

# **Phantom** Portable X-Ray System

# Installation, Operation & Service

Manual



P/N 8000-Phantom Revision: B, November 8, 2007 Table of Contents

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# **Safety Information**

# Introduction

The policy of Del Medical Systems Group is to manufacture X-ray equipment that meet high standards of performance and reliability. We enforce strict quality control techniques to eliminate the potential for defects and hazards in our products.

The intended use of this equipment is to provide an X-ray source for the purpose of acquiring X-ray images of the desired parts of a patient's anatomy. Use of this equipment in any other fashion may lead to serious personal injury.

The safety guidelines provided in this section of the manual are intended to educate the operator on all safety issues in order to operate and maintain the Phantom in a safe manner.

# **Statement of Liability**

To prevent excess radiation exposure to patient and operator from either primary or secondary radiation, this Phantom must be operated and serviced by trained personnel who are familiar with the safety precautions required. While this Phantom has been designed for safe operation, improper operation or carelessness may result in serious injury or damage to equipment. The manufacturer or its agents and representatives assume no responsibility for the following:

- 1 Injury or danger to any person from x-ray exposure.
- 2 Overexposure due to poor technique selection.
- 3 Injury or danger from improper use of the Phantom function.
- **4** Problems or hazards resulting from failure to maintain the equipment as specified in this manual.
- **5** Equipment which has been tampered with or modified. Del Medical Systems Group is not liable for any damage or injury arising from failure to follow the instructions and procedures provided within the manuals or associated informational material, or from user failure to use caution when installing, operating, adjusting, or servicing this equipment. Del Medical Systems Group is not liable for damage or injury arising from the use of this product for any other use than that intended by the manufacturer.

# Definitions

The table below defines the meaning of various symbols used on labels on the machine.

| $\triangle$  | This warning symbol is used to indicate a potential haz-<br>ard to operators, service personnel or equipment. It indi-<br>cates a requirement to refer to the accompanying<br>documentation for details.  |  |
|--|---|--|
| 4  | This symbol indicates that there is accessible dangerous voltage.   |  |
| Ţ  | This symbol identifies a protective earth terminal.   |  |
| Ť  | This symbol states that this product is categorized as<br>Type B.<br>Type B is defined as:<br>Equipment providing a particular degree of protection<br>against electric shock, particularly regarding allowable<br>leakage currents and reliability of the protective earth<br>connection (if present). |  |
| $\bigotimes$   | This product contains no field serviceable parts.   |  |
| Rest of the second seco | Special Cleaning Instructions   |  |
| One or more of the following regulatory symbols are found on the equip-<br>ment.   |   |  |
| c Us   | UL Classified Device  |  |

# Safety Conventions Used in this Manual

Specific safety information is listed in this manual in the form of WARNING and CAUTION statements. Pay close attention to these statements - they contain important information on avoiding potential hazards to you or the equipment.

#### **Warning Statements**

- are used to indicate hazards or unsafe practices which COULD result in severe personal injury or death.
- appear in **bold** type.
- have a triangular symbol with an exclamation point above the text.
- are preceded by the word **Warning**.
- are always found before the step or piece of information to which they refer to.
- look like the following example:

#### 🚺 Warning

This text will describe special safety precautions to follow in order to avoid unsafe practices that COULD result in severe personal injury or death.

#### **Caution Statements**

- are used to indicate hazards or unsafe practices which could result in minor personal injury or product or property damage.
- appear in **bold** type.
- have a triangular symbol with an exclamation point above the text.
- are preceded by the word **Caution**.
- are always found before the step or piece of information to which they refer to.
- look like the following example:



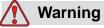
This text will describe special safety precautions to follow in order to avoid unsafe practices that could result in personal injury or product or property damage.

# **Equipment Safety Guidelines**

The following are general safety precautions:

- Do not defeat or bypass built-in equipment safety features.
- Observe all warnings and cautions, stated or implied, in the procedures.
- Follow all safety labels on the equipment.

The following warnings and cautions are specific to the Phantom. Read them carefully - some of them **are not obvious** to typical equipment use.



Do not perform any service procedures on this device until the power cord has been disconnected and the device has been allowed to discharge for at least 5 minutes. You can be fatally shocked if you do not.

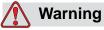
Voltage as high as 100,000 volts may be present in the Phantom's circuitry for a few minutes after it has been turned off.



All of the movable assemblies and parts of this equipment should be operated with care and routinely inspected in accordance with the manufacturer's recommendations contained in this manual.

Only properly trained and qualified personnel should be permitted access to any internal parts. Live electrical terminals are deadly; be sure line disconnect switches are opened and other appropriate precautions are taken before opening access doors, removing enclosure panels, or attaching accessories.

For all components of the equipment, protective earthing means must be provided in compliance with the national regulations.



This Phantom is intended to be used as part of a system for the intended generation of X-rays for medical diagnosis.

X-rays generate a potential risk for both patients and operators.

For this reason, the application of X-rays for a given medical purpose must aim at the minimization of radiation exposition to any persons.

Those persons responsible for the application must have the specific knowledge according to legal requirements and regulations and must establish safe exposure procedures for this kind of systems.

Those persons responsible for the planning and installation of this equipment must observe the national regulations.



Federal law restricts this device for sale or use by or on order of a physician or properly licensed practitioner.



Only qualified personnel may operate the Phantom. Operation of the equipment by persons who have not been trained or who are unfamiliar with the Phantom may cause serious injury to the patient, serious injury to the operator, or equipment damage.



The Phantom includes no user serviceable parts. For service assistance, contact Del Medical.

## Warning

The Phantom produces ionizing radiation. Operators must meet all state and local requirements and regulations.

#### 🚺 Warning

The Phantom and associated cables must not be operated in the presence of moisture.



The Phantom is rated as Class I Equipment, ensure that the earth grounding connections between the Phantom and its power source is maintained at all times.



The Phantom is not suitable for operation in the presence of a flammable anesthetic mixture with air, oxygen, or nitrous oxide.



Disconnect electrical power from the Phantom before servicing. Use care not to drop tools or other objects into the Phantom when working on or around the unit. Electrical shock could result.

# Safety and Compliance

Exposure to ionizing radiation such as X-rays can be hazardous. United States federal regulations establish appropriate exposure limits so that the patient, the operator, and the general public are not unnecessarily being exposed to such radiation. Personnel operating systems such as the Phantom must be trained and qualified. They must be familiar with established regulations and understand the risks associated with the operation of a X-ray system. They must know what action to take if and when a hazardous situation arises.

For a more complete understanding of radiological hazards and their control, X-ray system operators are referred to publications, such as:

Medical X-ray, Electron Beam and Gamma Ray Protection for Energies up to 50 MeV – Equipment Design, Performance and Use (Report No. 102, National Council on Radiation Protection)

Medical X-Ray Protection up to Three Million Volts (Handbook No. 76, National Bureau of Standards/National Institute for Standards and Technology)

In addition to ionizing radiation, other safety concerns are addressed by various U.S., Canadian, and international standards. The component parts and subsystems used in the Phantom have all been tested for compliance with the safety standards in effect at the time of manufacture in the United States (UL 187) & Canada (CAN/CSA C22.2 No. 114-M90).

The results of these safety tests and inspections show that the Phantom is safe. There are, however, certain residual hazards resulting from the mechanical articulation of the system. Minimizing the risk of injury to the patient and to the operator resulting from these residual hazards requires care and alertness at the time of installation. Pinch points are labeled as appropriate at the time of installation. These labels must not be removed. If they become soiled or damaged, they need to be replaced.

# **Radiation Protection**

Serious unfavorable health effects can result from short term exposure to high levels of ionizing radiation (such as X-rays) as well as from long term exposure to low levels. Personnel who operate the Phantom should familiarize themselves with both the short term and the long term effects of radiation exposure and take appropriate measures to minimize the amount of radiation to which they are exposed while performing their duties. Some effects of X-ray radiation are cumulative, and may extend over a period of months or years. The best safety rule for X-ray operators is to avoid exposure to the primary beam at all times.

Ionizing radiation occurs naturally in the environment. It is generated by astronomical radiation sources such as the sun and the stars, and by the soil under our feet. The atmosphere filters radiation from astronomical sources. As a result, the radiation level from these sources is much lower at sea level than on the summit of high mountains. Radiation generated in the soil varies greatly from place to place depending on the composition of the soil. For example, areas rich in granite rock have a higher level of radiation than other areas.

Any materials placed in the path of the beam absorb natural as well as man-made radiation, such as the X-rays used in the Phantom. Materials with a high atomic number, such as tungsten, lead, and uranium, absorb X-rays much more effectively than materials with a low atomic number such as hydrogen, aluminum, or beryllium. Therefore, lead is used for shielding the radiologist's workstation in most X-ray facilities, including ones using the Phantom. If there are windows in the partition separating the operator from the patient, these windows are typically glazed with lead glass and provide effective protection against ionizing radiation.

To minimize dangerous exposure, use movable lead screens, lead-impregnated gloves, and lead-impregnated aprons. These protective devices must contain 0.25 millimeter thickness of lead or the equivalent. Use such protective devices for all operators, observers, and/or servicing personnel exposed to radiation fields of five or more milli-Roentgens per hour.

The shielding provided for a typical X-ray facility's operator workstation is generally quite effective and reduces the residual radiation from diagnostic X-rays to a level that is comparable to or lower than natural background radiation. If the operator abandons the protected environment of the workstation, he or she may be exposed to a significantly higher level of radiation. For a single exposure this may still not lead to serious health effects, but repeated carelessness in this regard may lead to serious consequences.

Any object in the path of the primary beam produces scattered radiation. In the absence of proper precautions, scattered radiation can result in a substantial radiation dose to the operator or any other personnel in the facility. Moveable screens may be used to shield occupied areas from scattered radiation.

The X-ray Generator/host system used to power the Phantom only produces X-rays when high voltage is applied to the X-ray tube. When the high voltage is removed, X-ray emission ceases without delay.

#### Maximum Permissible Dose (MPD)

Various studies of the effects of x-ray radiation have provided a foundation for establishing the maximum permissible does (MPD) of x-ray radiation. The results of these studies have been used by the NCRP and the ICEP to develop recommendations for MPD.

ICRP recommends that the MPD to the most critical organs (heart, lungs, liver, kidney, brain, etc.) accumulated at any age shall not exceed five rems multiplied by the number of years beyond 18:

M PD = 5 X (N - 1 8) rems where n age in years

However, in no case shall the exposure exceed three (3) rems in any period of 13 consecutive weeks.

For hands, forearms, feet and ankles, the recommended MPD is 75 rems in any one year.

# **Identification Labels**

The Phantom components have manufacturing and certification information affixed. The manufacturing label contains:

- The full name and address of the manufacturer of the component
- The place, month, and year of manufacture
- The model number and serial number of the component

The certification label also states that the component complies with either "21CFR, Subchapter J", or the applicable DHHS standards under the Radiation Control for Health and Safety Act of 1968 (or its equivalent).

A label may combine both manufacturing and certification information.

#### **Phantom Labels**

The location of each Phantom identification label is shown in Figure i-1.

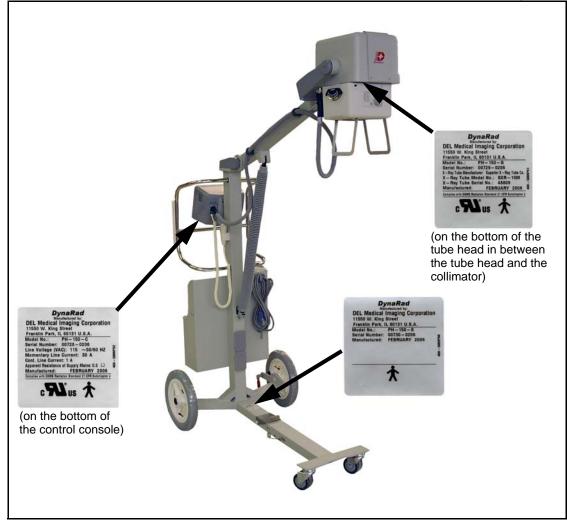


Figure i-1. Phantom Identification Labels

# **Radiation Safety**

#### Safety

Everyone associated with X-ray work must be familiar with the recommendations of the Center for Devices and Radiological Health (CDRH), the National Institute for Standards and Technology (NIST), the National Council on Radiation Protection (NCRP), and the International Committee on Radiation Protection (ICRP).

Be sure that all personnel authorized to operate the X-ray system are familiar with the established regulations of the authorities named above. All personnel should be monitored to ensure compliance with recommended procedures.

Current sources of information include:

- *National Council on Radiation Protection Report No. 33* ("Medical X-ray and gamma ray Protection for Energies up to 10 MEV-Equipment Design and Use").
- *National Bureau of Standards Handbook No. 76* ("Medical X-ray Protection up to Three Million Volts"). Refer to NCRP Report No. 33.
- Current recommendations of the International Committee on Radiation Protection.

Although X-ray radiation is hazardous, X-ray equipment does not pose any danger when properly used. Be certain all operating personnel are properly educated concerning the hazards of radiation. Persons responsible for the system must understand the safety requirements and special warnings for X-ray operation. Review this manual and the manuals for each component in the system to become aware of all safety and operational requirements.



Ensure exposure parameters are properly adjusted within safety limits.



Incorrectly positioning the X-ray tube and Collimator could cause the X-ray field to be misaligned with the bucky, resulting in unacceptable images.

# Manufacturer's Responsibility

Although this equipment incorporates protection against X-ray radiation other than the useful beam, practical design does not provide complete protection. Equipment design does not compel the operator or assistants to take the necessary precautions; nor does it prevent the possibility of improper use (authorized or unauthorized persons carelessly, unwisely, or unknowingly exposing themselves or others to direct or secondary radiation). Allow **only** authorized, properly trained personnel to operate this equipment.

Be certain that all individuals authorized to use the equipment are aware of the danger of excessive exposure to X-ray radiation.

This equipment is sold with the understanding that the manufacturer, its agents, and representatives, do not accept any responsibility for overexposure of patients or personnel to X-ray radiation.

Furthermore, the manufacturer does not accept any responsibility for overexposure of patients or personnel to X-ray radiation generated by the equipment used in conjunction with the Phantom components as a result of poor operating techniques or procedures.

No responsibility is assumed for any unit that has not been serviced and maintained in accordance with the technical service manual, or which has been modified or tampered with in any way.

## **Monitoring Personnel**

Monitoring personnel to determine the amount of radiation to which they have been exposed provides a valuable cross-check to determine whether or not safety measures are adequate. This cross-check may reveal inadequate or improper radiation protection practices and/or serious radiation exposure situations.

The most effective method of determining whether the existing protective measures are adequate is the use of instruments to measure the exposure (in rads). This measurement should be taken at all locations where the operator, or any portion of the operator's body, may be inadequately shielded during exposure. Exposure must never exceed the accepted tolerable dose.

A frequently used, but less accurate, method of determining the amount of exposure is placement of film at strategic locations. After a specified period of time, develop the film to determine the amount of radiation. Fluorescent screens (used in a darkened room) may also be used to detect excessive radiation.

A common method of determining whether personnel have been exposed to excessive radiation is the use of film badges. These are X-ray sensitive film enclosed in a badge that incorporates metal filters of varying degrees of transparency to X-ray radiation. Even though this device only measures the radiation reaching the area of the body on which it is worn, it does provide an indication of the amount of radiation received.

# **Radiation Protection Survey**

A radiation protection survey must be made by a qualified expert after every change in equipment or change in operating conditions which might significantly increase the probability of personnel receiving more than the maximum permissible dose equivalent.

Restrictions on Use



Do not install components or accessories that were not intend for use by the system. Failure to comply could result in damage to the equipment or injury to personnel.

The user is responsible for ensuring that the application and use of the Phantom does not compromise the patient contact rating of any equipment used in the vicinity of, or in conjunction with, the system.

The use of accessory equipment and/or hardware not complying with the equivalent product safety and EMC requirements of this product may lead to a reduced level of safety and/or EMC performance of the resulting system. Consideration relating to the choice of accessory equipment used with this product shall include:

- The use of the accessory in the patient vicinity
- Evidence that the safety certification of the accessory has been performed in accordance with the appropriate IEC 60601-1 and/or IEC 60601-1-1 Harmonized National Standards

Some components of the Phantom have been classified as to acceptable applications of use in accordance with Information Technology Equipment regulations such as EN60950.

### Caution

Observe all safety precautions recommended by the accessory equipment manufacturer in the user documentation provided with the equipment.

The hardware specified for use with the Phantom has been selected, tested, and verified by Del Medical to meet the intended applications. All specified hardware meets applicable regulatory agency requirements for those countries where it is offered for sale with respect to its intended applications. Consult the user documentation included with the equipment for specific information relating to product safety and EMC compliance.

# **Hazardous Materials**

The collimator used with the Phantom contains lead. Refer to the manual provided with the collimator for additional information regarding hazardous materials.

## **Applicable Standards**

This X-ray generator complies with the following regulatory requirements and design standards:

FDA 21 CFR Subchapter J, UL187 & CAN/CSA C22.2 No. 114-M90.

Type of protection against electric shock: Class I

Degree of protection against electric shock is Type B Applied Parts.

Degree of protection against harmful ingress of water: IPXO.Ordinary

Mode of Operation: 0.5% Duty Cycle.

Equipment not suitable for use in the presence of flammable anesthetic mixture with air, oxygen or nitrous oxide.

Degree of protection against electric shock is Type B applied part.

The equipment is intended to be used as a mobile X-ray generator in a mobile or stationary radiographic diagnostic X-ray configuration.

# **Record of Revisions**

# **Revision History**

| REV | Date    | Reason for Change   |
|-----|---------|---|
| А   | 6-15-06 | Original  |
| В   | 10-2-07 | Chapter 1: Line Volt Regulation added to Specifications<br>Chapter 3: Line Volt Regulation added to Specifications, start-up<br>indications added<br>Chapter 4: items added to periodic maintenance<br>Chapter 5: calibration added<br>Chapter 6: instructions to remove control console back cover<br>added, X-Ray tube head replacem. procedure changed<br>Chapter 7: schematics removed (ref. to chapter 8)<br>Chapter 8: rev. level column added to table, schematics revised<br>Throughout the manual: uniform terminology |

Table ii-1. Revision History

# Introduction

# **1.1 Introduction**

This manual provides installation, operation and service information for the Phantom Portable X-Ray System. This manual also includes a spare parts list for the system.

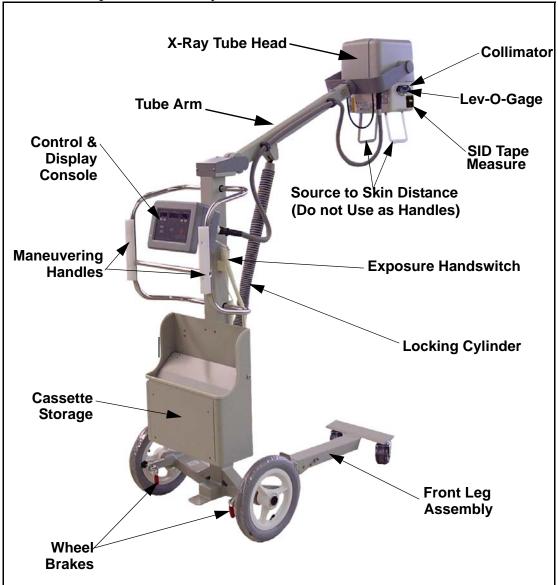


Figure 1-1. The Phantom Portable X-Ray System

# **1.2 Description**

The DynaRad Phantom is a portable and rugged x-ray system that provides high-quality x-ray images at an affordable price.

The Phantom can retract into a small, self-contained package that can be easily transported and set up in the most demanding environments.

And it's easy to maneuver and operate.

