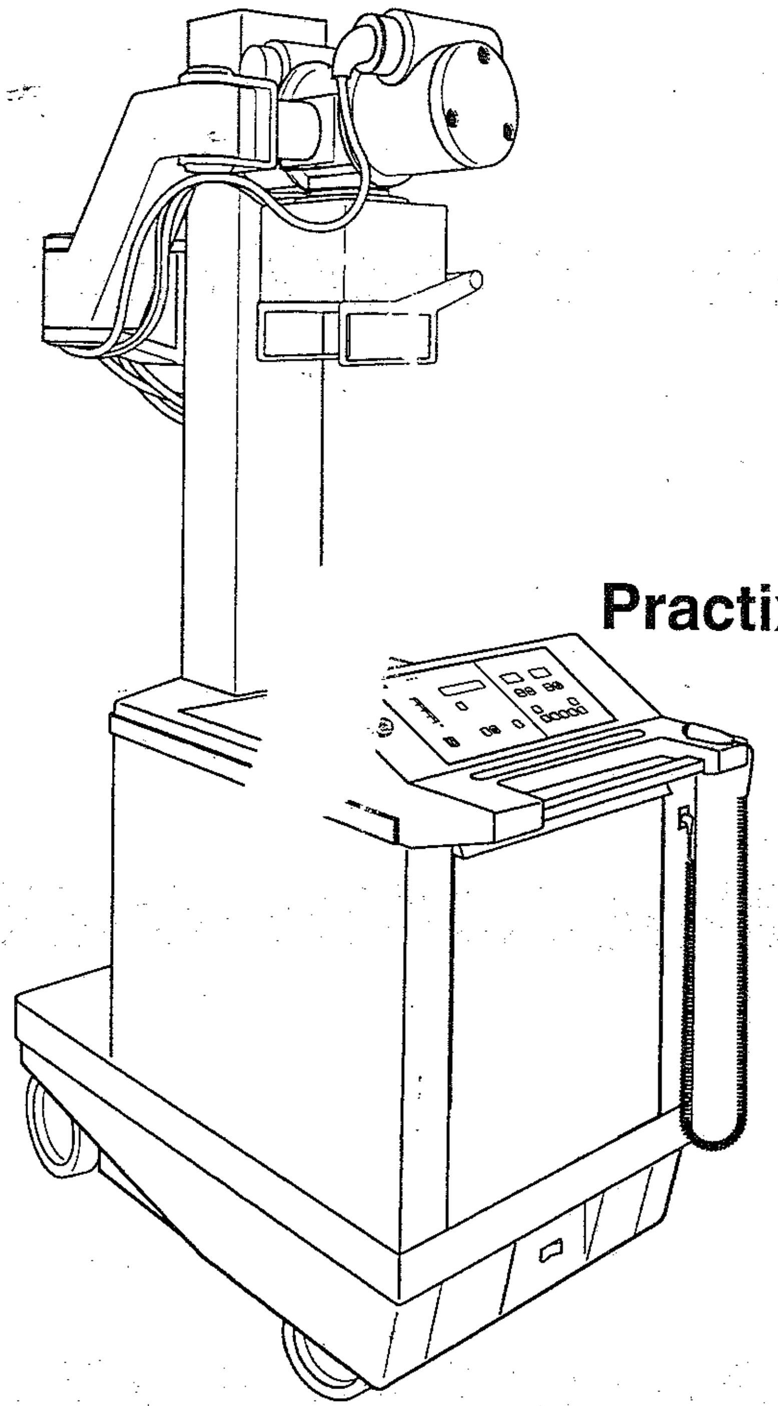

SERVICE MANUAL

PMX 2000
9804 086 00009

Practix 2000
9848 500 13701

Practix 2000 Short Mast
9848 500 29501

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PHILIPS

Manual Order No. 4535 800 28641
464 2737
Printed in the U.S.A. (98.0)

! ATTENTION !

With the exception of the input power requirements from the mains, the PHILIPS PMX-2000 and the PHILIPS Practix 2000 are identical x-ray units. Below are the mains specifications for both units:

Practix 2000 .... 230 VAC

PMX-2000 .... 120 VAC

PMX-2000 / Practix 2000
Microprocessor DIP Switch Configuration

SW	STATE	DESCRIPTION (Normal State Indicated By Asterisk)
1	OFF*	Normal Operation
	ON	Test Mode
2	OFF*	Not Used
	ON	Set EXN counter to zero
3	OFF*	Normal Operation
	ON	Set Battery Capacity to 33 Ampere-Hours
4		LANGUAGE - SEE SEPARATE CHART
5	OFF*	Normal Operation
	ON	Set Filament Auto-Corrections to Zero
6		LANGUAGE - SEE SEPARATE CHART
7	OFF*	Normal Operation
	ON	Motor Drive Fine Auto-Null
8	OFF*	Normal Operation
	ON	Adjust Filament Current on Faults (increase for tube current low, decrease for tube overcurrent)

SW	ENGLISH	GERMAN	FRENCH	SPANISH
4	OFF	OFF	ON	ON
6	OFF	ON	OFF	ON

NOTICE

This unit contains a Desiccant Drying Tube to allow for oil expansion in the High Voltage Tank. This Desiccant Tube should be replaced annually during regular preventive maintenance.

The replacement part number for the Desiccant is 4512-590-11681.

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1. PLANNING DATA

1.1 Description

The PMX-2000 Mobile Radiographic System is a battery powered, self-propelled x-ray unit intended for portable use in making film radiographs in a hospital environment. The following describes the major components of the unit (refer to Figures A-1, A-2, and A-3).

The Drive System comprises a pair of independent battery-powered motors, two 10-inch rear Drive Wheels, two 8-inch Front Swivel Casters, and a pressure sensitive Drive Handle with a built-in brake release bar. The unit is driven and steered by applying varying degrees of force to the Drive Handle. Braking is automatic upon release of the Drive Handle or upon impact of the Front Bumper.

The Control Panel at the rear of the unit houses all exposure controls and indicators. The Control Panel switches, indicators, and the LCD Message Screen communicate with the microprocessor board to accomplish technique factor set up, recall of technique factor combinations from memory, status/error messages, and display of individual exposure status. The unit can make exposures from 40 kVp to 125 kVp. A microprocessor times the exposure to achieve the operator selected mAs value (0.1 to 325 mAs). A two-position x-ray switch, on an eight-foot cord, starts the Rotor Boost and Filament Preheat cycle, and initiates the x-ray exposure.

At the rear of the unit, a top-opening hinged Cassette Drawer opens to permit access to a storage area that can be used to store manuals, cassettes, accessories, etc. The door is opened by pulling its top edge outward and down.

The system features a rotating anode x-ray tube, with a 0.7 millimeter focal spot. The x-ray tube head, on the end of the Tube Arm, holds the Beam Limiting Device, or collimator. The Beam Limiting Device is a four shutter, continuously variable type controlled by dials on its front side. A push-button switch on the Beam Limiting Device illuminates the x-ray field for approximately 30 seconds. The Control Panel contains a switch that duplicates the function of the lamp switch on the Beam Limiting Device. A Tape Measure is permanently installed on the Beam Limiting Device to determine SID.

The articulating Tube Arm travels vertically on a Mast and holds the x-ray tube head. The Tube Arm is held by four electromechanical locks: one at each pivot joint in the Tube Arm and one within the mast structure. A Release Handle on the Beam Limiting Device releases the locks, allowing virtually infinite tube head positioning. An additional Release Handle is located on the top surface of the Tube Arm to facilitate moving the Tube Head out of its cradled position.

Ten 12-volt, 33 ampere-hour, rechargeable lead-acid batteries supply power to the unit. A retractable AC Mains Input Cord is plugged into a 120 Vac, 50/60 Hz wall outlet to recharge the batteries. A front panel LED bar graph displays the charge status of the batteries when the unit is ON or when the batteries are recharging. The approximate charging time for the unit is 8 hours (dead to full charge). There is a Circuit Breaker that must be set to ON to enable charging when the Mains Cord is connected.

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1. Control Panel with Keyswitch
2. Top Cover
3. Drive Handle & Brake Release
4. X-ray Pendant Switch
5. Cassette Drawer
6. Cassette Holder
7. Upper Right Cover
8. Lower Right Cover
9. Front Swivel Casters
10. Rear Drive Wheels
11. Input Line Circuit Breaker
12. Lower Rear Cover

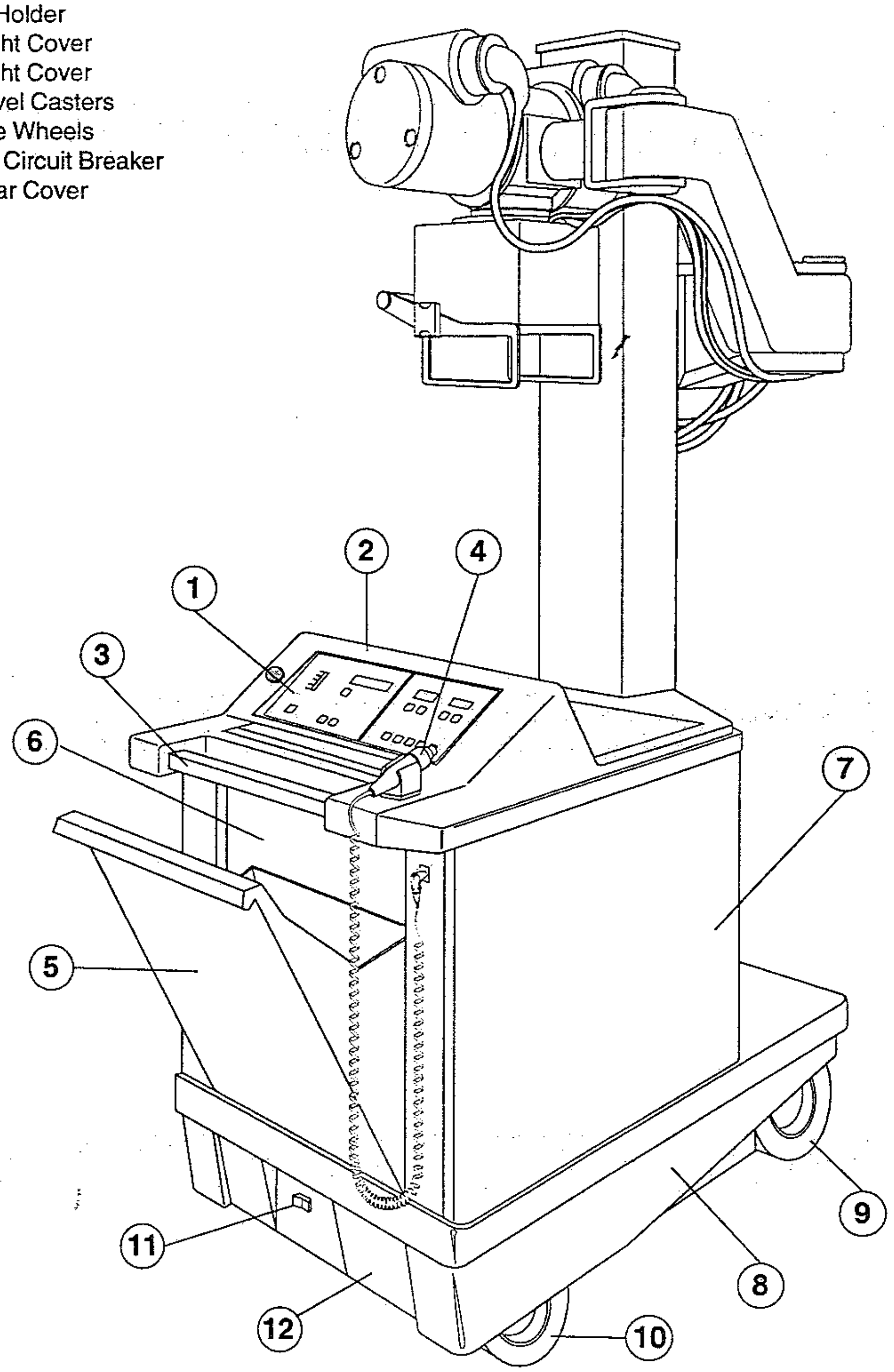

Figure A-1: Component Call-Outs, Operator Side

1. X-ray Arm Transport Lock
2. Apron Hook
3. Mast
4. Input Line Cord (Cable Reel)
5. Front Bumper
6. X-ray Head Cradle Switch
7. Upper Left Cover
8. Lower Left Cover

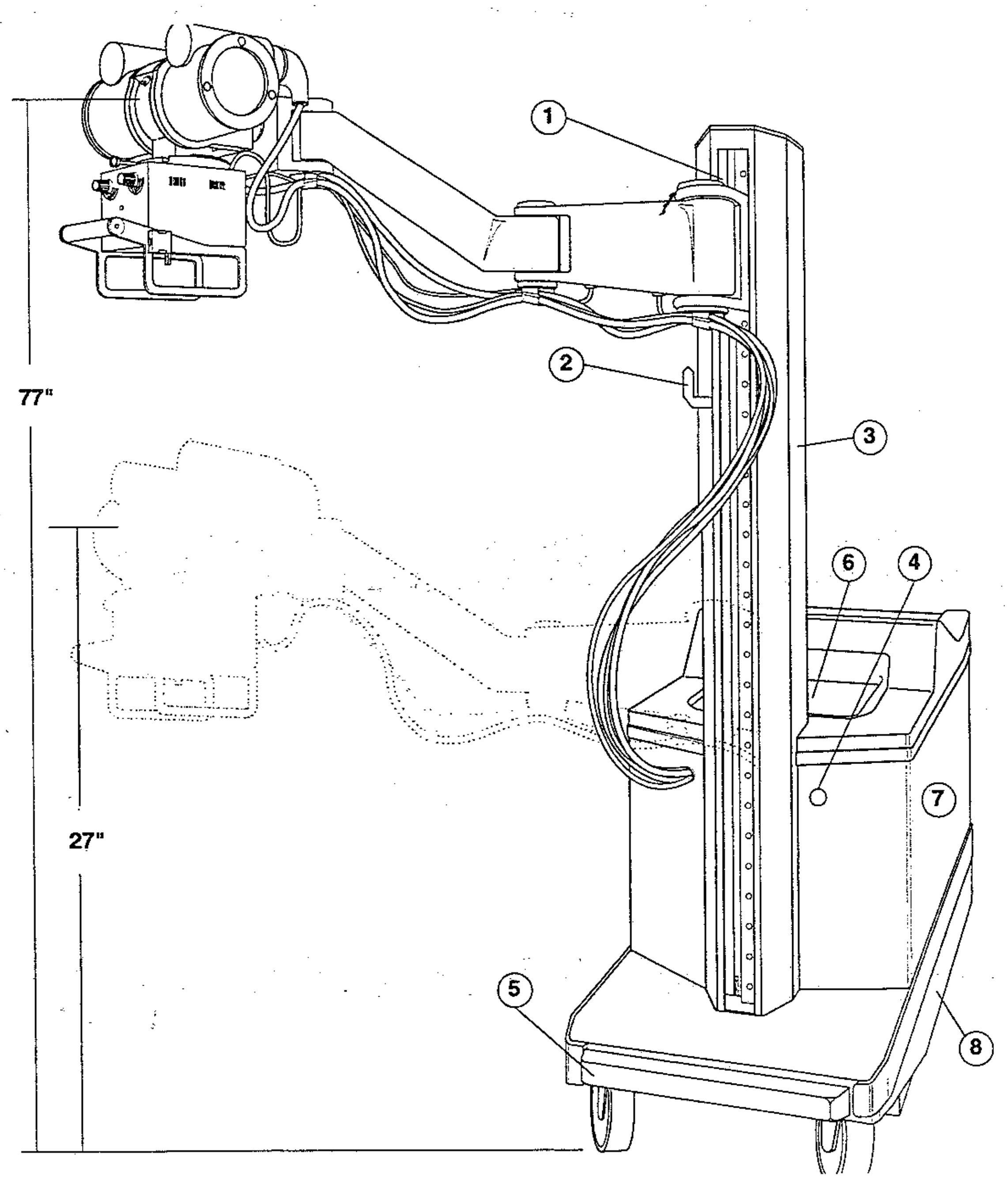

Figure A-2: Component Call-Outs, Patient Side

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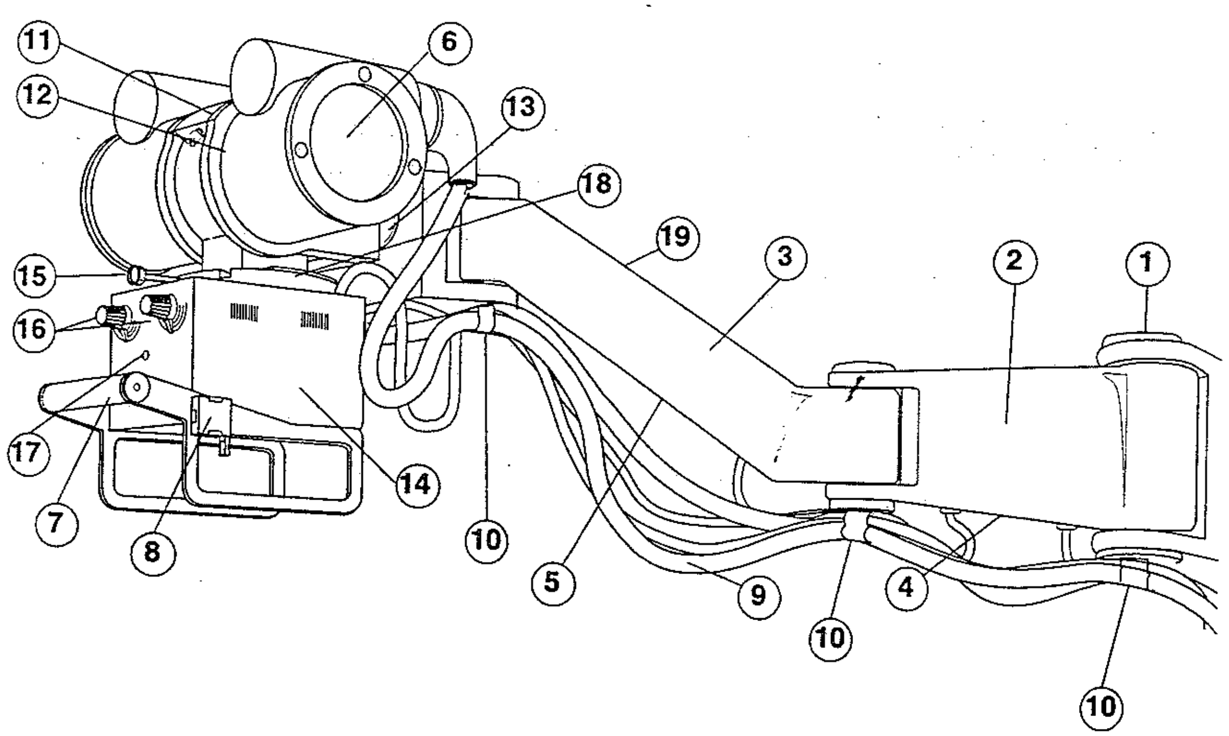

1. Carriage Arm
2. Pivot Arm
3. Extension Arm
4. Pivot Arm Brake Cover
5. Extension Arm Brake Cover
6. X-ray Tube Head
7. X-ray Head Handle & Brake Assembly
8. SID Tape Measure
9. High Voltage & Signal Cables
10. Cable Clamps
11. Trunnion & Trunnion Lock
12. Trunnion Angle Indicator
13. Clevis & Clevis Angle Indicator
14. Collimator
15. Collimator Knurl Knob
16. Collimator Shutter Controls
17. Collimator Field Size Lamp Switch
18. Collimator Collar Assembly
19. Aux. X-ray Head Brake Release

Figure A-3: Component Call-Outs, X-ray Head

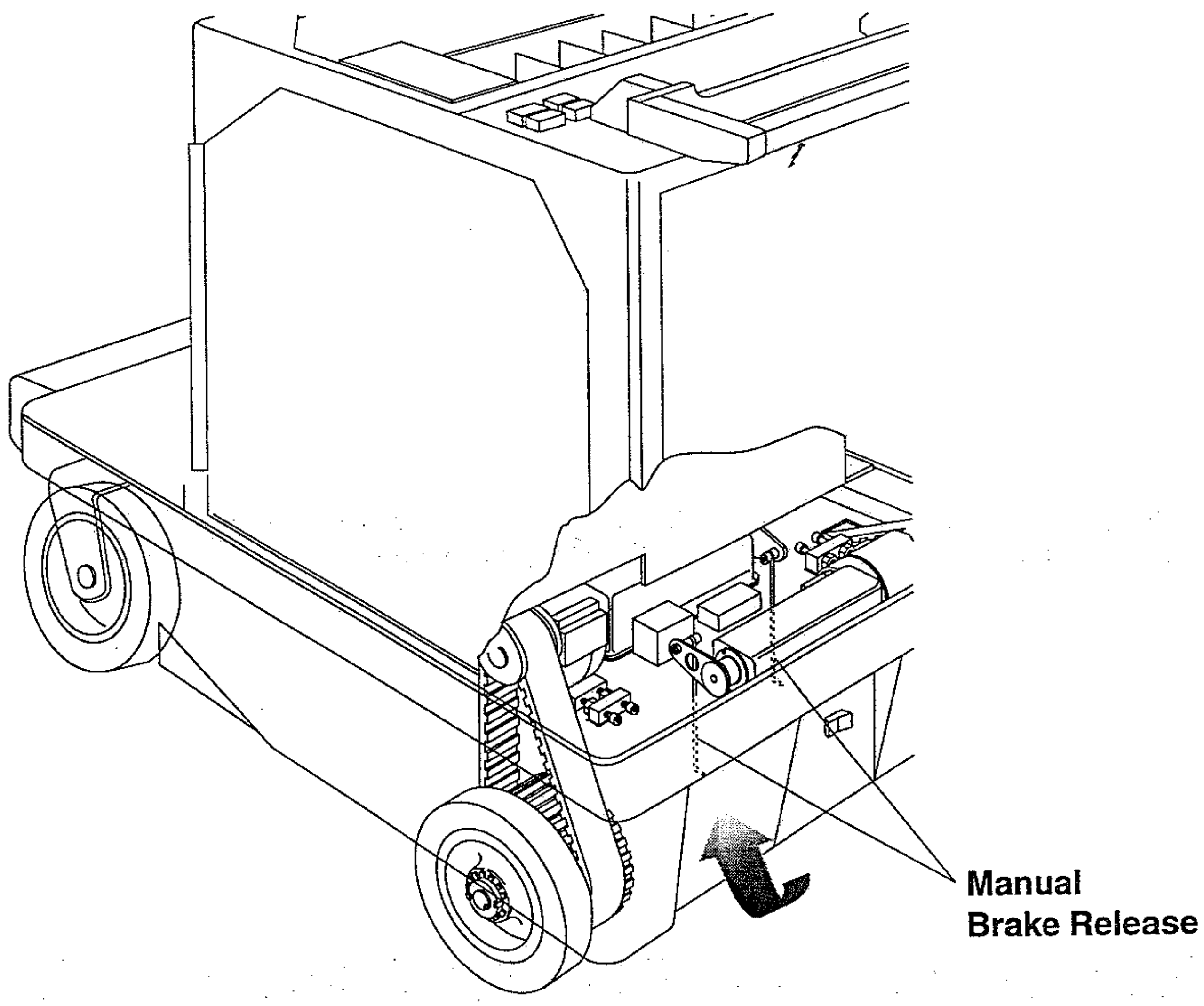

Figure A-4: Component Call-Outs, Manual Brake Release

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1.2 Dimensions

Technical dimensions for the PMX-2000 can be taken from Figure A-2. Although the unit is mobile, when choosing a temporary installation site, take care that proper radiation protection of the radiographer and other personnel is ensured.

Height:	195.6 cm (77") from the floor to the top of the tube mast with the tube in the parked or stowed position. 185.6cm (73") - short mast: from the floor to the top of the tube mast with the tube in the parked or stowed position.
Width:	62.25 cm (24.5")
Length:	106.7 cm (42") with the tube head in the stowed position.

1.3 Weights

PMX-2000 with Installed Battery Pack:	495 kg (1100 lbs) approximate
Battery Pack Only:	135 kg (300 lbs) approximate

1.4 Mechanical Data

1.4.1 Drive System Parameters

Type:	Battery powered; 2 independent motors (left and right drive)
Wheels:	Two 10-inch rear drive wheels; two 8-inch front swivel casters
Steering Control:	Handle Bar with force transducers to control steering operation
Braking Control:	Automatic upon release of Drive Handle; also activates upon front safety bumper impact.
Forward Speed:	0 - 3 mph variable or continuous (arm cradled)
Reverse Speed:	0 - 1.5 mph variable or continuous (arm cradled)
Low Speed:	Forward: 0 - 0.5 mph (arm extended) Reverse: 0 - 0.5 mph (arm extended)
Force Required to Achieve Max Speed:	2.25 - 3.15 kg (5 -7 lbs)
Braking Distance:	91.44 cm (3 ft) or less at maximum forward speed
Incline Capability	8° Ramp

1.4.2 Tube Stand Performance

Maximum Focal Height .... 200 cm (79") - floor to focal spot
190cm (75") - floor to focal spot - short mast version

Minimum Focal Height .... 69 cm (27") - floor to focal spot

Vertical Travel .... 134.6 cm (53")

Horizontal Travel .... 111.8 cm (44")

Z-Axis Rotation .... -15° to +95° (110° Total)

X-Axis Rotation .... ±180° (360° total)

1.4.3 Cassette Storage Capacity

The cassette drawer is at the rear of the unit directly below the drive handle. The drawer can accommodate up to ten 35 cm x 43 cm cassettes.

! CAUTION !
The upper right and left side covers act as stops for the cassette drawer. Always remove the cassette drawer after removing the side covers to prevent it from falling to the floor.

1.5 Electrical

1.5.1 AC Line Input, Motors

Input AC Power Voltage .... 120 Vac ±10%

AC Input Power Protection .... Circuit Breaker

Maximum Line Current .... 6.0 Amp

Drive Motor Output Voltage .... 0 - 100 Vdc

Drive Motor Current Limit .... 450 mA holding after 2 seconds

1.5.2 Battery Pack and Charging Circuit

Quantity .... 10 sealed lead acid batteries

Capacity .... 33 ampere/hrs each

Charging Time .... 8 hours - total discharge to 90% charge
8 hours - 90% charge to full charge

Recommended Discharge
Before Charging .... None; can be recharged at any level of discharge.

Battery mAs Capacity	25,000 mAs
Battery Charger Input	120 VAC 230 VAC, nominal, (International)
Battery Charger Output	Two Stage: 137V/147V ±0.5V @ 0-3.5 Amps maximum
Battery Pack Fuse:	Dual element timed delay FRN-R-60 Amp
Charge Indicator	LED on Front Panel
Battery Level Gauge	LED array on Front Panel

1.5.3 Operator Control Panel

Contains switches, indicators, and an LCD display that communicates bidirectionally with the microprocessor to control technique factors, recall of previously set factor combinations (APRs), status and error message display, and exposure status via individual indicators.

Power ON/OFF Keyswitch	Main Power Switch, with keyswitch security
Charging Indicator	Illuminates in Battery Charge Mode
Battery Status	20 LED arrangement forming a lighted bar-graph. Indicates charge status of battery pack between 0% and 100%.
Message Screen	LCD Display indicating user prompts, status messages, and operational errors.
Reset Switch	Restores unit to operational status if a transient fault condition occurs.
Ready Indicator	Illuminates when the system Is ready for an x-ray exposure.
X-ray Indicator	Illuminates when the system is emitting x-rays, during which time an audible warning tone sounds.
Field Size Lamp Switch	Illuminates the positioning light in the x-ray tube head.
kV Indicator	Three position LED - kV range between 40 & 125 kV
mAs Indicator	Three position LED - mAs range between 0.1 & 325 mAs
Minus/Plus Switches	Under kV and mAs Indicators - decrement or increment kV and mAs settings
Anatomical Programs Switches/Indicators Set/Select, 1, 2, 3, 4, 5	Switches illuminate during set and recall of Technique factor combinations 1 through 5.
Auto Shut Off	Automatically shuts unit OFF after 30 minutes if neither the Drive Controls or the Exposure Controls are used. To reset the system, turn the system keyswitch OFF and then ON.
Emergency Motion OFF Switch	Shuts unit OFF. Unit can be reactivated by turning the switch clockwise with the key switch ON.

1.5.4 X-ray Tube - Physical Characteristics

Type .... Eureka 0.7 Single Focus Rotating Anode X-ray Tube

Frame .... Borosilicate glass with controlled window thickness

Inherent Filtration .... 0.5 mm aluminum equivalent, minimum at 100 kV

Weight .... 16 kg (37 lbs) approximate

Dimensions .... Approximately 107.9 mm (4.25") x 244.3 mm (9.62")

Focal Spot .... 0.7 mm

Target Angle .... 14°

Target Diameter .... 80 mm (3.1")

Nominal Focal Track Diameter .... 63 mm (2.5")

Target Material .... Tungsten track on a molybdenum alloy substrate

X-ray Field Coverage .... 50.8 cm x 50.8 cm at 100 cm SID
(20" x 20" at 40" SID)
90 cm x 91.4 cm at 180 cm SID
(36" x 36" at 72" SID)

1.5.5 X-ray Tube - Thermal Characteristics

Anode Heat Storage Capacity .... 222,000 J (300,000 H.U. - see note below)

Maximum Anode Heat
Dissipation Rate .... 740 Watts (60,000 H.U./min - see note below)

NOTE:
H.U. (Heat Units) = kVp x mA x time (in seconds).

1.5.6 X-ray Tube - Electrical Characteristics

Maximum Peak Voltages .... Anode to cathode - 125 kV
Anode to ground - 68 kV
Cathode to ground - 68 kV

Filament Characteristics .... Focal Spot: 0.7 mm, Voltage (V): 5.1 - 7.5, Current (A): 3.8 - 4.6

Maximum Continuous
Filament Current .... 3.3 Amperes, or to a value which will produce a tube current of 3 mA or less at 80 kV

Kilowatt Ratings .... Single Exposure Rating at 0.1 second, 0.7 mm Focal Spot - 10.50 Hz/14.8 kW; 10.60 Hz/16.2 kW; 30.50 Hz/16.9 kW; 30.60 Hz/18.2 kW.

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1.5.7 X-ray Tube Housing

Physical	Shockproof housing; Aluminum; lead lined, with high dielectric insulating oil; hermetically sealed. Expansion chamber provides adequate compensation for full temperature range of operation; contains stator for driving rotor.
Thermostat	Mounted on anode end of housing and connects to actuate external circuits to protect housing from excessive heat and pressure. Normally closed contact opens when housing temperature is exceeded. (Does not protect insert (X-ray Tube) against overheating.)
Stator	Employs a conventional stator requiring a 24-30 mfd phase shifting capacitor for 60 Hertz, 3450 rpm operation.
Operating Temperature	Minimum ambient temperature for storage and transportation -18°C (0°F). Normal operating range of housing is 16°C to 75°C (60°F to 167°F).
Inherent Filtration	0.6 mm aluminum equivalent minimum
Rayproofing	Stray radiation complies with DHHS standards under Radiation Control for Health and Safety Act 1968.
X-ray Coverage	12° target - 43.8 cm x 43.8 cm (17" x 17") at 101.6 cm (40") SID; 16° target - 43.8 cm x 43.8 cm (17" x 17") at 76.2 cm (30") SID
Weight	16.2 kg (36 lbs.) without cables or accessories
Housing Cooling Rate, Max	1,300,000 H.U. (see note below)
Without Air Circulator	15,000 H.U./Min (see note below)
With Air Circulator	30,000 H.U./Min (see note below)

NOTE:

H.U. (Heat Units) = kVp x mA x time (in seconds).

1.6 Collimator

Maximum kVp	125 kVp
Outer Dimensions	182 mm x 197 mm x 222 mm (7.2" x 7.8" x 8.75")
Net Weight	Approximately 5.9 kg (13.1 lbs)
Shutters Drive	2 manual control knobs - left/right & front/rear
Field Size Lamp	Philips Type 7158 Halogen Lamp, 24 V/150 W (rated)
Power Supply to Lamp	19 Vac (under load), measured at lamp socket
Field Size Lamp Switch	Pushbutton type - 30 seconds electronic timer

Minimum Line Current	5.8A 19 Vac under load
Maximum Field Size	13cm x 35 cm at SID 65 cm
Minimum Field Size	Less than 5 cm x 5 cm at SID 100 cm
Minimum Aluminum Equivalence	1.5 mm AL. (at 50 kvp)
Average Light Field Illuminance	160 lux or more at 100 cm SID
Contrast Ratio on the Light Field Edges	3.5:1 or more
Scales	Calibrated to indicate the light field sizes at each SID within 2% of SID
Installation Method	By installation of adapter flange on tube housing with 4 bolts
Tube Focal Distance	60 mm, as the standard tube focal distance, from tube focus to the bottom surface of adaptor flange.
Leakage Radiation at SID 100 cm	within 50 mR/h
Insulation Resistance	2M ohms between source circuit and ground

1.7 Ambient Conditions

Ambient Temperature During Operation	+10°C to +40°C (50°F to 104°F) recommended 28° ± 5°C (82°F)
Humidity	0% to 90% relative humidity, non-condensing
Temperature	0°C to 40°C (32°F to 104°F)

2. PLANNING / INSTALLATION / SETTING TO WORK

2.1 Transport

Shipping Weight	approximately 569 kg (1,263 lbs)
Battery Pack	approximately 135 kg (300 lbs)
Packing Dimensions	130 cm x 82 cm x 208 cm (51" L x 32" W x 82" H)

2.2 Tools and Equipment Required

1. Aluminum - 1.0 mm
2. Aluminum - 2.0 mm
3. Aluminum - 3.0 mm
4. Aluminum - 4.0 mm

5. Cable - 10 Foot
6. Densitometer
7. Digital Display - Dynalyzer II
8. Digital Voltmeter (true RMS reading DVM) - Fluke Model 87 (or equivalent)
9. High Voltage Unit - Dynalyzer II
10. Lifting Tool - Battery Pack
11. Light Meter - Minolta Model IIIF with Fiber Optic Adapter
12. Lumidisc Diffuser
13. Oscilloscope - 50 MHz (storage)
14. Power Supply - 24V, 5A
15. Radiation Probe - Victoreen 660-1 (or equivalent)
16. Radiation Probe - Victoreen 660-3 (or equivalent)
17. Radiation Protection Booth - Lead Lined
18. Radiographic Film - to fit assortment of cassettes
19. Survey System - Victoreen 660 (or equivalent)
20. Test Device - Image Quality
21. Tool - Collimator Test (p/n: 07-0661)
22. Tool set - standard hand

2.3 Personnel Requirement for Installation

Unpacking and Uncrating	1 man hour
Installation	1.5 – 8 man hours (determined by battery charge level)

THIS CALCULATION DOES NOT INCLUDE:

- Preparatory work
- Handing the system over to customers and training
- Acceptance Test

3. COMPLIANCE (REFER TO FIG A-5)

The PMX-2000 conforms to all applicable FDA regulations. Labels addressing the certifiable components are affixed to the unit at several locations as shown in Figure A-5. The main identification label, containing the equipment model number, serial number, and control number, is on the lower rear cover by the circuit breaker.

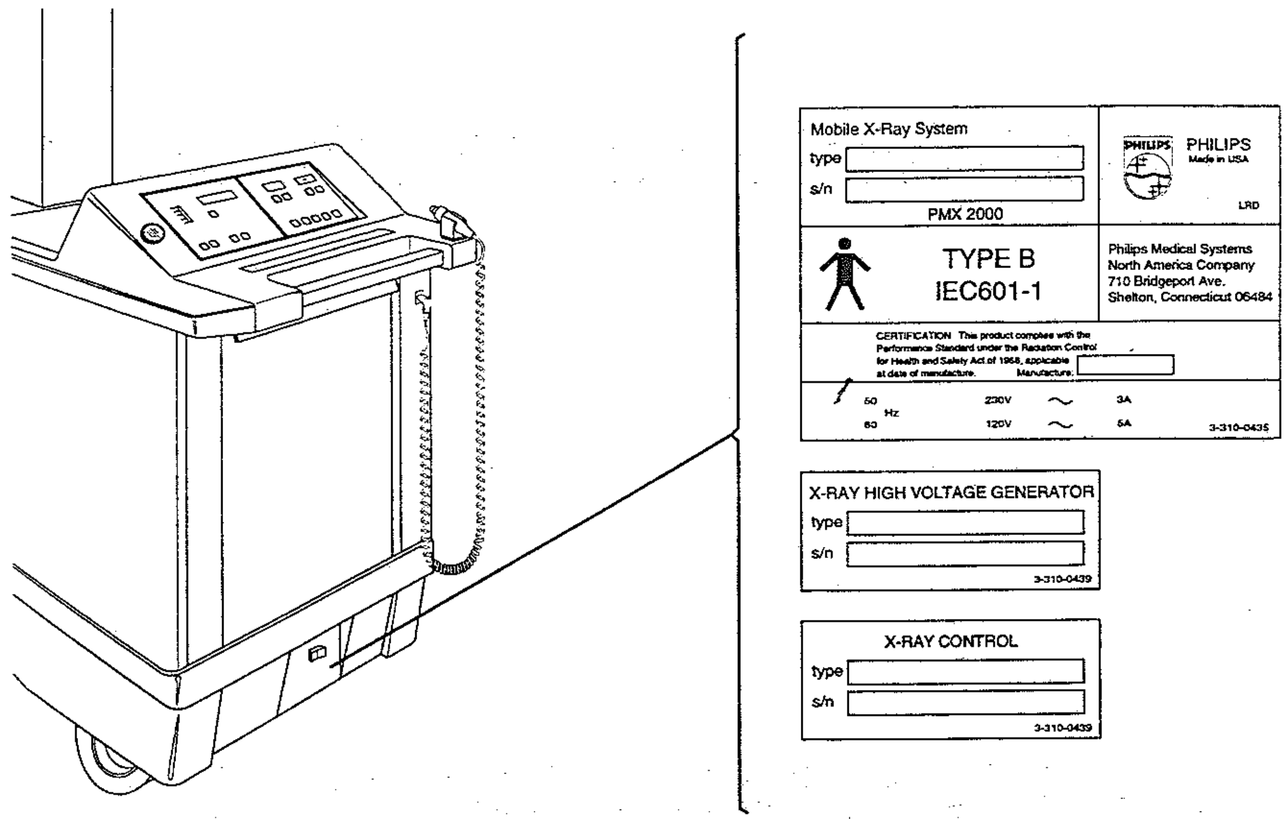

Figure A-5: Compliance Labels

4. COMPATIBILITY

The PMX-2000 is compatible with the following optional equipment:

- MOBILE-AID Automatic Exposure Control Model# D1321.

INSTALLATION

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1. INSTALLATION B-1
1.1 Uncrating Instructions B-1
1.2 Unpacking Instructions B-3
1.3 X-ray Pendant Switch B-3

FIGURES

Figure B-0 Reconnecting Battery Power B-1
Figure B-1 Crate, Unpacking, Accessories B-2
Figure B-2 Pendant Switch Installation B-3

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1. INSTALLATION

This unit is unpacked using the instructions attached to the outside of the shipping crate. Any signs of damage must be reported immediately.

1.1 Uncrating Instructions

1. Remove the corrugated cardboard cap and sleeve. Remove the hold-down straps and the drive handle packing cushion.

2. Unbolt and remove the wheel locking bar. Lift the ramp from the crate and position it as shown in Figure B-1. Make sure the ramp locking pins are seated in the holes in the crate.

3. The battery supply is disabled prior to shipping to prevent battery drainage during delivery of the system. Disabling was accomplished by putting the rocker switch, located in the upper left corner of the cassette drawer, at the OFF position.

Note
After setting the rocker switch back ON, the Battery Status Indicator will ALWAYS indicate a battery pack charge of less than 20%. Therefore, it will be necessary to completely charge the battery pack before use.

To reconnect battery power, perform the following steps: (Note that these instructions were also attached to the front of the unit when shipped.)

a. Open the cassette pull out drawer, located on the rear of the unit.

b. Locate the two holes in the upper left corner of the drawer.

c. Insert a screwdriver, with a diameter less than 5/16", into the right hole and depress the rocker switch located inside. This puts the rocker switch at the ON position and reconnects the unit's battery supply.

d. Close the cassette drawer.

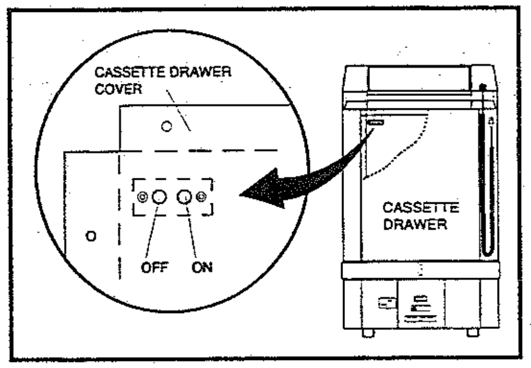

Figure B-0: Reconnecting Battery Power

Note
If the unit does not move when the keyswitch is turned ON, the battery will need to be recharged. To release the brakes manually, reach underneath the unit and pull the two manual brake release levers all the way down (see Figure B-1). The unit can then be rolled to a recharging station (see Section C 1.1).

Once the unit is charged, the manual brake release levers must be returned to their original position.

4. Turn the unit's keyswitch ON. Grasp the drive handle and pull back gently. When the unit begins to move, carefully guide it down the ramp and onto the floor.

5. Remove x-ray tube head packing cushion.

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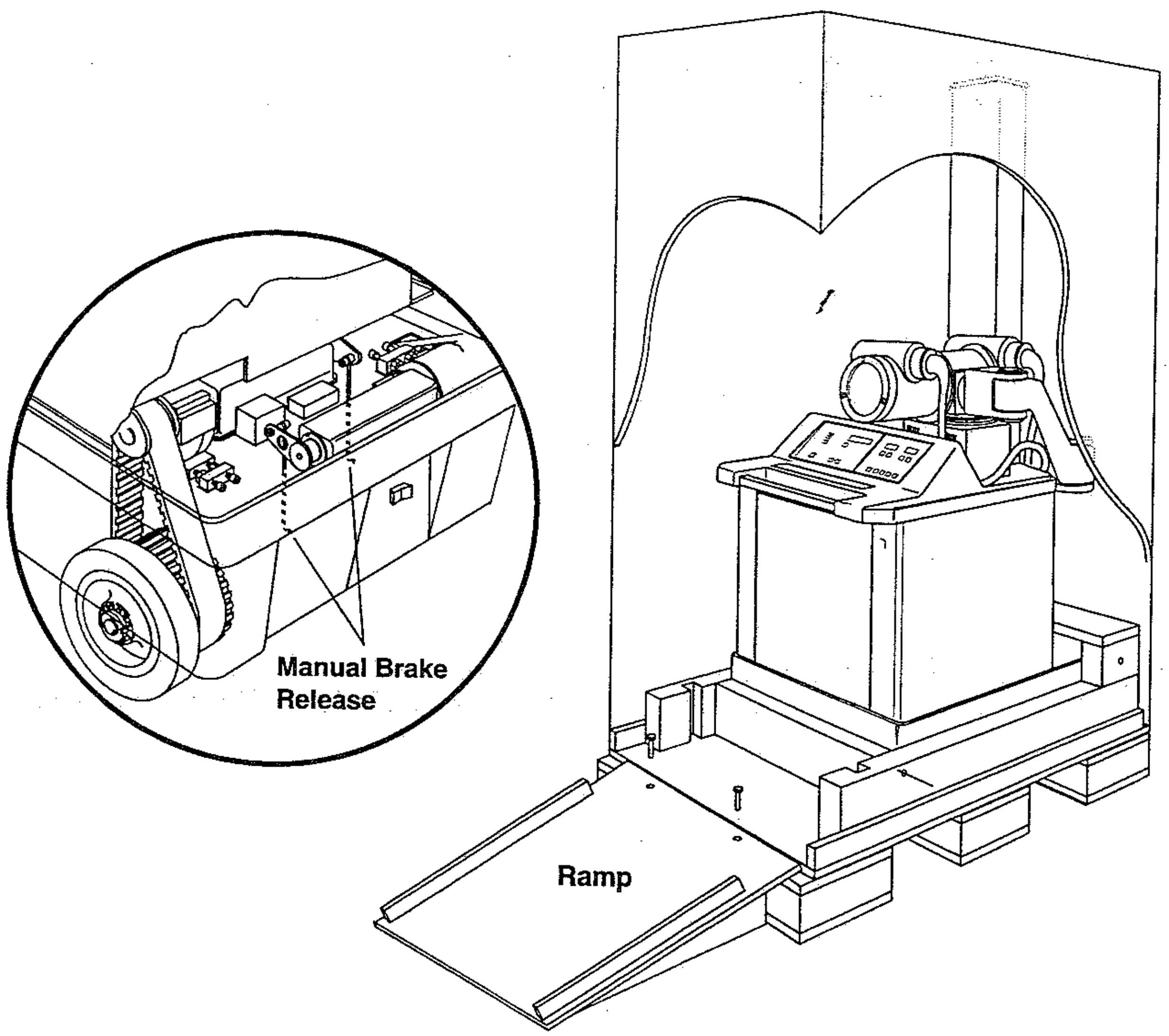

Figure B-1: Crate, Unpacking, Accessories

1.2 Unpacking Inspection

After uncrating the unit, check the Cassette Drawer for the following (Refer to Figure B-1):

1. Operator Manual
2. Service Manual
3. X-ray Pendant Switch
4. Control Panel Keyswitch Keys

NOTE:

Separate uncrating instructions, attached to the outside of the crate, refer the Servicing Engineer to this section.

1.3 X-ray Pendant Switch (Refer to Figure B-2)

The x-ray pendant switch is a hand held, two-position, push-button switch with an 8 foot cord. Pressing this switch to the first detent energizes the anode rotor drive and boosts the x-ray tube current to the exposure level. When the system is at the exposure level, pressing the switch to the second detent initiates the x-ray exposure.

1. Install the x-ray pendant switch connector to the keyed receptacle just below the right side of the Drive Handle.

2. Secure the pendant switch in its cradle on the top cover near the right side of the drive handle.

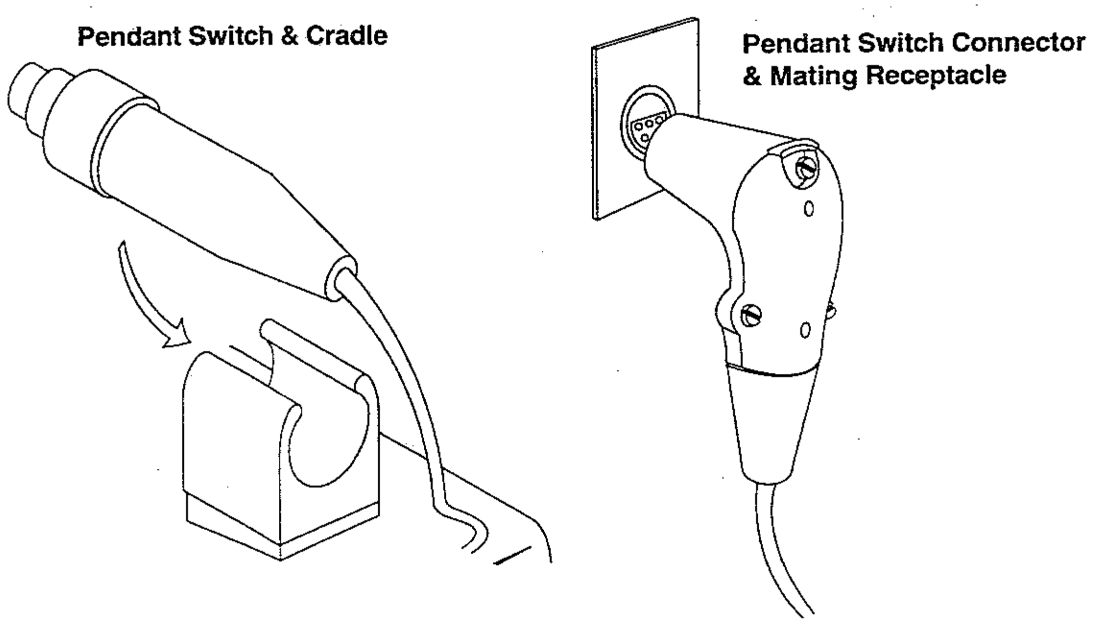

Figure B-2: X-ray Pendant Switch Installation

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SETTING TO WORK

NOTE:
The PMX-2000 does not require any calibration upon normal installation. If the unit has been in storage or has not been used for an extended period of time, the calibration in this section is required.

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1. Battery Charger System

1.1 Battery Charging

Upon completing the unpacking and initial checkout procedures, the unit must be connected to an AC power source for battery charging. Battery charging should continue until the batteries are fully charged. The charging process is indicated by the CHARGING LED on the front panel, which will cycle on and off while the batteries are being charged. Depending on the amount of time the unit was stored before installation, reaching full charge may take up to 8 hours.

NOTE:
The circuit breaker, on the lower rear cover, must be ON for the battery pack to charge. The battery pack will achieve 75% charge within 2 hours.

After plugging in the power cord, check that the CHARGING LED indicator lights. When the CHARGING LED is lit, it indicates that the charging system is operational and the battery pack is recharging. Verify that the message "Line Cord Connected" appears on the LCD message display.

1.2 Battery Charger Trip Point

The trip point of the battery charger is factory adjusted with a fully charged battery pack.

