant Current Source Q13. Since initially the voltage on C10 is lower than the voltage on pin n, diode D20 is forward biased, keeping the voltage at U4-3 close to that of C10. When the voltage on C10 rises to that on pin n, D20 becomes reverse biased, and C10 no longer influences U4. The C10 voltage continues to rise to +15 volts. The 0 to +10 volt control voltage on pin n alone is then buffered by U4.

The buffered control voltage from U4 is divided by 10, and reversed in polarity at U1, and is then applied to Error Amplifier U2. A 0 to -1 volt sense voltage from the Tube Head, proportional to 0 kV to 160 kV, enters the board at pin s. This sense voltage is applied to the other input of the Error Amplifier U2. The difference between the Control Voltage and the Sense Voltage is amplified with high gain by U2. The amplified difference voltage is applied to the Pulse-Width-Modulator U3. The higher this voltage is, the greater the duty cycle of U3. The sense voltage is also buffered by U5. This buffered voltage is multiplied by 10, and inverted in polarity in U6 providing a 0 to +10 volt analog voltage proportional to 0 to 160 kV at pin R.

Unregulated D.C. from the Main Rectifier/Doubler enters the board at pin C and pin U, and is applied to switches Q1, Q2, Q3, and Q4. The output pulses from the Pulse-Width-Modulator U3 are coupled to the transistor switches through Transformer T1. Q2 and Q4 turn on 180° out of phase with Q1 and Q3. The current pulses from the transistor switches are routed to the storage inductor assembly mounted on the Mother Board. Regulated filtered D.C. at amplitude, that is a function of the Front Panel kV Control, is provided at the output of the Storage Inductor assembly, and enters the kV Board at pin K.

Q5 through Q12 form a full wave inverter. U7 serves as an oscillator providing two 25kHz square wave outputs (pins #11 and #14) 180° out of phase. These outputs are provided to Q14 and Q15, and cause the transistors to switch on at a 25kHz rate 180° out of phase. These pulses are coupled through T3 and T4, to Transistors Q5 through Q12. Parallel pair Q8 and Q7, and parallel pair Q9 and Q10, turn on together while parallel pair Q5 and Q6, and parallel pair Q11 and Q12 are off causing P3, pin P to be more positive than P3, pin F by an amount nearly equal to the regulated voltage at P3, pin K. On the other half of the 25 kHz cycle, Q8, Q7, Q9, and Q10 are off, while Q5, Q6, Q11, and Q12 are on. At this time, P3, pin F is more positive than P3, pin P by the amount of the regulated voltage. This developed square wave goes to the Tube Head by way of the Front Panel Tube Head connector (pins D and J).

Transformer T2, Diodes D16 through D19, Resistors R60 and R61 form a current sense/limiting circuit. The current pulses provided to the Tube Head cause a pulsing voltage to be developed in the secondary of T2. This voltage is rectified by the Diode Bridge and slightly filtered by R61 and C27. This slightly smoothed, pulsing D.C. is fed to pin #9 of U7 which is the Pulse-by-Pulse current limiting input. If a pulse of voltage exceeds approximately 1 volt, the output pulse of U7 is terminated, and the Inverter output current is limited.

U9, U11, U10, and Q16 form a circuit which turns off x-ray generation if the regulated voltage provided to the inverter exceeds a preset level. The voltage between P3, pin K and the D.C. common, causes a current to flow through the Photo Coupler U9. When this voltage reaches approximately 270 volts, U9 conducts, developing a voltage at TP22. The TP22 voltage is fed to one side of Comparator U10, pin #2. A fixed stable reference voltage from U11 is fed to the other side of Comparator U10. When the TP22 voltage exceeds the reference voltage, the U10 output (pin #7) switches to its alternate state, causing Q16 to turn on. Q16 causes the Processor Board to terminate x-ray production.

5.2.2.5 Low Voltage Power Supply Circuit Description

The Low Voltage Power Supply (LVPS) Board provides two regulated voltage sources for use by other circuitry in the Control Unit. The voltages provided are +15 volts and -15 volts. The following paragraphs describe the LPX-160's L.V.P.S. Board circuitry. Refer to Low Voltage Power Supply Board Drawings (Chapter 6) while reading this section.

Diode Bridge D1 serves as two full wave rectifiers, rectifying the voltage from the 30 volt center tapped winding of the chassis mounted Transformer T201. D1 provides unregulated D.C. approximately +20 volts at C1, and approximately -20 volts at C2. The +20 volts is regulated down to +15 volts by VR1. Q1 and Q3 provide current boost and short circuit protection. VR3 regulates the -20 volts at -15 volts.

5.2.2.6 Digital Front Panel Circuit Description

The microcontroller is the Motorola MC68HC705C8 in a 40 pin package (U14) with a 4 mHz crystal. The microcontroller has four 8 bit ports. Port A is configured as an output, and provides control signals for the analog to digital converter, the digital to analog converter, and the front panel switch buffers. Port B functions as a bi-directional "data bus" between all of the peripherals and the microcontroller. Port C controls the LCD displays, and Port D is an input port to monitor the LCD busy signal and the x-ray relay.

Front panel switches (except the X-RAY and STOP switches) are read every 25 msec. through buffers U13 (74HCT244) and U15 (74HCT244) When Port A bit 0 (SW1) is low, the contents of U15 are placed on the Port B bus and read by the microcontroller. Port A bit 1 enables the other buffer (U13). J5, J6, and J7 connect the front panel switches to an RC filter and the pull-up resistor network (RN1 and RN3).

U17 (74HCT244) buffers the interlock and status signals. These signals are placed on the bus when Port C bit 6 (BUFF) is active. The EPROM (U9) has 1024 bits of non-volatile memory. Resistor network RN5 forces Port B to a known state (high) when there is no active data.

The analog to digital converter consists of the ADG526 multiplexer (U2) and the AD678 ADC (U6). The ADC is a 12 bit converter with a conversion time of 5 msec., and a built in reference. The ADC is connected for +10 volt input unipolar and straight binary output coding (2.44 mv/1sb). Multiplexer input S1 is connected to the reference output of the ADC, inputs S2, S3, S4, S6, and S7 are connected to ground. Input S5 is the tube current (MA SENSE) input which is 1 volt per millimes, 5 volts full scale. Multiplexer input S8 is the high voltage (KV SENSE) line which is 10 volts full scale, 62.5 millivolts per kV.

To read an input, the code for the selected input is written to the data bus and latched into the multiplexer by strobing Port A bit 2 (MUX). When the settling time is satisfied, the conversion is started by writing a zero to the ADC chip select (A2DCS), then strobing the start conversion (A2DSC) pin. With the high byte enable pin low, the output enable (A2DOE) pin is reset, and the data is read by the microprocessor, then the output enable pin is set. The low byte is read with the high byte enable pin high, and the output enable pin low.

The digital to analog converter (U1) is an AD7237 dual 12 bit multiplying voltage output converter. Both converters are connected for 5 volt unipolar operation such that writing all 1's yields a +5 volt output, writing $800 yields 0 volts out, and writing all 0's gives -5 volts out. Writing to the converters is accomplished first by writing the least significant 8 bits to the data bus, then selecting the low byte latch (A0=A1=0 for DACA; A0=0, A1=1 for DACB), then activating the chip select (DAC). Next, the most significant 4 bits are written to the data bus, and the high byte latch is selected (A0=1, A1=0 for DACA; A0=A1=1 for DACB), and chip select is activated. With chip select high, the 12 bits of both Days are transferred to the output latches when LDAC is strobed.

Both DAC outputs have offset and full scale adjustments. R15 provides zero adjustment, and R18 provides full scale adjustment for the high voltage control. R6 and R9 provide zero and full scale adjustment for the current control. The high voltage control amplifier (U3B) has a gain of 2, while the current control amplifier (U3A) has a gain of 1.

The 2x40 character LCD and the 2x24 character LCD are connected by J12 and J8 respectively. Both LCDs share a common data path which is buffered from the data bus by U12 (74HCT244) Instructions are written to the LCDs by first resetting Port A6 (A0), then placing the instructions on the data bus, activating the WRITE* line (low), and strobing the appropriate Port C output (LCD1 or LCD2). Characters are sent in the same manner with A0 high. The "busy" state of the LCD (DB7 high) is read on Port D (BUSY1), with A0 low and WRITE* high, while strobing LCD1 or LCD2.

Contrast adjustment is provided for the 2x40 LCD by R22 and for the 2x24 LCD by R10. Backlight adjustment is by R21 and R19 which set the input voltage to the DC to AC Inverters U10 and U7. The output of the DAS5V7 inverters is in the range of 100 Vrms, and the output frequency is 300 to 400 Hz with a 4 volt input. Emitter followers Q3 and Q4 source the current for the inverters.

X-Ray initiation is controlled by the Safety Relay K1, and the X-Ray Relay K2. Unfiltered +15 volts is routed to the Cooling Unit flow switch. If adequate coolant is flowing, the switch is closed and the +15 volts goes on to pins A and B of the front panel INTERLOCK connector. If pins A and B are interconnected, the +15 volts passes to the front panel SAFETY switch. Switching the SAFETY switch to the ON position causes the +15 volts to be connected to the kV and mA Boards. K1 contacts also complete a connection between the front panel X-RAY ON switch and the X-Ray Relay K2.

Unfiltered +15 volts flows through the normally closed X-RAY OFF switch, to the normally open X-RAY ON switch. Pressing the X-RAY ON switch connects the +15 volts through the closed K1 contacts, to the X-Ray Relay K2. If a READY signal is provided by the microcontroller to Q2, Q2 is on. The current then flows through K2 and Q2, out to the normally closed Tube Head mounted pressure and temperature switches where it finds ground. K2 then energizes.

K2 contacts parallel the X-RAY ON switch, keeping K2 latched. Other K2 contacts ground the X-RAY ENABLE line, causing x-ray generation to start. Pressing the X-RAY OFF switch, or turning the SAFETY SWITCH to LOCKED OFF, interrupts current to K2, terminating x-ray generation.

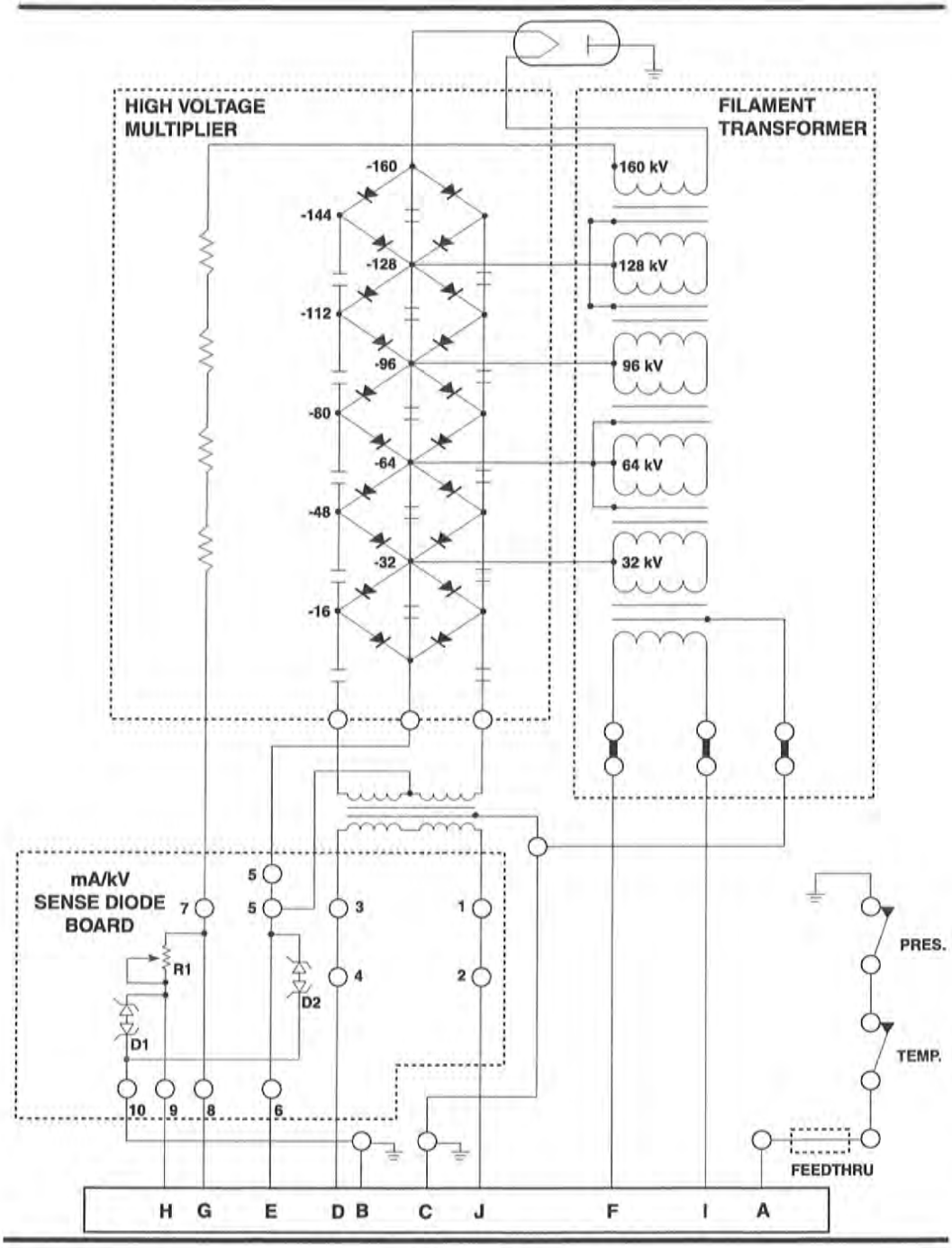


FIGURE 5-4:

TUBE HEAD ASSEMBLY SCHEMATIC

5.2.2.7 Tube Head Circuit Description

The Tube Head circuitry converts the square wave drive signal from the Control Unit's kV Board into -160 kV maximum bias for the cathode of the x-ray tube. The circuitry also steps down the square wave filament drive signal from the Control Unit's mA Board to the approximate 3 volt, 4 amp signal required to heat the x-ray tube filament. The following paragraphs describe the LPX-160's "Tube Head" circuitry. Refer to Figure 5-4 while reading this section.

The kV drive signal enters the Tube Head on pins D and J of the end plate connector. Pins D and J are connected to the primary of the High Voltage Step Up Transformer. The Transformer steps up the drive signal to approximately 32 kV (for 160 kV out) at the secondary. The secondary is connected to a five stage, full wave, diode-capacitor Multiplier/Rectifier which converts the 32 kV A.C. Transformer output to -160 kV D.C. A -32 kV increase is added at each stage of the Multiplier D.C. leg. The -160 kV D.C. point is connected to the x-ray tube cathode. The x-ray tube anode is connected to ground. A series combination of four (4) 3,000M ohm resistors is connected to the tube cathode on one end, and pin G of the End Plate connector on the other. This series combination, along with the parallel combination of R1 on the sense diode P.C. Board, and R52 on the Control Unit's kV Board, form a 160,000:1 voltage divider. This divider furnishes a feedback voltage at pin G of the End Plate connector, to the Control Unit for kV regulation.

A five stage Filament Transformer steps up the filament drive signal (pins F and I of the End Plate connector) from the Control Unit's mA Board down to approximately 3 volts, 4 amps, and provides 160 kV of isolation between the first primary and the fifth secondary. Diodes D1 and D2 on the Sense Diode Board limits the voltage on the feedback lines in the event of a malfunction.

5.3 TEST AND CALIBRATION INTRODUCTION

The following procedures outline the step to test and calibrate each assembly within the Control Unit, Cooling Unit, and Tube Head. Detailed throughout this section are the materials and equipment required to perform the individual tests, followed by the checks to complete procedure. These checks include the necessary calibration procedures to restore the unit to its proper operating condition. To gain access to the components discussed, follow all applicable removal procedures outlined in section five of this manual.

> **! NOTE !**
>
> Calibration shall be performed by qualified personnel only.

5.3.1 Testing and Calibrating the kV Board

The following tests require the application of a +15 and -15 volts only. There can be no other voltages present on the kV board. To accomplish this, ensure that all power is OFF, and the 5200uf storage capacitors (C201 and C202) are fully discharged. Disconnect the black and the

white/black AC line wires leading to the main bridge rectifier and insulate leads.

> **! NOTE !**
>
> To perform the following test and calibration procedures, install the jumper across pins "A" and "B" of the INTERLOCK Connector, jumper pins "A" and "H" of the Cooling Unit Connector, and jumper pins "A" and "B" on Tube Head connector on front panel.

5.3.1.1 Required Test Equipment and Materials

1. 2 Digital Multimeters (Fluke 77 or equivalent);
2. Oscilloscope (dual channel, 35 mHz min.);
3. kV Board Extender Cable; P/N SK3741
4. Variac; 10 amps, 0 to 130 Volts, 60HZ5.0 to 5 volt D.C. Power Supply; 100 mA min.
5. 3 ohm, 50 watt resistor;
6. Temperature Probe (Fluke 80T-150U or equiv.)
7. Simpson model 260 VOM or equivalent

5.3.1.2 2 kV Board Visual Checks

Remove the kV Board from the Control Unit (see section 5.4.1.6) and inspect its overall integrity. Check the board for signs of damage, including cracks, broken or burnt components, signs of arcing, etc. Any discrepancies found during this visual inspection must be noted, and corrected before continuing.

5.3.1.3 kV Board Resistance Checks

With the kV Board still removed from the Control Unit, perform the following resistance checks (use Simpson 260) using the given test points or pins (Refer to kV Board Assembly Drawing (Chapter 6) while reading this section. All pins are located on the board's 37 pin connector. Pin locations are denoted by upper and lower case lettering (lower case letters identified by the underscore (_) symbol). The measured resistance between these points should read as shown below (> signifies greater than). TP 27 should be used as ground.

A.	Pin C to pin U:	> 2 M ohm
B.	Pin Q to TP 27:	> 1 k ohm
C.	Pin P to TP 27:	> 1 k ohm
D.	TP 25 to TP 3:	> 50K
E.	TP 26 to TP 27:	infinity
F.	TP 3 to TP 27:	infinity
G.	TP 25 to TP 27:	infinity
H.	Pin C (+) to TP 27 (-):	infinity

5.3.1.4 Inverter Frequency Calibration

Step #1

Plug the kV board into the kV board extender cable, and the extender cable into the Control Unit. Turn the power ON, turn Safety Switch ON, and with the oscilloscope isolated from AC input ground, view the waveform at TP21 use TP27 for oscilloscope ground reference. A square wave should be present at this test point. On the board, adjust R70 until the displayed waveform has a square wave period of 40 µsec as illustrated below.

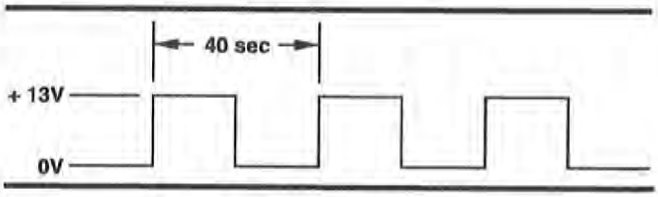


FIGURE 5-5:

INVERTER FREQUENCY (40 µSEC SQUARE WAVE)

5.3.1.5 ±11 Volt Power Supply Checks

Step #1

Using a digital volt meter measure the voltage present at TP11 and TP12. The voltage at TP11 should be +11.15, ±0.5 volts. The voltage at TP12 should be -11.15, ±0.5 volts.

Step #2

Using a temperature probe, carefully check the temperature of the Heat Sinks on Q14 and Q15 and ensure they are not overheating. The temperature should be less than 125°F (DO NOT touch the Heat Sinks with your fingers). If they are overheating, T3 and T4 are probably connected improperly, or phased inaccurately. Refer to the "Transformer Phasing" procedures (section 5.3.1.11).

5.3.1.6 Regulator Frequency Calibration

Step #1

Unplug relays K1 and K2, and set the Control Unit's kV Control to a setting greater than 40 kV. With the oscilloscope, observe the waveform present at TP8.

Step #2

A square wave should be present at TP8. Using R55, adjust the displayed square wave period to 33 µsec as illustrated below (use TP27 for oscilloscope ground reference).

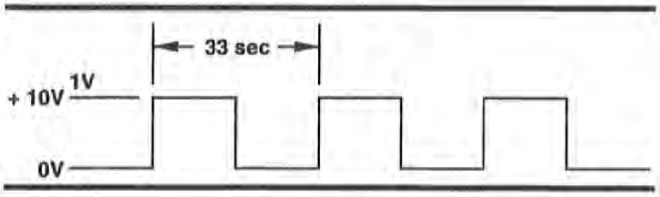


FIGURE 5-6:

REGULATOR FREQUENCY 33 µSEC SQUARE WAVE

5.3.1.7 Operational Amplifier Calibration

Step #1

Connect TP15 to the ground test point (TP27). Measure the voltage present at TP10. Adjust R35 so that the voltage present at TP10 is 0.010 volts, then remove the ground.

Step #2

Connect TP14 to the ground test point (TP27). Measure the voltage present at TP17. Adjust R54 so that the voltage present at TP17 is 0.000 volts, then remove the ground.

5.3.1.8 kV Set Check

Step #1

Set the kV Control on the front panel of the Control Unit to 160 kV. Measure the voltage present at both TP16 and TP10 as referenced to the ground test point (TP27).

Step #2

The voltage at TP15 should be approximately 10.0 volts. The voltage present at TP10 should be one tenth the voltage present at TP15, ±2%.

5.3.1.9 Indicated kV Check

Step #1

Connect the 0 to 5 volt power supply to TP14 (negative lead to TP14, positive lead to Ground TP27), and set its output to 1 volt ±0.2. Measure the voltage present at TP17.

Step #2

The measured voltage at TP17 should be positive, and ten times greater than the voltage present on TP14, ±2% (approximately +10 volts).

5.3.1.10 Regulation Amplifier Check

Step #1

Reduce the power supply voltage to 0.5 volts ±0.1. Using an oscilloscope, view the waveform present at TP8. A square wave should be present.

Step #2

Slowly decrease the Control Units kV setting. The square wave should disappear when the kV Control reaches approximately 80 kV ±20 kV.

Step #3

Reduce the kV setting even further to 40 kV, then slowly begin increasing it. The waveform should again appear upon reaching approximately 80 kV ±20 kV.

5.3.1.11 Transformer Phasing

Step #1

Check the phasing on the Transformer (T1). The waveform present on TP2 should be 180° out of phase with the waveform on TP1. Use TP3 as ground, scope must be isolated from ground.

Step #2

Check the phasing on both Transformers (T3 and T4). The waveforms present at TP4 and TP7 as well as TP5 and TP6 should be in phase, and 180° out of phase with the waveforms present at TP4 and TP5. Use TP3 as ground, scope must be isolated from ground.

5.3.1.12 Arc Detector Checks

Step #1

Connect the negative lead of a variable power supply to ground (TP27). Using an oscilloscope, observe the waveform present at TP18 (use TP27 as ground reference for oscilloscope). This waveform should be a D.C. level reading approximately -15 volts ±3.

Step #2

Now, observe the waveform present at TP20. This waveform should be a square wave.

Step #3

Set the control of the Variable Power Supply to +1.5 volts ±0.3. Simulate an arc by momentarily touching the positive lead to TP19. The D.C. level on TP18 should switch to +15 volts ±3 for approximately 1 to 2 seconds. The square wave on TP20 should disappear while the +1.5 volts are applied to TP19.

5.3.1.13 Power Switching Check

Step #1

Turn front panel main switch OFF and disconnect Control Unit from line power. Replace relays K1 and K2 before proceeding. Connect a variac between the A.C. input lines (white/black wire from mother board, and black wire from E9) and the A.C. input pins on the main power bridge rectifier (D201). This configuration is shown in Figure 5-7. and Figure 5-8.

> **! WARNING !**
>
> Dangerous voltages are present on the kV board while it is connected to the Variac and the Control Unit. All applicable electrical safety precautions must be observed while performing the following procedures.

> **! WARNING !**
>
> The variac must be connected exactly as shown or line voltage will still be applied to the rectifier even at minimum settings.

Step # 2

Place the Variac to its minimum setting, and set the kV control to 160 kV. Using two multimeters, connect one between TP25 (+) and TP3(-), and the other between C201 (+) and C202 (-). Re-connect the Control Unit to line power and turn main switch ON. Set the Timer for a 30 minute exposure, then press the x-ray "ON" Button.

Step #3

Gradually advance the variac setting. The voltage between TP25 and TP3 should rise with the voltage across C201 and C202. When the voltage between TP25 and TP3 reaches 20 volts, stop advancing the variac. If no variac control of the voltage on C201/C202 is available check the wiring of the variac. It must be as shown in Figure 5-8.

Step #4

Observe the waveform on TP26 using an oscilloscope (scope ground must be floated by using an isolation plug, and TP24 must be used as reference). A square wave should be present with a peak-to-peak amplitude approximately twice the voltage present between TP25 and TP3. Return the variac to zero (0).

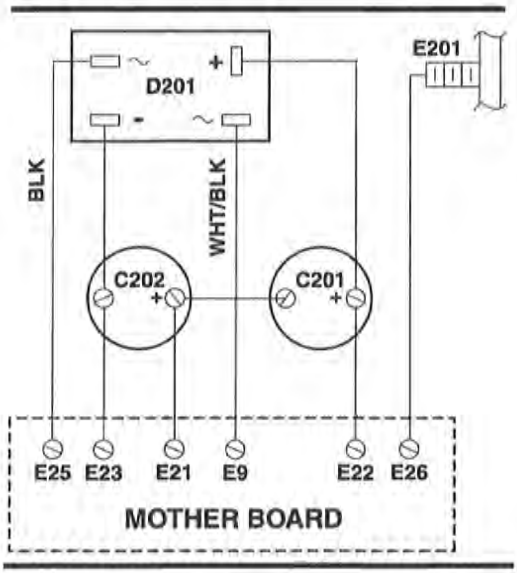


FIGURE 5-7:
CONTROL UNIT CONFIGURATION (NORMAL)

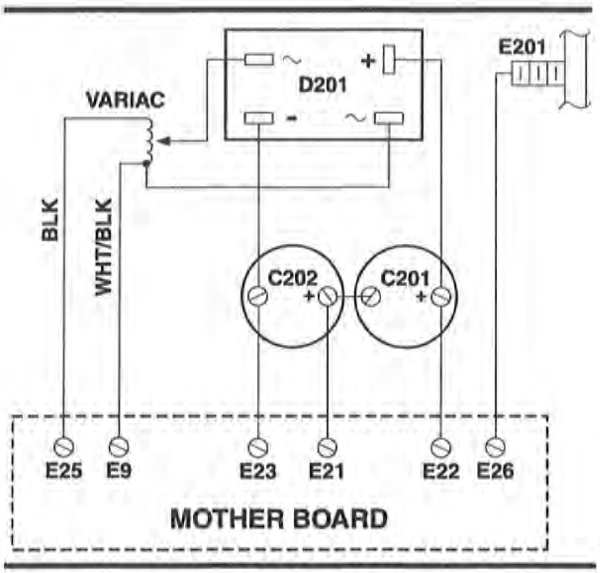


FIGURE 5-8:
CONTROL UNIT CONFIGURATION (WITH VARIAC)

5.3.1.14 Pulse-by-Pulse Current Limiting Check

Step #1

Connect an oscilloscope to TP19 (use TP27 as ground reference for oscilloscope), and a 3 ohm, 50 watt resistor between TP26 and TP24. Apply power and briefly run the voltage between TP25 and TP3 up to 12 volts using the Variac. Observe the wave form on TP19. The waveform should be similar to the one illustrated below. Turn power OFF.

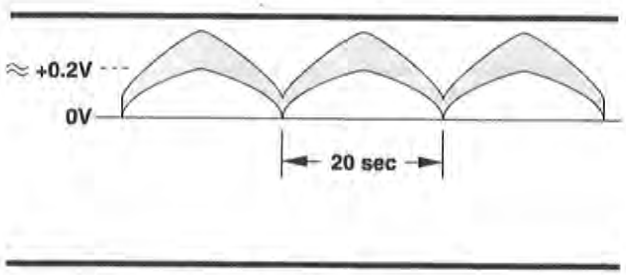


FIGURE 5-9:

PULSE-BY-PULSE CURRENT LIMITING WAVEFORM

5.3.1.15 Regulation Check

Step #1

Return the variac to zero (0). Connect the Control Unit to the Tube Head simulator and remove the previously installed 3 ohm resistor from TP26 and TP24. Turn power ON, press x-ray "ON" button. Set the Control Unit's kV control to 20 kV, then slowly advance the Variac.

Step #2

The kV Meter on the front panel of the Control Unit should start to rise. As the voltage on TP25/TP3 reaches approximately 65 to 70 volts, the kV meter should stop rising and return to approximately 20 kV as the regulator proceeds into regulation.

Step #3

Return the variac to zero (0) and turn power OFF.

5.3.1.16 High kV Cut Out Check

Step #1

Remove the extender cable and plug the kV board into the Mother Board so it is cooled by the fan (leave the variac connected). Apply power to the Control Unit. Measure the voltage between TP25 and TP3, and the voltage across C201/C202.

Step #2

Press x-ray "ON" button. Advance the Variac gradually. The kV meter should regulate at 20 kV (kV Control knob still at 20 kV). Continue advancing the Variac until approximately 320 volts is measured across C201/C202.

Step #3

Slowly advance the kV control setting until the voltage between TP5 and TP3 is 270 volts (±15 volts).

Step #4

The X-RAY ON should switch OFF cleanly with no humming or oscillation.

5.3.1.17 X-ray Operational Check

Step #1

With the kV Board still in the Control Unit, connect the Control Unit to a working Tube Head and Cooling Unit and check for proper operation up to 160 kV as outlined in Section Four of this manual.

5.3.2 Testing the mA Board

With power OFF, remove the A.C. Input wires from the Main Bridge Rectifier and insulate Black & Black/White wires (no power can be applied to the 5200uf Capacitors). Remove the kV Board for these tests.

> **! NOTE !**
>
> Before performing these test and calibration procedures, install the jumper across pins "A" and "B" of the INTERLOCK Connector, jumper pins "A" and "H" of the Cooling Unit Connector, and jumper pins "A" and "B" of Tube Head connector. Use care as voltage is present on other pins when power is ON.

5.3.2.1 Required Test Equipment and Materials

1. Digital Multimeters (Fluke 77 or equivalent);
2. Oscilloscope (dual channel, 35 mHz min.);
3. mA Board extender cable; P/N SK3740
4. Variac; 10 amps min., 0 to 130 Volts, 60HZ
5. Variable power supply to +5 VDC, 100 ma min.
6. Simpson model 260 VOM or equivalent

5.3.2.2 mA Board Visual Checks

Remove the mA Board from the Control Unit and inspect its overall integrity. Check the board for signs of damage, including cracks, broken or burnt components, signs of arcing, etc. Any discrepancies found during this visual inspection must be noted, and corrected before continuing.

5.3.2.3 mA Board Resistance Checks

With the mA Board removed from the Control Unit, perform the following resistance checks using the given test points or pins locations (use the Simpson 260). Refer to mA Board Assembly Drawing (Chapter 6). All pins on this board are on the 15 pin connector. The measured resistance between these points should read as shown below (>signifies greater than, and TP9 is used as ground).

A.	Pin D to pin F:	> 1M ohm
B.	Pin F to TP9:	infinity
C.	Pin D to TP9:	infinity
D.	Pin N to TP9:	> 10K ohm
E.	Pin S to TP9:	> 500 ohm
F.	TP4 (+) to TP1 (-):	> 50K ohm
G.	TP4 to TP9:	infinity
H.	TP14 (+) to TP1 (-):	> 50K ohm

5.3.2.4 Regulator Frequency Calibration

Step #1

Plug the mA Board o the extender cable and the extender cable into the Control Unit. Locate R19 on the mA Board and set it to mid-range. Connect and isolate an oscilloscope to TP6 (using TP9 as ground reference for the oscilloscope). Apply power to the Control Unit.

Step #2

Press the x-ray "ON" Button and view the waveform present at TP6. A square wave similar to the one illustrated in Figure 5-10 should appear on the scope. Using R19, set the period of the square wave to 20 µsec.

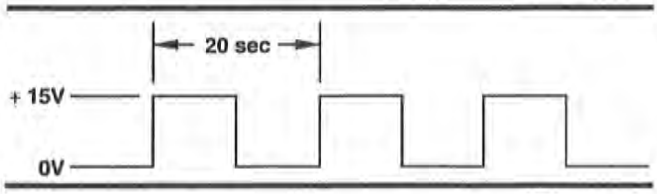


FIGURE 5-10:

REGULATOR FREQUENCY 20 µSEC SQUARE WAVE

5.3.2.5 Inverter Frequency Calibration

Step #1

With the power still ON, use an oscilloscope to view the waveform present at TP12 (using TP9 as ground reference). A square wave similar to the one illustrated in Figure 5-11 should be present.

Step #2

Using R20, adjust the time period of the square wave to 30 usec.

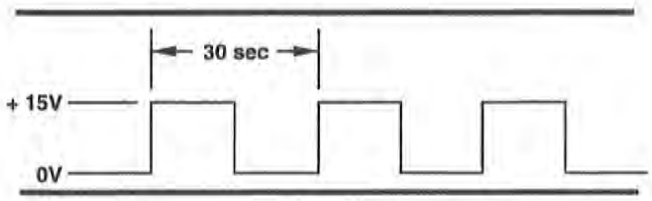


FIGURE 5-11:

INVERTER FREQUENCY 30 µSEC SQUARE WAVE

5.3.2.6 Transformer Phase Check

Step #1

Verify that the square waves present at TP2 and TP3 are 180° out of phase (TP1 is used as ground reference).

Step #2

If the waveforms are not 180° out of phase, swap the leads of one of the secondary windings of T2 to put them out of phase.

Step #3

Compare the waveforms at TP14 and TP15, and ensure they are 180° out of phase. The oscilloscope must still be connected to a floating ground (using the isolation plug). Use TP1 as reference.

Step #4

If the waveforms are not 180° out of phase, turn power off, then swap the leads of one of the secondary windings of T3 to put them out of phase.

5.3.2.7 Indicated mA Check

Step #1

Connect a variable 0 to +5 VDC Power Supply to TP7 through a milliammeter as shown in Figure 5-12. Connect the positive lead of the Power Supply to the input of the milliammeter, and the output of the meter to TP7. Connect the negative lead of the Power Supply to ground (TP9).

Step #2

Connect the positive lead of a voltmeter to TP8, and the negative lead to ground (TP9). Set the mA Control on the front panel of the Control Unit to 5 mA.

Step #3

Increase the Power Supply output until 1 mA ±1 is indicated on the milliammeter. Press the x-ray "ON" button and compare the voltage present at TP8 to the reading on the milliammeter. The voltage present at TP8 should be equal to the indicated mA reading on the milliammeter, ±0.1 volts (i.e., 1.0 mA yields 1.0 volts ±0.1 volt).

Step #4

Increase the output of the Power Supply until 2.5 mA ±1 is displayed on the milliammeter, then again until 4 mA ±1 is displayed. The voltage reading at TP8 should increase equally with the increases applied to the milliammeter (±0.1 volts).

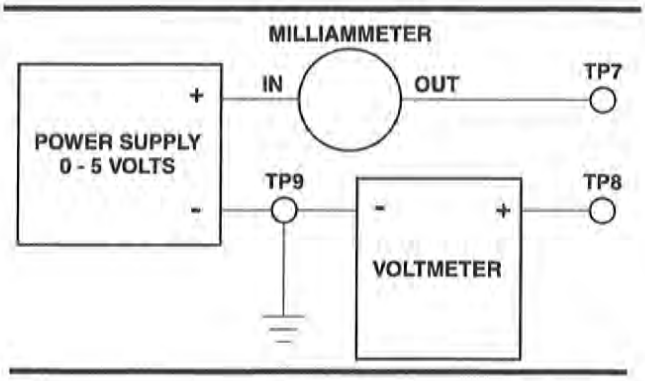


FIGURE 5-12:
INDICATED MA CHECK

5.3.2.8 Regulation Amplifier Check

Step #1

Connect an Oscilloscope to TP6 and set the current into TP7 to 4 mA ±1 by increasing the output of the Power Supply. A 50kHz square wave should be present at TP6.

Step #2

Slowly reduce the Control Unit's mA control. The square wave should disappear when the mA control reaches 4.0 mA ±0.5. Reduce the mA control setting to 3 mA, then slowly increase it. The square wave should reappear as the mA control setting passes through 4.0 mA ±0.5.

5.3.2.9 Voltage Limiting Adjustment

Step #1

Remove the Power Supply from TP7, and remove power from the Control Unit. Connect a variac between the A.C. input lines (white/black wire from mother board, and black wire from K201) and the A.C. input pins on the main power bridge rectifier (D201). This configuration is shown in the Figure 5-14.

! WARNING !

Dangerous voltages are present on the mA board while it is connected to the Variac and the Control Unit. All applicable electrical safety precautions must be observed while performing the following procedures.

! WARNING !

The variac must be connected exactly as shown or line voltage will still be applied to the rectifier even at minimum settings

Step #2

Set the Variac to its minimum setting, and connect a voltmeter between TP4 and TP1. Turn the power ON, and press the x-ray "ON" button. Slowly advance the Variac while watching the voltage reading across TP4 and TP1. This voltage should increase as the Variac is advanced

Step #3

The voltage across TP4 and TP1 should become constant at a voltage level less than 200 volts, even with further increases on the Variac.

Step #4

Ground TP7 using a clip lead and the ground test point (TP9). Adjust R16 until the voltage reading between TP4 and TP1 is 158 volts.

Step #5

Remove the ground from TP7 and adjust R15 until the voltage reading between TP4 and TP1 is 150 volts. Repeat steps #4 and #5 until the two voltages are obtained.

Step #6

If R15 or R16 reach their upper or lower limits before the required voltages are obtained, decrease R13 (if the voltages are too low), or increase R13 (if voltages are too high). Repeat steps 4, 5, and 6 until the 150 volts and 158 volts are obtained across the appropriate test points.

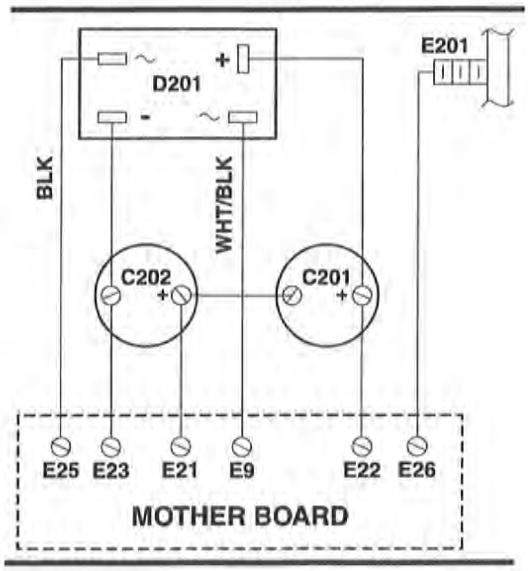


FIGURE 5-13:
CONTROL UNIT CONFIGURATION (NORMAL)

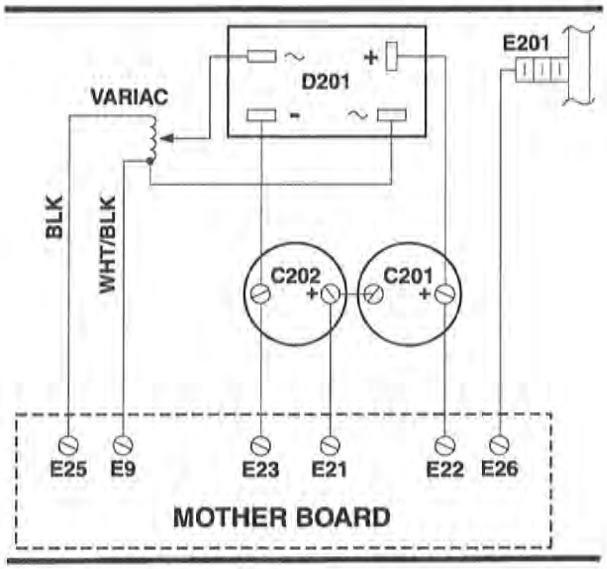


FIGURE 5-14:
CONTROL UNIT CONFIGURATION (WITH VARIAC)

5.3.2.10 Power Switching Check

Step #1

Return the Variac to its minimum setting (0), and remove the power from the Control Unit.

Step #2

Connect a 20 ohm, 50 watt resistor between TP10 and TP11. Place a floating ground on an oscilloscope (using an isolation plug), and connect the probe between TP10 and TP11.

Step #3

Turn the power ON, and press the x-ray "ON" button. Advance the variac until the voltage between TP4 and TP1 is 10 volts. A 30 kHz square wave, 10 volts peak-to-peak signal should be present on the oscilloscope.