#### **1.2.1 Standard Features**

- 1.25 Kilowatt X-Ray Generator
- Tape Measure for SID Distance
- Inclinometer
- Detachable, Two-Stage Handswitch
- 30-Second Timer on Collimator Lamp
- Digital Displays on Membrane Switch Control Panel
- Manually Controlled Certified Collimator
- Pneumatic Rear Tires
- Spring-Loaded Counter Weight Ram to Ease Positioning of X-Ray Tube

# 1.3 Dimensions

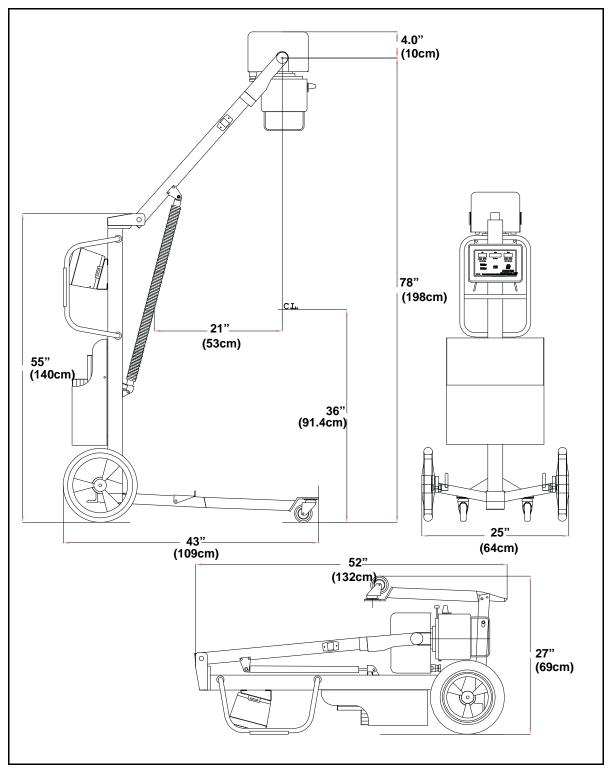


Figure 1-2. Dimensions

# **1.4 Specifications**

| Specifications                                    |  |  |
|---|--|--|
| Voltage   | 104-126VAC/208 - 253 VAC   |  |
| Line Voltage Regulation                           | 5% maximum at maximum output   |  |
| Current   | 30 Amps Maximum Momentary @ 115VAC<br>Requires 30 amp or greater dedicated breaker or line fuse.<br>18 Amps Maximum Momentary @ 230VAC<br>Requires 18 amp or greater dedicated breaker or line fuse. |  |
| Frequency   | 50/60 Hz Single Phase  |  |
| Generator Type                                    | High frequency inverter, 1.25 kilowatt output  |  |
| kVp Range   | 50-100 kVp continuously adjustable, with 1 kVp resolution  |  |
| mA Range  | Fixed, 12.5 mA, constant independent of kVp or time settings   |  |
| Exposure Time                                     | 0.01 to 4.0 seconds in 96 increments   |  |
| X-Ray Tube  | Stationary Anode 100 kVp   |  |
| Filtration  | 3.6 mm Aluminum Equivalent or More @ 100kVp  |  |
| Target Material                                   | Tungsten   |  |
| Anode Capacity                                    | 25,000 Heat Units  |  |
| Focal Spot  | 1.0 mm (NEMA)  |  |
| Beam Angle  | 15°  |  |
| Collimator  | Certified Manual   |  |
| Collimator Lamp Source                            | 30 second timer  |  |
| Duty  | 3.3%   |  |
| Mode of Operation                                 | Momentary  |  |
| Relative Humidity Limits                          | Transit/Storage<br>10% to 100%<br>Operating<br>10%-80% Non-Condensing  |  |
| Atmospheric Limits                                | 14.5 inHg to 30.74 inHg<br>500 hPa to 1060 hPA   |  |
| Weight  | 95 lbs (42 Kg) Total/ X-Ray Generator 39lbs (17.7 kg)/Control<br>Console (7 lbs (3.2kg)  |  |
| Certifications:                                   | Classified To UL 187. Certified To CAN/CSA C22.2 No. 114-M90.  |  |
| Equipment not suitable for use in the preservide. | nce of flammable anesthetic mixtures with air, oxygen or nitrous   |  |
| No user serviceable parts                         |  |  |

Table 1-1: Specifications

# **1.5 Abbreviations**

- % Percent
- Btu British Thermal Unit
- ° C Degree Celsius
- cm Centimeter
- ° F Degree Fahrenheit
- ga Gauge
- hPa Hecto Pascal
- inHg Inches Mercury
- Kg Kilogram
- Lb Pound
- M Meter
- max. Maximum
- min. Minimum
- mm Millimeter
- UL Underwriters Laboratories

# **1.6 Accuracy Statements**

#### kVp

Kilovoltage will not deviate from the selected value by more than +/- 5%

Measurements made with a Keithley kVp Divider model 35080A and a Keithley Dosimeter model 35050A at 0.1 seconds.

#### mΑ

mAs will not deviate from the selected value more than +/-10% or .5 mAs which ever is greater within a range of .125 - 50 mAs.

Measurements made with a Keithley mAs meter model 35035 or equivalent.

#### Time

Exposure time will not deviate from the selected value more than +/-2 %, plus +/-3ms. within a range of 0.01 - 4.0 seconds.

Measurements made with a Keithley kVp Divider model 35080A and a Keithley Dosimeter model 35050A

# Installation

# 2

# 2.1 Assembly Instructions

#### **Tools Required:**

- Claw Hammer
- Diagonal Cutters
- Medium Flat-Tip Screwdriver
- 1 Cut and remove shipping straps (1 in Figure 2-1).
- **2** Remove box cover (2).
- **3** Remove nails (3) from side of shipping box with claw hammer.



Figure 2-1. Shipping Box

- 4 Cut strap (1 in Figure 2-2) and remove accessories box (2).
- **5** Remove shipping braces (3).

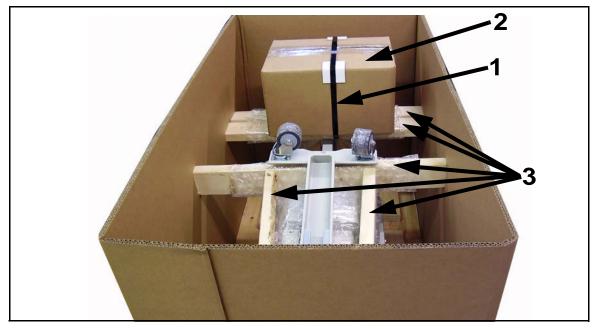


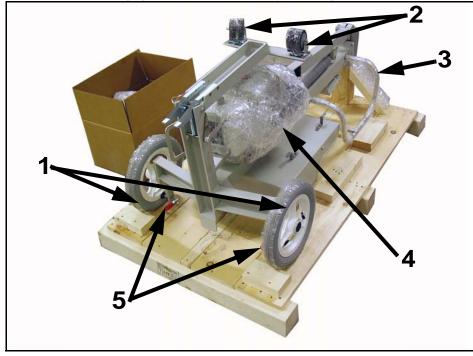
Figure 2-2. Shipping Box - Open



**6** Open and empty accessories box. Figure 2-3 shows proper contents of box.

Figure 2-3. Accessory Box Contents

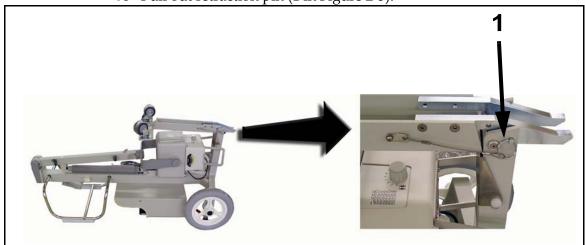
7 Remove shipping plastic from rear wheels (1 in Figure 2-4), front wheels (2), handle bars (3) and X-ray head (4).



8 Disengage wheel brakes (5) by turning red knobs inward.

Figure 2-4. Phantom on Pallet

9 Lift unit off of its shipping skid and place it on floor as shown below



**10** Pull out retraction pin (1 in Figure 2-5).

Figure 2-5. Retraction Pin

- 11 Tilt front leg assembly (1 in Figure 2-6) to its vertical position and lock in place by reinserting pin (2).
- **12** Lift up on handle bar (3) to tilt unit into its upright position as shown in Figure 2-7.

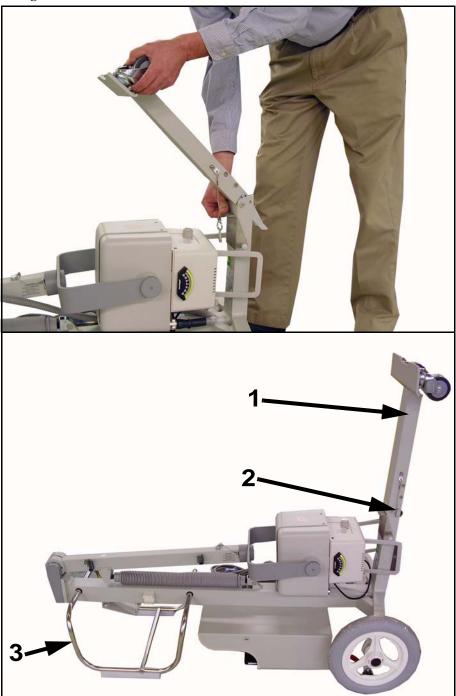


Figure 2-6. Extending Front Leg Assembly

**13** SLide release lever (1 in Figure 2-7) forward and tilt tube arm assembly (2) into an approximate horizontal position as shown in Figure 2-7.



Figure 2-7. Release Lever on Tube Arm



Figure 2-8. Tube Arm - Horizontal Position



**14** Tilt X-ray assembly (1 in Figure 2-9) down.

Figure 2-9. X-Ray Head Assembly

**15** Align four pins (1 in Figure 2-10)on control console with holes (2) on frame. Then tap console into place with the ball of your hand as shown in Figure 2-11.

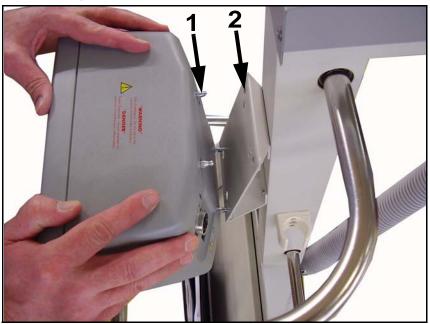


Figure 2-10. Control Console Alignment

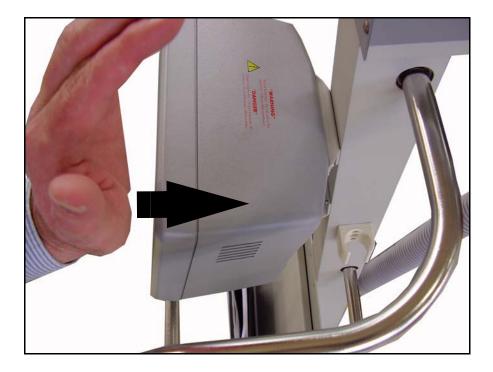


Figure 2-11. Control Console Mounting



Be very gentle in the next step. The clamps are very fragile and break easily.

**16** Very gently insert screwdriver into each clamp hole (1 in Figure 2-12) and gently open each clamp.

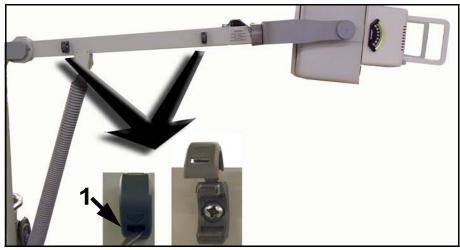


Figure 2-12. Opening Clamps



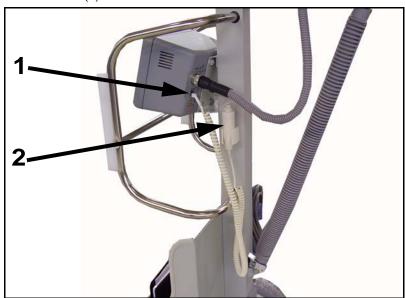
**17** Connect interconnect cable (1 in Figure 2-13). Female end to X-ray head (2) and male end to control console (3).

Figure 2-13. Interconnect Cable Connections



**18** Insert cable into clamps (1 in Figure 2-14) and close clamps.

Figure 2-14. Interconnect Cable in Clamps



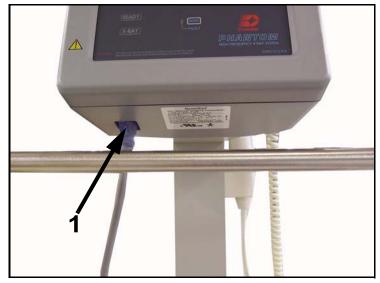
**19** Insert handswitch cable (1 Figure 2-15) into control console and place handswitch (2) into its holder.

Figure 2-15. Handswitch Connection

**20** Remove power cable (1 in Figure 2-16) from its hook and unwrap it.



Figure 2-16. Power Cord



**21** Connect power cord (1 in Figure 2-17) to control console.

Figure 2-17. Power Cord Hookup

# Installation is Complete

# Operation

# 3.1 Safety Precautions



X-rays generate a potential risk for both patients and operators.

For this reason, the application of X-rays for a given medical purpose must aim at the minimization of radiation exposure to any persons.

Those persons responsible for the application must have the specific knowledge according to legal requirements and regulations and must establish safe exposure procedures for this kind of system.

Those persons responsible for the planning and installation of this equipment must observe the national regulations.

# 3.2 Operation Specifications

|  | Specifications   |  |
|--|--|--|
| Voltage  | 104-126VAC/208 - 253 VAC   |  |
| Line Voltage Regulation                          | 5% maximum at maximum output   |  |
| Current  | 30 Amps Maximum Momentary @ 115VAC<br>Requires 30 amp or greater dedicated breaker or line fuse.<br>18 Amps Maximum Momentary @ 230VAC<br>Requires 18 amp or greater dedicated breaker or line fuse. |  |
| Frequency  | 50/60 Hz Single Phase  |  |
| Generator Type                                   | High frequency inverter, 1.25 kilowatt output  |  |
| kVp Range  | 50-100 kVp continuously adjustable, with 1 kVp resolution  |  |
| mA Range   | Fixed, 12.5 mA, constant independent of kVp or time settings   |  |
| Exposure Time                                    | 0.01 to 4.0 seconds in 96 increments   |  |
| X-Ray Tube                                       | Stationary Anode 100 kVp   |  |
| Filtration                                       | 3.6 mm Aluminum Equivalent or More @ 100kVp  |  |
| Target Material                                  | Tungsten   |  |
| Anode Capacity                                   | 25,000 Heat Units  |  |
| Focal Spot                                       | 1.0 mm (NEMA)  |  |
| Beam Angle                                       | 15°  |  |
| Collimator                                       | Certified Manual   |  |
| Collimator Lamp Source                           | 30 second timer  |  |
| Duty   | 3.3%   |  |
| Mode of Operation                                | Momentary  |  |
| Relative Humidity Limits                         | Transit/Storage<br>10% to 100%<br>Operating<br>10%-80% Non-Condensing  |  |
| Atmospheric Limits                               | 14.5 inHg to 30.74 inHg<br>500 hPa to 1060 hPA   |  |
| Weight   | 95 lbs (42 Kg) Total/ X-Ray Generator 39lbs (17.7 kg)/Control<br>Console (7 lbs (3.2kg)  |  |
| Certifications:                                  | Classified To UL 187. Certified To CAN/CSA C22.2 No. 114-M90.  |  |
| Equipment not suitable for use in the presoxide. | sence of flammable anesthetic mixtures with air, oxygen or nitrous   |  |
| No user serviceable parts                        |  |  |

Table 3-1: Operation Specifications

# 3.3 Controls

This section describes the controls of the Phantom x-ray system.

### 3.3.1 Main Control Panel

Figure 3-1 below shows the main control panel of the Phantom X-ray system. The paragraphs that follow describe each control.

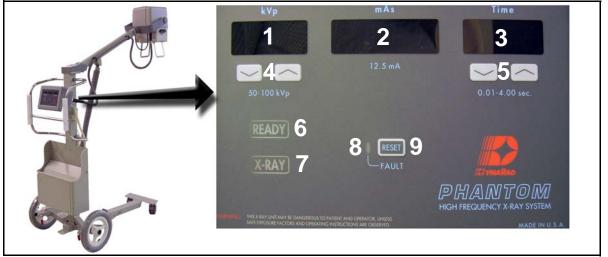


Figure 3-1. Main Control Panel

- 1 **kVp Display** This display shows the selected kVp in 1 kVp increments.
- 2 mAs This display shows the computed mAs level prior to exposure.
- **3 Time** This display shows the preset exposure time in intervals of 0.01 to 4 seconds.
- **4 kVp Adjust Buttons** These two momentary buttons adjust the displayed kVp value from 50 to 100 kVp in 1 kVp increments.
- **5 Time Adjust Buttons** These two momentary buttons adjust the displayed exposure time from 0.01 to 4 seconds in 0.01 second increments.
- 6 **READY Indicator** This indicator lights up when the unit is ready to make an exposure. It's time delayed circuit prevents excessive exposure frequency which could damage the unit.
- **7 X-RAY Indicator** This indicator lights up when the exposure button is pressed and an exposure is made. An audio tone is also generated during exposure.
- **8 FAULT Indicator** This indicator lights up when an internal circuitry fault occurs. A numerical code with also appear in the control panel's display to indicate what type of fault has occurred.
- **9 RESET Button** This button must be pressed to reset a fault condition.

### 3.3.2 Miscellaneous Controls

Figure 3-2 below shows the miscellaneous controls of the Phantom X-ray system. The paragraphs that follow describe each control.

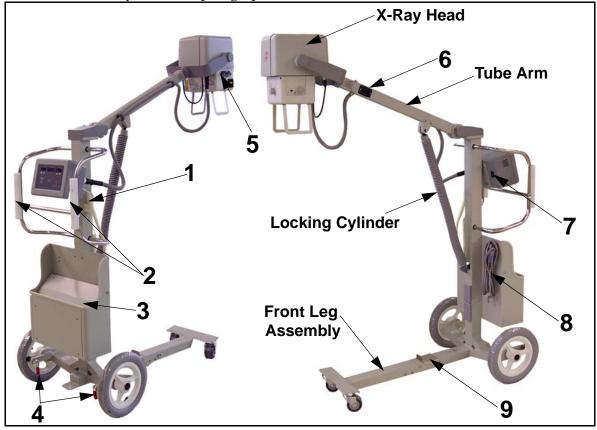


Figure 3-2. Miscellaneous Controls

- 1 **Prep/ Exposure** This two-position switch controls x-ray output. The first position is for prep. This causes the READY light on the main control panel to go out and then come on again to indicate the unit is ready for exposure. The button is then pressed and held all the way down to start an exposure as indicated by the X-RAY indicator on the main control panel lighting up. If you press and release the button before the READY light comes on, the process will be stopped and the FAULT light will come on. The unit can be reset by pressing the RESET button on the main control panel.
- **2 Control Handles -** These handles are used to maneuver the unit into position over the patient.
- **3 Cassette Holder** This compartment is used to hold film cassettes. The compartment has a spring-loaded brace that holds the cassettes firmly in place to keep them from rattling when the unit is moved.
- **4 Wheel Brakes** These brakes lock the rear wheels in place after the unit has been positioned over the patient.

- **5 Lev-O-Gage** This gage indicates the angular position of the X-Ray head.
- 6 **Release Lever** This device locks and unlocks the tube arm and allows the X-ray head to be moved up or down. The tube arm is connected to a locking cylinder that acts as a counterweight to the 39lb (17.7 kg) x-ray head and allows the head to be moved with the touch of a finger.
- 7 **On/Off Switch** This switch turns the unit on or off.
- 8 Power Cord This cord provides power to the unit.

### 🚺 Warning

Do not attempt to use the retraction latch until you read about how to use the latch in Section "Unfolding Phantom" on page 3-14 or "Folding Phantom" on page 3-19. You or your patient can be seriously injured or the unit may get damaged if you do not.

**9 Retraction Latch** - This latch allows the front wheel assembly to be retracted when the unit needs to be shipped or stored. Refer to Section "Unfolding Phantom" on page 3-14 or "Folding Phantom" on page 3-19 for proper use of this feature.

### 3.3.3 Collimator Controls

Figure 3-3 below shows the collimator controls of the Phantom X-ray system. The paragraphs that follow describe each control.

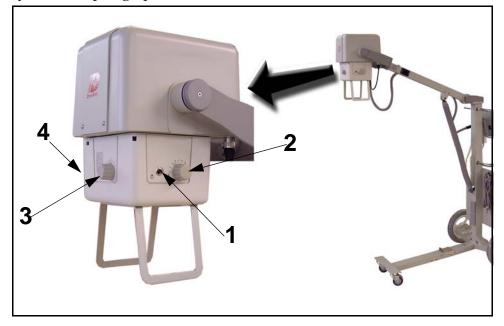
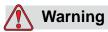


Figure 3-3. Collimator Controls

- 1 **Lamp Button** Pressing this button will turn the collimator lamp on. The lamp turns itself off automatically after about thirty seconds. The lamp cannot be turned off by manually pressing the button when it is on. It only turns off automatically.
- **2** Left-Right Adjustment Knob This knob adjusts the width of the light and x-ray field to match the width of the film cassette.
- **3 In-Out Adjustment Knob -** This knob adjusts the depth of the light and x-ray field to match the depth of the film cassette.
- **4 Tape Measure (hidden in this view) -** The tape measure is used to set the SID distance between the x-ray head and the film cassette. The tape measures out to 72" (1829 mm) so it is long enough to accommodate all SID distances. The tape is marked in inches. You may also notice that the tape starts at 7" (179 mm). This is because the face of the collimator is 7" below the focal point of the X-ray tube and the SID is always measured from the focal point of the x-ray tube. So when you measure out a 40" SID, always align the 40" mark on the tape with the face of the collimator.

### 3.4 Operating Instructions



Make sure that you are familiar with the safety issues listed in Prelude I "Safety" of this manual before attempting to operate the Phantom for the first time. You may get seriously injured if you do not.

1 Check if your Phantom is currently in an unfolded or folded position as shown in the figure below. If it is unfolded, go to the next step. If not, unfold it according to Section "Unfolding Phantom" on page 3-14 and then go to the next step.

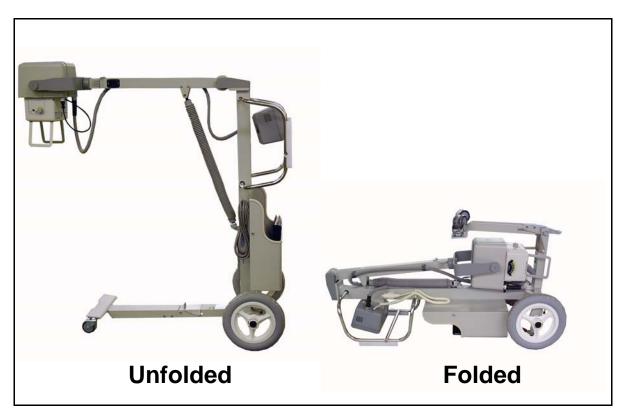
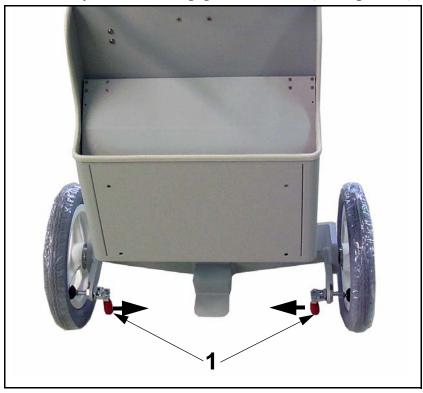


Figure 3-4. Unfolded & Folded Positions



**2** If not already done so, disengage wheel brakes (1 in Figure 3-5).

Figure 3-5. Wheel Brakes

- **3** Roll the unit over to the patient area.
- **4** If necessary, plug power cord in (1 in Figure 3-7).