1.3 Trip Point Verification

To verify the battery charger trip point, perform the following:

1. Connect the power cord to a 120 VAC power source and charge the batteries fully (until the CHARGING LED indicator begins to cycle on and off).
2. Turn the unit OFF and connect the DVM + lead to fuse F3 on the Power chassis, and the DVM – lead to chassis ground.
3. Turn the unit ON and verify that voltage goes to 147 volts in 20 seconds, and switches to 137 volts within several minutes. If the voltage switch does not occur, replace the charger and repeat the verification procedure.

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ACCEPTANCE

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1. VOLTAGE CHECKS (Figure D-1)

1.1 Input Power Voltage

The unit is powered by an internal rechargeable battery pack. To assure peak battery performance, always plug in the AC power cord whenever the unit is not in use. Before connecting the unit to an input AC power source, verify the voltage source at the power receptacle. The unit's battery charging system requires an AC power input of 120 Vac ±10%, 60 Hz .

1.2 Battery Pack Operation and Indicators

Always leave the system POWER keyswitch (item 1 of Figure D-1) OFF and the circuit breaker ON, unless otherwise instructed.

Complete installation requires a minimum of 50% battery charge. The unit should arrive with its battery pack fully charged or near fully charged. Check the front panel BATTERY STATUS indicators (item 2 of Figure D-1) before continuing.

If the battery pack is not fully charged, plug the unit's power cord into an appropriate AC power source and allow the batteries to recharge.

> **NOTE:**
> **The circuit breaker, on the lower rear cover, must be ON for the battery pack to charge. The battery will achieve 75% charge within 2 hours.**

The BATTERY STATUS Indicator (item 2 of Figure D-1) consists of a vertical row of LEDs that form a bar-graph showing the charge status of the battery pack. A scale at the left of the indicator denotes the battery charge status between 0% and 100%.

Check that the unit's recharging system is operational by connecting the unit's power cord into an AC input power source. The CHARGING indicator (item 3 of Figure D-1), located below the BATTERY STATUS indicator, will illuminate to indicate that the battery pack is being recharged and that the unit is operational. The Line Cord Connected status message should also appear on the LCD message screen (item 4 of Figure D-1).

2. OPERATOR CONTROLS (Figure D-1)

Completion of this installation requires a BATTERY STATUS indication of 50% or higher. Disconnect the AC input power cord and verify that the CHARGING indicator light extinguishes.

2.1 System Keyswitch

The System POWER keyswitch (item 1 of Figure D-1) on the control panel turns the unit ON or OFF. Before driving the unit, or attempting to make x-ray exposures, turn the System POWER keyswitch ON. Always turn the System POWER keyswitch OFF before plugging in the power cord for recharging.

NOTE:
A timer automatically shuts the unit OFF if the Drive Controls or the Exposure Controls are not used within a 30 minute period. To turn the unit back ON, turn the POWER keyswitch OFF and then ON again.

With the x-ray tube in the parked position, and the POWER keyswitch turned ON, the following indications should appear:

- All indicators momentarily illuminate.
- The message screen displays READY TO DRIVE.

With the x-ray tube out of the parked position, and the POWER keyswitch turned ON, the following indications should appear .

- All indicators momentarily illuminate.
- The READY indicator illuminates (item 9 of Figure D-1)
- The message screen displays "SOFTWARE VERSION xx" (xx = firmware revision level)
- The kV display window indicates 80 (default)
- The mAs display window indicates 2.0. (default)

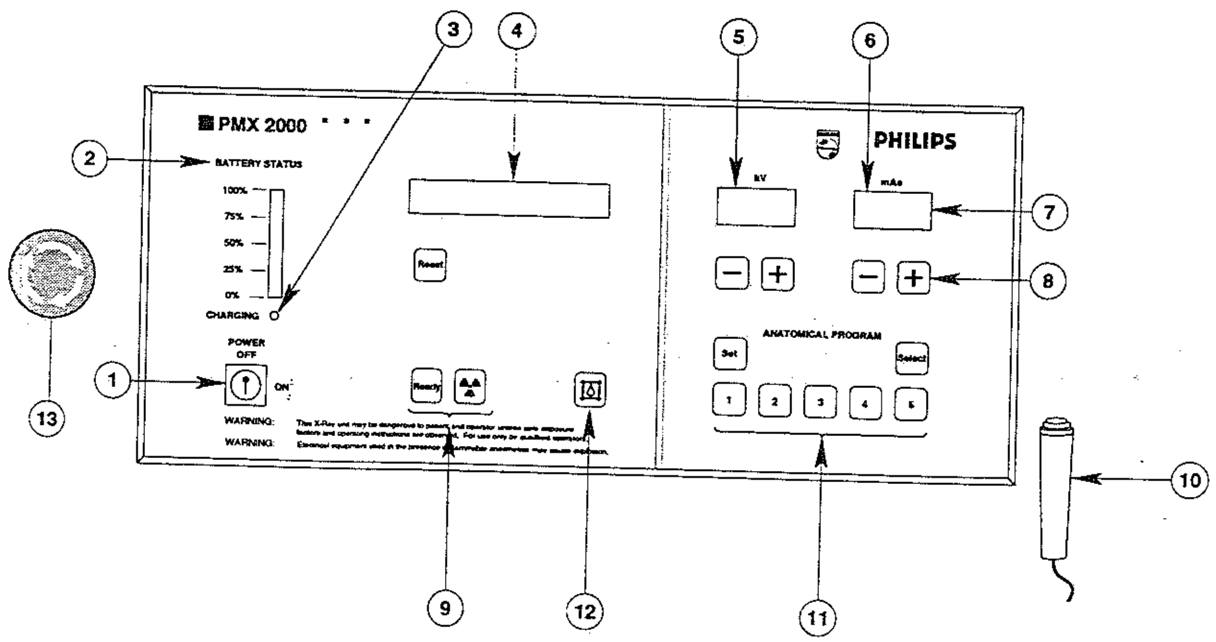

Figure D-1: Control Panel

2.2 kV Readout and Switches

The kV readout window (item 5 of Figure D-1) is a three-character LED display used to show the selected voltage applied to the x-ray tube. The kV range of the unit is between 40 kV and 125 kV.

The kV + and – pushbutton switches (item 6 of Figure D-1), located below the kV readout window, increment or decrement the kV setting and kV readout. Depressing the + (plus) pushbutton increments the kV value in steps, as shown below. The – (minus) pushbutton decrements the kV values in similar steps.

40 - 80 kV : 2 kV steps
80 - 125 kV : 5 kV steps

2.3 mAs Readout and Switches

The mAs readout window (item 7 of Figure D-1) is a three-character LED display used to show the selected milliampere seconds. The mAs range of the unit is as follows:

0.1 mAs - 325 mAs total
0.1 to 325 mAs maximum from 40 - 60 kVp
0.4 to 325 mAs maximum from 62 - 90 kVp
0.4 to 250 mAs maximum from 95 - 105 kVp
0.4 to 200 mAs maximum from 110 - 125 kVp

NOTE:
To display the full range of mAs readings, the kV setting must be changed.

The mAs + and – pushbutton switches (item 8 of Figure D-1), located below the mAs readout window, increment or decrement the mAs settings and mAs readout. Depressing the + (plus) pushbutton increments the mAs settings by 25%; the – (minus) pushbutton decrements the mAs settings approximately 20%.

2.4 Field Size Lamp Switch

The Field Size Lamp switch (item 12 of Figure D-1) is used to illuminate the Field Size Lamp in the collimator for 30 seconds. Press this button to verify operation.

2.5 Anatomical Program Switches

The ANATOMICAL PROGRAM pushbutton switches (item 11 of Figure D-1) are used to store and recall up to five values for the kV and mAs settings. Verify their functions as follows:

2.5.1 Programming Anatomical Switches

1. Adjust the kV and the mAs settings (using the +/- switches) to the desired settings.
2. Depress the SET switch. The SET switch will flash, and the LCD display will show "Select Program No.".

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3. Depress switch 1. Switch 1 will illuminate, the SET switch will extinguish, and the LCD display will show "Setup Program No. 1".

4. The kV and mAs values will be stored in memory under setting number 1.

2.5.2 Verifying Anatomical Switch Settings

1. Change the kV and mAs settings.

2. Depress the SELECT switch. The SELECT switch will flash, and the LCD display will show "Select Program No.".

3. Depress switch 1. Switch 1 will illuminate, the SELECT switch will extinguish, and the LCD display will show "Recall Program No. 1".

4. The values previously set for switch 1 should now appear.

Repeat the programming and verification procedures (sections 2.5.1 and 2.5.2) for the ANATOMICAL PROGRAM switches 2, 3, 4, and 5.

2.6 Emergency Motor OFF Switch

The Emergency Motion OFF Switch (item 13 of Figure D-1) is a red, mushroom-shaped button on the left side of the control panel. Pressing this button causes immediate system shut down. To resume operation after pressing this switch, turn this switch 1/4 turn.

2.7 X-ray Pendant Switch - Refer to Figures D-1 and D-2

The X-ray Pendant Switch (item 10 on Figure D-1) is a hand-held, two-position, pushbutton switch with an 8-foot cord. Pressing this switch to the first detent energizes the anode rotor drive and boosts the x-ray tube current to the exposure level. When the system is at the exposure level, pressing this switch to the second detent (fully depressed position) initiates the x-ray exposure. See Figure D-2.

To verify operation of this switch, perform the following steps:

1. Turn the system POWER keyswitch ON.
2. Lift the x-ray tube head from the cradle (park position).
3. Verify that the READY light on the control panel illuminates.
4. Press and hold the x-ray Pendant Switch to the first detent.
5. Verify that the tube anode begins to spin.

NOTE:

Only the first detent of the Pendant Switch can be verified at this point. The second detent level can be verified during the COMPLIANCE TESTING phase (see section D 5).

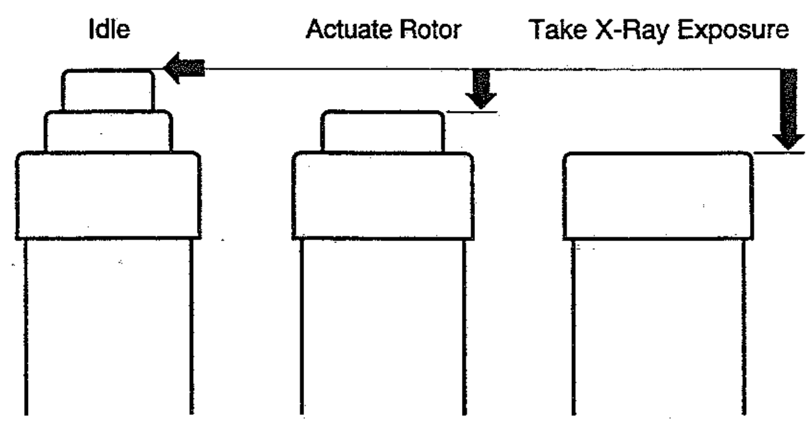

Figure D-2: X-ray Pendant Switch

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3. DRIVE SYSTEM - Refer to Figure D-3

The unit has a battery powered self-propelled drive system comprising a pair of independent motors, two 10-inch rear drive wheels, two 8-inch front casters, and a pressure sensitive operator-controlled Drive Handle with a built-in brake release bar. The unit is driven from the rear and is steered by applying varying degrees of pressure to the Drive Handle. Braking is automatic upon release of the Drive Handle or upon impact of the front bumper.

3.1 X-ray Arm Transport Lock and Cradle Switch

A lever located on the carriage arm locks the x-ray arm so that the x-ray tube head does not come out of its cradle during transport. Verify that the lever keeps the x-ray tube head cradled in place. Unlock the arm to remove the x-ray tube head from its cradle.

The cradle switch detects if the x-ray tube head is in its cradle, and will determine the speed that the unit can be driven. Verify that when the tube head is in its cradle, the READY, mAs, and kV lights extinguish, and the LCD message screen displays "READY TO DRIVE".

3.2 Drive Brakes

Verify brake operation by pushing or pulling on the Drive Handle without touching the brake release located on the bottom of the Drive Handle.

NOTE:

The brake is automatically applied to the drive system when the Drive Handle is released.

The unit should lock in position and not move in any direction when pushing or pulling on the drive handle.

3.3 Forward Drive

To release the brake and drive the unit forward, squeeze the Drive Handle and Brake Release Bar simultaneously (using both hands). Gently push the Drive Handle forward, applying equal force to both sides to prevent swerving. Turn the unit by applying more force to one side of the Handle Bar. To turn right, push harder on the left side of the Drive Handle; to turn left, push harder on the right side of the Drive Handle. To make sharp turns, push one end of the Drive Handle while pulling the other end in the opposite direction.

3.4 Reverse Drive

Gently pull back on the Drive Handle to move the unit backwards. Apply equal force to both sides of the Drive Handle to prevent swerving. To turn the unit in reverse, manipulate the Drive Handle in the opposite manner as when driving the unit forward. Sharp turns are made in the same manner as when driving the unit forward.

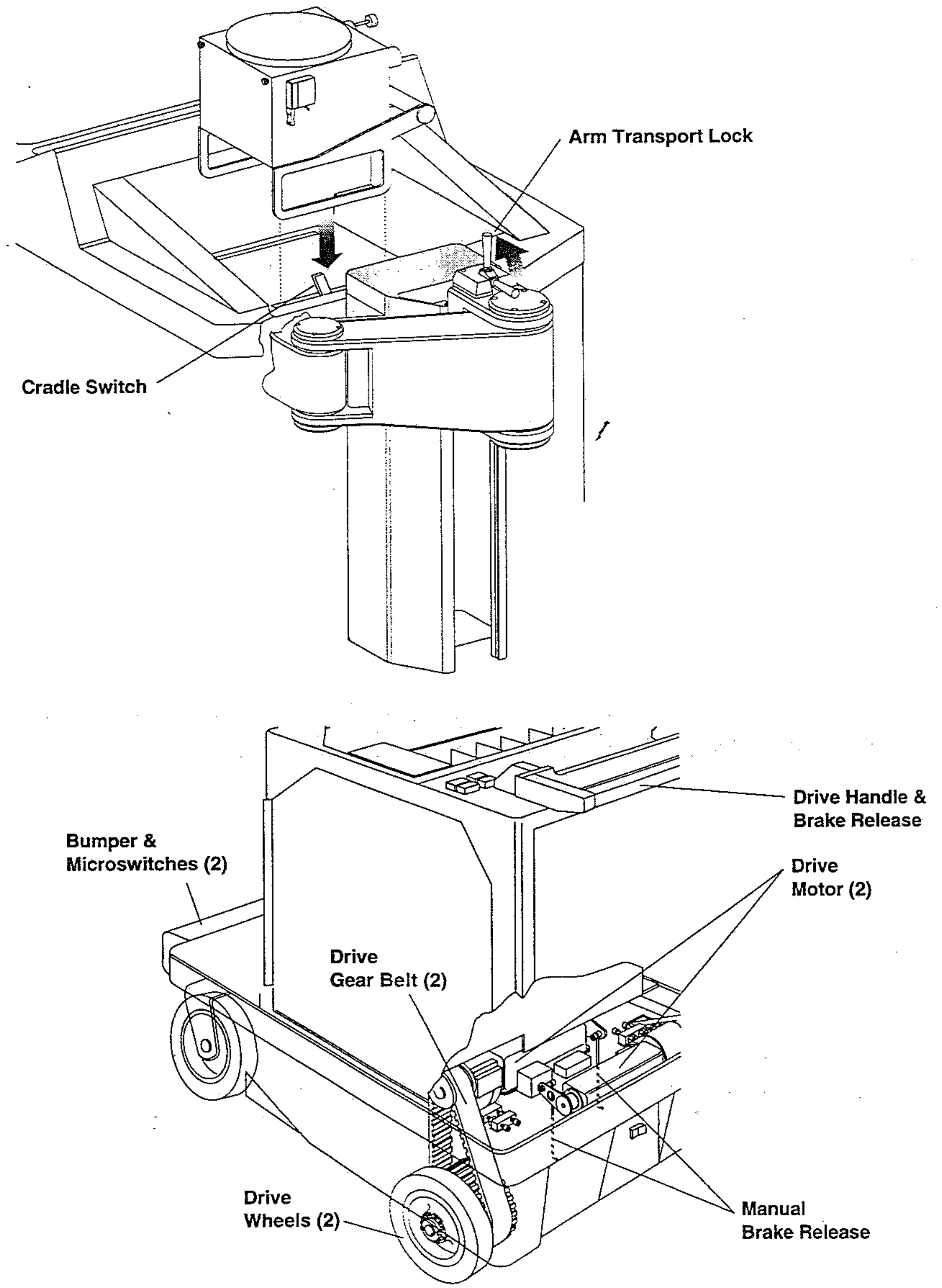

Figure D-3: Drive System

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3.5 Drive Speed

The degree of force applied to the Drive Handle controls the speed of the unit. Apply firm pressure to increase the drive speed; ease the pressure to decrease the drive speed. To stop the unit and set the brakes, release the Drive Handle.

Verify that unit can be driven approximately 3 miles per hour with the x-ray tube head in the parked position. Mark a 22 foot distance and clock the time it takes for the unit to travel that distance. This time should be approximately 5 seconds.

Verify that unit can be driven approximately 0.5 miles per hour with the x-ray tube head raised from the parked position. Mark a 22 foot distance and clock the time it takes for the unit to travel that distance. This time should be approximately 30 seconds.

3.6 Front Bumper Safety Switch - Refer to Figure D-3

Two limit switches are on either side of the front bumper. If the bumper accidently strikes an obstruction, the unit will automatically brake and an error message will appear on the LCD Message Screen.

Turn the unit's System Keyswitch ON, then push in either side of the bumper. Verify that the following message appears on the LCD screen:

"Bumper Hit, Back UP!"

To clear the error, drive the unit a short distance in reverse, until the bumper clears the obstruction. Verify that the error message clears. Repeat this safety feature for the other side of the bumper.

3.7 Drive Handle Sensor - Refer to figure D-3

Pressure applied to the handle for 1.5 seconds prior to engaging drive brake release bar will result in the following message on the LCD screen:

"Clear Drive Handle".

To clear the error and reactivate the drive system, let go of the drive handle or clear any obstruction which may be putting pressure on the handle.

4 X-ray HEAD

4.1 Motion and Braking - Refer to Figure D-4

On the front of the Collimator is a brake release handle with a built-in pressure switch. Grasping this handle releases a brake within the mast structure, and three brakes on the Tube Arm (one at each pivot joint), allowing Tube Arm movement. Move the Tube Arm vertically, horizontally, and/or laterally to place the x-ray head to any position between 27" and 79" from the floor.

1. Raise the x-ray tube head completely. Verify that the distance to the floor is 79" (use attached tape measure).

2. Lower the tube head completely. Verify that the distance to the floor is 27" (use attached tape measure).

3. Verify the tube arm horizontal motion. The tube arm should be able to rotate freely to the left and the right. Movement should allow tube head parking in both directions.

A Collar assembly attaches the Collimator to the x-ray head. A threaded pin with a knurled knob locks the collimator in place. Loosening this pin allows the Collimator to rotate ±45° about its central axis. Verify motion with pin tightened and loosened.

A dual collar assembly (trunnion) secures the x-ray tube to the Tube Arm assembly. A locking lever tightens the collars to secure the tube in position. Lifting the lever enables the user to rotate the x-ray tube in the X-axis for angular projections between -15° and +95°. Verify motion with lever locked and unlocked.

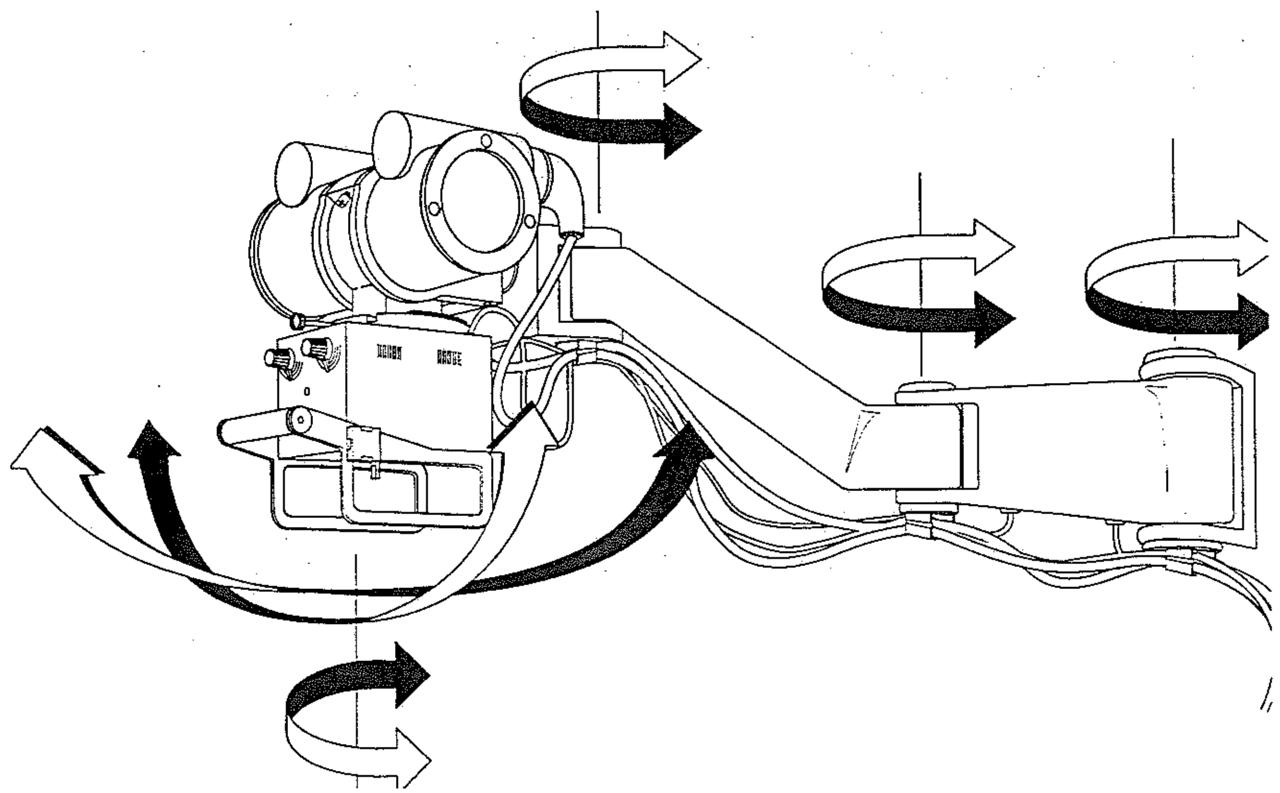

Figure D-4: X-ray Head Range of Motion

4.2 Collimator Field Size Lamp Switch & Shutters - Refer Figure D-5

4.2.1 Collimator Field Size Lamp

The push-button switch on the collimator illuminates the Field Size Lamp in the collimator for 30 seconds. Push this button and verify operation.

4.2.2 Collimator Shutters

A pivot mechanism in the collimator houses a dual-shutter beam limiting device. Two dials on the front of the beam limiter move separate shutters that collimate the four edges of the x-ray beam. Four-level scales encircle the Shutter Controls to show the approximate size of the x-ray field (in inches) for SIDs of 36", 40", 46", and 72". Turn both Shutter Controls and verify operation.

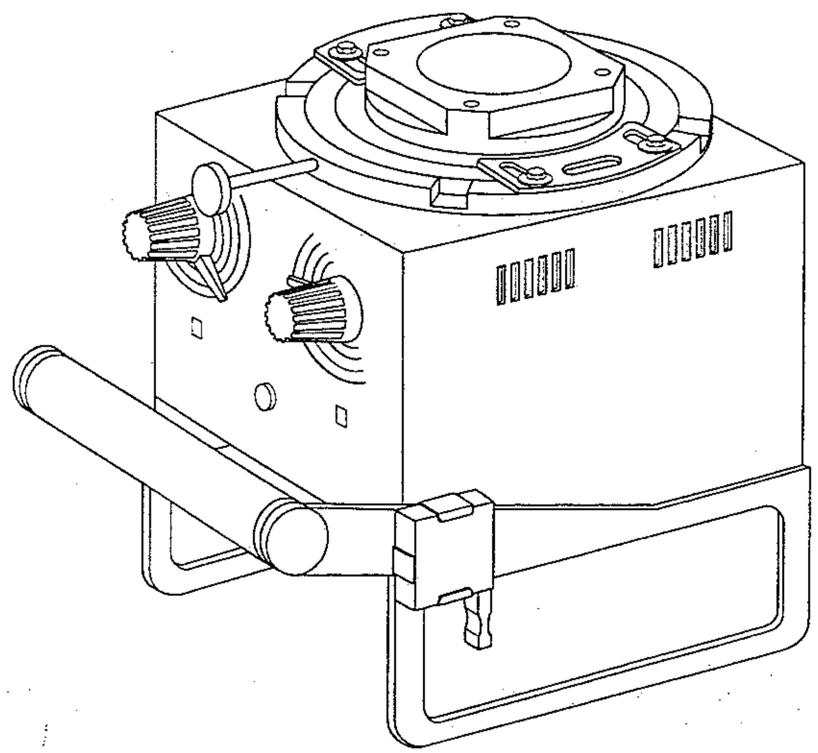

Figure D-5: Collimator Switches and Shutters

4.3 X-ray Tube Conditioning

If the x-ray tube has not been energized for a period of eight hours or more, it is necessary to start at a kV considerably lower than the highest kV normally used on a given tube in order to realign the internal distribution of charges.

It is recommended that the unit be conditioned by taking a series of five radiographic exposures. Start with 80 kV @ 15 mAs and increase by 10 kV increments. Exposures are to be spaced approximately 20 seconds apart.

Adherence to the above procedure will also minimize target cracking due to thermal shock. Thermal shock can cause a target to fracture, and in extreme cases, the target may break apart, causing damage to insert and/or tube housing.

5. COMPLIANCE TESTING

5.1 Illuminance of Light Localizer

Equipment Required:

1. Minolta Meter Model IIIF
2. Lumidisc Diffuser

Procedure:

1. Open both collimator shutters completely, then turn the unit on. Attach a Diffuser to the light meter probe's sensor, then place the light meter probe 100 cm from the open collimator with its sensor facing up. Position the probe, in turn, in the center of each quadrant of the light field as shown in Figure D-6 below:

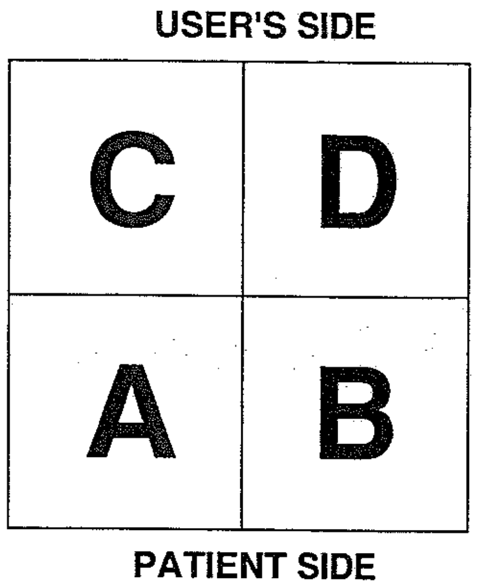

Figure D-6: Light Field Quadrants

2. At each quadrant, take a background reading with the collimator lamp OFF. Take another reading at each quadrant with the collimator lamp ON. Record each reading.

3. Use the Lux Conversion Table (Table 1) to convert the meter readings to lux values. Subtract the background lux from the light field lux for each quadrant. Any difference that is less than 160 lux is cause for rejection. Record the lux value for each quadrant.

4. Calculate the lux using the formula: $LUX=2.5X2^{EV}$ (EV = value from the conversion table).

TABLE 1: LUX VALUE CONVERSION

(LX at ASA 100)

	DECIMAL									
INTEGRAL	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
-2	0.625	-	-	-	-	-	-	-	-	-
-1	1.25	1.17	1.09	1.02	0.947	0.884	0.825	0.769	0.718	0.670
-0	2.50	2.33	2.18	2.03	1.89	1.7	1.65	1.54	1.44	1.34
0	2.50	2.68	2.87	3.08	3.30	3.54	3.79	4.06	4.35	4.67
1	5.00	5.36	5.74	6.16	6.60	7.07	7.58	8.12	8.71	9.33
2	10.00	10.7	11.5	12.3	13.2	14.1	15.1	16.2	17.4	18.7
3	20.00	21.4	23.0	24.6	26.4	28.3	30.3	32.5	34.8	37.3
4	40.00	42.9	45.9	49.2	52.8	56.6	60.6	65.0	69.6	74.6
5	80.00	85.7	91.9	98.5	106	113	121	130	139	149
6	160.00	171	184	197	211	226	243	260	279	299
7	320.00	343	368	394	422	453	485	520	557	597
8	640.00	686	735	788	844	905	970	1040	1110	1190
9	1280	1370	1470	1580	1690	1810	1940	2080	2230	2390
10	2560	2740	2940	3150	3380	3620	3880	4160	4460	4780
11	5120	5490	5880	6300	6760	7240	7760	8320	8910	9550
12	10200	11000	11800	12600	13500	14500	15500	16600	17800	19100
13	20500	21900	23500	25200	27000	29000	31000	33300	35700	38200
14	41000	43900	47100	50400	54000	57900	62100	66500	71300	76400
15	81900	87800	94100	101000	108000	116000	124000	133000	143000	153000
16	164000	176000	188000	202000	216000	232000	248000	266000	285000	30600

5.2 Reproducibility

Equipment Required:

1. Victoreen Survey System 660 or equivalent
2. Read/out Logic Unit (660-1)
3. Beam Measurement Probe (660-3)
4. 10 Foot Cable

Procedure:

1. Connect a 10 cm^2 radiation probe to the Survey System's readout/logic module with a 10 foot cable. Place the readout/logic module where it can be read from behind a radiation protective shield. Use the modules function switch to read exposure in milliroentgens.

2. Set the unit for an SID of 100 cm relative to the probe. Press the light field button and align the center of the collimator's crosshairs to the center of the 10 cm^2 probe. Adjust the collimator shutters for an x-ray field size of 15 cm x 15 cm.

3. Set the unit for an 80 kV, 100 mAs exposure.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Make an exposure and record the mR reading. Cycle both the kV and mAs settings, then reset both settings to 80 kV and 100 mAs. Make another exposure and record the reading. Repeat this procedure until ten exposures have been made and recorded.

5. Calculate the average milliroentgen reading and subtract this average from each step #4 reading.

6. Square each difference and divide them by 9.

7. Add all these quotients together and calculate the square root of this sum.

8. Divide the number from step #7 by the average milliroentgen reading to calculate the coefficient of variation.

9. Multiply the coefficient of variation from step #8 by 1.02 (2% correction factor). This product must not be greater than 0.05.

Table 2.: Reproducibility Data Sheet

	Step #4 Meter Reading (mR)	Step #5 mR - Average mR	Step #6 $\text{Difference}^2 \div 9$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Step #7 Calculation ____________

Step #8 Calculation ____________

Step #9 Calculation ____________

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5.3 Linearity Test

Equipment Required:

1. Victoreen Survey System 660 or equivalent
2. Read/out Logic Unit (660-1)
3. Beam Measurement Probe (660-3)
4. 10 Foot Cable

Procedure:

1. Connect a 10 cm^2 radiation probe to the Survey System's readout/logic module with a 10 foot cable. Place the readout/logic module where it can be read from behind a radiation protective shield. Use the modules function switch to read exposure in milliroentgens.

2. Set the unit for an SID of 100 cm relative to the probe. Press the light field button and align the center of the collimator's crosshairs to the center of the 10 cm^2 probe. Adjust the collimator shutters for an x-ray field size of 15 cm x 15 cm.

3. Set the unit for an x-ray exposure of 90 kVp and 1 mAs.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Make an exposure and record the mR reading. Repeat this procedure for mAs values of 2 mAs, 5 mAs, 10 mAs, 50 mAs, 100 mAs, 150 mAs, 200 mAs, and 250 mAs. Record the mR reading for each exposure.

5. For each of these tests, divide the milliroentgen reading by its corresponding mAs value. Record these findings as "mR/mAs".

6. For each pair of successive tests (1 mAs & 2 mAs, 2 mAs & 5 mAs, and so on), calculate the difference between each corresponding Step #5 result. Record these findings as "mR/mAs Difference".

7. For each pair of successive tests, calculate the sum of each Step #5 result. Record these findings as "mR/mAs Sum".

8. Divide each Step #6 difference by each Step #7 sum. The absolute value of the quotients must not be greater than 0.10.

Table 3: Linearity Data Sheet

	mAs Setting	Meter Reading (Milliroentgen)	Quotient mR/mAs	Difference mR/mAs	Sum mR/mAs	Difference / Sum
1						
2						
3						
4						
5						
6						
7						
8						
9						

5.4 Beam Quality (Half Value Layer)

Equipment Required:

1. Victoreen Radiation Survey System 660 (or equiv.)
2. Readout Logic Unit (660-1)
3. Beam Measurement Probe (660-3)
4. 1.0 mm, 2.0 mm, 3.0 mm, and 4.0 mm Aluminum
5. Lead Booth

Procedure

1. Place the beam measurement probe in a probe holder. Position it in the x-ray field with no additional material under the probe.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

2. Make an initial exposure at 80 kVp and 100 mAs and record the mR reading. Take additional exposures with 1.0 mm, 2.0 mm, 3.0 mm, and 4.0 mm aluminum in the x-ray field. Record each mR reading.
3. Repeat Step #2 for 100 kVp and 100 mAs exposures.
4. At 80 kVp, the Half value layer reading should be greater than 2.3 mm Aluminum equivalent. At 100 kVp and 100 mAs, the mR reading should be greater than 2.7 mm Aluminum equivalent.
5. To determine the half value layer, plot the above measured mR in the X and Y axis on the Beam Quality graph. Determine what half of the original no filtration value would be and note this value on the graph. Draw a line across the semilog paper from the noted half mR level until the line intersects with the plotted values. The value at the intersection is the half value layer.

Table 4: Beam Quality (Half Value Layer) Data Sheet

Aluminum Thickness	mR Reading at 80 kVp	mR Reading at 100 kVp
0.0		
1.0		
2.0		
3.0		
4.0		
Half Value Layer	at 80 kVp=	at 100 kVp=

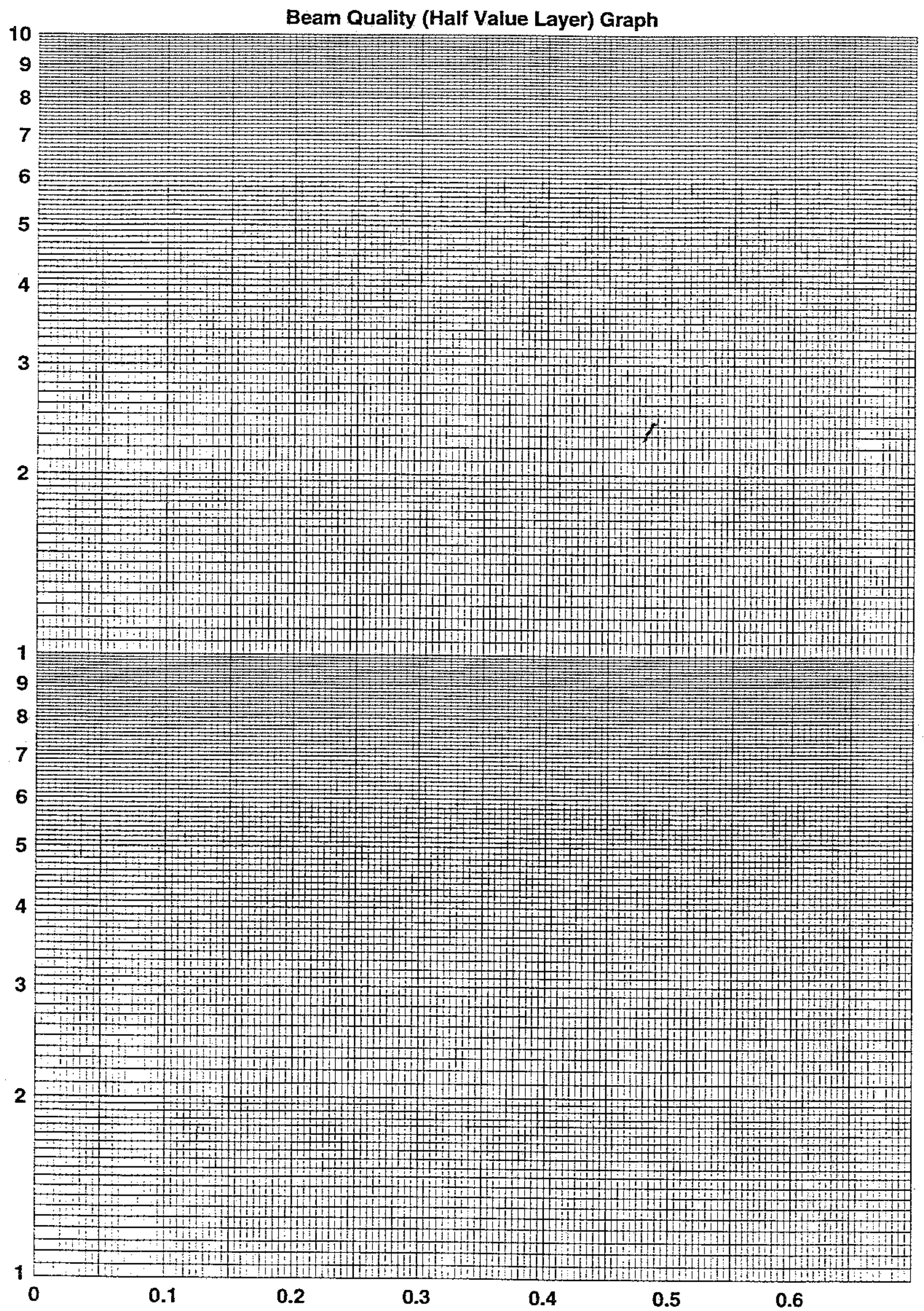

Figure D-7: Beam Quality Graph

5.5 Peak Tube Potential Test

Equipment Required:

1. Dynalyzer II High Voltage Unit
2. Dynalyzer II Digital Display

Procedure

1. Connect the Dynalyzer High Voltage Unit's transformer cathode connection (negative) to the cathode connection on the high voltage tank. Connect the transformer anode connection (positive) to the anode connection on the high voltage tank.

2. Connect the Dynalyzer High Voltage Unit's tube cathode connection (negative) to the x-ray tube's cathode connection. Connect Dynalyzer High Voltage Unit's tube anode connection (positive) to the x-ray tube's anode connection.

3. Connect the Dynalyzer II High Voltage Unit to the Dynalyzer II digital display.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Conduct an exposure at the following settings. Record the kV values indicated by the Dynalyzer Digital Display.

5. kV readings must be within the minimum and maximum limits stated. Any reading outside a limit is cause for rejection.

Table 5: Peak Tube Potential

kVp	mAs Setting	Tube Voltage (kV)	Minimum Permitted kV	Maximum Permitted kV
40	5		38.0	42.0
70	50		66.5	73.5
90	325		85.5	94.5
125	200		119.0	131.0

5.6 Alignment of Visually Defined X-ray Fields

Equipment Required:

1. Collimator Test Tool
2. Loaded film Cassette (18 x 24 cm)

Procedure:

1. Place the collimator test tool on a loaded cassette. Orient the dot in the lower left corner of the collimator tool to the left forward corner of the cassette. Center both in the light field.
2. Position the tube head to an SID of 100 cm for the cassette utilization.
3. Adjust the collimator shutters until the edge of the light field coincide with the rectangular outline on the collimator tool.
4. Set the technique factors to 60 kV at 3 mAs and take an exposure.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

5. Measure the distance from the edge of the x-ray field to the rectangle created by the collimator test tool. Record the distance. Calculate the % of misalignment by dividing the measured distance by the SID. Use the following formula:

% of misalignment = (Distance ÷ SID) x 100

6. The percentage of misalignment must be less than 1.76%. If it is not, perform the Field Size Adjustment in Section 7.2.4 of this manual.

5.7 Tube Current-Exposure Time Product (mAs)

Equipment Required:

1. Dynalyzer II High Voltage Unit
2. Dynalyzer II Digital Display

Procedure:

1. Connect the Dynalyzer High Voltage Unit's transformer cathode connection (negative) to the cathode connection on the high voltage tank. Connect the transformer anode connection (positive) to the anode connection on the high voltage tank.

2. Connect the Dynalyzer High Voltage Unit's tube cathode connection (negative tube) to the x-ray tube's cathode connection. Connect Dynalyzer High Voltage Unit's tube anode connection (positive) to the x-ray tube's anode connection.

3. Connect the Dynalyzer II High Voltage Unit to the Dynalyzer II digital display.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Conduct an exposure at each required kV and mAs settings (see Table 6 below). Record the mAs values indicated by the Dynalyzer Digital Display.

5. mAs readings must be within the minimum and maximum limits stated on the data sheet. Any reading outside a limit is cause for rejection.

Table 6: Tube Current - Exposure Time Product (mAs)

kV Setting	mAs Setting	mAs Measured	mAs Min. Permitted	mAs Max. Permitted
40	5		4.50	5.50
70	50		47.50	52.50
90	325		308.80	341.30
125	200		190	210

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5.8 X-ray Field Size Verification

Equipment Required:

1. Loaded Film Cassette (24 x 30)
2. Leaded Booth

Procedure:

1. Place a loaded cassette on the cassette table in the lead booth. Adjust the collimator shutter pointers to the 7 mark of the 40 SID scale. Using a tape measure mounted on the side of the collimator, set the distance to the cassette's surface to 100 cm (40 inches).
2. Press the light field button and center the cassette in the middle of the light field.
3. Set the technique factors to 60 kVp at 3 mAs and take an exposure.
4. Develop the film.
5. Measure the width and length of the x-ray field. The field must be 7 inches (±0.7) wide by 7 inches (±0.7) long.
6. Record the measurements on the data sheet.

Table 7: X-ray Field Size Verification

Measurement Location	Distance	Minimum - /Maximum (inches)
Width		6.30 - 7.70
Length		6.30 - 7.70

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1. COMPONENT IDENTIFICATION

1.1 Left Side Component Identification - Refer to Figure F-1

1.	Input Power Cord Reel	3e.	Power Transformer
2.	Left Side Panel	4.	Left Drive Wheel and Gear Belt
2a.	High Voltage Driver Board	5.	Left & Right Drive Motors
2b.	High Voltage Control Board	6.	Left Manual Drive Motor Brake
2c.	Filament Board	7.	Card Cage
3.	Power Control Chassis	8.	Front Casters
3a.	D.C. Fuse Board	9.	Front Bumper & Microswitches
3b.	Input Contactor	10.	Drive Handle Assembly
3c.	D.C. Connector	11.	Mobile Interconnect Bd.
3d.	Rotor Transformer	12.	Input Circuit Breaker

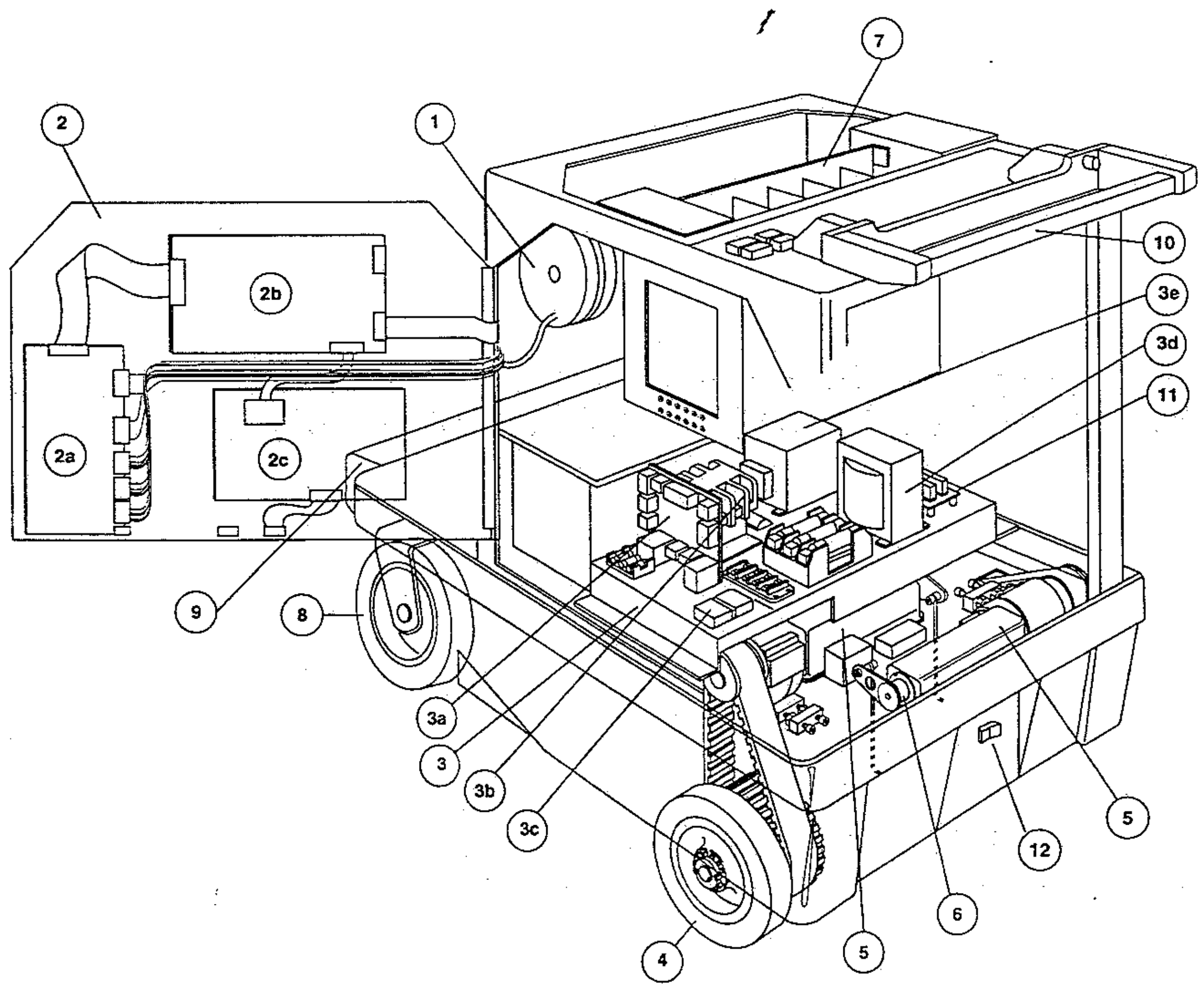

Figure F-1: Component Identification - Left Side

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1.2 Right Side Component Identification - Refer to Figure F-2

1. Top Cover
1a. Control Panel
1b. Keyswitch
1c. LCD Display
1d. Display Board
2. Microprocessor Board
3. Microprocessor Shield
4. Low Voltage Power Supply
5. H. V. Tank with L. V. Feedback Board
6. Right Drive Wheel and Gear Belt
7. Right Side Panel
7a. D.C. Motor Drive Control Board
7b. Rotor Board
7c. Phase Shift Capacitor
8. Battery Charger
9. Cooling Fan
10. Arm Interconnect Bd.
11. Motor Interconnect Bd.
12. Fan Interconnect Bd.
13. Desiccant

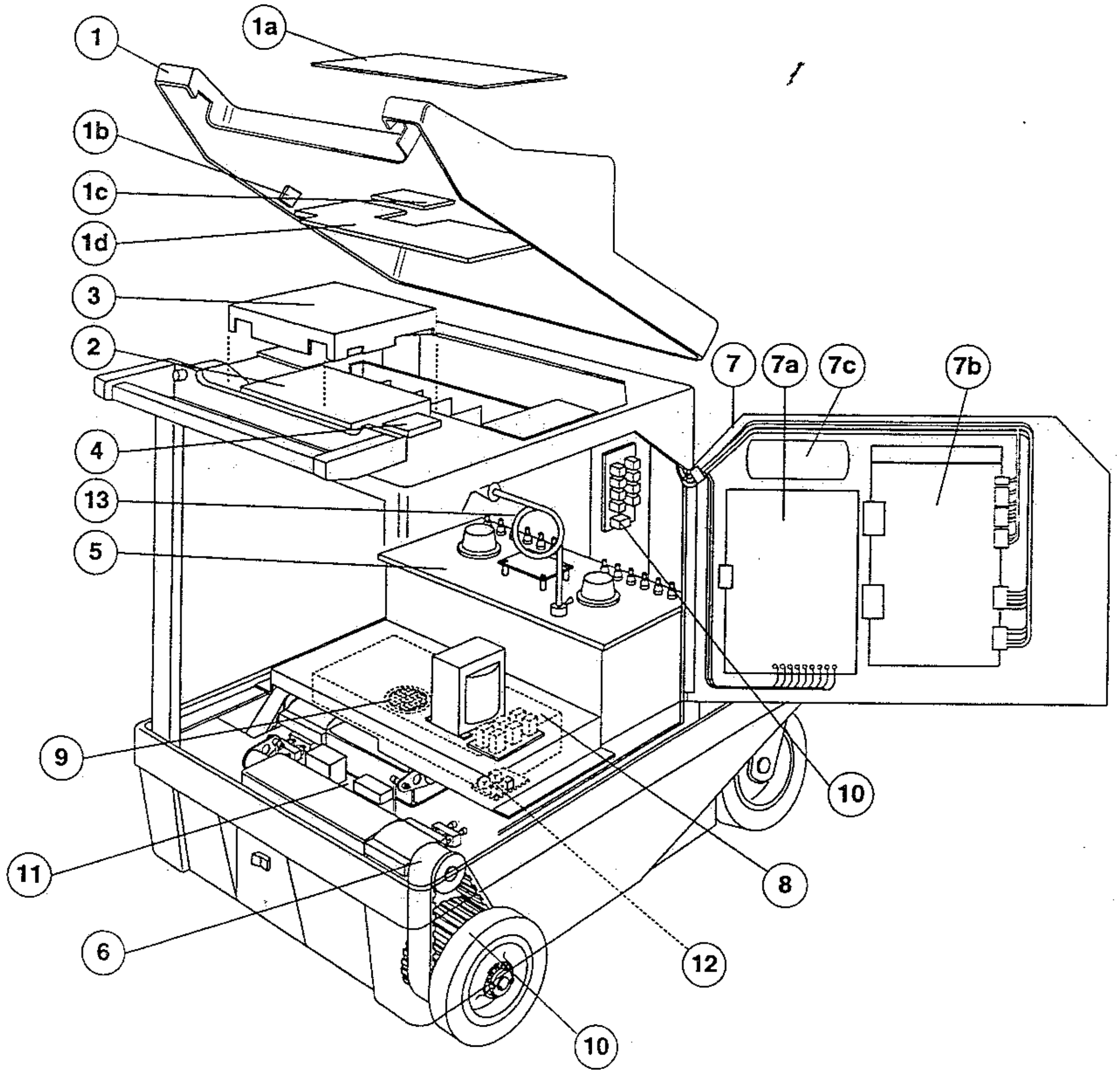

Figure F-2: Component Identification Right Side

1.3 Location of Fuses - Refer to Figure F-3

1. **Battery Pack**
   F1 60 A, 250 V, Dual Element Time Delay, FRN-R-60 (Buss)