Step #4

Return the variac to its minimum setting.

5.3.2.11 Pulse-by-Pulse Current Limiting Check

Step #1

Move the probe of the oscilloscope to TP17 using TP9 as ground reference. Advance the Variac until 30 volts is present at TP4 and TP1. The waveform at TP17 should be similar to the one illustrated in Figure 5-15. Return variac to 0: disconnect control from power. Remove variac and return wiring to original configuration.

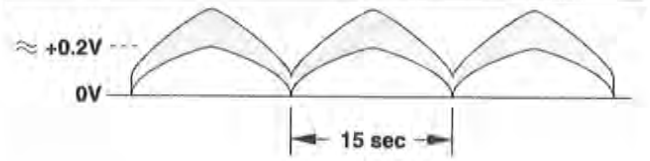


FIGURE 5-15:

PULSE-BY-PULSE CURRENT LIMITING WAVEFORM

5.3.2.12 Operational Test

Step #1

Insert a working kV Board into the Control Unit, and connect the Control Unit to a tested Tube Head and to the Cooling Unit. Place the tube head in a shielded x-ray container.

Step #2

Set the mA control on the front panel of the Control Unit to 5 mA and the kV control to 30 kV. Verify that 5 mA can be obtained with x-rays being emitted within the container.

Step #3

Vary the kV setting from 30 kV up to 160 kV. The indicated mA reading should not vary more than ±0.1 mA during the test.

Step #4

Vary the mA control between 5mA and 1mA. The indicated mA on the meter should follow the setting on the control as it is varied. varied.Vary the mA control between 5mA and 1mA. The indicated mA on the meter should follow the setting on the control as it is varied.

5.3.3 Testing the Low Voltage Power Supply

The following procedures outline the steps to test, and calibrate the Low Voltage Power Supply outside the Control Unit. Detailed below are the materials and equipment required to perform these tests, followed by the individual checks to perform on the board.

5.3.3.1 Required Test Equipment and Materials

1. Digital Multimeter (Fluke 77 or equivalent);
2. L.V.P.S. Extender Cable (P/N SK3740)
3. Resistor, 10 ohm/50 watts;
4. Resistor, 30 ohm/25 watts;
5. Oscilloscope, 35mHz min.
6. Simpson model 260 VOM or equivalent

5.3.3.2 Low Voltage Power Supply Visual Checks

Disconnect Control Unit from power line. Remove kV, mA, and L.V.P.S. Boards (see section 5.4.1.6). Inspect the Low Voltage Power Supply for overall integrity. Check the board for signs of damage, including cracks, broken or burnt components, signs of arching, etc. Any discrepancies found during this visual inspection must be noted, and corrected before continuing.

5.3.3.3 Low Voltage Power Supply Resistance Checks

Perform the following resistance checks using the given test points or pins (use the Simpson 260). The pins are located on Connector (P2) on the Power Supply (refer to L.V.P.S. Drawings (Chapter 6). The measured resistance between these points should read as shown below (> signifies greater than).

A.	Pin N to TP3:	> 5K ohm
B.	Pin R to TP3:	> 10K ohm
C.	Pin A to TP3:	> 5K ohm
D.	Pin C (+) to TP3 (-):	>10K ohm

5.3.3.4 Low Voltage Power Supply Checks and Calibration Procedures

Step #1

Plug the Low Voltage Power Supply into the Extender Cable and the Extender Cable into the Control Unit.

Step #2

Connect the two load resistors mentioned in section 5.3.3.1 to the Low Voltage Power Supply as illustrated in Figure 5-16. Connect the 10 ohm/50 watt resistor to the +15 volt output, and the 30 ohm/25 watt resistor to the -15 volt output. The illustrated Test Points may be used with TP3 as ground for making these connections.

! CAUTION !

The load resistors will become hot during the following test. Care must be taken when handling the Low Voltage Power Supply with the loads connected to the Test Points.

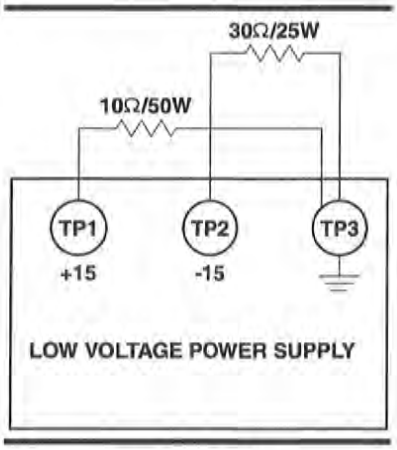


FIGURE 5-16:

LOW VOLTAGE POWER SUPPLY LOAD CONNECTIONS

Step #3

Apply power to the Transformer and measure the output voltages across each load on the Power Supply. Do this by connecting a voltmeter between TP1 and TP3, and then between TP2 and TP3. The measured voltages should read as shown below.

A. TP1 to TP3: +14.4 volts to +15.6 volts;

B. TP2 to TP3: -14.4 volts to -15.6 volts;

If these voltages readings do not fall within the given parameters, their respective Voltage Regulators may be faulty. Check the appropriate Voltage Regulator (VR1 and VR3 on the Low Voltage Power Supply) for proper operation.

Step #4

Leave the loads (resistors) attached to the test points. Using an Oscilloscope, measure the ripple present at each output of the Low Voltage Power Supply. Connect the positive lead to TP1 and the negative to TP3, then connect the positive lead to TP2. The measured values at each point should be as follows:

A. TP1 to GND (TP3): $Vr < 0.05$ volts;

B. TP2 to GND (TP3): $Vr < 0.05$ volts;

Step #5

Remove the loads (the two resistors) from the Low Voltage Power Supply. Using an ammeter, measure the current between TP1 and TP3, and then TP2 and TP3. The measured current values should read as shown below.

A. TP1 to GND (TP3): $i < 3$ amps;

B. TP2 to GND (TP3): $i < 1$ amp;

Step #6

Turn power OFF.

5.3.4 Testing the Mother Board

The following procedures outline the step to test and calibrate the Mother Board outside the Control Unit. Detailed below are the materials and equipment required to perform these tests, followed by the individual checks to perform on the board.

5.3.4.1 Required Test Equipment and Materials

1. Multimeter (Fluke 77 or equivalent);
2. Mother Board Test Fixture, P/N: SK3784
3. Simpson model 260 VOM or equivalent

5.3.4.2 Mother Board Visual Checks

Remove the Mother Board from the Control Unit and inspect its overall integrity. Check the board for signs of damage, including cracks, broken or burnt components, signs of arching, etc. Any discrepancies found during this visual inspection must be noted, and corrected before continuing.

5.3.4.3 Mother Board Resistance Checks

Using the Simpson 260 perform the following resistance checks on the Mother Board using the given test points or pins. The pins are located on Connector (J4) on the board (refer to Mother Board Drawings in Chapter 6). The measured resistance between these points should read as shown in the following table (> signifies greater than, and x signifies infinity).

A.	J4, pin 1 (+) to GND (-)	infinity
B.	J4, pin 3 & 4 (+) to GND (-)	infinity
C.	J4, pin 6 (+) to GND (-)	infinity
D.	J4, pin 8, 9, 10 (+) to GND (-)	infinity
E.	E22 (+) to E23 (-):	infinity

5.3.4.4 Mother Board Checks and Calibration Procedures

Step #1

Connect the Mother Board to the Test Fixture as shown in Figure 5-17. Plug K1 and K2 into Mother Board.

Step #2

Turn on Test Fixture Power. Using the Variac, increase the Transformer's output voltage until the A.C. Voltmeter indicates 145 volts ±3V RMS, then apply power to the Mother Board. Observe Relays (K1 and K2) and ensure they do not operate at this voltage setting. Remove power from the Mother Board.

Step #3

Using the Variac, increase the Transformer's output voltage until the A.C. Voltmeter indicates 175 volts ±3VRMS, then reapply power to the Mother Board. Observe Relays (K1 and K2) and ensure they are operating at this voltage setting. Remove power from the Mother Board.

Step #4

Using the Variac, increase the Transformer's output voltage until the voltmeter indicates 120 volts ±1 RMS, then reapply power to the Mother Board. The Power "ON" Lamp should illuminate within approximately 2 seconds.

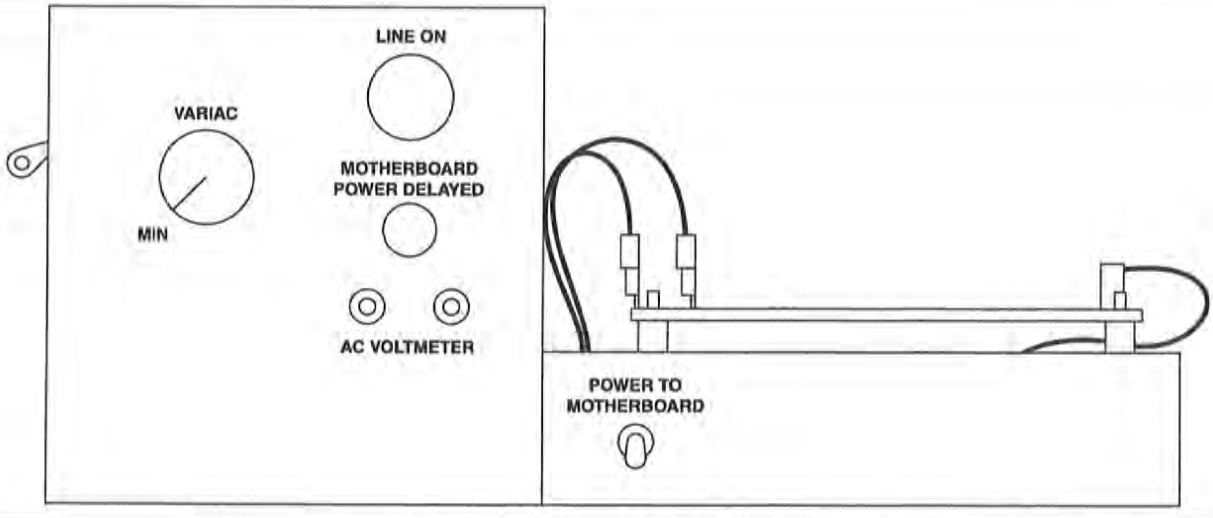


FIGURE 5-17:
MOTHER BOARD TEST FIXTURE

5.3.5 Test & Calibration - Digital Front Panel

5.3.5.1 Purpose

This procedure describes how to calibrate and test the Digital Front Panel Assembly when it is mounted on the Digital Control Unit.

5.3.5.2 Equipment Required

1. Digital voltmeter (Fluke Model 77 or equivalent.)
2. Tube Head simulator P/N 9-200A-0101
3. Cooling Unit Jumper Plug

5.3.5.3 Test Procedure

Step #1

Before connecting the Control Unit to line power, disconnect the AC input wires (the black and the white/black wires) from the main rectifier bridge (D201) mounted on the rear side of the chassis. Insulate them with electrical tape.

Step #2

Connect the Control Unit to the Tube Head Simulator. Install the Cooling Unit jumper plug into the Control Unit COOLER connector. Connect the Control Unit to line power.

Step #3

Lift the Front Panel Assembly so that the internal components are accessible, then turn power on. Use care to avoid contacting the internal components. Verify that the green MAINS indicator lights. Rotate R21 until the backlight in the EXPOSURE LCD is at maximum brilliance.

Step #4

Rotate R19 until the backlight in the MODE LCD is at maximum brilliance.

Step #5

Rotate R22 until the alphanumeric information appears with good contrast on the EXPOSURE display. The letters and numbers should be at maximum darkness without the darkened block appearing behind them. The information displayed should be as shown below.

0KV SET	**0.0 MA SET**	**00:00 TIME SET**
0KV OPR	**0.0 MA OPR**	**00:00 TIME REMAINS**

Step #6

Rotate R10 until the alphanumeric information appears in the MODE display. Adjust until the contrast is the same as that of the EXPOSURE display in Step 5. The information displayed should be as shown below.

AUTOWARM: X-RAY READY

> 30 Days

Step #7

Press the SCROLL switch until the MODE display reads OPERATE: X-RAY READY. Press the KV, MA, and EXPOSURE up buttons and verify that the corresponding displays (upper line) increment up to 160, 5.0, and 99:59 respectively.

Step #8

Press the KV, MA, and EXPOSURE down buttons and verify that the corresponding displays decrement to 0, 0.0, 00:00 respectively.

Step #9

Set the system for a 20 minute exposure. Place the SAFETY switch in the LOCKED OFF position, then press the X-RAY ON switch. Verify that the MODE display flashes the message: "SAFETY SWITCH".

Step #10

Connect a digital voltmeter between TP8 (KV CNTL) and TP23 (ground). Set the SAFETY switch to the ON position. Press the X-RAY ON switch and check that the red X-RAY ON indicator lights, and the EXPOSURE timer begins to count down. Also, verify that the Tube Head Simulator's red X-ray On indicator lights.

Step #11

Adjust R15 (KV ZERO ADJ.) until the digital voltmeter reads 0.100 volts.

Step #12

Press the KV up button until the EXPOSURE display indicates 160KV SET. Adjust R18 (KV FULL SCALE) until the digital voltmeter reads 10.10 volts.

Step #13

Press the KV down button until the EXPOSURE display indicates 80KV SET. Check that the digital voltmeter reads 5.10 volts (±0.02 volts).

Step #14

Set the unit so that the EXPOSURE display indicates 0.0 MA SET. Connect the digital voltmeter between TP9 (MA CNTL) and TP23 (ground). Adjust R6 (MA ZERO ADJ.) until the digital voltmeter reads 0.000 volts.

Step #15

Set the unit so that the EXPOSURE display indicates 5.0MA SET. Adjust R9 (MA FULL SCALE) until the digital voltmeter reads 5.00 volts.

Step #16

Press the MA down button so that the EXPOSURE display reads 2.5 MA SET. Verify that the digital voltmeter reads 2.50 volts (±0.03 volts).

Step #17

Press the X-RAY OFF switch. Make sure that the timer stops counting down, and that the red X-RAY ON indicator goes off. Check that the MODE displays the message: EXPOSURE INTERRUPTED.

Step #18

Disconnect the digital voltmeter and carefully lower the front panel to the operating position.

Step #19

Press the RESET button and verify that the EXPOSURE timer resets to 20:00 minutes, and the MODE display indicates: X-RAY READY.

Step #20

Press the ELAPSED/REMAINS switch. Check to see that the lower line on the EXPOSURE timer switches from 20:00 to 00:00.

Step #21

Press the X-RAY ON switch. Verify that the timer begins to count up toward 20:00. Press the ELAPSED/REMAINS switch again.

Step #22

Place the SAFETY switch to the LOCKED OFF position. Make sure that the red X-RAY ON indicator turns off, and the EXPOSURE timer stops. Check that the MODE display indicates: EXPOSURE INTERRUPTED.

Step #23

Press the RESET button, then press the TIME/mAs button. Verify that the EXPOSURE timer changes from 20:00 to 0 mAs.

Step #24

Press and hold the EXPOSURE up button and verify that the EXPOSURE timer increments to 29995 mAs. Press and hold the EXPOSURE down button and verify that the EXPOSURE timer decrements to 0 mAs.

Step #25

Press the TIME/mAs button.

Step #26

Place the MAINS switch to the OFF position. Lift the front panel and re-connect the black and the white/black AC input wires onto the rectifier bridge (D201). Carefully lower the front panel again.

Step #27

Place the MAINS switch in the ON position. Check the MODE display for the message:

AUTOWARM: X-RAY READY >30DAYS.

Step #28

Press the SCROLL switch 4 times. Verify that the lower line in the MODE display progressively reads the following: 7-30 DAYS; 16HR-7DAYS; 8-16HOURS; 4-8HOURS.

Step #29

Turn the SAFETY switch to the ON position, then press the X-RAY ON switch. Make sure that the upper line on the EXPOSURE display indicates 160KV SET, 5.0MA SET, and 03:00. Verify that the lower line of the EXPOSURE display rises to 100KV and 5.0MA within 5 seconds, and that the timer counts down from 03:00. Check that after one minute the KV rises to 130KV, then after two minutes to 160KV. After three minutes, verify that the X-RAY automatically stops and that the MODE display reads: OPERATE.

Step #30

Set the unit for an exposure at 160KV, 5.0MA, and 10:00 minutes, then press the X-RAY ON switch. Verify that the operating (lower line) KV and MA rise to 160 and 5.0. Reduce the KV and MA in 10KV and 0.5MA increments. Check that the operating KV and MA agree with the set KV and MA within ±1 kV, and ±0.1 mA.

Step #31

Press the X-RAY OFF button, then place the MAINS to OFF. While depressing the X-RAY ON switch, place the MAINS to the ON position. Check the MODE display for the message: X-RAY SWITCH FAULT-SERVICE.

Step #32

Place the MAINS switch OFF, then turn it back ON. Press the X-RAY ON switch. Switch the Interlock switch on the Tube Head Simulator. Verify that the X-RAY stops, and the MODE display shows the message: INTLK FAULT. Place the Interlock switch in its original position and restart the X-RAY.

Step #33

Remove the Cooling Unit jumper plug. Verify that the X-RAY stops and the MODE display shows: INTLK/FLOW FAULT. Replace the jumper plug and restart the X-RAY.

Step #34

Switch the Tube Head button on the Tube Head Simulator. Check that the X-RAY stops and the MODE display indicates: TUBE HEAD FAULT. Place the Tube Head button in its original position.

Step #35

Place the MAINS switch to the OFF position to remove power from the unit. Measure the resistance between pins "E" and "F" on the front panel COOLER connector, and then between pin "B" and ground. Verify that both measurements indicate 0 ohms.

Step #36

Place the MAINS switch to the ON position. Measure the voltages between the following pins on the front panel COOLER connector. The voltages should be as follows:

Pin "C" to pin "D"	120 VAC (line voltage)
Pin "E" to pin "F"	0 volts
Pin "G" to pin "D"	120 VAC (line voltage)
Pin "C" to pin "B"	120 VAC (line voltage)
Pin "G" to pin "B"	120 VAC (line voltage)

Step #37

Place the MAINS switch to the OFF position.

5.3.6 Test Procedure - Digital Control Unit

5.3.6.1 Purpose

This procedure describes how to test the Digital Control Unit after all the individual subassemblies have been tested (as outlined in Chapter 5 of the original document).

5.3.6.2 Equipment Required

1. Tube Head simulator P/N 9-200A-0101
2. Working Tube Head
3. Working Cooling Unit
4. Cooler Jumper Plug
5. Variable Power Transformer

5.3.6.3 Test Procedure

Step #1

Before connecting the Control Unit to line power, disconnect the AC input wires (the black and the white/black wires) from the main rectifier bridge (D201) mounted on the rear side of the chassis. Insulate them with electrical tape. Adjust R20 and R21 on the mother board to the maximum clockwise position.

Step #2

Connect the Control Unit to the Tube Head Simulator. Attach the high voltage cable (from the Control Unit Tubehead connector) to the Simulator Tubehead connector. Attach the Interlock cable to (from the Control Unit Interlock connector) to the Simulator Interlock connector. Install the Cooling Unit jumper plug into the Cooler connector on the Control Unit. Connect the Control Unit to line power.

Step #3

Set the MAINS switch to the ON position. Verify that the green MAINS indicator lights, the Control Unit fan starts, and the MODE (lower) LCD shows the information below:

AUTOWARM: X-RAY READY

> 30 Days

Step #4

Check that both LCD screen backlights are glowing, and that the EXPOSURE (upper) LCD shows the following information:

0KV SET	0.0 MA SET	00:00 TIME SET
0KV OPR	0.0 MA OPR	00:00 TIME REMAINS

Step #5

Press the SCROLL switch until the MODE display reads: OPERATE: X-RAY READY. Press the KV, MA, and EXPOSURE UP switches to verify that the corresponding displays (upper line) increment up to 160 kV, 5.0 mA, and 99:59 minutes/seconds respectively.

Step #6

Press the KV, MA, and EXPOSURE down buttons to verify that the corresponding displays decrement to 0 kV, 0.0 mA, 00:00 minutes/seconds respectively.

Step #7

With the SAFETY switch in the LOCKED OFF position, configure the unit for a 20 minute EXPOSURE. Press the X-RAY ON switch and check that the MODE display flashes the fault message: "SAFETY SWITCH".

Step #8

Set the SAFETY switch to the ON position, then press the X-RAY ON switch. Verify that the red X-RAY ON indicator lights, and that the EXPOSURE timer begins to count down. Also check that the Tube Head Simulator's red X-ray ON indicator lights.

Step #9

Press the X-RAY OFF switch. Make sure that the timer stops counting down, and that both red X-RAY ON indicators go off. Verify that the MODE display reads: EXPOSURE INTERRUPTED.

Step #10

Press the RESET button and check that the EXPOSURE timer resets to 20:00 minutes and the MODE display indicates: X-RAY READY.

Step #11

Press the ELAPSED/REMAINS switch and verify that the lower line on the EXPOSURE timer switches from 20:00 to 00:00.

Step #12

Press the X-RAY ON switch and check that the timer begins counting up toward 20:00. Press the ELAPSED/REMAINS switch again.

Step #13

Turn the SAFETY switch to the LOCKED OFF position and verify that the red X-RAY ON indicator go off, and that the EXPOSURE timer stops counting. Check the MODE display for the message:

EXPOSURE INTERRUPTED.

Step #14

Press the RESET button, then press the TIME/mAs button. Make sure the EXPOSURE timer changes from 20:00 to 0 mAs.

Step #15

Press and hold the EXPOSURE up button, and verify that the EXPOSURE timer increments up to 29995 mAs. Press and hold the EXPOSURE down button, and verify that the EXPOSURE timer decrements down to 0 mAs.

Step #16

Press the TIME/mAs button, then turn the MAINS switch OFF. Lift the front panel and connect the black and the white/black AC input wires to the rectifier bridge (D201). Carefully lower the front panel again.

Step #17

Place the MAINS switch to ON and check that the MODE display indicates: AUTOWARM: X-RAY READY >30DAYS.

Step #18

Press the SCROLL switch four times. Check that the lower line of the MODE display progressively displays the following messages: 7-30 DAYS; 16HR-7DAYS; 8-16HOURS; 4-8HOURS.

Step #19

Turn the SAFETY switch ON, then press the X-RAY ON switch. Make sure that the upper line on the EXPOSURE display indicates 160KV SET, 5.0MA SET, and 03:00, and that the lower line display rises to 100KV and 5.0MA within 5 seconds. The time will count down from 03:00. After one minute, verify that the lower line KV rises to 130KV, and after two minutes to 160KV. Confirm that after three minutes the X-RAY automatically stops and the MODE display indicates: OPERATE.

Step #20

Set the unit for an exposure at 160KV, 5.0MA, and 10:00 minutes. Press the X-RAY ON switch and check that the operating (lower line) KV and MA rises to 160 and 5.0. Reduce the KV and MA in 10KV and 0.5MA increments and verify that the operating KV and MA agree with the set KV and MA within ±1 kV and ±0.1 mA.

Step #21

Press the X-RAY OFF button and switch the MAINS to OFF. While holding the X-RAY ON switch down, switch the MAINS to ON. Make sure that the MODE display indicate the fault message: X-RAY SWITCH FAULT-SERVICE.

Step #22

Turn the MAINS switch OFF, then back to ON. Press the X-RAY ON switch. Switch the Interlock switch on the Tube Head Simulator and check that the X-RAY stops. Make sure the MODE display shows: INTLK FAULT. Place the Interlock switch in its original position and restart the X-RAY.

Step #23

Remove the Cooling Unit jumper plug. Verify that the X-RAY stops and that the MODE display shows the message: INTLK/FLOW FAULT. Replace the jumper plug and restart the X-RAY.

Step #24

Switch the Tube Head switch on the Tube Head Simulator. Make sure the X-RAY stops, and that the MODE display indicates: TUBE HEAD FAULT. Place the Tube Head switch in its original position.

Step #25

Turn the MAINS switch to the OFF position to remove power from the unit. Measure the resistance between pins "E" and "F" on the front panel COOLER connector, and then from pin "B" to ground. The resistance for both measurements must indicate 0 ohms.

Step #26

Place the MAINS switch to the ON position. Measure the voltages between the following pins on the front panel COOLER connector. The voltages should be as follows:

Pin "C" to pin "D"	120 VAC (line voltage)
Pin "E" to pin "F"	0 volts
Pin "G" to pin "D"	120 VAC (line voltage)
Pin "C" to pin "B"	120 VAC (line voltage)
Pin "G" to pin "B"	120 VAC (line voltage)

Step #27

Set the MAINS switch to the OFF position.

Step #28

Disconnect the Tube Head Simulator and connect the Control Unit to a working Tube Head and Cooling Unit.

! WARNING !

The following tests require the generation of x-rays. The tube head must be placed in an x-ray safe container shielded for 160 kV. All applicable safety precautions MUST BE strictly followed.

Step #29

Set the MAINS switch to ON. Press the SCROLL switch until the appropriate AUTOWARM schedule appropriate for the Tube Head being used is displayed. Start the AUTOWARM mode and warm-up the Tube Head to 160 kV.

Step #30

Select the OPERATE mode and run the Tube Head at 160 kV and 5.0 mA. Verify that the OPR KV and MA agree with the SET KV and MA within ±1KV, and ±0.1MA.

Step #31

Decrease the kV and mA to 100 and 3.0 respectively, then to 35 kV and 0.5 mA. The OPR KV and MA should agree with the SET KV and MA within ±1KV, and ±0.1MA at each of the settings.

Step #32

Turn line power OFF and connect the unit to the variable power transformer. Set the input voltage (to the unit) to 120 VAC (RMS).

Step #33

Turn line power ON. Set the Control Unit to generate 160 kV, 5 mA. Activate the X-RAY and verify that the kV rises to 160 and the mA rises to 5.

Step #34

Decrease the input line voltage to 97 VAC (RMS). Slowly adjust R21 (counter-clockwise) on the mother board until the X-RAY ON message just cuts out.

Step #35

Increase the input line voltage to 120 VAC and activate the x-ray. Slowly decrease the line voltage and verify that the X-RAY ON message cuts out at 97, ±2 VAC (Repeat Step #34 if necessary.

Step #36

Increase the line voltage to 132 VAC and (RMS). Turn the SAFETY switch OFF. Slowly adjust R20 (counter-clockwise) on the mother board until the front panel circuit breaker just trips.

Step #37

Decrease the line voltage to 120 V and reset the circuit breaker. Slowly increase the line voltage. The circuit breaker should trip at 132, ±2 VAC (Repeat step 36 if necessary).

5.3.7 Testing the Tube Head

The following procedures outline the steps to test, age, and calibrate the tube head assembly. These procedures are used when a new x-ray tube has been installed into the tube head, and a "break in" period is required. Detailed below are the materials and equipment needed to perform these tests, followed by the individual checks to perform on the assembly.

5.3.7.1 Required Test Equipment and Material

1. Halogen Leak Detector;
2. Working Cooling Unit;
3. Working Control Unit;
4. Victoreen 660 Rate Meter w/660-3 Probe

5.3.7.2 Tube Head Assembly Checks and Calibration Procedures

Step #1

Using a Halogen Leak Detector, check the tube head for signs of SF_6 leakage. If leaks are detected, they must be noted and corrected before continuing.

Step #2

Connect the Twin Hose assembly to the Tube Head and a working Cooling Unit. Connect a working Control Unit to the Cooling unit and apply power to the system. Allow coolant to flow through the tube head. Check all the fittings and hoses on the tube head for signs of leakage. Any leaks found during this test must be noted, and corrected before proceeding.

! WARNING !

The following tests require the generation of x-rays. The tube head must be placed in a shielded x-ray container, and all applicable safety precautions must be strictly followed.

Step #3

Run the tube head up to 160 kV at 5 mA according to the procedure in section 4.6.

Step #4

Using a Victoreen 660 Rate Meter with a 660-3 Probe, measure the radiation output emitted from the Tube while it is operating at 160 kV and 5 mA. Radiation levels of at least 230 R/min @ 50cm should be obtained (> 13 R/min through 0.50" Type 1100 Al.).

Step #5

Run the tube head at 160 kV and 5 mA for 5 hours. During this time, closely monitor the mA and kV Displays on the Control Unit for signs of arcing or instability. If any signs of arcing occur, reduce the kV level 20 kV below the point where the erratic arching began, run for 5 minutes, then advance the kV level.

Step #6

Measure the Focal Spot on the tube head by following the appropriate ASTM (American Society for Testing Materials) procedures. The Focal Spot should not exceed the specification for a 1.5mm square (ASTM E-1165).

5.3.8 Testing the High Voltage Generator

The following procedures outline the steps to troubleshoot, and calibrate the High Voltage Power Supply within the tube head. Detailed below are the materials and equipment required to perform these tests, followed by the individual checks to perform on the assembly.

5.3.8.1 Required Test Equipment and Materials

1. 33 kHz, 10V amplitude signal generator;
2. Dual Channel Oscilloscope;
3. 4 Digital Multimeters (Fluke Model #73 or equiv.);
4. 1 High Voltage Probe (Fluke Model # 80K-40 or equiv.);
5. Oscilloscope High Voltage Probe (Tektronix #P6015 or equiv.);
6. Tubehead Load Simulator #SK3690;
7. Calibration Test Set #SK3691;

5.3.8.2 Filament Tests

Step #1

Connect a signal generator to pins " I " and " F " of the end plate power cord connector. Connect an oscilloscope probe from channel 1 of the scope to the output of the signal generator as shown in Figure 5-18.

Step #2

Connect an oscilloscope probe from channel 2 of the scope to the tube contacts within the x-ray tube socket. Set the signal generator to output a 33 kHz, 10 V peak-to-peak signal, then apply power.

Step #3

Observe the primary voltage and the voltage across the tube socket contacts. The ratio of the peak-to-peak primary voltage to the peak-to-peak secondary voltage should be approximately 9:1.

5.3.8.3 Multiplier Tests

! WARNING !

Dangerous voltages are present on the multiplier & load while the test set is on. All applicable electrical safety precautions must be observed while performing the following procedures.

Step #1

Connect the multiplier to the test equipment as shown in Figure 5-19. Connect the Control Cable between the tube head Calibration Test Set and the Tube Head Connector. Connect one multimeter to the "kV Sense" jacks and another multimeter to the "Inverter D.C." jacks on the Tube Head Calibration Test Set.

Step #2

Connect a High Voltage lead from the connector on top of the Tube Head Load to the un-insulated tube contact within the Tube Socket. Connect the supplied coaxial cable from the connector on the Tube Head Load to a third multimeter. Finally, connect a ground lead from the test point on the Load to ground on the End Plate.

Step #3

Set the Variac (knob on Tube Head Test Set) to minimum, then plug in the Test Set. Turn the power switch "ON" and slowly advance the variac. The Inverter D.C., the inverter current (meter on test set), and the load voltage should slowly rise as the variac knob is advanced.

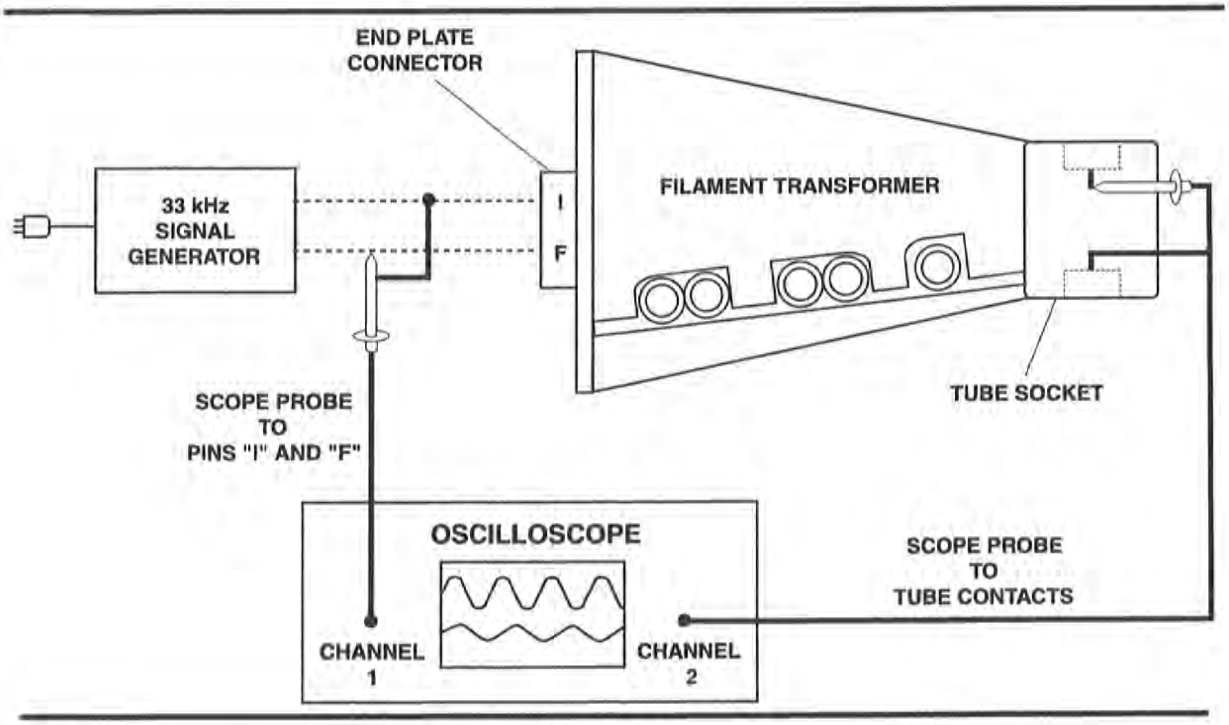


FIGURE 5-18:

FILAMENT TEST CONFIGURATION

Step #4

Advance the variac until the load voltage reads 20.0 kV. The Inverter D.C. should be approximately 30.0 volts, and the Inverter Current approximately 0.5 amps.

Step #5

Using a fourth multimeter with a high voltage probe, measure the voltage across each capacitor in the multiplier D.C. leg (center capacitor string with filament transformer leads attached). Do this by recording the voltage above the bottom capacitor. Move the probe above the second capacitor and record the voltage present (the second reading is the sum of both capacitors). Subtract the first reading from the sum. Repeat this process for the entire D.C. leg. There should be 4 kV, ±0.3 kV across each capacitor.

Step #6

Using an oscilloscope with a high voltage oscilloscope probe, observe the 25 kHz waveform on each capacitor in both A.C. legs of the multiplier. The A.C. voltage should be equal on each capacitor within ±400 volts. (Some 120 Hz ripple may be evident on the waveform - read the average value).

Step #7

Note the exact value of the load voltage. While monitoring the kV sense voltage, adjust the pot on the kV Sense PCB until the kV sense voltage is obtained. The kV sense voltage is obtained by performing the formula below:

$$V_{kV\ SENSE} = \frac{V_{LOAD\ (kV)}}{160}$$

Example:

With a load voltage of 20.0 kV, V kV sense should be equal to 0.125 volts. With a load voltage of 21.1 kV, V kV sense should be equal to 0.132 volts.

Step #8

Check that proper Vkv SENSE voltage (from formula above) is present at load voltages of 14 kV and 17 kV (within ± 0.001 Volt).

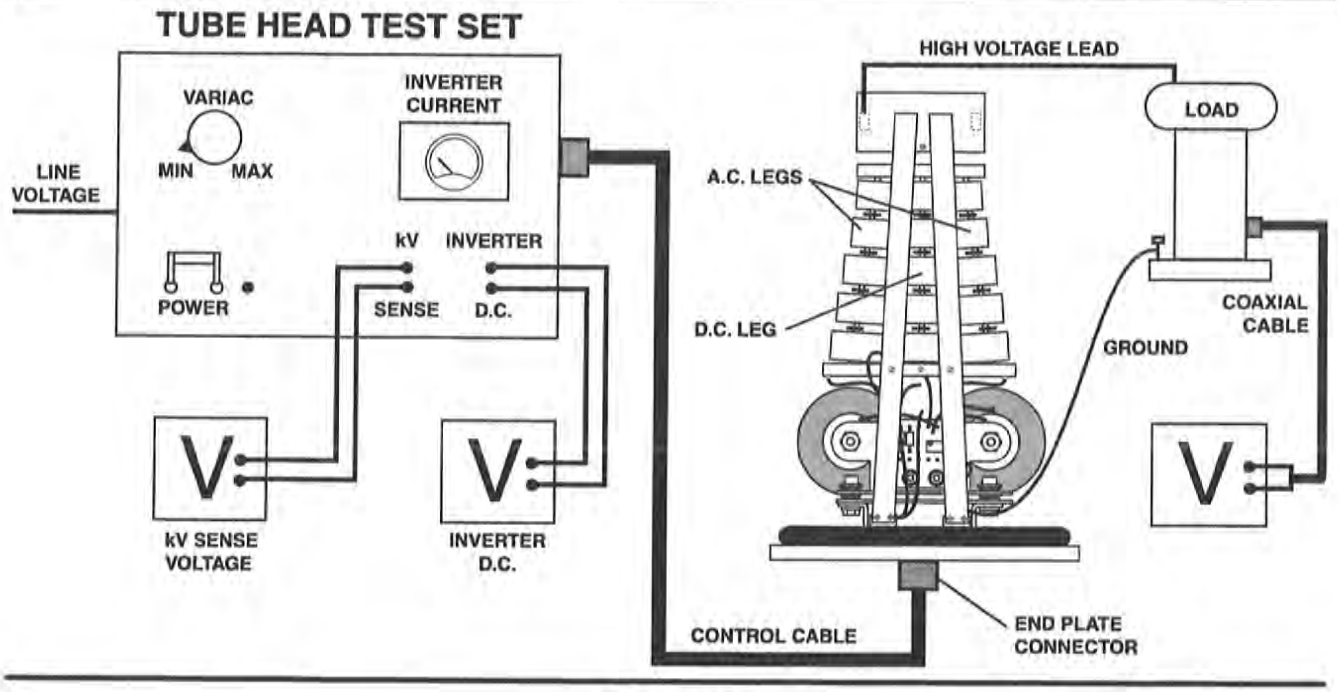


FIGURE 5-19:

MULTIPLIER TEST CONFIGURATION

5.3.9 Testing the Coolant Unit

The following procedures outline the steps to troubleshoot, and pressure test the Cooling Unit. Detailed below are the materials and equipment required to perform these tests, followed by the individual checks to perform on the assembly.

5.3.9.1 Required Test Equipment and Materials

1. Cooling Unit Pressure Test Fixture SK3743 (see Figure 5-20);
   a. Pressure Gauge (0 to 100 psi);
   b. "TEE" Fitting;
   c. Male Fittings to mate with Cooler;
   d. 2 lengths of tubing.
2. Working Control Unit.

5.3.9.2 Cooling Unit Checks

Step #1

Connect a working Control Unit to the Cooling Unit. Connect the Control Unit to a 115 volt source. Apply power and verify that the Cooler's motor operates. Remove power, then connect the Control Unit to a 230 volt source. Again, verify the Cooler's motor operates.

Step #2

Connect the Pressure Test Fixture to the coolant flow couplings on the Cooling Unit. Connect the Control Unit to a 115 volt source and apply power to the system. Measure the coolant pressure and ensure at least 18 psi of coolant flow is achieved.

Step #3

Verify the Flow Switch within the Cooling Unit closes when coolant is circulated through the system. Remove power, and verify the Flow Switch opens as coolant flow stops.

Step #4

Apply power and check all fittings, hoses, tubes, and the radiator for leaks. Ensure the Fan is turning. Remove Power, and check to the tension of the fan belt. Ensure the belt does not slip during operation.

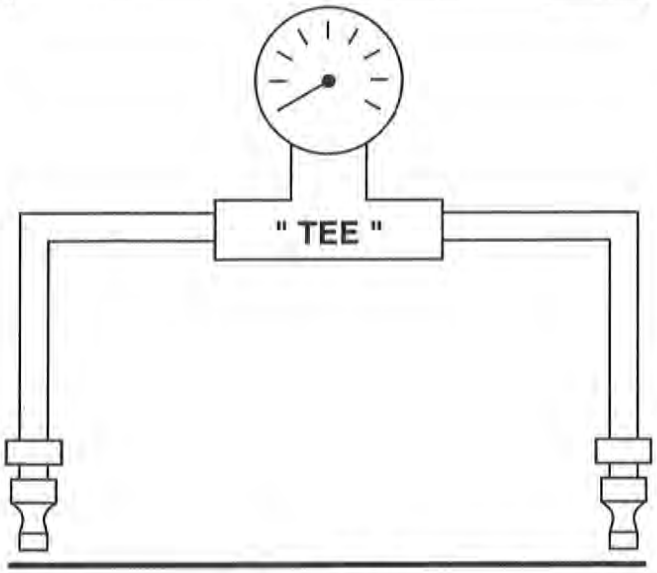


FIGURE 5-20:
COOLING UNIT PRESSURE TEST FIXTURE

5.4 REMOVAL & REPLACEMENT PROCEDURES

This section outlines removal and replacement procedures of the major assemblies within each unit of the x-ray apparatus. This information will be needed to restore the x-ray unit to its normal operating condition should a malfunction develop during use.