### Caution

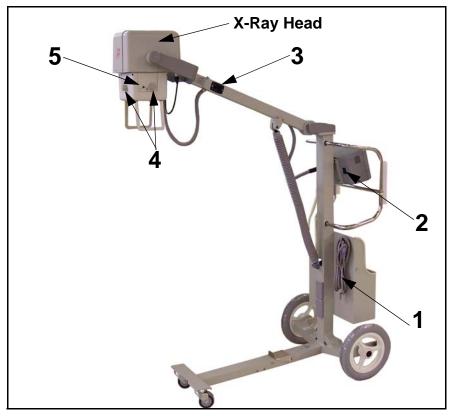
Make sure that power cord is plugged into dedicated power line (no other devices are connected to power line. Also, the power line must have a current rating of at least 18 amps for 115 VAC service or 10 amps for 230 VAC service. If these two points are not followed, the unit may not work properly.

**5** Turn power switch (2) on. The control panel lights up as shown in Figure 3-6.



Figure 3-6. Control panel at start-up.

- 6 Place cassette under patient.
- **7** Slide the tube arm release lever (3) forward. This will allow the x-ray head to move up and down.
- 8 Set the collimator knobs (4) to desired cassette size.
- **9** Press the collimator light button (5) to turn collimator light on.
- **10** Use collimator light beams to position unit so that x-ray head is directly over cassette. Use collimator tape measure (1 in Figure 3-8) to set SID height. The collimator light will automatically turn off in 30 seconds.



**11** When head is adjusted properly, close tube arm lock and reengage brakes.

Figure 3-7. Positioning X-Ray Head

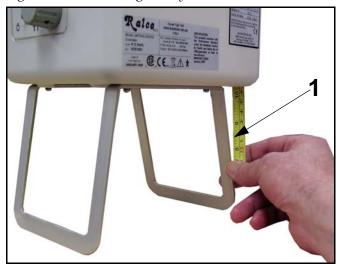


Figure 3-8. SID Tape Measure

**12** Using the Technique Chart in Section 3.5 as a guide, set the desired kVp by pressing buttons (1 in Figure 3-9) until desired setting appears in display (2).

- **13** Set the desired time us by pressing buttons (3) until desired setting appears in display (4). The computed mAs will appear in display (5)
- 14 Wait for the Ready Light (6) to light up. In some cases, as when the unit is first turned on, this may take a couple of minutes.
- **15** After the READY light comes on, pull the Pull the Prep/Exposure switch (7) out of its holder and back away from the control panel about six feet (two meters).
- **16** Press and HOLD the switch half way down (first stage is pressed down) until the READY light goes out and comes on again. The press the switch all the way down (second stage is down) until the X-Ray light (8) comes on and a beeping sound is heard. This indicates that the exposure has been made.

#### Note

If you release the first stage of the switch before the READY light comes back on, a fault condition will occur as indicated by the FAULT light (9). If this occurs, press the RESET button (10) and restart the process.

- **17** If you wish to make another exposure, wait until the READY light comes back on. Then repeat the process. The light is on a timed circuit to let the x-ray cool between exposures.
- **18** If the unit will not be used again in the near future, turn the power switch off.

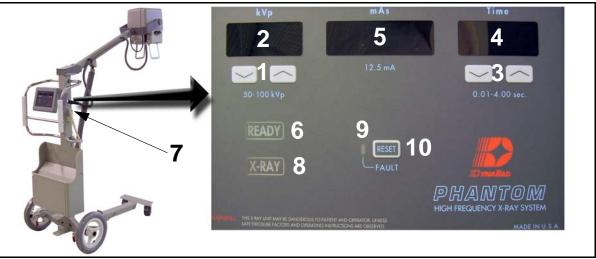


Figure 3-9. Main Control Panel

# 3.5 Technique Chart

Film Screen: Kodak OG Film: Lanex Regular Screen (400 Speed) 40" SID

| Examination   | Thickness | k\/n | mAs | Grid |
|---------------|-----------|------|-----|------|
|               | Thickness | kVp  |     |      |
| Hand          | 2-4 cm    | 50   | 2.0 | No   |
|               | 5-7 cm    | 50   | 2.0 | Νο   |
| Wrist         | 2-4 cm    | 52   | 2.0 | No   |
|               | 5-7cm     | 52   | 2.0 | No   |
| Forearm (AP)  | 2-4 cm    | 50   | 2.0 | No   |
|               | 5-7 cm    | 56   | 2.5 | No   |
|               | 8-10 cm   | 60   | 2.5 | No   |
| Forearm (LAT) | 4-6 cm    | 50   | 2.0 | No   |
|               | 7-9 cm    | 56   | 2.5 | No   |
|               | 10-12 cm  | 60   | 2.5 | No   |
| Elbow (AP)    | 5-7 cm    | 60   | 2.5 | No   |
|               | 8-10cm    | 63   | 2.5 | No   |
| Elbow (LAT)   | 4-6 cm    | 60   | 2.5 | No   |
|               | 7-9 cm    | 63   | 2.5 | No   |
| Humerus       | 5-7 cm    | 60   | 2.5 | No   |
|               | 8-10cm    | 63   | 2.5 | No   |
| Ankle (AP)    | 5-7 cm    | 60   | 2.5 | No   |
|               | 8-10cm    | 63   | 2.5 | No   |
| Ankle (LAT)   | 5-7 cm    | 60   | 2.5 | No   |
|               | 8-10cm    | 63   | 2.5 | No   |
| Knee          | 7-9 cm    | 60   | 4.0 | No   |
|               | 10-12cm   | 66   | 5.0 | No   |
| Foot (AP)     | 2-4 cm    | 50   | 2.0 | No   |
|               | 5-7 cm    | 54   | 2.5 | No   |
| Foot (LAT)    | 4-6 cm    | 58   | 2.0 | No   |
|               | 7-9 cm    | 64   | 2.5 | No   |
| Femur         | 6-8 cm    | 63   | 3.0 | No   |
|               | 12-14 cm  | 66   | 3.5 | No   |
| Shoulder      | 4-6 cm    | 60   | 3.2 | No   |
|               | 7-9 cm    | 64   | 4.0 | No   |
| L/Spine (AP)  | 21-23 cm  | 80   | 20  | Yes  |
| L/Spine (LAT) | 32-34 cm  | 100  | 30  | Yes  |
|               |           |      |     |      |

| Examination | Thickness | kVp | mAs | Grid |
|-------------|-----------|-----|-----|------|
| Pelvis/Hip  | 12-14 cm  | 73  | 10  | Yes  |
|             | 20-22 cm  | 77  | 18  | Yes  |
|             | 26-28 cm  | 78  | 40  | Yes  |
| Chest (AP)  | 12-16 cm  | 80  | 1.0 | No   |
|             | 22-24 cm  | 80  | 1.6 | No   |
|             | 30-34 cm  | 80  | 2.2 | No   |
| Chest (LAT) | 32-36 cm  | 90  | 2.0 | No   |
|             | 36-40 cm  | 90  | 2.2 | No   |
| Abdomen     | 8-12 cm   | 72  | 10  | Yes  |
|             | 18-22 cm  | 77  | 18  | Yes  |
|             | 28-32 cm  | 80  | 36  | Yes  |

# 3.6 Unfolding Phantom

Unfold the Phantom as follows:

**1** Pull pin (1 in Figure 3-10) out.

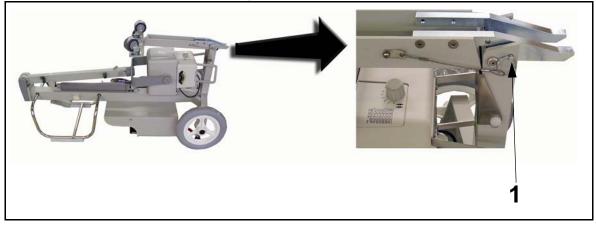


Figure 3-10. Reinserting Pin

**2** Tilt front leg assembly (1 in Figure 3-11) all the way up.

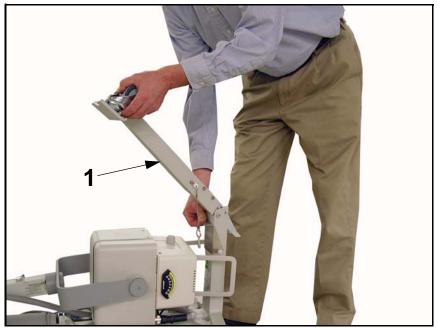
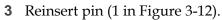


Figure 3-11. Tilting Front Leg Assembly Back



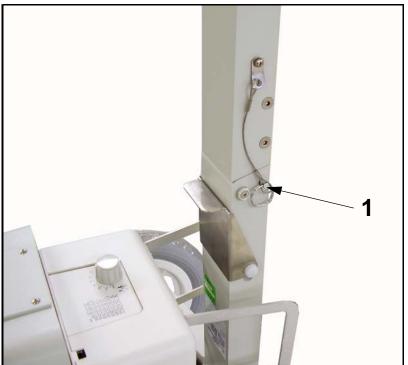


Figure 3-12. Inserting Pin



**4** Tilt unit up as shown below. Place your foot on the tab on the bottom of the frame to stabilize unit.

Figure 3-13. Tilting Unit Up

**5** Slide release lever (1 in Figure 3-14) forward and lift the tube arm (2) up so that it's approximately horizontal as shown in Figure 3-15.

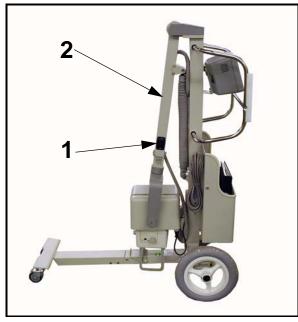


Figure 3-14. Release lever



Figure 3-15. Phantom fully unfolded



6 Turn X-ray head (1 in Figure 3-16) so that it points down.

Figure 3-16. X-Ray Head

**Procedure Complete** 

# 3.7 Folding Phantom

The Phantom can be folded into a smaller profile for storage or transport.

Fold the Phantom as follows:

- 1 Turn X-ray head (1 in Figure 3-17) to its 180° position.
- 2 Slide the tube arm lever (2) forward and push tube arm (3) all the way down as shown in Figure 3-18. Make sure that cable (4) does not get pinched between locking cylinder (5) and frame (6) when tube arm is fully down. Figure 3-19 on the next page illustrates this problem.

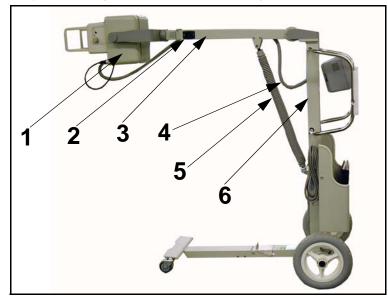


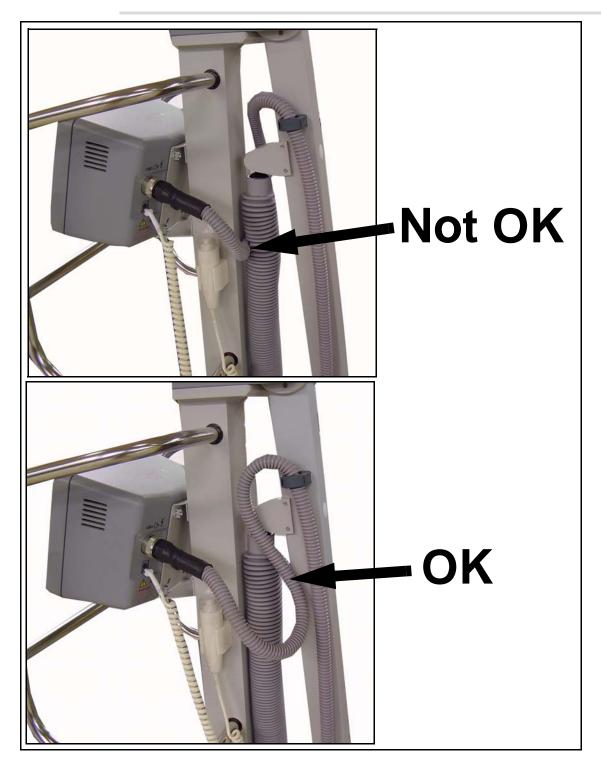
Figure 3-17. X-Ray Head in 180° Position



Figure 3-18. Tube arm In Down Position



Make sure that cable does not get pinched between ram and frame when turning tube arm down or cable may get damaged.



*Figure 3-19. Good and Bad Cable Positioning* 



**3** Place your foot on the tab on the bottom of the frame and tilt the unit back and down as shown below.

Figure 3-20. Tilting Unit Back and Down

**4** Pull pin (1 in Figure 3-21) out.

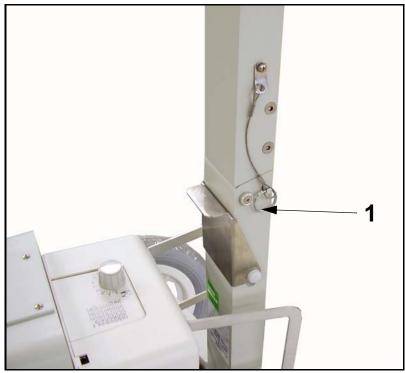
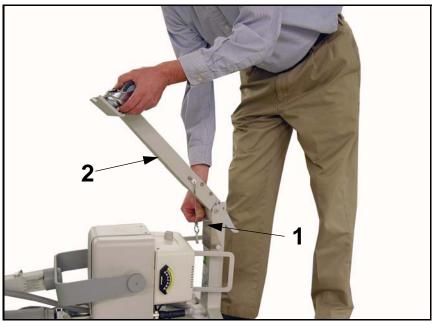


Figure 3-21. Release Pin Ring

**5** Press down on latch (1 in Figure 3-22) and tilt leg assembly (2) all the way down.



*Figure 3-22. Tilting Leg Assembly Back* 

**6** Reinsert pin (1 in Figure 3-23).

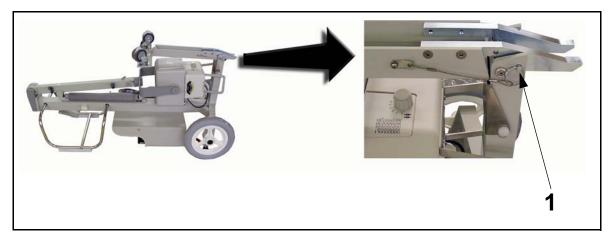


Figure 3-23. Reinserting Pin

**Folding Complete** 

# **Periodic Maintenance**

# 4

# 4.1 Periodic Maintenance Schedule

Refer to the schedule below for information on when to perform periodic maintenance on the Phantom.

Note: Due to varying operating conditions, the procedures listed below may have to be performed at greater or lesser intervals. You may have to adjust intervals according to your unit's performance.



The Phantom does not need any power during the maintenance activities listed below. Make sure to unplug and turn off the Phantom before continuing.

| What to Do                                  | When to Do It             | Refer to Section  |  |
|---|---------------------------|---|--|
| Clean external surfaces                     | Every Week or as Required | "Cleaning External Surfaces"<br>on page 4-2               |  |
| Verify calibration                          | Every six months          | "Calibration" on page 5-2                                 |  |
| Check fasteners for tightness               | Monthly                   | "Check fasteners for tight-<br>ness" on page 4-3          |  |
| Check collimator tightness                  | Monthly                   | "Check collimator tightness"<br>on page 4-4               |  |
| Check interconnect cables                   | Monthly                   | "Check interconnect cables"<br>on page 4-5                |  |
| Check tube head rotation<br>(friction lock) | Monthly                   | "Check tube head rotation<br>(friction lock)" on page 4-6 |  |

Table 4-1: Periodic Maintenance Schedule

# 4.2 Cleaning External Surfaces

### **Tools Required:**

- cleaning wipes
- non-abrasive, hospital-grade cleaner

Use cleaning wipes and non-abrasive, hospital-grade cleaner to clean external surfaces of the Phantom.



This equipment is NOT classified as anaesthetic-proof and may ignite flammable anesthetics. Flammable agents used for skin cleaning or disinfecting may also produce an explosion hazard.

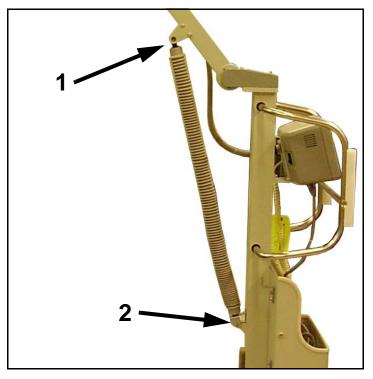
- Ensure the power has been disconnected before starting any cleaning operation.
- Ensure no liquid gets into the unit.
- Do not immerse the equipment, including any components or accessories, in liquid.
- Do not autoclave the equipment, including any component or accessories.
- Do not use water. Water can short-circuit the electrical installation and cause corrosion to mechanical parts.
- Do not use acid or abrasive products.
- Use only a dry cloth to clean chrome-plated parts.
- Only the surface areas of unit parts, including accessories and connection cables, should be disinfected using a gaseous disinfectant. For safety reasons, do not spray disinfectants.
- Clean painted parts with a cloth and products appropriate for cleaning plastic materials; after cleaning wipe the surfaces with a clean, dry cloth.
- Do not spray cleaning or disinfection solution directly on the equipment. To disinfect, moisten a cloth with a 70% Isopropyl alcohol solution or equivalent and wipe the surface of the equipment.
- When disinfecting the examination room, ensure the unit is covered with plastic sheets.

### 4.3 Check fasteners for tightness

### **Tools Required:**

- medium flat screw driver
- phillips screw driver
- set of open-end wrenches
- set of hex keys

Check **all exposed fasteners** and hardware for tightness and tighten accordingly. Be certain to inspect the piston mounts, make sure that top (1 in Figure 4-1) and bottom (2) mounting bolts are secure.



Top and bottom mounting bolts.

# 4.4 Check collimator tightness

### **Tools Required:**

• n/a

Check that collimator is tight mounted to the tube. Should the collimator be loose, refer to "X-ray to light field alignment" on page 5-8 to re-align and tighten the collimator.

### 4.5 Check interconnect cables

**Tools Required:** 

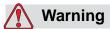
• n/a

- 1 Check all interconnect cables for broken or frayed wires.
- **2** Replace any broken or frayed wires.

## 4.6 Check tube head rotation (friction lock)

### **Tools Required:**

• 5/16" Allen Wrench



Ensure that the both wheels are securely locked before beginning this inspection.

Check that the tube head rotation (friction lock) is properly adjusted, proceed as follows:

1 Check to ensure that there is no gap (1 in Figure 4-1) between the tube head arm (2) and the friction pad (3) and that the bolt is flush (4).

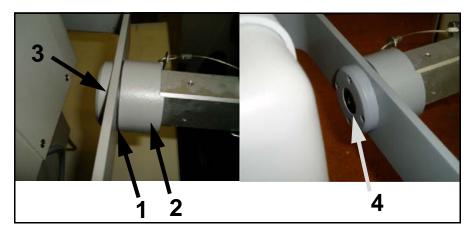
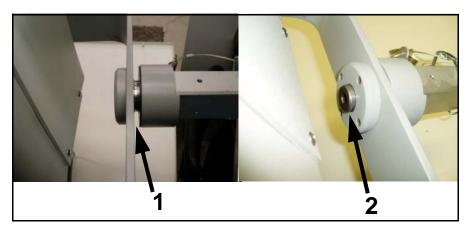


Figure 4-1. Gap and bolt oh.

**2** If there is a gap (1 in Figure 4-2) or if the bolt is not flush (2), then tighten the bolt so that there is no gap and the bolt is flush.



*Figure* 4-2*. Gap and bolt not ok.* 

When the gap and bolts is ok, check the tube head rotation as follows.

**3** With the boom arm in the up position, put the 5/16" Allen wrench into shoulder bolt (#383121), noting location of the Allen wrench (1 in Figure 4-4).

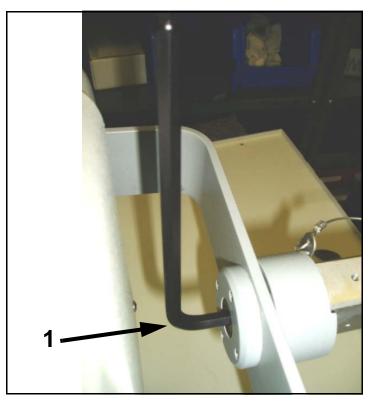


Figure 4-3. Allen wrench in shoulder bolt.

- **4** Turn tube head 45° each way. Ensure that the Allen wrench does not move from the original position while repeating this back and forth motion 10 times.
- **5** If the Allen wrench moved from the original position, tighten the bolt and repeat step 3 and 4.

# Calibration and Adjustments

# 5

## 5.1 Introduction

This chapter provides calibration and adjustment procedures for the Phantom.

## 5.2 Calibration

The calibration procedure for the Phantom requires many special tools and fixtures and should be done by Del Medical trained technicians only.

Tools required

- dual channel oscilloscope
- mAs meter (Keithely model 35035)
- kVp divider (Keithely model 35080A, with mobile filter pack 37946C)



#### Caution

This procedure must only be preformed by factory trained technicians. The Phantom may get damaged if this condition is not met.



## Use extreme caution not to come in contact with the Phantom's circuity when performing LIVE tests. You may get fatally injured if you do not.

#### 5.2.1 Equipment setup

Connect the mAs (Keithely model 35035) meter to the phone jack (J4), located in the bottom plate of the X-ray tube head. Load the kVp divider (Keithely model 35080A) with the 50 = 135 kVp filter pack #37946 and place it in the X-ray field, being careful to collimate down to the size of the filter pack. Set the function switch to Run.

Connect the kVp divider cable to the oscilloscope (storage type) and set up the scope as follows:

| Volts/Div: 0.1                 | Display: Set to storage |
|--------------------------------|-------------------------|
| Time/Div: 20 mS                | Source: Channel 1       |
| Ground input/trace: Lower line | Input: DC               |
| Mode: Channel 1                | Trigger mode: Single    |
| Pre trigger: 2 divisions       | Push "Ready"            |

Table 5-1: Channel 1 Settings

Connect X10 probe to test point TP12 of the control board (#500978). Connect the ground clip to the top (ground) side of CR15 for a positive going signal.