2. **High Voltage Inverter Boards (2)**
   F1 20 A, 600 V, Fast Blow, KTK Series (Buss)
   F2 20 A, 600 V, Fast Blow, KTK Series (Buss)

3. **Rotor PC Board**
   F1 1 A, 250 V, Fast Blow, 2AG Series (Littlefuse)
   F2 7 A, 250 V, Normal Blow, Ceramic 314 Series (Littlefuse)
   F3 7 A, 250 V, Normal Blow, Ceramic 314 Series (Littlefuse)
   F4 2 A, 250 V, Slow Blow, 2AG Series (Littlefuse)
   F6 2 A, 250 V, Slow Blow, 2AG Series (Littlefuse)
   F7 7 A, 250 V, Normal Blow, Ceramic 314 Series (Littlefuse)
   F8 4 A, 125 V, Slow Blow, 2 AG Series (Littlefuse)
   F9 4 A, 125 V, Slow Blow, 2 AG Series (Littlefuse)
   F10 4 A, 125 V, Slow Blow, 2 AG Series (Littlefuse)

4. **Power Control Chassis (Electrical Chassis)**
   F1 20 A, 250 V, Slow Blow MDA-20 (Buss)
   F2 10 A, 250 V, Slow Blow, MDA-10 (Buss)
   F3 1 A, 250 V, Slow Blow, 3AG Series (Littlefuse)
   F4 40 A, 250 V, One Time NON-40 (Buss)
   F5 40 A, 250 V, One Time NON-40 (Buss)
   F6 40 A, 250 V, One Time NON-40 (Buss)

5. **Fuse Board**
   F1 2 A, 125 V, Slow Blow, 2AG Series (Littlefuse)
   F2 15 A, 250 V, Slow Blow, MDA-15 (Buss)
   F3 3 A, 250 V, Fast Blow, 2AG Series (Littlefuse)
   F4 20 A, 250 V, Slow Blow, MDA-20 (Buss)
   F5 5 A, 125 V, Fast Blow, 2AG Series (Littlefuse)

6. **Low Voltage Power Supply**
   F101 5 A, 250 V, Slow Blow 3AG Series (Littlefuse)
   F102 1 A, 250 V, Slow Blow 3AG Series (Littlefuse)
   F103 1 A, 250 V, Slow Blow 3AG Series (Littlefuse)

7. **D.C. Motor Drive Control Board**
   F1 20 A, 250 V, Slow Blow, MDA-20 (Buss)

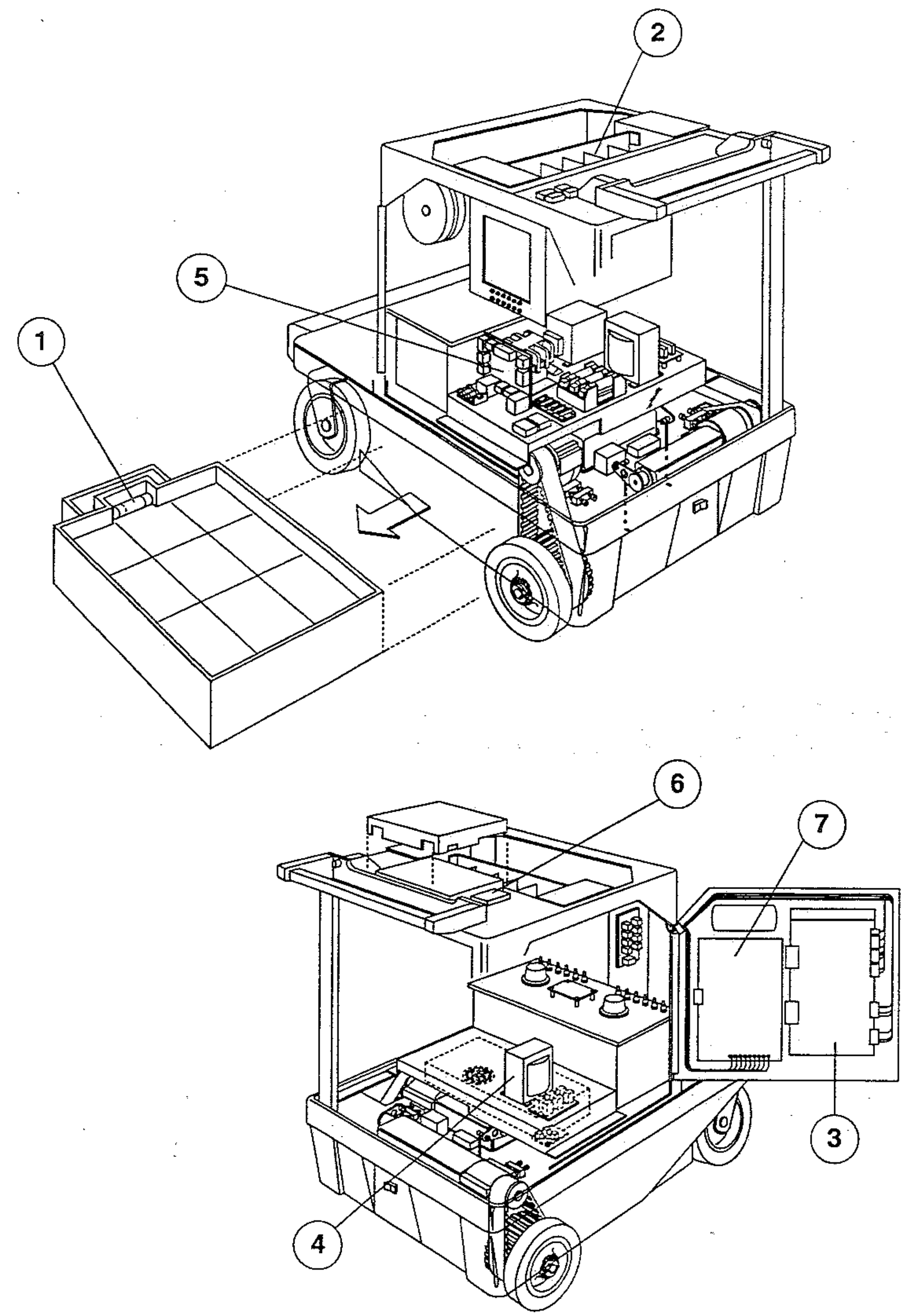

Figure F-3: Fuse Locations

2. TROUBLESHOOTING

This section of the manual provides information that, in the case of a failure, can be used to identify the area or component which may be responsible. The unit contains self-diagnostics which proceed throughout the operating program, and display a message on the LCD if a failure occurs. These messages, and the conditions that cause them, are explained in this section.

For problems outside the self-diagnostic capabilities of the unit, troubleshooting information is provided in a problem- probable causes format. Failure mode types are divided into four functional categories:

A. POWER/CHARGING PROBLEMS

B. DRIVE SYSTEM PROBLEMS

C. ARM POSITIONING PROBLEMS

D. MISCELLANEOUS FUNCTIONAL PROBLEMS

E. EXPOSURE PROBLEMS (Exposure mode problems are taken care of with the self-diagnostic System Messages, however, additional information is provided should the System Messages not indicate the failure)

The following list of symptoms, divided by categories, directs the technician to the Troubleshooting Tables, which are lists of the possible causes which are labelled, using the same numbers as the symptoms, in the following pages.

1. Power/Charging Problems

1.A Unit Won't Power Up When Keyswitch Turned ON
1.B Unit Powers Up But Turns Off Quickly
1.C Batteries Don't Recharge
1.D Unit Doesn't Turn OFF after 30 Minutes of Inactivity

2. Drive System Problems

2.A Unit Won't Drive At All
2.B Unit Drives but Starting and Stopping is Choppy
2.C Unit Drives in Low Speed Only
2.D Unit Drives Only in Reverse Direction
2.E Unit Drives Only in Forward Direction
2.F Brakes Do Not Turn On

3. Arm Positioning

3.A All Arm and Mast Brakes Won't Release
3.B One or Some Arm/Mast Brakes Won't Release
3.C Arm/Mast Brakes Do Not Stop Movement

4. **Miscellaneous Functions**

4.A Collimator Lamp Doesn't Illuminate
4.B Persistent Cable Fault

5. **Exposure**

5.A Power Shuts Off On Exposure Attempt or During Exposure

TROUBLESHOOTING TABLES - POSSIBLE CAUSES

1.A Unit Won't Power Up When Keyswitch Turned ON.

1.A.1 Unit Senses AC Power

- Connection to AC Mains (as is made for recharging batteries) will prevent power-up.
- Fuse Board's AC Sense circuitry not working properly or Relay K1 on Fuse Board improperly actuated or stuck in actuated position.

1.A.2 Power-up Circuit Not Operating

- Fuse F3 on Power Chassis open; will not supply Fuse Board with power to operate the Power-up circuitry.
- Components in Fuse Board keyswitch sensing circuit, or Fuse Board Relay K2 or associated circuitry, defective.
- Keyswitch on Control Panel not closing one or both sides when turned.
- Contactor (K1) on Power Chassis defective.

1.A.3 Microprocessor PC Board Not Operating

(must be operating to lift the signal "uP SHUTDOWN" which is connected to the Fuse Board)

- Low Voltage Power Supply not operating to supply the Microprocessor Board with power to operate.
- Contacts of Fuse Board's K2 relay not closing to connect battery power to Low Voltage Power Supply Input.
- Microprocessor PC Board defective (keeping "uP SHUTDOWN" signal active.

1.A.3 Battery Supply not Present

- Batteries discharged.
- Battery Pack fuse open.

1.B Unit Powers Up but Turns Off Quickly

1.B.1 Contactor Not Holding

- Relay Control circuitry on Fuse PC Board faulty (latching relay or associated switch sensing circuit).
- Contactor faulty.

1.B.2 Microprocessor PC Board Forcing Power Down

- Rotor PC Board power supply circuit faulty and sending a Rotor Fault signal to the Microprocessor.
- Low Voltage Power Supply module not supplying Microprocessor PC Board with correct operating voltages (check fuses F101, F102, and F103 under control console cover).
- Faulty Microprocessor PC Board incorrectly activating "uP Shutdown" signal to Fuse PC Board.

1.C Batteries Don't Recharge

1.C.1 Charger Module Not Connected to AC Line

- Check that power cord is connected and circuit breaker is on. ("LINE CORD CONNECTED" message must appear on Control Panel display).
- Circuit Breaker defective — no AC connection to Battery Charger.
- Fuse Board faulty — not sensing AC and connecting AC to Microprocessor Board.
- Power Cord or Reel Assembly faulty.

1.C.2 No Battery Charger Output

- Fuse F2 on Power Control Chassis open.
- Battery Charger module faulty or Trip Point grossly misadjusted.

1.D Unit Doesn't Turn Off After 30 Minutes

1.D.1 "UP Shutdown" Signal Not Initiating Turn -Off

- Fuse Board Faulty — turn off circuit not responding to shut down signal from Microprocessor.
- Microprocessor PC Board faulty — not transmitting "uP Shutdown" signal.
- Wiring faulty between Microprocessor PC Board, Fuse Board and Power Control Chassis.

2.A Unit Won't Drive At All

2.A.1 No Power To Drive System

- Fuse F4 on Fuse PC Board open.
- Fuse F1 on Power Control Chassis open.
- Fuse F1 on DC Motor Drive Control PC Board open.
- No power to system (See 1.A).

2.A.2 Drive System Circuits Not Operating

- DC Motor Drive Control PC Board Faulty.
- Microprocessor PC Board Faulty.
- Very low battery.

2.A.3 Brakes on Constantly

- DC Motor Drive Control PC Board faulty.
- Connection faulty between DC Motor Drive Control PC Board TB1 and J2 on Motor Interface PC Board.
- Brake(s) faulty.
- Microswitch on handle faulty.
- Handle Null out of balance.

2.A.4 Non-Resetable Drive Fault

- Welded K1 contacts on motor relay PC Board.

2.B Unit Drives but Starting or Stopping is Choppy

2.B.1 Drive Electrical System Misadjusted

- Auto-Null calibration necessary.
- Drive Handle Strain Gage Coarse Bias Adjustment necessary.
- DC Motor Drive Control PC Board Faulty.
- Gain Adjustment.

2.B.2 Mechanical Problem in Drive System

- Drive belt(s) worn or damaged.
- Motor Brake(s) binding.
- Wheel/Axle binding or damaged.
- Motor faulty.
- Drive handle faulty or binding.

2.C Unit Drives in Low Speed Only

2.C.1 Tube Cradle Indication Not Present

- Collimator arm not positioned in cradle correctly.
- Tube cradle microswitch/wiring faulty.
- Microprocessor PC Board Faulty — not respondinc ' ' tube cradle microswitch.

2.C.2 Drive System Not Exiting Low Speed Mode

- DC Motor Drive Control PC Board faulty.
- Microprocessor PC Board or wiring between Microprocessor PC Board and DC Motor Drive Control PC Board faulty.

2.D Unit Drives Only in Reverse Direction

(Display should show "Bumper Hit, Back Up" message)

2.D.1 Unit Senses Front Bumper Encountering Obstacle

- Front bumper microswitch(es) or associated wiring faulty.
- Bumper assembly binding or jammed inward.
- Microprocessor PC Board/wiring faulty.
- DC Motor Drive Control PC Board faulty.
- Rotor PC Board faulty.

2.E Unit Drives Only in Forward Direction

2.E.1 Drive System Not Receiving Correct Input

- DC Motor Drive Control PC Board Misadjusted (Auto Null or Strain Gage Coarse Bias).
- Drive Handle faulty.
- DC Motor Drive Control PC Board faulty.

2.E.2 Drive System Not Responding Properly to Input

- Drive PC Board faulty.

2.F Drive Brakes Do Not Work

2.F.1 Brake Release Latches Not Engaged

- The 2 brake release latches accessed from beneath the rear apron must be in the centered position (Brakes Enabled).

2.F.2 Brakes Not Actuating Properly

- Wiring faulty between DC Motor Drive Control PC Board TB1, Motor Interface PC Board and Brake Unit(s) on motor(s).
- DC Motor Drive Control PC Board faulty.
- Brake unit(s) faulty.

3.A All Mast and Arm Brakes Won't Release

3.A.1 Brake Release Request Not Detected

- Brake release switch(es) or associated wiring not sending brake release signal to Rotor PC Board.
- Rotor PC Board +12.5 volt power supply faulty (F1 open); likely if no relay click is heard from Rotor PC Board when Release Switch is engaged.

3.A.2 No Power to Operate Brakes

- Rotor PC Board +24 volt power supply for brakes faulty (F8); likely if relay click is heard from Rotor Board when Release Switch is engaged.

3.B One or Some Arm/Mast Brakes Won't Release

3.B.1 All brakes work concurrently so if one works, the problem is not in control circuits.

- Faulty wiring between Brake Diode PC Boards in arm sections.
- Faulty Brake Unit(s).

3.C Arm/Mast Locks Do Not Stop Movement

3.C.1 Faulty Brake Unit

- Replacement is indicated — not adjustable.

4.A Collimator Lamp Doesn't Illuminate

4.A.1 Collimator Lamp Faulty

- Replacement indicated.

4.A.2 No AC Power Supplied to Collimator

- Fuse F7 on Rotor PC Board open
- Rotor PC Board/Rotor Transformer Faulty

4.A.3 No Turn-On Signal Supplied to Collimator

- Image Field Lamp switch(es) faulty.
- Wiring between Microprocessor PC Board J210 to Arm Interface PC Board to Collimator faulty (likely if switch on Collimator works while switch on Control Panel doesn't).

4.B Persistent Counterweight Cable Fault

4.B.1 Erroneous Broken Cable Signal Supplied to Microprocessor PC Board.

- Counterweight cable tension misadjusted.
- Cable microswitch(es) misadjusted.
- Wiring between microswitch(es), Fan Interface PC Board, and Mast unit faulty.
- Microprocessor PC Board/wiring faulty.

4.B.2 Counterweight Cable Broken

- Replacement indicated.

5.A Power Shuts Off on Exposure Attempt or During Exposure

5.A.1 System Power Supply Failure Under Load

- Shuts down power via Microprocessor PC Board and Fuse PC Board ("uP Shutdown" signal) to avoid damage to circuits (displays short duration "ROTOR FAULT" message).
- Contactor faulty.
- Ground path faulty or intermittent causing erratic control circuit behavior.

6.A "Filament Shorted" or "Filament Open" appears on LCD Display.

6.A.1 Check Filament Board Operation

Note
The Filament Board is factory adjusted and should not require adjustment. This check is made to verify proper operation.

1. Remove all covers.

! WARNING !
High voltage is present.

2. Check presence of bias voltages with respect to ground (TP3).

   - TP1 = +15
   - TP2 = -15
   - TP18 = 80 V

3. Connect DVM + to TP13 on the Filament Board. Connect DVM - to ground (TP3). Verify that 4.5 V is present.

4. Turn the keyswitch OFF. Connect DVM across R50 (positive lead on the side away from the aluminum heat sink).

5. Turn the keyswitch ON. Verify that the voltage across R50 is approximately 60 mV (0.17 Amp). (The scale factor is 2.8 mA per millivolt.)

Battery Capacity Check

1. Connect the Power cord to the power source and charge the batteries fully, until the charging LED begins to cycle on and of.
2. Disconnect DC power (see Disconnecting DC Power section). Connect DVM+ to fuse F3 on the Power Chassis and DVM- to chassis ground. Connect Ammeter into the mAs socket located on the LV Feedback Board.
3. Disconnect the high voltage cables from the x-ray tube head and connect them to a dynalyzer.
4. Take eight exposures at 80 kV, 200 mAs one minute apart. Monitor the output current; it should be 150 mA and output kV should be 80 kV.
5. Observe and record the battery voltage during each exposure. At the end of the eighth expo sure, the voltage of a new battery should measure greater than 103 volts. A battery with less than 88 volts is considered weak and should be replaced.

Test Points and Fault Diode Indicators:

Microprocessor:

TP1 = mA Feedback 1V=91 mA
TP2 = Ground
TP3 = Battery Sense 1V=38.34 V
TP6 = kV Feedback 1V=25 kV
TP7 = -15 V
TP10 = Battery Charger Current 1V=1A
TP11 = +5 V
TP12 = +15 V
D7 (Cathode) = kV Control Voltage 1V=12.5 kV (left side of board)

Fuse Board:

LP1 = Spare Fuse
LP2 = Rotor Inv Fuse
LP3 = Filament Fuse
LP4 = Motor Drive Fuse
LP5 = Rotor Brake Fuse

D1 = PreRegulator 3, Fuse F6, Red LED
D2 = PreRegulator 2, Fuse F5, Red LED
D3 = PreRegulator 1, Fuse F4, Red LED

Rotor Board:

TP5 = Rotor Main voltage (return TP7)
TP6 = Rotor Phase voltage (return TP7)
TP7 = Rotor Common
TP13 = +40 V bias voltage for Filament and HV Control (return TP34)
TP14 = -40 V bias voltage for Filament and HV Control (return TP34)

TP19 = +15 V
TP22 = Tube rotor boost time (Active Low)
TP23 = Brake (Active Low, from microprocessor, K1 turn off time prior to K2 relay transferring)
TP25 = Brake (Tube rotor brake time, 2-second signal)
TP26 = Rotor Okay (Checks RPM)
TP28 = +12.5 V bias voltage (Logic, Brake FET)
TP31 = +5V bias voltage
TP33 = Ground
TP34 = ±40 V Ground, Bias com (for Filament and HV Control)

D22 = +40 V, Green LED, bias always on

LP1 = 110 Vac (when lit indicates F4 fuse is open)
LP3 = Auxiliary 110 Vac (when lit indicates F6 fuse is open)
LP4 = 0 Vac (when lit indicates F2 fuse is open)
LP5 = 220 Vac (when lit indicates F3 fuse is open)

HV Control Board:

TP2 = +12.5 V (Logic)
TP13 = Ground, HV com (return for VF+ and VF- signal)
TP17 = Voltage Shutdown
TP18 = + VF Overvoltage (latch)
TP25 = -VF Overvoltage (latch out)
TP26 = mA Overcurrent
TP30 = VC Local (10V = 125 kV, should approximate D7 on microprocessor)
TP38 = +15V (Logic)
TP42 = Filament Shutdown (inhibits Pre-Regulator and HV Inverter PWM's when filament supply faults)

D2 = +VF Overvoltage, Red, positive side of multiplier overvoltage fault indicator
D3 = -VF Overvoltage, Red, negative side of multiplier overvoltage fault indicator
D4 = HV Interlock, HV Arc, fault indicator activates if an arc occurs or if feedback connector is not connected
D20 = mA Overcurrent, Red, fault indicator activates if tube current exceeds 190 mA
D22 = -40V bias voltage present, Green, always on
D30 = Green
D21 = Green

PreRegulator:

TP1 = Battery Return
TP2 = Battery +
TP3 = Inverter Rail

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HV Driver Board:

TP12 = Inverter Overcurrent Fault
TP13 = +15 Undervoltage Fault
TP15 = PreRegulator Overcurrent Fault
TP16 = PreRegulator Overvoltage Fault
TP23 = PreRegulator Fuse Fault
TP24 = Inverter Fuse Fault
TP30 = +15V (Logic)
TP33 = Ground, Signal

D5 = Inverter Overcurrent Fault, Red LED fault indicator
D6 = +15V Undervoltage Fault, Red LED fault indicator
D7 = PreRegulator Overcurrent Fault, Red LED fault indicator
D9 = PreRegulator Fuse Fault, Red LED fault indicator
D10 = PreRegulator Overvoltage Fault, Red LED fault indicator
D12 = Inverter Fuse Fault, Red LED fault indicator

Filament Board:

TP1 = +15V
TP2 = -15 V
TP3 = Ground
TP4 = Fault Reset
TP5 = Shut Down (Active Low)
TP6 = Filament Overcurrent RMS
TP7 = Average Overcurrent
TP8 = Filament control sense (Input to Pwm)
TP13 = VP Local (Filament Control Voltage)
TP18 = +80 V (used for Rail)

D3 = -15 V bias voltage, Green LED, always lit
D4 = HV Enable, Green LED, EN/DIS, always lit except when a fault occurs
D7 = Rail Overcurrent, Red LED fault indicator
D8 = Filament Overcurrent, fault indicator (triggered by either Avg (AV) overcurrent, RMS overcurrent, or primary peak overcurrent)
D9 = Battery Indicator, Red LED, always on

Low Voltage Feedback Board:

TP1 = -IF
TP2 = -VF
TP3 = +VF
TP4 = HV Common
TP5 = HV Ground

HV Inverter Board:

TP1 = Battery Return

D49 = Inverter Rail Fuse F2 (Input)
D51 = Inverter Rail Fuse F1 (Input)

Note:
An illuminated lamp or LED indicates a fault condition, unless otherwise noted.

TP = Test Point
D = Diode
LP = Lamp

3. SYSTEM DIAGNOSTICS

The unit has two levels of self diagnostic modes, each of which place messages on the Control Panel LCD screen. Normal Mode, which occurs concurrently with normal unit operation, displays operational status messages and fault messages. Test Mode, which is entered by placing DIP Switch #1 on the Microprocessor Board ON, provides standard status and fault messages, and also provides expanded diagnostic information in place of several status and fault messages. All messages for each mode are provided in the following sections, with explanations of the conditions that make them appear.

3.1 Normal Mode

The messages described in this section appear during normal operation of the unit, or as a result of faults that occur during normal operation. Those messages marked with an asterisk (*) are replaced with expanded diagnostic information in Test Mode. Otherwise, all messages not asterisked are also available, as they appear here, in Test Mode. Each message explanation is prefixed with a notation as to whether it occurs during proper operation of the unit (STATUS) or only occurs when a problem is detected (FAULT).

Exposure Complete - XX mS*

(STATUS) This message appears upon successful completion of an x-ray exposure. The Microprocessor calculates the exposure time (in milliseconds), and displays it next to the message. This message is not an indication of trouble.

Line Cord Connected*

(STATUS) Plugging in the Line Cord delivers A.C. voltage to the charging circuitry. The Fuse Board's built-in A.C. power detection circuitry sends a signal to the Microprocessor which displays this message. The message is cleared by unplugging the line cord.

Recharge Battery, Now

(STATUS) During an exposure, if the battery voltage falls below 85 V, the rest of the exposure and subsequent exposures are continued at half power. When this message appears, approximately four more exposures are possible. To clear this message, recharge the batteries.

Battery Low, Recharge!

(STATUS) The Microprocessor's measurement of the battery voltage (via resistor on the Fuse Board) has determined that the battery charge level is below approximately 115 Vdc. To prevent damage to the batteries, the Microprocessor displays this message and shuts the system down after 10 seconds. To clear the fault, recharge the batteries.

Aborted - Low Batteries

(FAULT) During the exposure, the Microprocessor's battery voltage measurement (via resistor on the Fuse Board) has determined that the battery charge level is below optimum for exposure completion (approximately 80 Vdc). To prevent damage to the H.V. Generator, the Microprocessor terminates the exposure and displays this message. To clear the fault, recharge the batteries.

Ready to Drive
(STATUS) Indicates that tube is in nest and full speed driving is permitted.

Rotor Braking
(STATUS) Appears any time the rotor is braking.

Select Program Number
(STATUS) User has pressed Select button and is being invited to select a pre-programmed technique memory to store the currently set technique in.

Setup Program No. n
(STATUS) Confirms that the currently set technique has been programmed into pre-programmed technique memory "n".

Recall Program No. n
(STATUS) Confirms that pre-programmed technique has been recalled from pre-programmed technique memory "n".

Fault is Now Reset
(STATUS) Appears if resettable fault was successfully reset by pressing the RESET switch.

Bumper Hit, Back Up!
(FAULT) The front bumper has hit an obstruction causing one of the internal microswitches to open. The Microprocessor detects this condition and opens the unit's forward drive circuitry. Reset this fault condition by driving the unit in reverse until the front bumper clears the obstruction.

Counterweight Cable Fault
(FAULT) A microswitch in the mast structure, interlocked with the Microprocessor, has opened due to a broken counterweight cable. The Microprocessor detects the open switch, illuminates the RESET button, and terminates all drive and exposure circuitry. The counterweight cable must be replaced before this fault condition will clear.

Drive Fault
(FAULT) The Microprocessor detected an undesirable condition on the Motor Drive Board or in the motor drive circuitry. The Microprocessor terminates drive operation, illuminates the RESET button, and displays this message. If the fault condition was transient, pressing the RESET button will clear the fault.

Filament Short or Filament Open
(FAULT) The Microprocessor detected an undesirable condition in the filament or in the filament circuitry. The Microprocessor terminates exposure operation, illuminates the RESET button, and displays this message. If the fault condition was transient, pressing the RESET button clears the fault.

Aborted - Generator Fault*
(FAULT) The H.V. Generator's built-in fault detector has sent a signal to the Microprocessor indicating a high/low current, or a high/low voltage condition in the generator system. The Microprocessor terminates the exposure, illuminates the RESET button, and displays this message. If the fault condition was transient, pressing the RESET button clears the fault.

4

Rotor Boost Fault

(FAULT) The Microprocessor detected an undesirable condition in the x-ray rotor drive system causing the exposure to terminate, the RESET button to illuminate, and this message to appear. If the fault condition was transient, pressing the RESET button clears the fault.

Tube Overheated, Wait

(FAULT) The temperature in the x-ray tube head is sufficient to open the internal thermoswitch. The Microprocessor detects the condition of the thermoswitch and prohibits further exposures. Allow approximately 30 minutes for the tube temperature to drop to operable thermal conditions.

9

Rotor Inverter Fault

(FAULT) Indicates serious fault in Rotor inverter, displayed for 10 seconds, then unit shuts down to prevent damage.

Battery Charger Fault

(FAULT) Indicates that battery charger voltage is too high and continued use could damage the batteries.

Call For Service

(FAULT) Indicates fault condition that could not be attributed to specific cause.

Control Fault

(FAULT) Indicates that HV_EN signal is faulty since kV has been detected with this enable inactive, but HV interlock relay energized. This means that the HV interlock circuitry is faulty.

Aborted Tube Current Low*

Exposure was aborted because tube current was detected to be abnormally low.

Low KV, Exposure Aborted

(FAULT) Indicates that high voltage at least 80% of set kV was not seen by 10 milliseconds into the exposure.

Exposure Aborted

(FAULT) Displayed when exposure manually aborted by release of x- ray switch.

Switch Error

(FAULT) Appears in Ready mode if the x-ray switch is depressed without the boost switch being depressed, most likely due to a faulty switch.

Filament Fault

(FAULT) Appears if boost aborted due to over current in the filament driver.

Clear Drive Handle

(STATUS) Appears when pressure is applied to the drive handle prior to properly engaging the brake release bar of the unit.

3.2 Test Mode

The unit is set into Test Mode by placing Switch #1, on the Microprocessor Board, to the ON position. Test Mode allows operation of the unit, but displays more status and fault information than Normal Mode. In Test Mode, each of the previously explained Normal Mode messages, except those marked with an asterisk, appear during proper operation or if a fault condition occurs. However, several messages are replaced with more detailed messages that isolate the cause of a fault more precisely.

This following descriptions explain the messages seen only in Test Mode. For each message, its type (STATUS/FAULT), as well as its Normal Mode counterpart is provided.

Actual hv xx kV

(FAULT) Replaces "Aborted — Generator Fault". In test mode an exposure aborted for low or high kV after it had reached at least 80% in first 10 milliseconds; xx shows actual kV at time of shutdown.

Tube Current xxxmA*

(FAULT) Replaces "Aborted Tube Current Low"; shows actual tube current in mA at the time of shutdown.

Actual Fil Power %d, nnn

(FAULT) Replaces "Aborted Filament Low". In test mode an exposure aborted for abnormally low filament current; shows actual power to filament, should normally be 120-180.

Low Battery xxx.x V

(FAULT) Replaces "Aborted Low Batteries"; shows the actual battery voltage measurement (xxx.x) that caused an exposure to abort.

Pre-Reg Inv Fuse Fault

(FAULT) Replaces "Aborted Generator Fault; exposure aborted because of a opened Preregulator or Inverter fuse. If a Preregulator fuse is opened, it will not be possible to take an exposure. If it is an Inverter fuse opened it will be possible to start an exposure.

Pre-Reg/Inv Over Current

(FAULT) Replaces "Aborted Generator Fault"; appears after an exposure has been aborted due to overcurrent in the Preregulator or Inverter.

+15v UV, Rail Over Volts

(FAULT) Replaces "Aborted Generator Fault"; appears after an exposure has been aborted, due to +15 volts to the Generator FET drives is low, or the Inverter Rail is too high.

HV Arc, HV Interlock Fault

(FAULT) Replaces "Aborted Generator Fault"; appears after an exposure has been aborted due to an arc being detected, or interlock faults, i.e., missing low voltage feedback connector. If there is an interlock fault it will not be possible to take an exposure.

Tube Over Current Fault

(FAULT) Replaces "Aborted Generator Fault"; appears after exposure has been aborted due to over current in the x-ray tube.

Tube Over Voltage Fault

(FAULT) Replaces "Aborted Generator Fault"; appears after an exposure has been aborted due to over voltage in the x- ray tube.

Fil Over Current Fault

(FAULT) Replaces "Aborted Generator Fault"; appears after exposure has been aborted due to over current in the filament driver.

nnn

(STATUS) Exposure Counter — appears in test mode at the left side of the display; indicates successful exposures only, not aborted exposures. Counter digits will be covered if another message overwrites its position.

nnn Filament Shorted/Opened

(FAULT) Replaces "Filament Short/Open; appears if boost aborted due to abnormal filament power — should read 120 180 in normal operation. "Shorted" will appear for low numbers and "Opened" for high numbers.

xxx,yyy,zzz,aaaec,bbbfc

(STATUS) Replaces "Exposure Complete" message following a successful exposure below 50 milliseconds duration; "xxx" is for system use only; "yyy" signifies the software determined ideal exposure length in 250 microsecond increments; "zzz" signifies actual exposure length in 250 microsecond increments; "aaaec" signifies the correction to filament current demanded by the exposure in 13 mA increments; and "bbbfc" signifies the total filament offset in EPROM before the exposure.

aaais,bbbie,cccms,dddie

(STATUS) Replaces "Exposure Complete" message following a successful exposure above 50 milliseconds duration; "aaa" is the starting filament current in 13 mA increments; "bbb" is the ending filament current in 13 mA increments; "ccc" is the actual exposure length in milliseconds, and "ddd" is tube current at end of exposure in 100 microampere increments.

Charger Current xxx.xmA*

(STATUS) replaces "Line Cord Connected"; shows actual value of battery charger current while batteries are charging.

4. COVER REMOVAL & DISCONNECTING DC POWER

When replacing covers after a service operation, follow the reverse sequence i.e. top cover is removed first and replaced last. Always disconnect DC Power before attempting any service.

4.1 Lifting and Removing Top Cover - (Refer to Figure F-4)

LIFTING TOP COVER

1. Unplug the AC Line Cord from the wall outlet.
2. Extend the x-ray tube head as high as it will go (to the top of the mast).
3. Turn the system keyswitch OFF.
4. Disconnect the x-ray pendant switch from the receptacle below the Drive Handle.
5. Remove the Drive Handle shields on right and left underside of the Drive Handle assembly. Two 3/32" internal hex head (8 x 32) screws secure each shield to the unit.
6. Loosen the top cover securing hardware under each handle assembly (7/16" external hex head).
7. Lift the top cover from the operator's side approximately four inches.
8. Pull the top cover towards the operator side.
9. Slowly lift the top cover off the unit.
10. Rest the top cover against mast structure as shown in Figure F-4.
11. Support the operator's side of the top cover with the prop rod.

REMOVING TOP COVER

12 Disconnect the control panel ribbon cable from the microprocessor board.
13. Disconnect the park switch and keyswitch connectors.
14. Disconnect the top cover grounding wire.
15. Carefully place cover in a secured area.

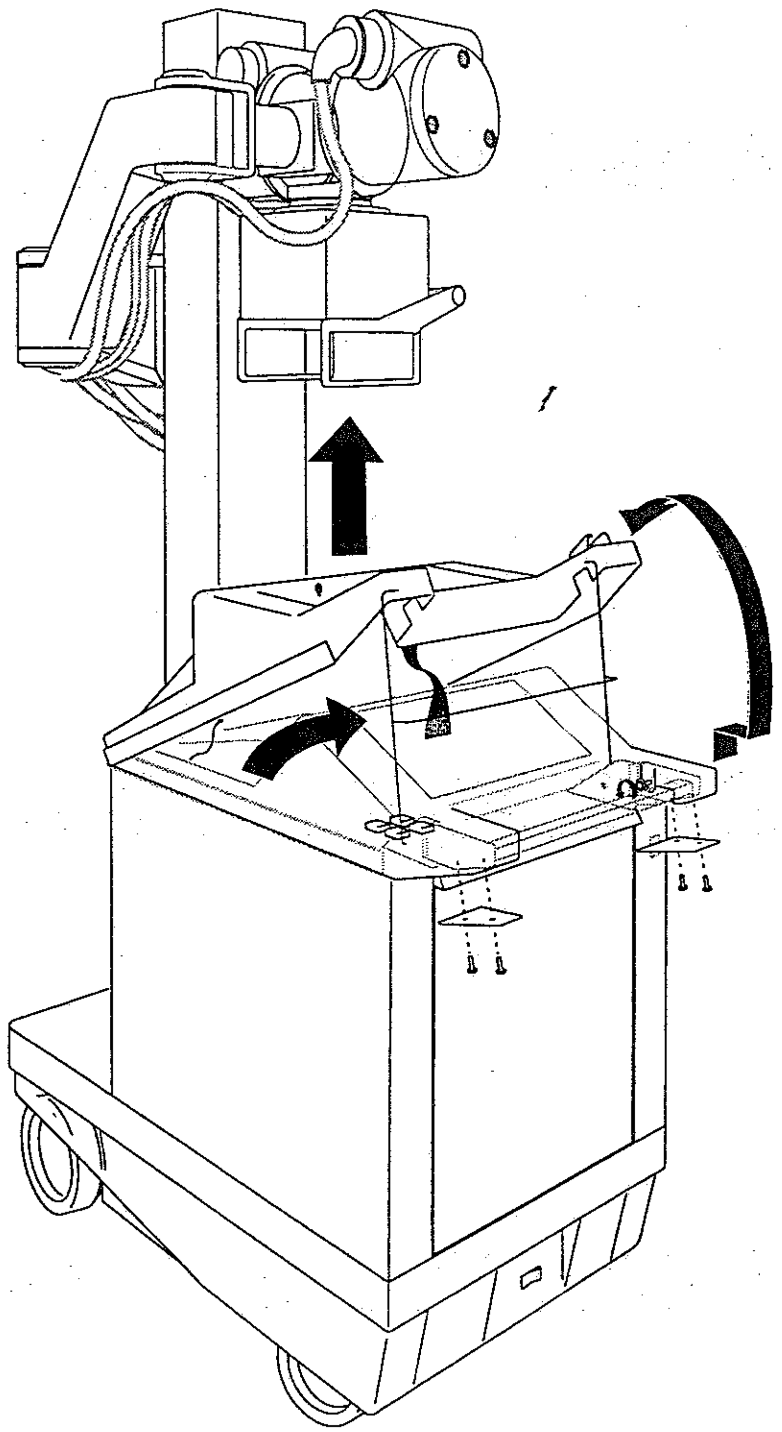

Figure F-4: Lifting and Removing Top Cover

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4.2 Removing Upper Left Cover and Disconnecting DC Power - (Refer to Figure F-5)

1. Remove the top cover as per paragraph 4.1 of this section.
2. Open the Cassette Drawer.
3. Release the two (philips) 1/4" turn fasteners at each top end of the upper left cover. (Access the fasteners through the hole in the cassette holder and the hole on the inside left wall of the unit).
4. Remove the upper left cover screw by the mast (qty 1, philips screw, lockwasher and washer).
5. Remove the electrical ground wire connected between the upper left cover and the unit's frame.
6. Slide the AC power cord reel grommet from the upper left cover cutout
7. Remove the upper left cover by lifting it from the locating pins on the frame.

NOTE:

When replacing the cover, slide the AC power cord reel grommet and line cord back into the upper left cover cutout. Position the cover around the operator's side first, then over the locating pins near the base of the mast, and the two locating pins below the left panel.

8. Remove the left panel screws (qty 3).
9. Disconnect the battery power connector.

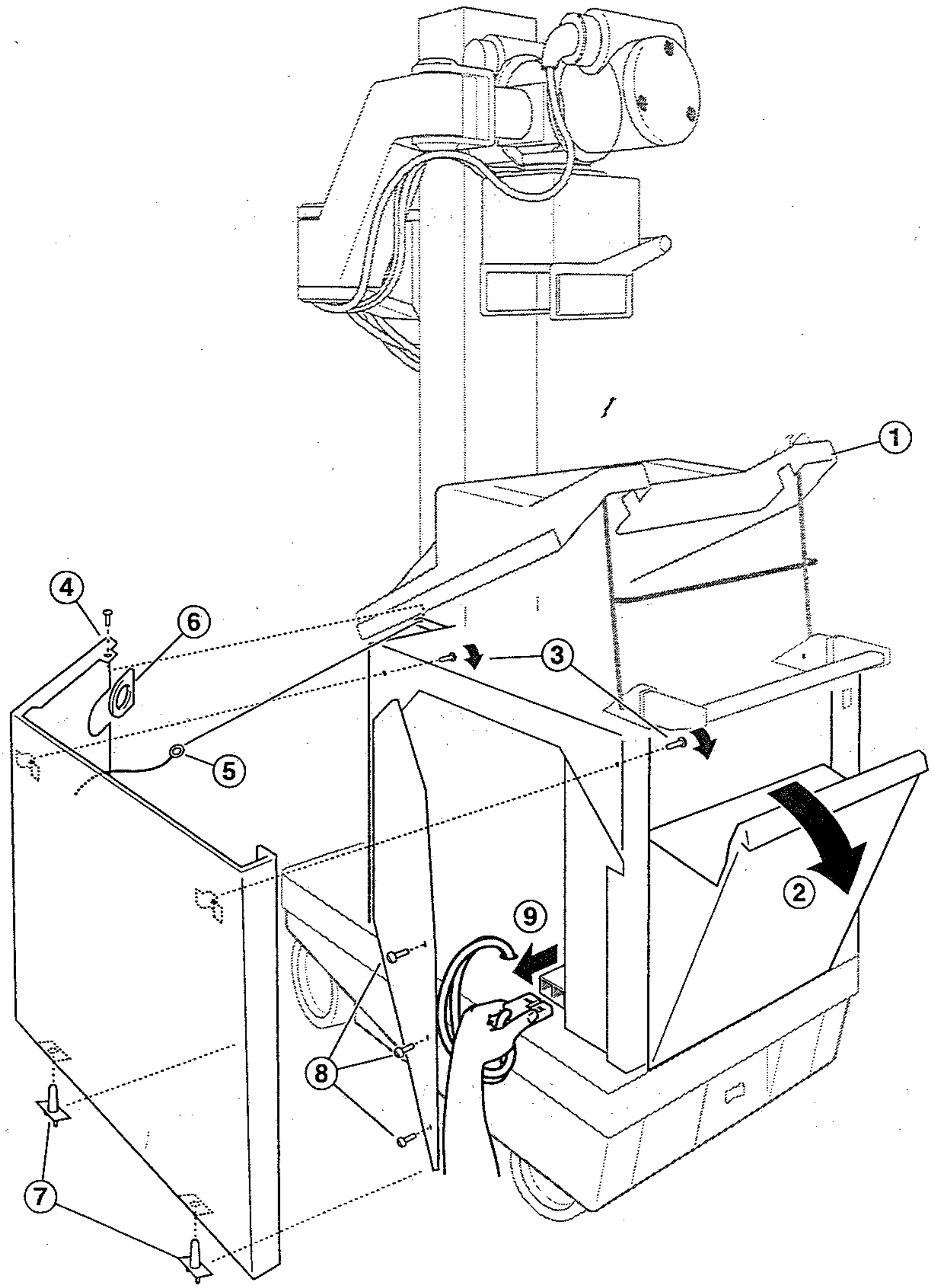

Figure F-5: Removing Upper Left Cover and Disconnecting DC Power

4.3 Removing Upper Right Cover - (Refer to Figure F-6)

! CAUTION !
The Upper Left and Upper Right Covers hold the Cassette Drawer in the unit. When removing the covers proceed carefully to prevent the Cassette Drawer from falling to the floor.

1. Lift the top cover as per paragraph 4.1 of this section.
2. Remove the microprocessor board shield (secured by four philips screws).
3. Disconnect the x-ray pendant switch cable from microprocessor board (remove P205).
4. Release the two (philips) 1/4 turn fasteners at each top end of the upper right cover. Access the fasteners through the hole in the cassette holder and the hole on the inside right wall of the unit.
5. Remove the upper right cover screw near the mast structure.
6. Remove the electrical ground wire from between the upper right cover and the unit's frame.
7. Remove the upper right cover by lifting the cover off of the locating pins. While removing the cover, back feed x-ray pendant switch cable through the chassis (the cable is attached to the connector on the cover).
8. Remove the right panel screws (qty 3).

NOTE:

When replacing the cover, slide the grommet and the tube head cables back into the upper right cover cutout. Position the cover around the operator's side first, then over the locating pins near the base of the mast, and the two locating pins below the left panel.

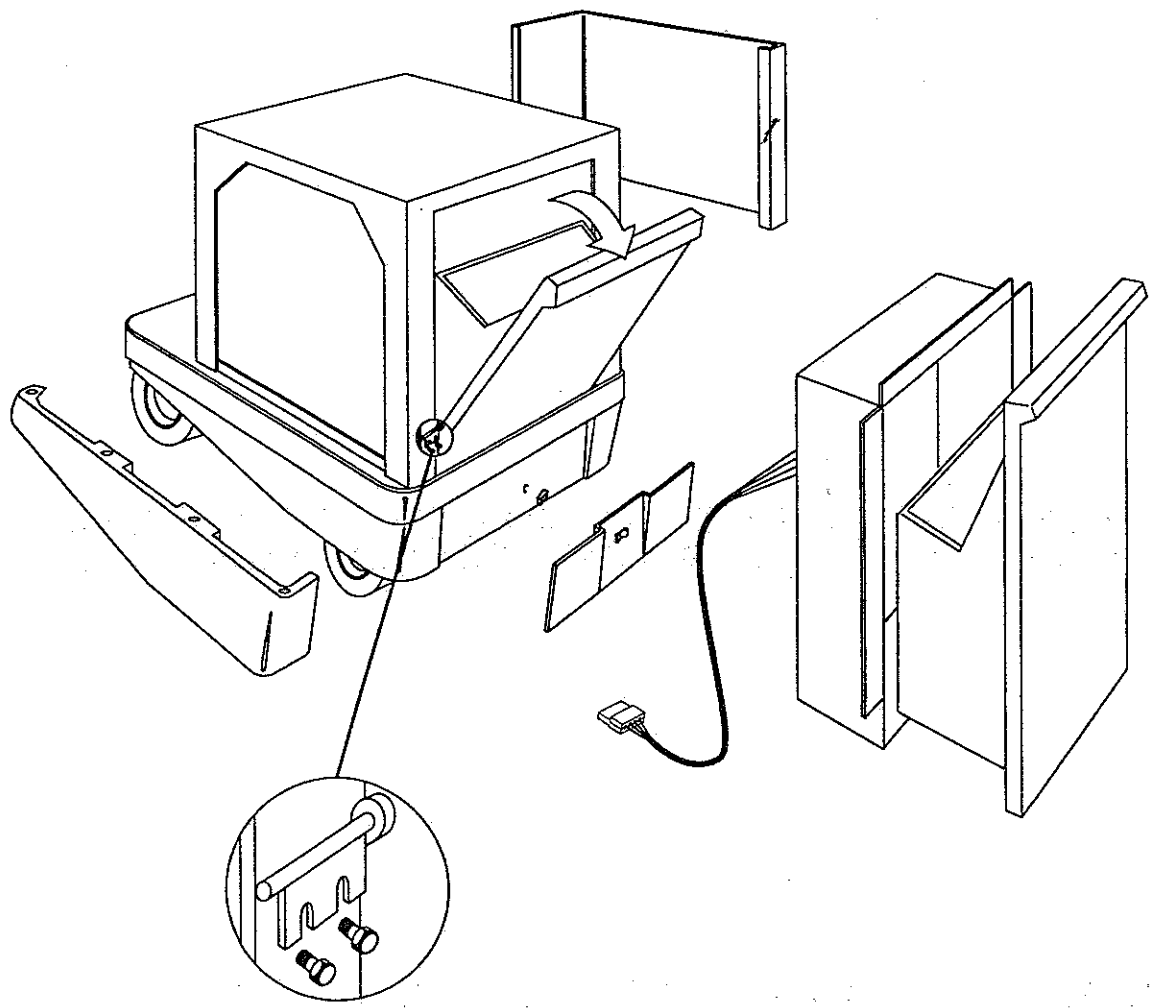

Figure F-6: Removing Covers

4.4 Removing Cassette Drawer and Holder - (Refer to Figure F-6)

1. Lift the top cover as per paragraph 4.1 of this section.
2. Remove the Upper Left Cover as per paragraph 4.2 of this section.
3. Remove the Upper Right Left Cover as per paragraph 4.3 of this section.

! CAUTION !
Removing upper left and upper right covers will remove cassette drawer stop. After disconnecting the cassette drawer grounding wire remove the drawer entirely to prevent it from dropping to the floor.