! WARNING !

Because of the high voltages used in this equipment, it is essential that only QUALIFIED electronic service personnel experienced in the maintenance and repair of high voltage x-ray apparatus be allowed to repair or calibrate the equipment.

! CAUTION !

While performing the following removal and replacement procedures, power must be removed from the system to prevent injury from electrical shock.

This section has been arranged into three major segments. These segments outline the following removal procedures:

1. Removal and replacement of components within the Control Unit;
2. Removal and replacement of components within the Cooling Unit;
3. Removal and replacement of components within the tube head.

Each procedure is accompanied by an illustration detailing the major components involved in the removal and replacement of a particular assembly. These illustrations provide a visual reference to aid the technician while performing these tasks. Each procedure should be read in its entirety, referenced to the illustration, and thoroughly understood before beginning. If there are questions regarding these procedures, call your local Hologic dealer.

5.4.1 Removal and Replacement of Control Unit Components

5.4.1.1 Power "ON" Circuit Breaker Removal

To remove the Power On Circuit Breaker, follow the procedures outlined below while referring to Figure 5-21.

Step #1

Remove the protective top cover and set it aside. Remove the six #8-32 Phillips Head screws on the outer edge of the Front Panel. Lift the Front Panel out of the Control Unit by loosening the two self contained locking screws. Raise the Panel upward, then gently push it forward to secure it in the vertical position. Remove the four wires connected to the spade-type terminals on the back of the Circuit Breaker. Note the terminal position of each wire.

Step #2

Lower the Front Panel so it rests on the Control Unit. Using a Pin Punch, carefully push the retaining pin out from the center of the Circuit Breaker Switch (Figure 5-21).

Step #3

Remove the four machine screws and slide the Circuit Breaker out the back of the Front Panel. Reverse these procedures to re-install the Circuit Breaker.

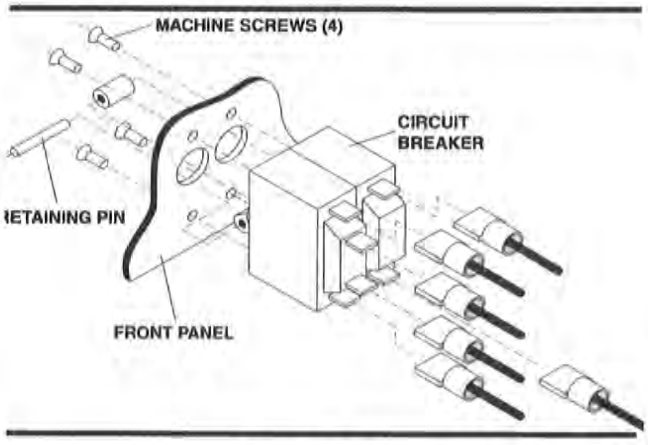


FIGURE 5-21:
POWER "ON" CIRCUIT BREAKER REMOVAL

5.4.1.2 Removing the Microcomputer Board

Step #1

Remove the top cover on the Control Unit, then lift the Front Panel out of the Controller by following the instructions in section 5.4.1.

Step #2

The Microcomputer Board (1-003A-4016) is located on the bottom side of the Front panel. Detach the connectors from the following terminals on the Microcomputer Board:

J9, J10, J11, J13, J14, J15, J16, J18, and J19

Mark each connector for installation identification purposes.

Step #3

Remove the six button head screws that fasten the Microcomputer Board to the standoffs on the front panel assembly. Cut the ty-wrap that fastens the pushbutton switch wiring harness to the main wiring harness.

Step #4

Lift the microcomputer board off the front panel. Disconnect the ribbon cables from J8 and J12 on the opposite side of the board. The microcomputer board can now be removed.

Step #5

To replace the microcomputer board, reverse the above procedures.

5.4.1.3 X-ray Button & Safety Lock Switch Removal

To remove the X-ray Button or the Safety Lock Switch, follow the procedures below while referring to Figure 5-22.

Step #1

Remove the protective top cover and set it aside. Remove the screws on the outer edge of the Front Panel. Lift the Front Panel out of the Control Unit by loosening the two self contained locking screws. Raise the Panel upward, then gently push it forward to secure it in the vertical position.

Step #2

To replace the X-ray Pushbutton Switch, remove the wires on the back of the switch by sliding them off the terminals. Note their positions on the switch.

Step #3

To replace the Safety Lock Switch, remove the wires from the back of the switch noting their terminal positions.

Step #4

All switches can be removed by sliding the entire assembly out the front of the panel. Replace if necessary.

Step #5

Once the new switches have been inserted into the panel, slide the wires onto their respective terminals.

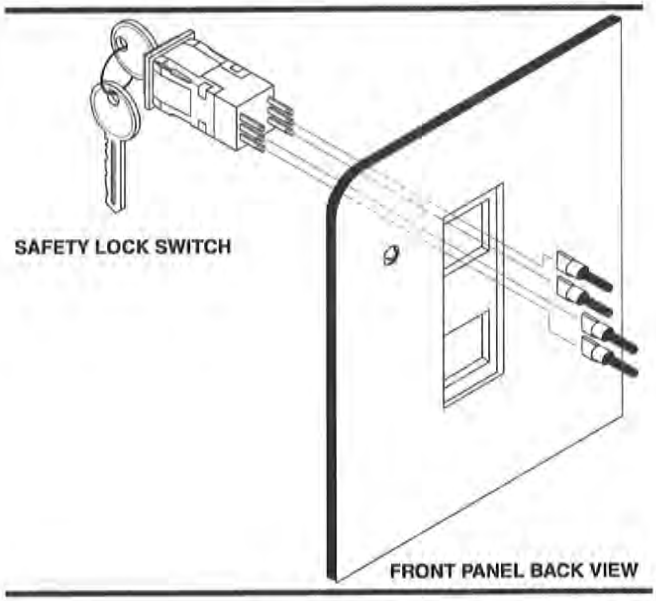


FIGURE 5-22:

X-RAY AND SAFETY LOCK SWITCH REMOVAL

5.4.1.4 X-ray "OFF" Button Removal

To remove the x-ray "OFF" Button, follow the procedures below while referring to Figure 5-23.

Step #1

Remove the protective top cover and set it aside. Remove the screws on the outer edge of the Front Panel. Lift the Front Panel out of the Control Unit by loosening the two self contained locking screws. Raise the Panel upward, then gently push it forward to secure it in the vertical position.

Step #2

There are four terminals on the back of the button. The two outer terminals are "normally open", and the two inner terminals (with wires attached) are "normally closed". Unsolder the wires from the back of the button (normally closed terminals).

Step #3

Unscrew the retaining ring from the back of the button, then slide the entire button out the front of the panel. Reverse these procedures to install the x-ray "OFF" Button.

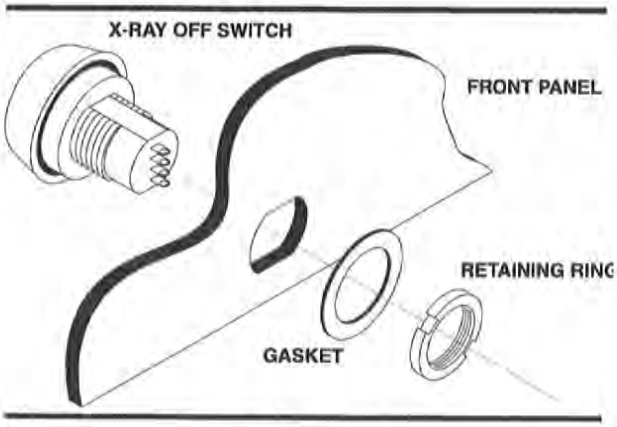


FIGURE 5-23:
X-RAY OFF BUTTON REMOVAL

5.4.1.5 Power & X-ray ON Indicator Light Removal

The procedure for removing the Power and X-ray ON Indicators are identical. To remove these indicators, follow the procedures below while referring to Figure 5-24.

Step #1

Remove the protective top cover and set it aside. Remove the screws on the outer edge of the Front Panel. Lift the Front Panel out of the Control Unit by loosening the two self-contained thumb screws. Raise the Panel upward, then gently push it forward to secure it in the vertical position.

Step #2

Remove the four screws from the corners of the Indicator Light circuit board. Lift the board away from the panel.

Step #3

Unplug the Indicator Light from the socket on the circuit board.

Step #4

Reverse these procedures to install the replacement Indicator Light.

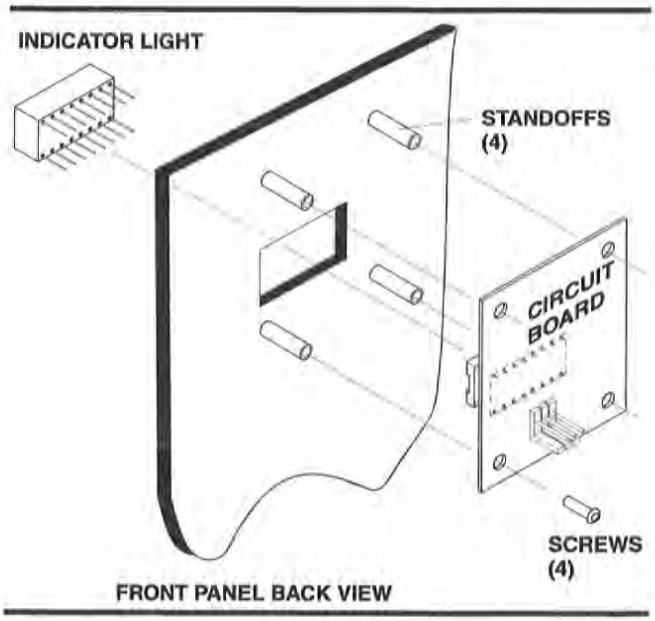


FIGURE 5-24:
POWER & X-RAY ON INDICATOR LIGHT REMOVAL

5.4.1.6 6 kV, mA and L.V.P.S. Board Removal

These boards are located within the Control Unit and are mounted onto the Mother Board by captive screws. To properly troubleshoot these boards, they must be removed from the Control Unit. To remove the kV Board, mA Board and/or Low Voltage Power Supply Board, follow the procedures below while referring to Figure 5-25.

Step #1

Remove the protective top cover and set it aside. Remove the screws on the outer edge of the Front Panel. Lift the Front Panel out of the Control Unit by loosening the two captive screws. Raise the Panel upward, then gently push it forward to secure it in the vertical position. Remove the clear polycarbonate panel and set it aside.

Step #2

The kV Board is attached to the Mother Board by four captive screws. Remove the kV Board by completely loosening these screws, and gently lifting the board out of the socket. The screws will remain in the board mounts.

Step #3

The mA Board is attached to the Mother Board by three captive screws. Remove the mA Board by completely loosening these screws, and gently lifting the board out of the socket. The screws will remain in the board mounts.

Step #4

The L.V.P.S. is attached to the Mother Board by two captive screws. Remove the L.V.P.S. by completely loosening these screws, and gently lifting the board out of the socket. The screws will remain in the board mounts.

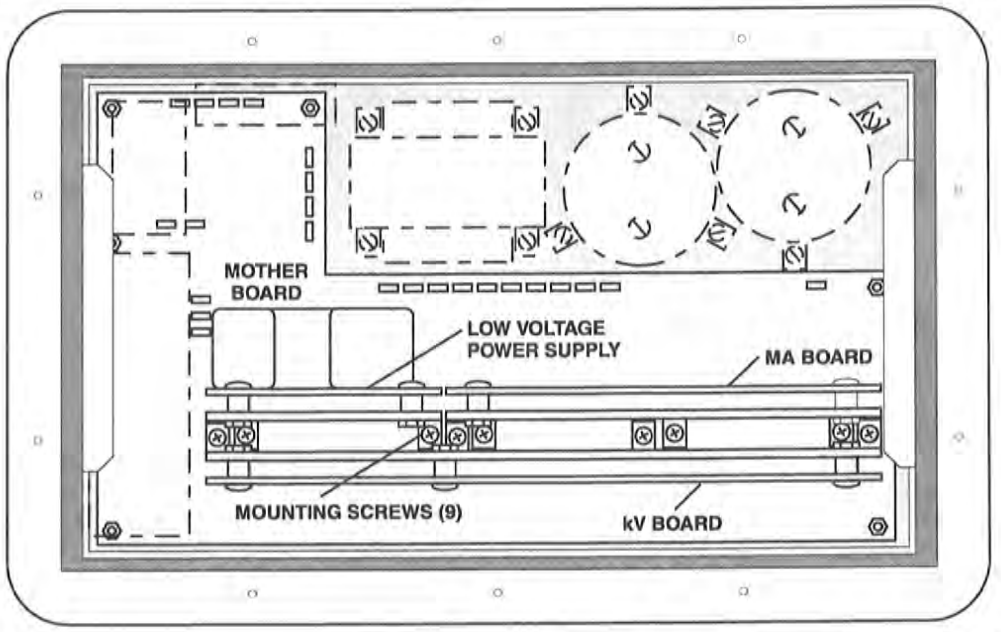


FIGURE 5-25:

KV, MA, AND L.V.P.S. BOARD REMOVAL

5.4.1.7 Transformer (T201) Removal

The Transformer (T201) within the Control Unit is mounted to the chassis by four machine screws. The input/output wires from the Transformer are connected to spade type terminals on the Mother Board. To Remove the Transformer, follow the procedures below while referring to Figure 5-26.

Step #1

Remove the protective top cover and set it aside. Remove the screws on the outer edge of the Front Panel. Lift the Front Panel out of the Control Unit by loosening the two captive locking screws. Raise the Panel upward, then gently push it forward to secure it in the vertical position. Remove the clear polycarbonate panel.

Step #2

Remove the input/output wires from the spade terminals on the Mother Board. Note the terminal number for each wire.

Step #3

Remove the four machine screws securing the Transformer to the chassis. Lift the Transformer out of the Control Unit and replace if necessary.

5.4.1.8 Storage Capacitor (C201 or C202) Removal

The Storage Capacitors (C201 and C202) within the Control Unit are secured to the chassis by a mounting bracket and three machine screws. To Remove the Capacitors, follow the procedures below while referring to Figure 5-26.

Step #1

Remove the protective top cover and set it aside. Remove the screws on the outer edge of the Front Panel. Lift the Front Panel out of the Control Unit by loosening the two captive locking screws. Raise the Panel upward, then gently push it forward to secure it in the vertical position. Remove the clear polycarbonate panel.

Step #2

Ensure the capacitors are fully discharged. Remove the screws from the posts on top of the capacitor, then remove the wires connected to the posts. Note the polarity of each wire.

Step #3

Remove the three mounting screws from the bracket securing the capacitor to the chassis, then remove the capacitor by lifting it out of the Control Unit. Replace if necessary, then reverse these procedures to install the capacitor.

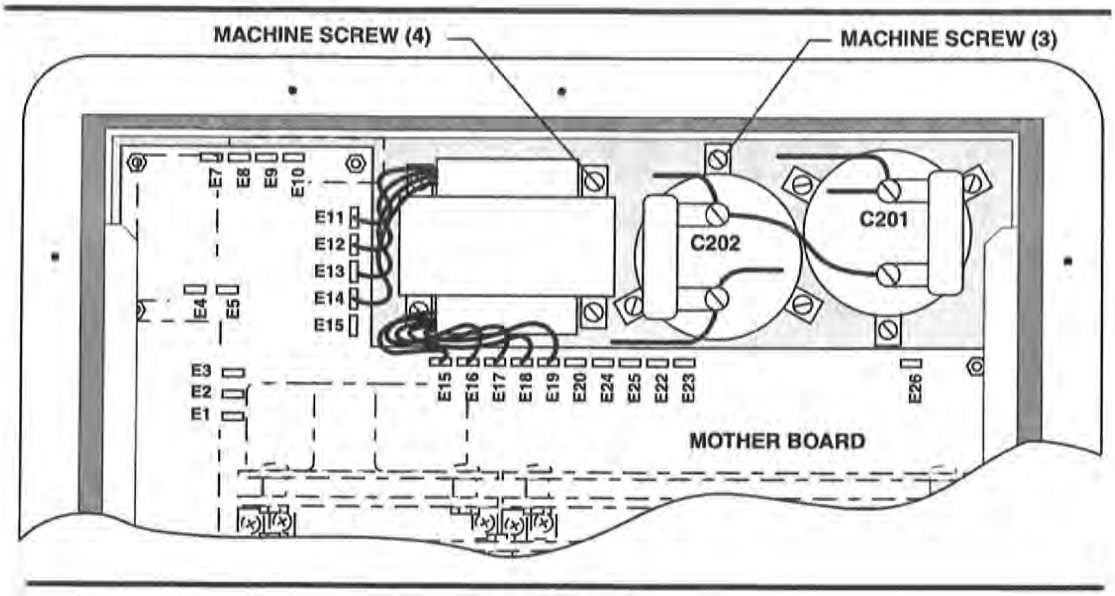


FIGURE 5-26:

TRANSFORMER & CAPACITOR REMOVAL

5.4.1.9 Mother Board Removal

The Mother Board houses the kV Board, the mA Board, and the Low Voltage Power Supply. It is secured to the chassis of the Control Unit by six 11/32" hex nuts. To properly troubleshoot the Mother Board, it must be removed from the Control Unit. To remove the Mother Board, follow the procedures below while referring to Figure 5-27.

Step #1

Remove the protective top cover and set it aside. Remove the six retaining bolts from the bottom of the Control, remove the screws on the outer edge of the Front Panel, then lift the chassis out of the case. Lift the Front Panel out of the Control Unit by loosening the two captive locking screws. Raise the Panel upward, then gently push it forward to secure it in the vertical position. Remove the clear polycarbonate panel.

Step #2

Remove the kV Board, mA Board, and the Low Voltage Power Supply as outlined in section 5.4.1.6. Remove the Transformer (T201) as outlined in section 5.4.1.7. Remove the eight flathead screws from the Fan Assembly and remove from chassis.

Step #3

Remove the Power Switching Relay by gently lifting it out of the socket in the Mother Board. Remove the wires from the spade type terminals E6 to E10, and E21 to E25. These wires lead to the Storage Capacitors (C201 and C202). Mark the "E" number for each wire as they are removed.

Step #4

Remove the six (6) 11/32" hex nuts securing the Mother Board to the chassis. Lift the Mother Board out of the Control Unit. Reverse these procedures to install the Mother Board. Unplug P4, P5, P6 and P7.

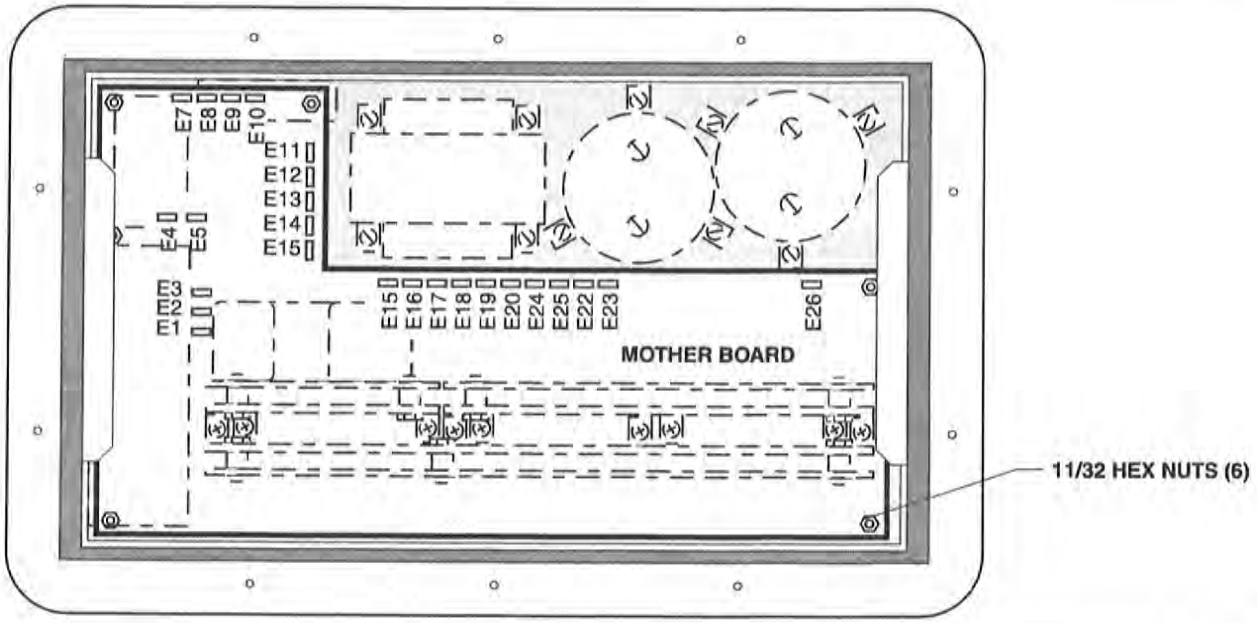


FIGURE 5-27:

MOTHER BOARD REMOVAL

5.4.2 Removal and Replacement of Cooling Unit Components

5.4.2.1 Radiator Removal

A malfunctioning radiator requires that it be removed from the Cooling Unit before corrective measures are taken. The following procedures outline the steps to properly drain, remove, and replace the radiator. Refer to Figure 5-28 while performing these procedures.

Step #1

Remove the lid from the Cooling Unit and drain the coolant from the reservoir. Remove the Top Cover from the unit by removing the ten button head screws securing it to the outer container.

Step #2

Remove the four hex bolts securing the chassis to the outer container. Lift the chassis out of the container, then place it in a large drip pan. Loosen the band clamps securing the coolant input and output hoses to the fittings on the radiator. Remove the hoses from the fittings and allow the coolant to drain from the radiator and hoses.

Step #3

Detach the radiator from the chassis by removing the machine screws from both brackets securing the radiator to the chassis. The radiator can now be repaired or replaced as necessary.

Step #4

Install the radiator by reversing these procedures. When the unit is completely assembled, attach the Cooling Unit to the Twin Hose assembly, and the Twin Hose to the tube head. Connect the Cooling Unit Cable to the Control Unit and plug in the power cord.

Step #5

Apply power to the system, allowing coolant to flow for approximately 2 minutes. Remove power and check the coolant level. Add coolant to the reservoir until the level is approximately 1/2" from the top. Repeat this step until the coolant level remains within limits.

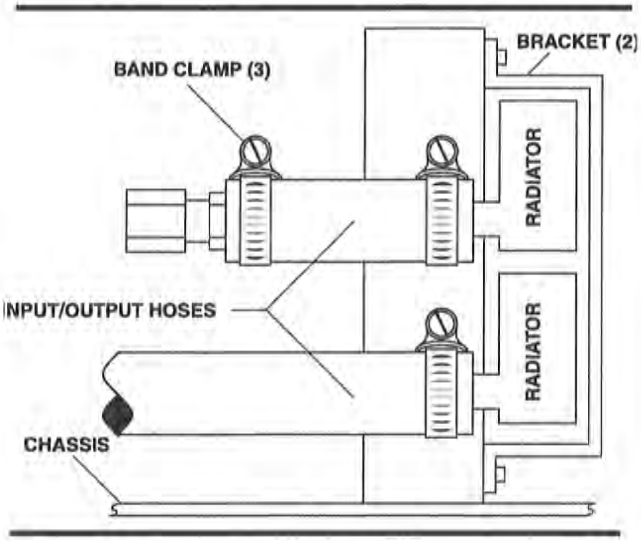


FIGURE 5-28:
RADIATOR ASSEMBLY REMOVAL

5.4.2.2 Motor and Fan Assembly Removal

The motor in the Cooling Unit drives a pump that forces coolant into the tube head, and a fan that generates air flow through the radiator. If this motor malfunctions, the anode cannot be cooled properly, which can result in damage to the x-ray tube. The following procedures outline the steps to remove the Motor and Fan assembly within the Cooling Unit (Figure 5-29).

Step #1

Remove the lid and top cover from the Cooling Unit's outer container. Remove the four hex bolts from the bottom of the container that secure the Cooling Unit's chassis to the container. Lift the entire chassis out of the container.

Step #2

The power cable enters the back of the motor, and is secured by a brace. Remove this brace, and the end plate from the back of the motor to gain access to the internal wiring. Remove the heat wraps from each connection and unsolder each wire (note each wire position). Remove the ground wire, and pull the entire power cable out of the motor.

Step #3

Remove the mounting bolts securing the motor to the chassis. Pull the motor away from the radiator so the fan clears the guard. Loosen the set screw securing the fan to the motor's drive shaft, then slide the fan off the shaft.

Step #4

Remove the drive belt from the pulley, and the motor from the chassis. Loosen the two set screws securing the pulley to the drive shaft, then slide the pulley off the shaft.

Step #5

Reverse these procedures to install the motor. When installing, apply tension to the drive belt by pulling the motor away from the pump. At the same time, align the motor pulley with the coolant pump pulley by sliding the motor left or right while the mounting bolts are still loose. Then tighten the mounting bolts.

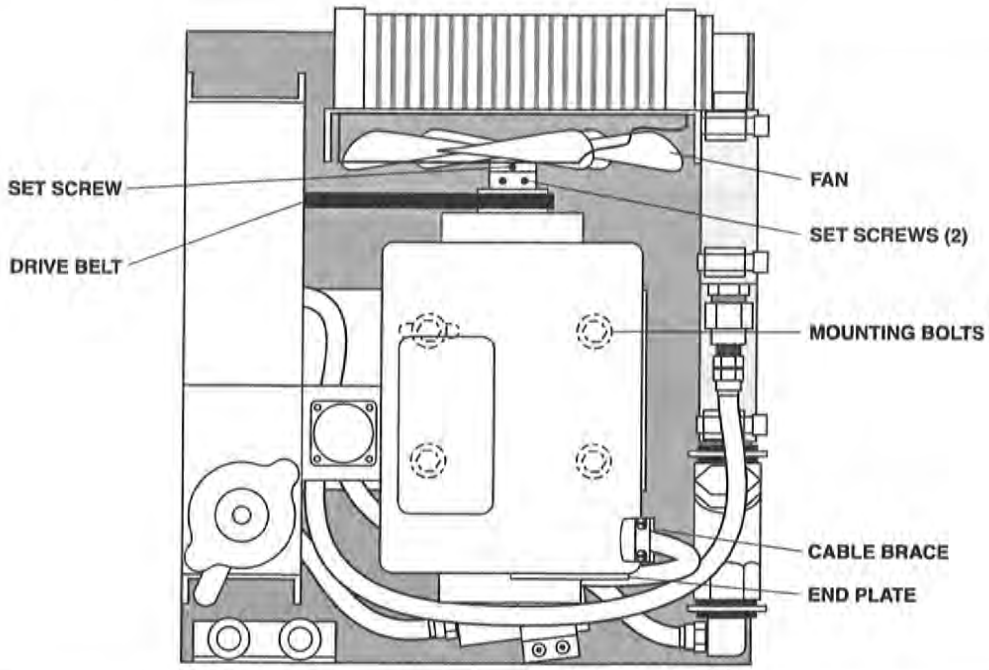


FIGURE 5-29:
MOTOR AND FAN ASSEMBLY REMOVAL

5.4.2.3 Coolant Pump and Drive Belt Removal

The Coolant Pump is powered by the motor assembly, and is linked to the drive motor by a belt and two pulleys. If a pump malfunction occurs, proper anode cooling cannot take place, resulting in damage to the x-ray tube. The following procedures outline the steps to remove and replace the Coolant Pump and Drive Belt (Figure 5-30).

Step #1

Remove the lid and Top Cover from the Cooling Unit's outer case. Drain the coolant from the reservoir. Remove the four hex bolts from the bottom of the case that secures the chassis to the unit. Lift the chassis out of the case and place it in a large drip pan.

Step #2

The Motor assembly may need repositioning to gain access to the Pump. Remove the four mounting bolts securing the motor to the chassis. Slide the motor outward so the fan clears the guard, then position it away from the Pump.

Step #3

Remove the coolant input and output hoses from the fittings on the sides of the Pump. Allow the coolant to drain from the pump and the hoses. Remove the two retaining bolts securing the pump to the chassis. Remove the belt from the pulley and lift the pump out of the unit. The belt may be removed by detaching the fan from the motor (as outlined in section 5.4.2.2).

Step #4

Loosen the set screws securing the pulley to the pump's end shaft, then slide the pulley off. Remove the hose fittings from the sides of the pump, and remove any remaining teflon tape affixed to the threads.

Step #5

Place fresh teflon tape around the threads of the hose fittings, and install them into the new pump. Slide the pulley onto the pump's end shaft, aligning the set screws with the "flats" on the shaft, then tighten the set screws.

Step #6

Install the new pump by reversing steps #1 through #5. When the unit is assembled, attach the Cooling Unit to the Twin Hose assembly, and the Twin Hose to the tube head. Connect the Cooling Unit Cable to the Control Unit and plug in the power cord.

Step #7

Apply power and allow the coolant to flow for 2 minutes. Remove power and check the coolant level. Add coolant to the reservoir so the coolant level is approximately 1/2" from the top. Repeat this step until the coolant level remains within limits.

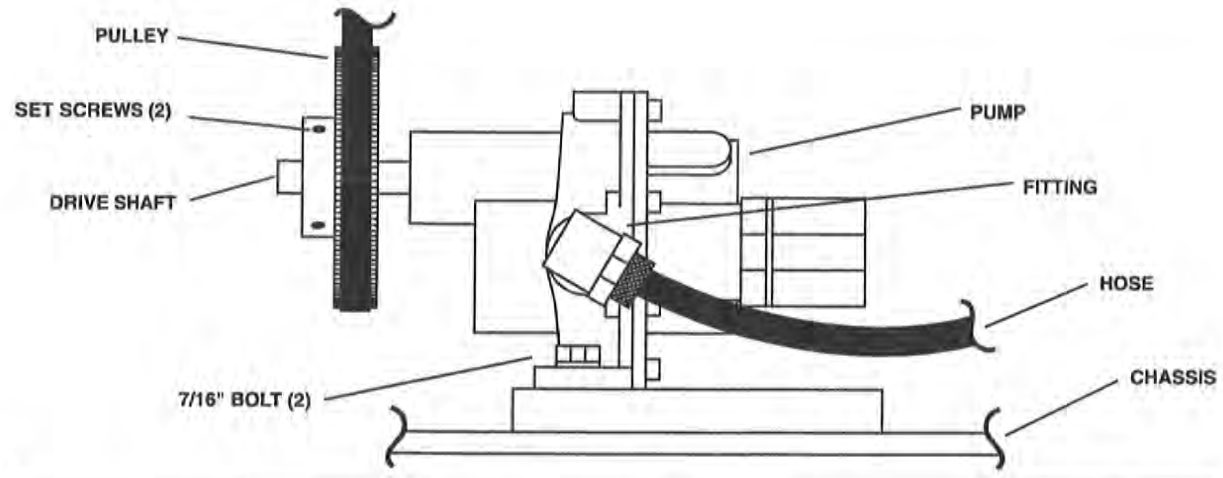


FIGURE 5-30:

COOLANT PUMP AND DRIVE BELT REMOVAL

5.4.2.4 Coolant Reservoir Removal

To Remove the Coolant Reservoir follow the procedures below while referring to Figure 5-31.

Step #1

Remove the lid and Top Cover from the Cooling Unit outer case. Drain the coolant from the reservoir. Remove the four hex bolts from the bottom of the case that secure the Cooling Unit's chassis to the case. Lift the chassis out of the case and place it in a large drip pan.

Step #2

Remove the coolant input hose from the fitting on the Coolant Pump. Remove the coolant hoses from the fittings on the bottom of the Reservoir. Allow excess coolant to drain from the pump and reservoir.

Step #3

Remove the four mounting screws that secure the reservoir to the chassis. Remove the hose fittings from the reservoir and remove any excess teflon tape from the threads. Reverse these procedures to install the reservoir. Apply fresh teflon tape to all threaded fittings to prevent leakage.

Step #4

Add Coolant Solution as outlined in section 5.4.2.1, step #5.

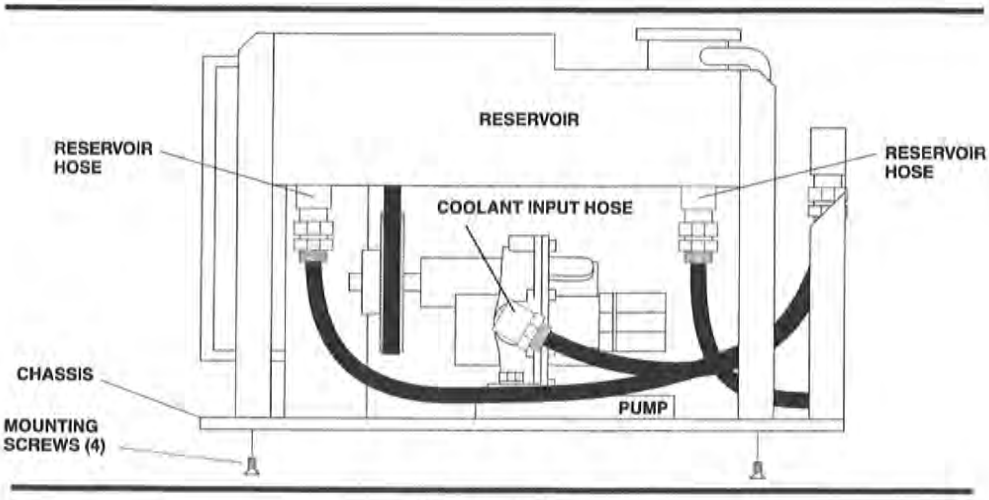


FIGURE 5-31:

COOLANT RESERVOIR REMOVAL

5.4.2.5 Twin Hose Quick-Disconnect Fitting Removal

To remove the Quick-Disconnect Fittings follow the procedures below while referring to Figure 5-32.

Step #1

Remove the lid and Top Cover from the Cooling Unit's outer case. Remove the four hex bolts (from the bottom of the case) securing the chassis to the case. Lift the chassis out of the case and place it in a large drip pan.

Step #2

Place a 7/16" wrench and a 9/16" wrench on the fitting as shown in the Figure 5-32. While holding the bottom wrench in place, remove the Quick-Disconnect Fitting by turning the top wrench counter-clockwise. Some coolant will seep from the fitting as it is removed.

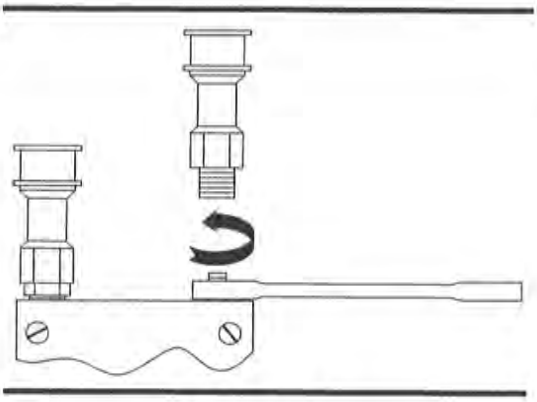


FIGURE 5-32:

QUICK-DISCONNECT FITTING REMOVAL

Step #3

Place a length of teflon tape around the threads of the new Quick-Disconnect Fitting, and install it onto the fitting on the chassis. The fitting must be tightly fastened to prevent leakage during operation.

5.4.2.6 Coolant Flow Switch Removal

The following procedures outline the steps to remove the Coolant Flow Switch (Figure 5-33).

Step #1

Remove the lid and Top Cover from the Cooling Unit's outer case.

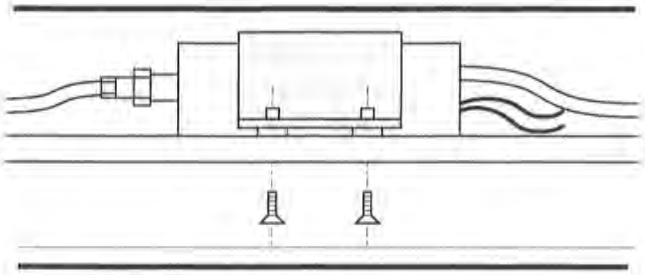


FIGURE 5-33:

COOLANT FLOW SWITCH REMOVAL

Step #2

Remove the four hex bolts (from the bottom of the case) that secure the Cooling Unit's chassis to the case. Lift the chassis out of the case and place it in a large drip pan.

Step #3

Remove the bracket securing the Flow Switch to the chassis as shown in Figure 5-33. Remove both coolant hoses from the fittings on the Flow switch. Cap off both hoses to prevent loss of excess coolant from the reservoir (some coolant will be lost from the Flow Switch while removing these hoses).

Step #4

Cut the "ty-wrap" securing the detector wires to the chassis. Remove the heat wrap from the wire connections and unsolder the wires. Remove the hose fittings from the Flow Switch and pull any excess teflon tape from the threads. Replace the Flow Switch by reversing the above procedures. When complete, add coolant solution as necessary and check for proper operation.

5.4.3 Removal and Replacement of Tube Head Components

5.4.3.1 Tube Head Coolant Tubing Removal

To gain access to the internal components of the tube head, the flat tubing, and associated hose fittings that direct coolant to the anode must be removed. The Top Plate and End Plate can then be removed from the tube head, thus granting access to the High Voltage Power Supply and the x-ray Tube. To remove the tubing follow the procedures below while referring to Figure 5-34.

Step #1

Coolant solution is routed to the anode, and back to the Cooling Unit through a double length of flat tubing. This tubing is located under a decorative cover on the tube head. To gain access to the tubing, this cover must be removed by unscrewing the two button head screws securing it to the tube head.

Step #2

Remove the anode coolant fittings that attach the round copper tubing (leading to the anode) to the flat coolant tubing.

Step #3

Remove the flat tubing and attached couplings from the outer case by removing the four button head screws (two at either end) that secure the tubing to the tube head.

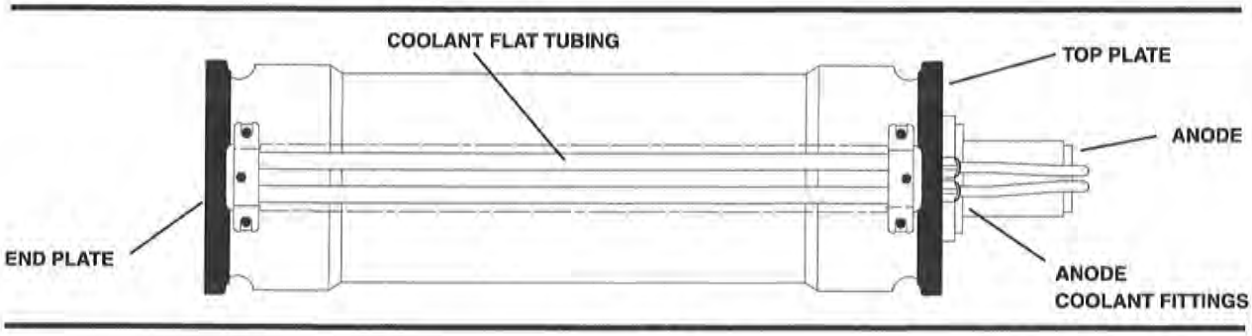


FIGURE 5-34:
TUBE HEAD COOLANT TUBING REMOVAL

5.4.3.2 Tube Head Top Plate Removal

To gain access to the x-ray Tube, the Top Plate must be removed from the tube head. To accomplish this, the Coolant tubes and fittings must first be removed, and the pressure in the tube head must be relieved. To remove the x-ray Tube from the Tube Head Assembly, follow the procedures below while referring to Figure 5-35.

Step #1

Remove the tube head's coolant tubing by following the procedures outlined in section 5.4.3.1. Release the SF_6 gas through the tire type valve on the End Plate by removing the stem cap, then pressing the relief valve. Using a large flat blade screwdriver, loosen the Safety Stud on the Top Plate until the remaining SF_6 gas is released from the tube head. When the tube head pressure is released, remove the Safety Stud from the Top Plate.

! WARNING !

The SF_6 gas pressure should always be released outdoors. Never release the gas pressure in a confined area.

Step #2

Remove the Retaining Ring by extracting the two screws securing it to the Top Plate. This allows access to the Top Plate's retaining screws.

Step #3

Remove the ground wire from the anode by unscrewing the retaining screw and cutting the "ty-wraps" securing the wire to the coolant tubing. Remove the Thermal Cutout Sensor by loosening the button head screws on the mounting bracket, sliding the sensor off of the anode, and cutting the "ty-wraps" securing the wire to the coolant tubing.

Step #4

Remove the six socket head screws securing the Top Plate to the outer casing. Insert three #6-32x1" socket head screws into the threaded holes around the Top Plate. These screws will be used as "jacks" to help extract the Top Plate from the tube head.

Step #5

Turn each "jack" screw evenly and equally (approximately one complete turn at a time) until the Top Plate can be lifted from the tube head. Once the x-ray Tube has been extracted, remove the "jack" screws from the Top Plate.