Connect to channel 2 of the oscilloscope and set up as follow:

| Volts/Div: 0.2                 | Display: Set to storage |
|--------------------------------|-------------------------|
| Time/Div: 20 mS                | Source: Channel 1       |
| Ground input/trace: Lower line | Input: DC               |
| Mode: Channel 2                | Trigger mode: Single    |
| Pre trigger: 2 divisions       | Push "Ready"            |

Table 5-2: Channel 1 Settings

#### 5.2.2 Pre-Calibration (only necessary if replacing an X-ray tube)

Attach a DVM to TP6 on PCB #500978 (located on the generator assembly), using R12, set TP6 to 18.00V

Attach a DVM to TP13 on PCB #500978 (located on the generator assembly), using R28, set TP13 to -10C

Set the dip switches as shown in row 18 of Table 5-3 (binary capacitor chart).

Set the service switch to position 1, set the kV to 80, set mA to 15 and time to 0.1 sec. Make exposure and note the leading edge of the kV waveform.

#### 5.2.3 kVp waveform

If the kVp leading starts low and slopes upward toward the desired kV value, then reset the switches as shown about four rows downward on Table 5-3 (about row 22). If the kVp leading edge is still starting low and sloping, reset the switches about four more rows downward (about row 26) and re-test.

If the kVp leading overshoots then slopes downward toward the desired value, reset the switches as shown about two or three rows upward.

When the capacitor selection results in a very small upward slope or small overshoot of the leading edge, reset the switches in smaller row steps of one or two rows up or down.

If the upper corner of the leading edge of the kV waveform shows a bevel effect (corner chopped about 30 degrees) then do not attempt to compensate this with capacitor selector until the mA waveform is free of under- or overshoot.

When the kV waveform appears to have a very low or no under- or overshoot, then check the waveform at low kV (50), mid kV (80), and high kV (100). adjust the capacitor selection for the best overall effect.

| Row | Selectable cap<br>values | Switch 1 | Switch 2 | Switch 3 | Switch 4 | Switch 5 | Switch 6 |
|-----|--------------------------|----------|----------|----------|----------|----------|----------|
| 1   | 0.015uF                  |          |          |          |          |          | Х        |
| 2   | 0.033uF                  |          |          |          |          | Х        |          |
| 3   | 0.048uF                  |          |          |          |          | Х        | Х        |
| 4   | 0.068uF                  |          |          |          | Х        |          |          |
| 5   | 0.083uF                  |          |          |          | Х        |          | Х        |
| 6   | 0.101uF                  |          |          |          | Х        | Х        |          |
| 7   | 0.116uF                  |          |          |          | Х        | Х        | Х        |
| 8   | 0.127uF                  |          |          | Х        |          |          |          |
| 9   | 0.142uF                  |          |          | Х        |          |          | Х        |
| 10  | 0.160uF                  |          |          | Х        |          | Х        |          |
| 11  | 0.175uF                  |          |          | Х        |          | Х        | Х        |
| 12  | 0.195uF                  |          |          | Х        | Х        |          |          |
| 13  | 0.210uF                  |          |          | Х        | Х        |          | Х        |
| 14  | 0.228uF                  |          |          | Х        | Х        | Х        |          |
| 15  | 0.243uF                  |          |          | Х        | Х        | Х        | Х        |

*Table 5-3: Binary Capacitor* 

Chart X = Switch closed (On)

| Row | Selectable cap<br>values | Switch 1 | Switch 2 | Switch 3 | Switch 4 | Switch 5 | Switch 6 |
|-----|--------------------------|----------|----------|----------|----------|----------|----------|
| 16  | 0.270uF                  |          | Х        |          |          |          |          |
| 17  | 0.285uF                  |          | Х        |          |          |          | Х        |
| 18  | 0.303uF                  |          | Х        |          |          | Х        |          |
| 19  | 0.318uF                  |          | Х        |          |          | Х        | Х        |
| 20  | 0.338uF                  |          | Х        |          | Х        |          |          |
| 21  | 0.353uF                  |          | Х        |          | Х        |          | Х        |
| 22  | 0.371uF                  |          | Х        |          | Х        | Х        |          |
| 23  | 0.386uF                  |          | Х        |          | Х        | Х        | Х        |
| 24  | 0.397uF                  |          | Х        | Х        |          |          |          |
| 25  | 0.412uF                  |          | Х        | Х        |          |          | Х        |
| 26  | 0.430uF                  |          | Х        | Х        |          | Х        |          |
| 27  | 0.445uF                  |          | Х        | Х        |          | Х        | Х        |
| 28  | 0.465uF                  |          | Х        | Х        | Х        |          |          |
| 29  | 0.480uF                  |          | Х        | Х        | Х        |          | Х        |
| 30  | 0.498uF                  |          | Х        | Х        | Х        | Х        |          |
| 31  | 0.513uF                  |          | Х        | Х        | Х        | Х        | Х        |
| 32  | 0.560uF                  | Х        |          |          |          |          |          |
| 33  | 0.575uF                  | Х        |          |          |          |          | Х        |
| 34  | 0.593uF                  | Х        |          |          |          | Х        |          |
| 35  | 0.608uF                  | Х        |          |          |          | Х        | Х        |
| 36  | 0.628uF                  | Х        |          |          | Х        |          |          |
| 37  | 0.643uF                  | Х        |          |          | Х        |          | Х        |
| 38  | 0.661uF                  | Х        |          |          | Х        | Х        |          |
| 39  | 0.676uF                  | Х        |          |          | Х        | Х        | Х        |
| 40  | 0.687uF                  | Х        |          | Х        |          |          |          |
| 41  | 0.702uF                  | Х        |          | Х        |          |          | х        |
| 42  | 0.720uF                  | Х        |          | Х        |          | Х        |          |
| 43  | 0.735uF                  | Х        |          | Х        |          | Х        | х        |
| 44  | 0.755uF                  | Х        |          | Х        | Х        |          |          |
| 45  | 0.770uF                  | Х        |          | Х        | Х        |          | Х        |

*Table 5-3: Binary Capacitor* 

Chart X = Switch closed (On)

| Row | Selectable cap<br>values | Switch 1 | Switch 2 | Switch 3 | Switch 4 | Switch 5 | Switch 6 |
|-----|--------------------------|----------|----------|----------|----------|----------|----------|
| 46  | 0.788uF                  | Х        |          | Х        | Х        | Х        |          |
| 47  | 0.803uF                  | Х        |          | Х        | Х        | Х        | Х        |
| 48  | 0.830uF                  | Х        | Х        |          |          |          |          |
| 49  | 0.845uF                  | Х        | Х        |          |          |          | Х        |
| 50  | 0.863uF                  | Х        | Х        |          |          | Х        |          |
| 51  | 0.878uF                  | Х        | Х        |          |          | Х        | Х        |
| 52  | 0.898uF                  | Х        | Х        |          | Х        |          |          |
| 53  | 0.913uF                  | Х        | Х        |          | Х        |          | Х        |
| 54  | 0.931uF                  | Х        | Х        |          | Х        | Х        |          |
| 55  | 0.946uF                  | Х        | Х        |          | Х        | Х        | Х        |
| 56  | 0.957uF                  | Х        | Х        | Х        |          |          |          |
| 57  | 0.972uF                  | Х        | Х        | Х        |          |          | Х        |
| 58  | 0.990uF                  | Х        | Х        | Х        |          | Х        |          |
| 59  | 1.005uF                  | Х        | Х        | Х        |          | Х        | Х        |
| 60  | 1.025uF                  | Х        | Х        | Х        | Х        |          |          |
| 61  | 10.040uF                 | Х        | Х        | Х        | Х        |          | Х        |
| 62  | 1.058uF                  | Х        | Х        | Х        | Х        | Х        |          |
| 63  | 1.073uF                  | Х        | Х        | Х        | Х        | Х        | Х        |

Table 5-3: Binary Capacitor

Chart X = Switch closed (On)

#### 5.2.4 Beam current (mA)

Set the kVp to 80 and the exposure time to 1.0 seconds. Note: the nominal mAs is 1.25.

- 1 Collimate the X-ray beam to size of the filter pack on the kVp divider and step away from the unit. Make an exposure and note the measured mA via the mAs meter.
- **2** If the measured output is low (less than 12.5), adjust R28 (located on the High Voltage control PCB) counter-clockwise.
- **3** Make another exposure and note the measured mA. Re-adjust if necessary and repeat step 2.
- **4** If the measured output is high (greater that 12.5), adjust R28 (located on the High Voltage control PCB) counter-clockwise.

- **5** Make another exposure and note the measured mA. Re-adjust if necessary and repeat step 4
- **6** If the filament pre-heat requires calibration and the leading edge of the waveform on channel 2 is low, add to the waveform by adjusting R12 (located on the High Voltage control PCB #500978) counter clockwise. If the leading edge is high, subtract from the waveform by adjusting R12 clockwise.
- 7 Make an exposure and verify change, repeat the above step if necessary. There is an interaction between steps 6 and 7 to steps 1-5, therefore, it is necessary to re-check one after adjusting the other.

#### 5.2.5 Tube potential

To enter the kVp calibration mode, turn the control (main power switch) off.

Depress the "TIME UP, "KVP' UP end "RESET" buttons at the same time. With all three buttons depressed turn the control unit ON. When the displays illuminate hold all three buttons for an additional four seconds until the displays go blank. When the displays go blank, release the button combination.

After an additional four seconds the displays will illuminate with the following information; 50 kVp, 1.25 mAs, and 5 seconds. The exposure time in the calibration mode is pre-set at 0.1 seconds.

- 1 Make an exposure and store the wave shape. Compute the kVp by counting the base line as 42 kVp and each division as 10 kVp.
- 2 Use the "UP" and "DOWN" arrow keys of the "TIME" adjust to calibrate the kVp. If the output is high, then use "DOWN" key to subtract from the kVp reference. If the output is low, then use the "UP" key to add to the kVp reference. Each 0.5 increment of the displayed time value is equal to 0.5 kVp for a total range of +/- 4.5 kVp.
- **3** Depress the "RESET" button to enter the change into the microprocessor. The kVp meter will now display 60 kVp.
- 4 Repeat steps 1,2 and 3 for the 60 100 kVp range in 10 kVp increments.
- **5** Once all the calibration points are completed, the kVp display will show 50 kVp and the other displays will be blank.
- 6 Recycle the power switch on the control unit. If any points need to be fine tuned, re-enter the calibration mode and toggle through the calibration points using the "RESET" button until the correct range is found.

#### 5.2.6 Exposure time

Remove the phone plug from the mA jack. Measure the time base of the kVp waveform at the 50% level.

#### 5.2.7 X-ray to light field alignment

- 1 Ensure that the collimator is level in both the front-to-back and the side-to-side directions.
- **2** Place a fluorescent screen, marked with a 5" square, on top of an empty cassette making sure that the surface of the screen is 40" from the tube focal spot and is level in both directions.
- **3** Press the collimator lamp button and collimate the light field to the 5" square marked on the fluorescent screen. Note: be sure to use the actual contrast edge of the light field, not the outside of the shadow.
- **4** Rotate the collimator to the following positions; left 90°, right 90°, and then back to center. The collimator light field should rotate about the center of the 5″ square with minimal deviation.
- **5** Re-check the level of the collimator and shoot a 2 to 3 second exposure at 60 to 70 kV noting the position of the x-ray field in relation to the 5" square on the screen.
- **6** If required, adjust the collimator position using the (4) ring adjustment set screws. Note: Move the collimator in the opposite direction that the X-ray field is off.
- 7 Re-center the fluorescent screen and repeat as required to ensure the X-ray field is aligned with the 5" square.
- 8 Remove the empty cassette and screen and place a loaded casette in the chamber. Place a collimator test tool on top of the cassette and position both so that the center of the light field is centered to the collimator test tool.
- **9** Place four coins around the perimeter of the light field to indicate light field position. Remember to use the contrast edge not the outside edge of the light field.
- **10** Take an exposure at approximately 60kVp and 2 mAs. Develop the film and place onto a light box. Mark the film to indicate collimator position ("0") and to identify front.
- 11 Measure the light field to X-ray field deviation (on all four sides) and record it on the film. Note: The total deviation front-to-back or left side-to-right side must be within 1% of SID (0.4" maximum).
- **12** Measure the overall X-ray field and record it on the film. Note: The size of the X-ray field must be within the indicated size on the

collimator within 1% of SID. If required, adjust the collimator knobs to obtain the correct reading.

**13** Repeat steps for collimator positions, 90° left and 90° right. Note: When rotating the collimator, re-adjust coins as required to indicate the new light field position.

## 5.3 Adjustments

Not applicable for this product.

## Component Replacement

# 6

## 6.1 Introduction

This chapter provides instructions for replacing many of the major assemblies on the Phantom.

## 6.2 Replacing Control Console

Replace control console as follows:

#### **Tools Required:**

- None
- 1 Unplug power supply cord from power outlet.

#### 🚺 Warning

Unplug power supply cord before servicing Phantom. Also, do not perform any maintenance procedures on the unit for at least five minutes after the power cord has been unplugged. The unit has large capacitors that need time to discharge their energy after the unit is unplugged. Failure to follow this can cause serious injury.

2 If not already done so, engage wheel brakes (1 in Figure 6-1).

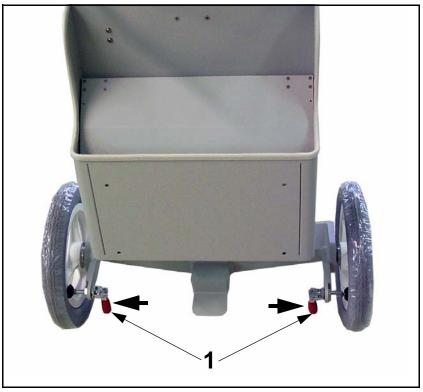
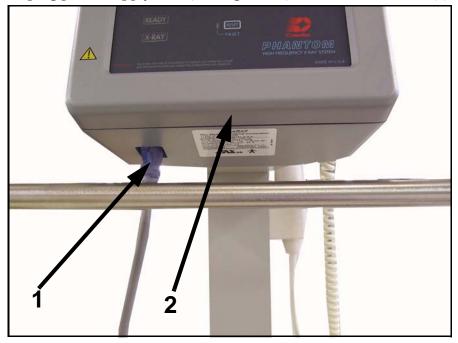


Figure 6-1. Wheel Brakes



**3** Unplug power supply cord (1 in Figure 6-2) from control console (2).

Figure 6-2. Power Cord

**4** Unplug hand switch cord (1 in Figure 6-3).



Figure 6-3. Hand Switch Cord

- **5** Jerk control console firmly backwards to disengage it from its spring-loaded mounting clamps.
- **6** Reverse steps to reassemble.

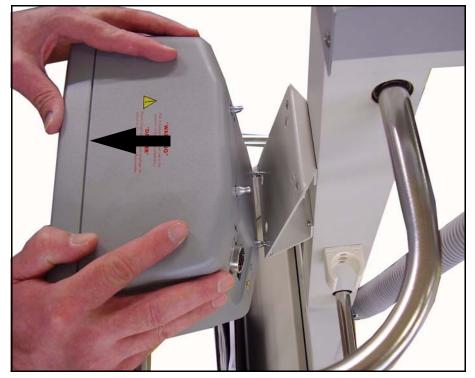


Figure 6-4. Control Console

**7** To access the inside of the control console, use a 1/4" wrench to unscrew the four screws (1 in Figure 6-5) that hold the back cover of the control console.



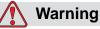
*Figure 6-5. Back of Control Console* 

### 6.3 Interconnect Cable Replacement

Replace main cable as follows:

#### **Tools Required:**

- Medium Flat-Tip Screwdriver
- 1 Unplug power supply cord from power outlet.



#### Unplug power supply cord before servicing Phantom. Also, do not perform any maintenance procedures on the unit for at least five minutes after the power cord has been unplugged. The unit has large capacitors that need time to discharge their energy after the unit is unplugged. Failure to follow this can cause serious injury.

**2** If not already done so, engage wheel brakes (1 in Figure 6-6).

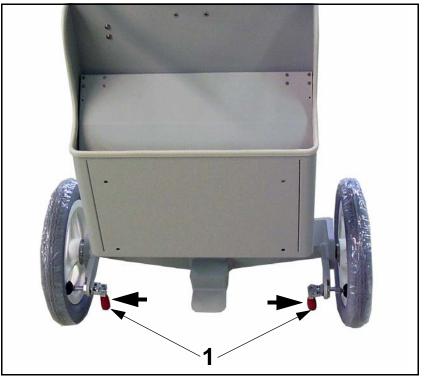


Figure 6-6. Wheel Brakes



Be very gentle in the next step. The clamps are fragile.

- **3** Very gently insert screwdriver into each clamp hole (1 in Figure 6-7) and gently open each clamp.
- 4 Pull cable out (2) of clamps.



Figure 6-7. Opening Clamps

- **5** Disconnect the interconnect cable (1 in Figure 6-8) from X-ray head (2) and control console (3).
- **6** Reverse steps to reassemble. Female end of cable to X-ray head (2) and male end to control console (3).



Figure 6-8. Interconnect Cable Connections

## 6.4 X-Ray Head Replacement

Replace x-ray head as follows:

#### **Tools Required:**

- None
- 1 Unplug power supply cord from power outlet.

#### 🚺 Warning

Unplug power supply cord before servicing Phantom. Also, do not perform any maintenance procedures on the unit for at least five minutes after the power cord has been unplugged. The unit has large capacitors that need time to discharge their energy after the unit is unplugged. Failure to follow this can cause serious injury.

2 If not already done so, engage wheel brakes (1 in Figure 6-9).

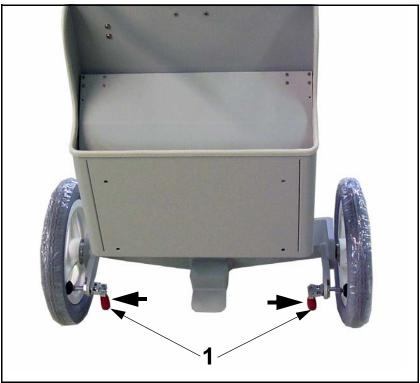


Figure 6-9. Wheel Brakes

- **3** Slide release lever (1 in Figure 6-10) forward and position tube arm (2) in its horizontal position (or a little higher) as shown in Figure 6-10.
- **4** Disconnect interconnect cable (3) from x-ray head (4).

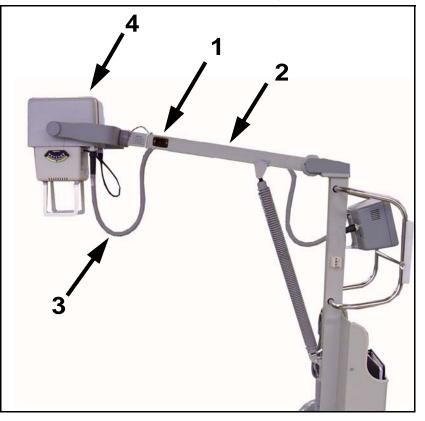


Figure 6-10. Disconnecting Interconnect Main Cable

**5** Pull spring retainer (1 in Figure 6-11) over tip of safety pin (2).

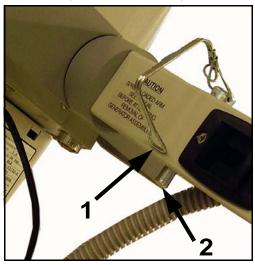
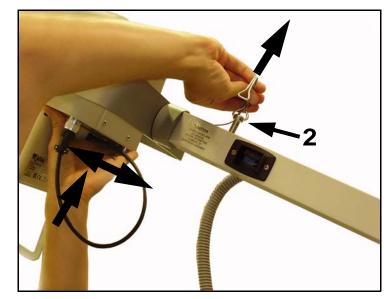


Figure 6-11. Remove Spring Retainer

**6** While pressing down the leg assembly (1 in Figure 6-12) with your foot and wiggle the X-ray head sideways/back and forth/pressing it up with one hand, use the other hand to pull the pin (2) out.



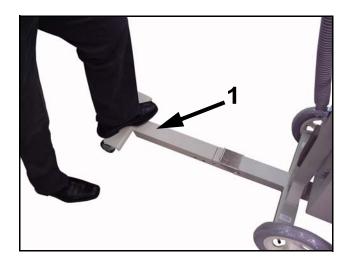


Figure 6-12. Pin Removal.

7 Pull the X-ray head out of the tube arm.



The X-ray head is heavy - 39 lbs (17.7 kg). Use caution when removing it.



Figure 6-13. X-Ray Head Removal



Never leave the Phantom unattended with the arm in horizontal position when the X-ray head is removed.

If the arm is released accidently by an unsuspecting person, it may pop up and injure that person.

If the Phantom will be left unattended with X-ray head removed, make sure to carefully set the arm to full upright position. **8** Reverse steps to reassemble. Make sure to insert the safety pin (1 in Figure 6-14) immediately after putting the new X-ray head in place.

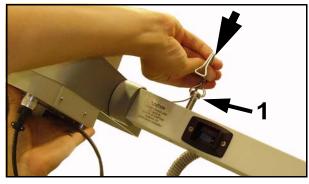


Figure 6-14. Replace and secure pin before lowering arm.

## 6.5 Locking Cylinder Replacement

Replace locking cylinder as follows:

#### **Tools Required:**

- 3/16" Hex Wrench
- 1 Unplug power supply cord from power outlet.



Unplug power supply cord before servicing Phantom. Also, do not perform any maintenance procedures on the unit for at least five minutes after the power cord has been unplugged. The unit has large capacitors that need time to discharge their energy after the unit is unplugged. Failure to follow this can cause serious injury.

2 If not already done so, engage wheel brakes (1 in Figure 6-9).

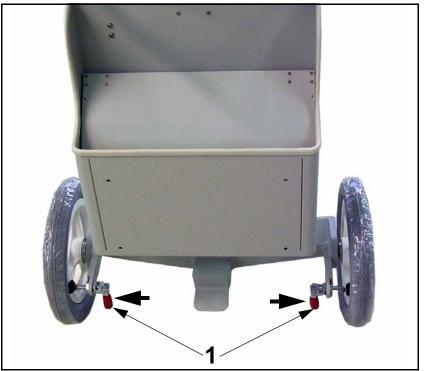


Figure 6-15. Wheel Brakes

- **3** Remove x-ray head according to Section "X-Ray Head Replacement" on page 6-8.
- **4** Carefully set the tube arm to full upright position.
- **5** Unscrew top screw (1 in Figure 6-16).
- **6** Unscrew cylinder (2) from bottom bracket (3).
- **7** Reverse steps to reassemble. Be sure to screw the cylinder down as far as it will go when installing it.