4. Disconnect the grounding wire between cassette drawer and unit's frame.
5. Lift and remove cassette drawer from the unit.
6. Remove the spacers on cassette drawer pivot pins.
7. Remove the cassette drawer holder screws (secured by six philips screws).
8. Loosen the two cassette drawer pivot pin brackets. Slide them outward and remove the brackets.
9. Disconnect the grounding wire between cassette holder and unit's frame.
10. Disconnect plug for battery disconnect switch.
11. Remove cassette holder.

NOTE:

When replacing the cassette holder, be sure that the DC power cables and other wires are dressed away from the cassette holder. Replace the cassette drawer pivot pin spacers.

4.5 Removing Lower Left Cover - (Refer to Figure F-6)

1. Lift the top cover as per paragraph 4.1 of this section.
2. Remove the Upper Left Cover as per paragraph 4.2 of this section.
3. Remove the 1/2" 10 x 32 philips head screws located on the left front (mast side), accessed underside the unit; remove the 3.5" 10 x 32 slotted screw located at the rear left corner through the access hole (operator's side).
4. Pull Cover off of retaining pins.

4.6 Removing Lower Right Cover - (Refer to Figure F-6)

1. Lift the top cover as per paragraph 4.1 of this section.

2. Remove the Upper Right Cover as per paragraph 4.3 of this section.

3. Remove the 1/2" 10 x 32 philips head screws located on the right front (mast side), accessed underside the unit; remove the 3.5" 10 x 32 slotted screw located at the rear right corner through the access hole (operator's side).

4. Pull Cover off of retaining pins.

4.7 Removing Lower Rear Cover - Refer to Figure F-6 and F-7

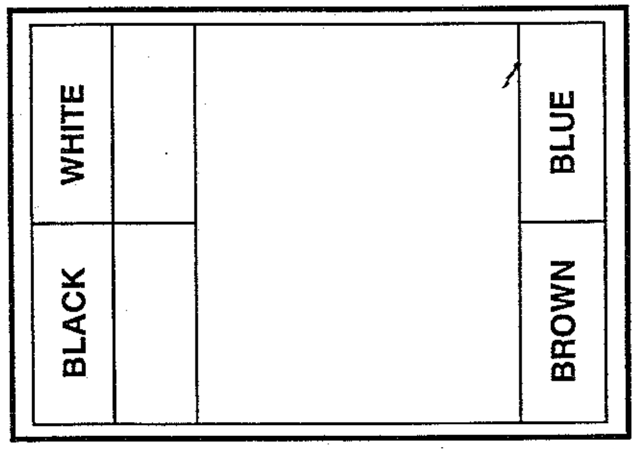

Figure F-7: Circuit Breaker Wiring

1. Lift the top cover as per paragraph 4.1 of this section.

2. Remove the Upper Left Cover as per paragraph 4.2 of this section.

! CAUTION !
Upper Right Cover prevents the Cassette Drawer from falling down; to prevent damage to Cassette Drawer keep Cassette Drawer in place while lifting and removing the Upper Right Cover; immediately remove the Cassette Drawer

3. Remove upper right cover (See Section F 4.3)

4. Remove cassette drawer and holder (See Section F 4.4)

5. Remove lower rear cover screws (qty 4, internal hex)

5. COMPONENT REMOVAL AND REPLACEMENT - BASE ASSEMBLY

5.1 Battery Pack - (See Figure F-8)

The following procedure requires disconnecting DC Power and removing all covers (see paragraph 4 of this section).

Equipment Needed:

- Battery Jack (Lift Buckle Mount)
- Guide Bars
- 3/8 inch Drive Socket Wrench with 1/2 inch 6 pt and 3/8 inch 8 pt socket

Procedure:

1. Manually turn the front casters to position them 90° relative to the rear drive wheels to provide additional room under the unit to maneuver the battery pack.

2. Place the Battery Lift Buckle Mount on the left-side frame weldment, between the alignment pin and the front frame weldment (see Figure F-8). Make sure that the notch in the mount is over the center battery pack mounting bolt.

3. Place the Battery Lift Jack on the floor on the right side of the unit (as viewed from the front of the unit). Orient the jack so that it is directly opposite the Buckle Mount, and the lower strap-side is flush against the unit (see Figure F-8). Bring the jack all the way up, then lower it 2 inches.

4. Slide both straps under the unit and weave them through the buckles on the Buckle Mount. Make sure that both straps are even, pull them as tight as possible, then tighten them further by raising the jack.

5. Using a ratchet with a 3/8" socket (8-point), turn the jack shaft clockwise to further tighten the straps. Remove the six battery pack mounting bolts.

6. Remove the six bolts, three on each side of the 1/2 inch socket (see Figure F-8).

! CAUTION !
Always tighten the straps completely and thoroughly before removing the battery pack mounting bolts.

7. Using the ratchet and socket, slowly turn the jack shaft counterclockwise to lower the battery pack. Use care not to strike the internal components or circuit boards with the ratchet during this step.

8. Pull the jack (two straps) out of the way. Be sure to watch the battery connector while reworking.

NOTE:

Rollers on the underside of the battery pack assist in maneuvering the assembly during removal and replacement.

9. Slide the battery pack from beneath the unit. Position the new battery pack under the unit, and slide the lifting strap beneath the battery pack.

10. Verify the position of the jack against the right side of the unit, move the jack to its lowest position, and then pull the straps through the buckles until they are tight.

11. Install the guide rods, one on each side in the center hole, and tighten them completely.

12. Using the ratchet and socket, slowly turn the jack shaft clockwise to raise the battery pack. Use care not to strike the internal components or circuit boards with the ratchet during this step.

13. Remove the guide rods after four of the six bolts have been installed.

    NOTE:

    While lifting the battery pack, occasionally check that the mounting holes are aligning properly. The suspended battery pack is easily maneuvered with one hand to help align the holes.

14. Install the battery pack mounting bolts and tighten. Loosen straps and remove the Jack and Buckle Mount.

15. Reconnect the DC Power Connector.

16. Verify power-up sequence. Turn ON the Control Panel Keyswitch. The following should occur:

    a. All the lighted indicators light up momentarily

    b. The READY indicator illuminates

    c. The message screen displays "Software Revision XX"

    d. (XX signified the firmware revision level)

    e. The kV display indicates 80 (default)

    f. The mAs display indicates 2.0. (default)

17. To reinitialize the microprocessor for the new battery pack, perform the following:

    a. Turn the keyswitch off.

    b. Turn SW1, position 3 on the microprocessor board on.

    c. Turn the keyswitch on, wait 5 seconds, then turn the keyswitch back off.

    d. Turn SW1, position 3 back off.

18. Replace all panels and covers. Perform the battery recharge as necessary.

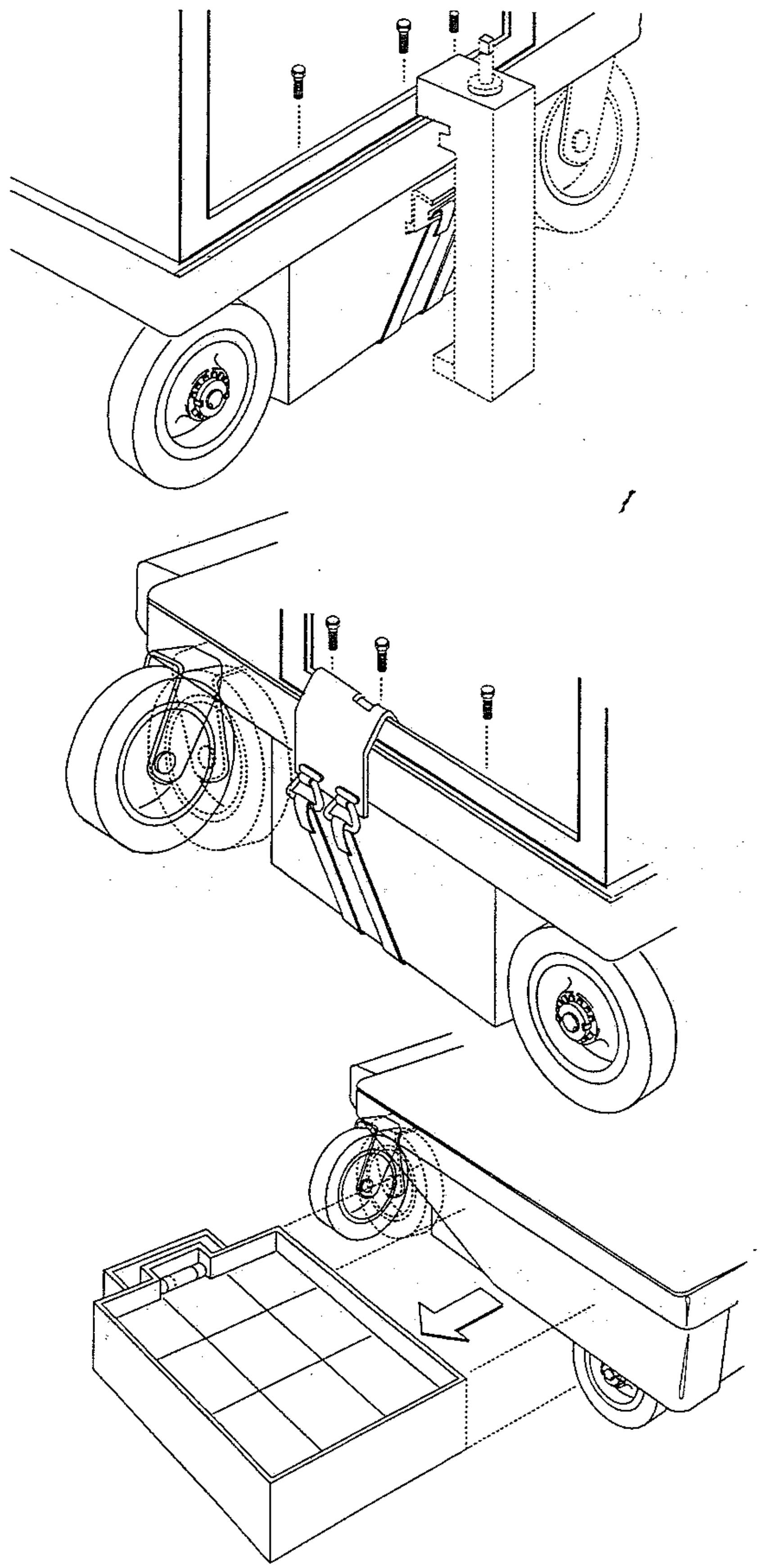

Figure F-8: Battery Pack Removal

5.2 Battery Charger - See Figure F-2

1. Disconnect DC Power (See Section F 4.4.2).
2. Remove the upper right cover (See Section F 4.4.3).
3. Disconnect the battery charger connector and associated hardware.
4. Remove the existing battery charger.
5. Install the replacement battery charger, then reconnect the charger connector and associated hardware.
6. Install the top cover to the lifted position, connect the park switch and display board.
7. Connect DC Power and AC Power.
8. Turn on the circuit breaker and the system keyswitch. Verify that the operator display reads "Line Cord Connected" and that the charging LED on the battery charger illuminates during battery charge. As the battery approaches full charge, the LED will start to cycle ON and OFF.
9. Perform the Battery Charger Trip Point verification. (See Section C1.3.)
10. Replace the panels and covers.

5.3 Front Casters - See Figure F-1

1. Place chocks behind the rear drive wheels to prevent the unit from rolling.
2. Lift the side of the unit where the wheel needs replacement.

NOTE:

The lift jack can be positioned under either side of the battery pack housing. If the battery pack is not installed, the lift jack can be placed under the unit's frame immediately adjacent to the wheel. Depending on the surface area required for your particular lift jack, the lower right or left cover may need to be removed to gain greater access to unit's frame.

3. Remove the front caster mounting plate bolts by removing the four bolts that secure the wheel to the underside of the chassis (four hex bolts).
4. Replace Wheel.
5. Verify that the replacement caster/wheel rotates freely and does not bind or make noise when driving the unit forward and reverse.

5.4 Front Bumper and Microswitches - See Figure F-1

1. Remove the two bumper rod retaining "C" clips located near springs.
2. Remove the bumper assembly.
3. Replace microswitches if worn or damaged.
4. Replace the bumper assembly.
5. Perform the front Bumper Microswitch adjustment. (See Section F 7.2.1).

5.5 Rear Drive Wheels, Left or Right - See Figure F-9

1. Disconnect DC Power (see Section F 4.4.2). Remove all covers (see Section F 4), then remove the Card Cage (see Section F 5.9).
2. Remove the Power Control Chassis (see Section F 5.10).
3. Loosen the two Gear Belt tension nuts and unscrew screws approximately 1/2" for the left or right motor. Manually lock the motor brake.
4. Loosen the left or right motor mounting hardware (four 1/2" bolts underneath chassis). Pry back the lock pin washer on the wheel axle and loosen the locking nut. DO NOT remove the nut.
5. Place chocks in front of the front casters to prevent the unit from rolling.
6. Position the jack in the center of the rear chassis. Jack the unit up approximately 1/2", until the bottom of the wheel clears the floor.
7. Remove the wheel axle by removing the four 7/16 bolts on each side of the axle.
8. Remove the wheel axle nut and lock pin washer, then remove the wheel. Install the replacement wheel (wrap the gear belt around the wheel gears).
9. Install the replacement wheel lock pin washer and hand tighten the locking nut. Lower and remove the jack.
10. Tighten the wheel locking nut and pry the lock pin washer over the locking nut.
11. Make sure that the gear belt position is directly over the wheel and motor.
12. Retighten the four 1/2" motor mounting bolts from underneath the chassis until they are snug. DO NOT tighten completely.
13. Adjust the Gear Belt tension screws so that the motor housing edge is parallel to the chassis frame. Adjust the tension screws and lock them in place with the locking bolts (see Section F 7.2.2).

13. Completely tighten the four 1/2" motor mounting bolts from underneath the chassis.

14. Release the manual motor brake.

15. Install the electrical chassis and the card cage.

16. Reconnect the top cover wiring, and connect DC Power.

17. Perform Drive Belt Tension Adjustment (see Section 7.2.2).

18. Replace all panels and covers.

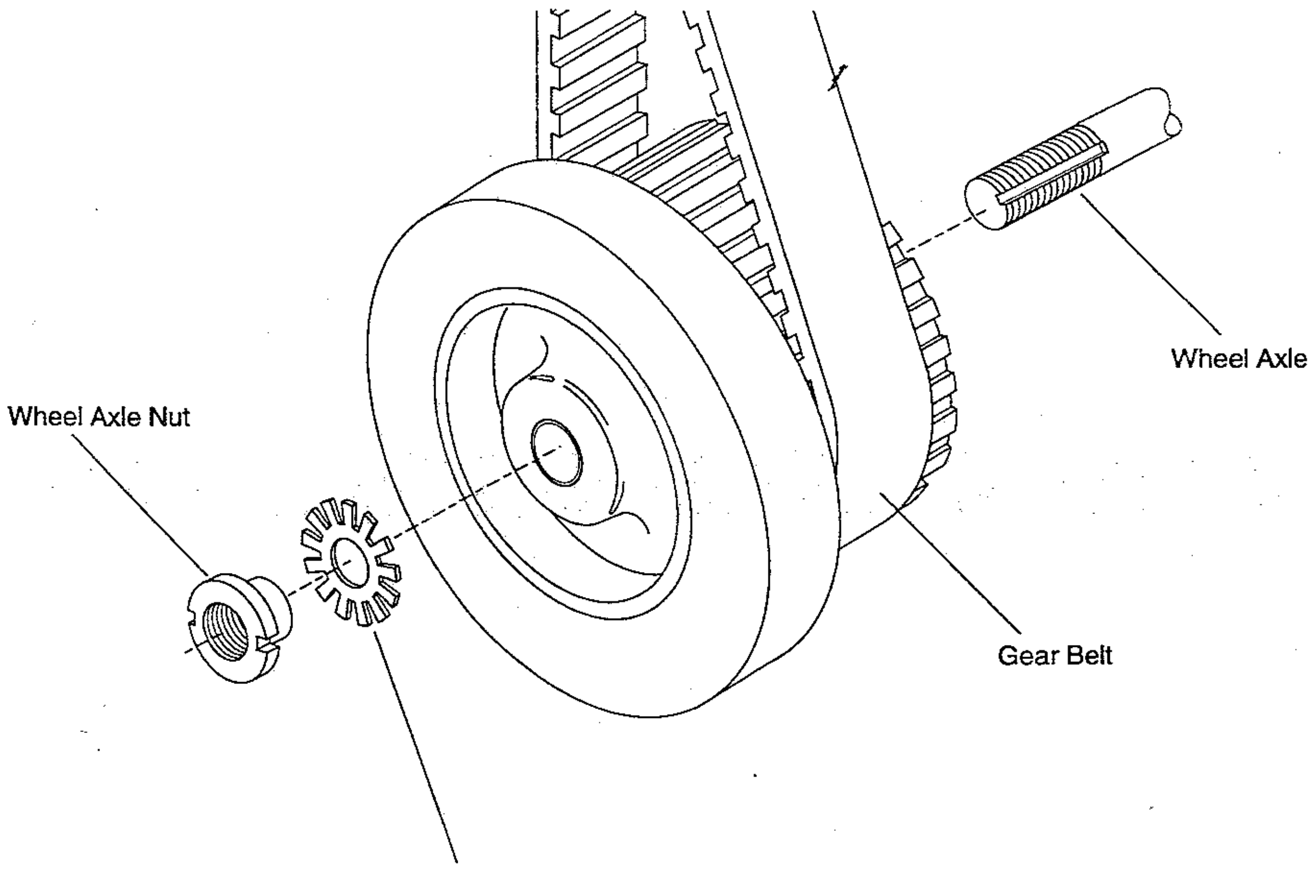

Figure F-9 - Rear Drive Wheel Removal

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5.6 Drive Handle Assembly - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), then lift the Top Cover (see Section F 4.1).
2. Remove the Top Cover prop rod and the microprocessor shield.
3. Remove the Drive Handle cable and associated hardware.
4. Install the replacement Drive Handle, associated hardware, and cable.
5. Reconnect DC Power.
6. Perform the Drive Control Board Coarse Bias Adjustment, the Auto-Null Adjustment, and the Drive Speed Calibration (see Section F 7.1).
7. Replace all shields, panels, and covers.

5.7 Drive Motors (Left or Right) - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), then remove all covers to access the motors (see Section F 4).
2. Remove the Power Control Chassis (see Section F 5.10). If replacing the innermost motor, remove or loosen the Card Cage to gain easier access to the motor.
3. Place chocks at the front and back of the front casters to prevent the unit from rolling. Loosen the two Gear Belt tension nuts and unscrew them approximately 1/2".
4. Remove the motor mounting bolts from the defective motor (four bolts underneath the motor mounting bracket). Note that the bolts are two different lengths.
5. Tilt the motor to remove the belt from the motor gear, then remove the motor. If the belt is to be replaced, perform the Gear Belt procedure (see Section F 5.8).
6. Insert the replacement motor in the gear belt, then reinstall the four motor mounting bolts (the two longer bolts belong next to the gear on the output shaft). DO NOT tighten the bolts.
7. Perform the Drive Belt Alignment and Tension Adjustment (see Section 7.2.2).
8. Tighten the Gear Belt tension screws, then lock them in place with the locking bolt.
9. Reinstall the Power Control Chassis and the Card Cage (if removed), then install the Top Cover and Top Cover wiring.
10. Connect DC Power, then temporarily secure the side panels.
11. Perform the Drive Control Board Coarse Bias Adjustment, the Auto-Null Adjustment, and the Drive Speed Calibration (see Section F 7.1).
12. Replace all shields, panels, and covers.

5.8 Gear Belt - See Figure F-1

1. Remove all covers, including the storage drawer and storage drawer frame. Remove the lower rear cover (under the storage drawer located between the rear drive wheels).

2. Place chocks at the front and back of the front casters to prevent the unit from rolling. Jack the drive wheel off the ground.

3. Loosen the motor mounting hardware (four bolts underneath the chassis). Tilt the motor and remove the belt from the motor gear and wheel gear.

4. Install the new belt by slipping the belt over the drive wheel and over the motor gear.

   Verify that the belt is properly positioned by manually rotating the wheel and observing that the belt rotates freely around the drive wheel gear and around the motor gear .

5. When satisfied that the belt is properly aligned and does not rub on any surface, lower the unit and remove the jack and chocks.

6. Perform the Drive Belt Alignment and Tension Adjustment (see Section F 7.2.2).

7. Replace the panels and covers, then check the unit to ensure integrity of the drive motor and belt assembly.

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5.9 Card Cage Removal - See Figure F-10

1. Disconnect DC Power (see Section F 4.2), then disconnect the ribbon cables to the Inverter Boards and Pre-Regulator Boards.
2. Loosen the screws and disconnect the lower row of wires on the wire block.
3. Remove the card cage hardware (Four 7/16" external hex head).
4. Lift and remove card cage.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

5. After replacing the card cage or any card cage board verify unit by taking x-ray exposures.
6. Replace all panels and covers.

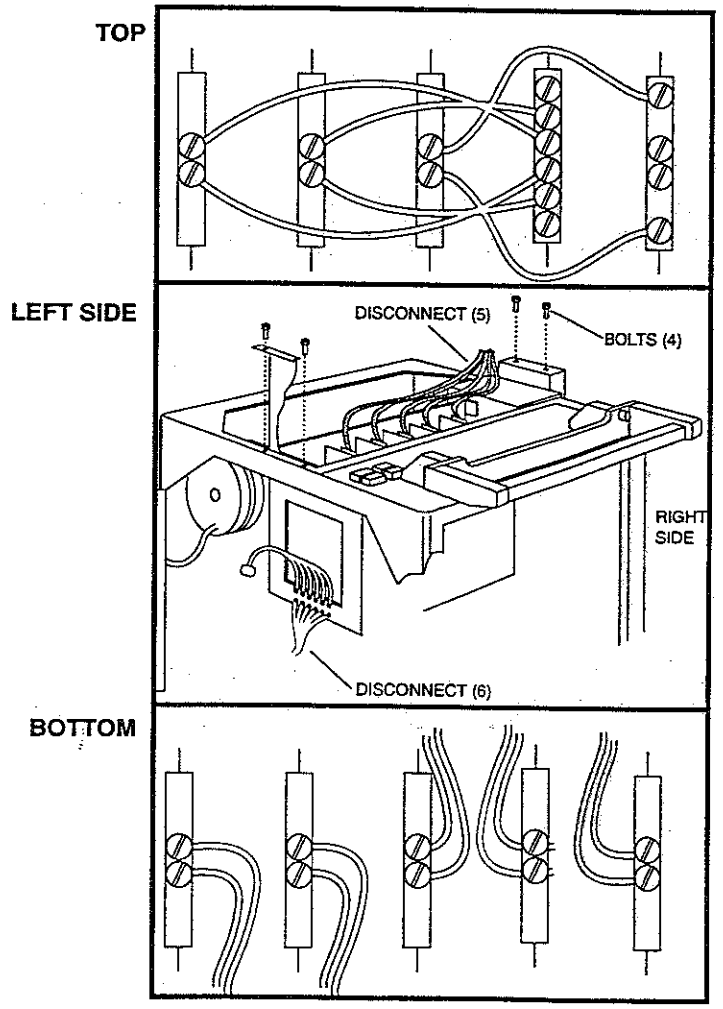

Figure F-10: Card Cage Removal

5.10 Power Control Chassis - See Figure F-11

1. Disconnect DC Power (see Section F 4.2), then remove the Card Cage (see Section F 4).
2. Remove connectors P108, P103, P106, P107, P101, P102 to Fuse Board. Remove connectors P402, P403, P408 to the Mobile Interconnect Board.
3. Disconnect the chassis ground wire from the Terminal Block and chassis ground, then remove the control chassis (4 nuts 7/16 inch).

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. After replacing the control chassis or any control chassis component verify unit by taking x-ray exposures.

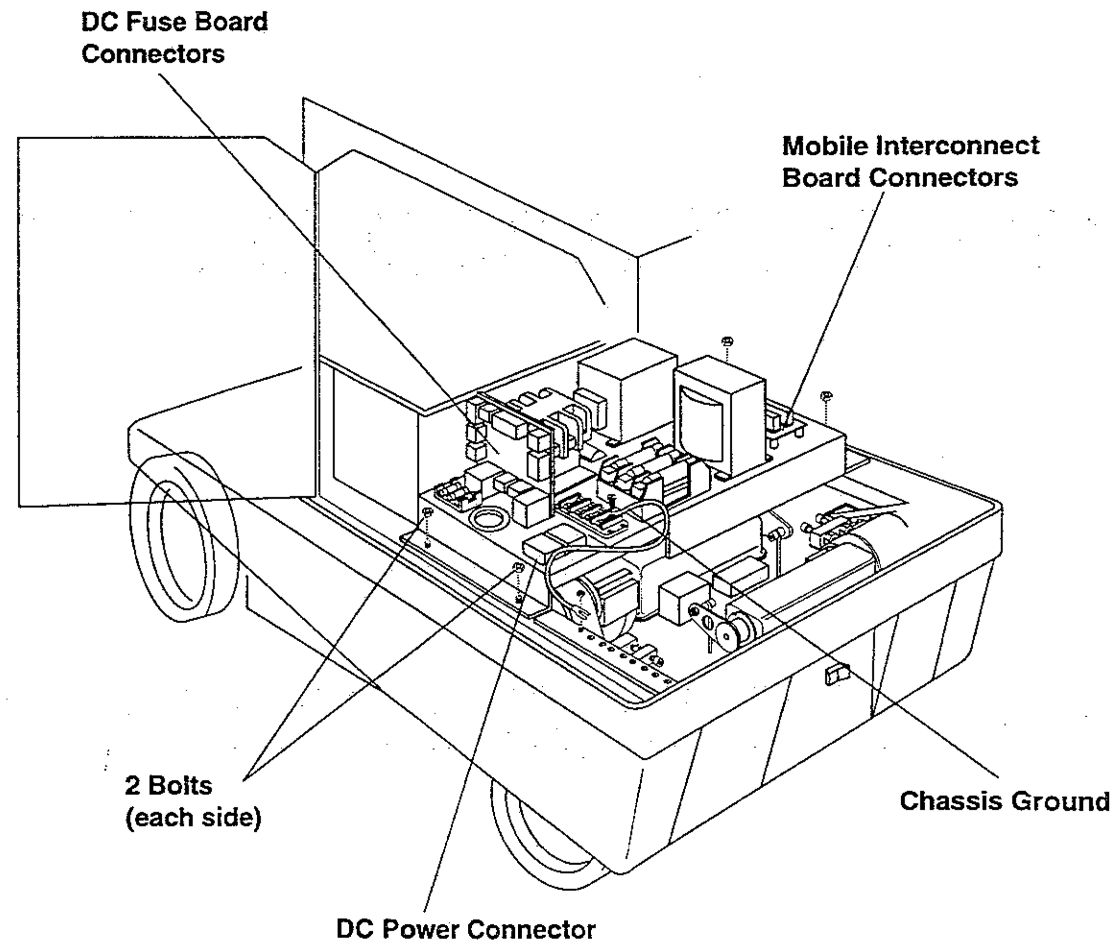

Figure F-11: Power Control Chassis Removal

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5.11 High Voltage Control PCB - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), then remove the cables and hardware from the High Voltage Control PCB.
2. Replace the High Voltage Control PCB, then reconnect hardware and cables.
3. Connect DC Power, then reconnect the top cover wiring.
4. Perform the kV Adjustment, the Arc Interlock Adjustment, the mAs Calibration and the kV Overvoltage Adjustment (see Section F 7.1).
5. Replace all panels and covers.

5.12 Filament PCB - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), then remove the cables and hardware from the Filament PCB.
2. Replace the Filament PCB, then reconnect the hardware and cables.
3. Connect DC Power, then reconnect the top cover wiring.
4. Perform the Filament Board Auto Calibration (See Section F 7.1.8).
5. Replace all panels and covers.

5.13 High Voltage Driver PCB - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), then remove the cables and hardware from the High Voltage Driver PCB.
2. Replace the High Voltage Driver PCB, then reconnect the hardware and cables.
3. Connect DC Power, then reconnect the top cover wiring.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. After replacing pc board verify unit by taking x-ray exposures.
5. Replace panels and covers.

5.14 Rotor PCB - See Figure F-2

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1. Disconnect DC Power (see Section F 4.2), then remove the upper right cover (see Section F 4.3). Remove the cable and hardware from the Rotor PCB.
2. Replace the Rotor PCB, then reconnect the hardware and cables.
3. Connect DC Power, then reconnect the top cover wiring.
4. Turn the keyswitch ON, then using a DVM, check the voltage of the following test points:
   - +40 V ± 5 V, on Rotor PCB TP13, negative lead to TP34
   - -40 V ± 5 V, on Rotor PCB TP14, negative lead to TP34
   - +24 V Range 21-28 V on Rotor PCB, TP15 negative lead to TP33.

   !WARNING!
   Observe all safety precautions while making an x-ray measurement.

   - Check for 245 Vac (±0.5V) with a true RMS DVM between rotor transformer pins 1 and 5. This measurement must be done with the battery voltage between 127 V and 129 V. (The 245 Vac is factory set and doesn't require calibration.)

   ! WARNING !
   Observe all safety precautions while making an x-ray exposure.

5. Verify the unit by taking x-ray exposures, then replace all panels and covers.

5.15 D.C. Motor Drive Control Board - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), then remove the upper right cover (see Section F 4.3).
2. Remove the cable and hardware from the D.C. Motor Control Board, then replace the board. Reconnect all hardware and cables.
3. Connect DC Power, then reconnect the top cover wiring.
4. Perform the Drive Control Board Coarse Adjustment, the Auto-Null Adjustment, and the Drive Speed Calibration (see Section F 7.1).
5. Replace all panels and covers.

5.16 Phase Shift Capacitor - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), then remove the upper right cover (see Section F 4.3).
2. Remove the wiring and clamps to the Phase Shift Capacitor, then replace the Capacitor. Reconnect the hardware and clamp.
3. Connect DC Power, then reconnect the top cover wiring.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Verify unit by taking x-ray exposures, then replace all panels and covers.

5.17 Microprocessor PCB - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), then remove the microprocessor shield.
2. Remove the cables and hardware from the microprocessor PCB, then replace the microprocessor board. Reconnect all cables and the shield.
3. Reconnect the top cover wiring, then connect DC Power.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Turn the system keyswitch OFF. Disconnect the high voltage cables from the x-ray tubehead and connect them to a Dynalyzer. Perform the Filament Board Auto Calibration (see Section 7.1.8). Perform mAs Calibration (see Section 7.1.13).
5. Perform a full functional test per section D, ACCEPTANCE, Compliance Testing.
6. Replace all panels and covers.

5.18 Low Voltage Power Supply - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), then remove the cables and hardware from the power supply. Remove the microprocessor shield.
2. Replace low voltage power supply, reconnect all hardware and cables, then reconnect the top cover wiring. Connect DC Power.
3. Verify presence of proper voltage at the following microprocessor test points:

   +5 V ±0.05 TP11 reference to ground TP8

   +15 V ±0.75 TP12 reference to ground TP8

   -15 V ±0.75 TP7 reference to ground TP8
4. Verify power-up sequence by performing 5.1 step 12.
5. Replace the microprocessor shield, then replace all panels and covers.

5.19 Control Panel Assembly - See Figure F- 2

1. Disconnect DC Power (see Section F 4.2), then remove the cables and hardware from the Control Panel Assembly.
2. Replace the Control Panel Assembly, then reconnect hardware and cables. Connect DC Power.
3. Perform the Display Contrast Adjustment (see Section 7.1.9).
4. Replace all panels and covers.

5.20 Display PC Board - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), then remove all cables and hardware from the Control Panel Assembly.
2. Remove cables and hardware securing the Display pc board.
3. Replace the Display pc board on the Control Panel Assembly. Install the Control Panel Assembly, then reconnect the hardware and cables.
4. Connect DC Power, then perform the Display Contrast adjustment (see Section 7.1.9).
5. Verify the following Switch Panel Switches and Indicators:

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Battery Status and Indicator

The CHARGING indicator should light with circuit breaker ON and Line Cord connected to AC Mains. The Battery Status should illuminate indicating battery status.

System Keyswitch

NOTE:

A timer automatically shuts the unit off if neither the Drive Controls nor the Exposure Controls is used for 30 minutes. (To turn the unit back on, turn the keyswitch "OFF" and then "ON" again.)

Turn on the System Keyswitch on the Control Panel to "ON" with the enclosed security key. The following should occur:

- All the lighted indicators light up momentarily
- The READY indicator illuminates
- The message screen displays "Software Revision XX" (Where XX signified the firmware revision level.
- The kV display indicates 80
- The mAs display indicates 2.0.

kV Readout and Switches

kV Up/Down Controls - The kV -/+ push-button controls, located below the kV Readout, decrement/increment the kV setting and the kV Readout. Depressing the kV push-buttons increments the kV as follows:

40 - 80 kV	:	2 kV steps
80 - 125 kV	:	5 kV steps

mAs Readout and Switches

The mAs readout is a three-character LED display that shows the selected milliampere seconds. The following is the mAs range of the PMX-2000.

0.1 mAs - 325 mAs total
325 mAs maximum from 40 - 90 kVp
250 mAs maximum from 95 - 105 kVp
200 mAs maximum from 110 - 125 kVp

NOTE:

To display the full range of mAs readings, the kV setting must be changed.

The mAs -/+ push-button controls are located below the mAs readout. Change the mAs settings by pressing the (-) and (+) push-buttons. The mAs readout should increase or decrease accordingly. Depressing the mAs push-buttons changes the mAs settings by approximately 25%.

Control Panel Field Size Lamp Switch

The FIELD SIZE LAMP switch located on the display panel illuminates the Field Size Lamp in the collimator for a 30 second time period. Verify operation.

Anatomical Program Switches

The anatomical program switches can store and recall up to five values for the kV and mAs settings. Verify their functions as follows:

<u>Programming Anatomical Switches</u>

1. Adjust the kV and the mAs settings (using the +/- switches) to the desired settings.
2. Depress the SET switch. SET will illuminate
3. Depress Switch number 1. Switch number 1 will illuminate and SET switch will extinguish
4. kV and mAs values will be stored in memory under setting number 1

<u>Verifying Anatomical Switch Settings</u>

1. Change kV and mAs settings
2. Depress SELECT switch. SELECT switch will illuminate
3. Depress switch number 1. Switch number 1 will illuminate and SELECT switch will extinguish.
4. The values previously set for number will now appear.
   Repeat the Programming and Verification for Program Switches 2, 3, 4 and 5.
5. Replace panels and covers.

5.21 LCD Display - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), then remove all cables and hardware from the Control Panel Assembly.

2. In order to change the LCD Display, remove the Display PCB. Replace the LCD Display on the Control Panel Assembly, then reinstall the Display PCB, then the Control Panel Assembly and reconnect the hardware and cables.

3. Connect DC Power, then perform the Display Contrast Adjustment (see Section F 7.1.9).

4. Replace panels and covers.

5.22 X-ray Pendant Switch

1. Unplug the hand switch assembly from the mating connector on the unit.
2. Verify that pressing the first detent will make Pins 1 and 4 on the replacement hand switch connector. Verify that pressing further to the second detent make Pins 5 and 6.
3. Plug in replacement switch assembly.

5.23 Low Voltage Feedback Board - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), then remove all covers.
2. Remove the cables and hardware from feedback board. Replace the Low Voltage Feedback Board, then reconnect the cables and hardware.
3. Reconnect the top cover wiring, then connect DC Power.
4. Perform the Divider Bias calibration, the kV adjustment, the Arc Interlock Adjustment and the kV Overvoltage Adjustment (see Section F 7.1).
5. Replace all panels and covers.

5.24 High Voltage Tank Assembly - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), remove all covers (see Cover Removal Section), then remove the Card Cage.

    NOTE:

    Remove cables and hardware from Low Voltage Feedback Board if replacement tank assembly did not come with a low voltage feedback board.)

2. Remove all cables and hardware from High Voltage Tank Assembly.
3. Replace the High Voltage Tank Assembly and the Low Voltage Feedback Board. Reconnect the cables and hardware, then reconnect the top cover wiring. Connect DC Power.
4. Perform the Divider Balance calibration, the kV adjustment, the Arc Interlock Adjustment and the kV Overvoltage Adjustment (see Section F 7.12).
5. Verify operation.

5.25 Cooling Fan - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), then remove all covers (see F 4) and the Battery Pack.

2. Remove the fan connector from fan interconnect board. Remove the fan and fan guard (4 slotted 6x32 screws accessed from underneath the base).

3. Remove the wires from the fan connector (DO NOT damage the connector as it is needed for the replacement). Remove connector strain relief, then remove wires.

4. Install replacement fan and fan guard so that the airflow is directed into the battery pack.. Insert fan wire (without connector) through 1/4" hole with grommet. Install wires to fan connector, then replace connector strain relief.

5. Connect fan connector to fan interconnect board (Connector is keyed). Reconnect the top cover wiring, then connect DC Power.

6. Connect AC Power and confirm audible fan rotation. Replace panels and covers.

5.26 PreRegulators - See Figure F-12

1. Disconnect DC Power (see Section F 4.2), then remove all covers. (See Section F 4).

2. Remove the wires from the PreRegulator in question.

3. Replace the PreRegulator, reconnect the wiring and ribbon cables, install the card cage and hardware.

4. Reconnect top cover wiring, then connect DC Power.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

5. After replacing the card cage or any card cage board verify unit by taking x-ray exposures.

6. Replace panels and covers.

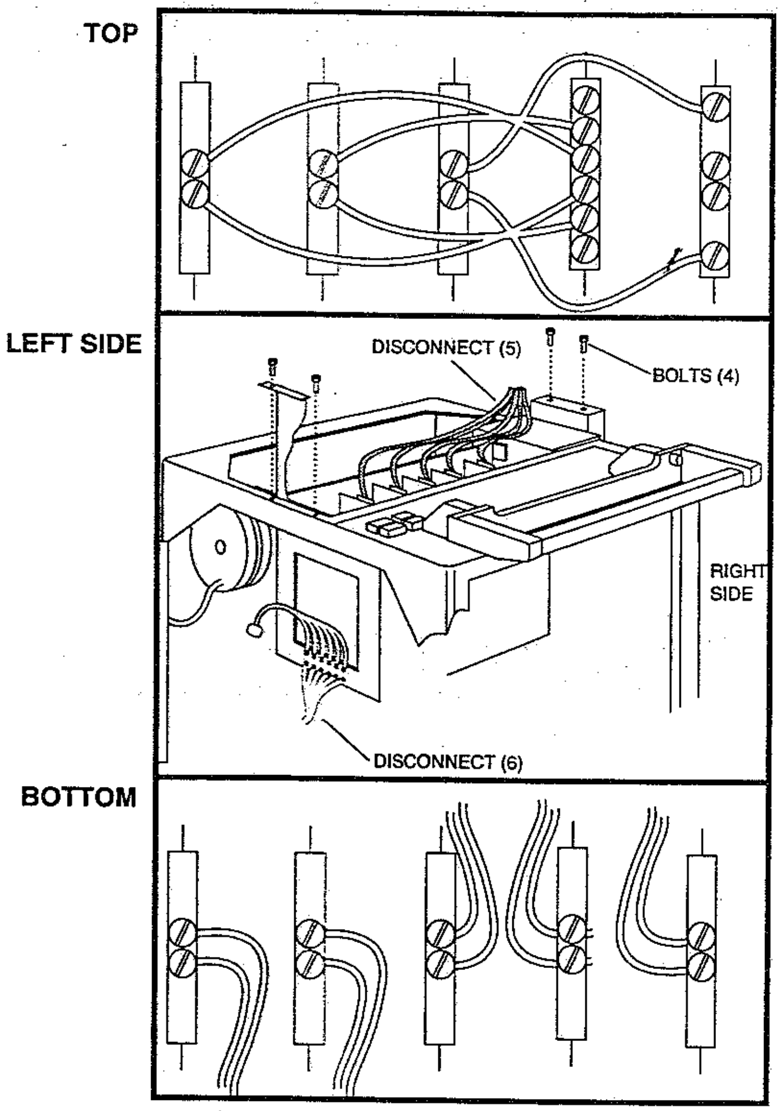

Figure F-12: Pre-Regulators and H.V. Inverter Removal

5.27 High Voltage Inverters - See Figure F-12

1. Disconnect DC Power (see Section F 4.2), remove all covers (see Section F 4).

2. Remove the cables and hardware from the Card Cage, then remove the cables and hardware from the High Voltage Inverter in question.

3. Replace the High Voltage Inverter, reconnect the cables, card cage, and hardware. Reconnect the top cover wiring and DC Power.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. After replacing card cage or any card cage board verify unit by taking x-ray exposures.

5. Replace panels and covers.

5.28 Transformer, T1, Rotor - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), remove the Upper right cover (see Section F 4), then remove the wiring and hardware from the T1 Transformer.

2. Replace transformer, then reconnect wiring and hardware. Reconnect the top cover wiring and DC Power.

3. Turn the keyswitch ON, then using a DVM, check the voltage of the following test points:

   - +40 V ± 5 V, on Rotor PCB TP13, negative lead to TP34
   - -40 V ± 5 V, on Rotor PCB TP14, negative lead to TP34
   - +24 V Range 21-28 V on Rotor PCB, TP15 negative lead to TP33.
   - Check for 245 Vac (±0.5V) with a true RMS DVM between rotor transformer pins 1 and 5. This measurement must be done with the battery voltage between 127 V and 129 V. (This voltage is factory set and doesn't require calibration.)

4. Replace panels and covers.

5.29 Transformer, T2, Power - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), remove the Upper right cover (see Section F 4), remove the Card Cage (see Section F 5.9), remove the Power Control Chassis, then remove the wiring and hardware from the T2 Transformer.

2. Replace the transformer, reconnect the wiring and hardware, replace the Power Control Chassis, replace the Card Cage, then reconnect the top cover wiring. Connect DC Power.

3. Perform the Battery Charger Trip Point verification (see F 7.1.1).

4. Replace panels and covers.

5.30 Mobile Interconnect Board - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), remove upper right cover (see Section F 4)), then remove wiring and hardware from the Mobile Interconnect Board.

2. Replace with replacement board, reconnect wiring and hardware, then reconnect top cover wiring. Connect DC Power.

3. Perform the following to verify that unit drive system is operational.

Brakes

Verify brake operation by pushing or pulling on the Drive Handle without touching the brake release bar located on the bottom of the Drive Handle.

Note:

The brake is automatically applied to the drive system when the Drive Handle is released.

The unit should lock in position and not move in any direction when pushing or pulling on the drive handle.

Forward Drive

To release the brake and drive the unit forward, squeeze the Drive Handle and Brake Release Bar simultaneously (using both hands). Gently push the Drive Handle forward, applying equal force to both sides to prevent swerving. Turn the unit by applying more force to one side of the Handle Bar. To turn right push harder on the left side of the Drive Handle, to turn left push harder on the right side of the Drive Handle. To make sharp turns, push one end of the Drive Handle while pulling the other end in the opposite direction.

Reverse Drive

Gently pull back on the Drive Handle to move the unit backwards. Apply equal force to both sides of the Drive Handle to prevent swerving. To turn the unit in reverse, manipulate the Drive Handle in the opposite manner as when driving the unit forward. Sharp turns are made in the same manner as when driving the unit forward.

Drive Speed

The degree of force applied to the Drive Handle controls the speed of the unit. Apply firm pressure to increase the drive speed; ease the pressure to decrease the drive speed. To stop the unit and set the brakes, release the Drive Handle.

Verify that unit can be driven approximately 3 miles per hour with the x-ray head in the parked position. Mark a 20 foot distance and clock the time it takes for the unit to travel that distance. This should be approximately 5 seconds.

Verify that unit can be driven approximately 1/2 miles per hour with the x-ray head out of the parked position. Mark a 20 foot distance and clock the time it takes for the unit to travel that distance. This should be approximately 10 seconds.

Verify the "Clear Drive Handle" message.

Front Bumper Safety Switch

Two limit switches are located on either side of the front bumper. If the bumper is accidently hit by an obstruction, the unit will automatically brake and indicate an error.

With the unit on (keyswitch to ON position), push in the left side of the bumper, the system message screen should indicate the following: "Bumper Hit, Back UP!"

To clear the error, grasp the Drive Handle and pull the unit a short distance, the error message should clear.

Verify this safety feature for the other side of the bumper.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Perform an x-ray exposure to verify proper operation.

5. Replace panels and covers.

5.31 Arm Interconnect Board - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), remove upper right cover (see Section F 4), then remove the wiring and hardware from the Arm Interface Board mounted on the mast.

2. Install the hardware and connectors to the replacement Arm Interface Board.

3. Reconnect the top cover wiring, then connect DC Power.

4. Verify that x-ray tubehead and arm moves freely when the Brake Release Switch is pressed. Verify that pressing both collimator field size lamp switches illuminates the collimator lamp for 30 seconds.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

5. Perform an x-ray exposure to verify proper operation, then replace panels and covers.

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5.32 Motor Interconnect Board - See Figure F-2

1. Disconnect DC Power (see Section F 4.2), remove the Cassette Drawer and Holder (see Section F 4), then remove the wiring to motor interface board.

2. Install the hardware and connectors to the replacement motor interface board, then reconnect the top cover wiring.

3. Connect DC power, then verify that the drive system is operational by performing 5.30 step 3 previously in this section.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Perform an x-ray exposure to verify proper operation, then replace all panels and covers.

5.33 Fan Interconnect Board - See Figure F-2

5.33.1 Removal

1. Disconnect DC Power (see Section F 4.2), remove the covers, the Card Cage (see Section F 5.9), the Power Control Chassis (see Section F 5.10), and the wiring and hardware to Fan Interconnect Board.

2. Install the replacement board and wiring, then install the Power Control Chassis, the Card Cage, and the Top Cover wiring.

3. Connect DC and AC Power.

5.33.2 Verification

1. Turn the circuit breaker and keyswitch ON.

2. The Charger LED on Control Panel should illuminate while battery is being charged. (As battery starts to approach full charge, LED will start to cycle on and off).

! WARNING !
Observe all safety precautions while making an x-ray exposure.

3. Perform an x-ray exposure to verify proper operation.

4. Replace panels and covers.

5.34 DC Fuse Board - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), then remove wiring to Fuse Board, remove Fuse Board.

2. Install connectors to replacement board, then reconnect the top cover wiring. Connect DC Power.

3. Verify power-up sequence outlined in section 5.1.

4. Verify charger by performing steps in section 5.34.2.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

5. Perform an x-ray exposure to verify proper operation, then replace panels and covers.

5.35 Input Circuit Breaker - See Figure F-1 & F-7

1. Disconnect DC Power (see Section F 4.2), then disconnect AC Power.

2. Remove the lower rear cover and the wiring from circuit breaker. Dismount circuit breaker from lower rear cover.

3. Mount replacement circuit breaker, then connect the wiring to the replacement circuit breaker.

4. Connect DC Power and verify charger by performing the procedure in 5.34.2.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

5. Perform an x-ray exposure to verify proper operation, then replace all panels and covers.

5.36 Input Contactor - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), remove DC Fuse Board (see Fuse Board Replacement Section), the DC Fuse Board Standoff Plate, and the Card Cage (see Card Cage Removal Section).

2. Disconnect wires to contactor.

3. Install replacement contactor and wiring, then install the Card Cage, the DC Fuse Board Standoff Plate, and the DC Fuse Board.

4 Connect DC Power and verify power-up sequence by performing 5.1.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

5. Perform an x-ray exposure to verify proper operation, then replace panels and covers.

5.37 Input Line Cord - See Figure F-1

1. Disconnect DC Power (see Section F 4.2), then disconnect AC Power.
2. Remove and replace the power reel line cord.
3. Connect DC and AC Power. Verify charger by performing 5.34.2.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

4. Perform an x-ray exposure to verify proper operation, then replace panels and covers.

6. COMPONENT REMOVAL AND REPLACEMENT ARM & MAST

6.1 Collimator Field Size Lamp - See Figure F-13

1. Disconnect DC Power (see Section F 4.2).

! CAUTION !
Make sure that lamp surface temperature has sufficiently cooled down before removing.

2. Close Collimator shutters, then remove lamp cover and the screen plate of lamp housing (DO NOT move the front acrylic plate). Remove the lamp.

! CAUTION !
Replacement lamp should be handled with a cloth, not directly touched with hands.

3. Wrap replacement lamp with soft cloth and insert lamp into socket. Install screen plate of lamp housing, then connect DC Power.

4. Perform the X-ray Field/Light Field Adjustment and the Field Size Adjustment (see Section F 7.2.3 and 7.2.4).

5. Install lamp cover and replace panels and covers

6.2 Collimator Mirror - See Figure F-14

1. Disconnect DC power (see Disconnecting DC Power Section).
2. Close the collimator shutters to minimum position.
3. Remove the rear plate by loosening the holding thumbscrews.
4. Remove the collimator cover by removing the 4 collimator cover holding screws.
5. (disconnect wires (2) from the terminal board to remove the collimator completely)

NOTE:
FOR PMX COURSE- DO NOT REMOVE THE MIRROR

5. Remove fastening screws of the 2nd Mirror Holders, then remove Mirror Holder A.
6. Mirror Holder B is bound to the mirror. Remove mirror with holder.
7. Install replacement mirror with Mirror Holder A.
8. Reconnect wires, install collimator cover and rear plate.
9. Connect DC Power.
10. Perform the X-ray Field/Light Field Adjustment, X-ray Field Adjustment and the Collimator Mirror Alignment (see Sections 6.3, 6.4, 6.5).