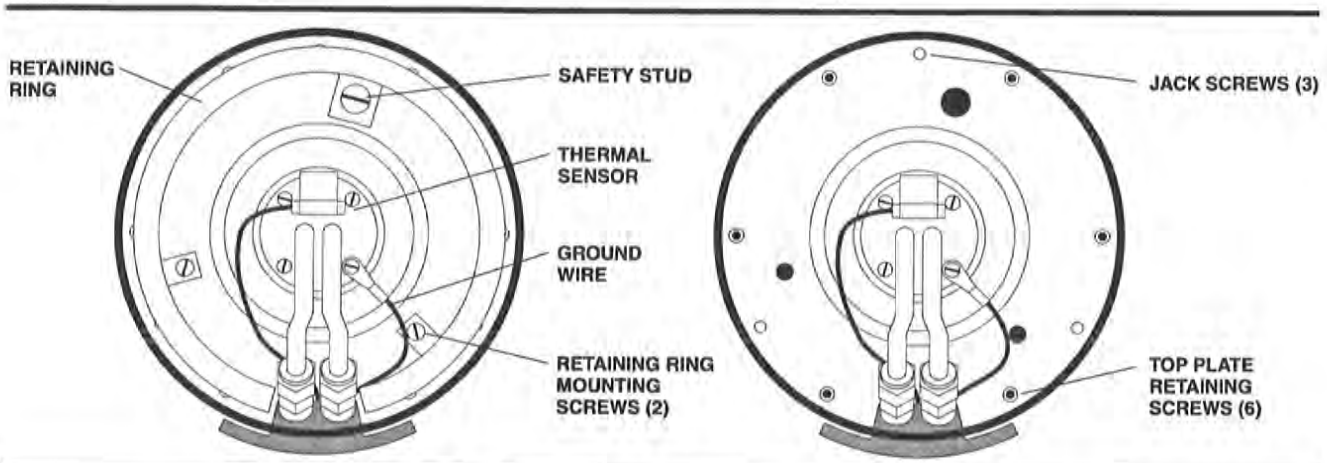


FIGURE 5-35:
TOP PLATE REMOVAL

5.4.3.3 X-Ray Tube Removal and Replacement

To replace a faulty x-ray Tube, the tube must be removed from the Top Plate Tube Support. This procedure requires the use of the Tube Wrench (p/n: 9-060A-0055, available through Hologic), and Silicone grease ("Dow Corning #55" or equivalent). To remove and replace the X-ray Tube, follow the procedures below while referring to Figure 5-36, 5-37 and 5-38.

! WARNING !

An x-ray tube can develop small punctures, and fill with SF_6 gas to an equalization pressure close to 50 psig. Most punctures occur when the tube is hot, and can seal themselves upon cooling. If this occurs, the x-ray tube remains pressurized, even after the tube head gas pressure has been released. The tube, if mishandled, can EXPLODE, and the results CAN BE FATAL. Safety glasses alone are not sufficient protection. Use suitable protection (i.e. full face shield, rubber gloves, protective apron) and exercise extreme care when inspecting a failed tube.

Step #1

Remove the tube head's coolant tubing by following the procedures outlined in section 5.4.3.1, then remove the Top Plate by following the procedures outlined in section 5.4.3.2.

Step #2

Remove the x-ray Tube Coolant Manifold from the anode by unscrewing the four brass machine screws (ensure manifold "O" Ring is undamaged). Once the manifold has been removed, slide the lead shield off the anode.

Step #3

Place the Tube Wrench around the Tube Retaining Nut. While holding the neck of the Top Plate in one hand, turn the wrench counter-clockwise to loosen the retaining nut (it may be necessary to tap the wrench with a small hammer to break the torque). When the nut is loose, the wrench can be removed and the nut may be extracted by hand.

Step #4

Hold the Top Plate in one hand, and the anode in the other. Carefully twist the x-ray Tube counter-clockwise until the tube can be extracted from the Top Plate.

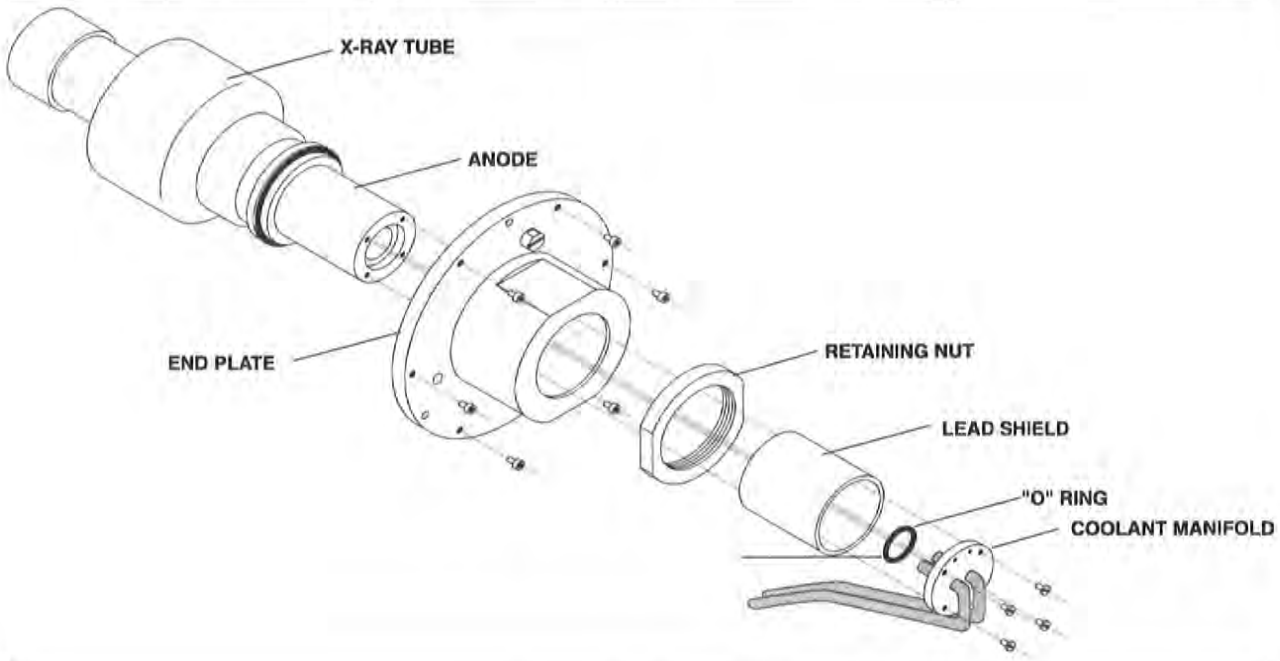


FIGURE 5-36:
X-RAY TUBE REMOVAL

Step #5

A new x-ray Tube can be inserted into the Tube Support. The x-ray Tube has an "O" ring that seals the tube to the Tube Support. Place a small amount of Silicone Grease (Dow Corning #55 or equivalent) on the "O" ring, barely coating the ring. Slide the Tube into the Top Plate until the threads protrude out the opposite side.

! NOTE!

It is standard practice to replace all seals and "O" Rings encountered during the disassembly and reassembly of the tube head. These parts may be obtained by contacting your local Hologic dealer.

Step #6

Hand tighten the Retaining Nut onto the tube's threads securing it to the Top Plate. Using the Tube Wrench, tighten the Retaining Nut until the "O" ring just seats into the back of the Top Plate.

Step #7

While holding the Top Plate in place, twist the Tube Wrench (this will turn the x-ray tube) until the Beryllium Window aligns with the scribe mark on the surface of the Top Plate. Snap a torque wrench onto the end of the Tube Wrench. Tighten the Retaining Nut to 35 ft/lbs while holding the tube's anode to ensure the x-ray tube does not move.

Step #8

Slide the lead shield onto the anode. Place a small amount of silicone grease on the "O" ring of the Coolant Manifold, then install the manifold so that the copper tubing is directed toward the side opposite the Beryllium Window.

Step #9

Using a clean cloth and alcohol, clean off any dirt, dust, or debris from the areas where the Top Plate and outer casing of the tube head will meet. Clean the x-ray tube with alcohol to remove any grease or oil that may have been left during installation. DO NOT touch the x-ray tube with bare hands after it has been cleaned.

Step #10

Place a small amount of silicone grease around the Top Plate's "O" Ring. Three round holes are machined into the outer casing of the tube head and are used to align the Beryllium Window. Insert the Top Plate into the tube head so that the Beryllium Window aligns with the center hole (the retaining screw holes should align with the threads in the outer casing).

Step #11

Insert the six retaining screws through the Top Plate and into the outer casing, giving each screw one complete turn. These screws MUST be tightened evenly, equally (one turn at a time), and in the sequence described below.

Step #12

Stand the tube head directly in front of you, with the Top Plate facing up. Rotate the entire tube head assembly so the retaining screws are located at the following clock positions: 12 o'clock, 2 o'clock, 4 o'clock, 6 o'clock, 8 o'clock, and 10 o'clock.

Step #13

Begin turning each screw one complete turn, starting with the screw at the 12 o'clock position, then proceed to the 6 o'clock position, then 10 o'clock, then 4 o'clock, then 8 o'clock, then 2 o'clock. Continue this exact pattern, giving each screw one complete turn at a time, until the Top Plate is firmly seated in the tube head (Refer to Figure 5-38).

Replace the tube head's coolant tubing by reversing the procedures outlined in section 5.4.3.1.

! CAUTION !

The tube head must be re-filled with SF_6 gas (50-55 psi @ 70°F) as instructed in Section Three of this manual before operating the unit or damage to the Tube will occur.

! CAUTION !

The proper Warm-Up Sequence for new tube as outlined in Section Two of this manual must be performed before operating this unit or damage to the Tube will occur.

! NOTE !

Use "Dow Corning #55" silicon grease or equivalent on "O" rings.

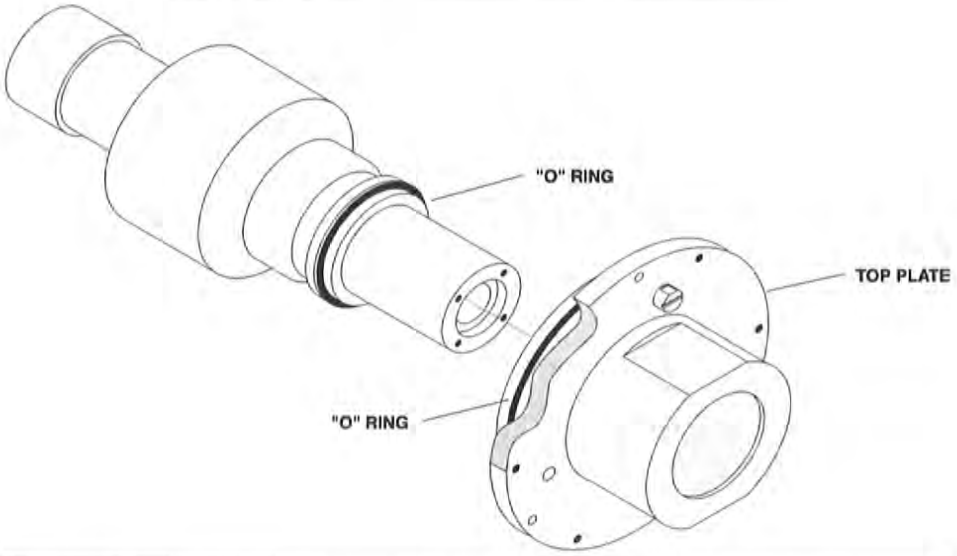


FIGURE 5-37:
X-RAY TUBE INSTALLATION

! NOTE

Follow sequence below, turning each screw one complete turn at a time to secure top plate to outer casing.

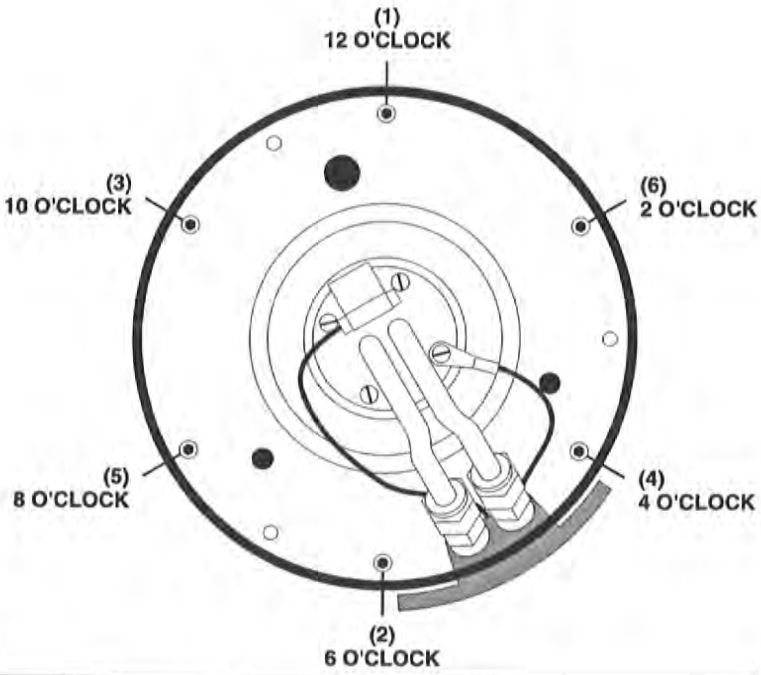


FIGURE 5-38:

TOP PLATE RETAINING SCREWS SEQUENCE OF TIGHTENING

5.4.3.4 Tube Head End Plate Removal

The High Voltage Transformer, High Voltage Multiplier, and the Filament Transformer form the High Voltage Generator. The High Voltage Generator, within the Tube Head Assembly, is attached to the x-ray tube and the End Plate. To gain access to these components, the x-ray tube and End Plate must be removed. To accomplish this, follow the procedures below while referring to Figure 5-39. Step #1

Step #1

Remove the tube head's coolant tubing by following the procedures outlined in section 5.4.3.1, then remove the Top Plate by following the procedures outlined in section 5.4.3.2.

> **! CAUTION !**
>
> The Top Plate MUST be removed before removing the End Plate to prevent damage to the x-ray tube.

Step #2

Remove the Safety Stud from the End Plate, then remove the Retaining Ring by unscrewing the securing screws from the End Plate. This allows access to the End Plate's retaining screws.

Step #3

Remove the ground wire from the End Plate, then remove the Thermal Cutout Sensor from the anode as outlined in section 5.4.3.2.

Step #4

Remove the six screws securing the End Plate to the outer casing. Insert three #6-32x1" socket head screws into the threaded holes around the End Plate. These screws will be used as "jacks" to help remove the End Plate from the tube head.

Step #5

Turn each "jack" screw evenly and equally (approximately one complete turn at a time) until the End Plate can be lifted from the tube head. Once the End Plate has been extracted, remove the "jack" screws.

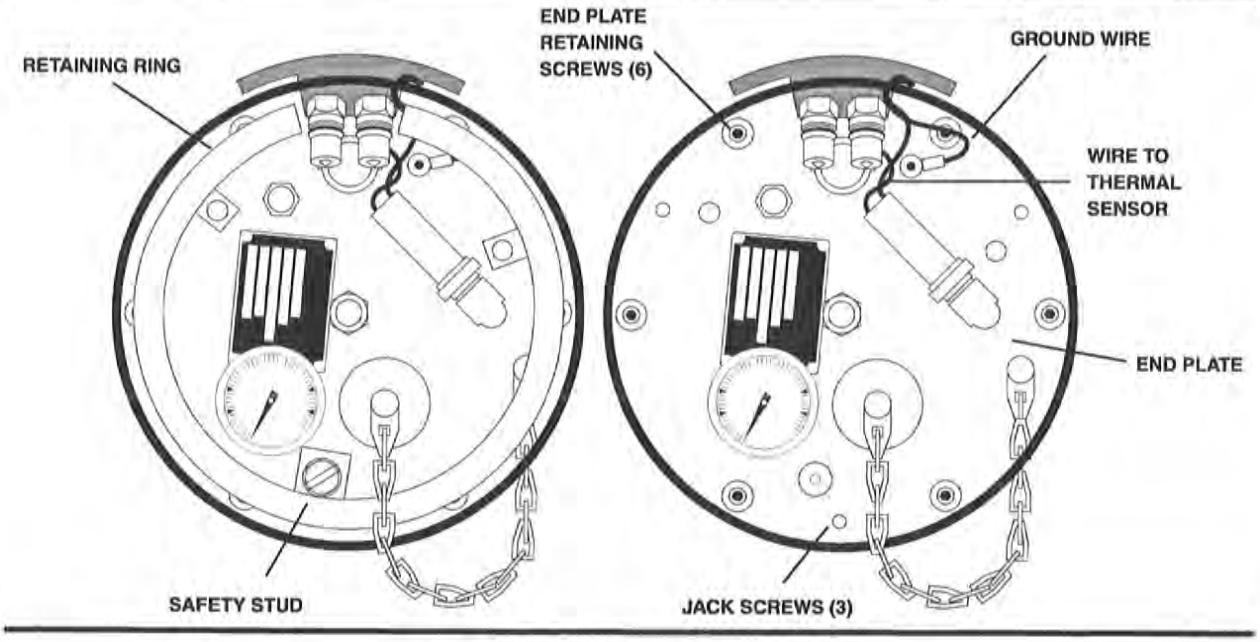


FIGURE 5-39:

TUBE HEAD END PLATE REMOVAL

5.4.3.5 High Voltage Multiplier/Filament Transformer Assembly Removal

The High Voltage Multiplier/Filament Transformer Assembly (known as the "stack") is connected to a mount located on the End Plate. Removal of this assembly requires the use of a soldering iron. To remove the High Voltage Multiplier/Filament Transformer, follow the procedures below while referring to Figure 5-40.

Step #1

Remove the tube head's coolant tubing by following the procedures outlined in section 5.4.3.1, then remove the Top Plate by following the procedures outlined in section 5.4.3.2. Remove the End Plate as outlined in section 5.4.3.4.

> **! CAUTION !**
>
> The Top Plate MUST be removed before removing the End Plate to prevent damage to the x-ray tube.

Step #2

Detach the two shielded cables from the contacts on the inside of the Tube Socket. Remove the feedback wire secured to the outside of the Tube Socket. Remove the Tube Socket by unscrewing the five button head screws securing it to the High Voltage Multiplier/Filament Transformer Assembly.

Step #3

Two high voltage leads (black wires) from the High Voltage Transformer are attached to connectors on the bottom of the High Voltage Multiplier. Using a soldering iron, remove these two leads from their connectors. Care must be taken so that solder is not dropped onto the Transformer.

Step #4

Located on one side of the High Voltage Transformer is a small circuit board (kV/mA Sense). Unsolder the wire from pin #7, and the top wire from pin #5. (! NOTE ! There are two pins designated as #5. Unsolder only the wire leading to the High Voltage Multiplier.)

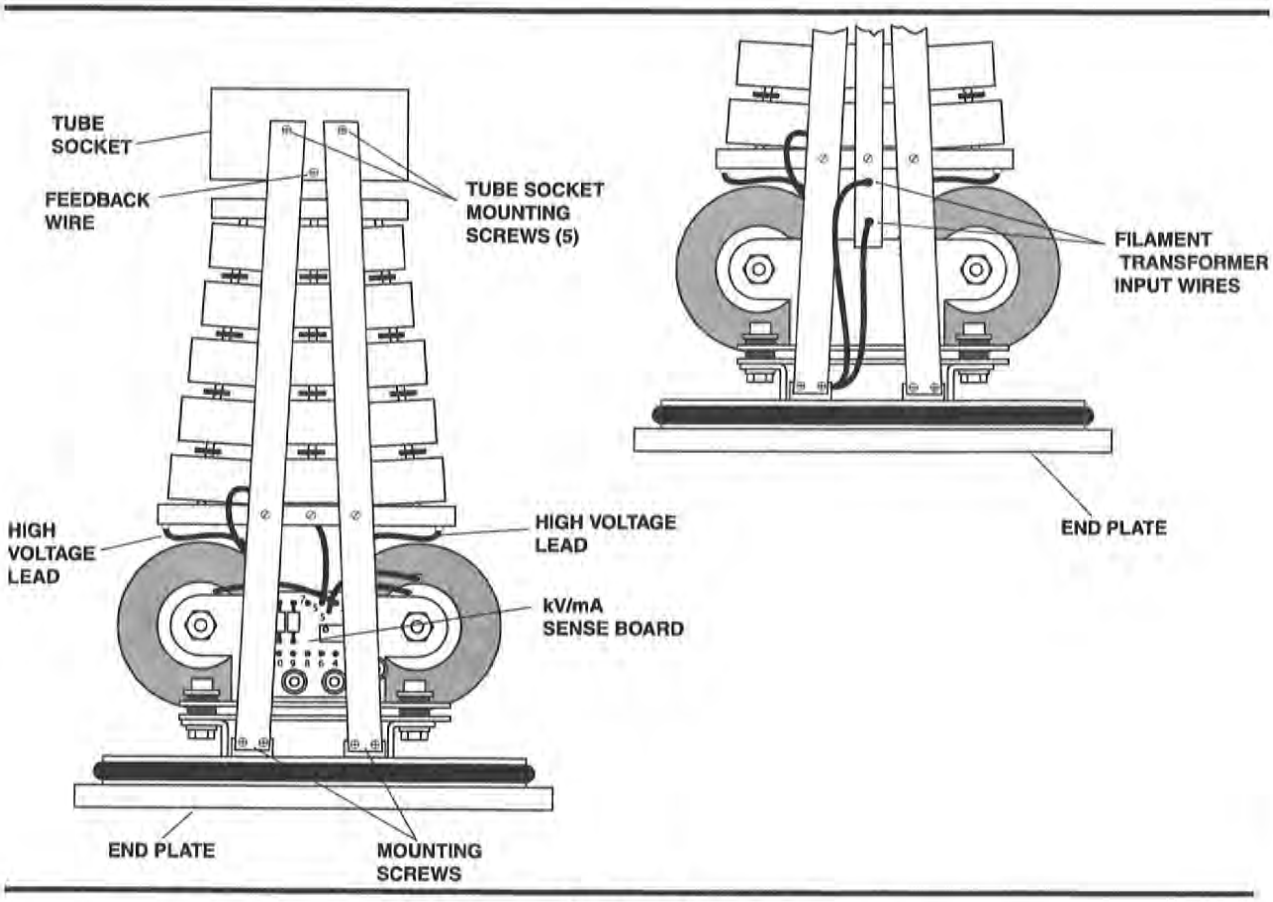


FIGURE 5-40:

HIGH VOLTAGE MULTIPLIER/FILAMENT TRANSFORMER REMOVAL

Step #5

Located on the Filament Transformer (opposite side of the kV/mA Sense Board) are the Filament Transformer input wires. Unsolder these wires from their pins. (! NOTE ! Input to the Transformer is an A.C. voltage, therefore the two leads are interchangeable.)

Step #6

Unscrew the eight button head screws from the mounting brackets securing the High Voltage Multiplier/Filament Transformer to the End Plate. Lift the entire assembly off of the mounts. Repair and replace as necessary, then reverse these procedures to install the assembly.

5.4.3.6 High Voltage Transformer Removal

The High Voltage Transformer is located beneath the Multiplier/Filament Transformer assembly, and is attached to the End Plate by shock absorbent mounting brackets. To remove the High Voltage Transformer follow the procedures below while referring to Figure 5-41.

Step #1

Remove the tube head's coolant tubing by following the procedures outlined in section 5.4.3.1, then remove the Top Plate by following the procedures outlined in section 5.4.3.2. Next, remove the End Plate as outlined in section 5.4.3.4, and finally, remove the High Voltage Multiplier/Filament Transformer assembly as outlined in section 5.4.3.5.

! CAUTION !

The Top Plate MUST be removed before removing the End Plate to prevent damage to the x-ray tube.

Step #2

Unsolder the wires from Pin #2, Pin #4, Pin #6, Pin #8, Pin #9, and Pin #10 of the Sense Board. Note the location of each wire.

Step #3

Disconnect the four mounting bolts (attached with hex nuts) securing the High Voltage Transformer to the shock absorbent mounts. Lift the Transformer off of the End Plate and set the shock mounts aside.

Step #4

Replace as necessary, then reverse these procedures to re-install.

! NOTE !

Competent High Voltage service practices must be followed. All parts must be kept meticulously clean and dry. After assembly, all parts must be washed with alcohol and kept dust free. All parts must not be touched after final wash.

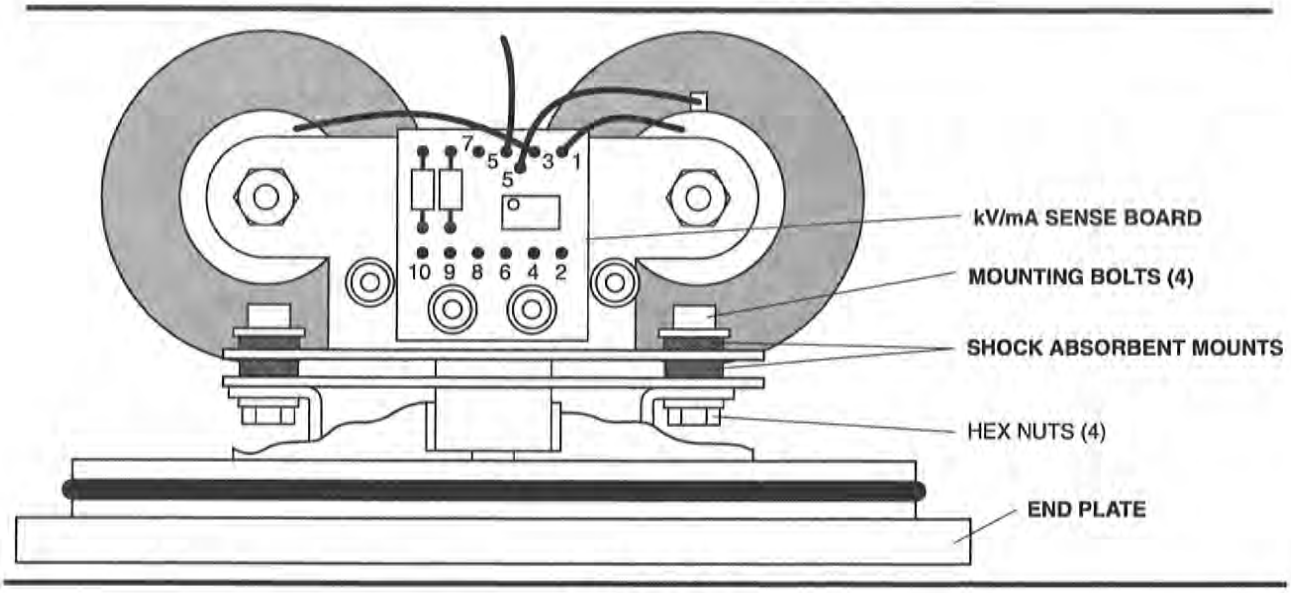


FIGURE 5-41:

HIGH VOLTAGE TRANSFORMER REMOVAL

5.4.3.7 Installing the End Plate

To install the End Plate back into the Tube Head Assembly, follow the procedures below while referring to the appropriate illustrations.

Step #1

Place a small amount of silicone grease around the End Plate's "O" ring. Three round holes are machined into the outer casing of the tube head and are used to align the scribe mark on the End Plate. Insert the End Plate into the tube head so that the scribe mark aligns with the center hole (the retaining screw holes should align with the threads in the outer casing).

Step #2

Insert the six retaining screws through the End Plate and into the outer casing, giving each screw one complete turn. These screws MUST be tightened evenly, equally (one turn at a time), and in the sequence described below.

Step #3

Stand the tube head directly in front of you, with the End Plate facing up. Align scribe marks on tube housing and end plate. Rotate the entire tube head assembly so the retaining screws are located at the following clock positions: 12 o'clock, 2 o'clock, 4 o'clock, 6 o'clock, 8 o'clock, and 10 o'clock.

Step #4

Begin turning each screw one complete turn, starting with the screw at the 12 o'clock position, then proceed to the 6 o'clock position, then 10 o'clock, then 4 o'clock, then 8 o'clock, then 2 o'clock. Continue this exact pattern, giving each screw one complete turn at a time, until the End Plate is firmly seated in the tube head (Refer to Figure 5-39).

Step #5

Insert the Top Plate by reversing the procedures outlined in section 5.4.3.3, then install the tube head's coolant tubing by reversing the procedures outlined in section 5.4.3.1. Ensure the Thermal Cutout Sensor and the ground wire are installed properly.

! CAUTION !

The tube head must be re-filled with SF_6 gas (50-55 psi @ 70°F) as instructed in Section Three of this manual before operating the unit or damage to the Tube will occur.

! CAUTION !

The proper Warm-Up Sequence for new tube as outlined in Section Two of this manual must be performed before operating this unit or damage to the Tube will occur.

5.5 TROUBLESHOOTING

The information contained in the following chart is to be used as a guide in troubleshooting problems that might occur with the LPX-160. To resolve the problem perform the action indicated.

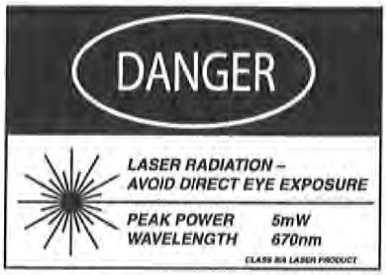
PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION	SECTION
1. Circuit breaker CB 101 disengages immediately upon activation.	a. Defective breaker.	a. Replace breaker.	section 5.4.1.1
2. Circuit breaker CB 101 disengages approximately 2 seconds after activation.	a. C201/C202 defective. b. Low voltage power supply defective. c. Cooler motor defective. d. Cooler cable defective.	a. Replace C201/C202. b. Test low voltage power supply. Repair/Replace. c. Replace motor. d. Replace cable.	section 5.4.1.8, section 5.3.3.4 section 5.4.1.6 section 5.4.2.2 ------
3. Green MAINS lamp lights immediately after circuit breaker is switched on. No 2 second delay encountered.	a. Electronic delay relay K201 defective.	a. Replace K201.	section 5.2.2.1
4. Green MAINS lamp does not light.	a. MAINS lamp defective.	a. Replace lamp.	section 5.4.1.5
5. Green MAINS lamp lights approximately 2 second after circuit breaker activation. Fan does not turn on.	a. Fan defective.	a. Replace fan.	section 5.4.2.2 (1)(2)
6. Incomplete, incorrect, or missing information on LCD displays.	a. Display defective. b. Microcomputer board defective.	a. Replace display. b. Test microcomputer board. Repair/replace.	section 5.4.1.2 section 5.3.5.3, section 5.4.1.2
7. LCD backlight not lighted.	a. Microcomputer board defective.	a. Test microcomputer board. Repair/replace.	section 5.3.5.3, section 5.4.1.2
8. No indicated kV or mA. X-ray lamp does not illuminate.	a. Microcomputer board defective. b. Safety switch defective.	a. Test board. Repair/Replace b. Replace safety switch.	section 5.4.1.2, section 5.4.1.3
9. No indicated kV or mA. X-ray ON lamp lights.	a. kV board defective. b. D201 defective. c. Tube Head high voltage generator defective.	a. Test boards. Repair/Replace. b. Replace D201. c. Test H.V. Generator.	section 5.2.2, section 5.3.1, section 5.3.2 section 5.3.8

PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION	SECTION
10. kV indicated. No mA indication.	a. mA board defective. b. Tube Head high voltage generator defective. c. X-ray tube filament open. d. Tube Head cable defective. e. Microcomputer board defective.	a. Test mA board. b. Test high voltage generator. c. Measure low resistance between x-ray tube cathode contacts (good filament less than 4 ohms). If open replace tube. d. Replace cable. e. Replace board.	section 5.3.2 section 5.3.8 section 5.3.8.2 ------- section 5.4.1.2
11. mA indicated. No kV indicated. X-ray ON lamp stays lit.	a. Defective kV board. b. Microcomputer board defective.	a. Test kV board. Repair/ Replace. b. Test board. Repair/replace.	section 5.3.1 section 5.4.1.6, section 5.3.6.3 section 5.4.1.2
12. High mA indicated. No kV indicated. X-ray ON lamp extinguishes almost immediately after lighting.	a. Defective kV board. b. X-ray tube defective.	a. Test kV board. Repair/ Replace. b. Replace x-ray tube.	section 5.3.1 section 5.4.1.6 section 5.4.3.3
13. No kV or mA indication. X-ray ON lamp extinguishes almost immediately after lighting.	a. Defective kV board. b. Tube Head cable defective. c. Tube Head high voltage generator defective.	a. Test kV board. Repair/ Replace. b. Replace cable. c. Test high voltage generator.	section 5.3.1 section 5.4.1.6 ------ section 5.3.8
14. Circuit breaker CB 101 disengages upon pressing the x-ray ON button	a. kV or mA boards defective.	a. Test kV and mA boards. Replace/Repair.	section 5.3.1 section 5.3.2 section 5.4.1.6
15. Green MAINS lamp lights approximately 2 seconds after circuit breaker CB 101 is engaged but cooler motor does not run.	a. Cooler cable defective. b. Cooler motor defective.	a. Replace cable. b. Replace motor.	-------- section 5.4.2.2

CHAPTER SIX: THE LASER POINTER DEVICE

6.1 DESCRIPTION

The LaserPointer (P/N: 3-000A-0792, NSN: 5860-01-378-6472) is a sighting device which when mounted on the LPX-160 Tube Head, locates the centerline of the emitted x-ray beam. The laser assembly contains a Class IIIA laser module and mounts to the x-ray tube window by a spring encircling the x-ray tube anode. Power is supplied by three AAA batteries in the laser assembly.



6.2 SPECIFICATIONS

Laser Type:	Visible laser diode
Out Power:	5mW maximum continuous
Laser Classification:	Class IIIA
Beam Color:	Deep red
Beam Accuracy:	Within 0.5° perpendicular to x-ray tube window
Battery Life:	Approximately 4.5 hour continuous
Operating Time Without Restarting:	30 seconds (±5 seconds)

6.3 DESCRIPTION OF CONTROLS AND INDICATORS

6.3.1 OFF - ON Switch:

This two position toggle switch connects the battery to the laser power/timing circuits in the battery pack.

It does not activate the laser but must be in the ON position in order for the laser to operate. Placing the switch in the OFF position while the laser is on abruptly terminates laser emission.

6.3.2 START

This momentary push button switch activates laser emission. Laser emission automatically ceases after approximately 30 seconds.

6.3.3 LASER ON:

This light emitting diode glows red whenever laser light is being emitted.

! WARNING !

Laser light is dangerous. Avoid exposure and direct eye contact.

6.4 OPERATION

Step #1

Make sure the MAINS switch on the LPX-160 Control Unit is in the OFF position before approaching the Tube Head.

Step #2

Mount the laser assembly on the Tube Head by placing the bottom end of the laser assembly against the x-ray tube window and stretching the spring over and around the tube anode. Make sure the end of the laser assembly is flat against the tube window.

Step #3

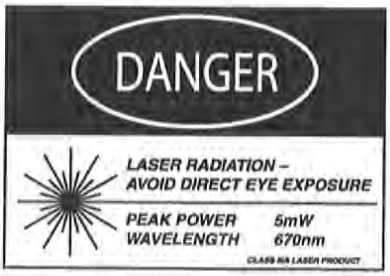
Point the Tube Head window at the object being radiographed.

Step #4

Turn the LaserPointer OFF - ON switch to the ON position.

Step #5

Press the START switch. The laser will start emitting light for a 30-second time period. At the end of that time it will stop automatically.



Step #6

Adjust the Tube Head position so that the laser spot is on the place at which the x-rays must enter the test object. If necessary, restart laser emission by again pressing the START button.

Step #7

Once the Tube Head is positioned properly, place the OFF - ON switch to the OFF position and remove the LaserPointer from the Tube Head.

6.5 MAINTENANCE

Step #1

Battery Replacement: If the LaserPointer fails to operate, the most likely cause is dead batteries.

Step #2

Remove the two screws holding the cover on the laser assembly.

Step #3

Gently remove the old batteries by prying them from the connector snaps and then out of the holder.

Step #4

Press the new batteries into place, making sure the contacts mate properly with those on the battery holder.

Step #5

Replace the laser assembly cover.

Step #6

If a new batteries fail to make the LaserPointer operational, return the LaserPointer to the factory for repair.

CHAPTER SEVEN: ILLUSTRATED PARTS BREAKDOWN

7.1 IDENTIFICATION OF EQUIPMENT

This Illustrated Parts Breakdown lists, illustrates and describes the parts for the LPX-160 Industrial X-Ray System, manufactured by Hologic Industrial Imaging Incorporated, Danbury, Connecticut.

7.2 GROUP ASSEMBLY PARTS LIST

This section consists of the number of separate lists required to breakdown all equipment covered in this publication into assemblies, subassemblies and detail parts.

The Group Assembly Parts List breaks the equipment down into its major assemblies. An illustration accompanies each list with index numbers assigned to each part or group of parts; these index numbers also appear in the list so that parts may be readily located and identified. Additional lists with appropriate illustrations break the major assemblies into subassemblies and detail parts.

Parts are not exploded in the illustration of those assemblies and installations for which there is no particular sequence of disassembly, and on which complete disassembly would not be performed. On these illustrations and lists, a single index number is often used to identify both a detail part and its attaching parts where their location is obvious.

7.3 USE OF THE ILLUSTRATED PARTS BREAKDOWN

The purpose of the Illustrated Parts Breakdown is to aid the user of this equipment when procurement, replacement, disassembly, or assembly of parts becomes necessary. Section Seven divides the LPX-160 into fifteen (15) subassemblies. When searching for a part number, refer to the subassembly that the part belongs to. Examine the illustration until the part is found and note the index number. Refer to the list preceding the illustration for description and part number.