*Figure 6-16. Counterweight Cylinder* 

### 6.6 Release Cable Replacement

Replace release cable as follows:

#### **Tools Required:**

- 3/16" Hex Wrench
- Diagonal Cutters (Side Cutters)
- Slip Joint Pliers (Channel Locks)
- Snap Ring Pliers
- 1 Unplug power supply cord from power outlet.



Unplug power supply cord before servicing Phantom. Also, do not perform any maintenance procedures on the unit for at least five minutes after the power cord has been unplugged. The unit has large capacitors that need time to discharge their energy after the unit is unplugged. Failure to follow this can cause serious injury.

**2** If not already done so, engage wheel brakes (1 in Figure 6-9).

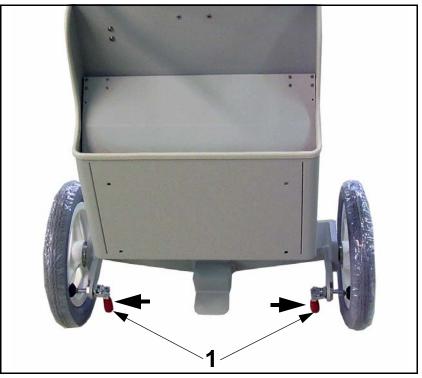


Figure 6-17. Wheel Brakes

- **3** Remove x-ray head according to Section "X-Ray Head Replacement" on page 6-8.
- **4** Remove locking cylinder according to Section "Locking Cylinder Replacement" on page 6-13.
- **5** Unscrew four cover screws (1 in Figure 6-18) and remove cover (2).

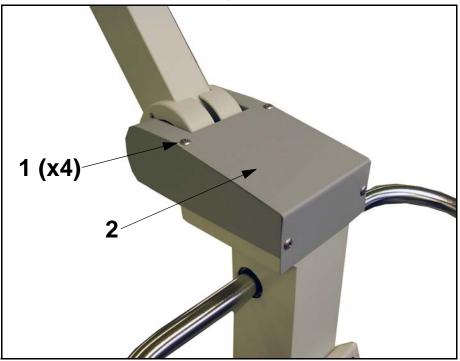


Figure 6-18. Cover

**6** Remove retaining ring (1 in Figure 6-19) and pull pin (2) out of bracket (3).

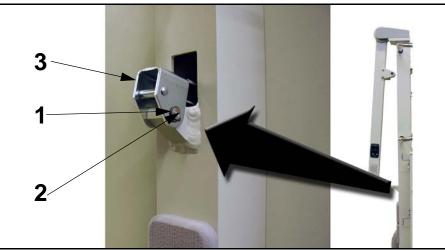


Figure 6-19. Retaining Ring and Pin

- 7 Attache a feeder wire to the cable sheath. Cut cable (1 in Figure 6-20) and pull bracket (2) off of cable sheath (3). Discard bracket.

Figure 6-20. Cable and Bracket

- 8 Make sure the feeder wire is securely attached to the cable sheath.
- **9** Unscrew two release lever screws (1 in Figure 6-21) and pull release lever (2) and cable assembly out of unit.

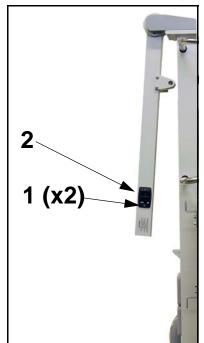


Figure 6-21. Release Lever Screws

- **10** Attache the new cable to the feeder wire. Route the new cable through the tube arm and the frame in the direction of arrows shown below by pulling the feeder wire back.
  - 2 (x2)
- **11** Secure release lever (1 in Figure 6-22) in place with two mounting screws (2).

Figure 6-22. Cable Routing



**12** Crimp bracket onto cable as shown below.

Figure 6-23. Crimping Cable

**13** Insert cable sheath (1) into upper part of bracket (2).

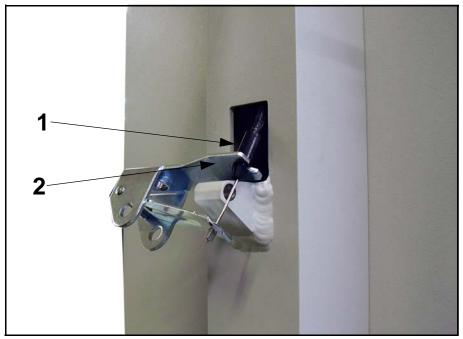
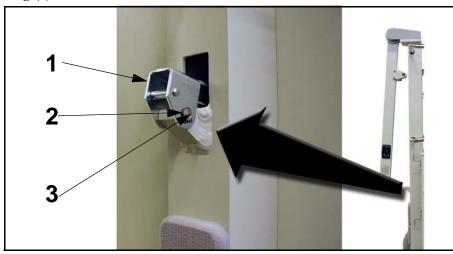


Figure 6-24. Cable and Bracket



**14** Connect bracket (1 in Figure 6-25) to frame with pin (2) and retaining ring (3).

Figure 6-25. Retaining Ring and Pin

- **15** Screw locking cylinder (1 in Figure 6-26) all the way into the bracket (2).
- **16** Connect upper end of locking cylinder with bolt (3).
- **17** Reattach x-ray head by reversing steps in Section "X-Ray Head Replacement" on page 6-8.



Figure 6-26. Locking Cylinder Connection

## Troubleshooting

## 7.1 Introduction

This chapter is divided into three sections.

The first section is a list of error messages that may appear on the Phantom's display and how to remedy them.

The second section is made up of an overall schematic of the Phantom and a group of photos that show the actual parts depicted on the schematic and their location on the table.

The third section is a technical theory of operation description.

7

## 7.2 Troubleshooting Index & Charts

If your machine malfunctions, it may display an error message number on its main display.

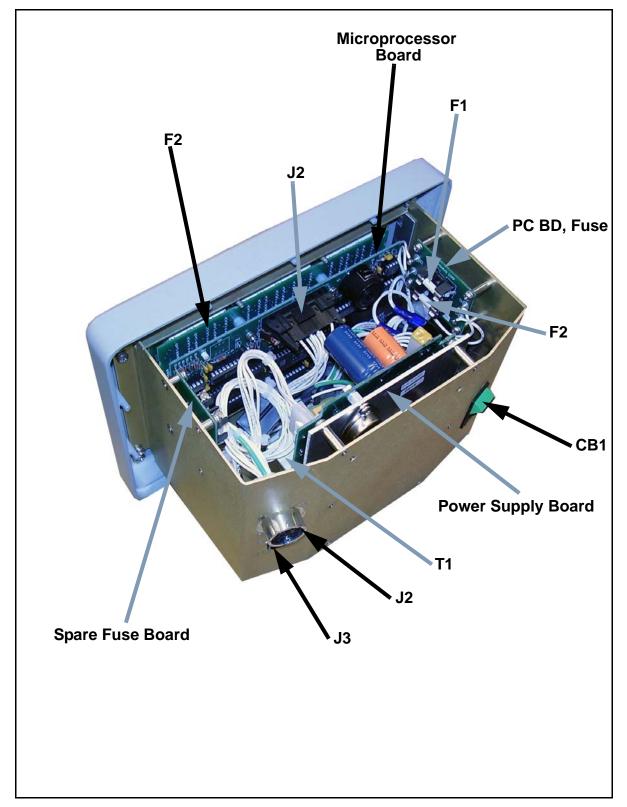
Use the following error message index as an aid in solving your machine's malfunction.

| Error Message No. | Possible Cause                                    | Remedy   |  |
|-------------------|---|--|--|
| 1                 | Memory failure - RAM.                             | Call for service.  |  |
| 2                 | Battery backup failure.                           | Call for service.  |  |
| 3                 | EPROM failure.                                    | Call for service.  |  |
| 4                 | Back-up timer activated                           | Press and hold RESET<br>button on control panel<br>until message clears. If<br>message reappears, call<br>for service. |  |
| 5                 | Exposure terminated by operator                   | Press and hold RESET<br>button on control panel<br>until message clears. If<br>message reappears, call<br>for service. |  |
| 6                 | Inverter failure.                                 | Press and hold RESET<br>button on control panel<br>until message clears. If<br>message reappears, call<br>for service. |  |
| 7                 | No mA signal.                                     | Call for service.  |  |
| 8                 | High voltage circuit Call for service.<br>failure |  |  |

TIP- Try disconnecting and reconnecting interconnect cables to remedy problem.

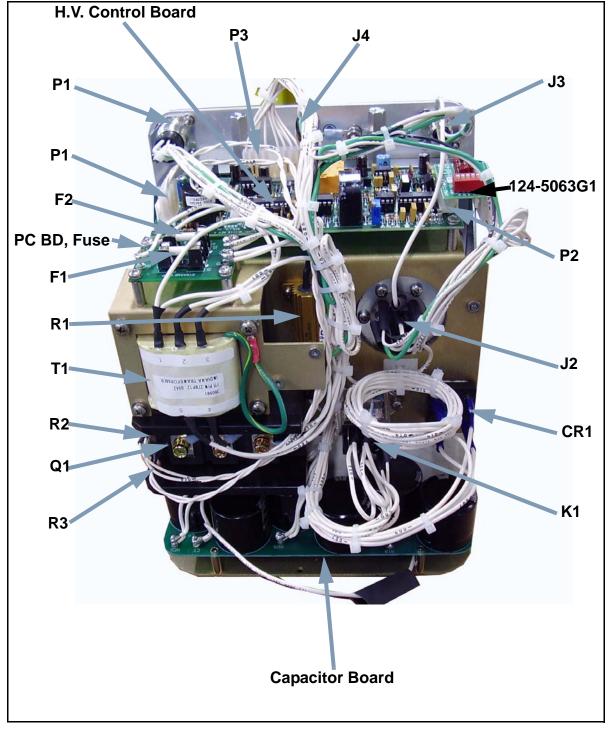
## 7.3 Schematic Troubleshooting

The two first schematic diagrams in chapter 8 "Electrical Schematics" can be used to troubleshoot electrical problems with the Phantom. The schematics covers all of the electrical components in the Phantom. Figures 7-1 and 7-2 show actual photos of the components listed on the schematics. This allows you to identify the location of the components and translate the fault isolation logic of the schematic into actual testing of components for failure.



#### 7.3.1 Main Control Console Layout

Figure 7-1. Main Control Console



#### 7.3.2 Generator Layout

Figure 7-2. Generator Layout

### 7.4 Technical Theory of Operation

#### 7.4.1 System Overview

The Phantom incorporates three major electrical sub-assemblies. The Generator Assembly consists of the high voltage circuitry, the x-ray tube and the collimator (further discussed in section 7.4.2). The Control Assembly houses all of the electronics, microprocessor, high frequency generating circuits and the front panel controls (further discussed in section 7.4.3). The Inverter Assembly is part of the Control Assembly, but is discussed in detail in section 7.4.3.

#### 7.4.2 Generator Assembly

The Generator Assembly is made up of both the High Frequency Head and the Collimator, which are both interconnected with the control assembly via connector J1 (Ref. Dwg. 700272). The voltage used to generate the high voltage at the high frequency head enters the assembly at pins A & B of connector J1. The voltage is approximately 600 VPP at an approximate 20 kHz square wave, for a 100 kVp output.

Coil L1 is used to limit the in-rush current. The filament voltage enters at pins F,G&H of connector J1. Pin H is at a DC level of approximately 15 V, and pins F & G have a high frequency voltage of about 30 VPP at approximately 400 Hz with respect to ground.

Pin L of J1 is the mA signal, typically 5 V during the exposure. Components CR1, R1 and Z1 make up a protection network for the mA signal. Pins C&D of J1 provide a 24 VAC voltage for the collimator lamp and timer. Pin E of J1 is the ground pin, pin K of J1 is the kV feedback signal (10 V=100 kV). Connector J2 (mA jack) places a mA meter in series with the mA line for calibration purposes.

#### 7.4.3 Control Assembly

The Control Assembly is made up of the following sub-assemblies; X-ray regulator/20 kHz Full Bridge Driver, Microprocessor, Front Panel, Filament Control, low voltage power supplies.

Resistor R2 is the bleeder for the capacitors, and resistor R1 is used to limit the in-rush current.

Relay contacts 1A shorts resistor R1 during the Prep and X-ray period to allow the line to deliver the required power. Transistors Q1 and Q2 make up a full bridge high frequency circuit operating at approximately 20 kHz. This circuit is energized during the X-Ray On period and is used to convert the DC voltage back to high frequency AC to drive the high voltage transformer in the generator assembly (approx. 20 kHz).

The X-ray regulator/Full bridge driver PCB (A1) takes commands from the microprocessor and converts them into high frequency signals to drive the full bridge. Current transformer T2 is used to monitor the high frequency current out of the Full Bridge, and provides an interrupt in the event of excessive current flow. The high frequency voltage output of the Full Bridge is taken from transistors Q1-C2E1 and Q2-C2E1. The output signal now flows through capacitor C3 and goes to connector J2 pins A and B. Capacitor C3 is used to block any DC voltage from entering the primary of the High Voltage Transformer in the Generator Assembly. Transformer T1 is an isolation transformer, one of its secondaries is 24 VAC and is used as the prime source of the filament control board and also goes to connector J2 pins C and D to power up the collimator lamp. The microprocessor PCB Assembly (A2) is used as the brain of the unit, it receives the X-ray Prep and X-ray On signals from the exposure switch, which is connected via J3. The x-ray prep signal which is active low (active low= approx.0V, active high= approx. +5V), goes into the microprocessor at P1 pin 1. It also goes to the filament control PCB via P5 pin 8, where it activates the filament circuitry and also energizes relay K1. All this prepares the unit for an x-ray exposure. When the x-ray signal (active low), is applied to J3 pin A the signal is fed into the microprocessor via P1 pin 2, that initiates a timed signal (active high), which exits from the microprocessor at P1 pin 17 and enters the X-ray regulator/Full bridge driver PCB (A1) at P15 pin 9. It is also used to initiate the audible beeper which is part of the microprocessor board (A2). The microprocessor also monitors the FAULT signal (active low), on P1 pin 40 from the x-ray regulator/20kHz full bridge driver assembly.

From the same PCB assembly it also receives an isolated + 15 VDC source on P3 pins 4, 5, and 6 which powers up the IC's used on the voltage reference section of the microprocessor. The microprocessor also outputs an adjustable voltage level from P3 pin 10 which is the reference out signal (typical 5 to 10 VDC) and is proportional to the kV output. The microprocessor also receives an mA signal from connector J2 pin L into P1 pin 25 (approx. 5 VDC level) and this signal is present during an x-ray exposure. The filament control signal leaves the microprocessor at P1 pin 23 (LM 350 control); it goes to U1 (filament regulator) and the filament control board via P5 pin 6. This signal controls the filament voltage to the x-ray tube (approx. 15V) and is preset during the X-ray Prep and X-ray On modes. A BCD buss (4 lines) is provided to the microprocessor at P1 pins 3, 5, 6 and 7 and comes from the filament control board (A4) at P8 pins 1, 4, 3 and 6. This buss represents the calibration selection signals coming from the BCD switch on the filament control board.

The filament regulator U1 receives an unregulated input voltage (approx. 24 VDC) from P5 pin 4 and provides a regulated voltage (approx. 15V) on P5 pin 6. The power supply assembly A5 provides the +15 VDC and +5 VDC for all the low voltage (signal processing) electronics.

# **Electrical Schematics**

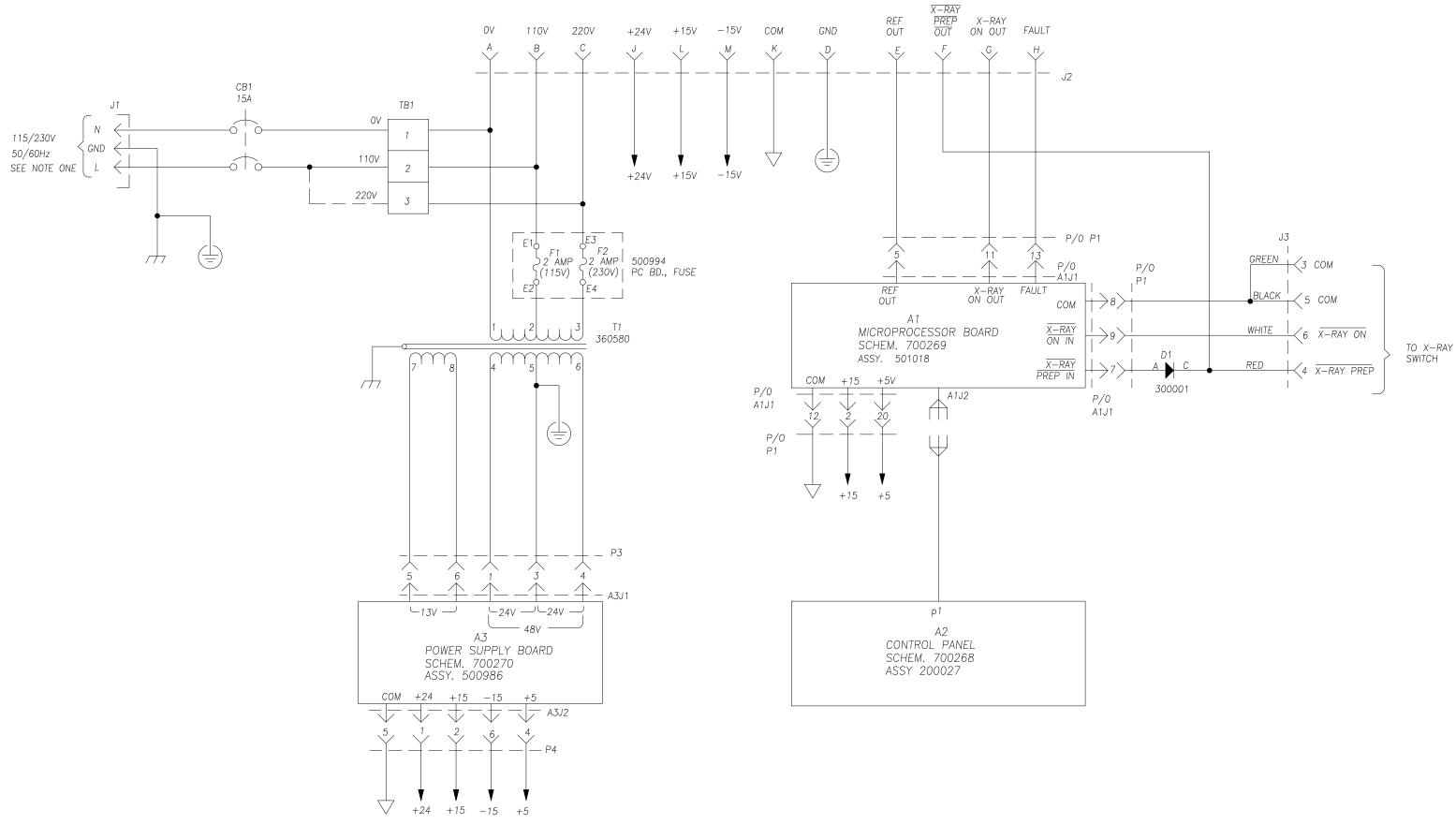
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# 8.1 Electrical Schematics

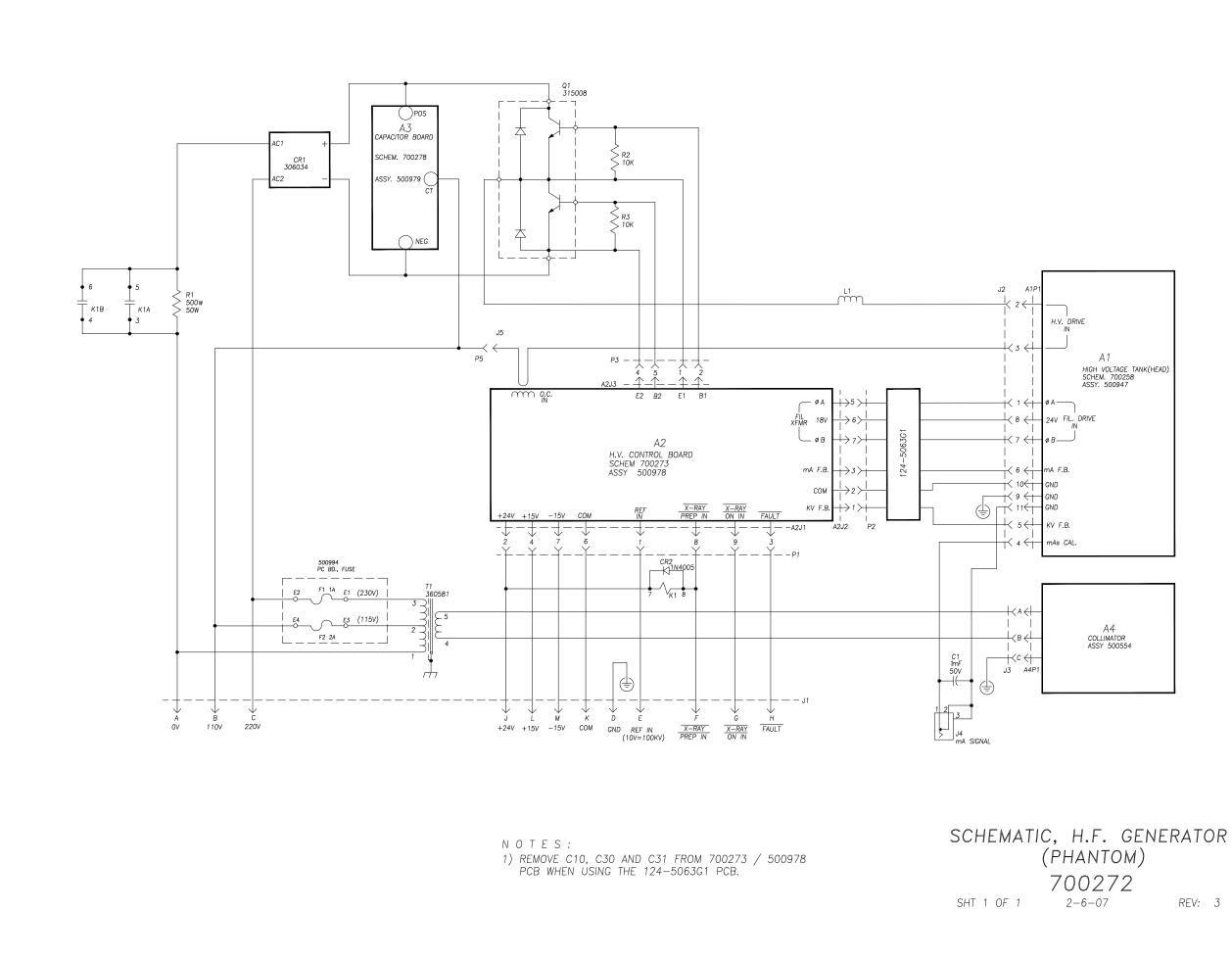
This chapter contains the electrical schematics for the Phantom.