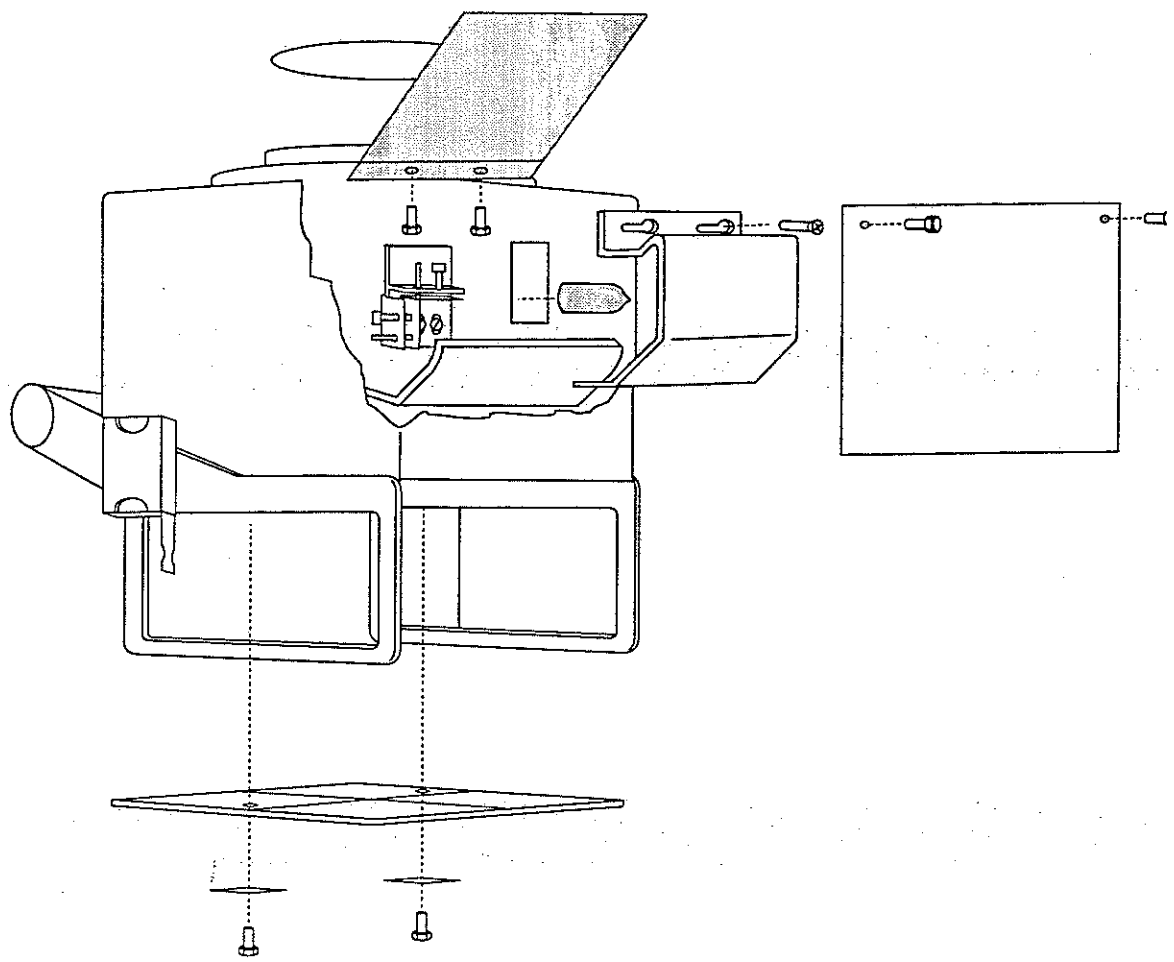

Figure F-13: Collimator, Lamp and Mirror

6.3 Collimator Assembly -See Figure F-14

1. Disconnect DC Power (See Section F 4.2).

!CAUTION !
Before disconnecting DC power, safely position x-ray head over a stable working area or table. Lock the pivot arm in position by inserting a suitable wedge inside the channel between the arm and the top of the mast. (e.g. wooden stick 1" x 3" x length A, length A determined by the height of your working table

2. Remove Upper Right Cover (see Section F4.3), then remove Rotation Stopper bolts. Remove collimator set screws and the adaptor flange.
3. Install replacement collimator with Rotation Stopper bolts and set screws.
4. Connect DC Power. Perform the X-ray Field/Light Field Adjustment and the Field Adjustment (see Section F 7.2.3 and 7.2.4).
5. Replace all panels and covers.

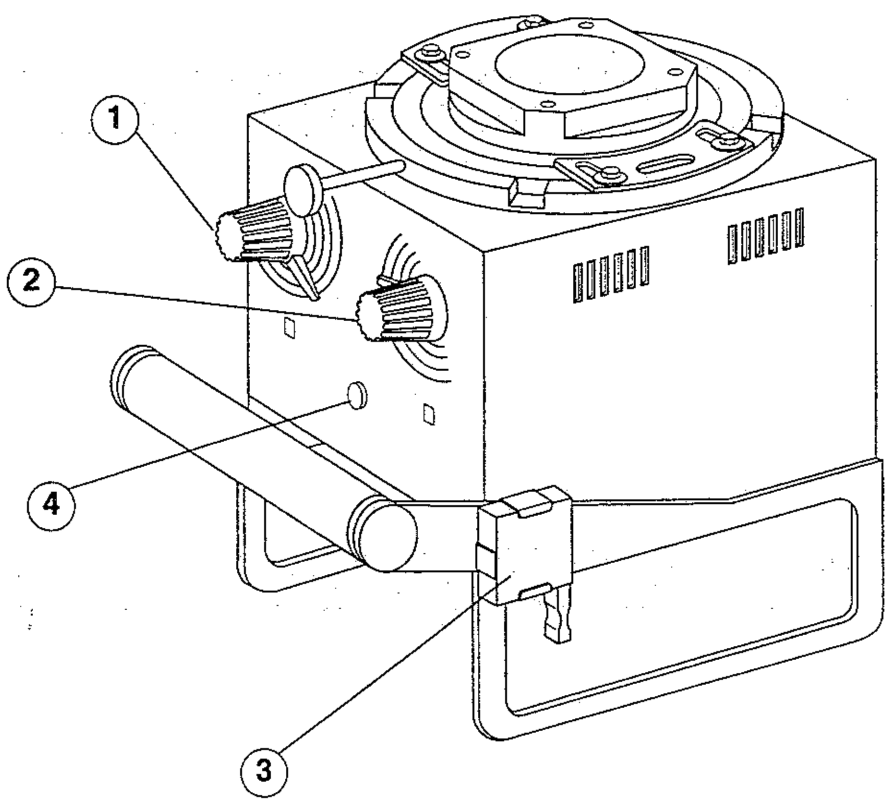

Figure F-14: Collimator Assembly

6.4 X-ray Tube Head Detent -See Figure F-15

! CAUTION !
Safely position and rest x-ray head over a working table.

1. Remove hardware and detent assembly (internal hex screw and split lock washer, qty 2 each).
2. Position the detent roller over one of the detent notches located on the trunnion bearing.
3. Firmly push detent assembly against trunnion bearing while locking the detent hardware.
4. Unlock trunnion lock handle.
5. Verify that the x-ray head detents at 90° intervals.

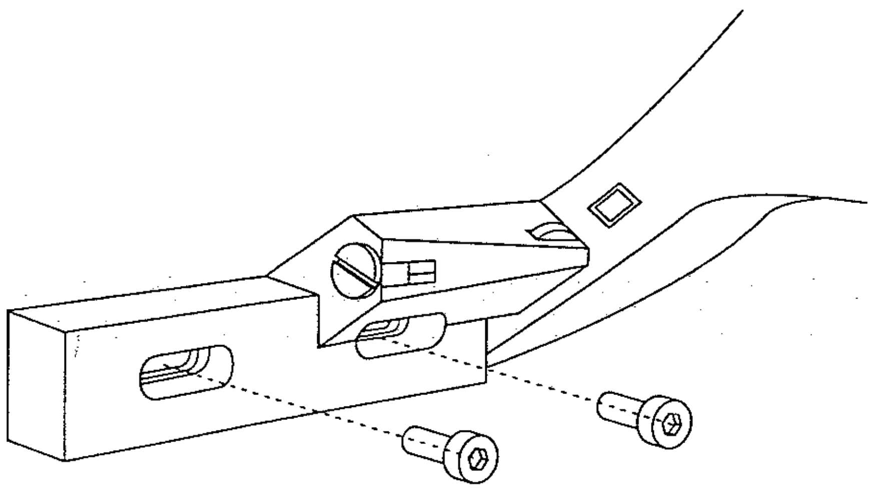

Figure F-15: Removing the X-ray Tubehead Detent

6.5 Trunnion Lock Handle -See Figure F-16

1. Disconnect DC Power (see Section F 4.2).

! CAUTION !
Before disconnecting DC power, safely position x-ray head over a stable working area or table. Lock the pivot arm in position by inserting a suitable wedge inside the channel between carriage support and the inside channel of the mast. (e.g. wooden stick 1" x 3" x length A, length A determined by the height of your working table.)

2. Remove lock handle shoulder screw and remove lock handle block support hardware.

   NOTE:

   Replacement shoulder screw requires Loctite® threadlocker 242, item # 24231; replacement block screws require Loctite® threadlocker 222, item # 22231.

3. Replace handle, delrin spacer, and pressure plate, then connect DC Power.
4. With the trunnion handle unlocked, verify that x-ray head can rotate freely and detents at 90 degrees, then lock the handle. Verify that x-ray head is held firmly in place and cannot be rotated.
5. Loosen or tighten locking screw for proper tension adjustment, then replace panels and covers.

6.6 Trunnion and Trunnion Bearing Assembly -See Figure F-15

1. Disconnect DC Power (see Section F 4.2).

!CAUTION !
Before disconnecting DC power, safely position x-ray head over a stable working area or table. Lock the pivot arm in position by inserting a suitable wedge inside the channel between carriage support and the inside channel of the mast. (e.g. wooden stick 1" x 3" x length A, length A determined by the height of your working table.)

2. Remove x-ray head detent (see Section 6.4 above), then replace trunion lock handle assembly (see Section F 6.5).

3. Remove left and right trunion (with sleeve bearings).

    NOTE:
    Replacement trunion hardware requires Loctite® Threadlocker 222, Loctite® item # 22231.

4. Replace sleeve bearings if necessary, then replace left and right trunion. Replace trunion lock handle and x-ray head detent. Connect DC Power.

    NOTE:
    Replacement sleeve bearings must be installed with 1/4" bend on the outside of the bearing raceway.

5. With the trunion handle unlocked, verify that x-ray head can rotate freely and detents at 90 degrees, then lock the handle. Verify that x-ray Head is held firmly in place and cannot be rotated.

6. Loosen or tighten locking screw for proper tension adjustment, then replace panels and covers.

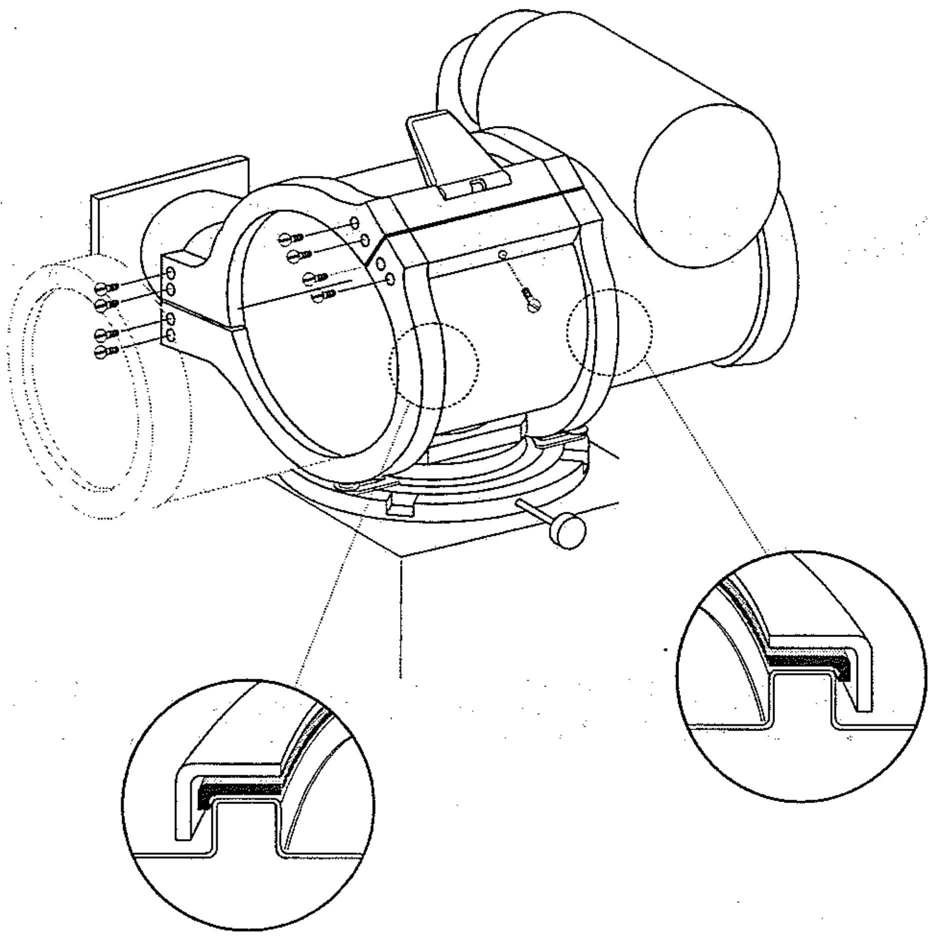

Figure F-16: Trunnion Lock & Trunnion Bearing Removal

6.7 X-ray Arm Locking Procedure -See Figure F-17

! CAUTION !
Removal of any major component on the x-ray tubehead or arm shifts the counterweight balance present in the mast. The following procedure should be performed in order to prevent the counterweight balance from upsetting the unit's equilibrium after a major component is removed.

1. Lower the x-ray arm to its lowest height.
2. Disconnect DC power (See Section F 4.2); remove all covers. (See Section F4) including the top cover.
3. Replace the two upper frame mast bolts with 1 1/2"-18 bolts (not supplied).
4. Slowly raise x-ray arm until it stops (the counterweight in the mast will be resting on the two bolts) and carefully position x-ray tubehead over a stable working surface (approximately 35 1/2" high).
5. Perform part replacement.
6. Lower X-ray Arm to its lowest height.
7. Replace the two upper frame mast bolts with the original bolts, replace covers and verify that unit is working properly.

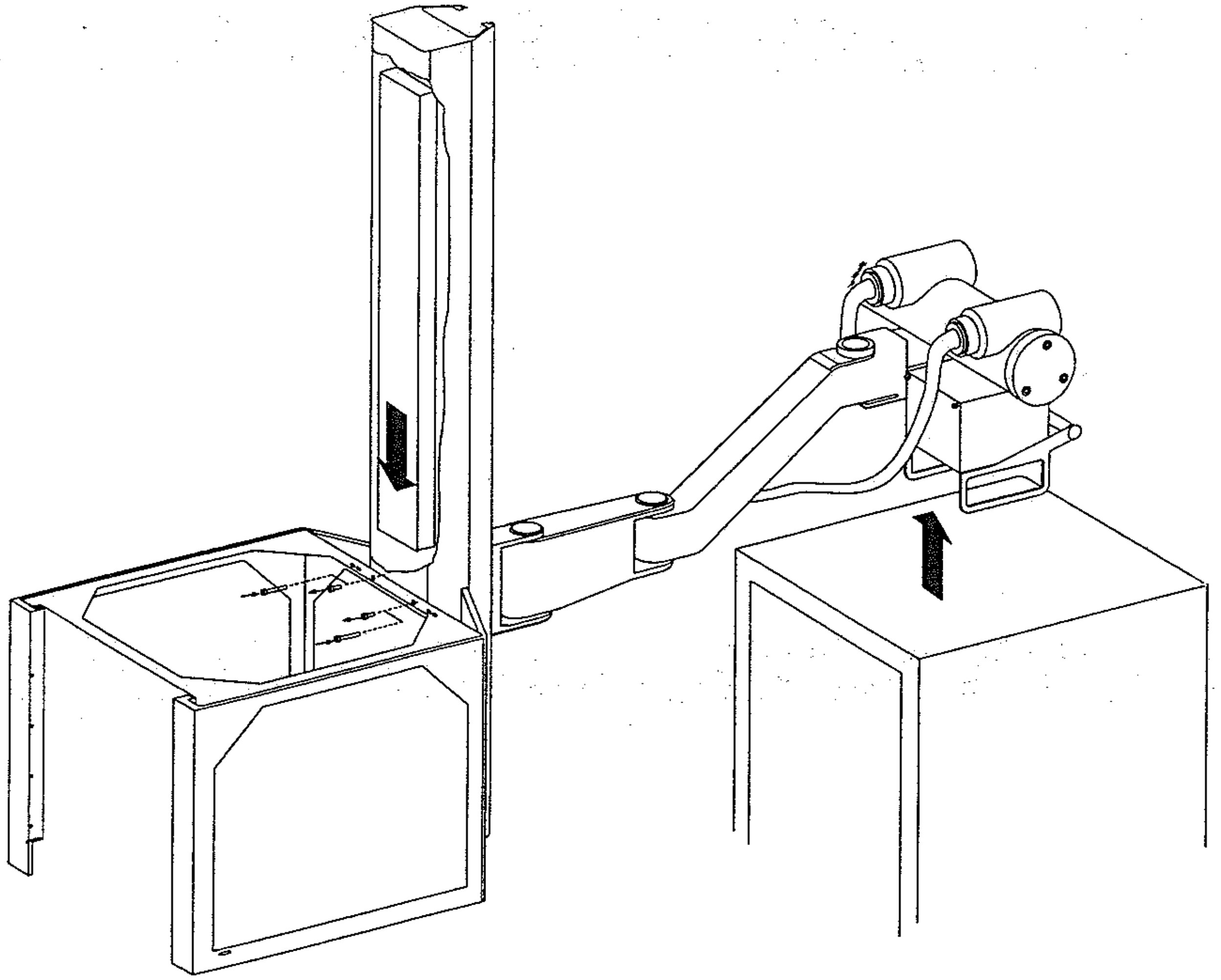

Figure F-17: X-ray Arm Locking Procedure

6.8 X-ray Tube -See Figure F-18

1. Disconnect DC Power (Seer Section F 4.2).

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F, 6.7).

2. Remove Upper Right Cover and disconnect cable to the Collimator, then remove Collimator Rotation Stopper bolts and set screws.
3. Remove the collimator and the adaptor flange.
4. Disconnect the x-ray head cables (High Voltage and signal), then remove trunion.
5. Install replacement x-ray tube, then install the trunion and the collimator with Rotation Stopper bolts.
6. Fasten the connector to the collimator lamp, then connect the x-ray head cables.
7. Connect DC Power.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

8. Verify unit by taking an x-ray exposure.
9. Perform Filament Board Auto Calibration (see Section F 7.1.8).
10. Replace all panels and covers.

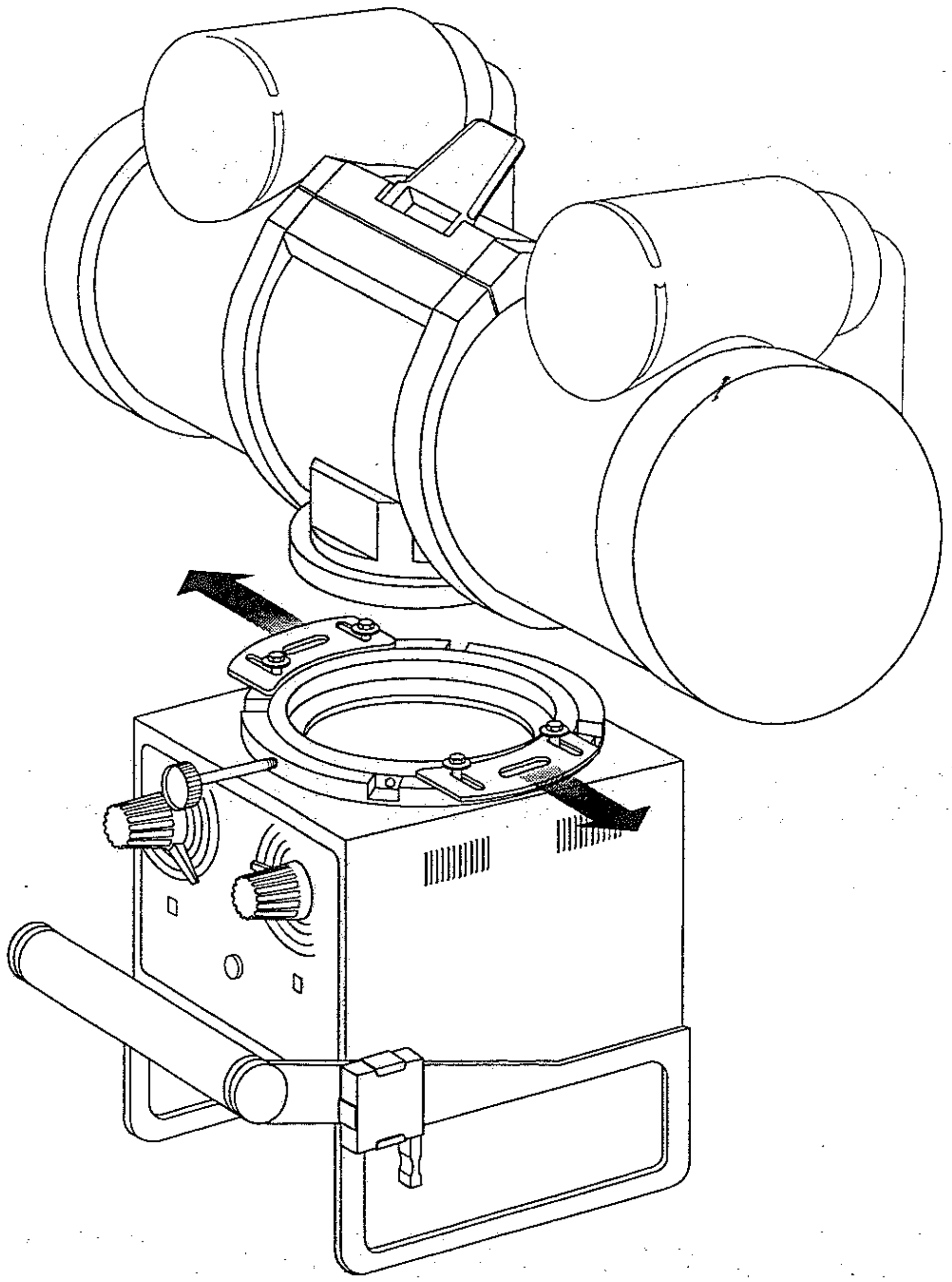

Figure F-18: X-ray Head

6.9 Pivot Arm Brake - See Figure F-19

1. Disconnect DC Power (See Section F 4.2).

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F 6.7).

2. Remove Cables and Cable Harness Clamp hardware located under carriage support, pivot arm and extension arm.

3. Remove x-ray head and hardware attached to Clevis (qty 8 bolts), then remove Pivot Arm Brake Cover and hardware (qty 4 screws).

4. Disconnect Pivot Arm Brake Cover connectors (connectors that are attached to the Pivot Arm Brake Cover).

5. With the Pivot Arm Brake Cover removed use a 3/16" allen key to loosen the set screws in the clamp collar located under the Pivot Arm Brake.

6. Remove Pivot Arm Pivot Shaft Cap with hardware (qty 4 screws), then remove the Pivot Pin. Remove Pivot Arm Pivot Shaft with hardware (qty 4 screws).

7. Remove pivot and extension arm from carriage support, then remove Pivot Arm bearing retainer assembly.

8. Remove Pivot Arm brake cable. Remove Pivot Arm brake and hardware (Brake hardware consists of four 1/4-28 x 5/8" socket head screws with high collar washers).

NOTE:

Before installing the replacement brake, the brake's internal disks need to be aligned by applying power to the brake and temporarily inserting the pivot shaft into the brake. To align the brake disks, loosely mount the replacement brake and apply power to the brake, slowly insert the pivot shaft through the brake hole. Tighten the brake hardware, remove the pivot shaft and disconnect DC power to continue.

9. Install Pivot Arm brake and the Pivot Arm bearing retainer assembly.

10. Position pivot with extension arm in the carriage support, then install Pivot Arm pivot shaft and hardware. Install Pivot Pin, Pivot Arm pivot shaft cap and hardware. Tighten the set screws in the clamp collar.

11. Connect Pivot Arm Brake Cover connectors. Install Pivot Arm Brake Cover and hardware, then mount the x-ray head on Clevis.

12. Install Cable and Cable Harness Clamp hardware under carriage support, pivot arm and extension arm. Connect DC Power.

13. After any x-ray arm parts replacement, check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

14. Verify unit by taking an x-ray exposure, then replace panels and screws.

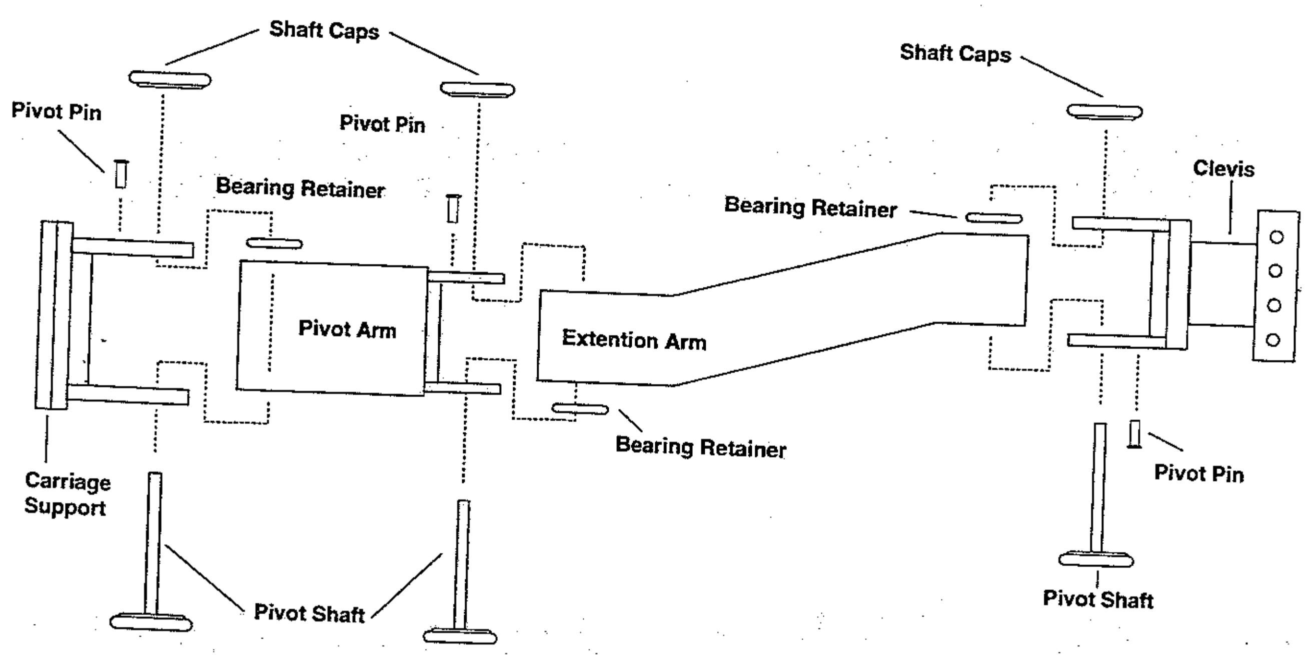

Figure F-19: X-ray Head Arms and Brakes

8. Install the Upper Extension Arm pivot shaft and hardware and the Upper Extension Arm pivot shaft cap and hardware. Connect the Upper Extension Arm Brake Cover connectors. Tighten the clamp collar.

9. Install the Extension Arm Brake Cover and hardware, then mount the x-ray head on Clevis. Install the Carriage support, pivot arm and extension arm.

10. After removing any x-ray arm components, connect DC Power and check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

11. Verify unit by taking an x-ray exposure, then replace all panels and screws.

6.12 Carriage Support Assembly - See Figure F-19

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F 6.7).

1. Disconnect DC Power (See Section F 4.2).

2. Remove the Cables and Cable Harness Clamp hardware under the carriage support, pivot arm and extension arm. Remove the x-ray head and hardware attached to Clevis (qty 8 bolts), the Pivot Arm Pivot Shaft Cap with hardware (qty 4 screws).

3. Remove the Pivot Pin, the Pivot Arm Pivot Shaft with hardware (qty 4 screws), and the pivot and extension arm from Carriage Support.

4. Replace the Carriage Support, then position the pivot with extension arm in the carriage support.

5. Install the Pivot Arm pivot shaft and hardware, the Pivot Pin, Pivot Arm pivot shaft cap and hardware, and the x-ray Head on Clevis.

6. Install the Cable and Cable Harness Clamp hardware under the carriage support, pivot arm and extension arm.

7. After replacing any component on the tube arm, connect DC Power, and check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure

8. Verify the unit by taking an x-ray exposure. Then replace all panels and screws.

6.13 Pivot Arm Assembly - See Figure F-19

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F, 6.7).

1. Disconnect DC Power (See Section F 4.2) . Remove the Cables and Cable Harness Clamp hardware under carriage support, pivot arm and extension arm.

2. Remove the x-ray head and hardware attached to Clevis (qty 8 bolts), then remove the Carriage Arm Brake Cover and hardware (qty 6 screws). Disconnect the Pivot Arm Brake Cover connectors (Connectors that are attached to the Pivot Arm Brake Cover).

3. With the Pivot Arm Brake Cover removed use an allen key to loosen the set screws in the clamp collar located under the Pivot Arm Brake.

4. Remove the Pivot Arm Pivot Shaft Cap with hardware (qty 4 screws), the Pivot Pin, the Pivot Arm Pivot Shaft with hardware (qty 4 screws), the Carriage and Extension Arm from carriage Support, and the Extension Arm Brake Cover and hardware (qty 6 screws).

5. Disconnect the Extension Arm Brake Cover connectors (Connectors that are attached to the Extension Arm Brake Cover).

6. Turn the Extension Arm at a 90° angle to access the clamp collar (located underneath the Brake). Using 3/16" allen key loosen the set screws in the clamp collar.

7. Remove the Lower Extension Arm Pivot Shaft Cap with hardware (qty 4 screws), the Pivot Pin, the Lower Extension Arm Pivot Shaft with hardware (qty 4 screws), and the Pivot Arm from extension arm.

8. Remove the Carriage Arm Brake Cover and hardware (qty 4 screws), the Pivot Arm brake cable, and the Pivot Arm brake and hardware (Brake hardware qty 3 of 1/4-28 x 5/8" socket head screws with high collar washers).

9. Place the brake in the new Pivot Arm.

NOTE:
Before installing the replacement brake, the brake's internal disks need to be aligned by applying power to the brake and temporarily inserting the pivot shaft into the brake. To align the brake disks, loosely mount the replacement brake and apply power to the brake, slowly insert the pivot shaft through the brake hole. Tighten the brake hardware, remove the pivot shaft and disconnect DC power to continue.

10. Install the Pivot Arm brake cable. Replace the brake in the Pivot Arm, then install Pivot Arm bearing retainer assembly.

11. Position the replacement Pivot Arm in the Carriage Support. Install the Pivot Arm pivot shaft

6.10 Lower Extension Arm Brake - See Figure F-19

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F, 6.7).

1. Disconnect DC Power (See Section F 4.2).

2. Remove Cables and Cable Harness Clamp hardware located under carriage support, pivot arm and extension arm. Remove x-ray head and hardware attached to Clevis (qty 8 bolts), then remove Extension Arm Brake Cover and hardware (qty 6 screws).

3. Disconnect Extension Arm Brake Cover connectors (Connectors that are attached to the Extension Arm Brake Cover).

4. Turn the Extension Arm to a 90° angle to access the clamp collar (located underneath the Lower Extension Arm Brake). Using a 3/16" allen key loosen the set screws in the clamp collar.

5. Remove Lower Extension Arm Pivot Shaft Cap with hardware (qty 4 screws), then remove the Pivot Pin.

6. Remove the Lower Extension Arm Pivot Shaft with hardware (qty 4 screws), the Lower Extension Arm from pivot arm, the Lower Extension Arm bearing retainer assembly, and the Pivot Arm brake cable.

7. Remove Lower Extension Arm brake and hardware (Brake hardware qty 3 of 1/4-28 x 1/2" socket head screws with high collar washers).

   NOTE:
   Before installing the replacement brake, the brake's internal disks need to be aligned by applying power to the brake and temporarily inserting the pivot shaft into the brake. To align the brake disks, loosely mount the replacement brake and apply power to the brake, slowly insert the pivot shaft through the brake hole. Tighten the brake hardware, remove the pivot shaft and disconnect DC power to continue.

8. Install the Pivot Arm brake and the Lower Extension Brake bearing retainer assembly. Position the Extension Arm in the Pivot Arm.

9. Install the Lower Extension Arm pivot shaft with hardware and the Lower Extension Arm pivot shaft cap.

10. Connect the Lower Extension Arm Brake Cover connectors. Tighten the clamp collar, then install the Extension Arm Brake Cover and hardware.

11. Install the x-ray head on the Clevis, then install the Cables and Cable Harness Clamp hardware under the carriage support, pivot arm and extension arm.

12. After any x-ray arm parts replacement, connect DC Power and check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

13. Verify unit by taking an x-ray exposure, then replace panels and screws.

6.11 Upper Extension Arm Brake - See Figure F-19

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F 6.7).

1. Disconnect DC Power (See Section F 4.2).
2. Remove the Cables and Cable Harness Clamp hardware located under carriage support, pivot arm and extension arm. Remove the x-ray head and hardware attached to Clevis (qty 8 bolts).
3. Remove Extension Arm Brake Cover and hardware (qty 6 screws). Disconnect Extension Arm Brake Cover connectors (Connectors that are attached to the Extension Arm Brake Cover).
4. Turn the Extension Arm at a 90° angle to access the clamp collar (located underneath the Lower Extension Arm Brake). Using a 3/16" allen key loosen the set screws in the clamp collar.
5. Remove the Upper Extension Arm Pivot Shaft Cap with hardware (qty 4), the Pivot Pin, the Upper Extension Arm Pivot Shaft with hardware (qty 4), the Upper Extension Arm from Clevis, the Upper Extension Arm bearing retainer assembly, and the Upper Extension Arm brake cable.
6. Remove Upper Extension Arm brake and hardware (Brake hardware Qty 3 of 1/4-28 x 1/2" socket head screws with high collar washers)

   NOTE:
   Before installing the replacement brake, the brake's internal disks need to be aligned by applying power to the brake and temporarily inserting the pivot shaft into the brake. To align the brake disks, loosely mount the replacement brake and apply power to the brake, slowly insert the pivot shaft through the brake hole. Tighten the brake hardware, remove the pivot shaft and disconnect DC power to continue.

7. Install the Upper Extension brake wires cable and the Upper Extension Brake bearing retainer assembly. Position the Extension Arm in Clevis.

and hardware, the Pivot Pin, Pivot Arm pivot shaft cap and hardware, then connect the Pivot Arm Brake Cover brake connectors. Tighten the clamp collar.

12. Install the Pivot Arm Brake Cover and hardware, and the Lower Extension bearing retainer assembly. Position the Pivot Arm in Extension Arm.

13. Install the Lower Extension Arm pivot shaft and hardware, the Lower Extension Arm pivot shaft cap and hardware, then connect the Lower Extension Arm Brake Cover brake connectors and tighten the clamp collar.

14. Install the Extension Arm Brake Cover and hardware, the x-ray head on the Clevis, and the Cable and Cable Harness Clamp hardware under the carriage support, pivot arm and extension arm.

15. After replacing any x-ray arm parts, connect DC Power, then check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

16. Verify unit by taking an x-ray exposure, then replace all panels and screws.

6.14 Extension Arm Assembly - See Figure F-19

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F 6.7).

1. Disconnect DC Power (See Section F 4.2), . Remove the Cables and Cable Harness Clamp hardware located under carriage support, pivot arm and extension arm.

2. Remove the x-ray head and hardware attached to Clevis (qty 8 bolts), then remove the Extension Arm Brake Cover and hardware (qty 6 screws). Disconnect the Extension Arm Brake Cover connectors (Connectors that are attached to the Extension Arm Brake Cover).

3. Turn the Extension Arm at a 90° angle to access the clamp collar (located underneath the Arm Brake). Using a 3/16" allen key loosen the set screws in the clamp collar.

4. Remove the Lower Extension Arm Pivot Shaft Cap with hardware (qty 4 screws), the Pivot Pin, the Lower Extension Arm Pivot Shaft with hardware (qty 4 screws), and the Extension Arm from Pivot Arm.

5. Remove the Upper Extension Arm Pivot Shaft Cap with hardware (qty 4 screws), the Pivot Pin, the Upper Extension Arm Pivot Shaft with hardware (qty 4 screws), the Upper Extension Bearing Retainer Assembly with hardware (qty 4 screws), and the Extension Arm from Clevis.

6. Remove the brake switch. Remove the Upper Extension Arm brake wires cable and the Upper Extension Arm brake and hardware (Brake hardware Qty 3 of 1/4-28 x1/2" socket head screws with high collar washers).

NOTE:
Before installing the replacement brake, the brake's internal disks need to be aligned by applying power to the brake and temporarily inserting the pivot shaft into the brake. To align the brake disks, loosely mount the replacement brake and apply power to the brake, slowly insert the pivot shaft through the brake hole. Tighten the brake hardware, remove the pivot shaft and disconnect DC power to continue.

7. Install the Upper Extension brake wire cable, install the brake switch, then replace the Upper and Lower Extension Brake as follows.

8. Remove Lower Extension Arm brake wires from the brake board. Remove the Lower Extension Arm brake and hardware (Brake hardware Qty 3 of 1/4-28 x 1/2" socket head screws with high collar washers). Install Lower Extension brake wire cable.

   NOTE:
   Before installing the replacement brake, the brake's internal disks need to be aligned by applying power to the brake and temporarily inserting the pivot shaft into the brake. To align the brake disks, loosely mount the replacement brake and apply power to the brake, slowly insert the pivot shaft through the brake hole. Tighten the brake hardware, remove the pivot shaft and disconnect DC power to continue.

9. Install the Lower Extension bearing retainer assembly. Position the Extension Arm in the Pivot Arm.

10. Install the Lower Extension Arm pivot shaft and hardware, the Lower Extension Arm pivot pin, the pivot shaft cap and hardware, and the Upper Extension bearing retainer assembly.

11. Position the Upper Extension Arm in the Clevis. Install the Upper Extension Arm pivot shaft and hardware, the Upper Extension Arm pivot pin, and the pivot shaft cap and hardware.

12. Connect the Lower Extension Arm Brake Cover connectors, then install the Extension Arm Brake Cover and hardware.

13. Connect the Upper Extension Arm Brake Cover connectors. Install the Extension Arm Brake Cover and hardware, the x-ray head on the Clevis, and the Cable and Cable Harness Clamp hardware under the carriage support, pivot arm and extension arm.

14. Connect DC Power and check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

15. Verify unit by taking an x-ray exposure, then replace panels and screws.

6.15 Clevis -See Figure F-19

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F 6.7).

1. Disconnect DC Power (see Section F 4.2). Remove the Cables and Cable Harness Clamp hardware under the carriage support, pivot arm and extension arm.

2. Remove the x-ray head and hardware attached to Clevis (qty 8 bolts), the Upper Extension Pivot Shaft and hardware (4 screws), the Pivot Pin and the covers. Loosen the clamp collar. Remove the Upper Extension Pivot Shaft Cap and hardware (4 screws), and the Clevis from Extension Arm.

3. Replace the Clevis, then position the Extension Arm on replacement Clevis.

4. Install the Upper Extension Pivot Shaft and hardware (4 screws), the Pivot Pin, the Upper Extension Pivot Shaft Cap and hardware (4 screws). Retighten the clamp collar, then install the x-ray head and hardware on Clevis, and the Cable and Cable Harness Clamp hardware under the carriage support, pivot arm and extension arm.

5. Connect DC Power and check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

6. Verify unit by taking an x-ray exposure, then replace panels and screws.

6.16 Microswitches, Mast

! CAUTION !
Before disconnecting DC power, perform the X-ray Arm Locking Procedure (Section F, 6.7).

1. Disconnect DC Power (See Section F 4.2), then remove the mast cover.

2. Replace the mast microswitches, connect DC Power, and check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

3. Verify unit by taking an x-ray exposure, then replace panels and screws.

6.17 High Voltage Cables-See Figure F-20

1. Disconnect DC Power (see Section F 4.2), then remove the Upper Right Cover (see Section F 4.3). Disconnect the High Voltage cables from the Tank Assembly (base of unit).

2. Remove the cable clamp hardware, then disconnect the High Voltage Cables from the x-ray tube.

3. Apply a liberal coating of High Voltage Grease to the electrical connections as shown, before inserting connectors in their mating sockets (Dow Corning H69 compound GA033233).

4. Connect the replacement cables and dress cable harness as shown. Connect DC Power and check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

5. Verify unit by taking an X-ray exposure, then replace all panels and screws.

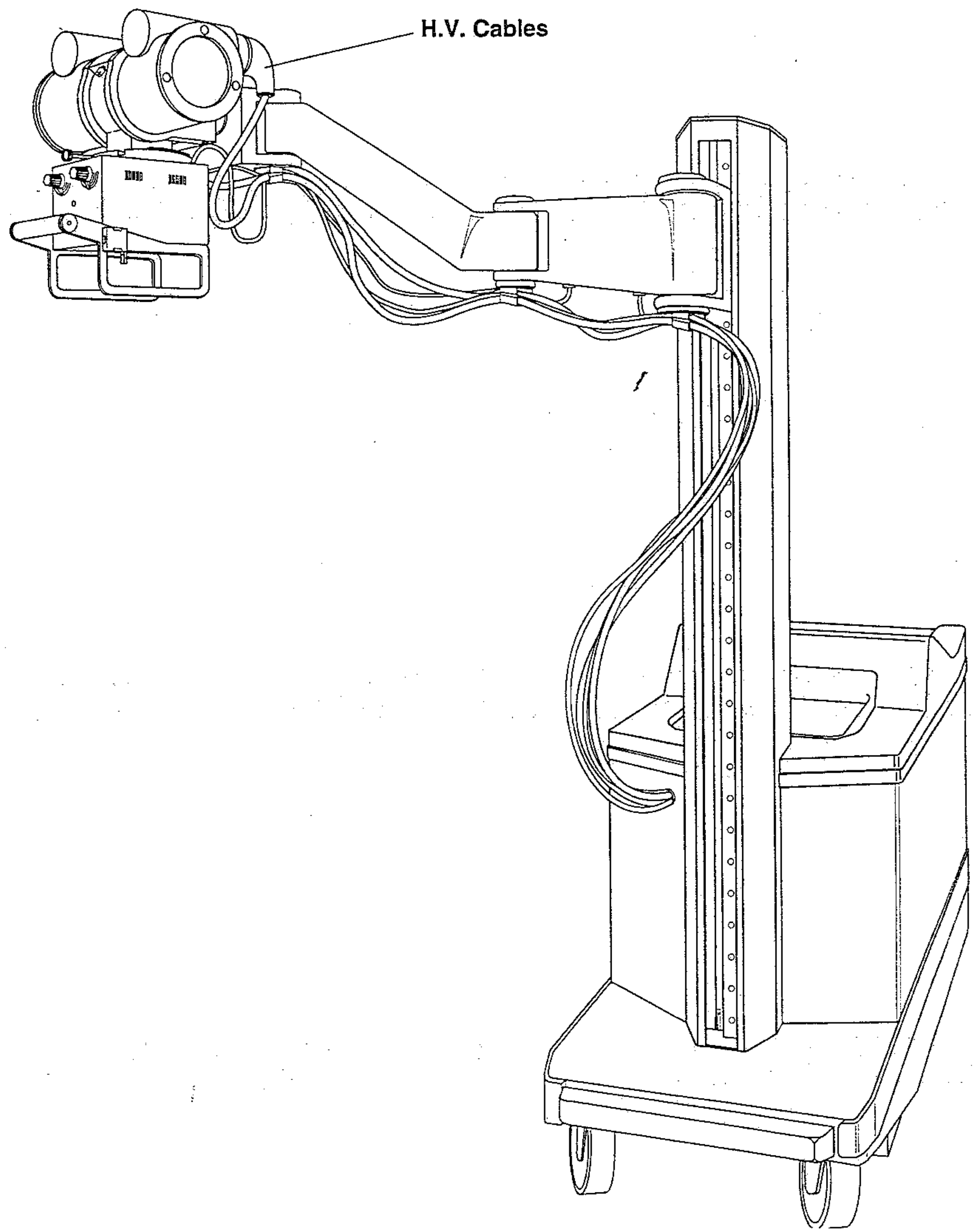

Figure F-20: Cables

6.18 Collimator Signal Cable -See Figure F-20

NOTE:
Place x-ray head about 8 inches above the parked position onto a temporary support.

1. Disconnect DC Power (see Section F 4.2), then remove the Upper Right Cover (see Section F 4.3).
2. Disconnect the Collimator cable from the base of unit, remove the cable clamp hardware, then remove the 4 rounded philips head screws on the top of the collimator. The collimator may have to be rotated in order to gain access to the screws.
3. Carefully lower the collimator by removing the temporary support. Disconnect the x-ray head Brake cable, the Collimator wires from wiring block, and the Collimator grounding wire.
4. Remove the collimator cable grommet and install the replacement cable.
5. Reconnect the replacement cables and dress the cable harness as shown. Connect DC Power and check all arm functions: braking, arm motion, field size lamp.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

6. Verify unit by taking an x-ray exposure, then replace panels and screws.

6.19 Transport Arm Lock Removal - See Figure F-21

1. Remove and replace hardware to the x-ray arm Transport Lock.
2. Verify that the lock holds the transport arm securely.

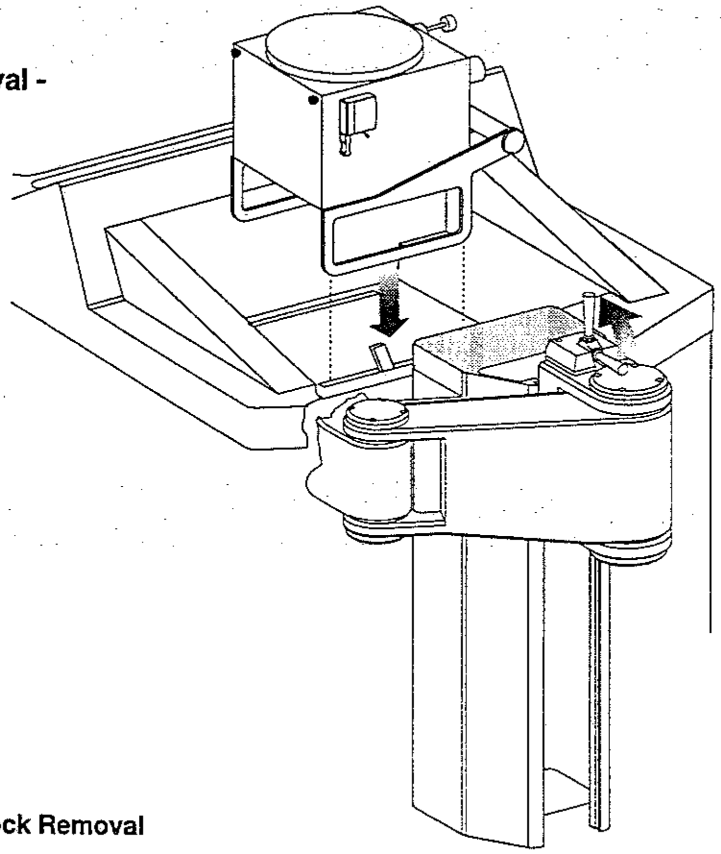

Figure F-21: Arm Transport Lock Removal

6.20 Mast Brake Removal - See Figure F-22

1. Lock the x-ray arm in place (see Section F 6.7, steps 1 – 4).
2. Remove the mast back cover (slide the cover up to remove). Some effort may be required to loosen the cover from the slide.
3. Loosen the cable tension, using the tension adjusters at the top of the mast. (See Section F 7.2.6 and 7.2.7, and Figure F-26.)
4. Unsolder the white brake wires from the diode brake board. See Detail illustration below.
5. Remove the pulley assembly, at the top of the mast, by removing the 3 bolts securing it to the frame.
6. Replace the brake assembly by removing the 2 screws holding the brake to the pulley assembly, mount the new brake, and replace the screws (apply locktite on the screws). See Figure F-22.
7. Mount the pulley assembly and secure it in place (with the 3 bolts removed in step 5).
8. Solder the brake wires to the Diode terminal strip.

    NOTE:
    A wire runs inside a channel in the mast on the left hand side. Ensure that it is in place before proceeding any further. The counterweight can damage this wire.

9. Tighten the cable tension adjustment to secure the cables (see Section F 7.2.6 and 7.2.7). Further calibration is required later in this procedure.
10. Remove the two 1-1/2 inch bolts from the upper frame (these were installed in step 1 to lock the x-ray arm in place). Replace the original bolts that were removed in step 1.
11. Verify the correct cable tension performed in step 9.
12. Verify correct Arm movement and brake function.
13. Reinstall all covers.