Table 7-1: Assembly, Front Panel Control - Digital

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1,2	3-670A-0068	ODTG5	Panel, Control - Digital	1
2/1,2	3-000A-0044	ODTG5	Assembly, LCD Display - 2x24	1
3/1	3-000A-0046	ODTG5	Assembly, LCD Display - 2x40	1
4/1,2	1-003A-4027	ODTG5	Assembly, Microcomputer Board	1
5/1	1-040A-0387	ODTG5	Assembly, Flat Cable (F.P.)	2
6/1	1-040A-0381	ODTG5	Assembly, Harness - Front Panel (Digital)	1
7/1	1-003A-4022	ODTG5	Assembly, LED Lightbar Board	2
9/1	JA2S-Z501-2	74193	Circuit Breaker (1-070A-0024) (ODTG5)	1
10/1	HLMP-2685	28480	LED Lightbar - Red (1-404A-3015) (ODTG5)	1
11/1	HLMP-2885	28480	LED Lightbar - Yellow (1-404A-3024) (ODTG5)	1
13/1	2899	28480	Panel Mount, Snap-In (2-605A-0031) (ODTG5)	2
14/1	AML27ABK2BC01AB	91929	Switch, Keylock (1-700A-0076) (ODTG5)	1
15/1	76-9450/4044/R	04426	Switch, Mushroom (1-700A-0060) (ODTG5)	1
17/1	AML21BBA2BA	91929	Switch, SPDT (1-700A-0075) (ODTG5)	11
18/1	AML51C10K	91929	Pushbutton Cap - Black (1-700A-5001) (ODTG5)	2
19/1	3-102A-0068	ODTG5	Pushbutton Cap w/Legend (Radiation)	1
20/1	3-102A-0069	ODTG5	Pushbutton Cap w/Legend (Time/mAs)	1
21/1	3-102A-0070	ODTG5	Pushbutton Cap w/Legend (Elapsed/Remains)	1
22/1	3-102A-0071	ODTG5	Pushbutton Cap w/Legend (D)	6
31/1,2	2-570A-2009	NONE	Flat Washer, #4 - 0.062 THK (Nylon)	8
32/1,2	2-480A-0400	NONE	Standoff, 1/4 Hex - 7/8 LG (4-40)	2
33/1	2-480A-0401	NONE	Standoff, 1/4 Hex - 1.00 LG (4-40)	4
35/1,2	2-500A-6201	NONE	Screw, Button Head - 4-40 x 1/4 LG	14
36/1	2-570A-1060	NONE	Lock Washer, #4 - EXT TTH	22
37/1	2-380A-0023	NONE	Hex Nut, 4-40	22
38/1	2-500A-0531	NONE	Screw, FL Socket Head - 6-32 x 3/8	4
39/1,2	2-251A-0015	NONE	Handle	2
40/1,2	514	91833	Screw, Flat Head - 8-32 x 3/8 (2-500A-0641) (ODTG5)	4
42/1,2	2-580A-0525	NONE	Loctite 222	A/R
44/1,2	2-500A-9538	NONE	Screw, Captive - 8-32 x 3/4	2
45/1	2-570A-2041	NONE	Washer, Nylon - #8	2
46/1,2	2-380A-0605	NONE	Hex Nut, Nylon - 8-32	2
48/1	2-570A-1064	NONE	Lock Washer, #10 - EXT TH	1
49/1	2-380A-0088	NONE	Hex Nut, 10-32	1
50	3-160-0052	0DTG5	Assembly, Harness Shield	1

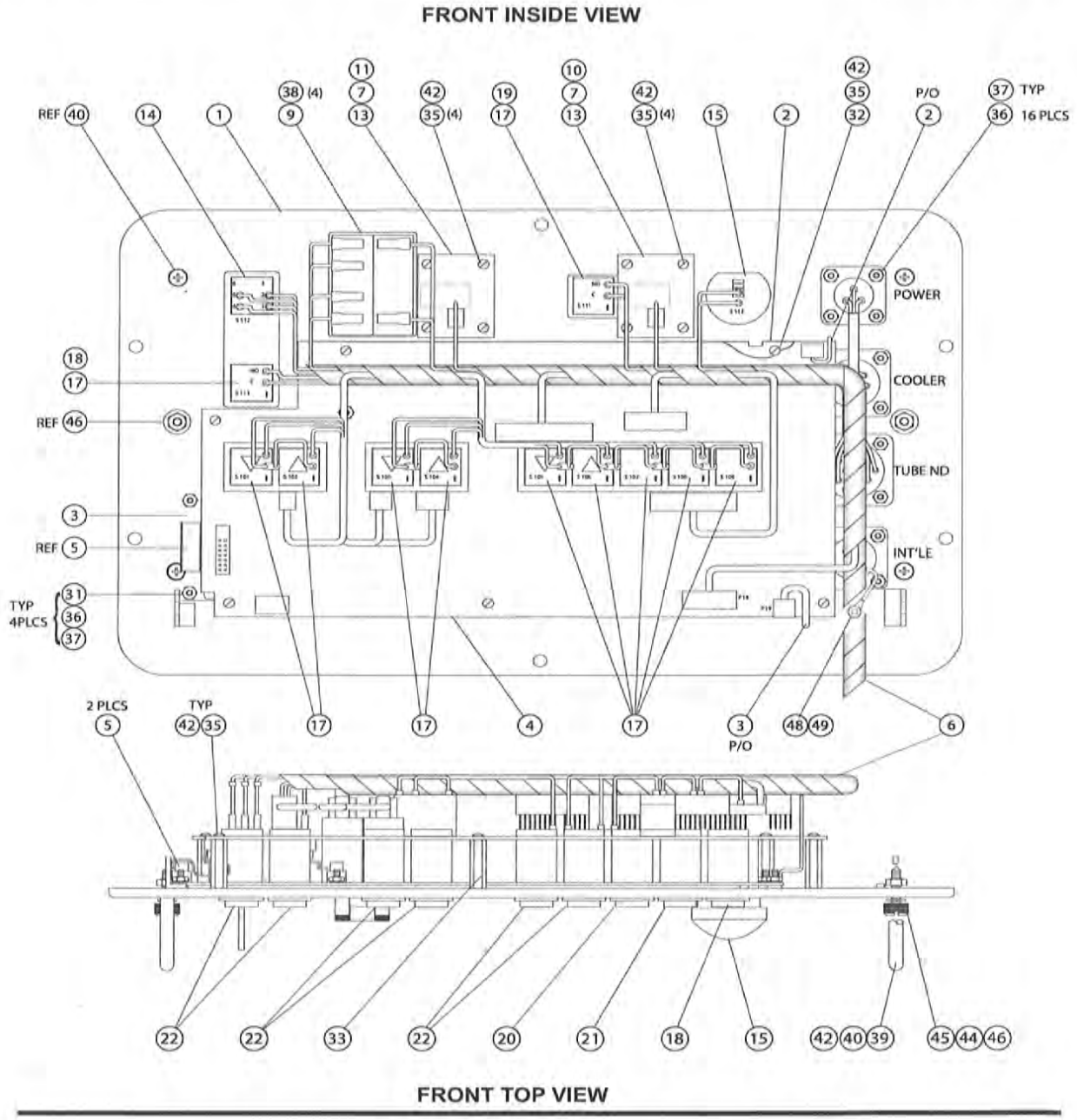


FIGURE 7-1:

ASSEMBLY, FRONT PANEL CONTROL - (SHEET 1 OF 2)

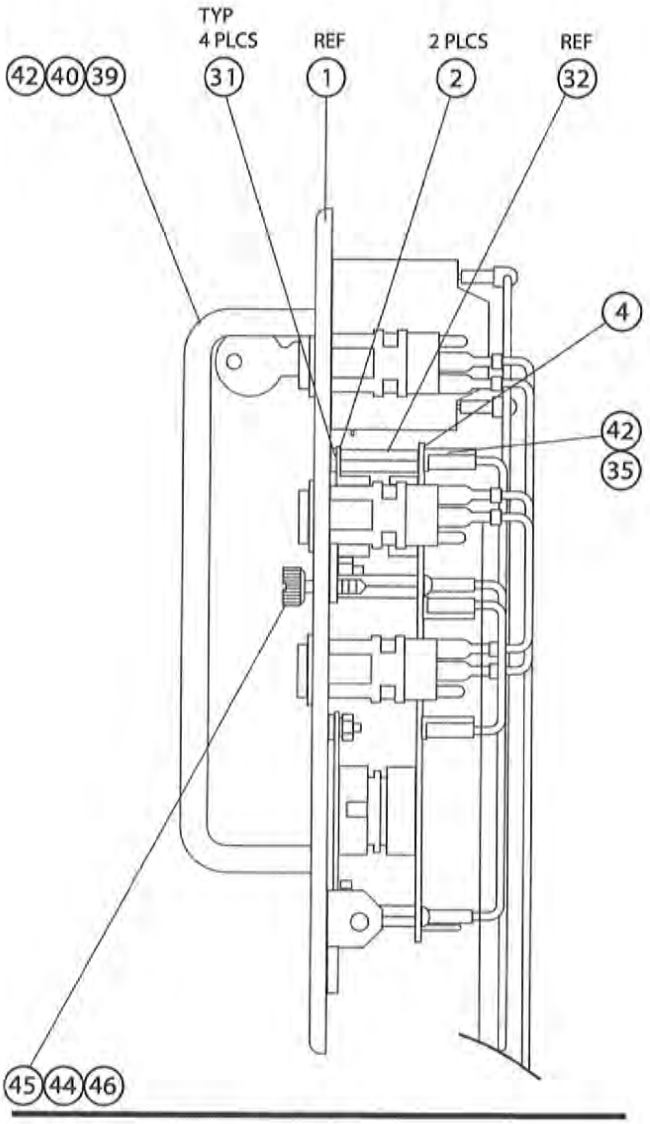


FIGURE 7-1:
ASSEMBLY, FRONT PANEL CONTROL (SHEET 2 OF 2)

Table 7-2: Assembly, Chassis Control

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-660A-0017	ODTG5	Chassis	1
2/1	3-605A-0519	ODTG5	Mount, Bar - Chassis	2
3/1	3-000A-0763	ODTG5	Assembly, Fan	1
4/1	36DY522F200CC2A	80183	Capacitor, 5200µf -200 VDC (1-300A-0019) (ODTG5)	2
5/1	4586-1	80183	Cap, Mounting Bracket (1-090A-0078) (ODTG5)	2
6/1	VPR-20H-20K	80353	Resistor, 20k-20 watts (1-103A-0002) (ODTG5)	2
7/1	KBPC35-10	1 AA44	Diode Bridge (1-401 A-0007) (ODTG5)	1
8/1	3-000-0733	ODTG5	Relay, Time Delay (1-461-0041)(ODTG5)	1
9/1	1-003A-4024	ODTG5	Assembly, Mother Board	1
10/1	1-003A-4012	ODTG5	Assembly, Low Voltage Power Supply	1
11/1	1-003A-4011	ODTG5	Assembly, kV Board	1
12/1	1-003A-4010	ODTG5	Assembly, mA Board	1
14/1	3-000A-0784	ODTG5	Assembly, Transformer	1
15/1	3-000A-0786	ODTG5	Assembly, Storage Inductor	1
17/1	3-680A-0061	ODTG5	Arm, Hinge - Left Hand Side	1
18/1	3-680A-0062	ODTG5	Arm, Hinge - Right Hand Side	1
19/1	51081	5P059	Isolation Mount (2-605A-0029) (ODTG5)	6
22/1	2-500A-0622	NONE	Screw, F. H. 82° - #6-32 x 3/8	12
23/1	LOCTITE#222	05972	Loctite, 222 (2-580A-0525) (ODTG5)	A/R
24/1	2-500A-5223	NONE	Screw, P.H. - #6-32 x 3/8	10
25/1	2-570A-1062	NONE	Lock Washer - #6 EXT TH	8
26/1	2-570A-1631	NONE	Flat Washer - #6	1
27/1	2-570A-1604	NONE	Lock Washer - #6 I NT TH	1
28/1	2-380A-0025	NONE	Hex Nut - #6-32	3
29/1	2-500A-5242	NONE	Screw, P.H. - #8-32 x 5/16" LG	2
31/1	2-570A-1060	NONE	Lock Washer - #4 EXT TH	2
32/1	2-380A-0023	NONE	Hex Nut - #4-40	2
33/1	2-500A-5245	NONE	Screw, P.H. - #8-32 x 1/2" LG	2
34/1	2-500A-5243	NONE	Screw, P. H. - #8-32 x 3/8	4
35/1	2-570A-1632	NONE	Flat Washer - #8	16
36/1	2-570A-1703	NONE	Lock Washer - #8 Split	4
37/1	2-570A-1063	NONE	Lock Washer - #8 EXT TH	16
38/1	2-380A-0026	NONE	Hex Nut - #8-32	14
39/1	2-570A-1064	NONE	Lock Washer - #10 EXT TH	1
40/1	2-500A-5263	NONE	Screw, P. H. - #10-32 x 3/8	4
41/1	2-570A-1633	NONE	Flat Washer - #10	4
42/1	1-091A-0010	NONE	Solder Lug - #10	4
43/1	2-380A-0088	NONE	Hex Nut - #10-32	1
44/1	2-570A-2010	NONE	Washer - #8 Nylon	8
45/1	2-380A-1104	NONE	Lock Nut - #8-32	4
47/1	2-580A-0307	NONE	Thermal Compound	A/R
50/1	1-090A-0011	NONE	Cable Tie - 4" LG.	A/R
52/1	1-040A-0097	ODTG5	Assembly, Harness - Control Chassis	1
55/1	SERIES E24	23783	Resistor, Carb Film - 200k, 1/4 watt, 5% (1-102A-0204)	1
56/1	D62V103M1 KY(0.01)	91984	Capacitor, Ceramic -0.01 MF, ±20% (1-202A-0004) (ODTG5)	1
57/1	1-061A-1006	NONE	Tubing, Teflon	A/R
58/1	1-003-4023	ODTG5	Assembly, Conditioning Board	1

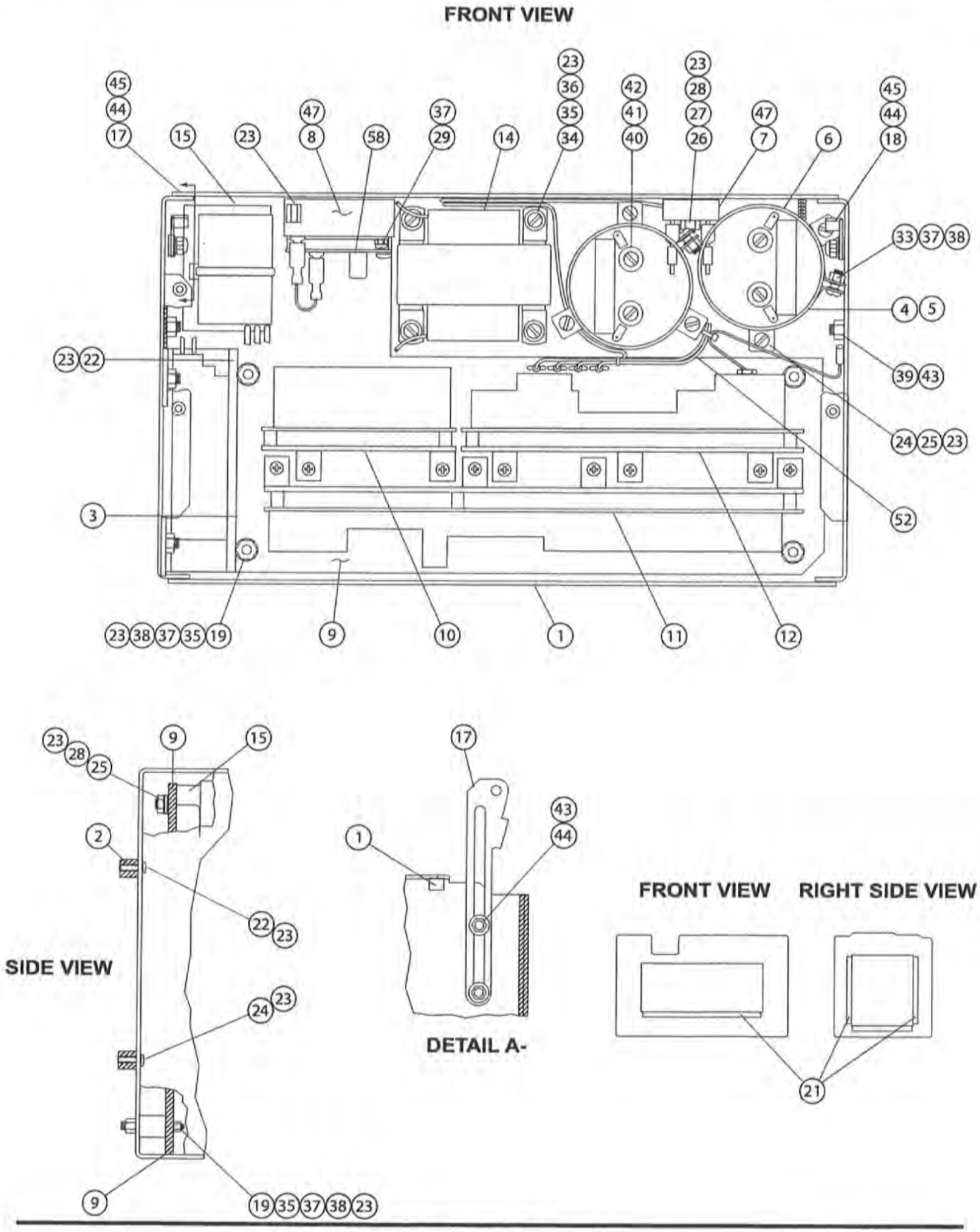


FIGURE 7-2:
ASSEMBLY, CHASSIS CONTROL (SHEET 1 OF 1)

Table 7-3: Assembly, Tube Head

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-000A-0740	ODTG5	Assembly, Tube and Lead Shield	1
2/1	3-000A-0787	ODTG5	Assembly, X-ray Tube	1
3/1	3-000A-0746	ODTG5	Assembly, High Voltage Power Supply	1
4/1	3-000A-0788	ODTG5	Assembly, Manifold and Flat Tubes	1
6/2	3-31 0A-0287	ODTG5	Label, Nameplate-Compliance (Small)	1
7/2	2-500A-1000	NONE	Screw, Button S. H. - #4-40 x 1/4" LG	4
8/1,2	3-160A-0038	ODTG5	Ring, Safety	2
9/1	3-620A-0253	ODTG5	Cover, Manifold and Flat Tube	1
10/1	2-500A-1020	NONE	Screw, Button S.H. - #6-32 x 1/4	2
11/1	2-570A-1604	NONE	Lock Washer, INT TH - #6	2
12/1	3-550A-0004	ODTG5	Pipe Fitting, Nipple - 1/8 NPT	2
13/1	2-550A-0005	NONE	Pipe Fitting, Coupling	2
14/1	2-580A-1111	NONE	Pipe Sealing Tape	A/
16/1	2-500A-1062	NONE	Screw, Button S. H. - #10-32 x 1/2	4
19/2	2-500A-0318	NONE	Screw, Socket Head Cap - #10-32 x 5/8	12
20/1,2	2-570A-1704	NONE	Lock Washer, Split - #10	16
21/2	2-500A-0297	NONE	Screw, Socket Head Cap - #8-32 x 3/8	4
22/2	2-570A-1703	NONE	Lock Washer, Split - #8	4
23/2	1-090A-0011	NONE	TYRAP, Cable	A/
24/2	2-570A-1633	NONE	Washer, Flat - #10	12

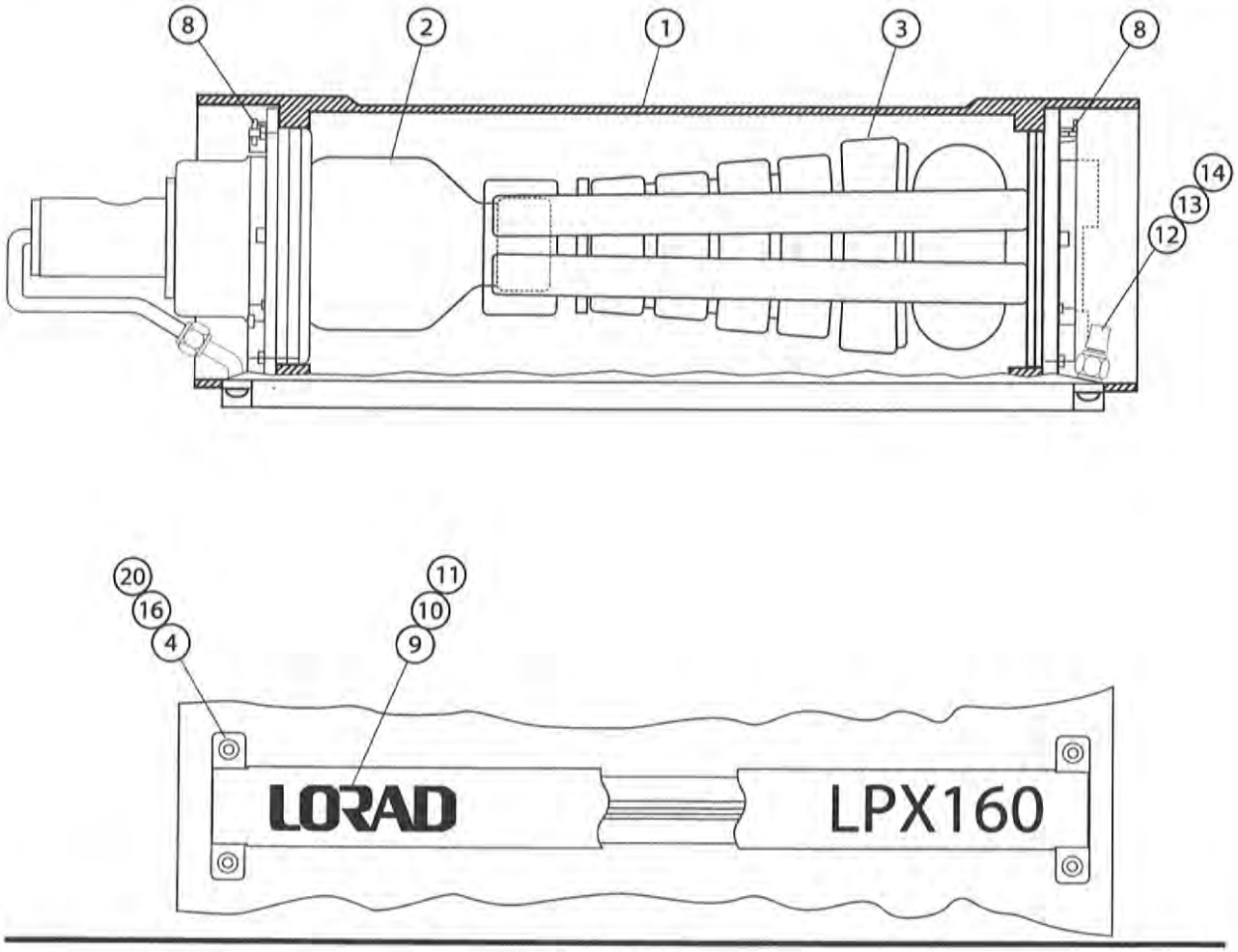


FIGURE 7-3:

ASSEMBLY, TUBE HEAD (SHEET 1 OF 2)

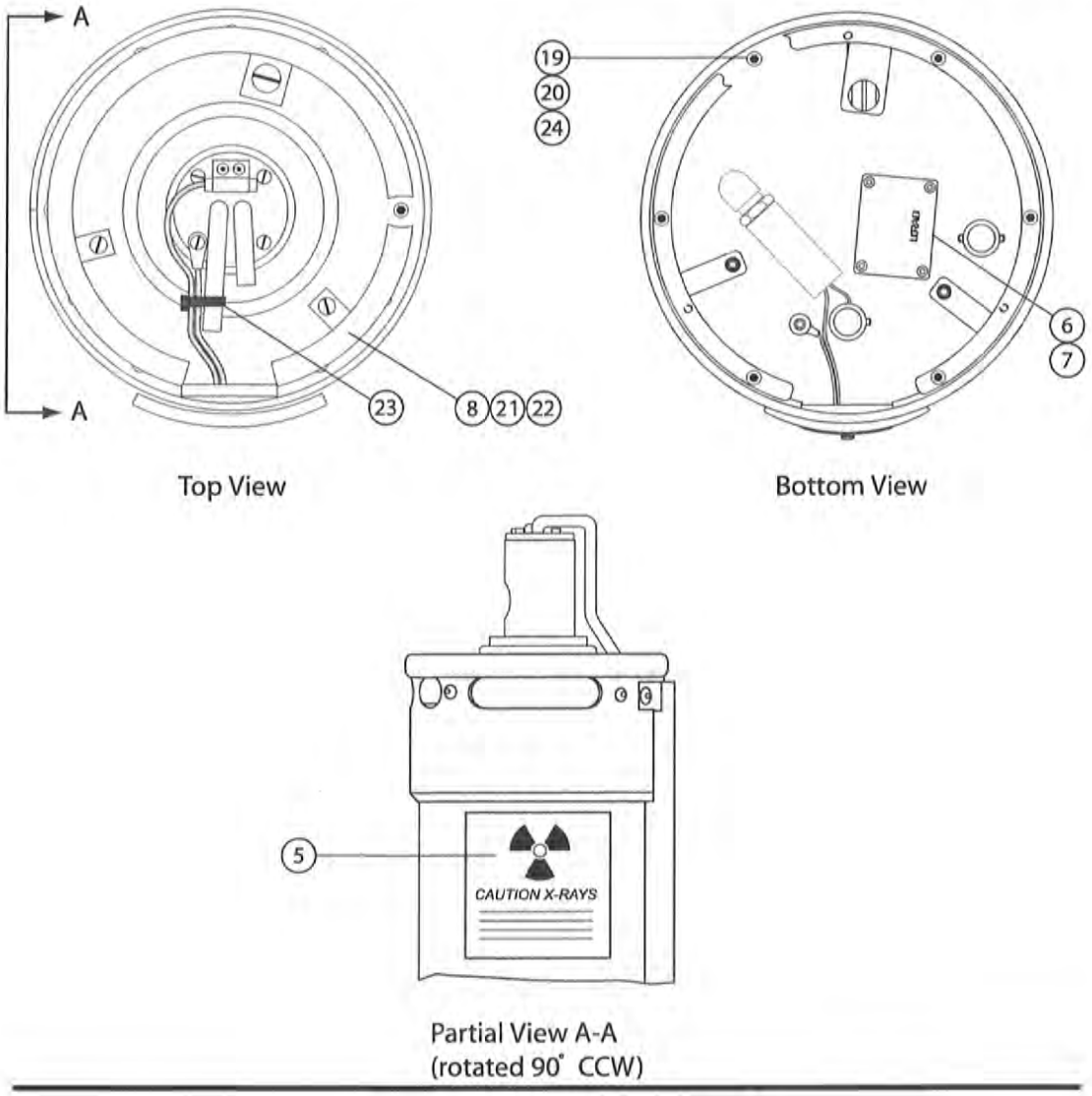


FIGURE 7-3:

ASSEMBLY, TUBE HEAD (SHEET 2 OF 2)

TABLE 7-4: ASSEMBLY, MANIFOLD AND FLAT TUBES

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-645A-0065	ODTG5	Weldment, Manifold and Flat Tubes	1
2/1	5211K53	5T847	Pipe Fitting, Elbow - 45° (2-550A-0003) (ODTG5)	2
4/1	2-580A-1111	NONE	Pipe Sealing Tape	A/R

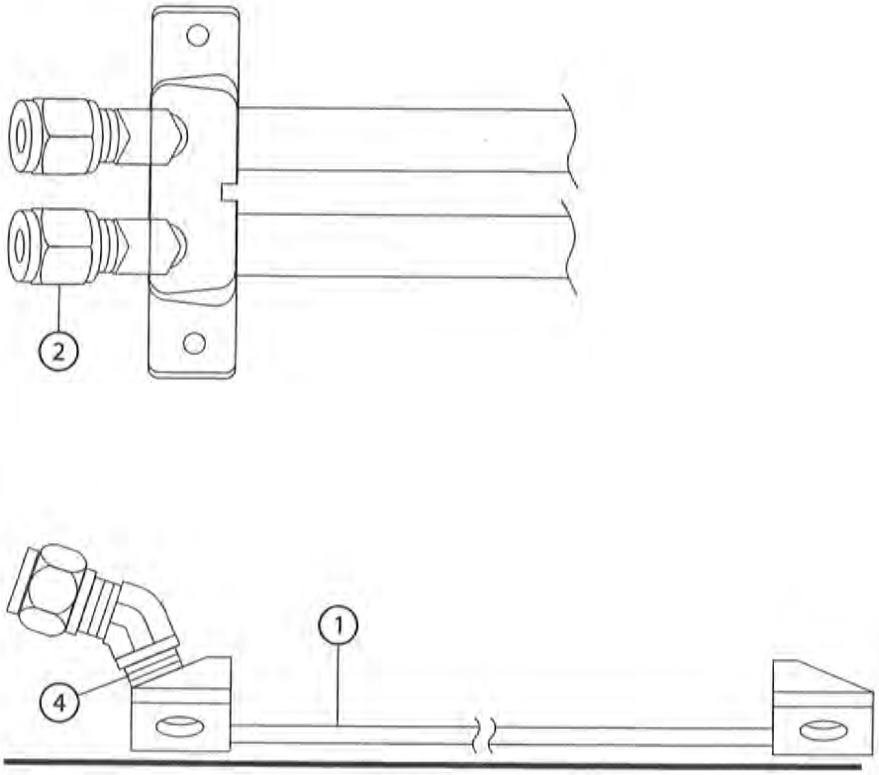


FIGURE 7-4:

ASSEMBLY, MANIFOLD AND FLAT TUBES (SHEET 1 OF 1)

Table 7-5: Assembly, X-Ray Tube

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-605A-0520	ODTG5	Support, X-ray Tube	1
2/1	3-405A-5125	ODTG5	Shield, X-ray Port	1
3/1	3-530A-0011	ODTG5	Safety Stud	1
4/1	3-380A-0010	ODTG5	Safety Nut	1
5/1	3-152A-0031	ODTG5	Clamp, Thermostat	1
7/1	.063 BERYLLIUM WINDOW	NONE	X-ray Tube (2-425A-0017) (ODTG5)	1
9/1	ARP568-011 EP70	07060	"0" Ring (2-390A-0008) (ODTG5)	1
10/1	ARP568-160EP70	07060	"0" Ring (2-390A-0009) (ODTG5)	1
12/1	2-500A-1020	NONE	Screw, Button S. H. - #6-32 x 1/4" LG	2
13/1	2-570A-1604	NONE	Lock Washer - #6 I NT TH, S.S.	2
15/1	MOLYKOTE #55	5D028	Lubricant, Molykote #55 (2-580A-0206) (ODTG5)	A/R
16/1	LOCTITE#242	05972	Adhesive, Loctite - #242 (Blue) (2-580A-0506) (ODTG5)	A/R

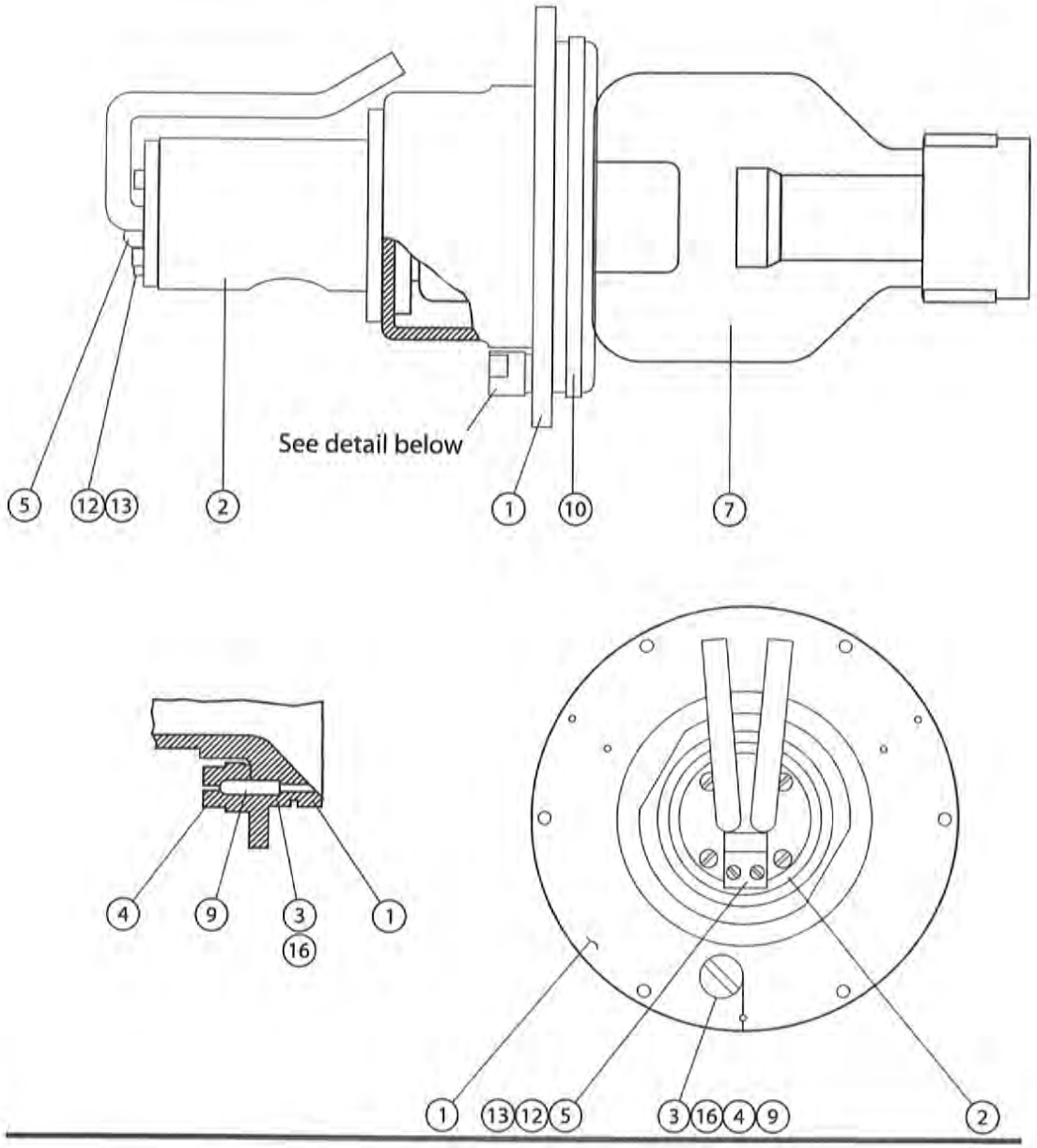


FIGURE 7-5:
ASSEMBLY, X-RAY TUBE (SHEET 1 OF 1)

Table 7-6: Assembly, Bottom End Plate

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-000A-0789	ODTG5	Sub-Assembly, Bottom End Plate	1
2/1	1-035A-0054	ODTG5	Assembly, High Voltage Transformer - NDT	1
3/1	3-605A-0480	ODTG5	Bracket, Transformer Mounting	2
4/1	1-003A-4015	ODTG5	Assembly, mA/kV Sense Diode PCB	1
5/1	3-405A-0279	ODTG5	Plate, Connector Shield	1
6/1	LOCTITE#242	05972	Adhesive, Loctite - #242 (2-580A-0506) (ODTG5)	A/R
7/1	Z-3078 (SILICONE)	76385	Grommet, Vibration Mount (2-241A-0023) (ODTG5)	4
8/1	2-500A-1020	NONE	Screw, Button Head - #6-32 x 1/4" LG	6
9/1	2-500A-1022	NONE	Screw, Button Head - #6-32 x 1/2" LG	2
10/1	2-570A-1604	NONE	Washer, Lock - #61 NT TH.	8
11/1	2-480A-0127	NONE	Spacer, Round - #6 x 1/4" LG	2
12/1	2-500A-1261	NONE	Screw, Button Head - #10-32 x 3/8" LG	2
13/1	2-570A-1606	NONE	Washer, Lock - #10 I NT TH	2
14/1	2-570A-1064	NONE	Washer, Lock - #10 EXT TH	3
15/1	2-500A-8124	NONE	Screw, Shoulder S. H. - 3/16 x 3/8 LG	4
16/1	2-570A-1633	NONE	Washer, Flat - #10	4
17/1	2-570A-1605	NONE	Washer, Lock - #81 NT TH	4
18/1	2-380A-0026	NONE	Nut, Machine - #8-32	4
19/1	1-040A-0379	ODTG5	Assembly, Cable -Thermostat	1
20/1	2-500A-1061	NONE	Screw, Button Head - #10-32 x 3/8 LG	1
21/1	1-061A-0004	NONE	Shrink Tubing	A/R

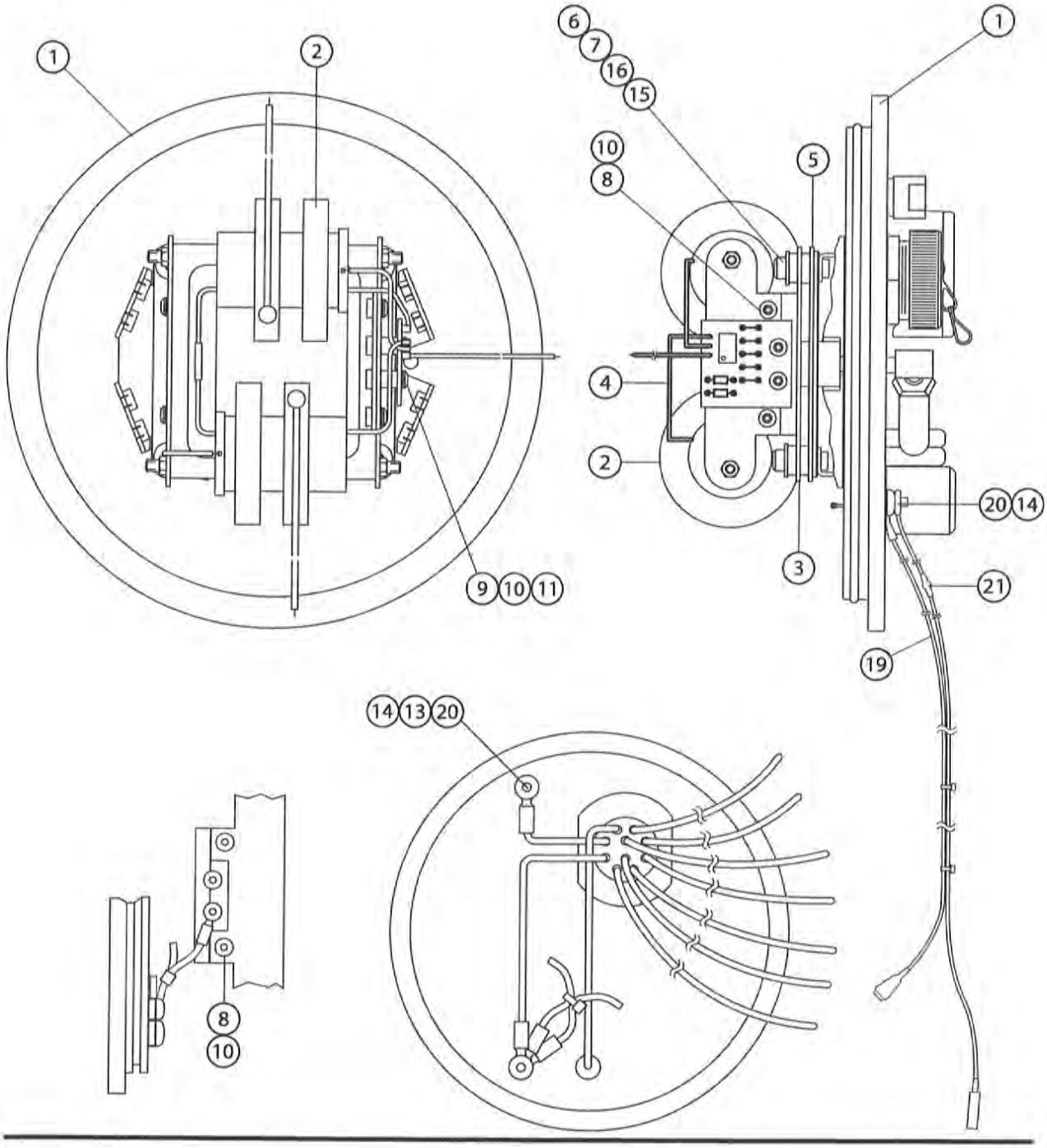


FIGURE 7-6:

ASSEMBLY, BOTTOM END PLATE (SHEET 1 OF 1)

Table 7-7: Sub-Assembly, Bottom End Plate

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-405A-0294	ODTG5	Plate, Bottom End	1
2/1	146013	61349	Gauge, Pressure (2-330A-0003) (OTDG5)	1
3/1	559B-1M-75	91816	Valve, Pressure Relief (2-561 A-0001) (ODTG5)	1
4/1	9166L-8	27783	Valve, Tank (2-560A-0001) (ODTG5)	1
5/1	7612	27783	Cap, Valve (2-150A-0006) (ODTG5)	1
6/1	1-091A-0023	NONE	Terminal, Feed Through	1
7/1	LCD-5+25	52139	Pressure Switch (1-700A-0056) (ODTG5)	1
8/1	1-040A-0357	ODTG5	Assembly, Harness - End Plate	1
9/1	3-605A-0474	ODTG5	Bracket, Stringer Mount	1
10/1	2-2 SE B	54939	Pipe Fitting, Elbow - 90° Street (2-550A-0006) (ODTG5)	1
12/1	3-530A-0011	ODTG5	Safety Stud	1
13/1	3-380A-0010	ODTG5	Safety Nut	1
14/1	ARP 568-011 EP70	07060	"O" Ring -0.301 I.D. x.441 O. D. (2-390A-0008) (ODTG5)	1
15/1	MS25043-18D	17001	Cap and Chain (1-090A-0063) (ODTG5)	1
16/1	ARP 568-160 EP70	07060	"0" Ring (2-390A-0009) (ODTG5)	1
17/1	3-150A-0020	ODTG5	Cap, Feed Through	1
18/1	2-500A-2222	NONE	Set Screw, Cup PT - #6-32 x 1/4" LG	2
19/1	2-500A-1021	NONE	Screw, Button Head - #6-32 x 3/8" LG	1
20/1	2-570A-1604	NONE	Washer, Lock I NT TH - #6	1
21/1	2-500A-1060	NONE	Screw, Button Head - #10-32 x 1/4" LG	4
22/1	2-570A-1606	NONE	Washer, Lock I NT TH - #10	4
23/1	LOCTITE#242	05972	Adhesive, Loctite - #242 (2-580A-0506) (ODTG5)	A/R
24/1	2-580A-1111	NONE	Teflon Tape, Thread Sealing	A/R