| Drawing Number | Drawing Description                | # Sheets | Current<br>Rev. |
|----------------|------------------------------------|----------|-----------------|
| 700271         | Control Chassis Schematic          | 1        | 1               |
| 700272         | High Frequency Generator Schematic | 1        | 3               |
| 700258         | High Voltage Tank Schematic        | 1        | С               |
| 700269         | Microprocessor Schematic           | 1        | E               |
| 501018         | Microprocessor PCB Assembly        | 1        | 2               |
| 700273         | Control PCB Schematic              | 1        | 2               |
| 500978         | Control PCB Assembly               | 1        | 5               |
| 700270         | Power Supply PCB Schematic         | 1        | 1               |
| 500986         | Power Supply PCB Assembly          | 1        | 2               |
| 700278         | Capacitor PCB Schematic            | 1        | -               |
| 500979         | Capacitor PCB Assembly             | 1        | 1               |

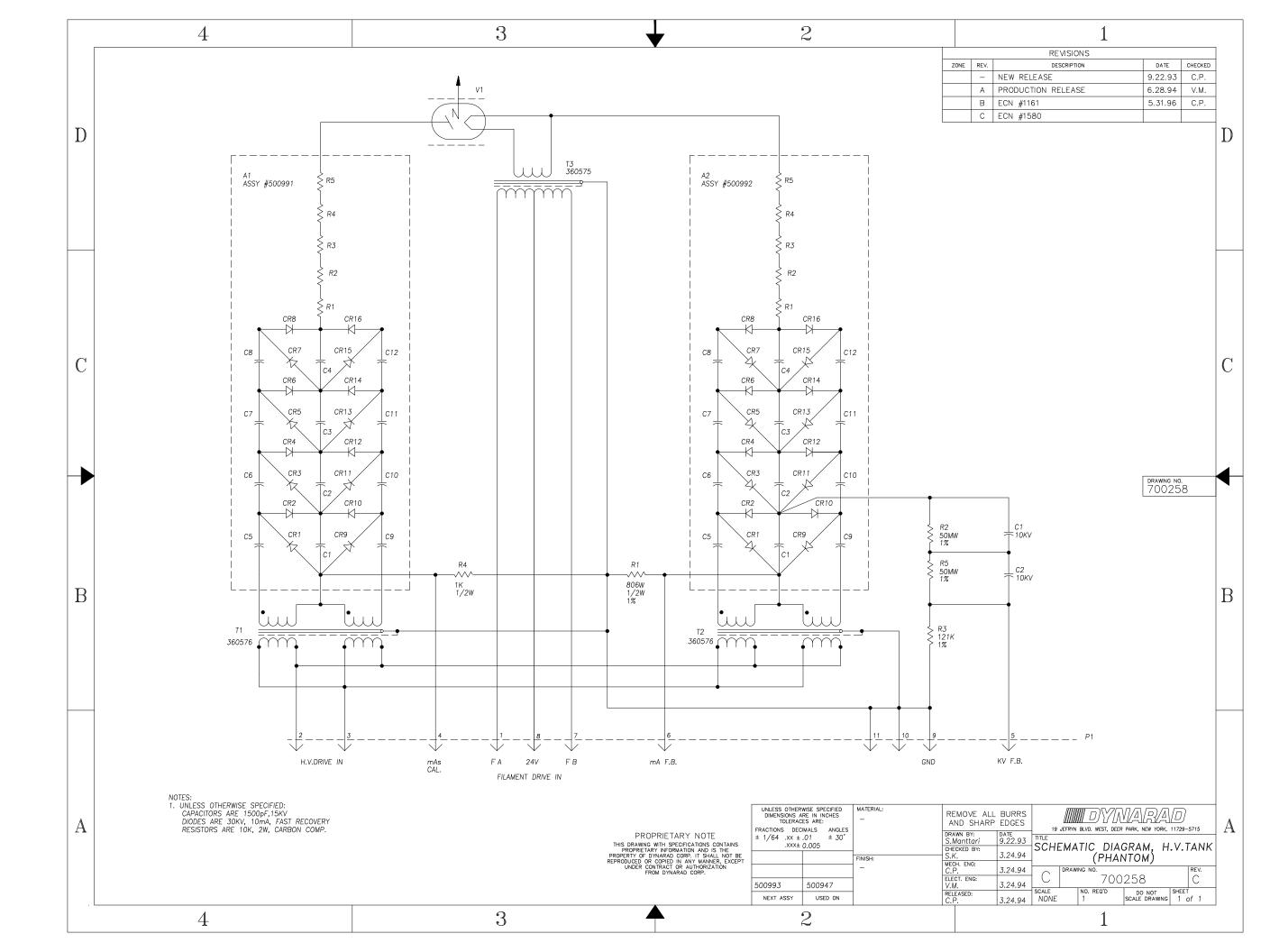
Table 8-1: List of Schematics

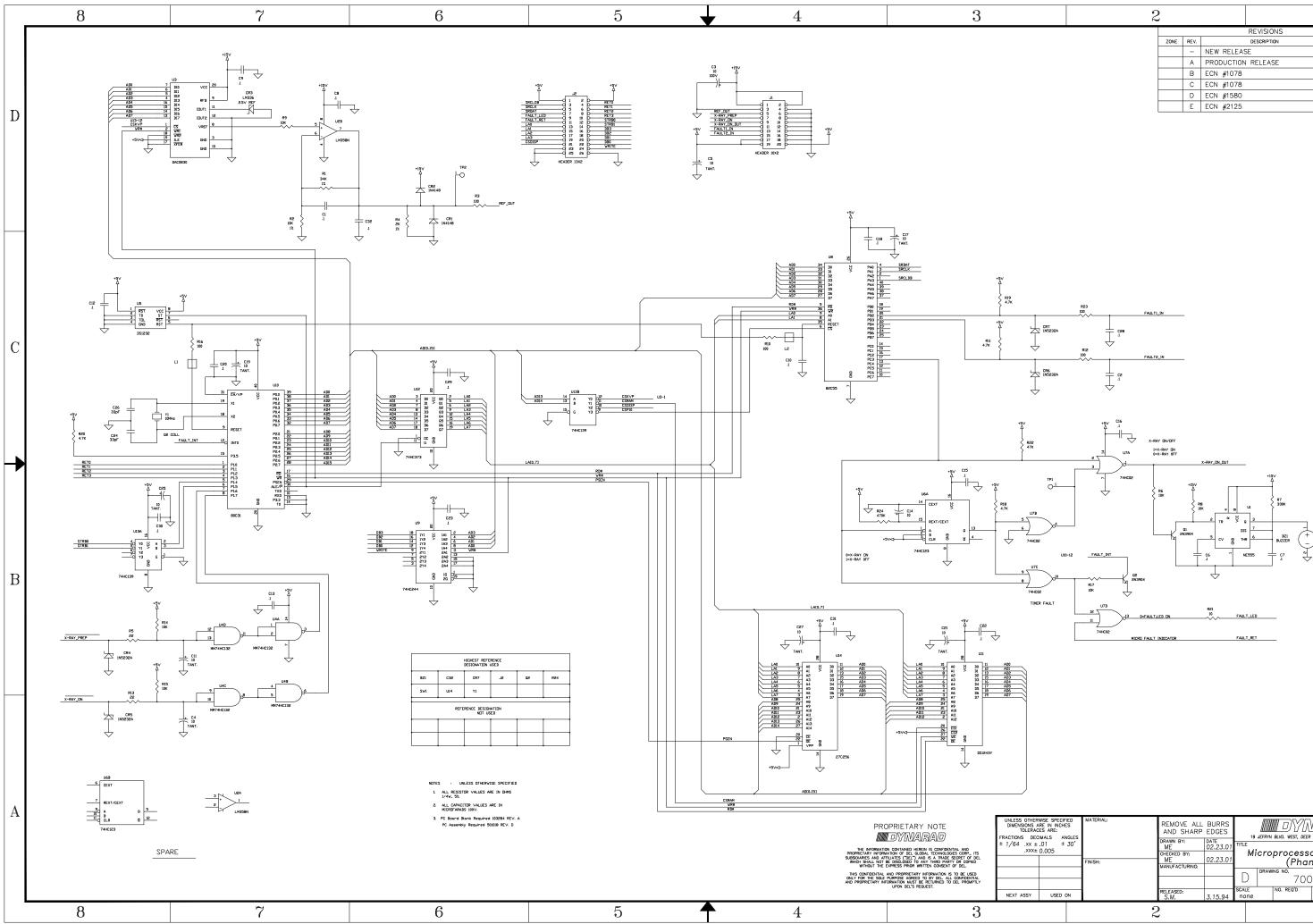


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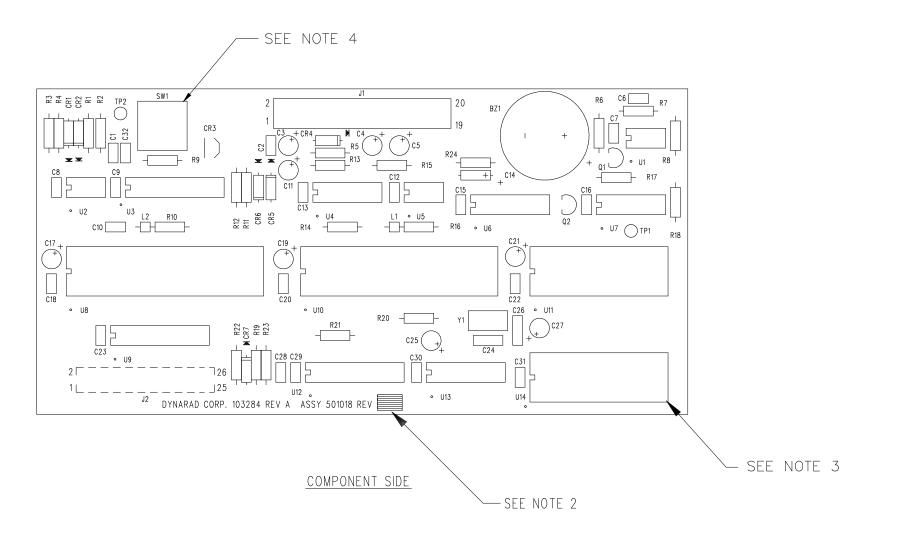
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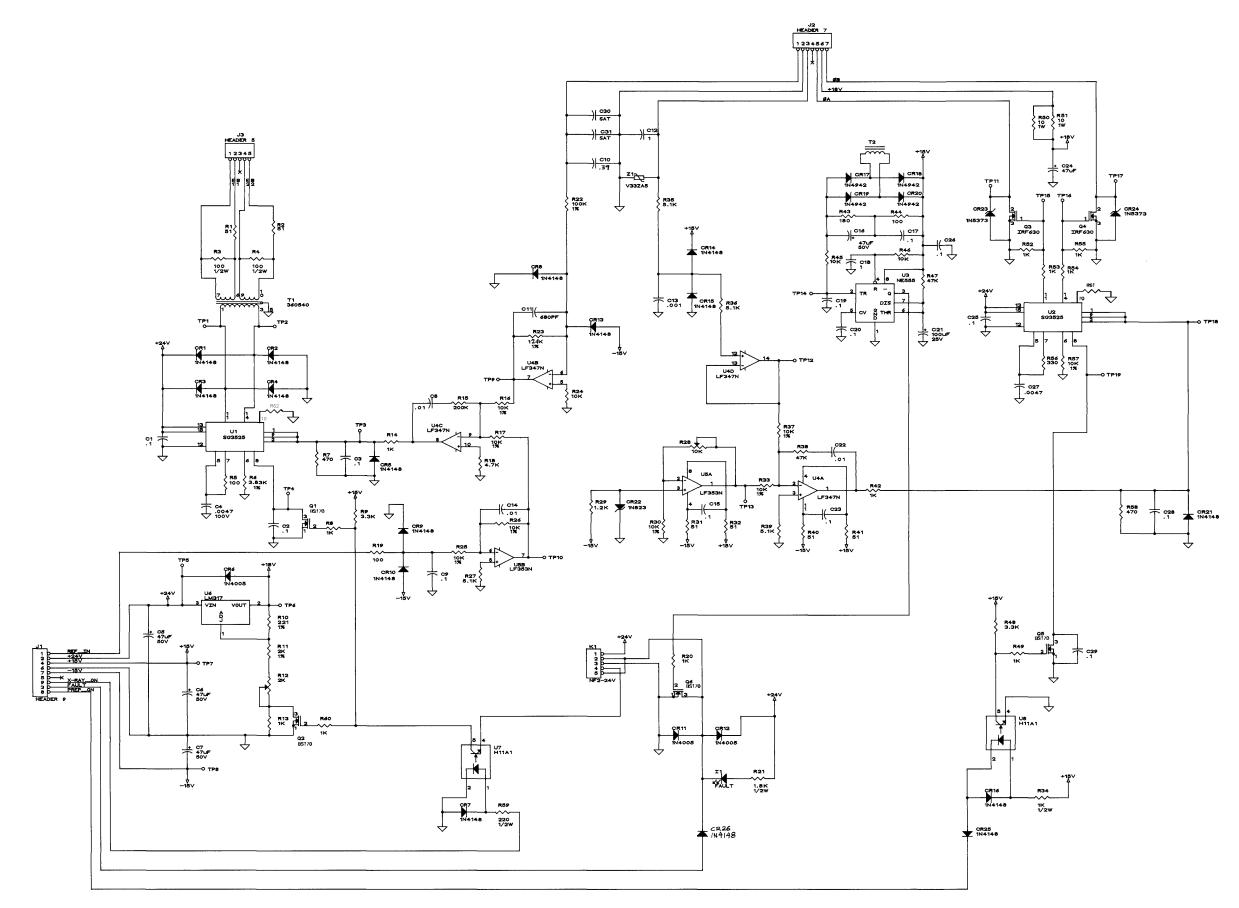
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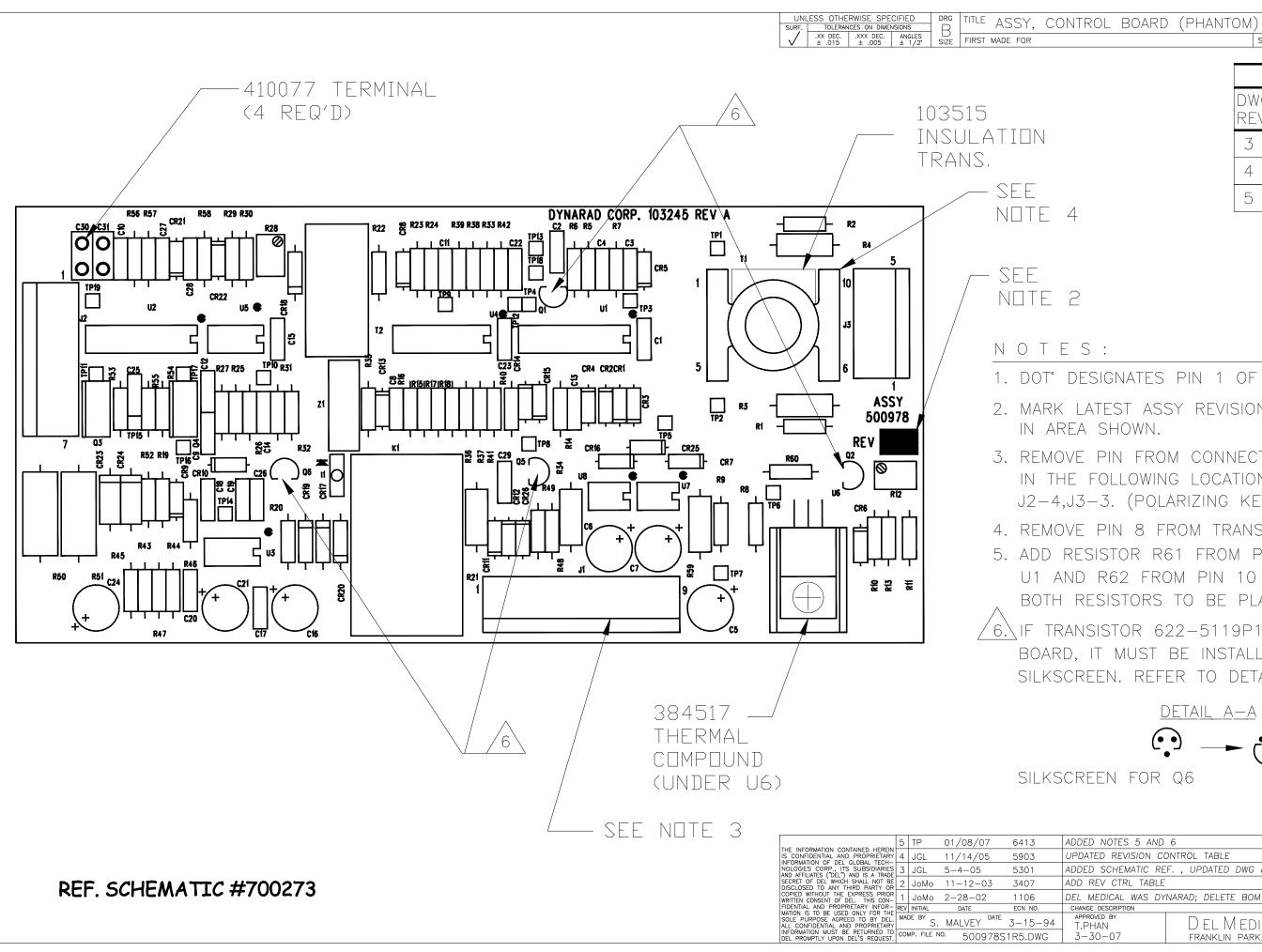
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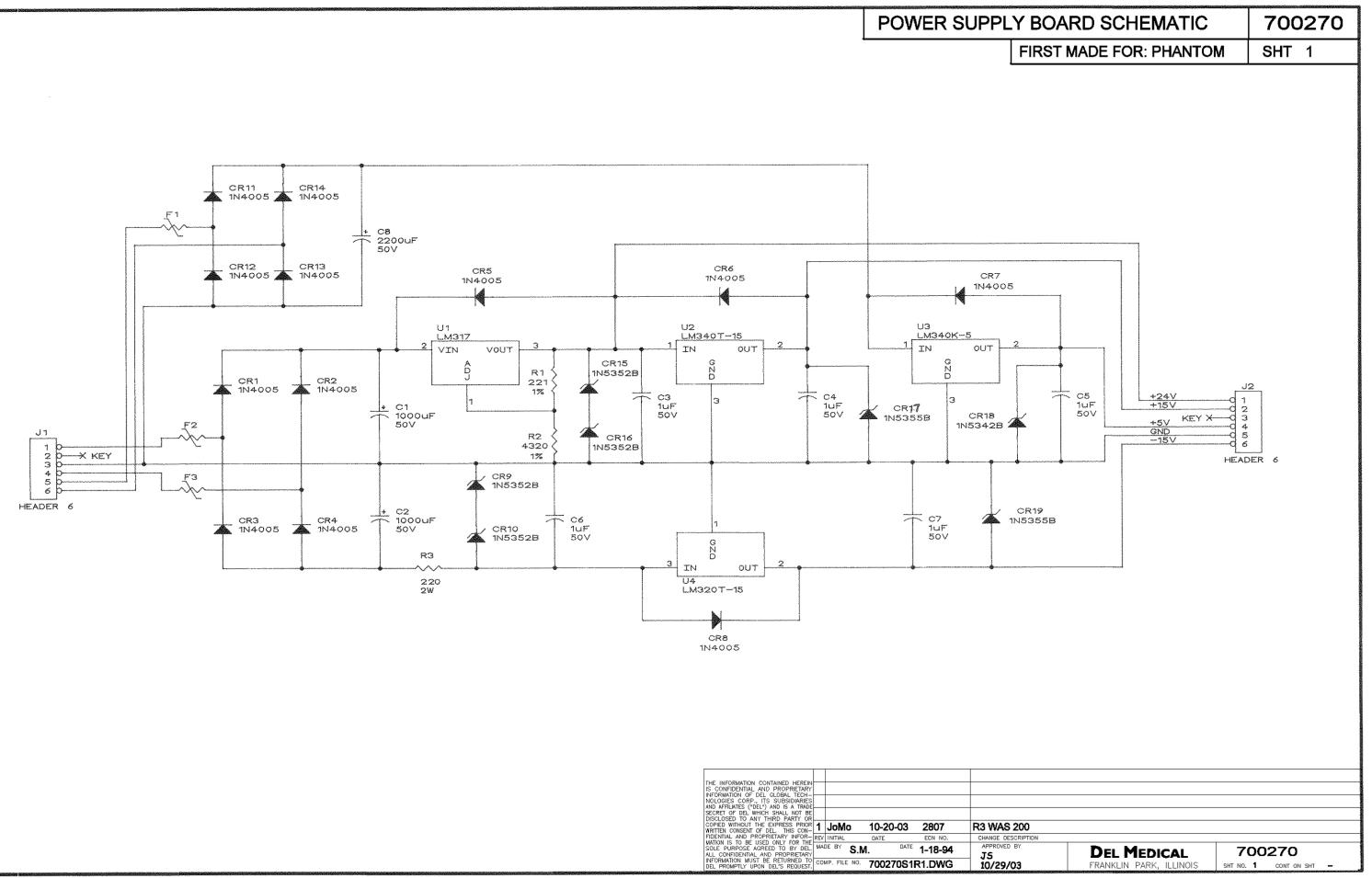
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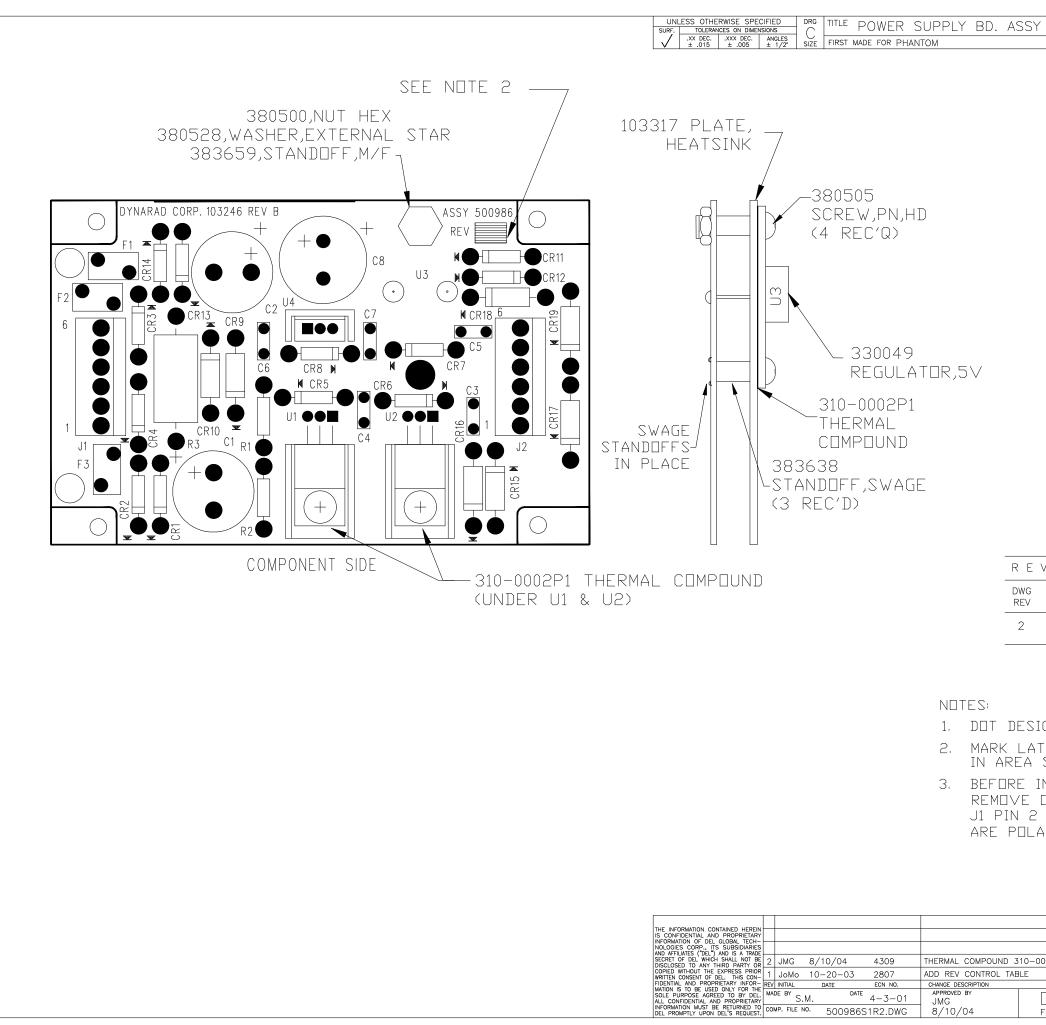
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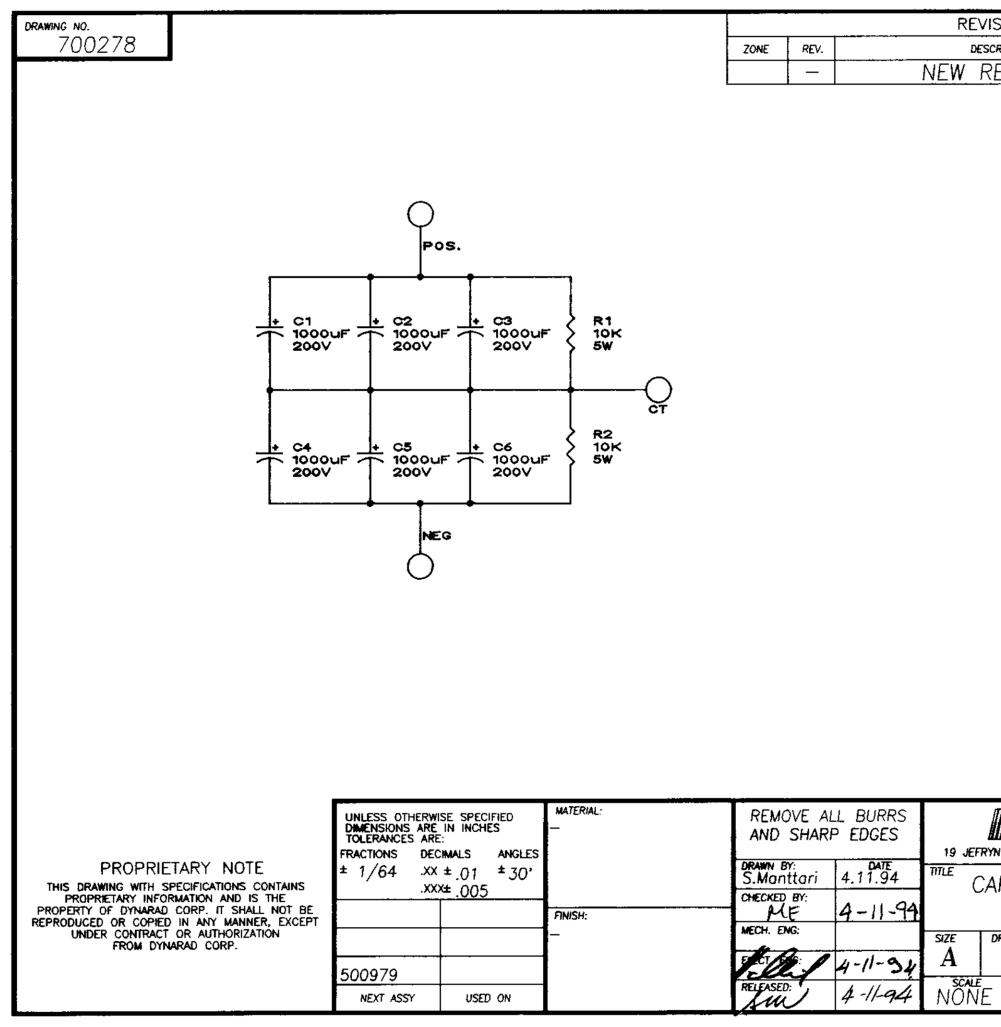
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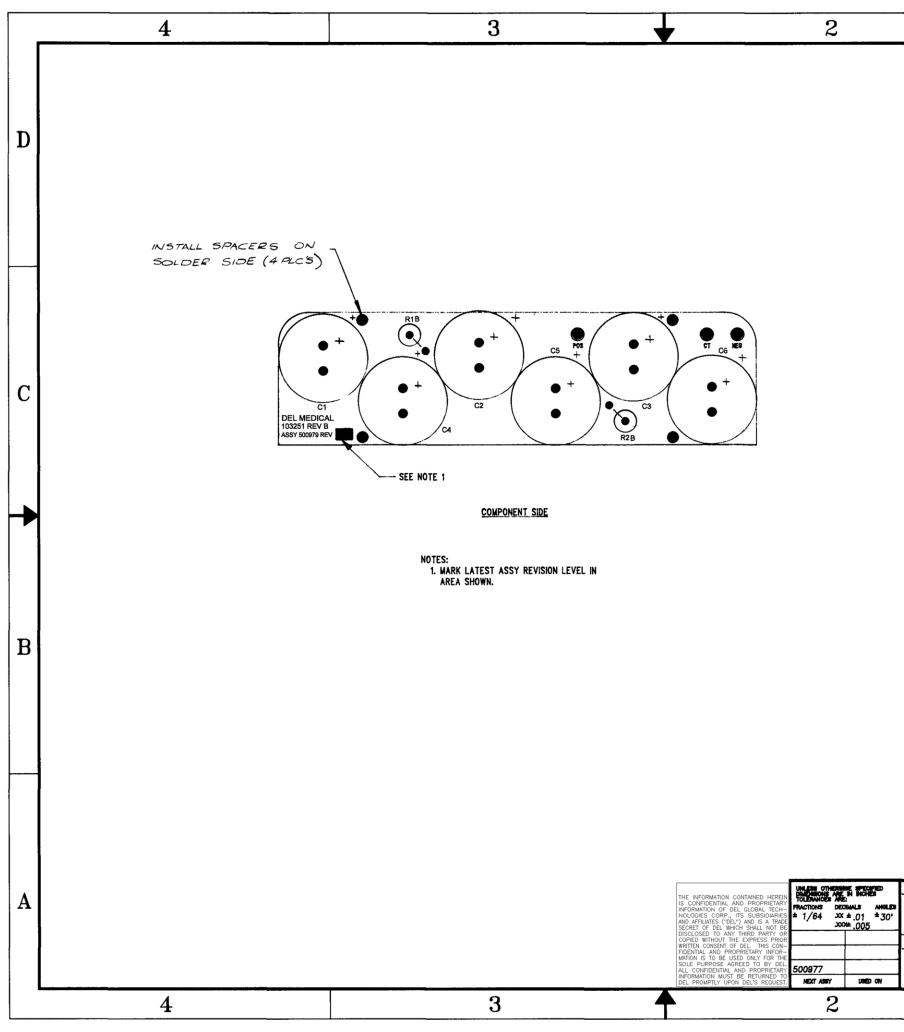
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|            |                   |                  |              |
|            |                   |                  |              |