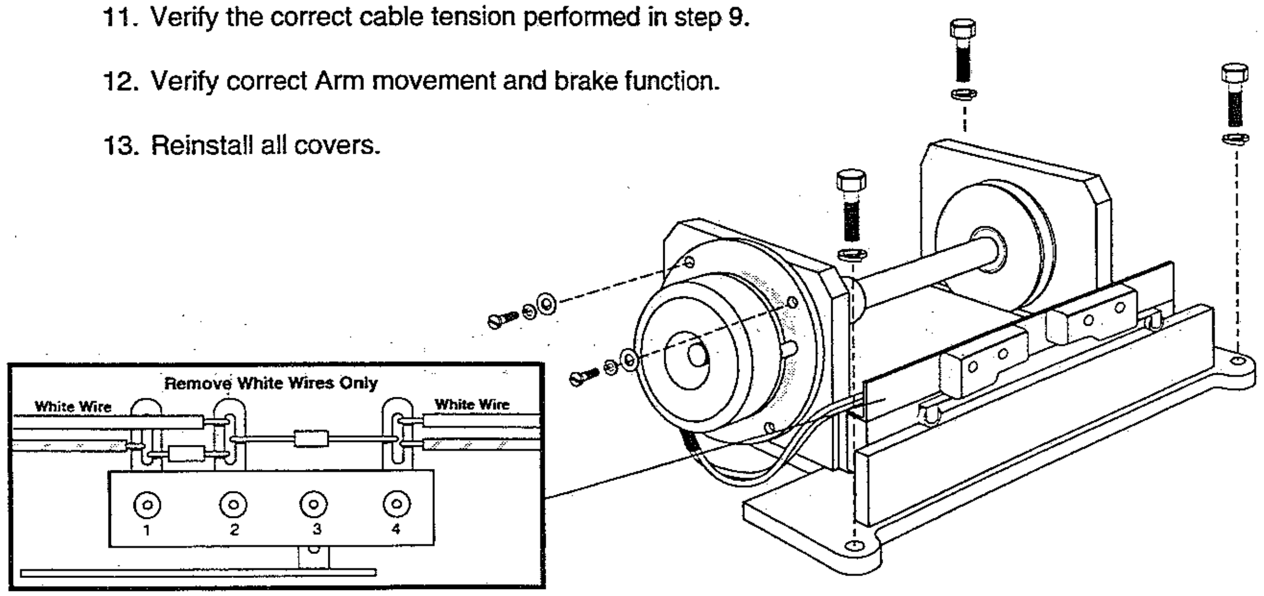

Figure F-22: Mast Brake Removal

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7. CALIBRATION AND ADJUSTMENTS

7.1 Electrical

7.1.1 Battery Charger Trip Point

Trip Point is verified at VR1 on the Battery Charger module.

1. Connect the power cord to a 120 VAC power source and charge the batteries fully, until the CHARGING LED begins to cycle on and off.
2. Turn the unit OFF and connect the DVM + to Fuse F3 on the Power Chassis ,and the DVM - to chassis ground.
3. Repower the unit and verify that voltage goes to 147 volts in 20 seconds, and switches to 137 volts within several minutes. If the switch does not occur, replace the charger and repeat the verification procedure.

7.1.2 Drive Board Coarse Adjustment - Left Side/Right Side

1. Set the brake handles on each motor to the center location engaging the brakes. The machine can not be pushed after setting the brakes.

   Note:
   Ensure that nothing is touching the drive handle.

2. Handle, Left Side Adjustment:
   Connect DVM to TP3 (+) and TP10 (GND, -).and adjust R35 for 0.00V ±0.05v
3. Handle, Right Side Adjustment:
   Connect DVM to TP4 (+) and TP10 (GND, -) and adjust R47 for 0.00V ±0.05v

7.1.3 Auto Null PWM Adjustment (Automatic Fine Handle Adjustment)

1. Turn off power and turn switch Sw1.7 on the microprocessor board to "ON" position.
2. Turn on power again and observe "Auto-null Command On" on the display and then a % reading for L and R. These should be 62% ± 5%.
3. Turn power "OFF", turn off Sw1.7.

   Note:
   Display may appear erratic.

4. Turn power "ON". After system boots up, push pink drive handle without engaging motor (drive handle switch), ensure message "clear drive handle" appears on LCD after 2 seconds. Message disappears once handle is released.

7.1.4 Drive Speed Calibration - High Speed (approx. 3 mph)

1. Move the x-ray tube head to its parked position (cradled).
2. Push the Drive Handle firmly to achieve maximum speed. Adjust R125 on the DC Motor Drive Board until the unit can be driven 44 feet in approximately 10 seconds.

7.1.5 Drive Speed Calibration - Low Speed (approx. 0.5 mph)

1. Lift the x-ray tube head from its parked position.
2. Push the Drive Handle firmly to achieve maximum speed. Adjust R121 on the DC Motor Drive Board until the unit can be driven 7 feet 4 inches in approximately 10 seconds.

7.1.6 Drive Fault Verification

1. Rotate the keyswitch to the "OFF" position.
2. Connect a jumper lead from the left side of R6 to the J4 side of R8 or R10 on the Motor Relay Board.
3. Rotate the keyswitch to the "ON" position.
4. Following system ON, verify the display reads: "DRIVE FAULT".
5. Rotate the keyswitch to the "OFF".
6. Connect a jumper from the left side of R7 to the J1 side of R9 or R11 on the Motor Relay Board.

   Note:
   R7 is located behind K1. Pins 9&6 on the K2 relay spot(see jumper wire on pcb) can be used if R7 can not be reached.

7. Repeat steps 3 through 5.

7.1.7 Filament Current Calibration:

Note:
DIP switch SW1.1 must still be "ON".

1. Rotate the key switch to the "OFF" position.
2. Connect a DVM to the filament board, TP13 (+) and TP3 (GND, -).
3. Rotate the key switch to the "ON" position.
4. Verify that the DVM reads 4.5 ±0.1Vdc. (No adjustment possible)
5. Connect a DVM(+) to the filament board "U2" point 14.
6. Adjust R39 for 0.390 ±0.05 VDC. 0.091

7. Rotate the key switch to the "OFF" position.

8. Turn SW1.1, and SW1.2, on the microprocessor board, to the "ON" position.

9. Rotate the key switch to the "ON" position and observe the display. As the auto filament calibration processes, the counter will count from 0 to 20 (approximately 3 -5 minutes). When complete, the display should read, " FIL AUTO CAL PASSED".

10. Rotate the key switch to the "OFF" position and turn DIP SW 1.1 SW 1. 2 "OFF", on the microprocessor board.

7.1.8 Auto Calibrate:

The filament current adjust is self-calibrating by performing the following.

Note:
For steps 5.6 and 5.8, please use the mAs meter. Connect the meter at the Low Voltage Feedback board (J3, phone jack).

1. Turn keyswitch "ON".

2. For the following exposure settings (see table below), take 5 exposures at each setting. Continue taking exposures until the time on the mAs meter display and the time on the LCD display (msec) are within the listed time range for that exposure setting. If a tube over current fault should occur, turn the keyswitch "OFF" and switch microprocessor board SW1. 8 to the "ON" position before continuing.

3. Following calibration, switch SW1. 8 back to the "OFF" position.

Note:
When taking calibration exposures, depress the hand switch through the first position and hold for 3-5 seconds before continuing through to second position.

kV	mAs	Time Range	# of exposures
40	2.0	12.0-17.0ms	
80	2.0	14.0-16.0ms	

7.1.9 kV Calibration on the HV Control Board:

Note:
For steps 5.7 and 5.8, use of the Non-invasive kV Meter is required.

1. Take three exposures, then collect data. Record results on following chart.

kV	mAs	kV Measured	Minimum kV	Maximum kV
80	20		79.2	80.8
40	20		38.4	41.6
120	20		115.2	124.8

2. If necessary, adjust kV delay on kV meter for 20msec at each condition. Take an 80kV, 20mAs exposure. Observe the read-out on the noninvasive kV Meter, adjust R34 (VF TOT) until kV reads 80kV ± 1%. Take exposures at 40kV, 20mAs and 120kV, 20mAs, check that the kV is within 4% of the setting. If necessary, adjust R34 until best accuracy at all three points is obtained.

7.1.10 mAs Calibration:

1. Take an 80kV l00mAs exposure. The mAs meter reading (J3 phone jack) should be l00mAs ± 1%. If necessary, adjust R76 on HV Control Board (adjust counter clockwise for increase). Repeat test until reading is within 1%.

2. Repeat for 80kV 50mAs and 80kV 200mAs. The mAs readings must be within 4%. While performing calibrations, observe kV on mAs meter.

3. Continue with auto calibration using the following table as a guide. Conduct 5 exposures for each of the kV, mAs conditions noted within the table.

Note:
If calibration problems occur at any setting rotate the key switch to “OFF” and turn DIP switch SW1.8 “ON”, on the microprocessor board. Rotate the key switch to ON and repeat the 5 exposures, or more if necessary, until the Kv, mAs and time readings on the kV meter and mAs meter are within limits for that setting with reproducible results. Rotate the key switch to “OFF” and turn DIP switch SW1.8 “OFF”, on the microprocessor board. Rotate the key switch to “ON” and repeat the 5 exposures, record the data and continue.

kV	mAs	Time Range (ms)
40	0.6	2 - 6
42	2	10 - 19
50	0.1	1 - 7
50	0.2	1 - 7
50	0.3	1 - 7
64	0.4	1 - 7
64	0.6	2 - 6
68	10	50 - 78
76	2	13 - 17
95	10	70 - 88
105	10	79 - 96
110	200	1830 - 2230
125	175	1880 - 2280

Note:
Anytime E-PROM is changed, auto calibration must be repeated

7.1.11 Display Board Contrast Adjustment

This adjustment is required after display board, control panel, or LCD Display is replaced.

1. Adjust potentiometer R30 for maximum contrast under prevalent light conditions.

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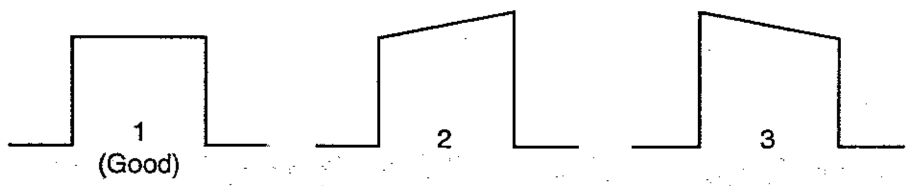
7.1.12 Divider Balance Calibration

! WARNING !
Observe all safety precautions while making an x-ray exposure.

1. Disconnect DC power. Disconnect P2 from the Low Voltage Feedback Board.
2. Set the resistance between TP2 and TP4 to 200K by adjusting R6. Set the resistance between TP3 and TP4 to 200K by adjusting R7.
3. Reconnect P2.
4. Connect Dynalyzer to the H.V. tank. Connect a storage scope to the Dynalyzer to measure kV total across the anode and cathode. (1 V/Div, .2 sec/Div). Reconnect DC power.
5. Take an 80 kV, 150 mAs exposure.
6. Compare the stored wave form with the following wave forms.



7. Disconnect DC Power (see Section F 4.2). Disconnect P2 and adjust R6 and R7 as follows:
   - Wave form 1 - good, requires no adjustment.
   - Wave form 2 - adjust R6 and R7 clockwise
   - Wave form 3 - adjust R6 and R7 counterclockwise
8. Ensure that the resistance value between TP2 and TP4 equals the value between TP3 and TP4.
9. Reconnect P2 and DC Power.
10. Repeat steps 5 through 8 until a flat (good) wave form is achieved.

7.1.13 Arc Interlock Adjustment

All adjustments, indicators, and test points are on the High Voltage Control Board, unless otherwise noted.

1. Attach the oscilloscope probe to TP16, ground to TP13.

NOTE
See Figure F-23 for scope settings.

! WARNING !
Observe all safety precautions while making an x-ray exposure.

2. Take an exposure at 125 kV, 10.0 mAs and record the highest peak (see Figure F-23).
3. Connect a DVM and measure voltage between U10 pin 3 and Ground. Adjust R111 for 2.5 volts greater than the highest peak voltage, but not less than 6V.
4. Remove the DVM and take another 125 kV, 10.0 mAs exposure. The unit should not create a fault condition.

NOTE
U10 pin 3 voltage should not be less than 6 V.

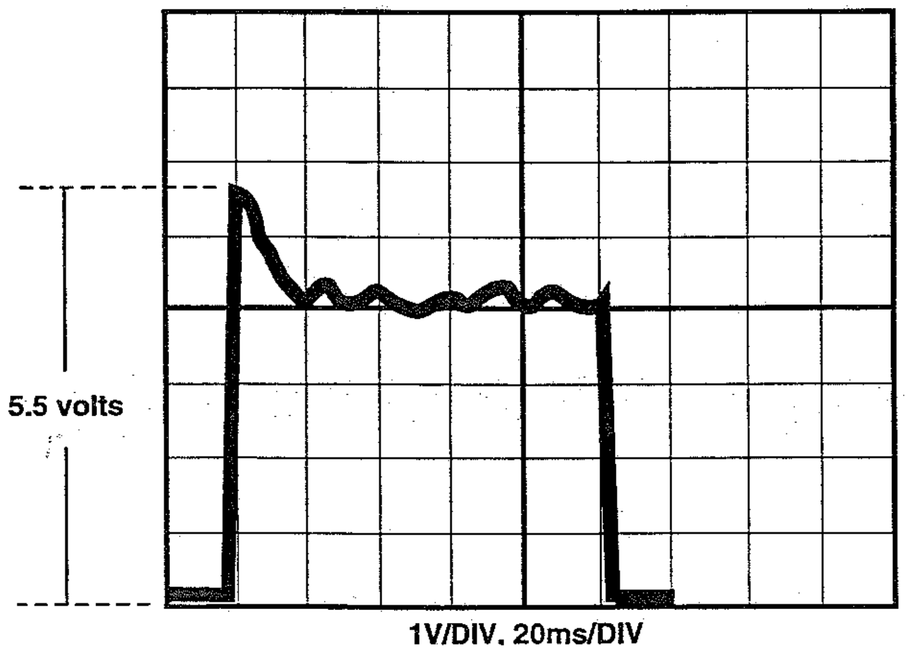


Figure F-23: Typical Waveform

7.1.14 kV Over Voltage Adjustment

All adjustments, indicators, and test points are on the High Voltage Control Board, unless otherwise noted.

kV+ Over Voltage Adjustment

1. Connect a storage scope to TP29 & TP32 (GND) on the High Voltage Control Board. Set the unit for an exposure using these techniques: 125kV, 100mAs.

2. Take 5 exposures using this technique and record the peak voltage of each. Check each waveform for irregularities. If there are no irregularities, note the highest peak voltage (of the 5 exposures).

3. Connect a DVM to TP40 & TP32 (GND). Adjust R44 until the voltage reading equals 108% of the peak volta i (highest) noted in step #2.

kV- Over Voltage Adjustment

1. Connect a storage scope to TP7 & TP32 (GND) on the High Voltage Control Board. Set the unit for an exposure using these techniques: 125kV, 100mAs.

2. Take 5 exposures using this technique and record the peak voltage of each. Check each waveform for irregularities. If there are no irregularities, note the highest peak voltage (of the 5 exposures).

3. Connect a DVM to TP41 & TP32 (GND). Adjust R46 until the voltage reading equals 108% of the peak voltage (highest) noted in step #2.

7.1.15 Rotor Voltage Calibration

Note:
Perform this test with a fully charged battery.

1. Remove the upper left and right covers (see Sections F 4.2 and 4.3).

2. Connect a true RMS reading DVM (e.g., Fluke Model 87 or equivalent) to fuse F3 and chassis ground, and turn the keyswitch ON. When the battery voltage equals 127 – 129 volts, connect the DVM to Rotor Transformer pins 1 and 5. This voltage should be 245 ± 0.5 Vac. If it is not, then adjust R61 on the Rotor Board.

3. This voltage directly controls the collimator lamp voltage. If it exceeds 245.5 V, the collimator lamp voltage will be too high.

7.1.16 Filament Current Check

Note:
The filament current is factory set and should not require adjustment. This check is made to verify operation.

1. Remove the upper left cover (see Section F 4.2).

2. Turn the keyswitch ON. Using a true RMS reading DVM (e.g., Fluke Model 87 or equivalent), connect the negative (–) lead to TP3 (ground) on the Filament Board. Connect the positive (+) lead to TP13 (Microprocessor Board). It should read 4.5 volts.

3. Place the positive (+) lead on U2-14; the DVM should now read 0.396 Vdc ±0.002 Vdc.

7.2 Mechanical

7.2.1 Bumper Microswitch Adjustment

Replacement of the front bumper or front bumper microswitches requires checking actuation adjustment. After replacing the bumper:

1. Adjust the microswitch so that the bumper actuates the microswitch when the bumper is pushed in about 1/4" to 1/2".

7.2.2 Drive Belt Alignment and Tension Adjustment - See Figure F-24

Equipment Needed:

Torque wrench, Loctite 242 (blue)

The motor drive belt alignment and tension should be verified after replacement of either the drive motor, gear belt, or drive wheel.

1. Disconnect DC power (see Section F 4.2).
2. Manually lock the motor brakes.
3. Loosen the four motor mounting bolts (underneath the chassis).
4. Adjust the motor adjustment screws so that the motor is square to the motor support, and perpendicular to the wheels.
5. Turn the wheel while observing the belt's tracking. The inner edge of the belt should track no less than 2mm from the edge of the gear.

   If the belt is tracking off the edge of the wheel gear, loosen the set screws on the motor's shaft-mounted pulley, and pull it away from the motor.
6. Recheck the belt tracking. If the belt tracks correctly, apply Loctite 242 (blue) on the treads of the motor pulley set screws and tighten them.
7. Adjust the tension of the drive motor belts by adjusting the motor adjustment screws until belt deflection is minimal (equal to or less than 1/4-inch with 20 lbs of force).

   Note:
   When tightening the belt, the opposite end of the motor has a tendency to shift upward. Ensure that the motor is kept square to the motor support, along the entire length of the motor.
8. Tighten the four motor mounting bolts using a torque wrench set between 45 to 48 inch pounds. Tighten the jam nut against the motor adjustment block welded to the motor support.
9. Adjust the opposite motor and tighten the mounting bolts as described in step 8.

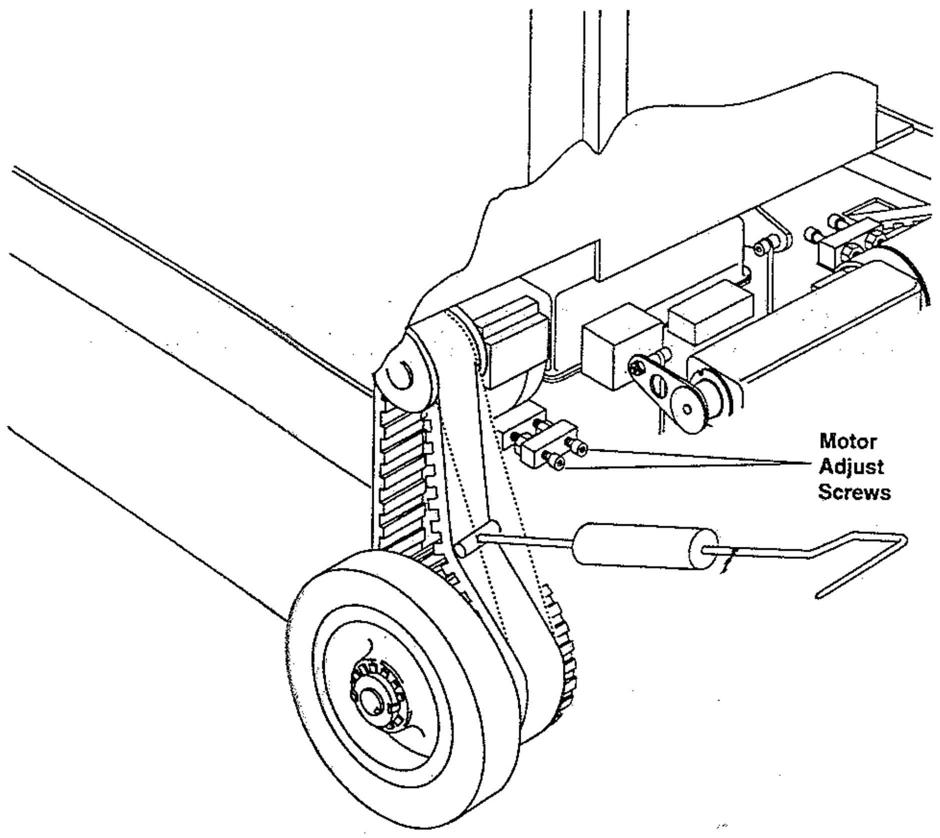


Figure F-24: Drive Belt Tension Adjustment

7.2.3 X-ray Field/Light Field Adjustment

Equipment Needed:
Collimator Test Tool (not supplied)

This procedure verifies compliance of the visually defined x-ray field to the Food and Drug Administration's performance standards.

1. Place the Collimator test tool upon a loaded film cassette. Orient the dot in the lower left corner of the Collimator tool to the left forward corner of the cassette. Center both in the light field.
2. Using the tape measure mounted on the side of the Collimator, position the tube head to an SID of 100 cm (40 inches) from the cassette surface.
3. Adjust the Collimator shutters until the edge of the light field coincide with the rectangular outline on the Collimator tool.
4. Set the technique factors to 60 kV at 3 mAs and take an x-ray exposure.
5. Measure and record the distance from the edge of the x-ray field to the rectangle created by the Collimator test tool. Calculate the percentage of misalignment by dividing the measured distance by the SID. The percentage of misalignment must not exceed 1.76%.

7.2.4 Field Size Adjustment - See Figure F-25

1. Press the collimator light button and verify that the centering cross mark is in the center of the light field.
2. If the centering cross mark is not centered, adjust the lamp filament position.
3. Measure length A and B in Figure F-25. If A length is greater than B, loosen the locking screws (X and Y) and rotate the Vertical (Up-Down) adjustment screw counter-clockwise. If length B is greater than A, rotate the adjustment screw clockwise.
4. Measure length C and D in Figure F-25. If length C is greater than D, turn the horizontal (Right-Left) adjustment screw counterclockwise. If length D is greater than C, turn the adjustment screw clockwise.
5. After adjusting A, B, C, and D to equal lengths, lock the lamp position with the locking screws X and Y.

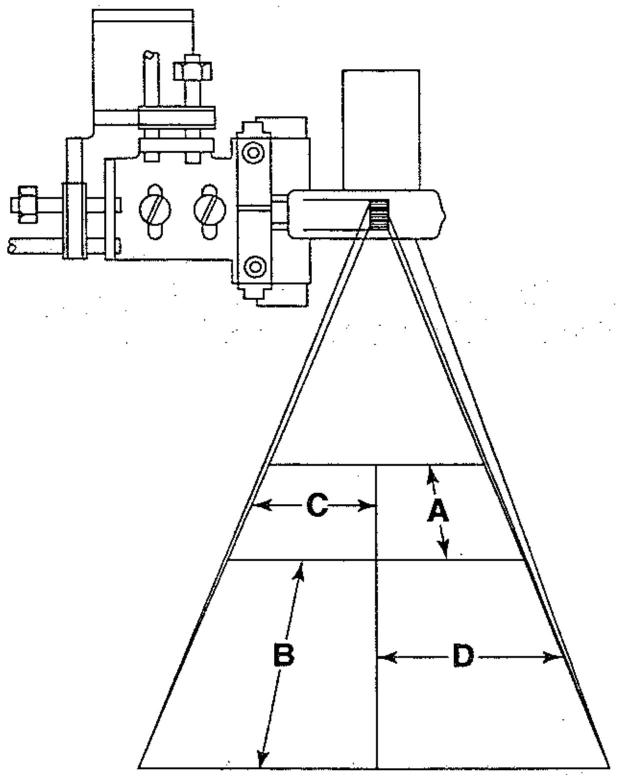


Figure F-25: Field Size Adjustment

7.2.5 Collimator Mirror Alignment

Perform this procedure after installing a replacement mirror

1. Temporarily install the front acrylic plate with a thin piece of paper over the acrylic surface.

2. Illuminate the collimator lamp. Lock the acrylic plate at the point where the centering cross mark is aligned with the center of the light.

7.2.6 Counterweight Cable Tension Check - See Figure F-26

1. Remove the top cover from the mast structure. Apply power and lift the Tube Arm completely.

2. Connect the spring-gauge to the counterweight cable at approximately mid-mast. Pull the spring-gauge toward the front to pull the counterweight cable outward. Stop pulling when the cable is extended to the inner lip of the mast cover.

3. The force necessary to pull the cable this distance must be between 9 lbs. and 11 lbs. If the cable tension is within limits, remove the spring-gauge and replace the mast top cover.

4. If the cable tension is not within limits, continue with the Counterweight Cable Tension Adjust.

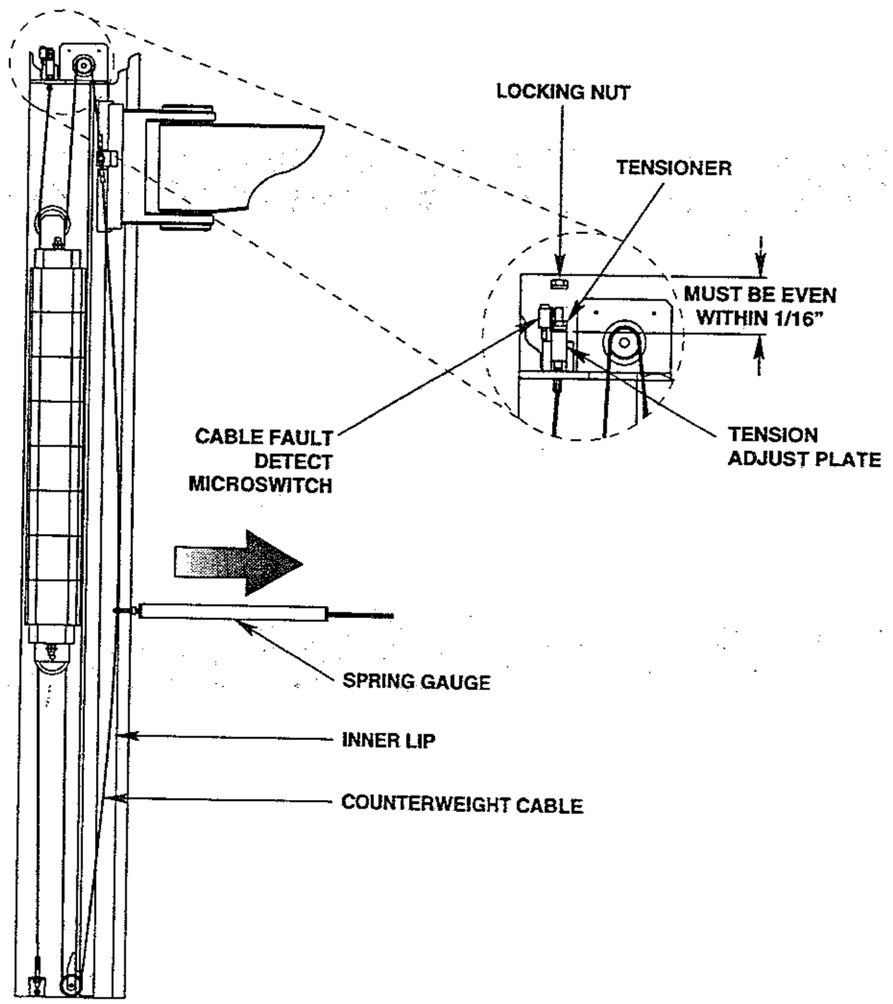


Figure F-26: Counterweight Cable Tension Check & Adjust

7.2.7 Counterweight Cable Tension Adjust - Figure F-26

The Cable Fault Microswitch assembly and the counterweight cable adjustment screws are accessed from the top of the mast structure.

1. Remove the Cable Fault Detect Microswitch assembly from the tension adjust plate in the mast. Remove the lock nuts on both cable tensioners.

2. Turn both tensioners clockwise to tighten, counterclockwise to loosen. Adjust both evenly. Ensure that the distance from the top of the mast to the top of the tension adjust plate is even with 1/16 inch.

3. Perform the above counterweight cable tension check to verify adjustment. Repeat adjustment and check as necessary until tension is within limits (9 lbs. to 11 lbs.).

4. Reinstall the lock nut on the tensioners and tighten. Reinstall the Cable Fault Detect Microswitch assembly. Replace the top mast cover.

7.2.8 Trunnion Lock Tension Adjustment - See Figure F-27

Perform this adjustment after replacement of the Trunnion Lock Handle, Trunnion or Trunnion Sleeve Bearings.

1. With the trunnion handle unlocked, verify that x-ray head can rotate freely and detents at 90 degrees.

2. With the trunnion handle locked, verify that x-ray head is held firmly in place and cannot be rotated.

3. Loosen or tighten locking screw for proper tension adjustment.

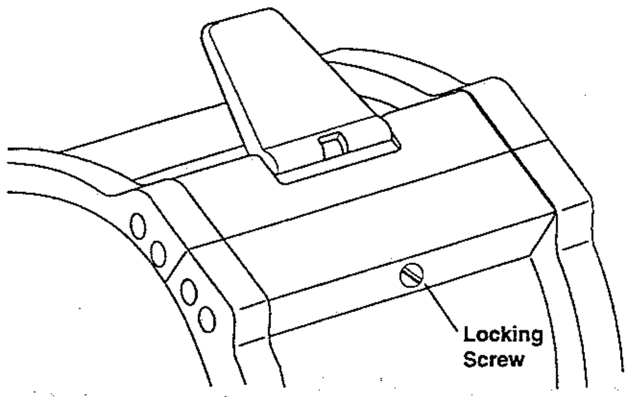


Figure F-27: Trunnion Lock Tension Adjust

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7.2.9 Clevis Detent Adjustment

1. Verify that the Clevis assembly properly detents and holds the x-ray head in position. If adjustment is required proceed to step 2.

2. Move the tube head to expose the Clevis detent/tension bolt. Pry back the bolt retention pin.

3. Tighten the bolt to the proper tension, verify that the x-ray head holds in detent position.

4. Pry bolt retention pin over any one of the bolt notches to keep the bolt from rotating.

7.2.10 Low Voltage Power Supply Adjustment

If the Low Voltage Power Supply requires adjustment, perform the following:

1. Turn the System Keyswitch ON.

2. On the Microprocessor Board, connect the positive lead of a DVM to TP11, and the negative lead to TP8.

3. Adjust R19 for a reading of +5.00 Vdc (± 0.05V).

NOTE:
If a low voltage reading is observed, check the +5 Vdc power supply fuse rating. A wrong fuse rating can act as a load to produce a lower voltage.

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THEORY OF OPERATION (continued)

Section G Explanations use letter designations A through GG to identify the following major assemblies:

A. .... High Voltage Tank
B. .... Rotor PC Board
C. .... High Voltage Control PC Board
D. .... High Voltage Driver PC Board
E. .... Right Side Panel
F. .... Filament PC Board
G. .... Fuse PC Board
H. .... Drive Motor Control PC Board
J. .... Microprocessor PC Board
K. .... Low Voltage Power Supply
M. .... Motor Interface PC Board
P. .... Power Control Chassis
S. .... Fan Interface PC Board
T. .... Arm Nest Switch
U. .... Control Panel
X. .... Main Buss Bar
W. .... Drive Control Handle
Z. .... Circuit Breaker
AA. .... Arm Interface PC Board
CC. .... Line Filter
DD. .... Line Cord Reel
EE. .... HV Inverter/Preregulator Card Cage
GG. .... Ground Lug

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1. POWER DISTRIBUTION

1.1 Overview (refer to Drawing GZ-1)

Operating power is supplied by a bank of ten rechargeable 12 volt batteries in series. Battery power is switched through a DC contactor (K1) on the electrical chassis (P) to power the x-ray generator and drive system, and converted to appropriate levels to power filament, rotor control circuits, logic systems and auxiliary systems such as the collimator, the arm positioning locks, etc. For the purposes of these circuit explanations, switched battery power refers to power that passes through the contactor while unswitched battery power refers to battery output tapped prior to the contactor.

The unit is connected to AC Mains to recharge the batteries. When such connection is made, it is sensed by the Microprocessor control circuits, which inhibit the power-up sequence, preventing x-ray or drive operation while the batteries are being charged.

Primary fusing of switched battery power to the High Voltage (HV) generator (high current) is provided by fuses F4, F5 and F6 on the electrical chassis. Unswitched battery power, which the system uses to detect and respond to power-up requests, is fused by F3 on the electrical chassis. F1 and F2 on the electrical chassis provide fusing for battery power to low voltage conversion circuits, and the battery charger output, respectively.

Distribution of battery power, and the conversion of battery power to appropriate levels to power logic circuits and peripheral devices throughout the unit, are performed in the following system components:

A. Electrical Chassis (P)

B. Fuse Board (G)

C. Rotor Inverter Board (B)

D. Low Voltage Power Supply (K)

1.1.1 Electrical Chassis (refer to Drawing GZ-1)

The Electrical Chassis (P) located at the bottom of the control console contains components related to the distribution and generation of power used throughout the unit. Primary fuses, low power fuses, an isolation transformer, a Rotor Inverter transformer, the Fuse Board, and various connection boards and terminal blocks are housed on the electrical chassis.

1.1.2 Fuse Board (refer to Drawing GZ-1)

The Fuse Board (G) provides these functions:

Visual indication of primary fuse failure.

Fusing and visual indication of fuse failure of switched battery voltage supplied to the Rotor Inverter Board, Filament Supply Board, and Motor Drive system.

Control of DC contactor in power-up and power-down sequences.

Switching of Mains power to supply Microprocessor Board when line cord is connected.

Interfacing of Battery Sense, Mains Connection and microprocessor-generated shut down signal with Microprocessor Board.

Transmission of primary fuse failure signal to HV Generator to halt high voltage production.

1.1.3 Rotor Inverter Board (refer to Drawing GZ-1)

The Rotor Inverter Board, located on the right side panel, provides the following functions.

- Conversion of switched battery power to AC and DC levels used elsewhere in the unit.
- Generation and switching of rotor drive and braking power signals to the x-ray tube rotor (this function is discussed in paragraph 3. of this section).

The Rotor Inverter Board contains Gate Drive and H-Bridge inverter circuits, which convert the switched battery input, which is DC, to an AC drive signal applied to the primary of the Rotor Inverter Transformer (T1) on the Electrical Chassis. Secondary windings of T1 are fed back to the Rotor Inverter Board and rectified to provide +40 Vdc and -40 Vdc used by the Filament Board and Motor Drive Board, and +24 and +12.5 Vdc used by the Arm Brakes. A T1 secondary is also passed through the Rotor Inverter Board to supply the Collimator device with a nominal 24 Vac at 150 watts to power the collimator lamp.

1.1.4 Low Voltage Power Supply (refer to Drawing GZ-1)

The Low Voltage Power Supply (K) provides the Microprocessor Board and Display Board with +15 Vdc, -15 Vdc and +5 Vdc operating voltages. During normal operation of the unit, the Low Voltage Power Supply is supplied with unswitched battery power after the power-up sequence has been completed. When the unit is connected to the AC Mains for battery charging, the Low Voltage Power Supply is supplied with Mains AC.

If the Low Voltage Power Supply requires adjustment, perform the following:

1. Turn the System Keyswitch ON.
2. On the Microprocessor Board, connect the positive lead of a DVM to TP11, and the negative lead to TP8.
3. Adjust R19 for a reading of +5.00 Vdc (± 0.05V).

NOTE:
If a low voltage reading is observed, check the +5 Vdc power supply fuse rating. A wrong fuse rating can act as a load to produce a lower voltage.

1.2 Power-Up/Power-Down Sequences (refer to Figure G-1)

The unit is powered on and off by the operator using a two-position keyswitch on the control panel. Provision is also made for automatic power-down if a period of inactivity has elapsed. The keyswitch connects to circuitry on the Fuse Board (G) which operates the DC contactor. This power control circuitry is supplied with unswitched battery power, fused by F3 on the Electrical Chassis.

One side of the coil of the DC contactor (K1 on the Electrical Chassis) is connected to unswitched battery power, also fused by F3. To operate the contactor, the other side of the coil is grounded through latching relay K2 on the Fuse Board. This relay contains two actuating coils. A pulse across the SET coil turns the relay ON; a pulse across the RESET coil turns it OFF. When the keyswitch is turned from OFF to ON, capacitor-stored energy is discharged through the K2 SET coil, actuating the relay and connecting the coil of the DC contactor to the source of FET Q3. Turning the keyswitch to ON has also lifted a ground from the gate of Q3, allowing the gate voltage to rise to approximately 10 volts. With its gate at 10 volts, Q3 conducts, closing a ground path for the contactor coil, thereby actuating it.

A second set of K2 contacts connects unswitched battery power to the Low Voltage Power Supply (via K1 on the Fuse Board), which powers up the Microprocessor and Display Boards.

The unit is powered down by removing the ground from the contactor coil. Removal of the ground can be accomplished two ways. For an operator-initiated shutdown, the keyswitch is moved to the OFF position, which discharges capacitor energy through latching relay K2's RESET coil. The K2 relay contacts connecting the contactor coil to ground through Q3 open, deactivating the contactor.

The Microprocessor Board can also effect a shutdown, overriding the keyswitch position. A inactivity timing function on the Microprocessor Board generates a signal uP Shutdown, which is sent to the Fuse Board when no control panel activity has been detected for a period of 30 minutes. This signal discharges capacitor energy through K2's RESET coil, which accomplished the same functions as if the keyswitch had been turned to OFF. Through Q2, the uP Shutdown signal also grounds the gate of FET Q3, causing Q3 to open, which redundantly removes the ground path from the contactor coil. Also, FET Q4 is caused to conduct by the uP Shutdown signal, which discharges the energy in the SET capacitor, thereby inhibiting the keyswitch. To repower the unit, the keyswitch must by turned OFF, then back ON to initiate the power-up sequence.

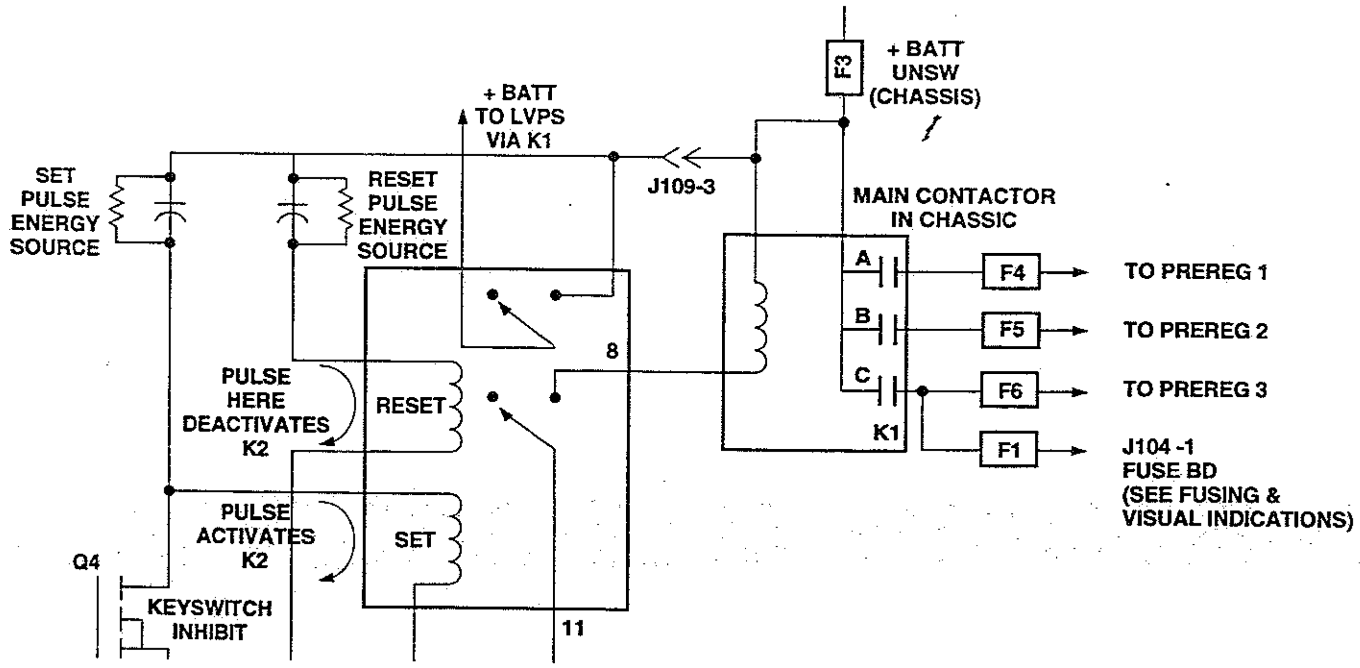

Figure G-1: Power Up / Power Down Sequence

1.3 Fusing and Visual Indicators (refer to Figure G-2)

The Fuse Board provides visual indicators that light when a fuse fails to signify to a service technician which fuse has opened. Below are the indicators and their respective circuits.

Fuse Board Indicator	Fuse	Circuit
D1	P-F6	Switched battery power to Preregulator Board #3
D2	P-F5	Switched battery power to Preregulator Board #2
D3	P-F4	Switched battery power to Preregulator Board #1
LP1	G-F1	Not Used
LP2	G-F2	Switched battery power to Rotor Inverter for power conversion
LP3	G-F3	Switched battery power to Filament Board
LP4	G-F4	Switched battery power to Motor Drive Board for drive system
LP5	G-F5	Switched battery power to Rotor Inverter Board for braking power to x-ray tube rotor

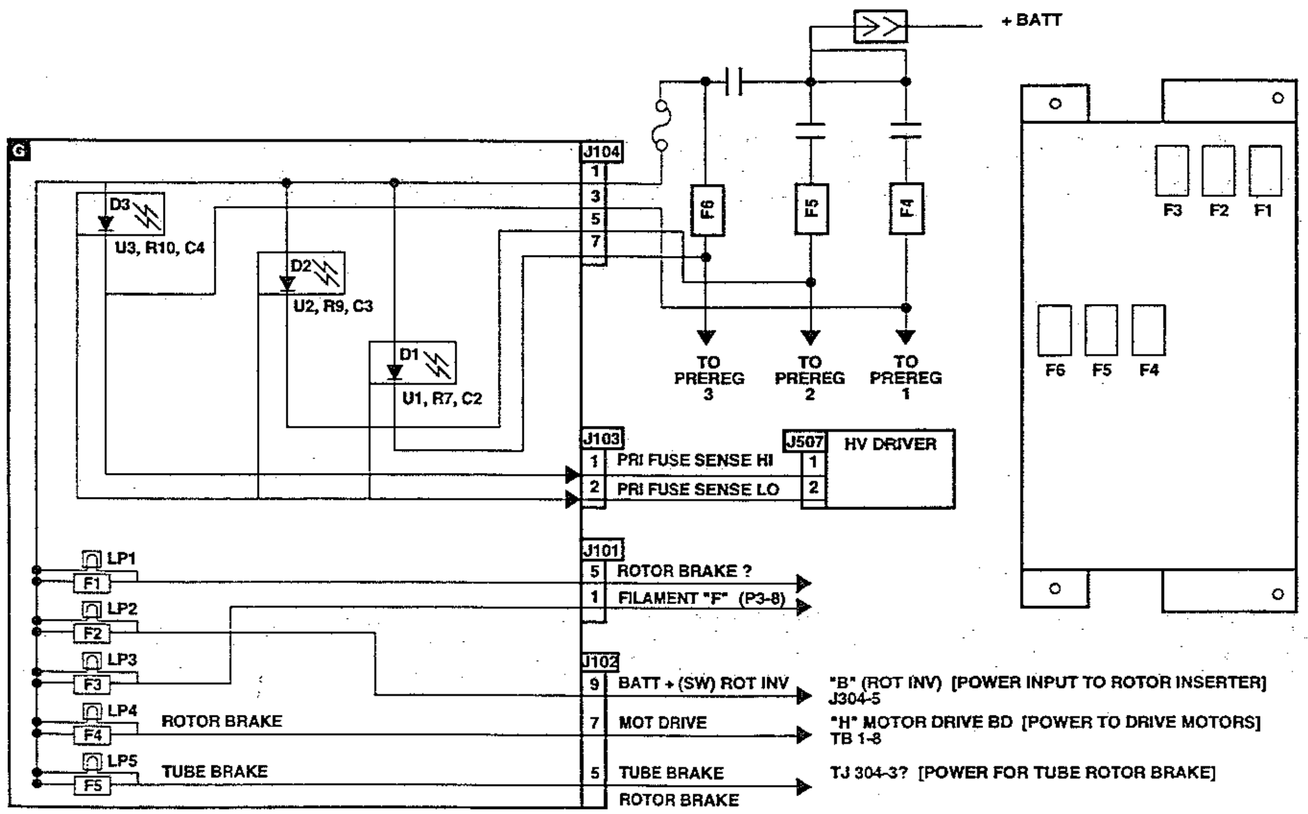

Figure G-2: Fusing & Visual Indicators

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To protect the HV Generator circuitry, if any of the 3 primary fuses (P-F4, P-F5, P-F6) opens, the signal PRI_FUSE_SENSE_HI is pulled low. This signal is sent to the HV Drive Board, and, when high, allows high voltage operation, and when low, inhibits high voltage operation.

The diagram provided as Figure G-2 shows the interconnections relating to the fuse sense and indicator circuits.

1.4 Mains Input Switching (refer to Figure G-3)

When the unit is connected to the AC Mains for battery charging, both x-ray operation and transport drive operation are prevented. In addition, circuitry on the Fuse Board disconnects battery power from the input of the Low Voltage Power Supply and connects the Mains power in its place. To keep the DC contactor from being operated, the Microprocessor Board reacts to the Line Sense signal, generated by the Fuse Board by presence of Mains power, by asserting the uP Shutdown signal. The uP Shutdown signal, while asserted, overrides the keyswitch function, and prevents the Power-up Sequence, or if the unit is already turned on when Mains power is detected, initiates the Power-down Sequence. Please refer to paragraph 1.2 for an explanation of the Power-Down Sequence.

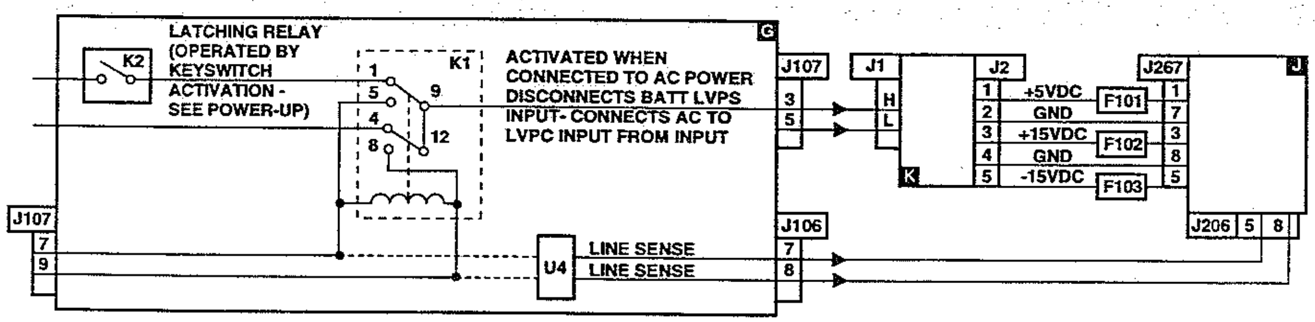

Figure G-3: Mains Input Switching

2. MICROPROCESSOR BOARD (J) - refer to Drawing G-4

The unit is controlled by a dedicated Motorola 68HC11 microprocessor based controller. The microcontroller device contains the unit's software operating program. The Microprocessor Board performs the following functions.

A. Senses state and responds to remote microswitches related to the safe operation of the system.

B. Receives operating commands from the control panel and displays the results of operations on the control panel LCD display.

C. Controls and monitors the x-ray exposure after operator initiation via the x-ray switch.

D. Monitors the state of charge of the batteries.

Each of the functions is described in the following paragraphs. A simplified circuit diagram of the Microprocessor Board, identifying inputs and outputs, is supplied as Figure G-4.

2.1 Safety Microswitches

The Microprocessor monitors the following safety switches which are contact closures to ground.

A. Arm Counterweight Cable Microswitches - the unit is disabled when a open switch (typically indicating a broken cable) is detected.

B. Bumper Microswitches (2) - if an open condition of either of the two Bumper microswitches is detected (typically caused by the bumper encountering an obstacle), only reverse direction drive is enabled until switch closure is again detected.

C. Arm is Cradle Microswitch - a ground condition enable full speed drive and "Ready to Drive" will be displayed on the Control Panel LCD. An open condition allows only low speed drive and enables x-ray exposures.

D. Drive Handle Microswitch - a +15 volt signal is applied to a separate drive relay which is in series with the drive control PC board and drive motors.

2.2 Operator Interface

2.2.1 Switch Interface - General

There are 13 switches on the Control Panel, arranged in a matrix. The closure of any switch causes the controller to interrupt the current program and scan the matrix to find the closed switch.

2.2.2 Displays - General

All Control Panel LEDs and 7 segment displays are multiplexed from a single display driver device.