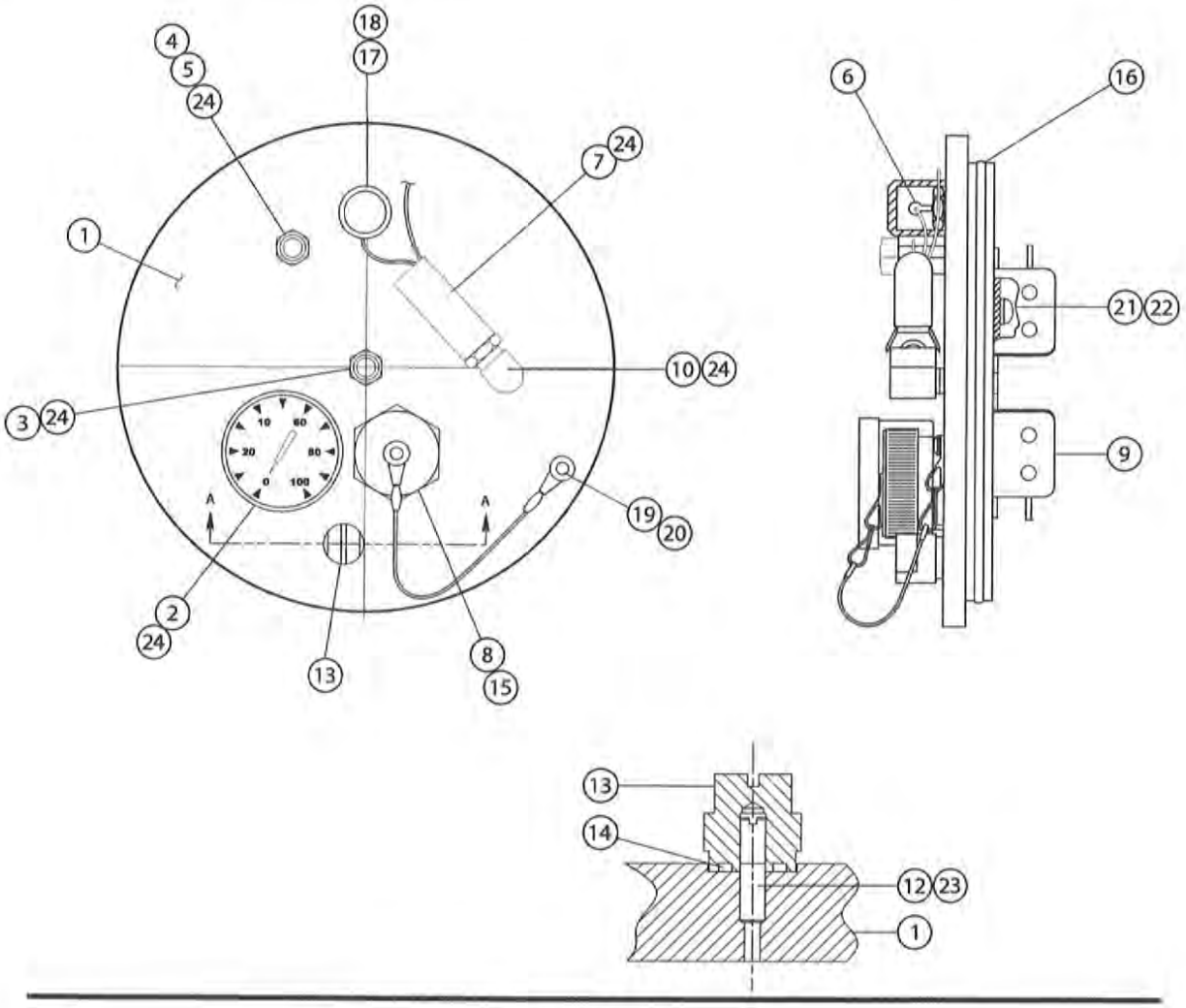


FIGURE 7-7:

SUB-ASSEMBLY, BOTTOM END PLATE (SHEET 1 OF 1)

Table 7-8: Assembly, High Voltage Power Supply

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-000A-0745	ODTG5	Assembly, Multiplier	1
2/1	1-035A-0062	ODTG5	Assembly, Filament Transformer	1
3/1	3-000A-0751	ODTG5	Assembly, Insulator Stringer	1
4/1	3-000A-0744	ODTG5	Assembly, Tube Socket	1
5/1	3-000A-0790	ODTG5	Assembly, Bottom End Plate	1
6/1	3-580A-0604	ODTG5	Insulator, Stringer	3
7/1	2-500A-6583	NONE	Screw, P. H. Slotted (Nylon) - #10-32 x 3/8" LG	5
8/1	2-500A-1041	NONE	Screw, Button Head S.S. - #8-32 x 3/8" LG	13
9/1	2-570A-1605	NONE	Washer, Lock INT TH S.S. - #8	13
10/1	2-500A-1040	NONE	Screw, Button Head S.S. - #8-32 x 1/4" LG	1

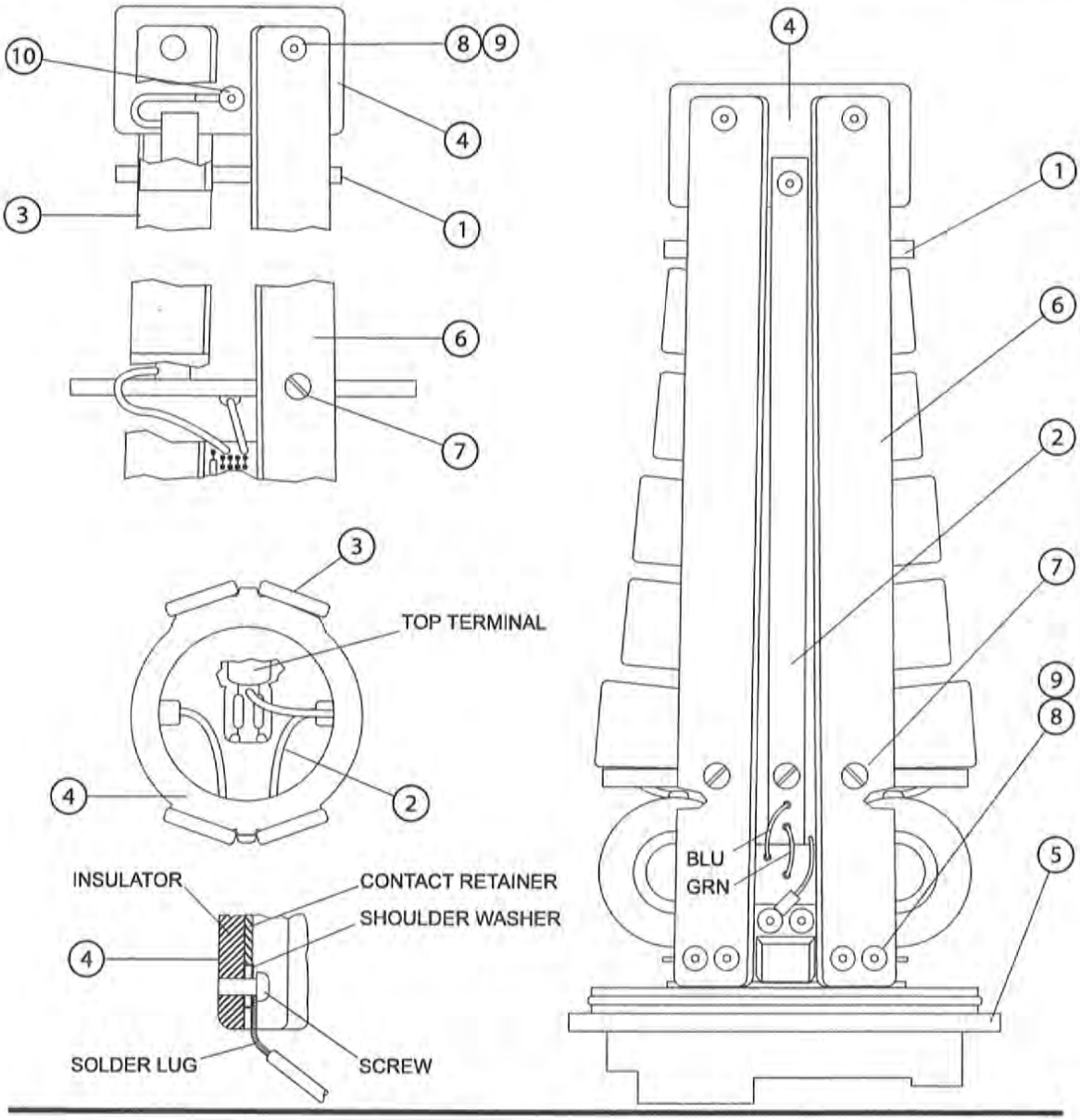


FIGURE 7-8:

ASSEMBLY, HIGH VOLTAGE POWER SUPPLY (SHEET 1 OF 1)

Table 7-9: Assembly, Multiplier

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-405A-0257	ODTG5	Plate, Mounting - Lower NDT	1
2/1	3-405A-0258	ODTG5	Plate, Mounting - Upper NDT	1
3/1	3-102A-0040	ODTG5	Terminal, Single Position	10
4/1	3-102A-0039	ODTG5	Terminal, Three Position	6
5/1	DHS52 N4700 132M-40KV	2H461	Capacitor, Ceramic - 1300pf, 40kV (1-202A-0046) (ODTG5)	2
6/1	DHS38 N4700701 M-40KV	2H461	Capacitor, Ceramic - 700pf, 40kV (1-202A-0047) (ODTG5)	4
7/1	DHS30 N4700441 M-40KV	2H461	Capacitor, Ceramic - 440pf, 40kV (1-202A-0049) (ODTG5)	9
8/1	ESJA53-20KV	1AA44	Diode, High Voltage Rectifier -20kV (1-401A-0017) (ODTG5)	40
9/1	2-191A-1000	NONE	Eyelet-0.045 I.D. x.219 LG	22
10/1	3-440A-0013	NONE	Rod, Threaded - #8-32 (Brass)	12
11/1	1-091A-0013	NONE	Lug, Solder Locking - FLT #8	3
12/1	2-570A-2039	NONE	Washer, Lock - I NT TH, Bronze #8	33
13/1	2-500A-9536	NONE	Screw, RD. HD. Machine - Brass #8-32 x 1/2	6
14/1	2-500A-0002	NONE	Screw, S.H. Cap - #4-40 x 1/2	16

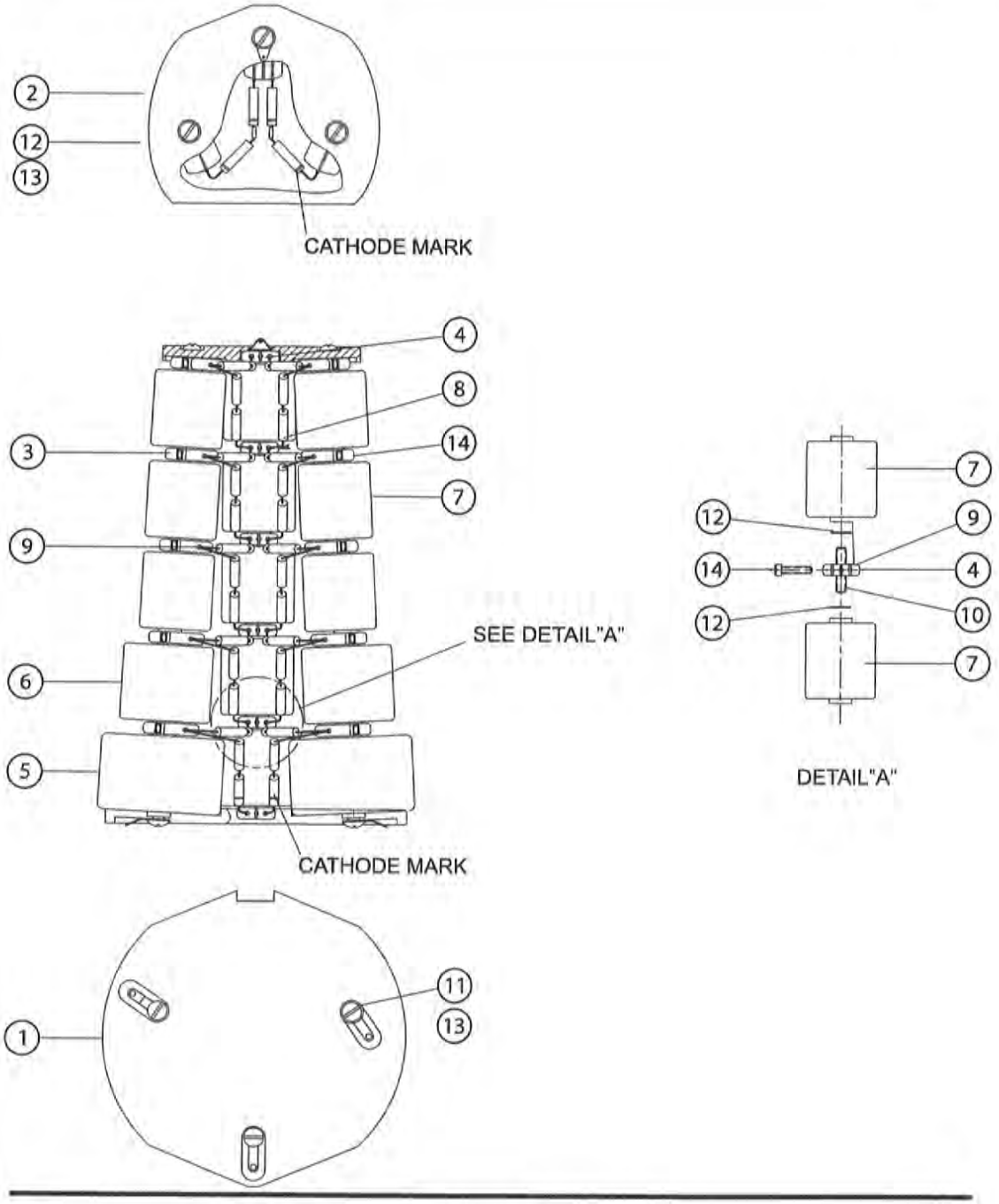


FIGURE 7-9:
ASSEMBLY, MULTIPLIER (SHEET 1 OF 1)

Table 7-10: Assembly, Stringer

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-580A-0604	ODTG5	Insulator, Stringer	1
2/1	SM208033007PS	63060	Resistor, High Voltage (1-110A-0003) (ODTG5)	4
3/1	1-055A-0806	NONE	Wire, PVC - #22 AWG Orange	5
4/1	1-091A-0013	NONE	Lug, Solder Locking - Flat #8	1
5/1	1-061A-0002	NONE	Shrink Tubing, 1/16"- Clear	A/R
6/1	1-061A-0010	NONE	Shrink Tubing, 1 Clear	A/R

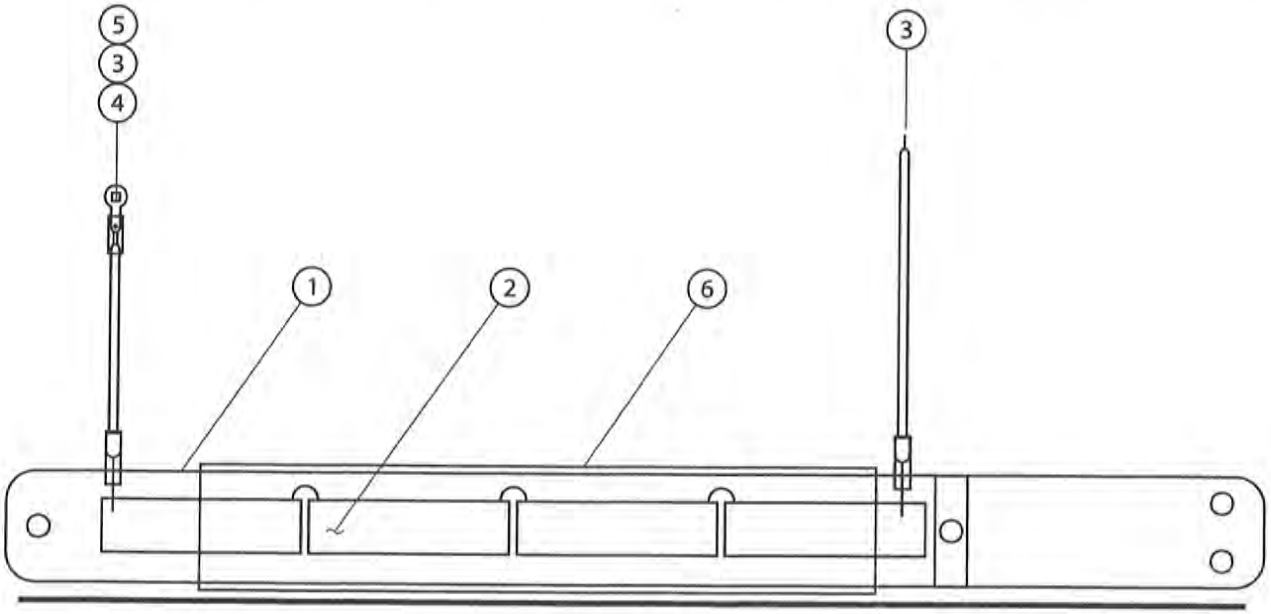


FIGURE 7-10:

ASSEMBLY, STRINGER (SHEET 1 OF 1)

Table 7-11: Assembly, Cooling Unit

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/2	3-700A-0006	ODTG5	Case, Cooler - Modified	1
2/1	3-645A-0058	ODTG5	Weldment, Fan Guard	1
3/1	3-605A-0468	ODTG5	Bracket, Mount - Heather Core	1
4/1	3-605A-0469	ODTG5	Support, Heather Core	1
5/2	3-61 0A-0015	ODTG5	Retainer, Vent Screen	2
6/2	3-605A-0475	ODTG5	Bracket, Mount - Strainer	4
7/1	3-605A-0476	ODTG5	Bracket, Mount - Flow Switch	2
8/1	3-625A-0005	ODTG5	Manifold, Cooling Unit	1
9/1	3-605A-0477	ODTG5	Bracket, Mount-Manifold	1
10/2	3-450A-0003	ODTG5	Gasket, Heather Core	1
11/1	3-645A-0059	ODTG5	Weldment, Reservoir	1
12/2	3-205A-0012	ODTG5	Vent, Screen	2
13/1	3-000A-0753	ODTG5	Assembly, Motor and Pump	1
14/1	66-P	1 H408	Tubing, 3/8" Ploy-Flo (2-540A-0014) (ODTG5)	37
15/2	1-040A-0356	ODTG5	Assembly, Harness - Motor Cooler	1
16/1,2	20012	62789	Clamp, Hose (2-152A-0017) (ODTG5)	4
17/1	268-P-06X04	1 H408	Fitting, Male Connector (2-540A-0010) (ODTG5)	5
18/1	269-P-06X04	1H408	Fitting, Elbow - 90°, 1/4" (2-540A-0009) (ODTG5)	2
19/1,2	KF10-06MB	1 H408	Fitting, Hose to Pipe - 5/8 to 3/8 NPT (2-540A-0017) (ODTG5)	2
20/1,2	5288K13	5T847	Hose, Heater - 300psi (2-545A-0001) (ODTG5)	9
21/1	1046FORD	78225	Radiator, Heater Core (2-170A-2002) (ODTG5)	1
22/1	4960K23	5T847	Flow Switch, 0.50 Gallons per Minute (2-545A-0003) (ODTG5)	1
23/2	A-15176	41947	Strainer, In-Line - "Y" Type (2-545A-0002) (ODTG5)	1
24/2	Z-2264	76385	Grommet (2-241 A-0022) (ODTG5)	2
25/2	2500T2	5T847	Feet Glides (2-210A-0001) (ODTG5)	4
26/1	B1 H11	73992	Fitting, Socket (2-540A-0011) (ODTG5)	2
27/1	122-B-02	1H408	Fitting, Nipple - Hex (2-540A-0015) (ODTG5)	2
28/1	119-B-06X04	1H408	Fitting, Reduced Bushing (2-540A-0013) (ODTG5)	1
29/1	R23	78225	Cap, Radiator (2-170A-2003) (ODTG5)	1
30/2	97121137	82866	Filter, Cooling Unit (2-350A-1002) (ODTG5)	1
31/1	3-405A-0253	ODTG5	Plate, Cooler Unit	1
32/1	MS25043-18D	17001	Cap and Chain (1-090A-0063) (ODTG5)	1
33/1	269-P-06X06	1H408	Fitting, Elbow - 90°, 3/8" (2-540A-0012) (ODTG5)	1
34/1,2	LOCTITE#242	05972	Adhesive, Loctite - #242 (2-580A-0506) (ODTG5)	A/R
35/1	2-580A-1105	NONE	Tape, Foam Transfer Adhesive	A/R
36/1	GRNY-085-9	5U337	Grommet Extruded (2-241 A-0021) (ODTG5)	A/R
38/1,2	2-380A-0026	NONE	Nut, Plain S.S. - #8-32 (2-500A-0643) (ODTG5)	8
39/1,2	2-570A-1605	NONE	Washer, Lock I NT TH - #8	12
40/1	2-500A-5263	NONE	Screw, P. H. - S.S. #10-32 x 3/8	4
42/1	2-500A-5265	NONE	Screw, Flat Head - Phil. #10-32 x 1/2	12
43/1	2-570A-1606	NONE	Washer, Lock I NT TH - #10	6
44/2	2-500A-1044	NONE	Screw, B.H. - S.S. #8-32 x 3/4	4
46/2	2-500A-1021	NONE	Screw, B.H. - S.S. #6-32 x 3/8	12
47/2	2-380A-0025	NONE	Nut, Plain - S.S. #6-32	12

Table 7-11: Assembly, Cooling Unit

48/2	2-570A-1604	NONE	Washer, Lock I NT TH - #6	12
49/2	2-500A-4233	NONE	Screw, Hex Head S.S. - #5/16-18 x 7/8	4
50/2	2-570A-1539	NONE	Washer, Split Lock - #5/16	4
51/2	11895A11	5T847	Handle, with Mounting Plate (2-500A-1401) (ODTG5)	3
52/1	2-500A-1401	NONE	Screw, Truss Head Phil. - #4-40 x 3/8	4
53/1,2	2-580A-1111	NONE	Tape, Teflon - Pipe Sealing 1/2	A/R
54/1	1-090A-0011	NONE	Cable Ties - 4	2
55/1	1-090A-0020	NONE	Mount, Cable Tie	1

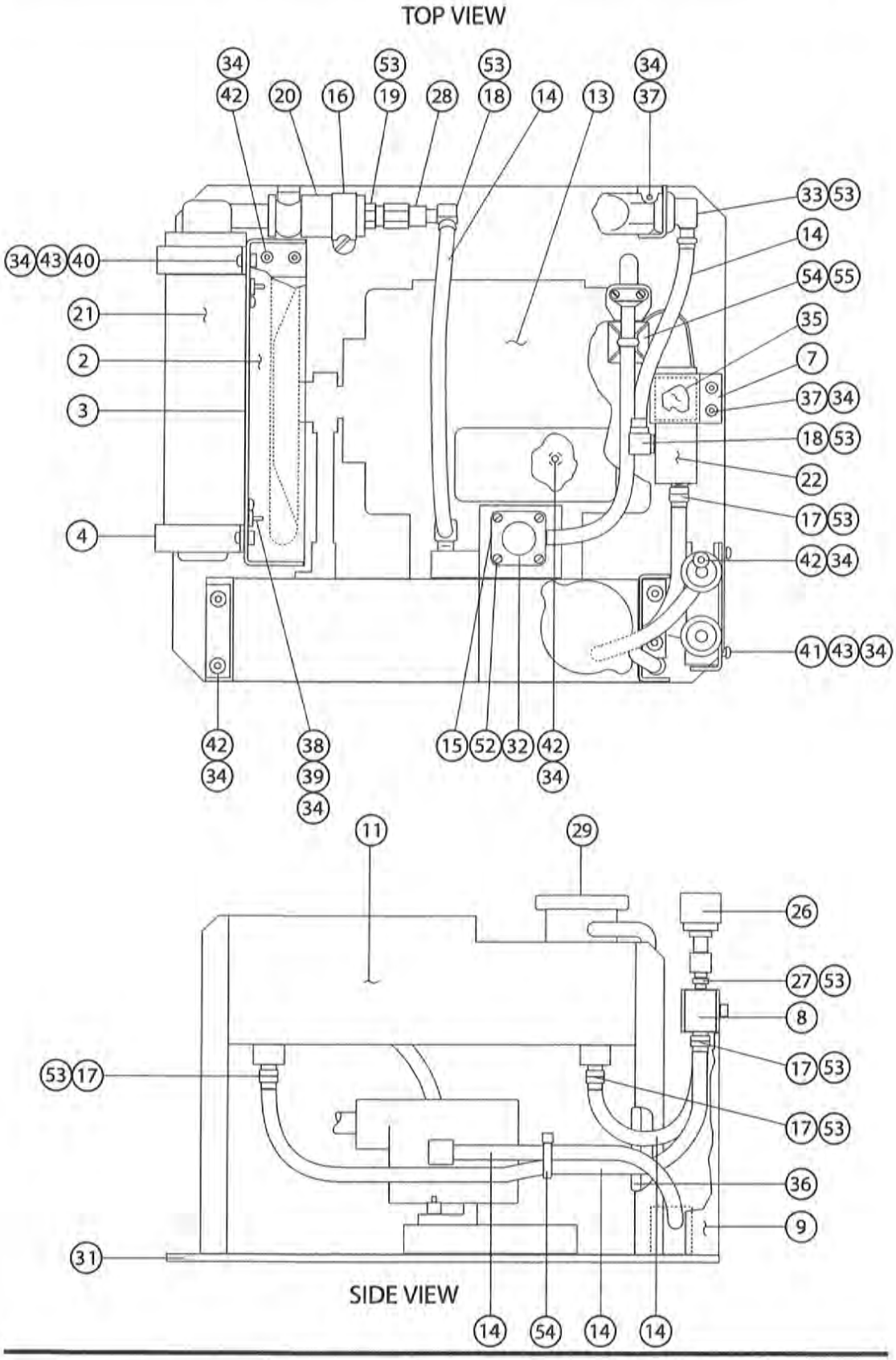


FIGURE 7-11:

ASSEMBLY, COOLING UNIT (SHEET 1 OF 2)

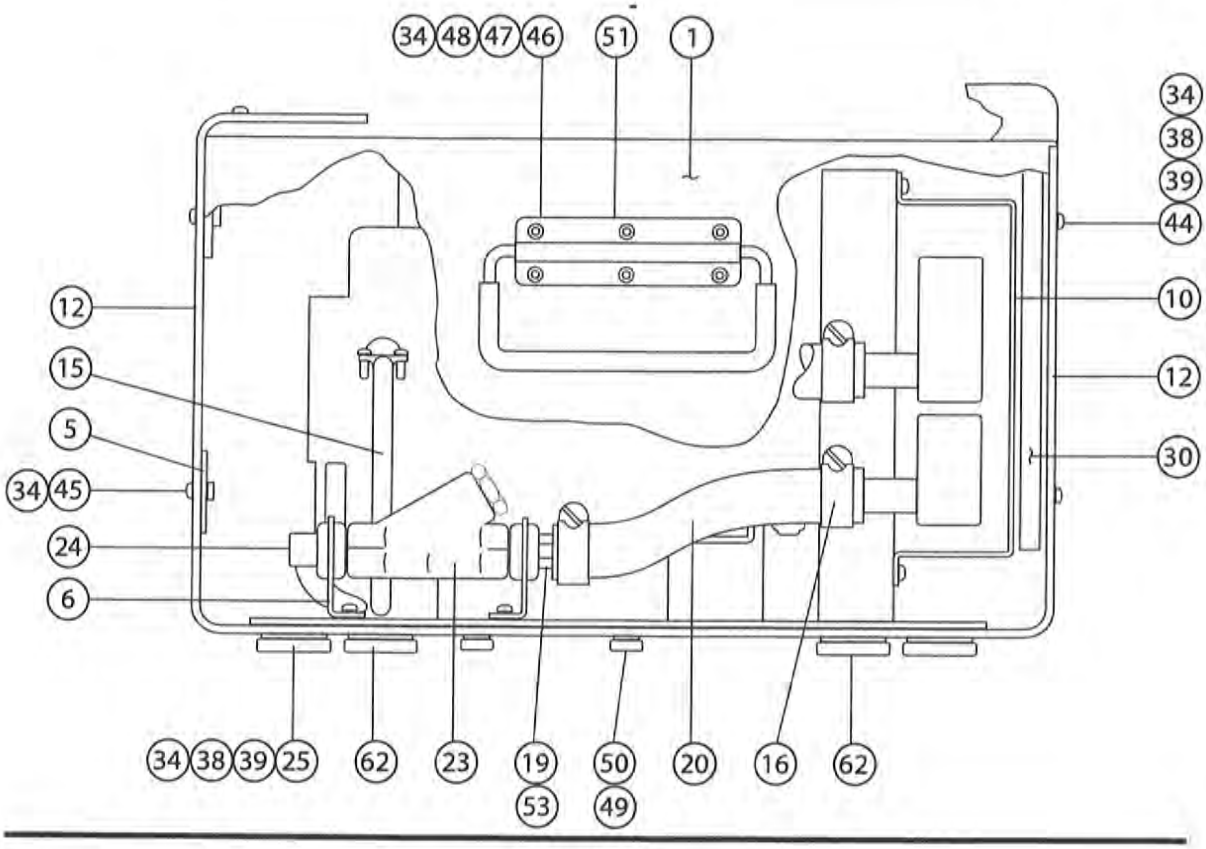


FIGURE 7-11:

ASSEMBLY, COOLING UNIT (SHEET 2 OF 2)

Table 7-12: Assembly, Motor and Pump

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	3-605A-0467	ODTG5	Support, Motor	2
2/1	3-405A-0251	ODTG5	Plate Mount, Motor and Pump	1
3/1	3-230A-3005	ODTG5	Pulley, Timing Belt-Modified	1
4/1	3-230A-3004	ODTG5	Pulley, Timing Belt-Modified	1
5/1	170XL 170XLO37	88173	Belt, Timing (2-230A-4003) (ODTG5)	1
6/1	102085.00	56065	Motor (2-320A-0011) (ODTG5)	1
7/1	MODEL 2000 R-9	44408	Pump (2-420A-0004) (ODTG5)	1
8/1	5BL 7" CCW 20° 0.5" DIS	63055	Fan, Five Bladed - 7" Diameter (2-200A-0002) (ODTG5)	1
9/1	269-P-06X04	1H408	Fitting, Elbow - 90', 1/4" (2-540-0009) (ODTG5)	2
10/1	66-P	1H408	Tubing, 3/8" - Ploy-Flo (2-540A-0014) (ODTG5)	12
11/1	3302	56501	Strain Relief (1-600A-0085) (ODTG5)	1
12/1	2-500A-2242	NONE	Set Screw, S. H. - #8-32 x 1/4	2
13/1	2-500A-2261	NONE	Set Screw, S.H. - #10-32 x 1/4	2
14/1	2-580A-0506	NONE	Adhesive, Loctite - #242	A/R
15/1	2-500A-4203	NONE	Screw, Hex Head - S.S. #1/4-20 x 3/4	2
16/1	2-570A-1538	NONE	Washer, Split Lock - #1/4	2
17/1	2-500A-4235	NONE	Screw, Hex Head - S.S. #5/16-18 x 1 1/4	4
18/1	2-570A-1539	NONE	Washer, Split Lock - #5/16	4
19/1	2-570A-0095	NONE	Washer, Flat SAE - #5/16	4
20/1	2-580A-1111	NONE	Tape, Teflon - Pipe Sealing, 1/2	A/R

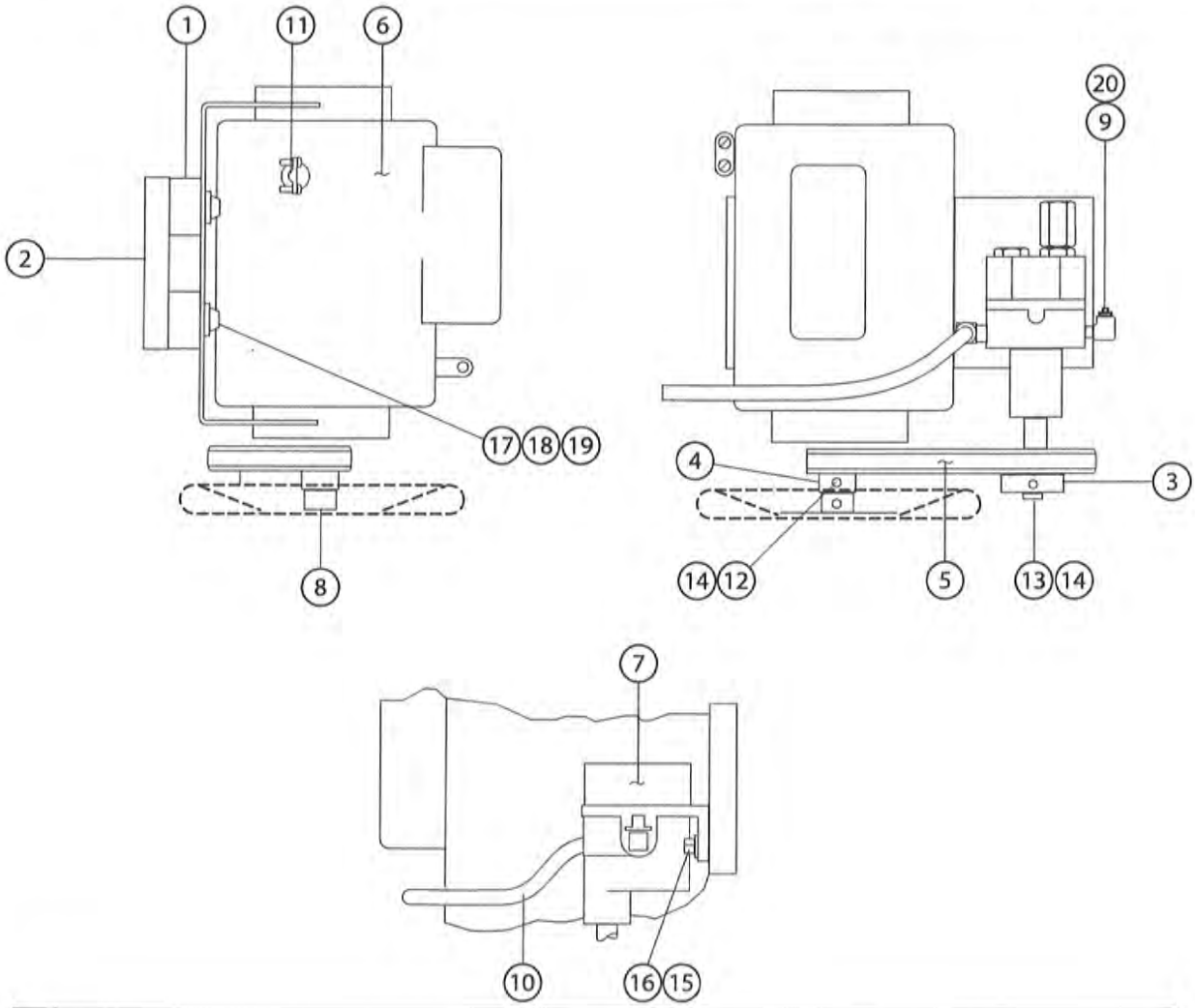


FIGURE 7-12:

ASSEMBLY, MOTOR AND PUMP (SHEET 1 OF 1)

Table 7-13: Assemblies, Cables and Hose

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	1-040A-0342	ODTG5	Assembly, Control Cable - 100 FT	1
2/1	1-040A-0343	ODTG5	Assembly, Cooler Cable - 50 FT	1
3/1	1-040A-0380	ODTG5	Assembly, Power Cable - 100 FT	1
4/1	3-000A-0742	ODTG5	Assembly, Cooling Hose - 50 FT	1

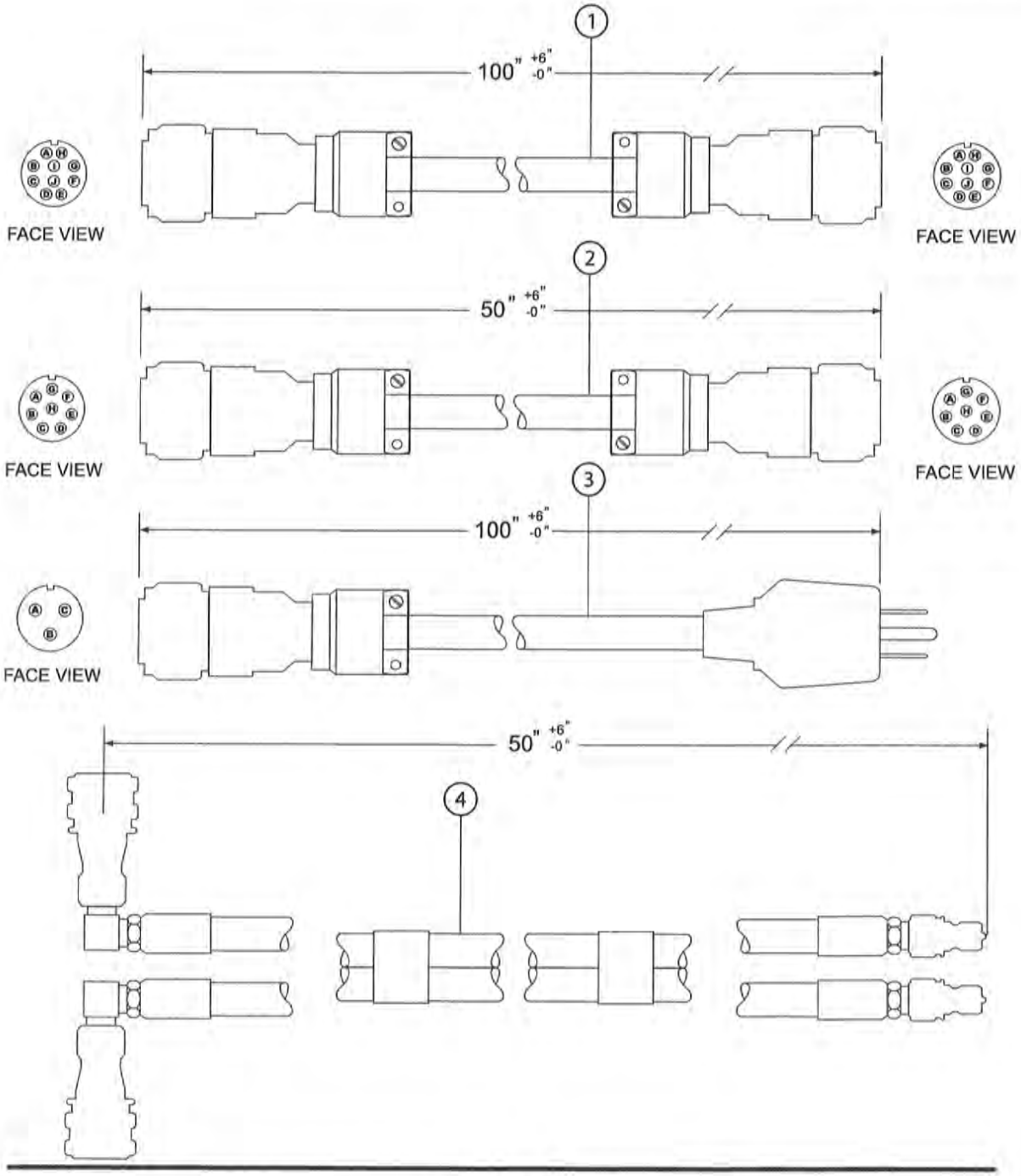


FIGURE 7-13:

ASSEMBLIES, CABLES AND HOSE (SHEET 1 OF 1)

Table 7-14: Assemblies, Transit Cases

FIGURE/INDEX/ SHEET #	PART NUMBER	CAGE	DESCRIPTION	UNITS PER ASSY
1/1	2-630-0025	ODTG5	Case, Transit, Tube Head	1
2/2	2-630-0026	ODTG5	Case, Transit, Control Unit	1
3/3	2-630-0027	ODTG5	Case, Transit, Cooling Unit	1
4/4	2-630-0028	ODTG5	Case, Transit, Cable	1

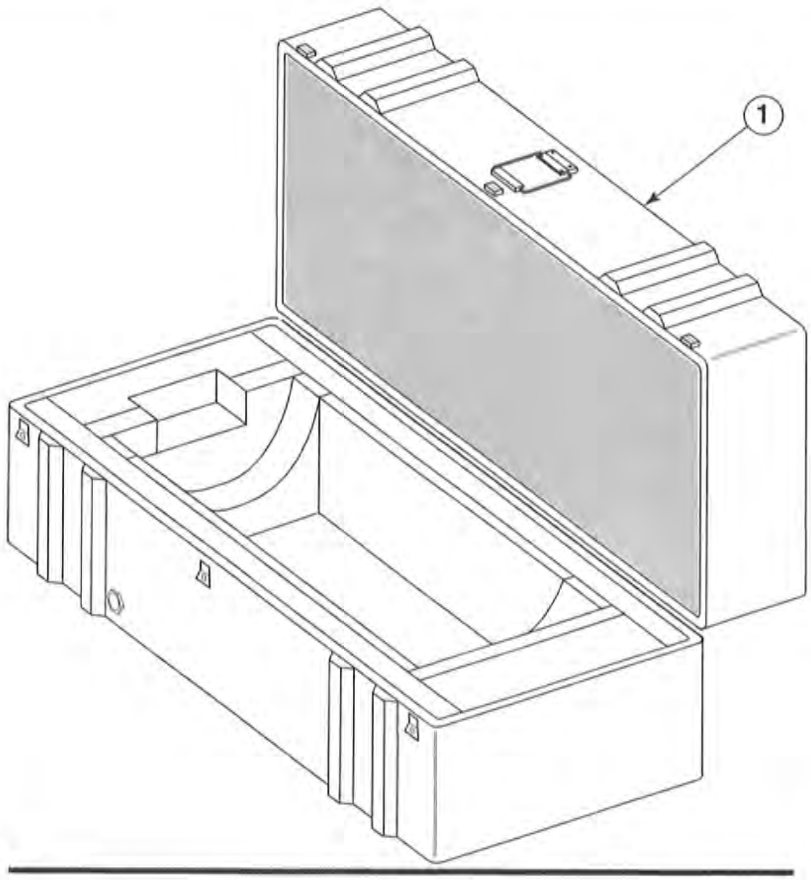


FIGURE 7-14:
ASSEMBLIES, TRANSIT CASES (SHEET 1 OF 4)