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| /INSH:         | S.MALVEY<br>CHEDRED BY:  | 4.9.94<br>4-11- 94        | fitt.E<br>SZT   | CAPACITOR ASSY<br>(PHANTOM) |                       |                |   |  |
|                | RLECT. DO  | <b>4-11-94</b><br>4-11-94 | <b>Č</b><br>1:1 |                             | 0979<br>Scale Drawing | sineer<br>1 of | 1 |  |
|                |  |                           |                 | 1                           |                       |                |   |  |

# **Illustrated Parts List**

# 9

# 9.1 Ordering Parts

For your convenience, replacement parts and accessories can be ordered from Del Medical Systems by fax 24 hours a day. Please have the following information available to ensure quick, easy, and accurate service.

- Your name and telephone number
- Your P.O. (Purchase Order) number
- Your preferred method of delivery
- The part number and quantity of all items required

#### 9.1.1 To Order by Fax

Fax your order to Del Medical Systems at 1-800-288-7011. Fax orders can be sent 24 hours a day, 7 days a week. Orders will be registered the following business day.

If you need additional assistance, please call Del Medical Systems at 1-800-800-6006 and speak to one our Customer Service Representatives. Telephone hours are 8:00 a.m. to 5:00 p.m., Monday through Friday (Central Standard or Daylight Time).

## 9.2 How to Use This Parts List

#### 9.2.1 General Part Numbers

This chapter contains all part numbers necessary to order Phantom replacement parts and assemblies.

This illustrated parts breakdown is presented in disassembled order. Detail parts are shown below their respective upper level assemblies whenever possible. The parts lists follow the illustration for a particular assembly and represent components of that assembly. The number listed in the quantity column is the number of the specific part required to complete the assembly and may not reflect the quantity needed for the entire system.

The lists are divided into four columns. The item/index numbers refer to the identification number located on the drawing. The part number is the Del Medical part number, used to identify the part for ordering. The part description column lists each part name, and the quantity column lists the quantity of that part used in that particular assembly.

Illustrations are shown before the parts list for each assembly. Some assembly illustrations require more than one page.

### 9.3 Commonly Ordered Parts (Collimator)

| Part Description  | Part number |
|---|-------------|
| Steel Spacers, Thickness 1.5mm                                      | RO 002      |
| Mounting Flange, Fixed Type, 10mm Thickness                         | RO181       |
| Focus - Skin Spacers  | RO 198      |
| Mounting Flange, Rotating Type                                      | RO 199      |
| Lamp, 100W 24V  | RS 006      |
| Ceramic Lamp Holder, CSA  | RS 033      |
| Timer FM338 24V   | RS 063      |
| Gray Knob R72 Index   | RS 451      |
| Lateral Panel, Long Aluminum with Index Scale                       | RS 533      |
| Lateral Panel, Cross Aluminum with Index Scale                      | RS534       |
| Lateral Panel, Long Aluminum with Index Scale with Push Button Hole | RS 535      |
| Lower Cover in ABS R72 Standard (H. 123)                            | RS 536      |
| Upper Cover R72 Standard  | RS 537      |
| Retractable Measuring Tape (Starting Point 176mm)                   | RS 538      |
| RS 449 Anti-Dust Panel R72 (CSA)                                    | RS 449      |
| Round Push button, Black/Chrome Plated                              | RS 050      |

Table 9-1: Commonly Ordered Parts

# 9.4 Commonly Ordered Parts (Main Unit)

| Part Description                    | Part number  |
|-------------------------------------|--------------|
| Modified Tape Measure               | 218001       |
| Gage, Level                         | 218003       |
| Interconnect Cable Assembly         | 501043       |
| Power Cord Assembly                 | 501038       |
| Hand Switch, Exposure Control       | 501022       |
| Fuse, 1 Amp                         | 203018       |
| Pad, Friction                       | 103088       |
| Screw, Fillister Head               | 381039       |
| Crown, Rotation                     | 103087       |
| Shaft, Pivot                        | 103086       |
| Washer, Flat                        | 216051       |
| Retaining Ring                      | 219015       |
| Pin, Pivot                          | 103140       |
| Locking Cylinder Assembly           | 500983       |
| Screw, Shoulder                     | 103443       |
| Release Bracket & Cable Assembly    | 218120       |
| Hook, Hand Switch Assembly          | 501022       |
| Wheel Assembly                      | 211021       |
| Washer, Wave Spring                 | 383142       |
| Screw, 1/4"-20 X 3/8" Button Head   | 382048       |
| Plug, Hole                          | 214064       |
| Washer, 1/4" Flat                   | 382001       |
| Bumper                              | 103424       |
| Cable Release Assembly              | 218120       |
| Fuse, Time Lag, (1A) 250V           | 203018       |
| Fuse, Time Lag, (2A) 250V           | 203019       |
| Pin, Lock                           | 383612       |
| Lanyard, Wire                       | 218058       |
| Bezel, Control                      | 103253       |
| Control Case                        | 103254       |
| Cassette Case Assembly              | 501088       |
| Band, Cover                         | 103970       |
| Brake Toggle Assembly               | 210040       |
| Technical Manual                    | 8000-HF-110A |
| Touch Up Paint (Light or Dark Grey) | -            |
| Cap Selector Kit                    | 112-5225G1   |
| Main On/Off Switch                  | 378090       |
| Crown, Rotation                     | 103087       |
| Table 9.2: Commonly Ordered Parts   |              |

Table 9-2: Commonly Ordered Parts



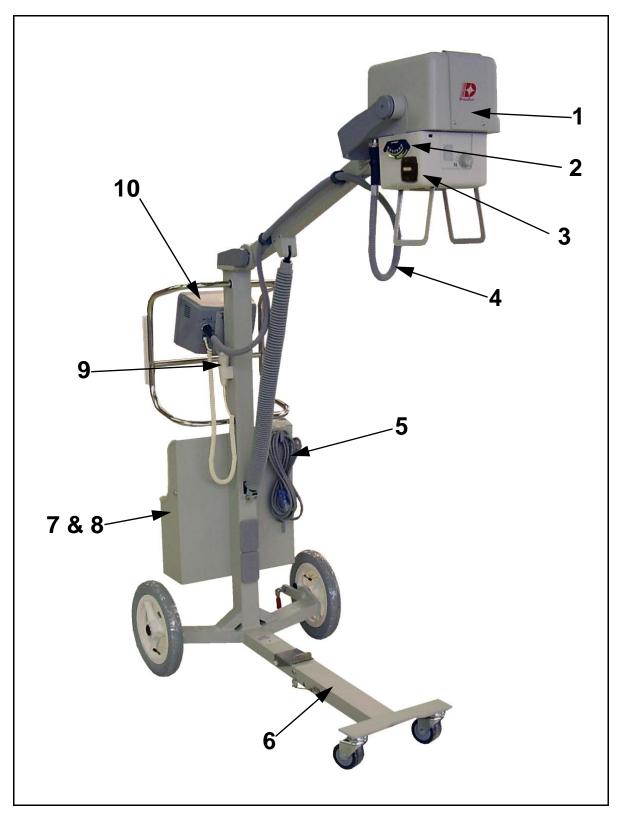
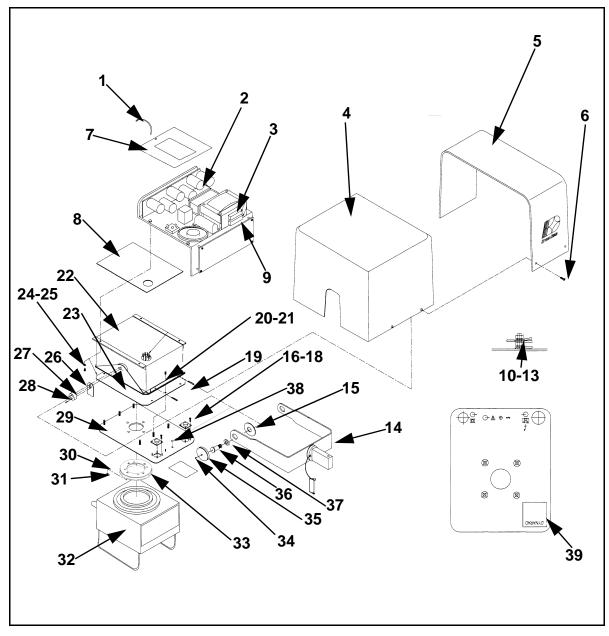


Figure 9-1. Overall Assembly

| Fig ref. | Part number | Description  | Qty |
|----------|-------------|--|-----|
| 1        | 500946      | Generator Assembly (See Section<br>"Generator Assembly (500946)" on<br>page 9-6 for breakdown of assem-<br>bly)            | 1   |
| 2        | 218003      | Gage, Level  | 1   |
| 3        | 218001      | Modified Tape Measure  | 1   |
| 4        | 501043      | Interconnect Cable Assembly  | 1   |
| 5        | 501038      | Power Cord Assembly  | 1   |
| 6        | 500982      | Portable Stand Assembly (See<br>Section "Generator Chassis<br>Assembly (500977)" on page 9-8<br>for breakdown of assembly) | 1   |
| 7        | 381550      | Screw, Flat Head   | 4   |
| 8        | 501088      | Cassette Case Assembly   | 1   |
| 9        | 501022      | Hand Switch, Exposure Control  | 1   |
| 10       | 501020      | Control Assembly (See Section<br>"Control Assembly (501020)" on<br>page 9-16 for breakdown of assem-<br>bly)               | 1   |

Table 9-3: Overall Assembly

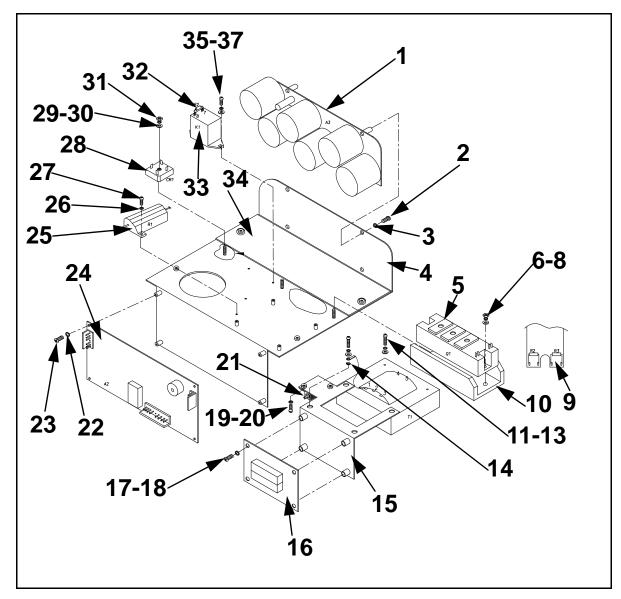


9.6 Generator Assembly (500946)

Figure 9-2. Generator Assembly

| Fig ref. | Part number | Description                     | Qty |
|----------|-------------|---------------------------------|-----|
| 1        | 415011      | Tie wrap, Small                 | 1   |
| 2        | 500977      | Generator Chassis Assembly (See | 1   |
|          |             | Section "Generator Chassis      |     |
|          |             | Assembly (500977)" on page 9-8  |     |
|          |             | for breakdown of assembly)      |     |
| 3        | 203018      | Fuse, 1 Amp                     | 1   |
| 4        | 103075      | Cover, Generator                | 1   |
| 5        | 103970      | Band, Shroud                    | 1   |
| 6        | 380553      | Screw, Truss Head               | 4   |
| 7        | 103400      | Label, Warning                  | 1   |
| 8        | 103295      | Shield, Tank                    | 1   |
| 9        | 203019      | Fuse, 2 Amp                     | 1   |
| 10       | 381000      | Nut, Hex                        | 2   |
| 11       | 381001      | Washer, Flat                    | 2   |
| 12       | 381002      | Washer, Lock                    | 2   |
| 13       | 381029      | Washer, External Tooth          | 1   |
| 14       | 500976      | Generator Yoke Assembly         | 1   |
| 15       | 103088      | Pad, Friction                   | 2   |
| 16       | 381000      | Nut, Hex                        | 8   |
| 17       | 381001      | Washer, Flat                    | 8   |
| 18       | 381002      | Washer, Lock                    | 8   |
| 19       | 383680      | Standoff                        | 6   |
| 20       | 381000      | Nut, Hex                        | 6   |
| 21       | 381001      | Washer, Flat                    | 6   |
| 22       | 500947      | Tube Head Assembly              | 1   |
| 23       | 103095      | Generator Shield                | 1   |
| 24       | 381002      | Washer, Lock                    | 4   |
| 25       | 381018      | Screw, Pan Head                 | 4   |
| 26       | 103090      | Side Plate                      | 2   |
| 27       | 103558      | Spacer, Yoke                    | 2   |
| 28       | 380524      | Screw, Socket Head              | 4   |
| 29       | 210-5061P1  | Plate, Transition, Ralco        | 1   |
| 30       | 382002      | Washer, Lock                    | 4   |
| 31       | 382000      | Nut, Hex                        | 4   |
| 32       | 500-5073P1  | Collimator Assembly, Ralco      | 1   |
| 33       | 112-5268G1  | Mounting Ring Assembly, Ralco   | 1   |
| 34       | 381039      | Screw, Fillister Head           | 2   |
| 35       | 103087      | Crown, Rotation                 | 2   |
| 36       | 103086      | Shaft, Pivot                    | 2   |
| 37       | 216051      | Washer, Flat                    | 2   |
| 38       | 4450-0335   | Washer                          | 1   |
| 39       | -           | Label                           | 1   |