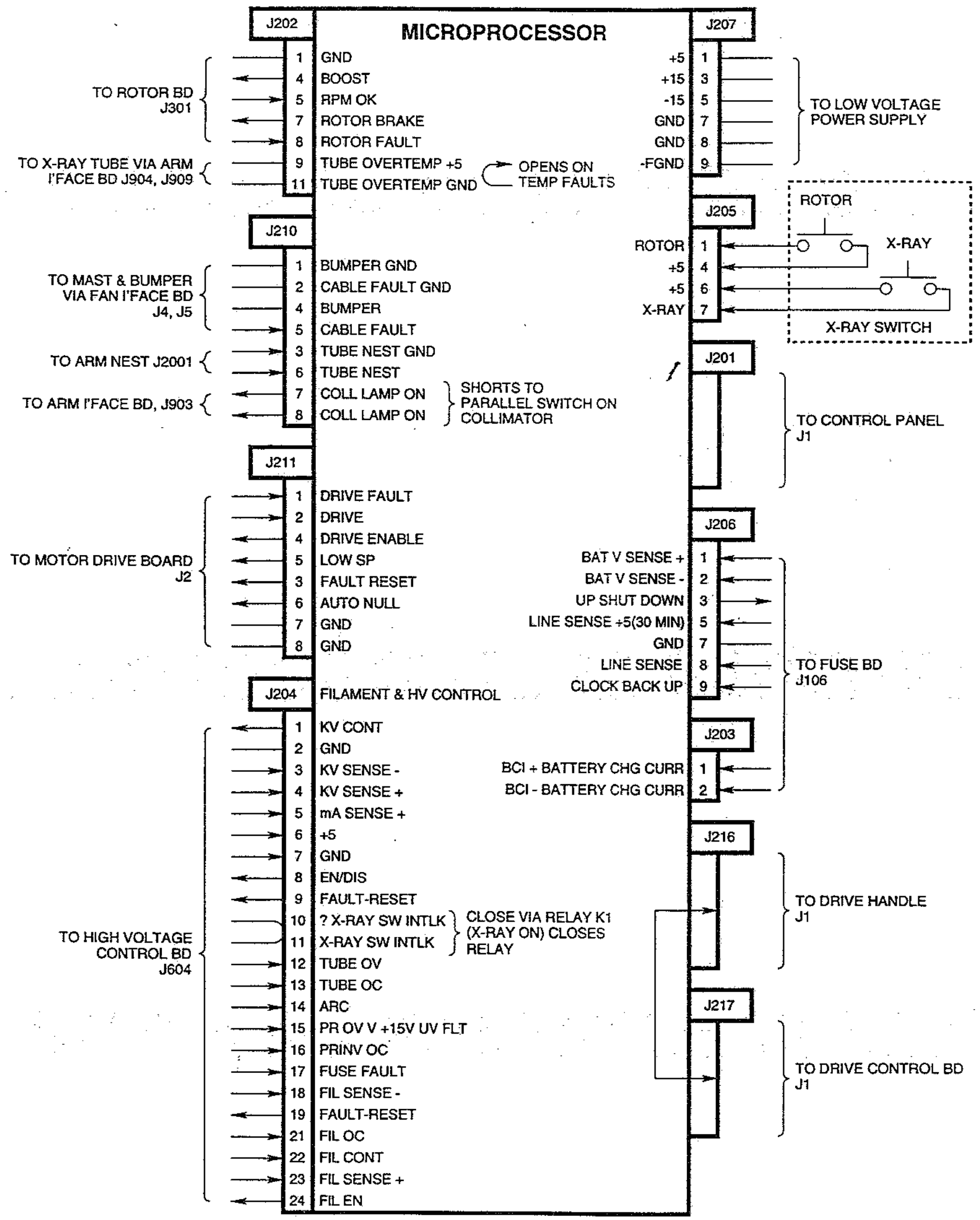

Figure G-4: Inputs / Outputs - Microprocessor Board

2.2.3 Technique Factor Switches and Display

Four Control Panel switches allow the direct setting of the technique factors: mAs UP/ DOWN and kV UP/DOWN. Seven segment displays indicate the current technique factor. For kV, the range is 40 to 125 in 2 kV increments up to 80 kV and 5 kV increments thereafter. For mAs the range is 0.4 to 325 mAs. Above 90 kV, mAs is restricted to 250 and above 105 kV, further restricted to 200. For 60 kV and less the range is extended to 0.1 mAs.

2.2.4 Technique Memory (APR)

Seven switches which have internal LEDs control the Technique memory. The Set switch allows the current technique to be loaded into one of 5 memory locations (the LCD display shows "Select Program No."). If one of the 5 Technique memory switches is depressed during this time, the current technique is loaded into that memory. Also, the internal LED in that switch lights, and the LCD display shows "Set-up Program No. [n]", where [n] is a number from 1 to 5. The memory is non volatile electrically programmable and erasable (EEPROM) contained in the controller, which means that the contents is held even when power is removed.

To recall the stored technique, the Select switch is depressed. Its internal LED flashes for 5 seconds and the LCD shows "Select Program No.". If one of the 5 technique memory switches is depressed during this time the stored technique factor replaces the current technique as indicated by the kV and mAs displays. Also, the LED in the switch lights and the LCD display shows "Recall Program No. [n]".

2.2.5 Status Indicators

Two LEDs indicate system status. READY indicates that the machine is able to take an exposure. X-ray indicates that an exposure is in progress. STANDBY indicates every other condition.

2.2.6 Reset Switch

Any potentially resettable fault condition will cause the LED within the Reset switch to light. If the switch is pressed, the operating program will attempt to reset the fault condition. If it is successful, the switch LED will extinguish.

2.2.7 Battery Status Indicator

The 20 element bar-graph indicator shows the firmware calculated state of charge of the batteries as a percentage in 5% increments.

2.2.8 Charge Indicator

Single element LED that lights when the battery is actually charging. The LED indicates that Mains power is connected, that the Circuit Breaker is turned on, allowing Mains power to reach the charging circuits, and that the charger system is working.

2.2.9 Collimator Switch

Depressing this switch lights the collimator lamp for 30 seconds, mirroring function of the switch on the front of the collimator device.

2.2.10 Exposure Control

The signals generated by the controller and transmitted to the filament circuit, high voltage circuit and motor drive circuit are described below.

kV CONT:
A variable voltage signal developed by digital to analog conversion on the Microprocessor Board and sent to the High Voltage Control Board. The level of this signal sets the kV level for an exposure.

KV SENSE-
KV SENSE+:
Differential signals proportional to the high voltage potential developed in the generator; fed back to the microprocessor board for monitoring.

MA SENSE-
MA SENSE+:
Differential signals proportional to the tube current in the high voltage circuit; fed back to the microprocessor board for monitoring.

EN/DIS:
Signal output from the Microprocessor Board that provides an enabling signal for the high voltage generator circuits.

FAULT-RESET:
Signal output from the Microprocessor Board that attempts to reset the high voltage circuitry and filament supply should a recoverable fault occur in the generator.

X-RAY SW INTLK
X-RAY SW INTLK:
Interlocking signals that are closed by contacts of relay J-K1 on the Microprocessor Board; contact closure actuates relay C-K1 on the High Voltage Control Board.

TUBE OV
TUBE OC:
Input signals to the Microprocessor Board that indicate overvoltage or overcurrent conditions in the high voltage/x-ray tube loops.

ARC:
Input signal to the Microprocessor that indicates a high voltage arc has occurred in the system (typically detected by a fast ground spike in the high voltage line).

PROC +15
UV FLT:
Input signal that indicates inverter rail overvoltage or +15 volt generator FET drive undervoltage fault.

PRINV OC:
Input signal that indicates Preregulator or HV Inverter overcurrent condition.

PRINV FUSE
FAULT:
Input signal that indicates that Preregulator or HV Inverter fuse has opened.

FIL OC:
Signal input to the Microprocessor that indicates that an overcurrent condition has been detected within the filament supply circuitry.

FIL CONT:
Output signal from the Microprocessor that communicates to the filament supply the filament current setting. The signal is variable voltage, and is developed through a digital to analog converter.

FIL SENSE-
FIL SENSE+:
Differential input signal to the Microprocessor Board from Filament Supply that provides measurement of power consumed by the filament, for end of filament boost detection.

FIL EN:
Output signal from the Microprocessor that turns on the filament regulation circuitry.

BOOST:
Output signal from the Microprocessor to the Rotor Board to begin driving the rotor motor.

RPM OK:
Signal feedback to the Microprocessor from the Rotor Board signifying that the rotor is up to speed.

ROTOR BRAKE:
Output signal from the Microprocessor to the Rotor Board to apply DC braking voltage to the rotor motor, after the completion of an exposure.

TUBE OTEMP +5
TUBE OTEMP GND:
Circuit path routed through a thermal sensor at the x-ray tube. Path opens if over-temperature trips the thermal sensor, and the controller inhibits further exposures until the path is again closed.

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2.3 Exposure Sequence

The sequence of events that occurs to generate an exposure is as follows:

2.3.1 X-ray Command

The two position x-ray switch, when depressed to its first stage, makes the controller turn on the rotor and raises the filament to boost level. The Rotor LED will begin to flash.

2.3.2 Boost Mode

While the boost cycle is initiated, the controller calculates the correct filament current for the exposure by, first, calculating the correct tube current which will produce 12 kW of power at the current kV unless the exposure time will be less than 3 milliseconds. In this case the tube current will be reduced to give an exposure time of 3 milliseconds. For long exposures, the effects of spot loading are calculated and, if necessary, the tube current is reduced according to spot loading curves stored in the controller.

Having calculated the tube current, the filament current is then calculated from curves stored in memory. The calculated value is then modified by a value, also stored in memory, which reflects experience gained with previous exposures using similar tube current and similar kV. This is to ensure that the filament current at the start of the exposure gives precisely the correct tube current. During Boost, the controller checks for filament faults. After 1.2 seconds of Boost, the controller checks for the presence of rotor current and filament current, and turns off rotor boost and lets it coast. During the 1.2 second Boost cycle, the controller monitors the filament power feedback. When the power level reaches that set for this filament run current, the controller adjusts the filament current to the previously calculated run level. This period runs to a maximum of 15 seconds or until the filament current is checked to be at least 3.2 mA and filament faults are checked. Also, the READY light turns on at this time. Any fault detected causes the rotor and filament to be shut down, the rotor braked, and the appropriate fault message to be displayed on the Control Panel LCD. The unit will enter Standby Mode and the LED within the RESET switch will illuminate.

During the remainder of the 1.2 second boost period, when the filament current is at the Run level, the power level is checked immediately after the current is switched to the Run Level, and again at the end of the Boost period. If the power level is greater at the end of the Boost period, the filament is taken to have warmed up. In this case, the filament Boost is too long and the table that holds power levels for the end of Boost is updated with a new higher value. If, on the other hand, the filament cools down during the Boost period, then the table is given a new, lower value. If the x-ray switch is released from the first level during this time, the rotor and filament are shut off and the machine stays in Standby mode for 1.2 seconds while the rotor is braking.

2.3.3 X-ray Mode

When the x-ray switch is pressed to the second level, an exposure takes place. First, there is a 50 millisecond delay to allow for contact debounce of the exposure interlock relay. Then, the warning beeper is turned on and the x-ray LED made to flash. After that the generator is enabled and the kV programming is ramped up at a rate to ensure there is no overshoot in the kV control loop. When the kV has reached 80% of its final value, mAs integration starts. During the exposure, the following parameters are monitored.

A. Battery Voltage

If the battery voltage drops below 80 volts, the exposure is terminated immediately. If the battery voltage drops only to 85 volts, the power level drops to 6 kW for the rest of the exposure, and subsequent exposures until the battery is charged.

B. Tube Current

If the tube current drops below 50% of its set value, the exposure is terminated immediately.

C. X-ray (Exposure) Switch

If the exposure switch is released, the exposure is terminated immediately. A message "EXPOSURE ABORTED" is displayed on the Control Panel LCD.

D. kV

If the high voltage is more than 20% high or low, the exposure is terminated immediately.

E. Rotor Inverter Fault

If this is detected, not only is the exposure terminated immediately, but the controller turns off the main contactor, removing all power to the machine.

F. mAs Integration

At regular intervals, the tube current is measured and is multiplied by the time since it was last measured (250 milliseconds). The product is subtracted from the total mAs required for the shot. When the total is less than zero or is calculated to be less than zero in the next 112.5 microseconds, then the exposure is terminated. The first level of backup is a timer in the controller which is set to the nominal exposure time +10% for the correct mAs at the nominal tube current. The 10% allowance is so that if the tube current is slightly low, the mAs integration method which is more accurate can finish the exposure at the correct time. A second level of backup is a hardware timer that is set for 6.2 seconds.

G. Tube Current Control

For exposures longer than 50 milliseconds, a closed loop controller adjusts the filament current in order to bring the tube current to the calculated value.

H. End of Exposure

When the exposure is finished, the x-ray indicator and beeper are turned off. If the exposure has been completed with no errors or faults, the message "Exposure Complete" appears on the control panel LCD, together with the actual time of the exposure. If an error or fault has been detected, the nature of the fault is displayed.

All faults cause the RESET switch LED to light. When the RESET switch is pressed, the controller attempts to reset the fault. If the fault was transient, the reset operation will be successful and the RESET indicator will go out. A message: "Fault is Reset" will appear on the LCD display. If the fault is permanent, i.e., a blown fuse, nothing happens upon pressing the RESET switch.

The generator and the filament are turned off. The heat units dissipated in the tube are calculated and the rotor is braked. For exposures less than 50 milliseconds, the actual exposure time is used to calculate an offset to the filament current so that , for the next exposure taken at similar kV and power level, the actual time can more closely approach the nominal for better consistency and also to avoid taking more than 12 kW from the generator which might lead to a fault condition. If the actual exposure time is longer than the nominal exposure time (for required mAs at nominal tube current), then the tube current was too low and filament current offset is increased (the opposite occurs if the actual exposure time was too short).

The last thing to occur is to set the standby time, which is 5 seconds after exposures of less than 60 mAs and 20 seconds for longer exposures, unless the heat units are almost all used up, in which case a longer standby time in enforced to allow for tube cooling so sufficient heat units for the set mAs.

I. Timers

1 Seconds Timer - This calculates the tube heat units available. It also counts the time the unit has been on and when it reaches 30 minutes without being used, the proper signal transitions are generated to effect a unit power-down sequence.

2.4 Miscellaneous Functions

2.4.1 Pulse Width Modulator Measurement - Drive Auto-Null

When Switch #7 is on and the power is turned on, the microcontroller will put the drive system control circuitry into Auto-Null mode and the LCD will display the duty cycle of the motor pulse width modulator signals.

2.4.2 Test Mode

When Switch #1 is on, the machine is in Test Mode. More service information is placed on the display.

2.4.3 Erase Offsets

When Switch #5 is on, filament calibration offsets in EEPROM are erased and put to 0.

3. ARM AND MAST BRAKE CONTROL (refer to Figure G-5)

The Rotor Board provides power to the Collimator mounted Brake Release Switch and the Arm mounted Brake Release Switch. The +12.5 volts from the Rotor Board flows through Fuse (F1), out J302 (pin 1), then into the Arm Interface Board at J903 (pin 3). The Arm Interface Board is a PCB that connects the Rotor Board to the Arm Brakes. The +12.5 volts flows out the Arm Interface Board at J908 (pin 1) to the Collimator Brake Release Switch, and out J907 (pin 6) to the Arm mounted Brake Release Switch.

When the Brake Release Switches are open, the voltage at switch contacts (1) is 0.0 volts. Logic circuit (U4) on the Rotor Board senses the low voltage input at both the switch contacts (2) and inverts the signal. The U4 (pin 17) output will equal approximately 12.5 volts, which keeps the potential across the K3 coil at 0.0 volts. With K3 de-energized, the voltage at pin 1 of the Arm and Mast Brakes coil is 0.0 volts. The four electromagnetic brakes are engaged in this state.

Pressing either Brake Release Switch completes the circuit between the switch contacts (1) and 2), causing the +12.5 volts to flow into the Arm Interface Board at J908 (pin 2), and out the board at J903 (pin 4). The voltage then enters the Rotor Board at J302 (pin 2) where it enters the Logic circuit (U4) at pin 2. The Logic circuit inverts the +12.5 volt input, causing the output at pin 17 to be approximately 0.0 volts. The pin 17 output creates a +12.5 volt potential on the Relay (K3) coil, which closes the relay contacts. When Relay (K3) closes, +24 volts leaves the Rotor Board at J302 (pins 5 and 6).

The +24 volt output at J302 (pin 5) flows into the Arm Interface Board at J902 (pin 4), then out at J907 (pin 3). The J907 (pin 3) output enters Diode Brake Board #1 at J3 (pin 2), and exits at J1 (pin 3) and J2 (pin 2). The J1 output energizes the brake coil and releases the brake. The three Diode Brake Boards and Arm Brakes are connected in parallel, and are powered by the J3 (pin 2) inputs. The circuit description for all three brakes are the same.

The +24 volts output at J302 (pin 6) flows into the Fan Interface Board at J4 (pin 5), then out at J5 (pin 5). The J5 output energizes the Vertical Mast Brake coil and releases the brake.

Zener Diodes D1 and D2 on the Diode Brake Boards, and the diode on the Vertical Mast Brake, absorb the energy of the brake coils when the Release Switch is released. This prevents arching of Relay (K3) on the Rotor Board.

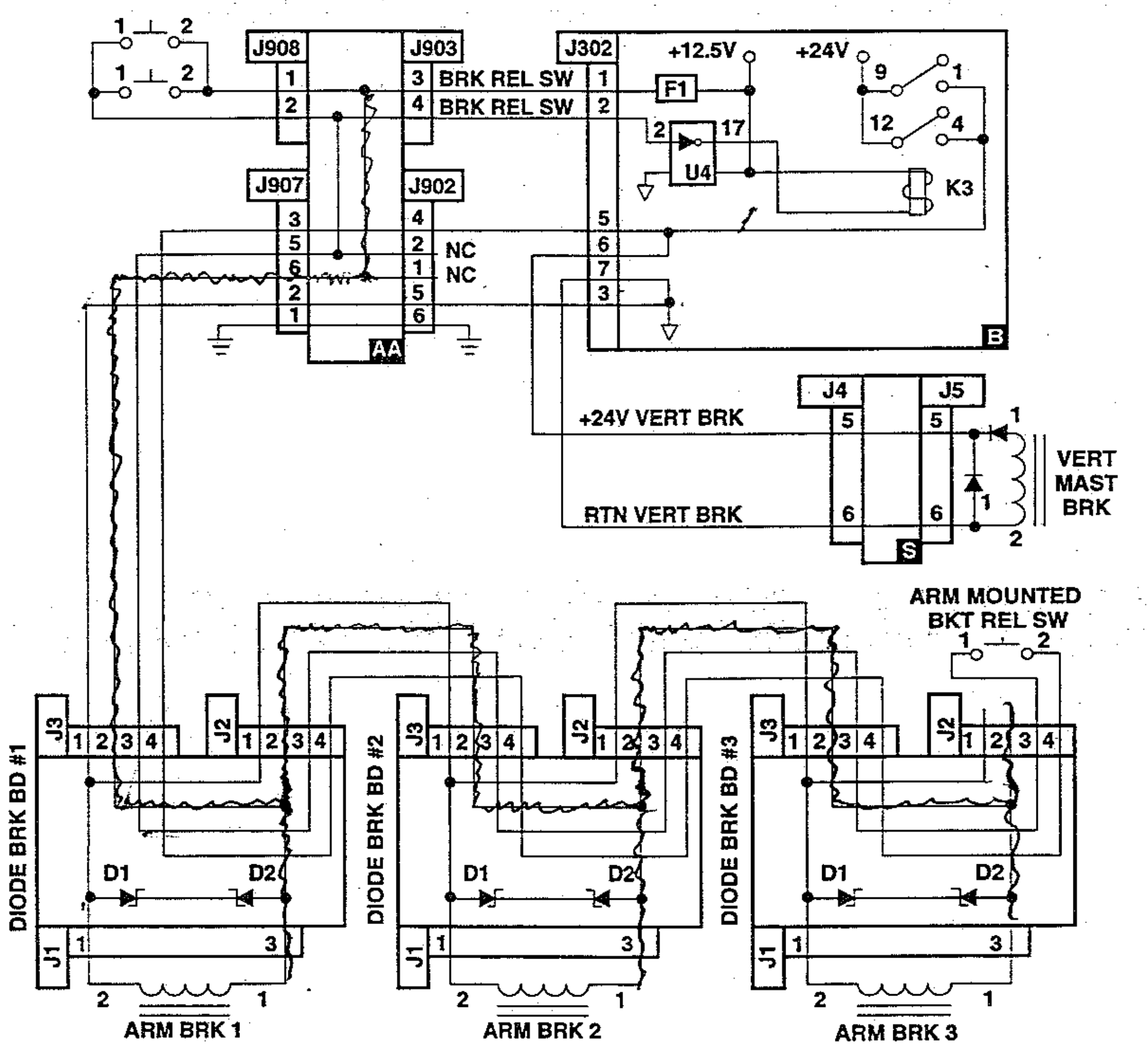

Figure G-5: Arm & Mast Brake Control

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4. X-ray GENERATOR

The battery pack supplies 120 Vdc to three Preregulator Boards which are connected in parallel. The Preregulator outputs supplies two Inverters, connected in parallel, with 200 Vdc, which supplies 200 Vac to the H.V. Tank. The H.V. Tank converts the 200 Vac input to -62.5 kV and +62.5 kV for the x-ray tube.

4.1 Preregulator Section (refer to Drawing GZ-2)

Three Preregulator, connected in parallel, boost the 120 Vdc from the batteries to 200 Vdc for the inverters. The H.V. Control Board controls the Preregulators through the H.V. Driver Board.

Ten sealed lead acid batteries supply a fused 120 Vdc input to the Preregulator boards. The Fuse Board senses the fuses, detects if any are open, and generates a signal to the H.V. Driver Board. This signal latches through U6, then continues to the H.V. Control Board. The U6 output signal (SHUT DN) shuts down the Preregulator Driver (U4), stopping high voltage production. An active low signal (FT/RS) from the Microprocessor releases the U6 latch.

The Microprocessor generates a signal (VC REMOTE) that controls the Preregulator Driver (U4) on the H.V. Control Board. Summing Amplifier (U7A) combines this signal with the kV feedback from the H.V. Tank. The two-signal sum is sent to the input of U4 (NINV), which affects the U4 outputs (PR REG DRA and PR REG DRB). The U4 outputs are pulsed out of phase and delivered to the H.V. Driver Board. A series of DIP Switches (DP-6 SW2) on the H.V. Driver Board feeds the signals to a FET, then to the appropriate Preregulator Board (the signal names are changed respectively to XFMR1 and XFMR2). These signals drive two separate primary windings of Transformer (T1) on the Preregulator Board. The secondary windings control flyby feedback circuits (three per signal, per board). Output of the circuits supply approximately -200 Vdc to the inverter board (INV RAIL).

The 15 Vdc from the H.V. Driver Board supplies power for the primary coils of the Preregulator Board Transformer (T1), which is interlocked with the x-ray switch. Pressing the x-ray switch to the secondary position causes an active low signal (X-RAY INT) to be sent from the microprocessor to the H.V. Control Board. This signal activates Relay (K1) on the H.V. Control Board, which supplies 15 Vdc to the H.V. Driver Board. The 15 Vdc drives Transformer (T1) on the Preregulator Boards, and Transformers (T1) and (T2) on the Inverter Boards (see Inverter Block Diagram). Releasing the x-ray switch terminates production of kV.

4.2 Inverter Section (refer to Drawing GZ-3)

The inverter boards primary function is to convert -200 Vdc to 200 Vac (20 kHz) for the HV tank. There are two inverter boards connected in parallel. They are controlled by the HV control board, through the HV driver board.

The -200 Vdc supply enters the inverter boards as 'INV RAIL'. The supply passes through two fuses before entering the H bridge circuit. If either of the two fuses open, a fuse sense circuit will detect this. The circuit will send a signal to the HV driver board. Here, the signal will latch U6C and U6D. When latched, two signals are generated. One travels to the microprocessor as 'PR-INV FUSE FAULT', the other travels to the HV control board as 'V SHUT DN'. 'V SHUT DN' disables both the preregulator driver IC U4 and the inverter driver IC U5, therefore disabling kV production. Both latching logics U2 and U6 are reset by a signal generated from the microprocessor board.

The inverter driver IC U5 produces two out of phase, 50% duty cycle signals called 'INV DRA' and 'INV DRB'. The signals pass through DIP-8 SW1 and drive two sets of FETs for each inverter board. There are two FETs per set. One drives T1, the other T2 of the inverter board. Within each set TxA and TxB are pulsed alternately, providing a push/pull source for the H bridge configuration circuit of the inverter board. The output of the H bridge is 200 Vac at 20 kHz which is then passed to the HV tank.

Two current sense circuits monitor the 200 Vac output and send feedback to the HV driver board. The feedback is then rectified and fed to the over current comparator U1A. If an overcurrent occurs, and the signal is strong enough to trip the comparator (set by R51), the latching logic U2A and U2B will become active. They produce two signals. One provides feedback to the microprocessor. The other, a shut down signal to deactivate U4 and U5 of the HV control board, therefore shutting down kV.

4.3 High Voltage Multiplier Section (refer to Drawing GZ-4)

The HV tank transforms 200 Vac to +62.5 kV and -62.5 kV for the x-ray tube. Feedback from the tank is provided to the HV control board to regulate and monitor kV production. The HV tank also has a desiccant attached to allow for oil expansion during temperature changes.

200 Vac is provided to the HV tank from both inverter boards. The current passes through the step up transformer T1 of the tank. The output (16 kV amplitude) is then fed through two sets of 'times four full wave multipliers'. One set provides up to +62.5 kV, the other -62.5 kV. Both kVs pass through softeners before exiting out to the x-ray tube. The positive kV goes to the anode, and the negative to the cathode.

'-IF' (mA sense) comes from the negative kV multiplier to the LV feedback board, where it is tied to 'HV GND' through a 10 ohm resistor R1. '-IF' is also passed to the HV control board as a feedback signal. It is then buffered and summed with 'IF ADJ' (U11B and R76), then fed through a buffer U10C, and on to the microprocessor as 'mA SENSE'. The output of U11B is also passed to a comparator and tube overcurrent adjust U11A and R80. If an overcurrent is detected, a signal is delivered to latching logic U9C and U9D. This logic has two outputs: one shuts down the preregulator and inverter drivers U4 and U5, the other signals the microprocessor as 'mA OC' (mA overcurrent).

There is an arc detect coil T2 on the positive kV output to the anode. If an arc occurs it will pass from the coil through the LV feedback board, and on to a bridge rectifier (D1) of the HV control board. The signal is then rectified and passed to a fixed comparator U10A. If the signal is strong enough to trip the comparator, it will activate the latching logic U6A and U6B. The negative output of the logic will initiate an 'HV INTLK' signal to the microprocessor. The positive output will shut down the filament supply ('FIL SD'), and send the signal 'SHUT DN' to both the preregulator and inverter drivers U4 and U5.

There are voltage dividers on both 62.5 kV outputs of the HV tank. The dividers send two signals to the LV feedback board, '+VF' and '-VF'. In the feedback board, these signals can be modified or adjusted by R7 and R6. The modified signals are then passed to the HV control board where they are fed to the amplifiers U1A and U8C. '+VF' and '-VF' are then summed and passed through the summing amps U7D, B, and A, where they are also summed with 'VC REMOTE' (control voltage from the microprocessor). This summation then ties to the NINV input of U4, and regulates the kV through the preregulator. The output of amplifier U1A ('+VF' line) also passes a signal to the comparator U1D. Here it is compared with the +VF overvoltage adjust R44. If '+VF' goes too high, the comparator trips and activates the latching logic U6C and U6D. The positive output of the latch circuit goes to the preregulator and inverter drivers, shutting them down. The negative output is returned to the microprocessor as 'KV OV' (kV overvoltage).

5. FILAMENT SUPPLY (refer to Drawing GZ-5)

The Microprocessor controls the self-regulating Filament Board. The Filament Board receives 120 Vdc from the battery pack, through the Fuse Board. R50, on the Filament Board, reduces the 120 Vdc input to 75 Vdc (FIL RAIL). T3, Q4, and Q5 use this reduced voltage for filament current power. Solid-state switches U3 and Q3 become active upon filament rail over-current, which activates the Rail Overcurrent Shut Down Comparator (RAIL OC SD). This sends a signal to both the Microprocessor (FIL OC FAULT) and the SHUT DN input of the Filament Current Pulse Width Modulator (U1).

The Microprocessor sends a signal (VP REMOTE) to the Filament Board. This signal passes through Program Amplifier (U5D) and Error Amplifier (U5B). The U5B output signal controls the output of Pulse Width Modulator (U1). U1 remains enabled by Microprocessor signal (EN/DIS). Variable current passes through T3 (depending upon the output of U1). The push/pull secondary winding configuration of T3 alternately activates FETs Q4 and Q5, which push and pull the J1-1 filament current line (FIL CURR) from 75 volts to ground. The second filament current line (J1-3) floats above ground at approximately 37.5 volts. This causes J1-1 to drive 75Vac peak-to-peak or 37.5Vac amplitude. The filament current lines exit the Filament Board at J1 and enter the H.V. Tank. Transformer (T2), within the H.V. Tank, isolates the filament current. The T2 output floats down to approximately -62.5kV for the x-ray tube cathode.

The Filament Board's J1-1 filament current line connects to filament current sense coil (T2) which sends feedback to RMS-to-DC Converter (U2). The U2 output flows to the IF scale and Adjust Amplifier (U5C and R34). The output of U5C and R34 is sent to Error Amplifier (U5B), which looks at the feedback and the control voltage (VP REMOTE). U5B then sends an analog output to the Microprocessor as filament control sense (FIL CONT SEN), and to Pulse Width Modulator (U1) for output regulation.

The Filament Board's J1-3 filament current line connects to filament current sense coil (T1). The T1 coil sends feedback to three circuits: a Primary Overcurrent Comparator and Adjust (U4B and R67), an Average Overcurrent Comparator and Adjust (U4C and R44), and an RMS Overcurrent and Adjust (U4D and R45). If any of the comparators senses an over-current, it will shut down Pulse Width Modulator (U1), signal the Microprocessor, and disable the Preregulator and Inverter Drivers of the H.V. Control Board. All over-current comparators are reset from the Microprocessor signal (FT/RST).

6. BATTERY CHARGER (refer to Figure G-6)

Performance Specification

The battery charger is two-step. In step 1, the battery charges to 147.5V and stays there until the current drops to 300 mA . The charger then switches to mode 2, float mode, where it holds the voltage at 137.5V. This is done to ensure the optimum charge on the battery.

The current charging the 120V battery is limited by either the transformer impedance or the internal current limit, whichever is lower. The internal current limit is designed to protect the transformer from overheating. The battery charger can also have a different current limit at 50Hz than at a 60Hz. For a 230V nominal input 600VA transformer, the current limit is set at 3A primary current at high line 255V a.c. 50Hz. For a 115V nominal 300VA transformer the current limit is set a 1.5A at 129V a.c. 60Hz on the primary.

Mode of Operation

U1 is a self-contained microcontroller running at 3.58MHz set by crystal Y1. BR1 full wave rectifies the incoming a.c. R7, C6, R5 and D5 provide the power supply for the microcontroller. D5 is a precise +5V reference which functions both as a power supply regulator and as a reference for the a/d converter in the microcontroller. R6 and R15 function as the input voltage divider that measure the input voltage. U28 functions as an amplifier and a buffer. R3 and R13 make up the battery voltage divider that measure the battery voltage. It is buffered to prevent back bias and latch up of the microcontroller when the a.c. is off but the battery is still connected. R14 is the current shunt used for measuring high currents. R14 also has an x6 input for measuring low current amplified by U2. The microcontroller contains a 4 channel a/d converter connected to Pins 1, 2, 17 and 18.

Q1 is a thyristor which fires at the right point in the input voltage cycle to regulate the current going into the battery.

D1, D2, C1 and C2 function as the voltage doubler and increase the input voltage to provide energy to fire the thyristor. This voltage charges C10 and R1 while D4 limits the voltage to 12V to protect U3. To fire the thyristor a 20us low going pulse is delivered no more than once each input cycle at Pin 10. This turns on U3 providing base drive to Q2. When Q2 turns on, it discharges C10 into the gate of Q1 causing it to fire. Once fired the thyristor remains on until the input voltage drops below the battery voltage, i.e. at the end of the cycle. R4 and C4 act as a snubber for the thyristor.

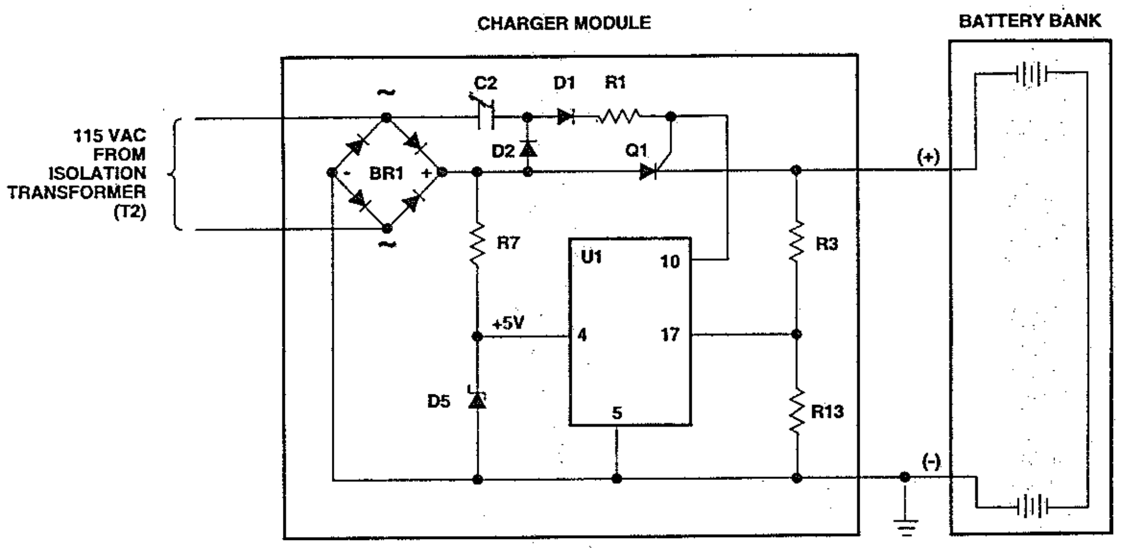

Figure G-6: Battery Charger Module

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7. MOTOR DRIVE SECTION (refer to Figure G-7)

The motor drive system consists of a motor drive board, strain gauge drive handle, grip switch, motor interface board, and two motors (left and right). The whole system is monitored by the microprocessor, and receives its power from ten batteries.

The motor drive board constantly monitors the inputs from the drive handle. The drive handle consists of a left and right strain gauge, and a grip switch. When the grip switch is engaged (normally open), the motor drive system is enabled. As pressure is applied to the strain gauges, their impedance drops, altering the voltage feedback. The feedback is amplified by the motor drive boards left and right preamplifiers, and fed to the speed control logic (analog). The logic controls the motor drive circuits, and power is fed to the motors. Motor voltage polarity depends upon the direction of travel.

The drive board has several sense circuits. There's a current sense circuit that detects if more than 10 amperes are applied (20 a surge), a temperature sense circuit that detects if the drive heat sinks get too hot (65° C), a lead sense that detects motor windings open or shorted, a battery sense circuit which monitors the battery voltage (more than 150 Vdc or less than 110 Vdc), and a handle sense circuit that detects the drive handles opened or shorted. If any of these circuits become active, they will notify the brake stop logic. This logic will stop the motor drive outputs, apply the brakes, and send a drive fault signal 'DR FLT' to the microprocessor. After the brakes are finished (applied for approximately two seconds), a drive signal 'DRIVE' is delivered to the microprocessor (this signal becomes a zero whenever the brakes are exerted).

The brake logic will behave differently depending upon the signals it receives. If the signal is from the sense circuits or the 'DR EN' (drive enable) is pulsed high, motor drive stops, and the brakes are applied. But, if both the drive enable and slow speed ('LOW SP') signals are pulsed high, the brakes are applied, motor drive stops, and when the brakes are released in two seconds, reverse drive at low speed is re-enabled.

If the drive handles are replaced, the motor drive board contains an auto null circuit which allows the motor drive board to be calibrated (coarse then fine adjust) to the new handles. This circuit would also be calibrated (fine adjust) if the motors are drifting. If properly calibrated, it will deliver an 800 Hz 62% duty signal to the microprocessor ('LT NULL' and 'RT NULL' signals).

The K1 relay on the motor relay PC board is activated by pressing the brake release bar on the drive handle. +15V is applied to K1. The normally open contacts of K1 which are in series with the motors are closed and apply DC voltage to the motors. When the brake release bar is released, K1 drops out and applies a resistor across each motor winding through a nomally closed contact. These results provide dynamic brake to the drive motors. The K1 contacts are monitored by the microprocessor. In the event the contacts become welded, a "Drive Fault" message will be displayed. This condition is non-resetable.

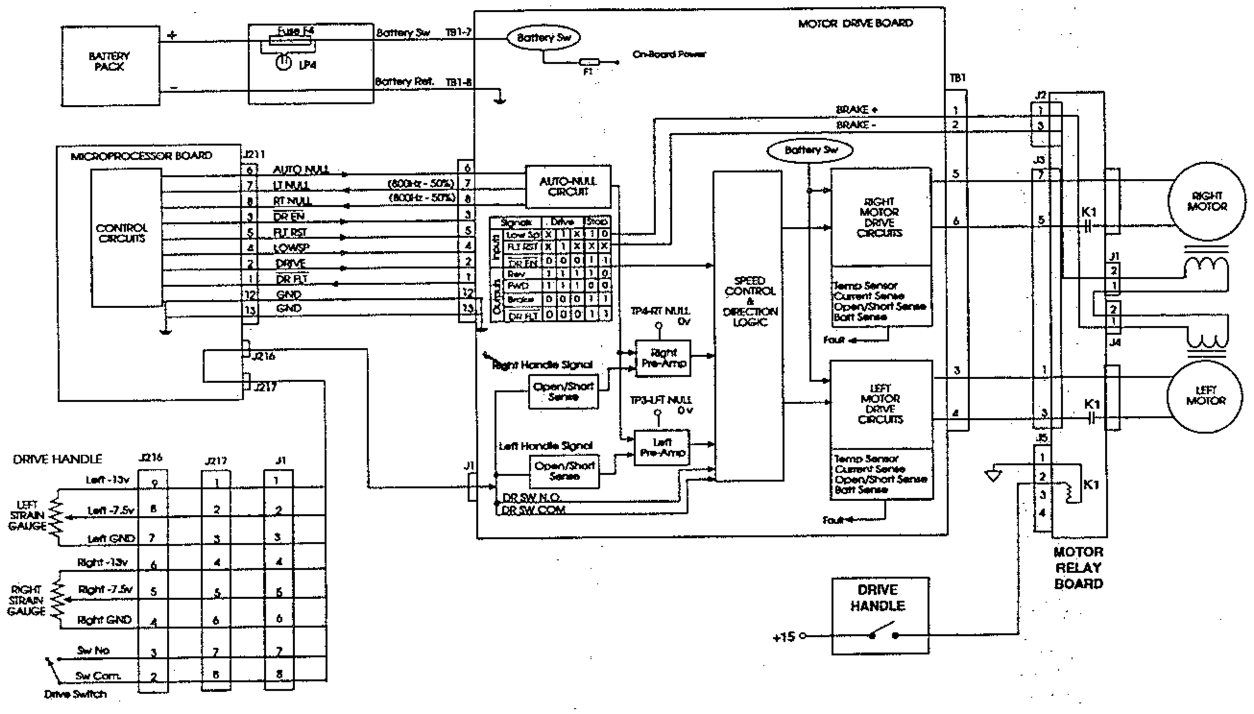

Figure G-7: Drive System

J1
1
330 (2
330 (3
658
4
6

90

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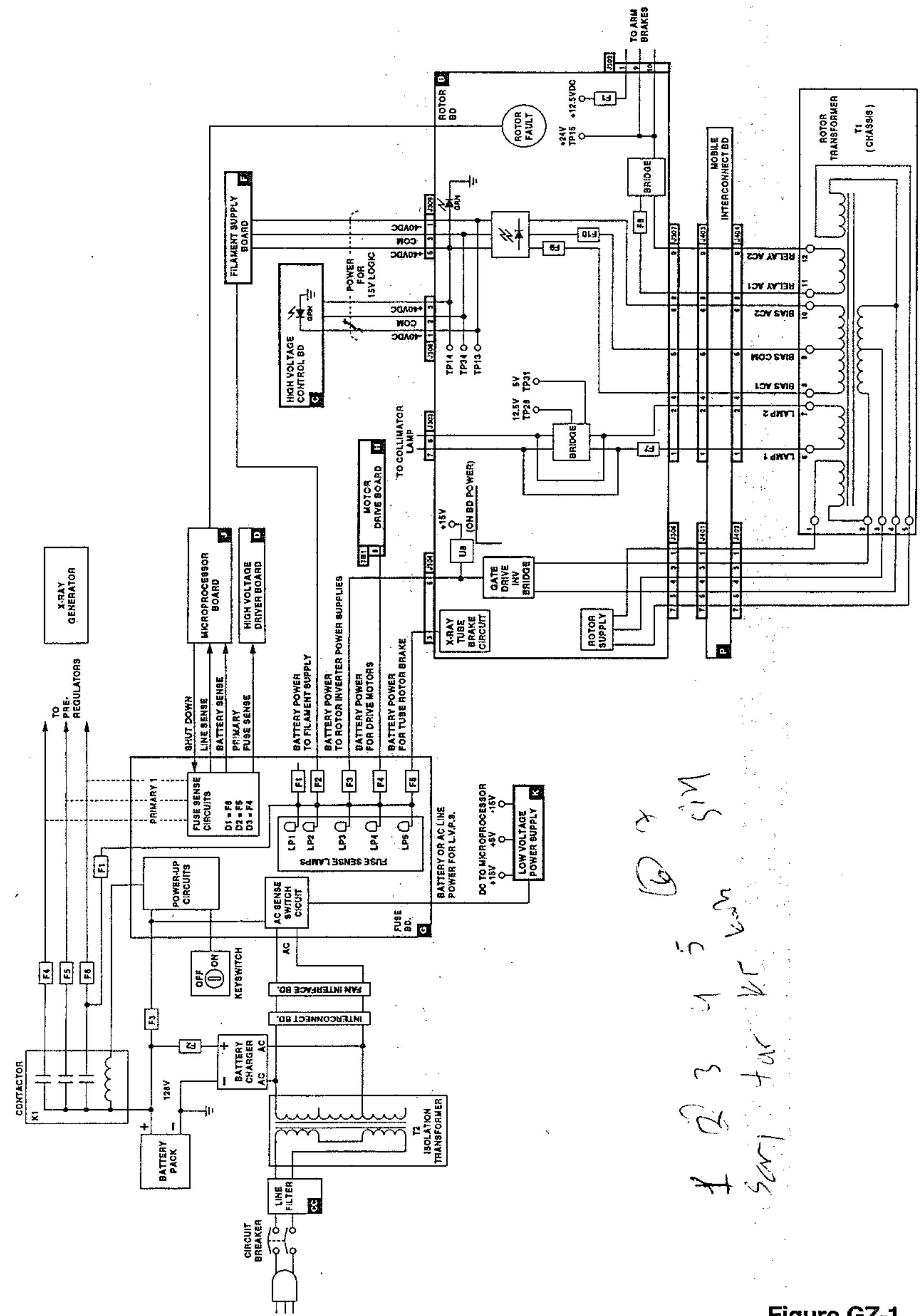

Figure GZ-1

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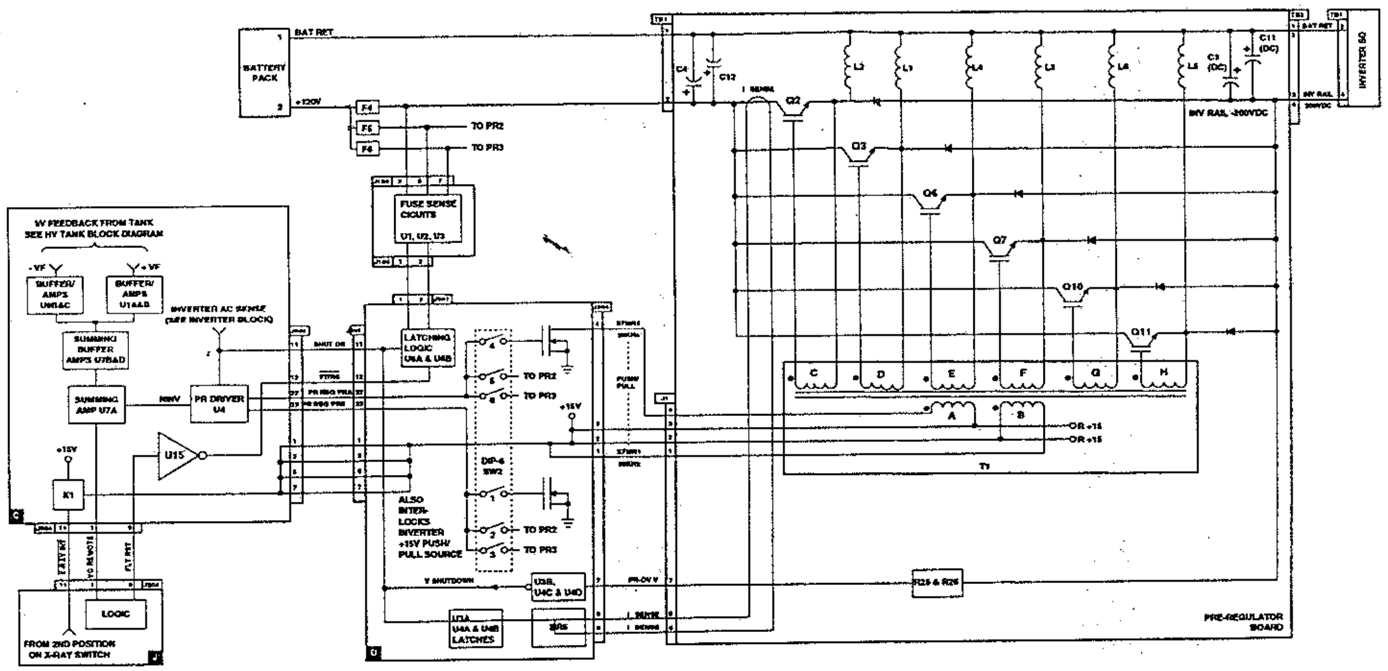

Figure GZ-2

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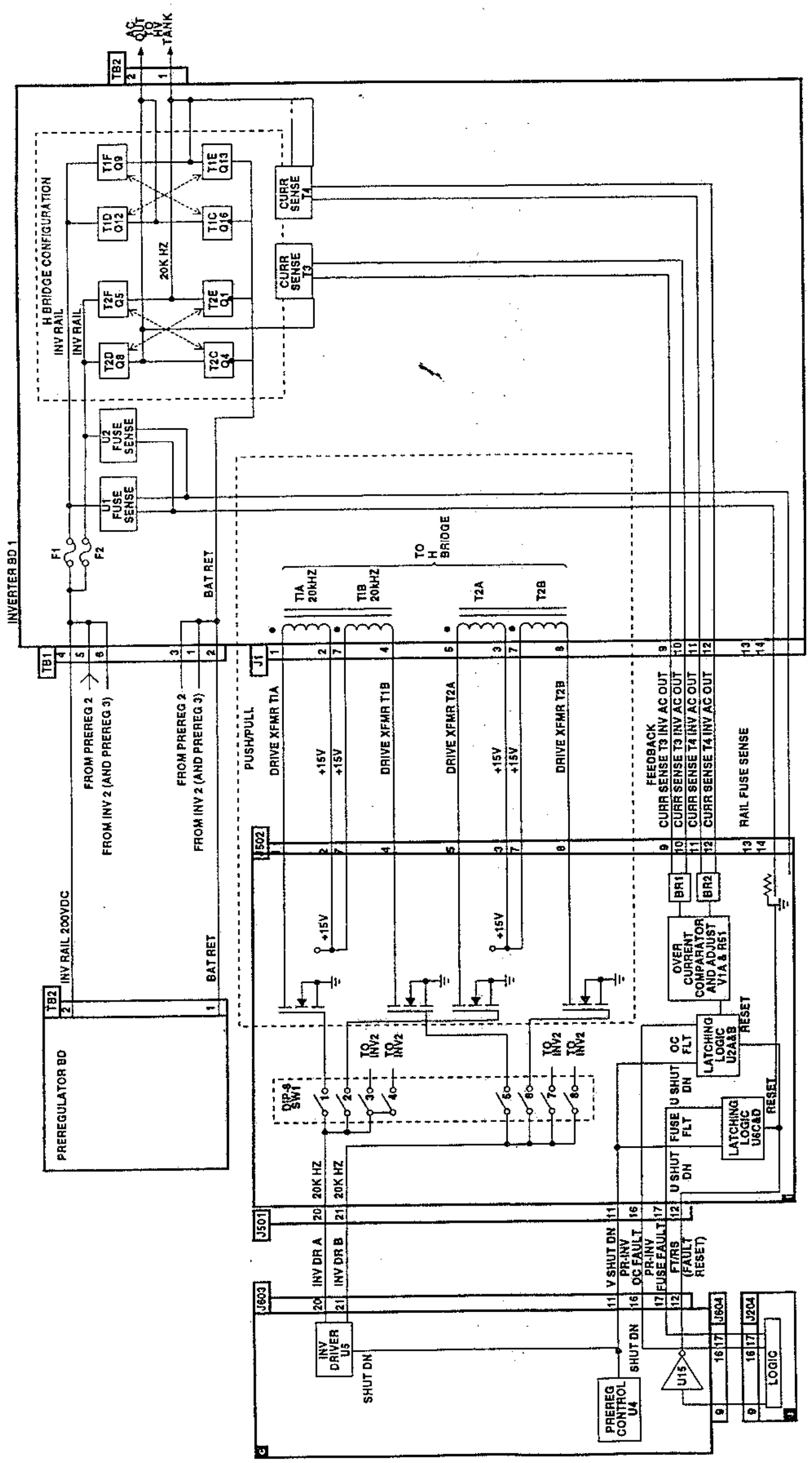