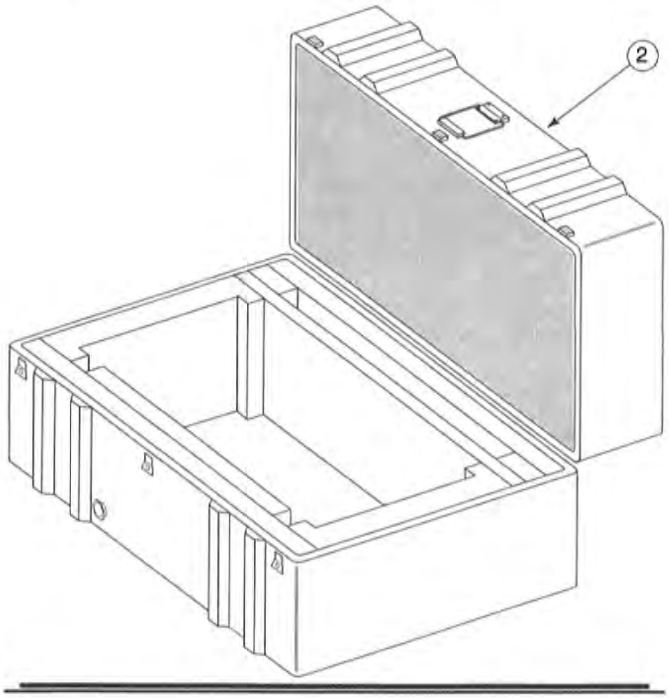


FIGURE 7-14:

ASSEMBLIES, TRANSIT CASES (SHEET 2 OF 4)

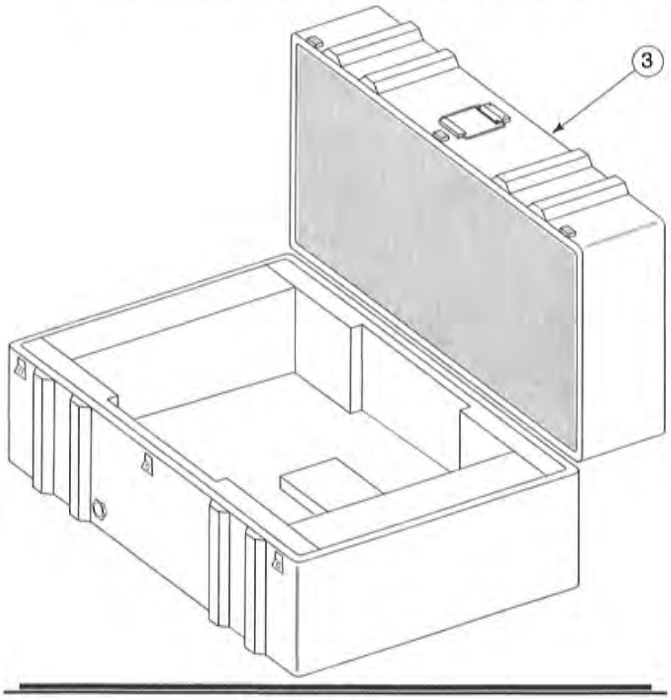


FIGURE 7-14:

ASSEMBLIES, TRANSIT CASES (SHEET 3 OF 4)

CHAPTER EIGHT: DIAGRAMS

PART NUMBER / DESCRIPTION	
1-004-4010	Schematic, mA Board
1-003-4010	Assembly Drawing, mA Board
1-004-4011	Schematic, kV Board (2 sheets)
1-003-4011	Assembly Drawing, kV Board
1-004-4012	Schematic, Low Voltage Power Supply
1-003-4012	Assembly Drawing, Low Voltage Pwr. Supply
1-004-4024	Schematic, Mother Board
1-003-4024	Assembly Drawing, Mother Board
1-004-4027	Schematic, Microcomputer Board
1-003-4027	Assembly Drawing, Microcomputer Board
3-000-0749	Assy/Wiring Diag., Control Chassis (2 sheets)
1-041-0086	Wiring Diagram, Front Panel to Mother Board
1-004-4023	Schematic, Conditioning Board
1-003-4023	Assembly Drawing, Conditioning Board

REVISIONS					
DATE	ZONE	REV	DESCRIPTION	DR	CHK'D	APP'D
8-93		7	PER EN4671	AF		WA
03/8/12		A	REVISED PER ECN 26582			JS;DC;GC
3/26/15		B	REVISED PER ECN 30864			JS;DC;WM

PI-M PI-P PH-L PI-R PI-F PI-D PI-K

MA SET · MA SENSE · RATE OF RISE · DC COMMON · UNREG DC

TP8 INDICATED MA

R27, 10K, 1%. R37, 10K, 1% R35, 10K, 1% R24 10K 1% R26 10K 1% U4 CA3240E +15V -15V

C26 .22 50V · D12 BYV95C · X RAY OFF K1-A · X-RAY ON · R38 1K 1% · R25, 1K

R23 470 · C13, 10, 35V · C14 22, 35V · C20 .01, 50V · U3 CA3140E · R22 1K · C21 .01 50V

TP18 · R21, 1M · C34 .47 50V · C17 .22 50V · TP9 · U2 CA3140E · C15 .01 50V · C16 .01 50V

PI-E PI-H PI-J PI-N PI-S +15V -15V

C18 10 35V · C19 10 35V

R29 10K

D13 BYV95C · C22 1 35V

U5 UC1825

TP5 · R32, 15 · D11 IN5819 · R30, 10 · C23 1 35V · TP6 · 50 KHZ · R34 470 · R31 15 · D10 IN5819 · R33 470

R17, 10K · R19, 100K · C35 15 PF 1KV · C24 .001 100V · C33 1 35V · C25 1 35V · X-RAY OFF K1-B X-RAY ON

R11 10K · D9 BYV95C · R28 470 · TP7

R4 47 · Q1 IRF450 · Q2 IRF450 · C3 .01 1KV · C36 .01 1KV · R5 47

L1 · D1 MUR1540 · C8 4.7 400V · R9 50K 2W · C9 1000 PF 1KV · C10 1000 PF 1KV · C1 .01 1KV · TP4 · TP1

K1 -15V

TP2 · T2 · TP3

Q7 2N3906 · R12 1K · Q6 2N3904 · R10 470 · Q5 2N3906 · R14 1K · R16 10C · R13, 500 · C11 1 35V

U1 4N37 · R8, 1.5K · R15 100

TP14 · R6 47 · Q3 IRF720 · D7 MUR 860 · D4 BYV 95C · C5 .0022 600V · C4 2 400V · R3 2K 2W · D3 BYV 95C · TP11 FIL DRIVE → PI-B

T3 · MUR860 D8 · TP15 · R7 47 · Q4 IRF720 · D5 BYV95C · C6 .0022 600V · C7 2 400V · R2 2K 2W · D6 BYV95C · L3 · TP10 FIL. DRIVE → PI-A

R43 47 · R44 47

T4 50T 1T · D16 D18 4X BYV95C D17 D19

R41, 4.7K · +15V · R42 10 · C27 1 35V · C28 1 35V · TP16 · C30 .01 100V · U6 UC1825 · R18 10K · R20, 100K · D15 IN5819 · R40 470 · TP12 · 33KHZ · D14 IN5819 · R39 470 · TP17 · C29 200PF 1KV · R45 470 · R46 15

NOTES:

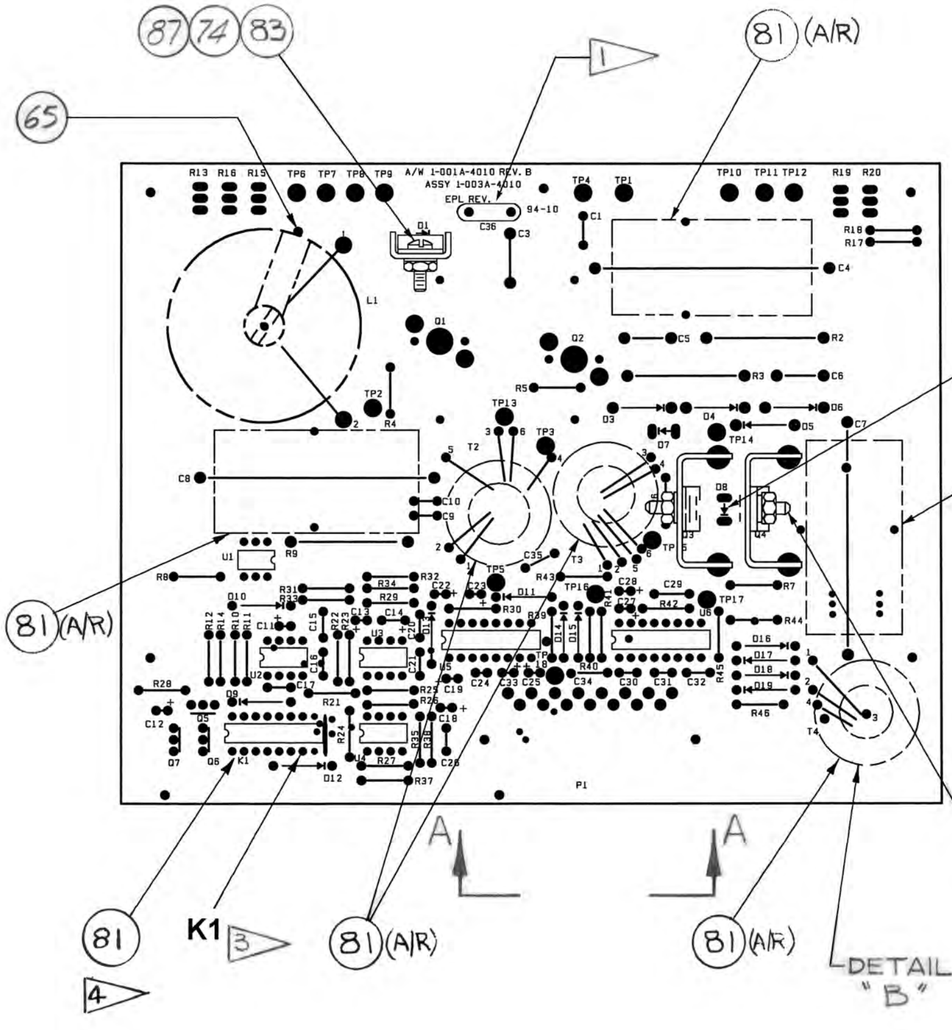
1. ALL RESISTOR VALUES ARE IN OHMS AND ARE 1/4W, 5% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICRO-FARADS (uf) UNLESS OTHERWISE SPECIFIED.
3. REF. LAST DESIGNATION USED: C35, D19, K1, L3, P1, R45, Q7, U6, TP15, T4.

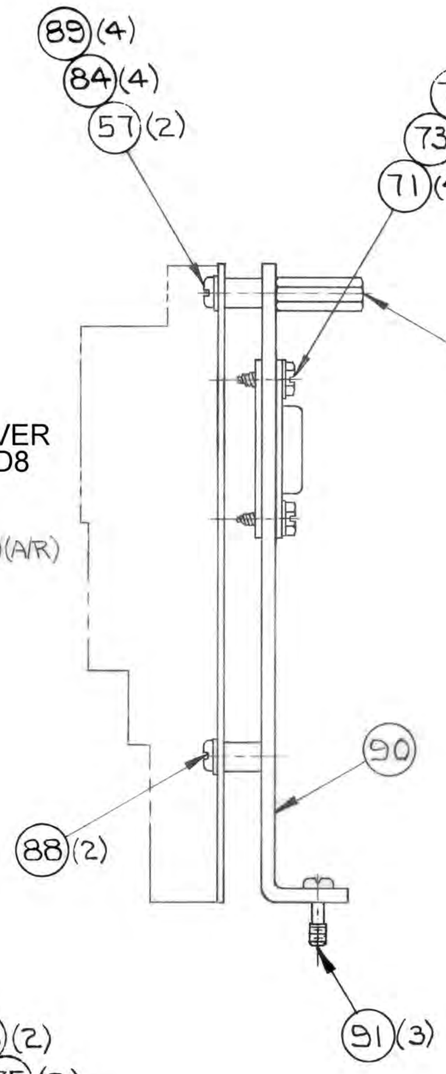
NEXT ASSY	GEOMETRIC TOLERANCE SYMBOLS – ANSI Y14.5			DIMENSIONAL TOLERANCES
1-003-4010	SYMMETRY	PROFILE OF A SURF.		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
	FLATNESS	ROUNDNESS		X .03 XX .01 XXX .005 ANGLES 1/2°
	PERP.	STRAIGHTNESS		FRACTIONS 1/64
	PARALLELISM	CONCENTRICITY		ALL MACH. SURF. 125 RMS BREAK & DEBURR ALL HOLES, CORNERS & EDGES .03 45° CHAMFER FIRST THREAD COML TOL APPLY TO STOCK SIZES
	POSITION	MAX MAT'L COND		
	RUNOUT	CYLINDERICITY		

DRAWN	3-22-91	F	LORAD MEDICAL SYSTEMS, INC. DANBURY, CT 06810
CHECKED	7/8/91		TITLE: SCHEMATIC, mA BD
ENGR.			SIZE D · DWG NO. 1-004-4010 · REV. B
RELEASED			SCALE: · SHT 1 OF 1
MATERIAL			
SURFACE TREATMENT			
USED ON	160 KV		

A. PH.

REVISIONS						
DATE	ZONE	REV	DESCRIPTION	DR	CHK'D	APP'D
5-07	~	018	ECO-10879 - BOM CHANGE ONLY			
03/8/12		A	REVISED PER ECN 26582		JS;DC;GC	
10/23/12		A1	REVISED PER ECN 27752		JS;DC;RK	
03/6/13		A2	REVISED PER ECN 28178		JS;DC;RK	
3/26/15		B	REVISED PER ECN 30864		JS;DC;WM	
10/13/15		B1	REVISED PER ECN 31542		JS;DC;WM	

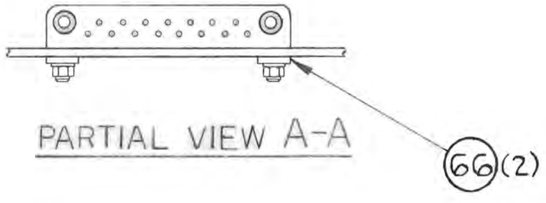


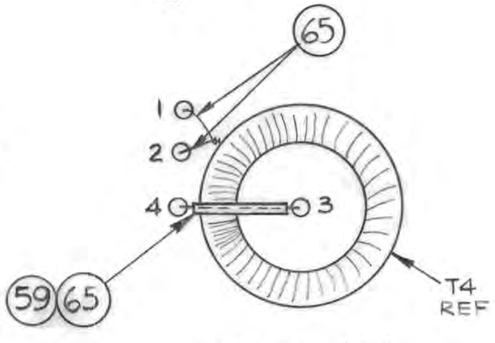


NOTES:

1. VENDOR TO PERMANENTLY MARK APPROPRIATE EPI. REV. LEVEL IN DESIGNATED AREA.
2. AFTER BOARD IS ASSEMBLED AND TESTED, REMOVE HEAT SINK (ITEM 90), MASK TEST POINTS SOCKETS, AND CONNECTOR AND COAT BOTH SIDES OF BOARD WITH CONFORMAL COATING, ITEM 82. WHEN DRY, REMOVE MASKING AND REASSEMBLE BOARD USING NEW SIL PADS (ITEM 73) AND RETEST.
3. INSTALL RELAY WITH BAR SIDE POSITIONED AS SHOWN.
4. APPLY A DAB OF ITEM 8. RTV TO EACH END OF THE RELAY/SOCKET K1, WITH THE RELAY PLUGGED IN.

TRANSFORMER WIRING			
TERMINAL		COLOR	LEAD
T2	1	WHT	START
	2	WHT	FINISH
	3	BLU	START
	4	BLU	FINISH
	5	GRN	START
	6	GRN	FINISH
T3	1	WHT	START
	2	WHT	FINISH
	3	BLU	START
	4	BLU	FINISH
	5	GRN	START
	6	GRN	FINISH
T4	1	BLU	EITHER
	2	BLU	EITHER





DETAIL "B"
N. T. S.

PART	1-003-4010
REV	B1

NEXT ASSY	GEOMETRIC TOLERANCE SYMBOLS – ANSI Y14.5				DIMENSIONAL TOLERANCES
3-000-0749	SYMMETRY		PROFILE OF A SURF.		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
	FLATNESS		ROUNDNESS		X ±.03 XX ±.01 XXX ±.008 ANGLES ±1/2°
	PERP.		STRAIGHTNESS		FRACTIONS ±1/64
	PARALLELISM		CONCENTRICITY		ALL MACH. SURF. 125 RMS BREAK & DEBURR ALL NICKS, CORNERS & EDGES .03
	POSITION		MAX MAT'L COND		45° CHAMFER FIRST THREAD
	RUNOUT		CYLINDERICITY		COML TOL APPLY TO STOCK SIZES

USED ON			
160NDT	DRAWN		11/26/97
	CHECKED		10/29/02
	ENGR. D. SHARPE		10/29/02
	RELEASED		
	MATERIAL	//	
	SURFACE TREATMENT	//	

LORAD MEDICAL SYSTEMS, INC.
DANBURY, CT 06810

TITLE: ASSY, MA BD 160KV

SIZE	DWG NO.	REV.
C	1-003-4010	B1

SCALE: FULL SHT 1 OF 1

A. PH.

REVISIONS						
DATE	ZONE	REV	DESCRIPTION	DR	CHK'D	APP'D
7/91	TR	2	NEW RELEASE, EN 3451			
1/1692		3	EN3678			
5/1992		4	EN3878			
12/92		5	EN4278 SH 1			
3-94		6	PER EN5049 SH 1 & 2			
11-94		7	EN 5570			
4-99		8	PER EN 11029			
03/8/12		A	REVISED PER ECN 26605		CF;DC;GC	
11/27/12		A1	REVISED PER ECN 27869		JS;DC;RK	

NOTES :

1. ALL RESISTOR VALUES ARE IN OHMS AND ARE 1/4W,5% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES ARE IN MICRO-FARADS (uf) UNLESS OTHERWISE SPECIFIED.
3. REF. LAST DESIGNATION USED :C46,D63,K2,T4,P3,Q16,R88,TP28,U11,VR2

NEXT ASSY	GEOMETRIC TOLERANCE SYMBOLS - ANSI Y14.5				DIMENSIONAL TOLERANCES
1-003A-4011	SYMMETRY		PROFILE OF A SURF.		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
	FLATNESS		ROUNDNESS		X .03 XX .01 XXX .005 ANGLES 1/2°
	PERP.		STRAIGHTNESS		FRACTIONS 1/64
	PARALLELISM		CONCENTRICITY		ALL MACH. SURF. 125 RMS, BREAK & DEBURR ALL HOLES, CORNERS & EDGES .03
	POSITION		MAX MAT'L COND		45° CHAMFER FIRST THREAD
	RUNOUT		CYLINDERICITY		CONF. TOL APPLY TO STOCK SIZES

DRAWN	4-12-91	F
CHECKED	10-3-91	
ENGR.	10-3-91	
RELEASED		
MATERIAL		
SURFACE TREATMENT		

USED ON: 160 KV

LORAD MEDICAL SYSTEMS, INC. DANBURY, CT 06810

TITLE: SCHEMATIC, KV BD.

SIZE	DWG NO.	REV.
D	1-004-4011	A1

SCALE: | SHT 1 OF 2

A. PH.

REVISIONS						
DATE	ZONE	REV	DESCRIPTION	DR	CHK'D	APP'D

SEE SHEET 1 FOR LATEST EN

U11 AD587KN: +15VO, C40 .01 50V, R79,1K,1%, R78,1K,1%

U9 4N37: +15V, C39 .01 50V, R72 1K, C38 .1 50V, R77 10K, R83 110 1W, D32 IN6297A, D33 IN6299A

U10 LM111: +15V, C36 .01 50V, R76,2.7K, D29 BYV95C, R75,470, C37,1,35V

TP22, TP25, TP23, TP26, TP24

Q16 2SD313E

HIGH KV DETECTOR → P3 b

KV DRIVE TO TUBEHEAD → P

KV DRIVE TO TUBEHEAD → F

C41 4.7 400V

P3-K

C28 .01 1KV

TP5, R17 100, D5 MUR1540, R18 47 2W, R20 100, Q7 IRF450, Q8 IRF450, D6 MUR860, C4 .0022 600V, R12 180 2W, R13 180 2W, T2 (3, 80T, 4), D16 4 X BYV95C, D17, D18, D19

TP4, R10,100, D3 MUR1540, Q5 IRF450, R11 47 2W, R14 100, Q6 IRF450, D4 MUR860, C3 .0022 600, R15 180 2W, R16 180 2W, R60 4.7, R61 4.7K

DC COMMON TO SHEET 1

T3 (2 12T 1, 3 12T 4)

C27 1000PF 1KV

D10 MUR1540, C6 .0022 600V, R27 180 2W, R28 180 2W, D9 MUR860, Q11 IRF450, R25,100, Q12 IRF450, R29 100, R26 47 2W

C5 .0022 600V, R22 180 2W, R23 180 2W, D7 MUR860, D8 MUR1540, TP6, Q9 IRF450, R21 100, R24 100, Q10 IRF450, R19 47,2W

T4 (1 12T 2, 4 12T 3; 5 15T 6, 7 15T 8)

D22 BYV95C

TP20, R65,270, Q14 IRF510, D27 IN5819, R62 270, D21 IN4744, D24 IN4755, C29 22 35V

D28 BYV 95C

TP21, R64,270, D26 IN5819, R63 270, D23 IN4744, Q15 IRF510, D25 IN4755

C30 22 35V

R66,4.7K, C31 1 35V, U7 UC1825, C33 .01 100V, R69,2K, R70,20T,5K, C34 .01,100V, R67,10, C32 1 50V, 25 KHZ

TP19, U8 CA3240E, R68,22K, R73 470K, R74 120K, C35 4.7,50V

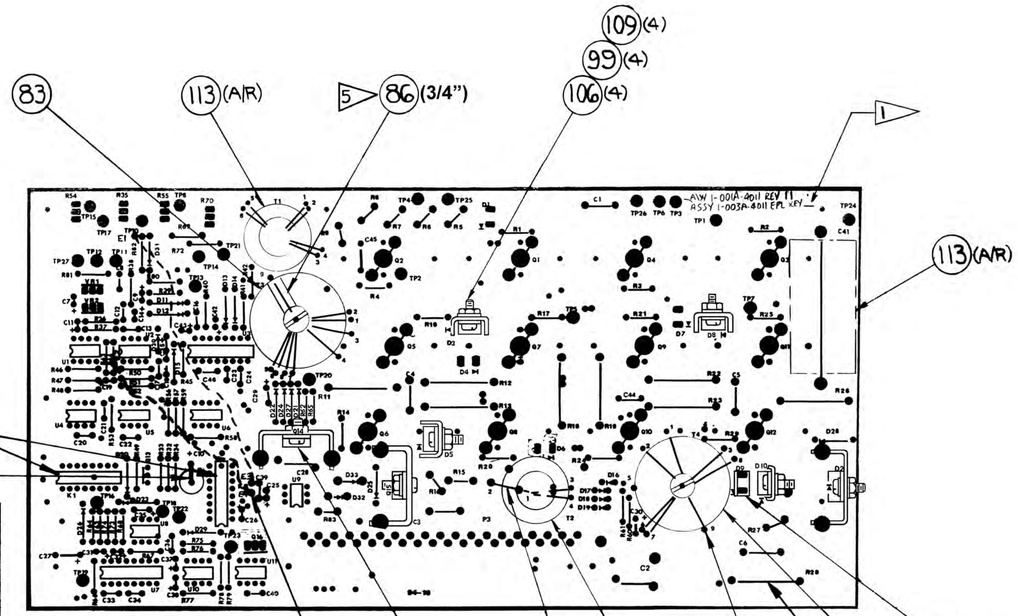
TP18 → ARC DET. → P3 d

NEXT ASSY	GEOMETRIC TOLERANCE SYMBOLS – ANSI Y14.5			DIMENSIONAL TOLERANCES
	SYMMETRY	PROFILE OF A SURF.		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
	FLATNESS	ROUNDNESS		X ±.03, XX ±.01, XXX ±.005, ANGLES ±1/2°
	PERP.	STRAIGHTNESS		FRACTIONS 1/64
	PARALLELISM	CONCENTRICITY		ALL MACH. SURF. 125 RMS
	POSITION	MAX MAT'L COND		BREAK & DEBURR ALL HOLES, CORNERS & EDGES .03
	RUNOUT	CYLINDERICITY		45° CHAMFER FIRST THREAD
				COML TOL APPLY TO STOCK SIZES

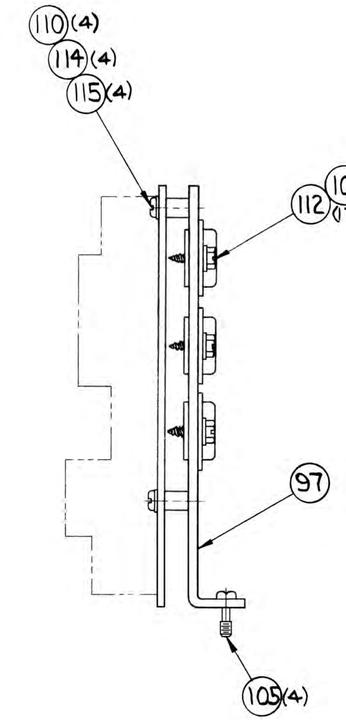
USED ON	DRAWN	F	LORAD MEDICAL SYSTEMS, INC. DANBURY, CT 06810
	CHECKED		TITLE: SCHEMATIC, KV BD
	ENGR.		
	RELEASED		
	MATERIAL		SIZE D; DWG NO. 1-004-4011; REV. A1
	SURFACE TREATMENT		SCALE: ; SHT 2 OF 2

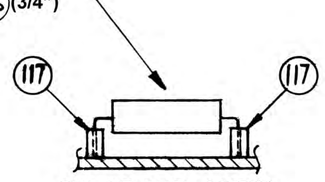
A. PH.

REVISIONS						
DATE	ZONE	REV	DESCRIPTION	DR	CHK'D	APP'D
6/17/11		023	ECO-23122 - BOM CHANGE ONLY	SS		GM
03/8/12		A	REVISED PER ECN 26605			CF;DC;GC
11/27/12		A1	REVISED PER ECN 27869			JS;DC;RK
03/6/13		A2	REVISED PER ECN 28178			JS;DC;RK
3/27/13		A3	REVISED PER ECN 28288			JS;DC;RK
6/05/13		A4	REVISED PER ECN 28549			JS;DC;GC



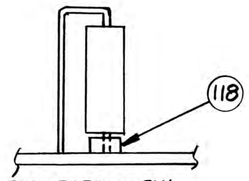
TRANSFORMER WIRING			
TERMINAL		COLOR	LEAD
T1	1	GRN	FINISH
	2	BLU	START
	3	BLU	FINISH
	4	GRN	START
	5	WHT	START
	6	WHT	FINISH
T2	3	BLU	EITHER
	4	BLU	EITHER
T3	1	ORN	FINISH
	2	ORN	START
	3	YEL	START
	4	YEL	FINISH
	5	BRN	START
	6	BLU	FINISH
	7	BRN	FINISH
	8	BLU	START
T4	1	GRN	START
	2	GRN	FINISH
	3	WHT	FINISH
	4	WHT	START
	5	BLK	FINISH
	6	BLK	START
	7	RED	FINISH
	8	RED	START





ENLARGED VIEW
N.T.S.

TYP R11, R12, R13, R18, R19, R22, R23, R26, R28, R1, R2, R3, R4, R10, R17, R20, R21, R24, R25, R29, R14



ENLARGED VIEW
N.T.S.

TYP R5–R9, R15 R16, R27, R83

NOTES:

1. VENDOR TO PERMANENTLY MARK APPROPRIATE EPL REV. LEVEL IN DESIGNATED AREA.
2. AFTER BOARD IS ASSEMBLED AND TESTED, REMOVE HEAT SINK (ITEM 97), MASK TEST POINTS, SOCKETS, AND CONNECTOR AND COAT BOTH SIDES OF BOARD WITH CONFORMAL COATING, ITEM 116, WHEN DRY, REMOVE MASKING AND REASSEMBLE BOARD USING NEW SIL PADS (ITEM 101) AND RETEST.
3. SOLDER WIRE, ITEM 81, FROM E1 TO E3, AND E2 TO E4 (FARSIDE) USING RTV, ITEM 113, TO SECURE.
4. AFTER TEST APPLY A DAB OF ITEM 113 RTV TO EACH END OF THE RELAY/SOCKET K1, K2, WITH THE RELAY PLUGGED IN.
5. SOLDER ITEM 86, BUS WIRE, TO GROUND STRAP AND TERMINAL 9.

PART	1-003-4011
REV	A4

NEXT ASSY	GEOMETRIC TOLERANCE SYMBOLS - ANSI Y14.5			
3-0004-0749	SYMMETRY		PROFILE OF A SURF.	
	FLATNESS		ROUNDNESS	
	PERP.		STRAIGHTNESS	
	PARALLELISM		CONCENTRICITY	
	POSITION		MAX MAT'L COND	
	RUNOUT		CYLINDERICITY	

DIMENSIONAL TOLERANCES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

X .015 XX .01 XXX .005 ANGLES ± 1/2°

FRACTIONS ± 1/64

ALL MACH. SURF. 125 RMS BREAK & DEBURR ALL HOLES, CORNERS & EDGES .03

45° CHAMFER FIRST THREAD

COML TOL APPLY TO STOCK SIZES

	DRAWN		
USED ON	CHECKED	12-13-91	
160KV	ENGR.	12-13-91	
	RELEASED		
	MATERIAL	//	
	SURFACE TREATMENT	//	

LORAD® Corporation Danbury, Ct. 06810

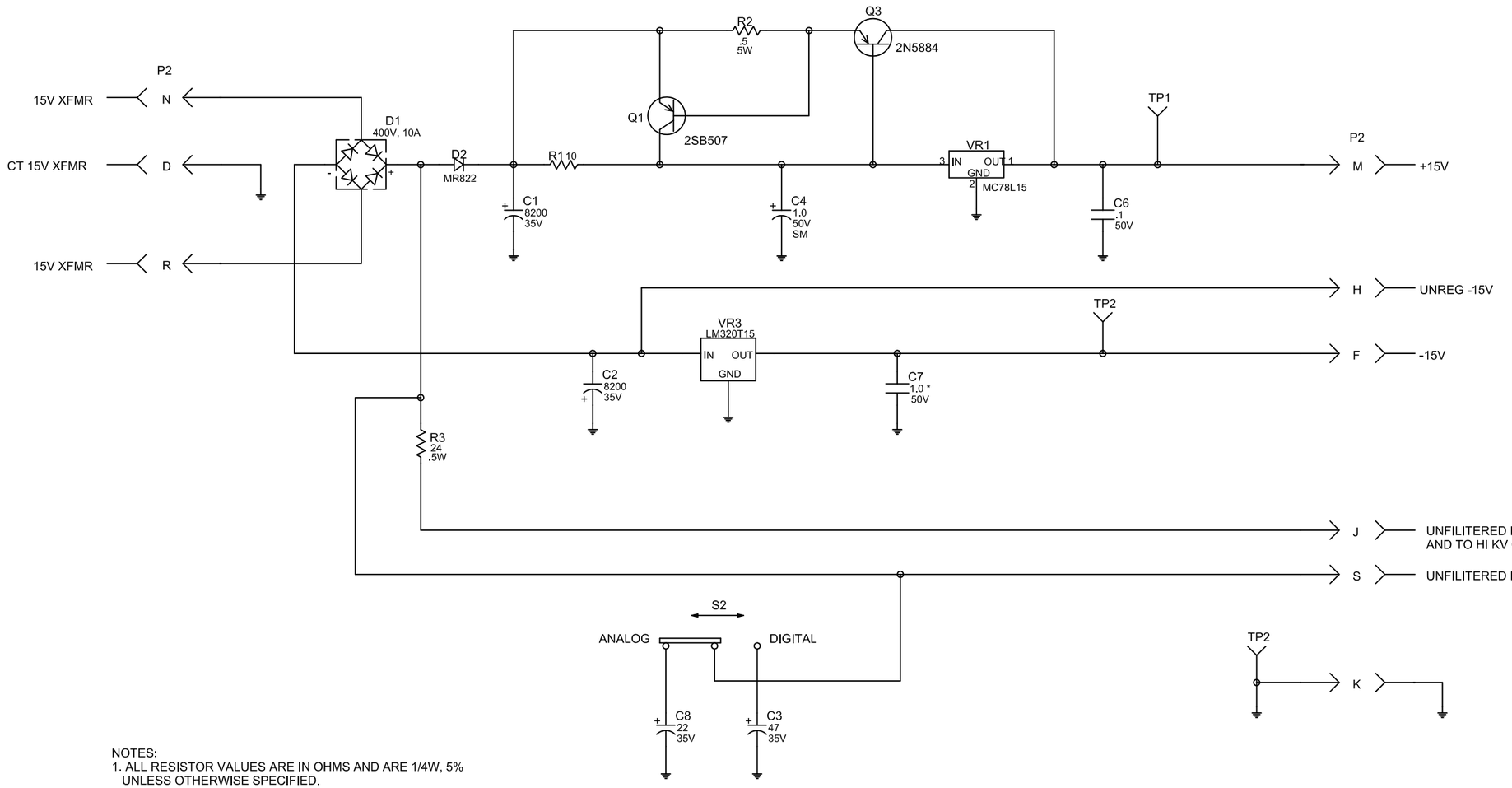
TITLE: ASSY, Kv BD (160KV)

SIZE D | DWG NO. 1-003-4011 | REV. A4

SCALE: FULL | SK- | SHT 1 OF 1

A. PH.

REVISIONS				APPROVED		
LTR	DESCRIPTION	DATE	MECH DESIGN	PROJ ENG	QUALITY	MFG ENG
A	REDRAWN IN CAD; REVISED PER ECN 27005	5/17/12	N/A	SK	DB	SK



NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS AND ARE 1/4W, 5% UNLESS OTHERWISE SPECIFIED.

2. ALL CAPACITORS VALUES ARE IN MICRO-FARADS (uf) UNLESS OTHERWISE SPECIFIED,

3. REF LAST DESIGNATION USED: C8,D2,P2,Q3,R3,VR3,TP3, S2
NOT USED: C5, P1, Q2, VR2

REV STATUS OF PARTS			
NO.			
REV			

NEXT ASSY	DIMENSIONAL TOLERANCES	DRAWN JS	3/28/91
1-003A-4012	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CHECKED N/A	N/A
	.X ±.015 .XX ±.01 .XXX ±.005 ANGLES ±.25°	ENGR. DS	7/19/91
	FRACTIONS ±1/64	RELEASED N/A	N/A
USED ON	ALL MACHINED SURFACES 125RMS	MATERIAL ----	
160KV	BREAK & DEBURR ALL HOLES CORNERS & EDGES .03		
	45° CHAMFER FIRST THREAD	SURFACE TREATMENT ------	
	COML TOL APPLY TO STOCK SIZES		

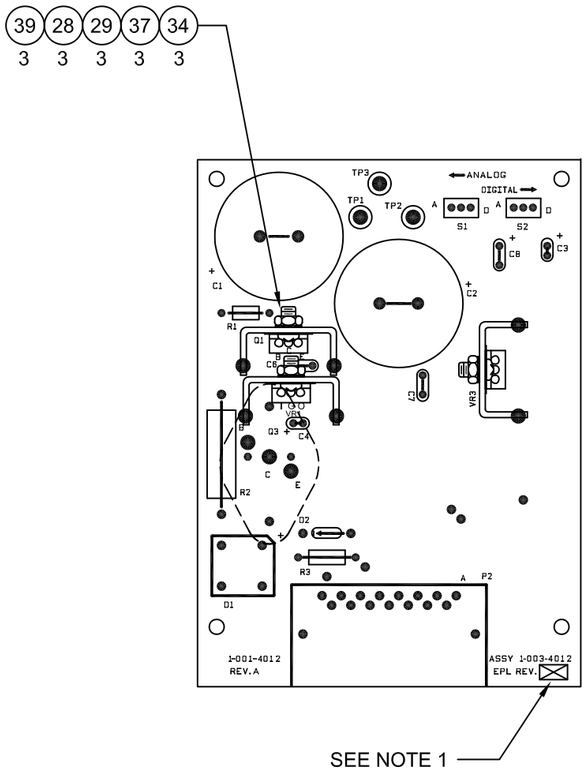
LORAD® CORPORATION DANBURY, CT. 06810

SCHEMATIC DIAGRAM L.V. POWER SUPPLY

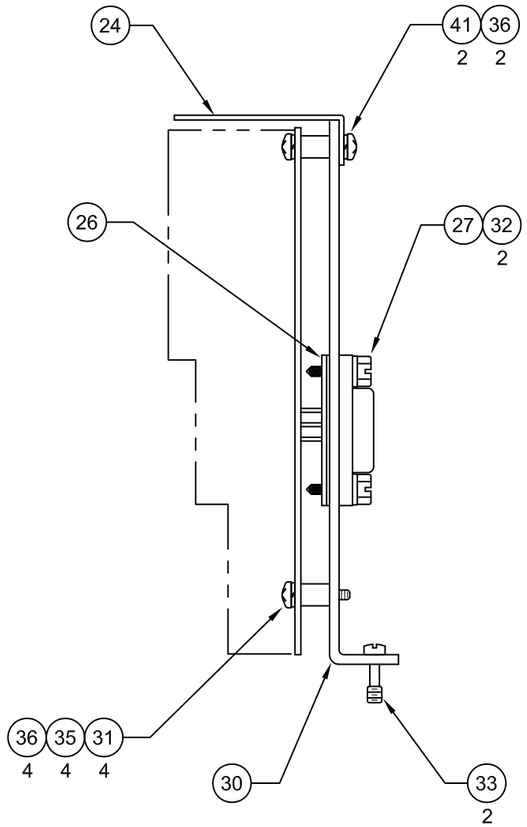
SIZE	DWG. NO.	REV.
D	1-004-4012	A

SCALE: NONE SK REV. SHEET 1 OF 1

REVISIONS				APPROVED		
LTR	DESCRIPTION	DATE	MECH DESIGN	PROJ ENG	QUALITY	MFG ENG
9	EN 6996	11/95	AF	DS	N/A	N/A
10	EN 10879 BOM CHANGE ONLY	5/7	SS	DS	N/A	N/A
A	REVISED PER ECN 26618	3/14/12	N/A	CF	DC	GC
A1	REDRAWN IN CAD; REVISED PER ECN 27005	5/17/12	N/A	SK	DC	RK
A2	REVISED PER ECN 29274	12/6/13	N/A	JS	DC	GC



ITEMS 24, 30 AND MOUNTING HARDWARE NOT SHOWN



NOTES:
1. VENDOR TO PERMANENTLY MARK APPROPRIATE EPL REV. LEVEL IN DESIGNATED AREA.