Table 9-4: Generator Assembly

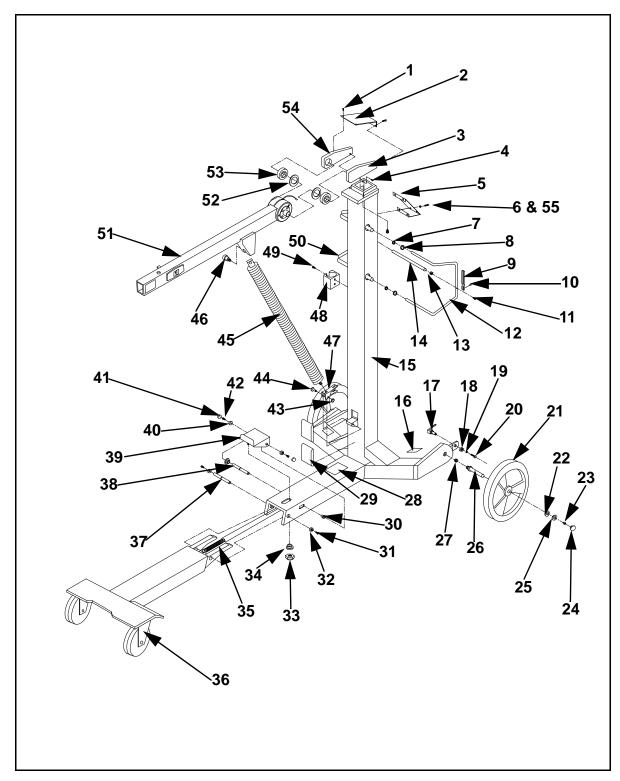


## 9.7 Generator Chassis Assembly (500977)

Figure 9-3. Generator Chassis Assembly

| Fig ref. | Part number | Description                      | Qty |
|----------|-------------|----------------------------------|-----|
| 1        | 500979      | Capacitor PCB Assembly           | 1   |
| 2        | 380514      | Screw, 6-32 X 3/8" Pan Head      | 4   |
| 3        | 380502      | Washer, #6 Splick Lock           | 4   |
| 4        | 103105      | Generator Chassis                | 1   |
| 5        | 315015      | IGBT, Half Bridge                | 1   |
| 6        | 383085      | Nut, 8-32 Hex                    | 2   |
| 7        | 381001      | Washer, #8 Flat                  | 2   |
| 8        | 381002      | Washer, #8 Split Lock            | 2   |
| 9        | 340001      | Resistor, 10K, 1/8 W 1%          | 2   |
| 10       | 103514      | Heatsink                         | 1   |
| 11       | 381001      | Washer, #8 Flat                  | 4   |
| 12       | 381002      | Washer, #8 Split Lock            | 4   |
| 13       | 381027      | Screw, 8-32 X 3/4" Phillips Head | 4   |
| 14       | 381029      | Washer, #8 External Lock         | 1   |
| 15       | 103440      | Fuse Bracket                     | 1   |
| 16       | 500994      | Fuse PC Board Assembly           | 1   |
| 17       | 380526      | Screw, 6-32 X 5/8" Phillips      | 4   |
| 18       | 380502      | Washer, #6 Split Lock            | 4   |
| 19       | 380010      | Screw, 4-40 X 1/4" Phillips      | 2   |
| 20       | 380002      | Washer, #4 Split Lock            | 2   |
| 21       | 603-5007P1  | Resistor, .22 Ohms, 25W          | 1   |
| 22       | 380526      | Screw, 6-32 X 5/8" Phillips      | 4   |
| 23       | 380502      | Washer, #6 Splick Lock           | 4   |
| 24       | 500978      | High Voltage Control PCB         | 1   |
| 25       | 340327      | Resistor, WW 500Ohm, 50W, 5%     | 1   |
| 26       | 380502      | Washer, #6 Split Lock            | 2   |
| 27       | 380526      | Screw, 6-32 X 5/8" Phillips      | 2   |
| 28       | 306034      | Bridge Rectifier                 | 1   |
| 29       | 381001      | Washer, #8 Flat                  | 1   |
| 30       | 381002      | Washer, #8 Split Lock            | 1   |
| 31       | 381000      | Nut, 8-32 Hex                    | 1   |
| 32       | 300002      | Diode, 1N4005                    | 1   |
| 33       | 378089      | Relay                            | 1   |
| 34       | 306-5008P1  | Insulator                        | 1   |
| 35       | 380502      | Washer, #6 Split Lock            | 2   |
| 36       | 380501      | Washer, #6 Flat                  | 2   |
| 37       | 380510      | Screw, 6-32 X 1/4" Phillips      | 2   |

Table 9-5: Generator Chassis Assembly



## 9.8 Portable Stand Assembly (500982)

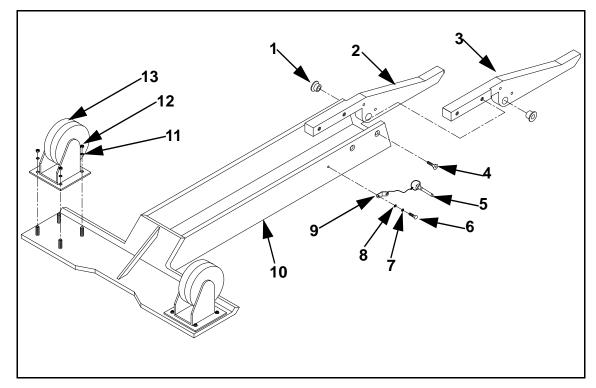
Figure 9-4. Portable Stand Assembly

| Fig ref. | Part number     | Description                                     | Qt<br>y |
|----------|-----------------|---|---------|
| 1        | 380556          | Screw, 6-32 X 1/4" Truss Head                   | 4       |
| 2        | 103125          | Pivot Cover                                     | 1       |
| 3        | 103135          | Boom Arm Pivot                                  | 1       |
| 4        | 382027          | Screw, 1/4"-20 X 9/16" Socket Head Cap<br>Screw | 4       |
| 5        | 103299          | Control Bracket                                 | 1       |
| 6        | 380514          | Screw, 6-32 X 3/8" Pan Head                     | 4       |
| 7        | 219028          | Retaining Ring                                  | 4       |
| 8        | 219027          | Retaining Ring                                  | 4       |
| 9        | 103302          | Slider Rail                                     | 2       |
| 10       | 773-00-19107511 | Screw, 10-32 X 3/4" Self Threading              | 4       |
| 11       | 381566          | Screw, 10-32 X 1.25" FL Head                    | 2       |
| 12       | 103301          | Hand Rail, Left                                 | 1       |
| 13       | 218130          | Connector, Tube                                 | 2       |
| 14       | 103308          | Bar, Cross                                      | 1       |
| 15       | 800329          | Weldment, Portable Stand Assy                   | 1       |
| 16       | 102371          | Label, Tire                                     | 2       |
| 17       | 210040          | Clamp, Toggle                                   | 2       |
| 18       | -               | Nut, Supplied with Clamp 210040                 | 2       |
| 19       | 382018          | Nut, 1/4"-20 Low Profile Hex                    | 2       |
| 20       | 218121          | Glide, Adjustable                               | 2       |
| 21       | 211021          | Wheel Assembly                                  | 2       |
| 22       | 383142          | Washer, Wave Spring                             | 2       |
| 23       | 382048          | Screw, 1/4"-20 X 3/8" Button Head               | 2       |
| 24       | 214064          | Plug, Hole                                      | 2       |
| 25       | 382001          | Washer, 1/4" Flat                               | 2       |
| 26       | 102701          | Rear Wheel Axle                                 | 2       |
| 27       | 383141          | Insert, Threaded                                | 2       |
| 28       | -               | Label, Serial Number                            | 1       |

 Table 9-6: Portable Stand Assembly

| Fig ref. | Part number | Description  | Qt<br>y |
|----------|-------------|--|---------|
| 29       | 103424      | Bumper   | 2       |
| 30       | 216002      | Bushing, Flanged   | 2       |
| 31       | 381576      | Screw, 10-32 X 1/2" Flat Head  | 2       |
| 32       | 102086      | Shaft Retainer   | 2       |
| 33       | 382064      | Nut, Locking   | 1       |
| 34       | 216018      | Bushing, Flange  | 1       |
| 35       | 213010      | Spring, Extension  | 1       |
| 36       | 500980      | Leg Assembly, Front (See Section "Front<br>Leg Assembly (500980)" on page 9-13 for<br>breakdown of assembly) | 1       |
| 37       | 101659      | Shaft, Hinge   | 1       |
| 38       | 102020      | Shaft, Kick Bracket  | 1       |
| 39       | 102019      | Kick Bracket   | 1       |
| 40       | 214027      | Screw Base   | 2       |
| 41       | 214030      | Screw Cover  | 2       |
| 42       | 381504      | Screw, 10-32 X 9/16" Flat Socket Head  | 2       |
| 43       | 219015      | Retaining Ring   | 1       |
| 44       | 103140      | Pin, Pivot   | 1       |
| 45       | 500983      | Locking Cylinder Assembly  | 1       |
| 46       | 103443      | Screw, Shoulder  | 1       |
| 47       | 218120      | Release Bracket & Cable Assembly   | 1       |
| 48       | -           | Included in Hand Switch Assembly, part#<br>501022  | 1       |
| 49       | 380521      | Screw, 6-32 X 3/8" Flat Head   | 2       |
| 50       | 103300      | Hand Rail, Right   | 1       |
| 51       | 500981      | Tube Arm Assembly (See Section "Tube<br>Arm Assembly (500981)" on page 9-14 for<br>breakdown of assembly)    | 1       |
| 52       | 101992      | Washer, Rubbing  | 2       |
| 53       | 216052      | Bearing, Spherical   | 2       |
| 54       | 103136      | Pivot, Boom Arm  | 1       |
| 55       | 380502      | Washer, #6 Split Lock  | 4       |

Table 9-6: Portable Stand Assembly



# 9.9 Front Leg Assembly (500980)

| Figure   | 9-5. | Front   | Leg | Assembly    | U |
|----------|------|---------|-----|-------------|---|
| 1 121110 | 00.  | 1 /0/// | LUS | 11000000000 | 1 |

| Fig ref. | Part number | Description                               | Qty |
|----------|-------------|---|-----|
| 1        | 216054      | Bushing                                   | 2   |
| 2        | 102021      | Hinge, Right Hand                         | 1   |
| 3        | 102018      | Hinge, Left Hand                          | 1   |
| 4        | 382004      | Screw, 1/4"-20 X 5/8" Flat Socket<br>Head | 4   |
| 5        | 383612      | Pin, Lock                                 | 1   |
| 6        | 381006      | Screw, 8-32 X 3/8 Pan Head                | 1   |
| 7        | 381002      | Washer, #8 Split Lock                     | 1   |
| 8        | 381001      | Washer, #8 Flat                           | 1   |
| 9        | 218058      | Lanyard, Wire                             | 1   |
| 10       | 800331      | Leg, Weldment                             | 1   |
| 11       | 381501      | Washer, #10 Flat                          | 8   |
| 12       | 381556      | Nut, 10-32 Hex                            | 8   |
| 13       | 211010      | Wheel, Swivel                             | 2   |

Table 9-7: Front Leg Assembly



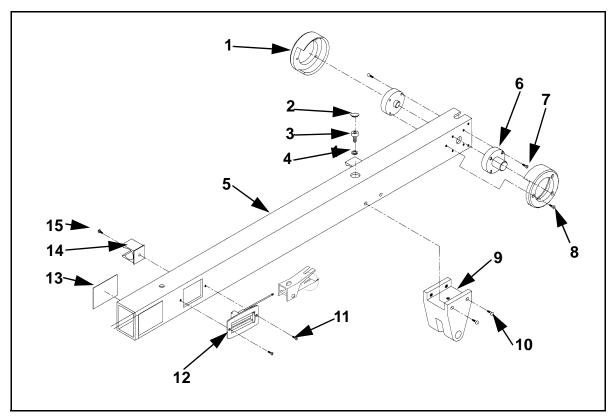
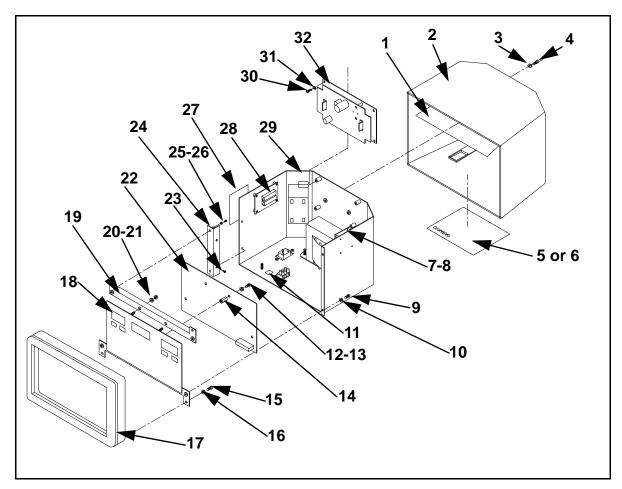


Figure 9-6. Tube Arm Assembly

| Fig ref. | Part number | Description                            | Qty |
|----------|-------------|--|-----|
| 1        | 104594      | Cap, End                               | 2   |
| 2        | 214032      | Plug, Hole                             | 1   |
| 3        | 382028      | Screw, 1/4" X 5/8" Socket Head         | 1   |
| 4        | 382002      | Washer, 1/4" Split Lock                | 1   |
| 5        | 104638      | Arm, Tube                              | 1   |
| 6        | 101607      | Axle, Arm                              | 2   |
| 7        | 381067      | Screw, 8-32 X 5/8 Flat Socket Head     | 8   |
| 8        | 380515      | Screw, 6-32 X 5/8" Flat Socket<br>Head | 6   |
| 9        | 103134      | Cylinder Mount                         | 1   |
| 10       | 382063      | Screw, 1/4" X 2" Button Socket<br>Head | 2   |
| 11       | 381009      | Screw, 8-32 X 1/2" Flat Socket<br>Head | 2   |
| 12       | 218120      | Cable Release Assembly                 | 1   |
| 13       | 102559      | Label, Caution                         | 1   |
| 14       | 214081      | Mount, Hose                            | 2   |
| 15       | 382091      | Screw, 1/4"-28 X 3/8" Button Head      | 2   |

Table 9-8: Boom Arm Assembly



9.11 Control Assembly (501020)

Figure 9-7. Control Assembly

| Fig ref. | Part number | Description  | Qty |
|----------|-------------|--|-----|
| 1        | 103470      | Thermal Barrier  | 1   |
| 2        | 103524      | Case, Control  | 1   |
| 3        | 380501      | Washer, #6 Flat  | 4   |
| 4        | 218055      | Stud, Ball   | 4   |
| 5        | -           | Label (115V)   | 1   |
| 6        | -           | Label, (230V)  | 1   |
| 7        | 203018      | Fuse, Time Lag, (1A) 250V  | 1   |
| 8        | 203019      | Fuse, Time Lag, (2A) 250V  | 1   |
| 9        | 380510      | Screw, 6-32 X 1/4" Phillips Pn Hd  | 2   |
| 10       | 380502      | Washer, #6 Split Lock  | 2   |
| 11       | 103336      | Decal, Protective Ground   | 1   |
| 12       | 380510      | Screw, 6-32 X 1/4" Phillips Pn Hd  | 4   |
| 13       | 380502      | Washer, #6 Split Lock  | 4   |
| 14       | 383639      | Spacer, Hex 6-32 X 7/16", 1/4" Hd  | 4   |
| 15       | 380510      | Screw, 6-32 X 1/4" Phillips Pn Hd  | 4   |
| 16       | 380502      | Washer, #6 Split Lock  | 4   |
| 17       | 103253      | Bezel, Control   | 1   |
| 18       | 200027      | Control Panel Assembly   | 1   |
| 19       | 103287      | Bracket, Panel   | 1   |
| 20       | 383056      | Nut, 6-32 Hex  | 4   |
| 21       | 380502      | Washer, #6 Split Lock  | 4   |
| 22       | 501018      | Micro-P PCB Assembly   | 1   |
| 23       | 380510      | Screw, 6-32 X 1/4" Phillips Pn Hd  | 2   |
| 24       | 103286      | Hinge, Control   | 1   |
| 25       | 380510      | Screw, 6-32 X 1/4" Phillips Pn Hd  | 2   |
| 26       | 380502      | Washer, #6 Split Lock  | 2   |
| 27       | 103399      | Label, Fuse  | 1   |
| 28       | 203319      | Fuse, Time Lag, (2A) 250V  | 2   |
| 29       | 501203      | Control Chassis Assembly (See<br>Section "Control Chassis Assem-<br>bly (501203)" on page 9-18 for<br>breakdown of assembly) | 1   |
| 30       | 380526      | Screw, 6-32 X 5/8" Phillips Pn Hd  | 4   |
| 31       | 380502      | Washer, #6 Split Lock  | 2   |
| 32       | 500986      | Power Supply PCB Assembly  | 1   |

Table 9-9: Control Assembly

# 9.12 Control Chassis Assembly (501203)

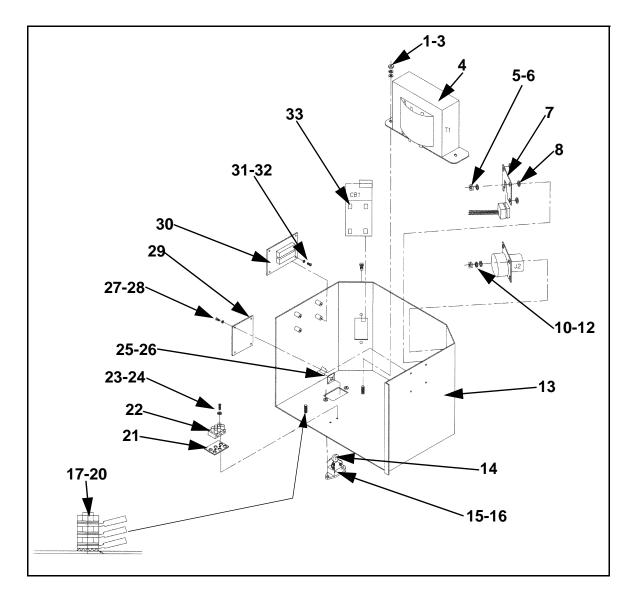


Figure 9-8. Control Chassis Assembly

| Fig ref. | Part number | Description                       | Qty |
|----------|-------------|-----------------------------------|-----|
| 1        | 381001      | Washer, Flat #8                   | 2   |
| 2        | 381002      | Washer, Lock #8                   | 2   |
| 3        | 383085      | Nut, Lock 8-32                    | 2   |
| 4        | 360580      | Transformer Assembly              | 1   |
| 5        | 380002      | Washer, Lock #4 Split             | 4   |
| 6        | 380023      | Nut, Hex 4-40                     | 4   |
| 7        | 103288      | Holder, Jack                      | 1   |
| 8        | 380001      | Washer, Flat                      | 4   |
| 9        | -           | Not Used                          | -   |
| 10       | 380000      | Nut, Hex 4-40                     | 4   |
| 11       | 380001      | Washer, Flat #4                   | 4   |
| 12       | 380002      | Washer, Lock #4 Split             | 4   |
| 13       | 103285      | Control Chassis                   | 1   |
| 14       | 350076      | Capacitor, Ceramic. 03UF, 500V    | 1   |
| 15       | 385351      | Connector Inlet                   | 1   |
| 16       | 380521      | Screw, Fillister Head 6-32 X 3/8" | 2   |
| 17       | 380000      | Nut, Hex 4-40                     | 4   |
| 18       | 380001      | Washer, Flat #4                   | 4   |
| 19       | 380002      | Washer, Lock #4 Split             | 4   |
| 20       | 381029      | Washer, #4 External Lock          | 4   |
| 21       | 420062      | Strip, Marking 3 Pos              | 1   |
| 22       | 420061      | Strip, Terminal 3 Pos             | 1   |
| 23       | 380002      | Washer, Lock #4 Split             | 4   |
| 24       | 380041      | Screw, 4-40 X 3/4" Phillips       | 4   |
| 25       | 385511      | Adhesive                          | -   |
| 26       | 415010      | Cable, Mount                      | 1   |
| 27       | 380502      | Washer, #6 Splick Lock            | 4   |
| 28       | 380510      | Screw, 6-32 X 1/4" Phillips       | 4   |
| 29       | 500998      | Fuse PC Board Assembly (Spare)    | 1   |
| 30       | 500994      | Fuse PC Board Assembly            | 1   |
| 31       | 380502      | Washer, #6 Split Lock             | 4   |
| 32       | 380526      | Screw, 6-32 X 5/8" Phillips       | 4   |
| 33       | 378090      | Circuit Breaker, 15 Amp           | 1   |

Table 9-10: Generator Chassis Assembly

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