REV STATUS OF PARTS			
NO.	1-003-4012		
REV	A2		

NEXT ASSY	DIMENSIONAL TOLERANCES	DRAWN JF	9/4/91
3-000-0749	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CHECKED	
	.X ±.02 .XX ±.01 .XXX ±.005 ANGLES ±.25° FRACTIONS ±1/64 ALL MACHINED SURFACES 125RMS BREAK & DEBURR ALL HOLES CORNERS & EDGES .03 45° CHAMFER FIRST THREAD COML TOL APPLY TO STOCK SIZES	ENGR. DF	9/11/91
		RELEASED	
USED ON		MATERIAL —	
160 NDT		SURFACE TREATMENT —	

LORAD® CORPORATION DANBURY, CT. 06810

ASSEMBLY, L.V. POWER SUPPLY

SIZE	DWG. NO.	REV.
C	1-003-4012	A2

SCALE: 1/1 SK REV. SHEET 1 OF 1

CHASSIS MOUNTED

K201 TIME DELAY RELAY

FAN

SCHEMATIC CONDITIONING BD. 1-004-4023

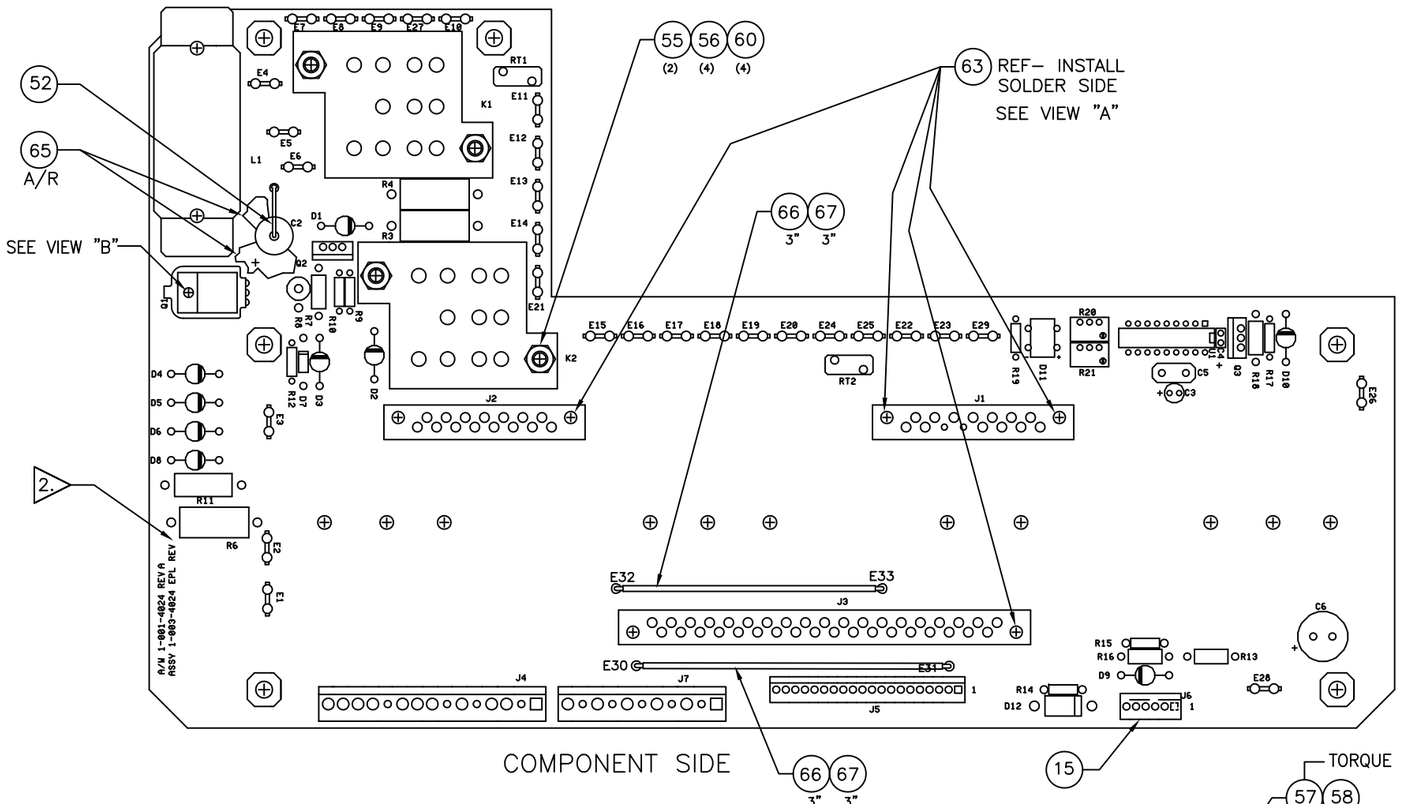
STORAGE CIRCUIT ASSY 3-000-0786

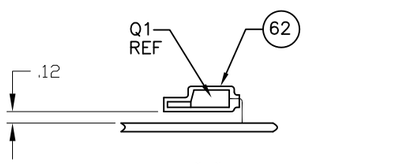
E29 TO CB101 RELAY TRIP COIL

TO CB101

LORAD CORPORATION DANBURY, CT. 06810	
TITLE	SCHEMATIC, MOTHER BD.
SIZE D	DWG. NO. 1-004-4024 REV. 4
SCALE: 1:1	SH REV. SHT 1 OF 1

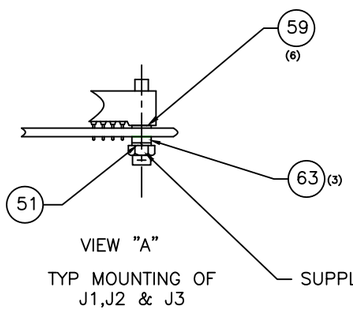
REVISIONS			APPROVED			
LTR	DESCRIPTION	DATE	MECH DESIGN	PROJ ENG	QUALITY	MFG ENG
A	REVISED PER ECN NO. 26676	3/21/12	N/A	MS	DS	MS
A1	REVISED PER ECN NO. 27005	5/17/12	N/A	JK	DS	RK
A2	REVISED PER ECN NO. 28572	6/12/13	N/A	JV	DS	MS
A3	REVISED PER ECN NO. 29274	12/6/13	N/A	JV	DS	MS





VIEW "B"

PRIOR TO BENDING Q1 OVER, COVER BODY OF PART WITH SHRINK TUBING AS SHOWN.



VIEW "A"

TYP MOUNTING OF J1,J2 & J3

SUPPLIED WITH HEADER

3. AFTER BOARD IS POPULATED AND TESTED, MASK SOCKETS, "E" POINTS, CONNECTORS, AND AREA ALONG CENTER OF BOARD WHERE NO SOLDER MASK EXISTS AND COAT BOTH SIDES OF BOARD WITH CONFORMAL COATING, ITEM 61. WHEN DRY, REMOVE MASKING AND COMPLETE ASSEMBLY.

2. USING PERMANENT INK MARK APPROPRIATE EPL REV. LEVEL IN DESIGNATED AREA.

1. REF. DRAWING : DO NOT SCALE.

NOTES :

REV STATUS OF PARTS		
NO.	1-003-4024	
REV	A3	

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
.X ±.015 .XX ±.01 .XXX ±.005 ANGLES ±1/2°
FRACTIONS ±1/64
ALL MACHINED SURFACES 125RMS
REMOVE ALL BURRS AND SHARP EDGES EQUIVALENT TO R .005/.010
45° CHAMFER FIRST THREAD
COML TOL APPLY TO STOCK SIZES

DRAWN	06-07-94	TF
CHECKED		
ENGR.	11-02-94	JP
MATERIAL		
SURFACE TREATMENT	N/A	

LORAD® A HOLOGIC COMPANY DANBURY, CT 06810

TITLE: ASSY, MOTHER BD.

SIZE	DWG. NO.	REV.
C	1-003-4024	A3

SCALE: 1:1 SHEET 1 OF 1

REVISIONS			APPROVED			
LTR	DESCRIPTION	DATE	MECH DESIGN	PROJ ENG	QUALITY	MFG ENG
A	REVISED PER ECN NO. 26394	1/24/12	N/A	ES	DG	SG
B	REVISED PER ECN NO. 26664	5/1/12	N/A	SK	DG	SK

1. U5 & U18 ARE OPTIONAL ITEMS AND ARE ONLY INSTALLED ON SPECIFIC CUSTOMER ORDERS.
2. ALL RESISTORS ARE 1/4W,5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
3. ALL CAPACITORS ARE IN MICROFARADS.
4. HIGHEST REFERENCE DESIGNATIONS USED: R43, RN5, C62, K2, D26, Q4, U21, Y1, J19, TP24.

NOTES :

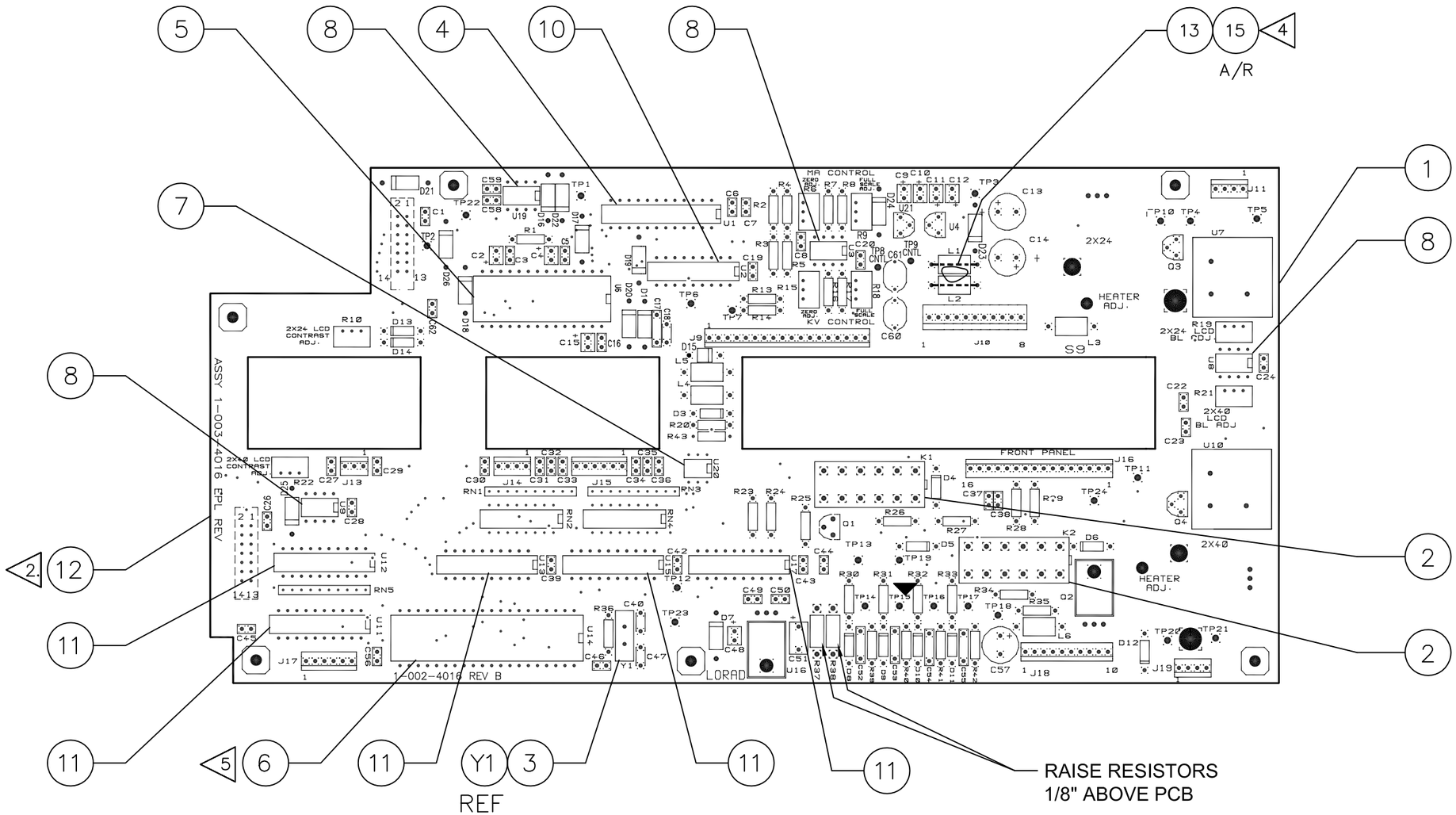
DIMENSIONAL TOLERANCES	DRAWN A. FROEHLICH	5/3/99
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CHECKED	
.X .XX .XXX ANGLES ±.015 ±.01 ±.005 ±1/2°	ENGR. D. SHARPE	12/02/99
FRACTIONS ±1/64	RELEASED	
ALL MACHINED SURFACES 125RMS	MATERIAL	N/A
BREAK & DEBURR ALL HOLES CORNERS & EDGES .03	SURFACE TREATMENT	N/A
45° CHAMFER FIRST THREAD COML TOL APPLY TO STOCK SIZES		

LORAD® CORPORATION DANBURY, CT. 06810

TITLE: SCHEMATIC MICROCOMPUTER BD

SIZE	DWG. NO.	REV.
D	1-004-4027	B
SCALE: 1:1	SK	SHT 1 OF 1

REVISIONS			APPROVED			
LTR	DESCRIPTION	DATE	MECH DESIGN	PROJ ENG	QUALITY	MFG ENG
A	REVISED PER ECN NO. 26394	1/25/12	NA	CF	DC	GC
B	REVISED PER ECN NO. 26664	5/1/12	NA	SK	DC	RK
B1	REVISED PER ECN NO. 27227	6/27/12	NA	JP	DC	RK
B2	REVISED PER ECN NO. 27566	9/12/12	NA	JP	DC	RK
B3	REVISED PER ECN NO. 27877	12/6/12	NA	JP	DC	RK
B4	REVISED PER ECN NO. 28495	5/21/13	NA	JP	DC	RK



PRIMARY SIDE

5. U14 IS INSTALLED AT UPPER LEVEL ASSEMBLY.

4. SEPARATE L1 AND L2, APPLY ITEM 15.

3. UNLESS OTHERWISE SPECIFIED: THIS ASSEMBLY IS TO MEET OR EXCEED IPC-A-610B CLASS 2 WORKMANSHIP STANDARDS.

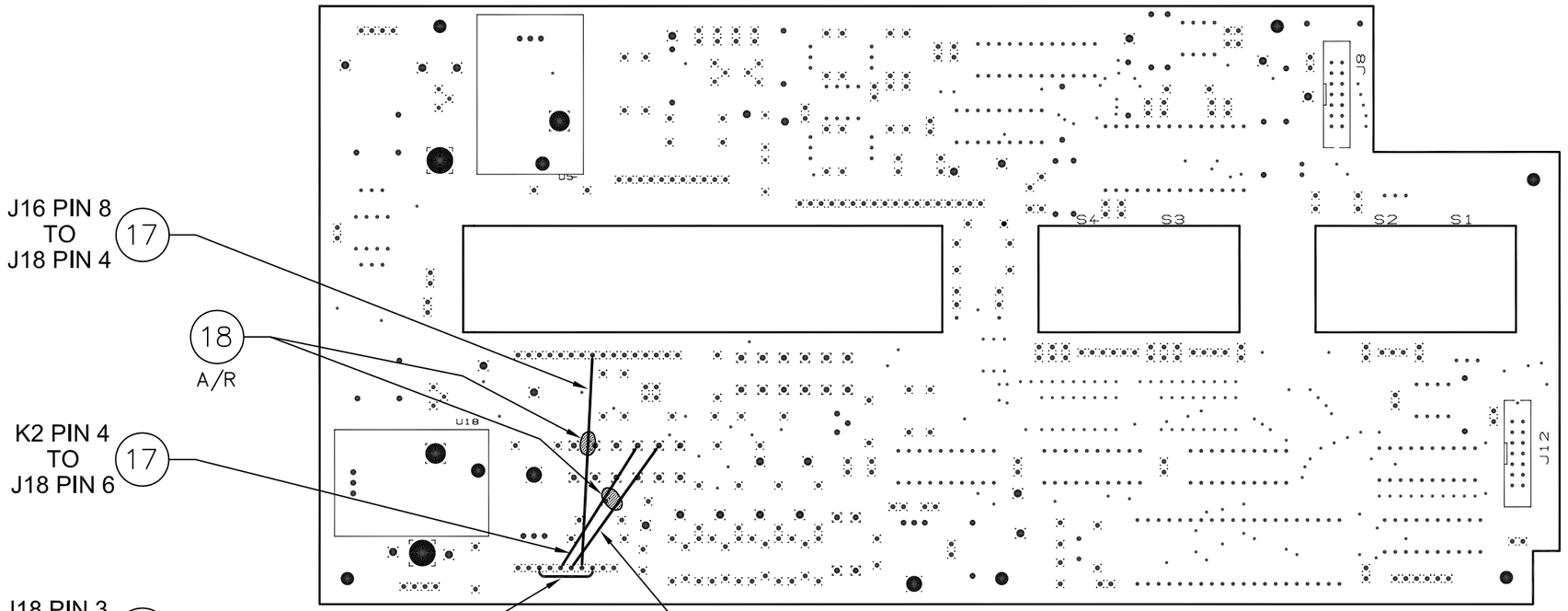
2. USING ITEM 12, LABEL APPROPRIATE ASSEMBLY NO. AND EPL REV. LEVEL APPROX AS SHOWN.

1. REF. DRAWING : DO NOT SCALE.

NOTES :

REV STATUS OF PARTS		
NO.	1-003-4027	
REV	B4	

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES .X ±.015 .XX ±.01 .XXX ±.005 ANGLES ±1/2° FRACTIONS ±1/64 ALL MACHINED SURFACES 125RMS BREAK & DEBURR ALL HOLES CORNERS & EDGES .03 45° CHAMFER FIRST THREAD COML TOL APPLY TO STOCK SIZES	DRAWN A. FROEHLICH	5/3/99	LORAD® CORPORATION DANBURY, CT. 06810
	CHECKED		
	ENGR. D. SHARPE	7/14/99	TITLE: ASSY, MICROCOM. BD DIGITAL
	RELEASED		
	MATERIAL: N/A		SIZE: D; DWG. NO.: 1-003-4027; REV.: B4
	SURFACE TREATMENT: N/A		SCALE: 1:1; SK; SHT 1 OF 2



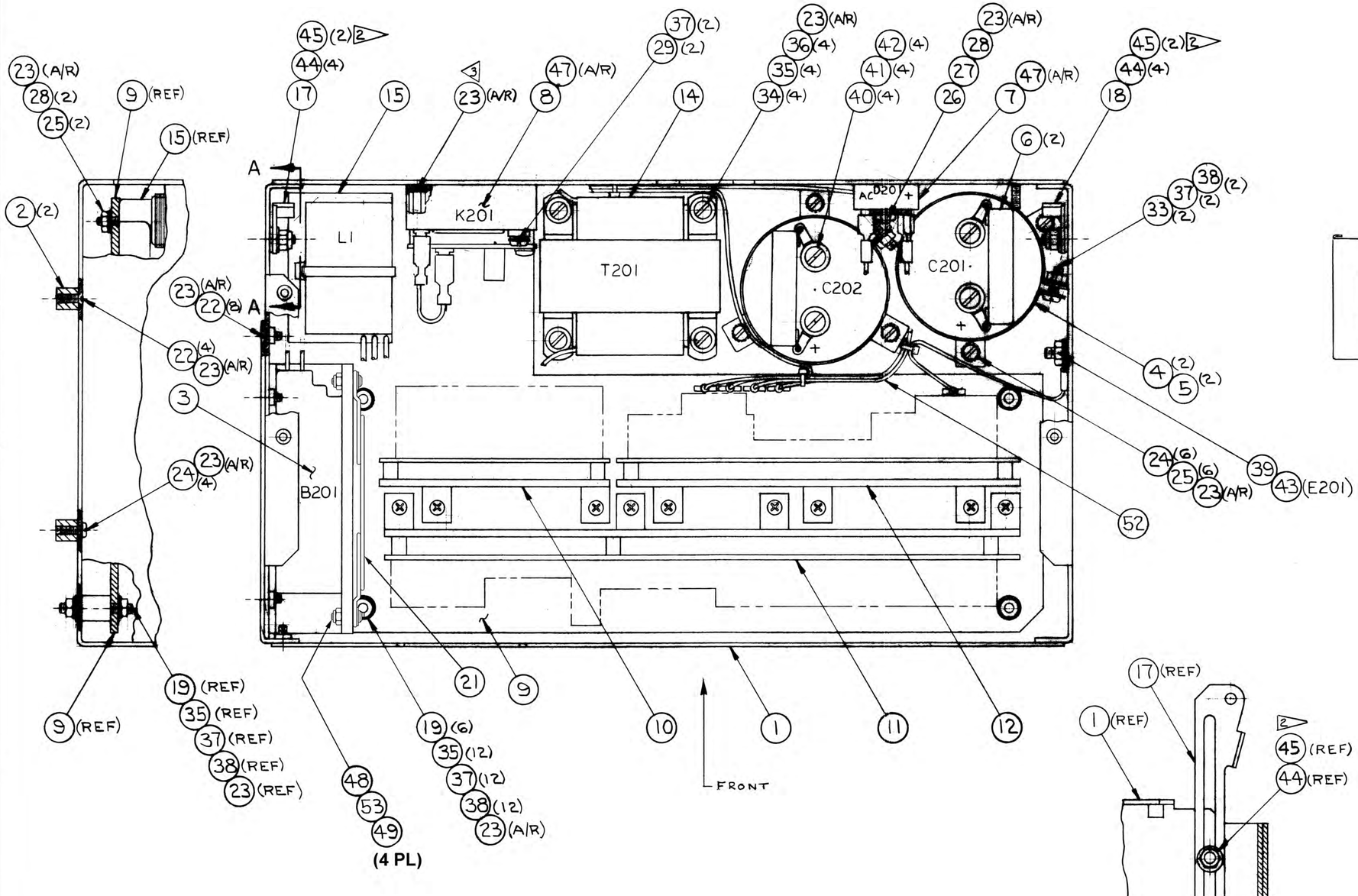
INSTALL 4 JUMPERS USING WIRE ITEM 17 AS SHOWN

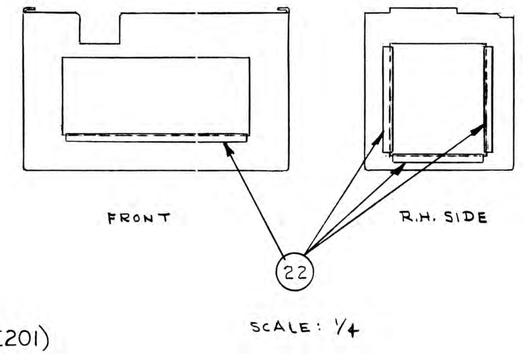
SECONDARY SIDE

LORAD® CORPORATION DANBURY, CT. 06810

TITLE		
ASSY, MICROCOM. BD DIGITAL		
SIZE: D	DWG. NO.: 1-003-4027	REV.: B4
SCALE: 1:1	SK	SHT 2 OF 2

REVISIONS						
DATE	ZONE	REV	DESCRIPTION	DR	CHK'D	APP'D
5/16/91		1	NEW RELEASE EN3566			
6-94	+	5	PER EN5233			
1-95	+	6	PER EN5759			
2-95		7	EN 5912			
3/23/12		A	REVISED PER ECN 26688		JS;DC;GC	
4/20/15		B	REVISED PER ECN 30962		JS;DC;JS	
7/27/15		B1	REVISED PER ECN 31249		CF;DC;WM	





PARTIAL VIEW A-A (TYP)
ROTATED 90° CW

3 TO ASSEMBLE ITEM 8: DISASSEMBLE RELAY, PC BD AND STANDOFF DISCARDING TWO SCREWS. REASSEMBLE AS SHOWN.

2 NUTS TO BE TIGHTENED SNUGLY, YET ALLOWING HINGE ARMS (ITEMS 17 & 18) TO SLIDE FREELY.

1. SEE SHEET 2 FOR CONTROL CHASSIS WIRING DIAGRAM.

NOTES:

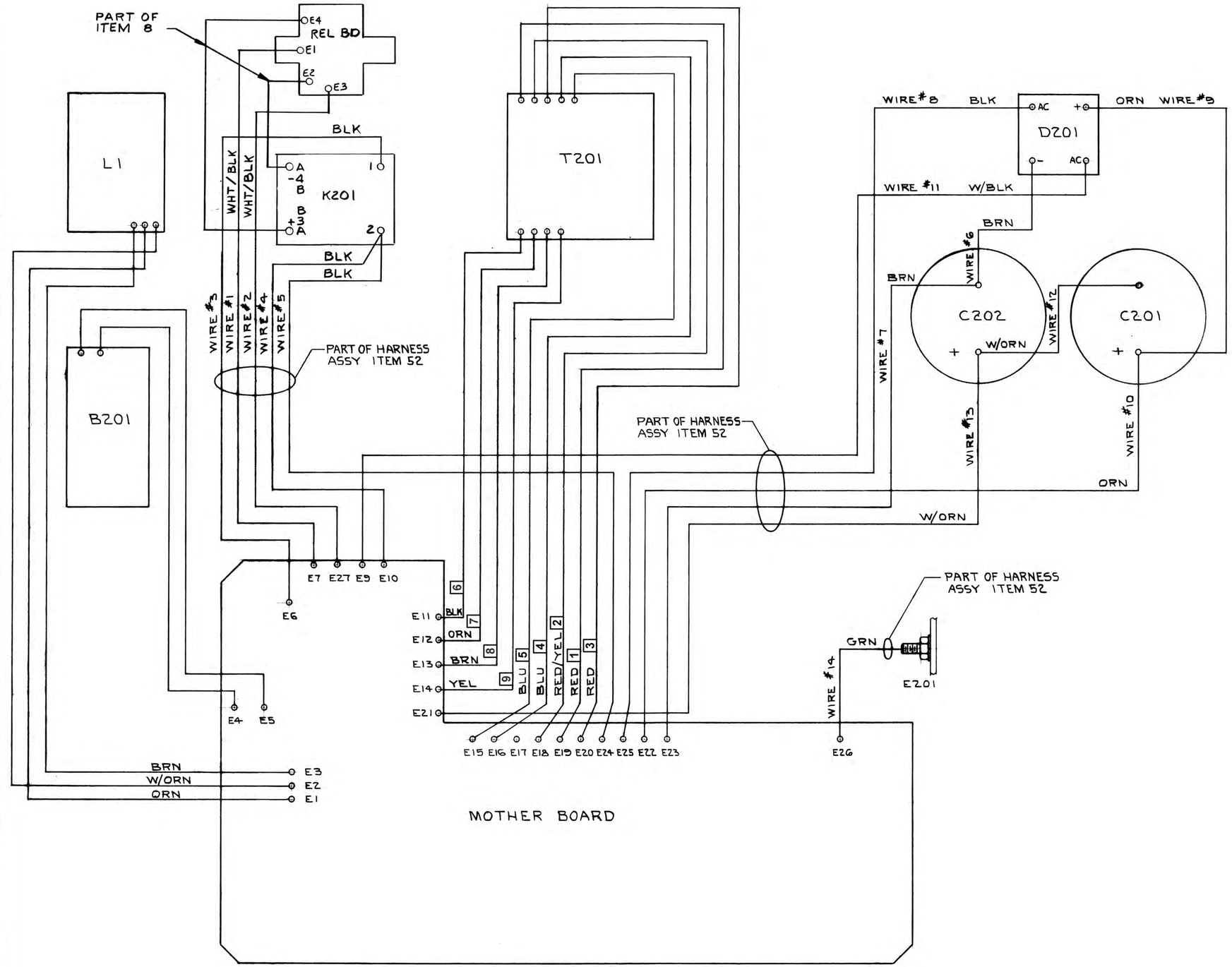
REV STATUS OF PARTS	
NO.	3-000-0749
REV	B1

NEXT ASSY	GEOMETRIC TOLERANCE SYMBOLS – ANSI Y14.5				DIMENSIONAL TOLERANCES
3-000A-0762	SYMMETRY		PROFILE OF A SURF.		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
	FLATNESS		ROUNDNESS		X .XX .XXX ANGLES .03 .005 .010 ±1/2°
	PERP.		STRAIGHTNESS		FRACTIONS 11/64
	PARALLELISM		COCENTRICITY		ALL MACH. SURF. ✓ BREAK & DEBURR ALL HOLES, CORNERS & EDGES .03
	POSITION		MAX MAT'L COND		45° CHAMFER FIRST THREAD
	RUNOUT		CYLINDERICITY		CONF. TOL. APPLY TO STOCK SIZES

USED ON	DRAWN		LORAD MEDICAL SYSTEMS, INC. DANBURY, CT 06810
LPX160	CHECKED 11-11-91		TITLE: ASSY, CHASSIS, CONTROL (LPX160)
	ENGR. 11-11-91		
	RELEASED		SIZE D DWG NO. 3-000-0749 REV. B1
	MATERIAL —		SCALE: FULL SHT 1 OF 2
	SURFACE TREATMENT —		A. PH.

REVISIONS						
DATE	ZONE	REV	DESCRIPTION	DR	CHK'D	APP'D
10/91		1	NEW RELEASE EN3566			

SEE SHEET 1 FOR LATEST EN



NEXT ASSY	GEOMETRIC TOLERANCE SYMBOLS - ANSI Y14.5				DIMENSIONAL TOLERANCES
	SYMMETRY		PROFILE OF A SURF.		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
	FLATNESS		ROUNDNESS		X 1.03 XX 1.01 XXX 1.008 ANGLES 1°/2°
	PERP.		STRAIGHTNESS		FRACTIONS 11/64
	PARALLELISM		COCENTRICITY		ALL MACH. SURF. ✓ RMS BREAK & DEBURR ALL HOLES, CORNERS & EDGES .03
	POSITION		MAX MAT'L COND		45° CHAMFER FIRST THREAD
	RUNOUT		CYLINDERICITY		CONF. TOL. APPLY TO STOCK SIZES

DRAWN		
CHECKED		
ENGR.		
RELEASED		
MATERIAL	//	
SURFACE TREATMENT	//	

USED ON //

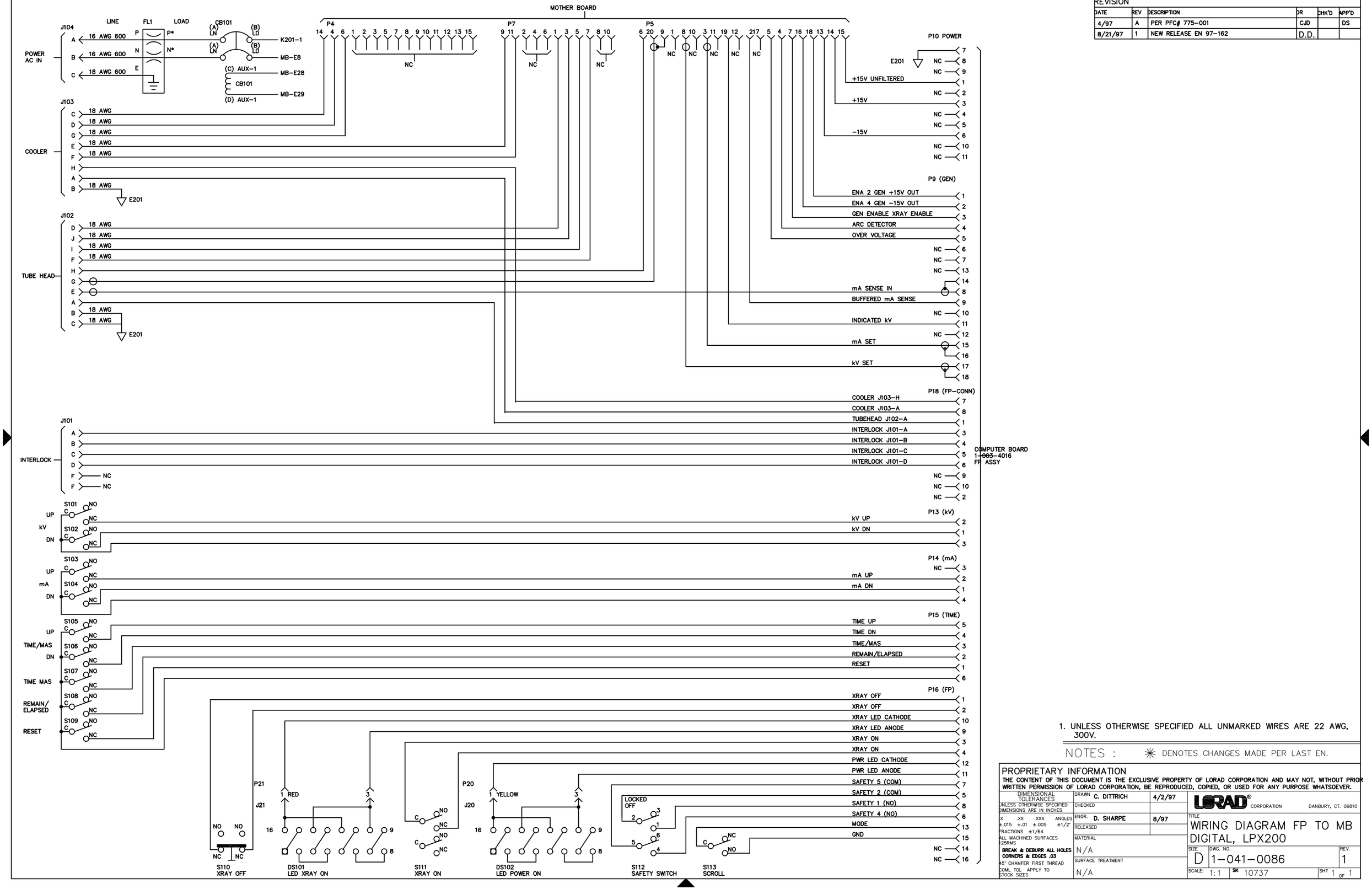
LORAD MEDICAL SYSTEMS, INC.
DANBURY, CT 06810

TITLE: ASSY, CHASSIS, CONTROL (LPX160)

SIZE D | DWG NO. 3-000-0749 | REV. B1

SCALE: — | SHT 2 OF 2

REVISION					
DATE	REV	DESCRIPTION	DR	CHK'D	APP'D
4/97	A	PER PFC# 775-001	CJD		DS
8/21/97	1	NEW RELEASE EN 97-162	D.D.		

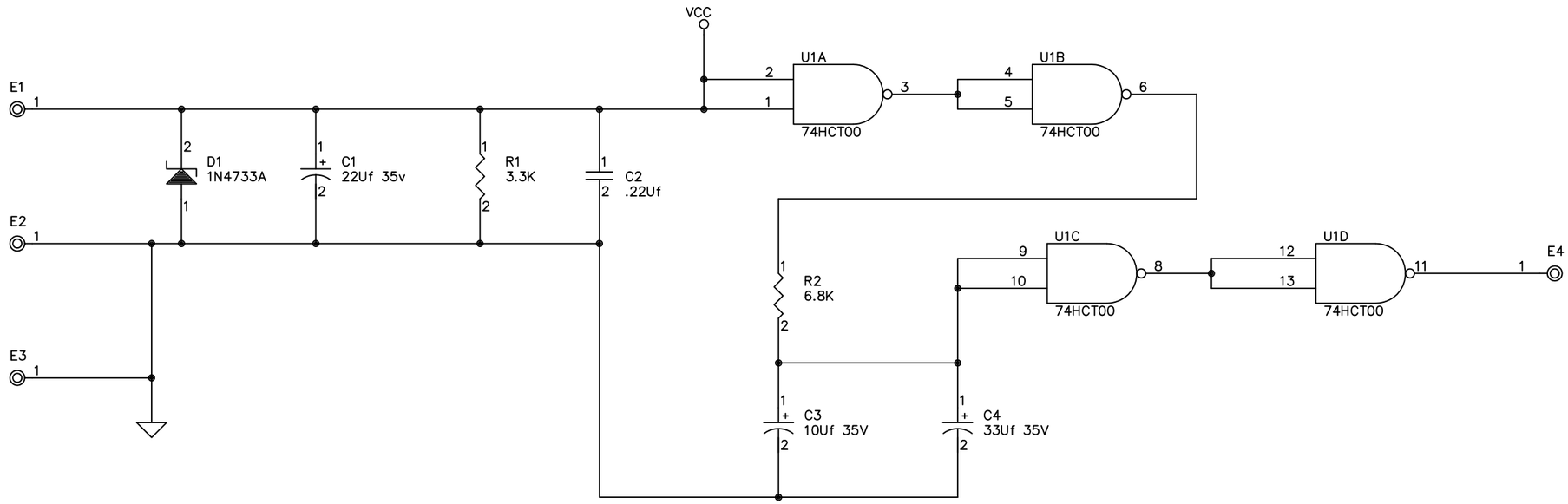


1. UNLESS OTHERWISE SPECIFIED ALL UNMARKED WIRES ARE 22 AWG, 300V.

NOTES : ✳ DENOTES CHANGES MADE PER LAST EN.

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES X .XX .XXX ANGLES ±.015 ±.01 ±.005 ±1/2° FRACTIONS ±1/64 ALL MACHINED SURFACES 125RMS **BREAK & DEBURR ALL HOLES CORNERS & EDGES .03** 45° CHAMFER FIRST THREAD COML TOL APPLY TO STOCK SIZES	DRAWN C. DITTRICH	4/2/97	LORAD® CORPORATION DANBURY, CT. 06810
	CHECKED		TITLE: WIRING DIAGRAM FP TO MB DIGITAL, LPX200
	ENGR. D. SHARPE	8/97	
	RELEASED		
	MATERIAL N/A		SIZE D · DWG. NO. 1-041-0086 · REV. 1
	SURFACE TREATMENT N/A		SCALE: 1:1 · SK 10737 · SHT 1 OF 1

REVISION						
DATE	ZONE	REV	DESCRIPTION	DR	CHK'D	APP'D
9–94		1	NEW RELEASE PER EN #5402	TF		DS



1. ALL RESISTORS ARE 1/4W,5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARADS.

NOTES :

NEXT ASSY	DIMENSIONAL TOLERANCES	DRAWN 04–25–94	TF
1–003–4023	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CHECKED	
	.X .XX .XXX ANGLES ±.015 ±.01 ±.005 ±1/2°	ENGR.	
	FRACTIONS ±1/64	RELEASED	
USED ON	ALL MACHINED SURFACES 125RMS	MATERIAL SEE NOTE 1	
LPX160	BREAK & DEBURR ALL HOLES CORNERS & EDGES .03	SURFACE TREATMENT SEE NOTE 2	
	45° CHAMFER FIRST THREAD		
	COML TOL APPLY TO STOCK SIZES		

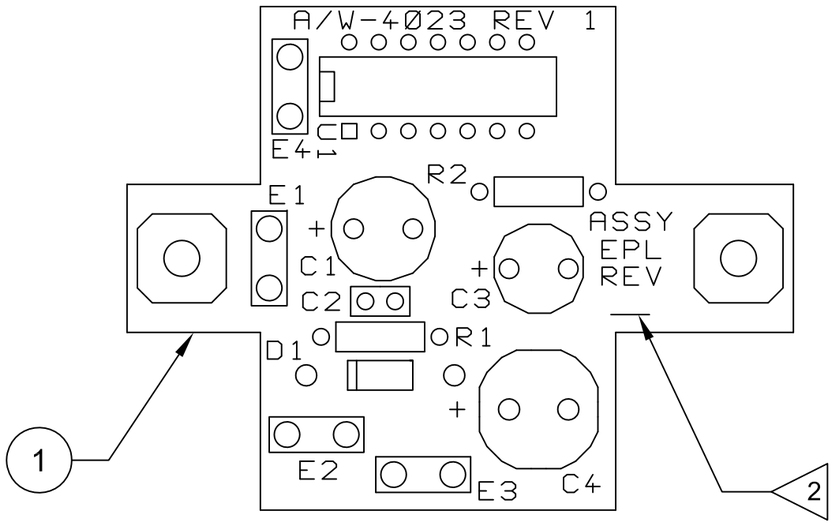
LORAD® CORPORATION DANBURY, CT. 06810

TITLE
SCHEMATIC,
CONDITIONING BD.

SIZE	DWG. NO.	REV.
B	1–004–4023	1

SCALE: 1:1	SK REV.	SHT 1 OF 1

REVISIONS				APPROVED		
LTR	DESCRIPTION	DATE	MECH DESIGN	PROJ ENG	QUALITY	MFG ENG
2	REV PER EN #5914	2/95	AA			
A	REVISED PER ECN NO. 26737	4/3/12	N/A	CF	DC	RK



NOTES:
1. REF DRAWING : DO NOT SCALE.

2. USING PERMANENT INK MARK APPROPRIATE EPL REV LEVEL IN DESIGNATED AREA.

REV STATUS OF PARTS			
NO.	1-003-4023		
REV	A		

NEXT ASSY	DIMENSIONAL TOLERANCES	DRAWN JF	4/25/94
3-000-0733	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CHECKED	
	.X ±.015 .XX ±.01 .XXX ±.005 ANGLES ±.25°	ENGR. D SHARPE	9/94
	FRACTIONS ±1/64	RELEASED	
USED ON	ALL MACHINED SURFACES 125RMS	MATERIAL	
LPX-160	BREAK & DEBURR ALL HOLES CORNERS & EDGES .03	SEE NOTE 1	
	45° CHAMFER FIRST THREAD	SURFACE TREATMENT	
	COML TOL APPLY TO STOCK SIZES	SEE NOTE 2	

LORAD® CORPORATION DANBURY, CT. 06810

ASSY, CONDITIONING BD

SIZE	DWG. NO.	REV.
B	1-003-4023	A

SCALE: 1/1 | SK | REV. | SHEET 1 OF 1