Figure GZ-3

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SERVICE INFORMATION LOG

Service Information Checklist:

Equipment: ______________________________

Type No: ____________________ **Serial Number:** ____________________

N-Sheet No. Service Information No.	Implemented		Remarks
	Date	Signature	

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N-Sheet No. Service Information No.	Implemented		Remarks
	Date	Signature	

ILLUSTRATED PARTS LISTS

PARTS LIST P-1

DRAWINGS

MOBILE FINAL ASSEMBLY PZ-1
MOBILE MAIN ASSEMBLY PZ-2
CONSOLE ASSEMBLY PZ-3
CONTROL ASSEMBLY PZ-4
COLLIMATOR ASSEMBLY PZ-5
ARM ASSEMBLY PZ-6
BASE/FRAME ASSEMBLY PZ-7
MAST ASSEMBLY PZ-8
HINGED PANEL ASSEMBLY PZ-9
POWER CONTROL ASSEMBLY PZ-10
BASE SUB-ASSEMBLY PZ-11
WHEEL DRIVE ASSEMBLY PZ-12

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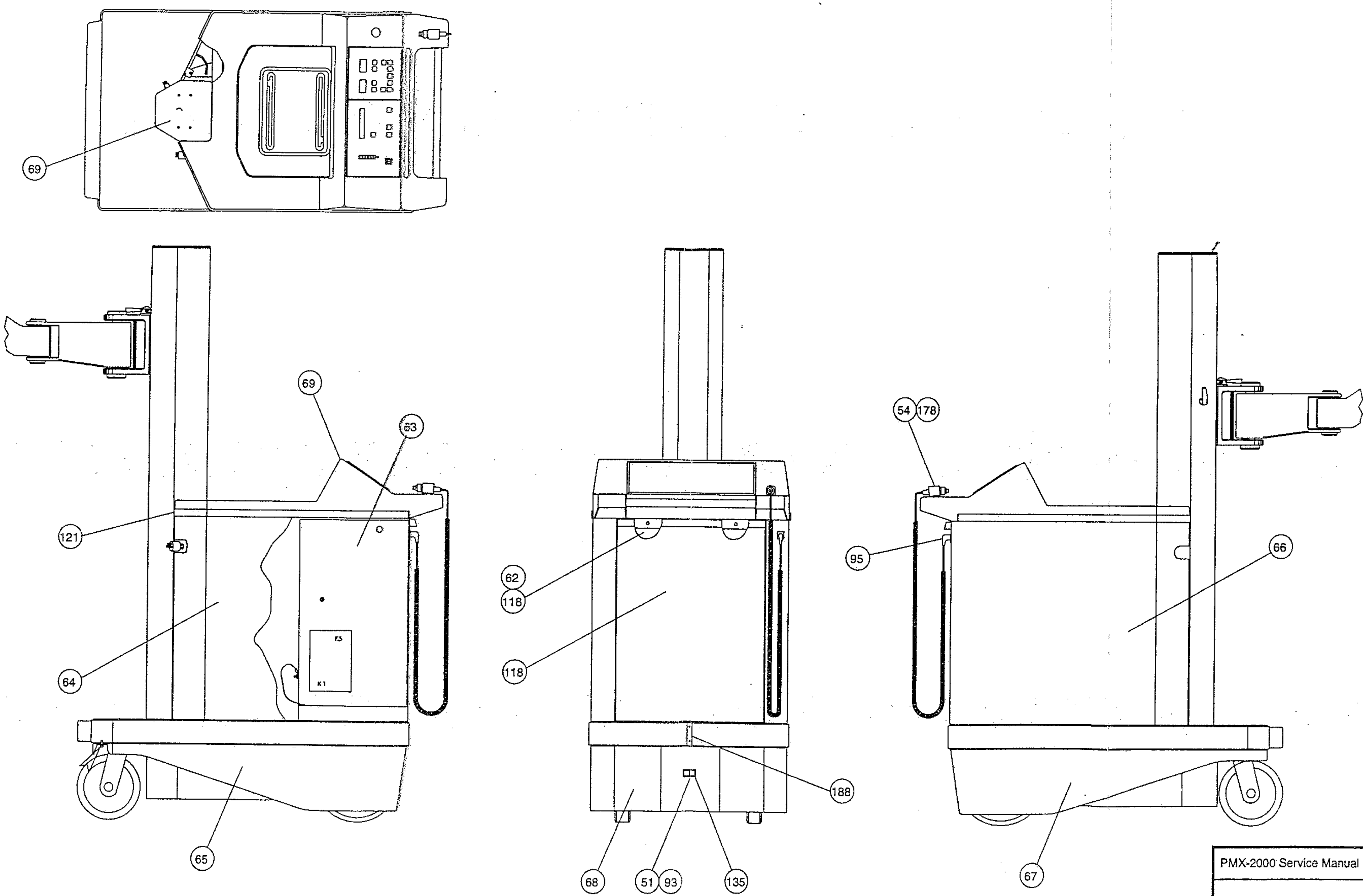
ITEM	PHILIPS PART#	DESCRIPTION	ILLUSTRATON REFERENCE
1	4512590 10001	ASSY, LV FEEDBACK BOARD	PZ-7
2	4512590 10041	DRIVE MOTOR	PZ-12
3	4512590 10051	GEAR BELT 1/2PX1,WX330LG	PZ-12
4	4512590 10063	ASSY,HANDLE	PZ-7
5	4512590 10071	ASSY CABLE COUNTERWEIGHT	PZ-8
6	4512590 10081	ASSY, CABLE SHOCK ABSORBING	PZ-8
7	4512590 10091	MICROSWITCH, MAST	PZ-8
8	4512590 10101	MICROSWITCH, BUMPER	PZ-11
9	4512590 10111	FAN COOLING	PZ-11
10	4512590 10121	X-RAY TUBE, DOMESTIC, PMX	PZ-2
11	4512590 10131	BEARING TRUNION	PZ-2
12	4512590 10141	ASSY, COLLIMATOR	PZ-2, PZ-5
13	4512590 10151	ASSY, BATTERY PACK (Picker/Philips-white)	PZ-2
14	4512590 10152	ASSY, BATTERY PACK (Philips - pink)	PZ-2
15	-----	ASSY, BATTERY PACK (all others - grey)	PZ-2
16	4512590 10162	ASSY, H.V.TANK	PZ-7
17	4512590 10171	ASSY, CONTROL PANEL	PZ-3
18	4512590 10181	SWITCH, PANEL MOUNT, CONSOLE (PARK)	PZ-3
19	4512590 10191	LABEL,ROTATION TUBEHD-RT (2X)	PZ-2
20	4512590 10201	LABEL,ROTATION TUBEHD-LFT(2X)	PZ-2
21	4512590 10211	LABEL, ROTATION HOUSING (2X)	PZ-2
22	4512590 10231	H.V.CABLES	PZ-2
23	4512590 10241	ASSY, HARNESS, CONSOLE	PZ-3
24	4512590 10251	ASSY, HARNESS, KEYSWITCH	PZ-3
25	4512590 10261	ASSY, RIBBON CABLE, DISPLAY PCB-J2	PZ-3
26	4512590 10271	ASSY, RIBBON CABLE, DISPLAY PCB-J1	PZ-3
27	4512590 10281	ASSY, DISPLAY BOARD	PZ-4
28	4512590 10291	ASSY, LCD DISPLAY	PZ-3, PZ-4
29	4512590 10301	ASSY, PRE-REGULATOR PCB	PZ-7
30	4512590 10311	ASSY, H.V. INVERTER PCB	PZ-7
31	4512590 10331	ASSY, ROTOR TRANSFORMER	PZ-10
32	4512590 10341	ASSY, FUSE PCB	PZ-1-
33	4512590 10363	ASSY, BATTERY CHARGER & PCB	PZ-10
34	4512590 10371	MOBILE INTERCONNECT PBC	PZ-10
35	4512590 10381	ASSY, H.V. CONTROL PCB	PZ-9
36	4512590 10391	ASSY, H.V. DRIVE PCB	PZ-9
37	4512590 10401	ASSY, FILAMENT SUPPLY PCB	PZ-9
38	4512590 10411	ASSY, ROTOR PCB	PZ-9
39	4512590 10422	ASSY, D.C. MOTOR DRIVE CONTROL	PZ-9
40	4512590 10432	CPU BOARD	PZ-7
41	4512590 10441	ASSY, POWER SUPPLY	PZ-7

ITEM	PHILIPS PART#	DESCRIPTION	ILLUSTRATON REFERENCE
42	4512590 10451	ARM INTERFACE PCB	PZ-7
43	4512590 10462	ASSY, MOTOR RELAY PCB (SN468 and up)	PZ-12
43	4512590 25091	ASSY, MOTOR RELAY PCB (SN467)	PZ-12
44	4512590 10472	ASSY, PIVOT BRAKE, ARM	PZ-6
45	4512590 10482	ASSY, PIVOT BRAKE, CLEVIS	PZ-6
46	4512590 10492	ASSY, PIVOT BRAKE, EXTENSION	PZ-6
47	4512590 10501	MAST BRAKE	PZ-8
48	----	RESERVED	
49	4512590 10513	CASTERS	PZ-2
50	4512590 10522	ASSY, POWER CORD REEL	PZ-7
51	4512590 10531	INPUT CIRCUIT BREAKER	PZ-1
52	4512590 10541	INPUT CONTACTOR	PZ-10
53	----	RESERVED	
54	4512590 10552	ASSY, HAND SWITCH	PZ-1
55	4512590 10561	LINE FILTER, RFI	PZ-12
56	4512590 10571	SWITCH, PUSHBUTTON COLLIMATOR	PZ-5
57	4512590 10581	SWITCH, POWER ON KEYSWITCH	PZ-3, PZ-4
58	----	RESERVED	
59	4512590 10592	1/4" TAPE RULE/BRACKET KIT	PZ-5
60	4512590 10601	TRANSFORMER, POWER	PZ-10
61	4512590 10611	ASSY, BUMPER	PZ-2, PZ-7, PZ-12
62	4512590 10621	CASSETTE DRAWER	PZ-1
63	4512590 10631	CASSETTE DRAWER COVER	PZ-1
64	4512590 10641	COVER UPPER LEFT	PZ-1
65	4512590 10651	COVER, LOWER LEFT	PZ-1
66	4512590 10661	COVER, UPPER RIGHT	PZ-1
67	4512590 10671	COVER, LOWER RIGHT	PZ-1
68	4512590 10681	COVER, LOWER REAR	PZ-1
69	4512590 10691	COVER,TOP	PZ-1
70	----	RESERVED	
71	4512590 10711	ASSY, CABLE, BATTERY INTERCONNECT	NOT SHOWN
72	4512590 10722	WHEEL KIT	PZ-11, PZ-12
73	4512590 10731	ASSY, RIBBON CABLE, LT SIDE PANEL	PZ-9
74	4512590 10741	ASSY, RIBBON CABLE, BOX FRAME	PZ-7
75	4512590 10751	FUSE KIT	NOT SHOWN
76	4512590 10761	PULLEY 1/2" P.X 16 GROOVE	PZ-12
77	4512590 10771	CAPACITOR, 25UF,370 VAC	PZ-9, PZ-10
78	4512590 10781	ASSY, DIODE RECTIFIER, BYV95C	PZ-10
79	4512590 10791	RESISTOR,POWER 330OHM,50W,+/-1	PZ-10
80	4512590 10801	ASSY, BRAKE DIODE PCB	PZ-6
81	4512590 10811	HOLE PLUG, BUTTON MUSHROOM, .50 DIA,	PZ-6

ITEM	PHILIPS PART#	DESCRIPTION	ILLUSTRATON REFERENCE
82	4512590 10821	ASSY, CABLE	PZ-6
83	4512590 10831	ASSY,COVERS/CABLE	PZ-6
84	4512590 10841	SHAFT, BEARING PIVOT ARM	PZ-6
85	4512590 10851	CAP, BEARING PIVOT ARM	PZ-6
86	4512590 10861	CAP,BEARING EXT ARM,LOWER	PZ-6
87	4512590 10871	SHAFT BEARING EXT ARM, LOWER	PZ-6
88	4512590 10881	CAP BEARING EXT ARM, UPPER	PZ-6
89	4512590 10891	SHAFT, BEARING EXT ARM, UPPER	PZ-6
90	4512590 10901	BATTERY LIFT ACCESSORY	NOT SHOWN
91	4512590 10911	INTERCONNECT CABLE	PZ-9
92	4512590 10932	GROUNDING STRAPS	PZ-12
93	4512590 10961	KIT, CIRCUIT BREAKER SNAP ON	PZ-1
94	4512590 10972	BUMBER, X-RAY TUBE	PZ-2
95	4512590 10981	PLUG, HANDSWITCH PMX	PZ-1
96	4512590 10991	RECEPTICLE, HANDSWITCH PMX	NOT SHOWN
97	4512590 11011	ASSY, CONSOLE PMX	PZ-2, PZ-3
98	4512590 11022	ASSY, HARNESS (R.H. COVER)	NOT SHOWN
99	4512590 11051	KIT, CABLE ASSY(CAS HLD/COVER)	NOT SHOWN
100	----	RESERVED	
101	----	RESERVED	
102	----	RESERVED	
103	4512590 11112	COLLIMATOR BULB	PZ-5
104	4512590 11121	BEARING ASSY, R SERIES	PZ-6
105	4512590 11131	BEARING ASSY, S SERIES	PZ-6
106	4512590 11141	RETAINING BEARING, EXT ARM	PZ-6
107	4512590 11151	RETAINER BEARING, PIVOT ARM	PZ-6
108	4512590 11162	CLAMP, CABLE	PZ-2
109	4512590 11171	MOUNT, CLAMP	PZ-2
110	4512590 11181	CONTROL PANEL, PRACTIX	PZ-3, PZ-4
111	4512590 11191	CONSOLE ASSY, PRACTIX	PZ-2, PZ-3
112	4512590 11201	CONSOLE OVERLAY. PRACTIX	PZ-3, PZ-4
113	4512590 11211	ACTUATOR, SWITCH CONSOLE (PARK)	PZ-3
114	4512590 11221	WASHER, LOCKBEARING-SERIES W	PZ-6
115	4512590 11231	BATTERY CHARGER 600VA	PZ-10
116	4512590 11241	BATTERY CHARGER 300VA RETRO	PZ-10
117	4512590 11251	ARM PIVOT	PZ-6
118	4512590 11261	ASSY, CASSETTE DRAWER	PZ-1
119	4512590 11271	PIN, HINGE	NOT SHOWN
120	4512590 11281	COMBINATION KIT	NOT SHOWN
121	4512590 11291	CONSOLE BUMPER KIT	PZ-1
122	4512590 11301	X-RAY TUBE BUMPER KIT	PZ-2

ITEM	PHILIPS PART#	DESCRIPTION	ILLUSTRATON REFERENCE
123	4512590 11311	PRE REGULATOR UPGRADE KIT	NOT SHOWN
124	4512590 11321	COVER, PIVOT ARM	PZ-2
125	4512590 11331	COVER, EXTENSION ARM	PZ-2
126	4512590 11341	TUBE CABLE	PZ-2
127	4512590 11352	CONSOLE COVER	PZ-3
128	4512590 11361	7A,250V NORM BLO	NOT SHOWN
129	4512590 11371	250V FAST BLO 2AG	NOT SHOWN
130	4512590 11381	3A,250V FAST BLO 2AG	NOT SHOWN
131	4512590 11391	5A,125V FAST BLO 2AG	NOT SHOWN
132	4512590 11401	4A,125V SLO BLO 2AG	NOT SHOWN
133	4512590 11411	10A,250V SLO BLO	PZ-10
134	4512590 11421	60A,250V	NOT SHOWN
135	4512590 11441	SNAP ON FRAME	PZ-1
136	4512590 11451	PCB TIMER, COLLIMATOR	NOT SHOWN
137	4512590 11461	SWITCH, PUSH BUTTON, COLLIMATOR	PZ-5
138	4512590 11471	SCREW, REAR PANEL, COLLIMATOR	PZ-5
139	4512590 11482	SCREW, STOPPER, COLLIMATOR	PZ-5
140	4512590 11431	PINK PAINT	NOT SHOWN
141	4512590 11491	KNOB, DIAL, COLLIMATOR	PZ-5
142	4512590 11501	RING, INNER, COLLIMATOR	PZ-5
143	4512590 11511	PLATE, RING, COLLIMATOR	PZ-5
144	4512590 11521	FLANGE, DIAL, COLLIMATOR	PZ-5
145	4512590 11531	INDICATOR, DIAL, COLLIMATOR	PZ-5
146	4512590 11542	MOTOR SUPPORT, COLLIMATOR	PZ-12
147	4512590 11551	COVER,PLATE (COLLIMATOR DOCK), COLLIMATOR	NOT SHOWN
148	4512590 11561	COLLIMATOR CABLE	PZ-2
149	4512590 11571	PROG EPROM VER 2.4E MOBILE	NOT SHOWN
150	4512590 11572	2.52 VERSION EPROM	NOT SHOWN
151	4512590 11581	TRUNION NUT	NOT SHOWN
152	4512590 11591	ROD CLAMP	NOT SHOWN
153	4512590 11601	BEARING, CLAMP	NOT SHOWN
154	4512590 11621	BUMPER, CONSOLE	PZ-2, PZ-3
155	4512590 11631	ASSY, CLEVIS ARM	PZ-6
156	4512590 11641	ARM	PZ-6
157	4512590 11651	SOFTWARE UPGRADE KIT	NOT SHOWN
158	4512590 11661	KIT, 3.0 AEC UPGRADE PMX	NOT SHOWN
159	4512590 11662	KIT, S/W UPGRADE V3. 0.1 PMX	NOT SHOWN
160	4512590 11671	KEY, SWITCH (PART OF ITEM 57)	PZ-4
161	4512590 11681	DESICCANT DRYING TUBE	NOT SHOWN
162	4512590 11691	3.0 VERSION AEC EPROM	NOT SHOWN
163	4512590 11701	BUMPER, BASE	PZ-11

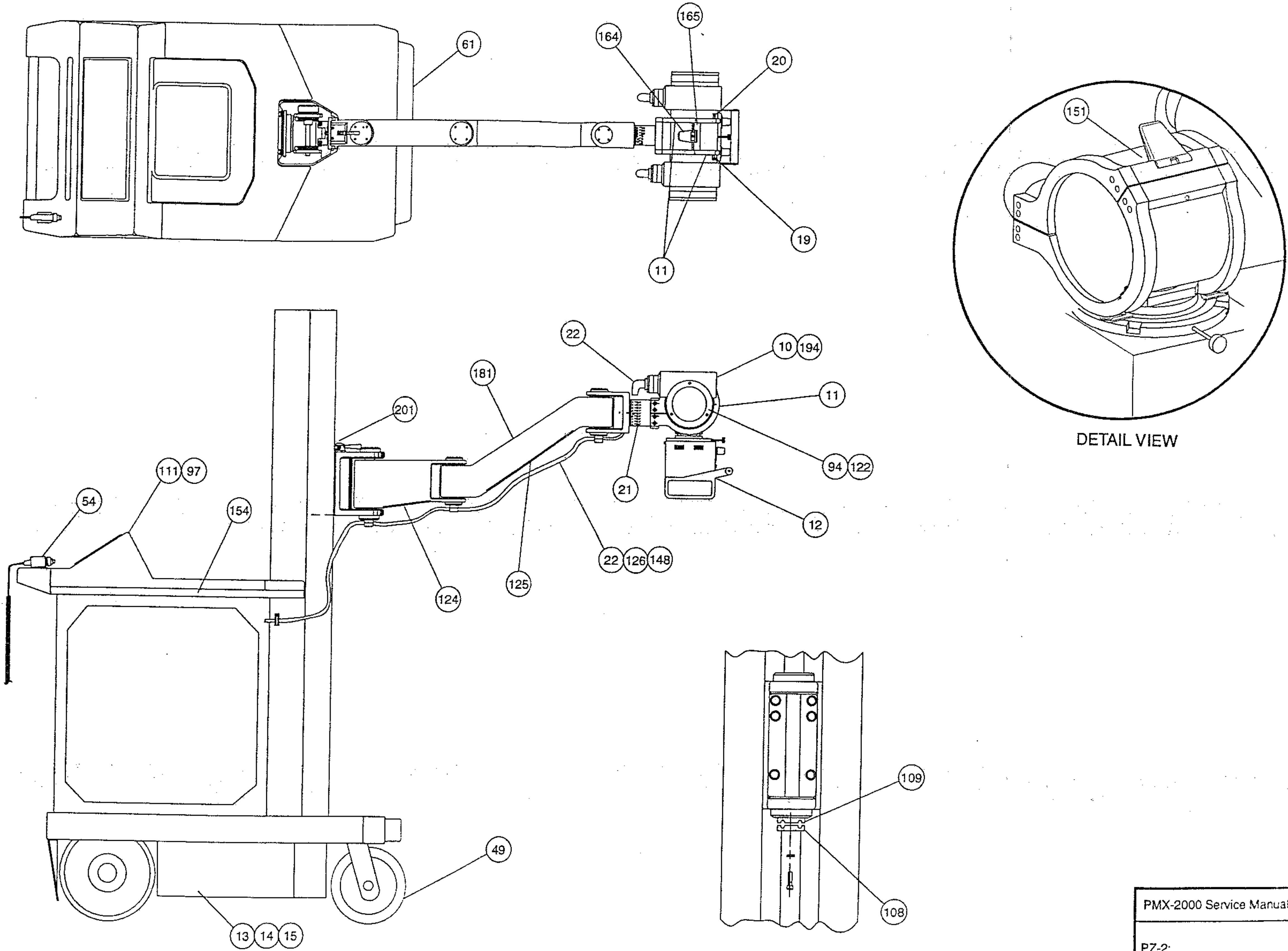
ITEM	PHILIPS PART#	DESCRIPTION	ILLUSTRATON REFERENCE
164	4512590 11711	LEVER, CLAMP	PZ-2
165	4512590 11721	CLAMP	PZ-2
166	4512590 11741	MOD, PIN DOWEL	NOT SHOWN
167	4512590 11751	BUSHING, TAPER-LOCK	PZ-12
168	4512590 11761	PULLEY ASSY	PZ-8
169	4512590 11771	PULLEY ASSY	NOT SHOWN
170	4512590 11781	KIT, 3.0 AEC UPGRADE (PRACTIX)	NOT SHOWN
171	4512590 11782	KIT, S/W UPGRADE V3.0.1 PRACTX	NOT SHOWN
172	4512590 11791	KIT, COLLIMATOR LAMP REPLACE	NOT SHOWN
173	4512590 11801	CASSETTE DRAWER HINGE KIT	NOT SHOWN
174	4512590 11811	MOTOR SHAFT KEY	NOT SHOWN
175	4512590 11821	MAIN WIRING HARNESS	PZ-9
176	4512590 11831	FILTRATION LABEL	NOT SHOWN
177	4512590 11841	CARRIAGE SUPPORT	PZ-6
178	4512590 11851	KIT, EXPOSURE HAND SWITCH REPL	PZ-1
179	4512590 11861	KIT, COMBINATION MOBILE #2	NOT SHOWN
180	4512590 11871	FUSE, ONE TIME 250VAC	PZ-10
181	4512590 11881	ARM ASSY	PZ-2
182	4512590 11891	FUSE, CERM,-SLO-BLO 15AMP	NOT SHOWN
183	4512590 11901	FUSE, CERM.-SLO-BLO 20AMP	PZ-10
184	4512590 11911	DRIVE AXLE	PZ-11, PZ-12
185	4512590 11921	FASTENER,RECEPTACLE-1/4T	NOT SHOWN
186	----	RESERVED	
187	4512590 11941	RETAINER, FRONT BUMPER	PZ-11
188	4512590 11951	RETAINER, REAR BUMPER	PZ-1
189	4512590 11961	SHIELDED FLAT CABLE, CPU PCB-J201	NOT SHOWN
190	4512590 11981	SCREW, SHS 1/4 X 3/4 LG	NOT SHOWN
191	4512590 11991	KIT, PRATIX 120V CONVERSION	NOT SHOWN
192	4512590 12991	AUX PUSHBUTTON BRAKE RELEASE	PZ-6
193	4512590 25021	KIT, FMI, DRIVE PCB REPLACEMNT	NOT SHOWN
194	4512590 25032	X-RAY TUBE, INTERNATIONAL, PRACTIX2000	PZ-2
195	4512590 25041	RESISTOR 20 OHM 50 WATT	PZ-9
196	4512590 25061	ASSY, FAN INTERFACE BD.	PZ-12
197	4512590 25071	STOP SWITCH, EMERGENCY "OFF"	PZ-3
198	4512590 25051	SCREW, SHC 6-32 UNC-3A X 1/2	NOT SHOWN
199	4512590 25081	BUMPER SPRING, COMPRESSION	PZ-11
200	4512590 25101	RELEASE, BRAKE DRIVE MOTOR	PZ-12
201	4512590 25111	ASSY, ARM TRANSPORT LOCK	PZ-2
202	4512590 25121	ASSY, PULLEY-MAST (BOTTOM)	PZ-8
203	4512590 25141	EPROM, MAIN MOBILE, V3.0.5	NOT SHOWN
204	4512590 25161	KIT, DR. SYSTEM UPGRADE, PHILIPS	NOT SHOWN



PMX-2000 Service Manual

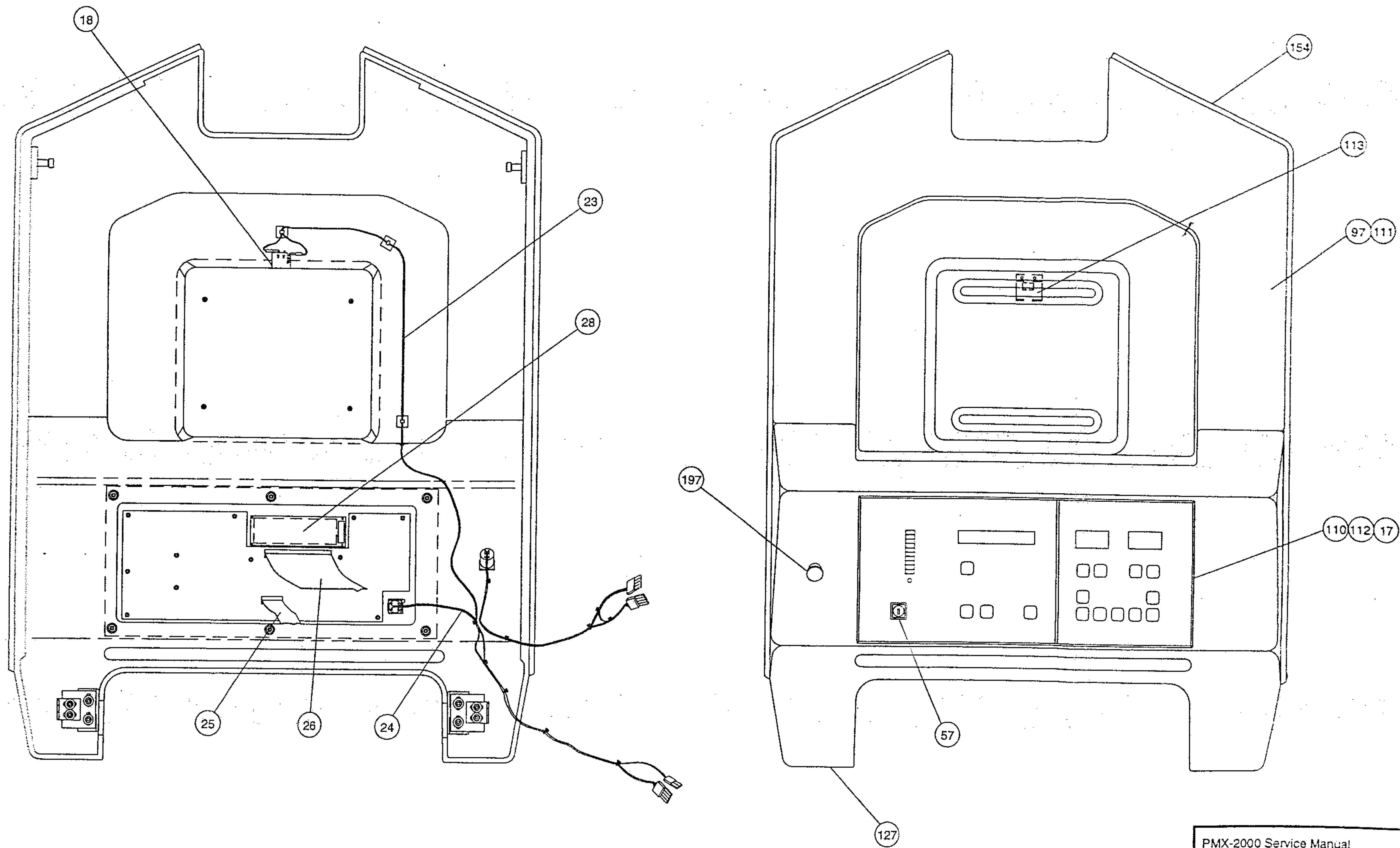
PZ-1:
MOBILE FINAL ASSEMBLY

(98.0) 4535-800-28641



PMX-2000 Service Manual

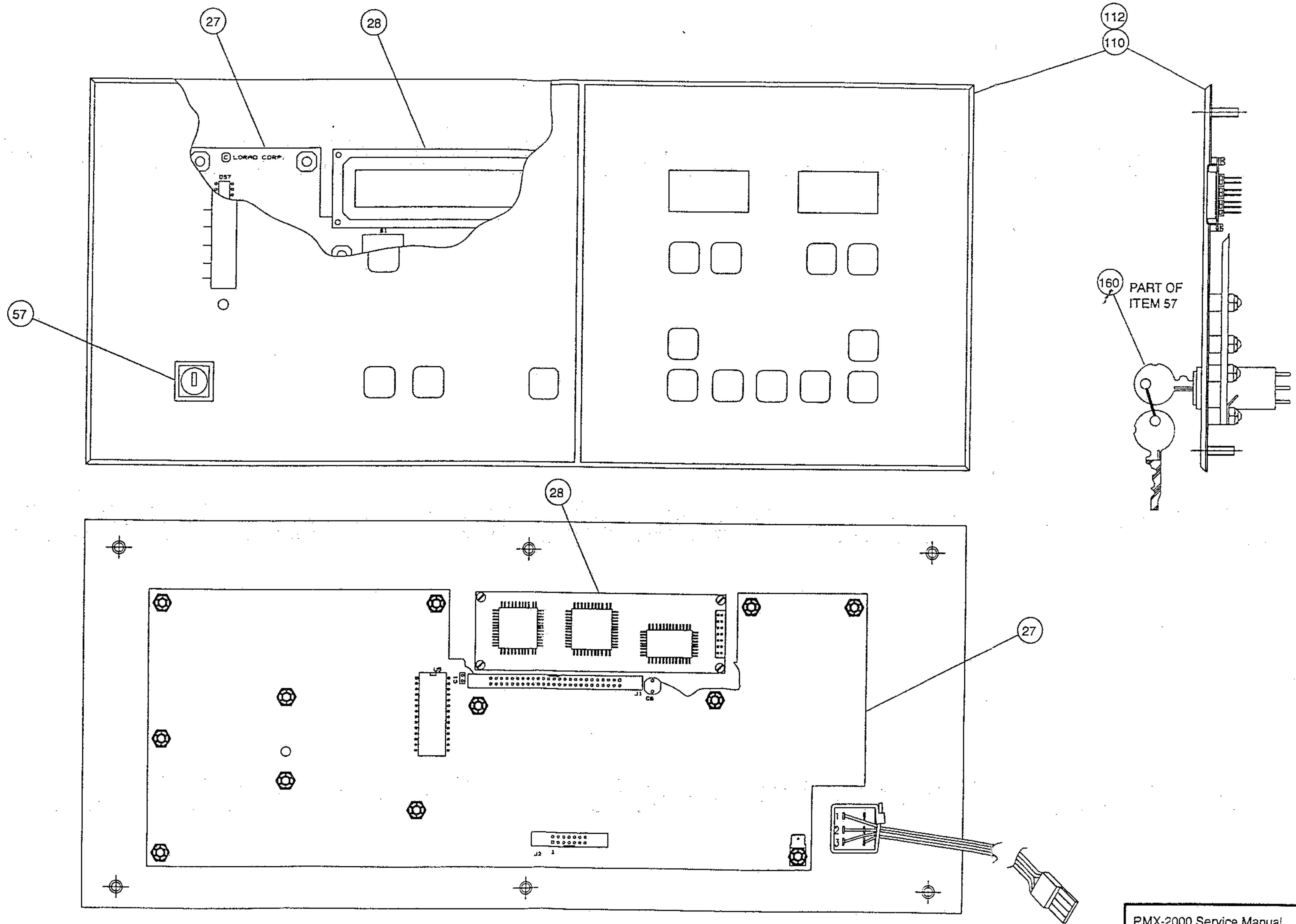
PZ-2:
MOBILE MAIN ASSEMBLY



PMX-2000 Service Manual

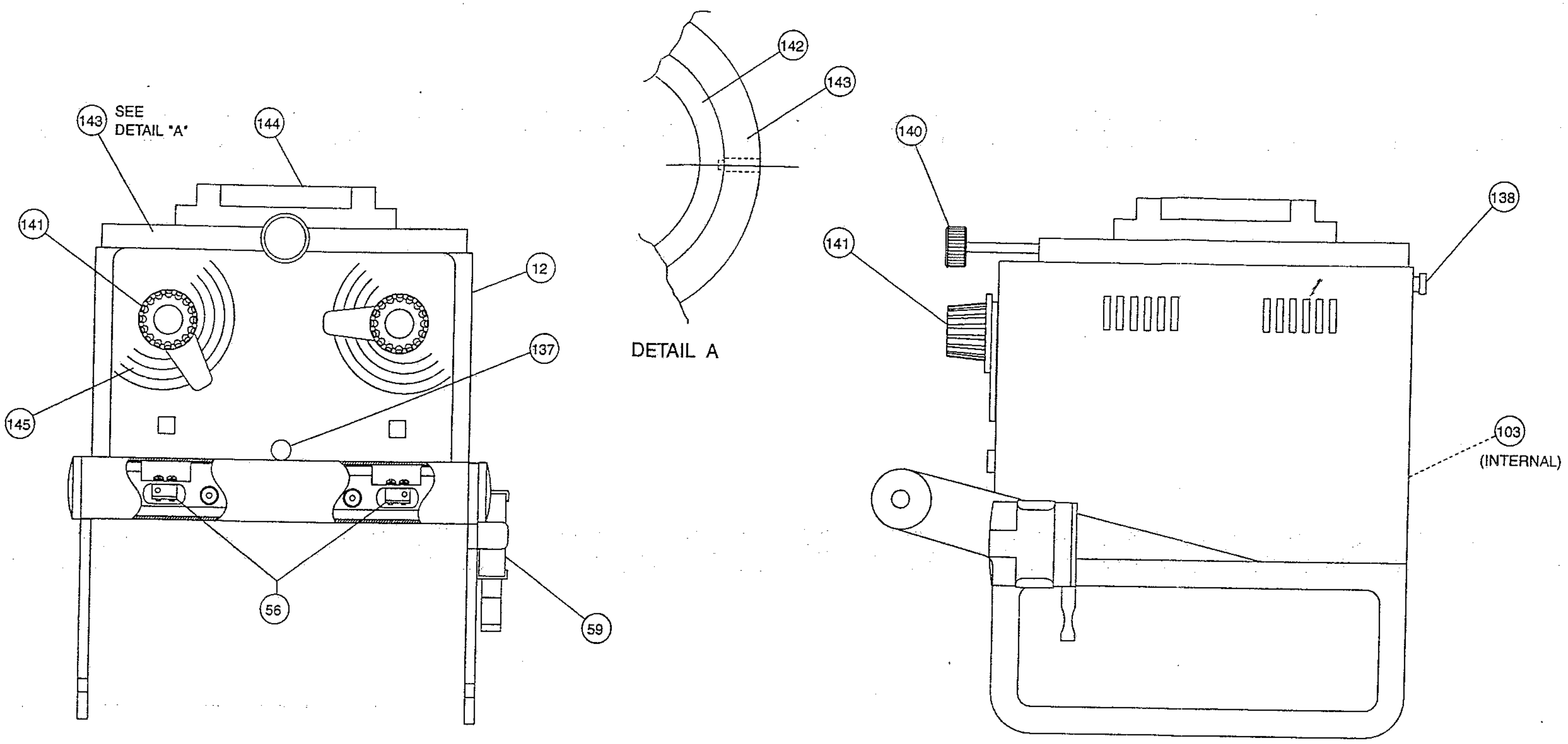
PZ-3:
CONSOLE ASSEMBLY

(98.0) 4535-800-28641



PMX-2000 Service Manual

PZ-4:
CONTROL PANEL ASSEMBLY



PMX-2000 Service Manual

PZ-5:
COLLIMATOR ASSEMBLY

(98.0) 4535-800-28641

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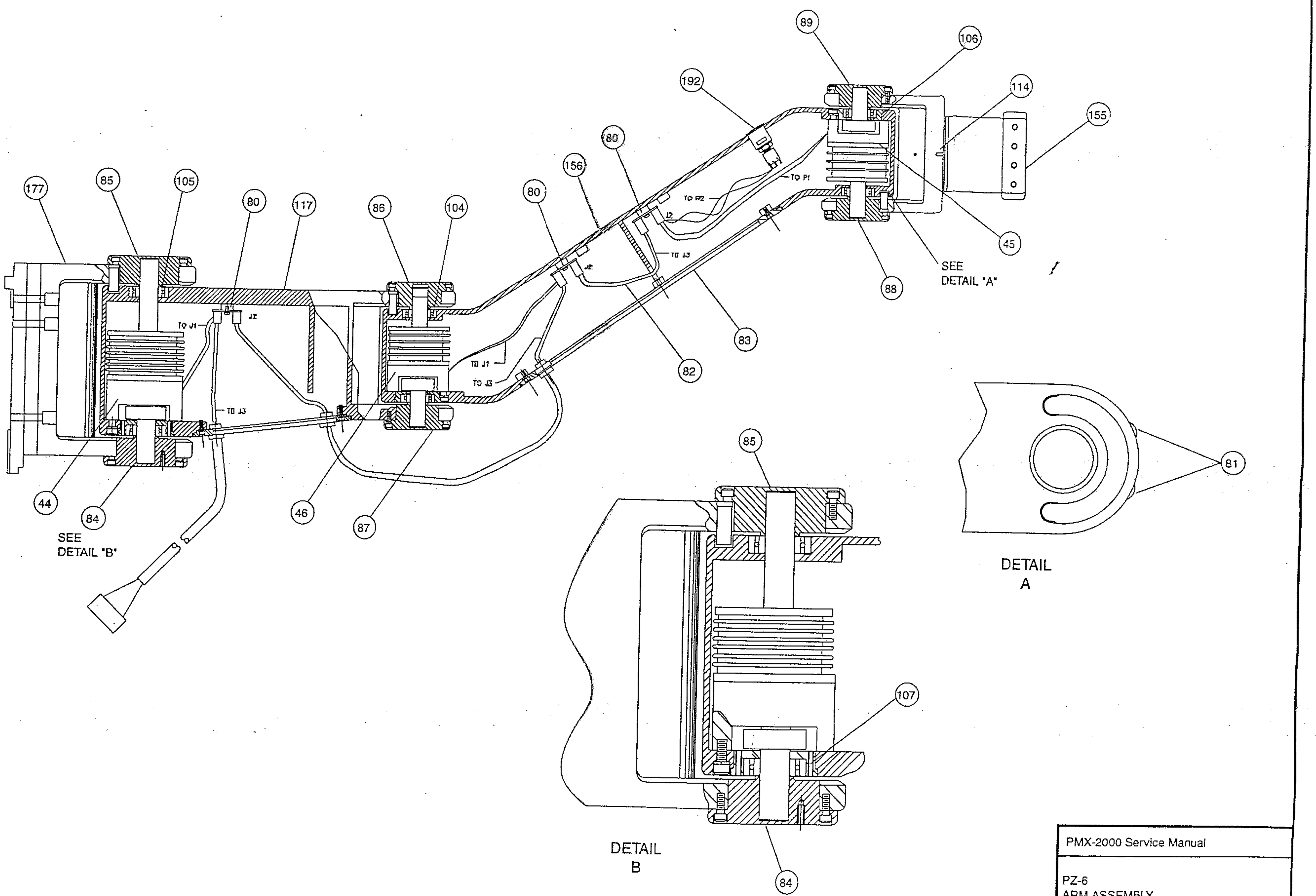
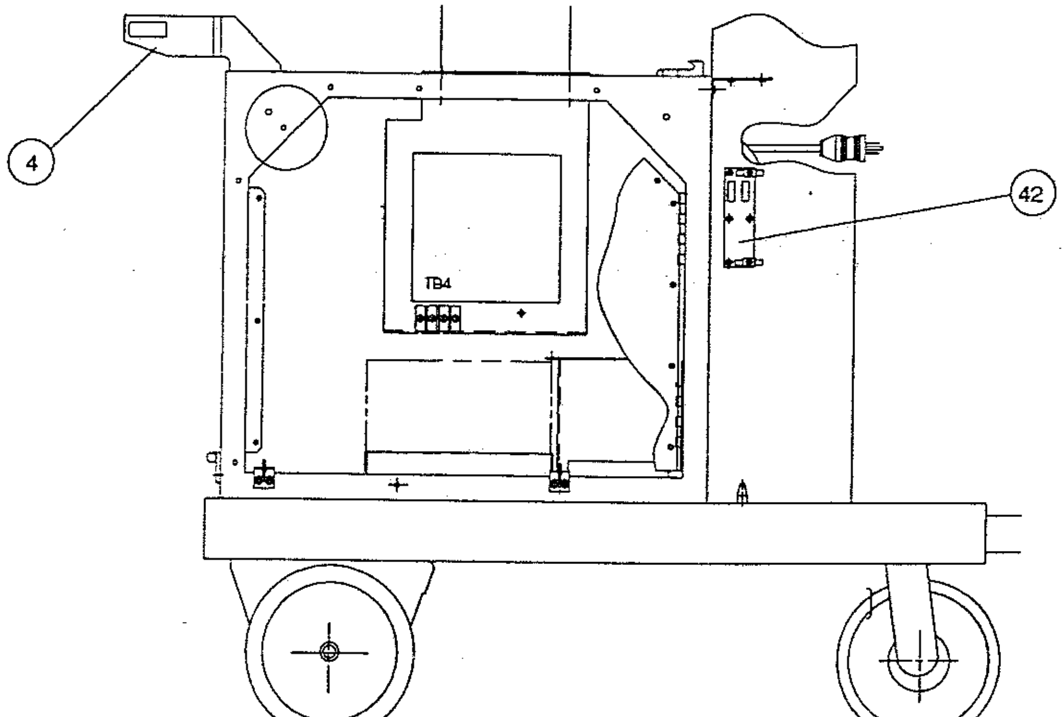


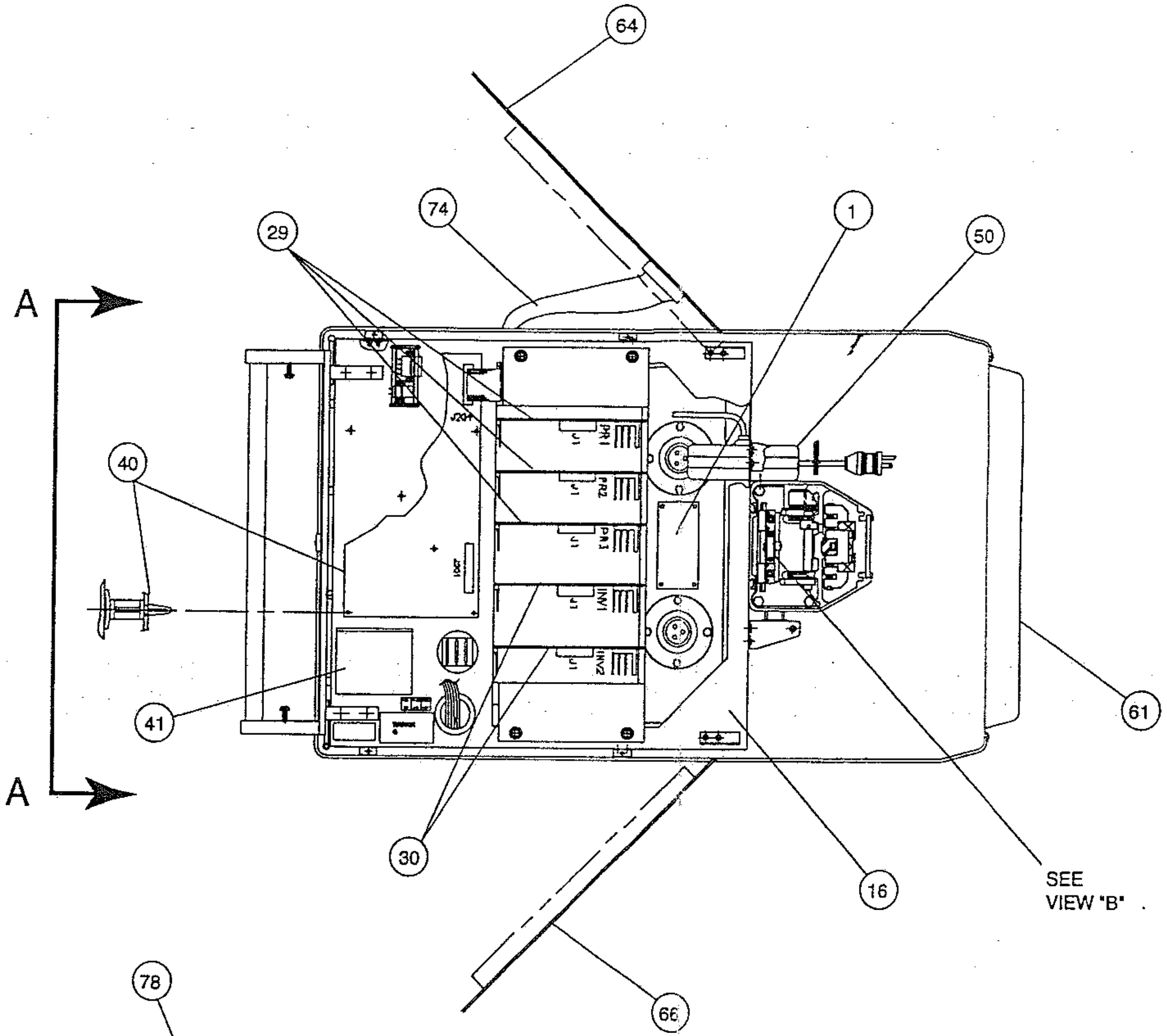
PMX-2000 Service Manual

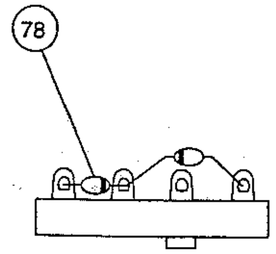
PZ-6
ARM ASSEMBLY

(98.0) 4535-800-28641

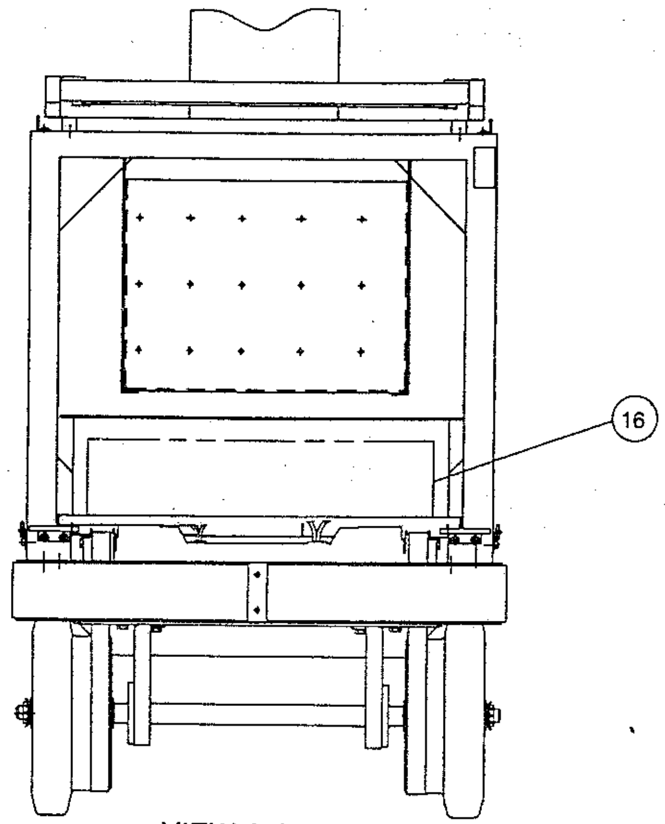


RIGHT SIDE VIEW



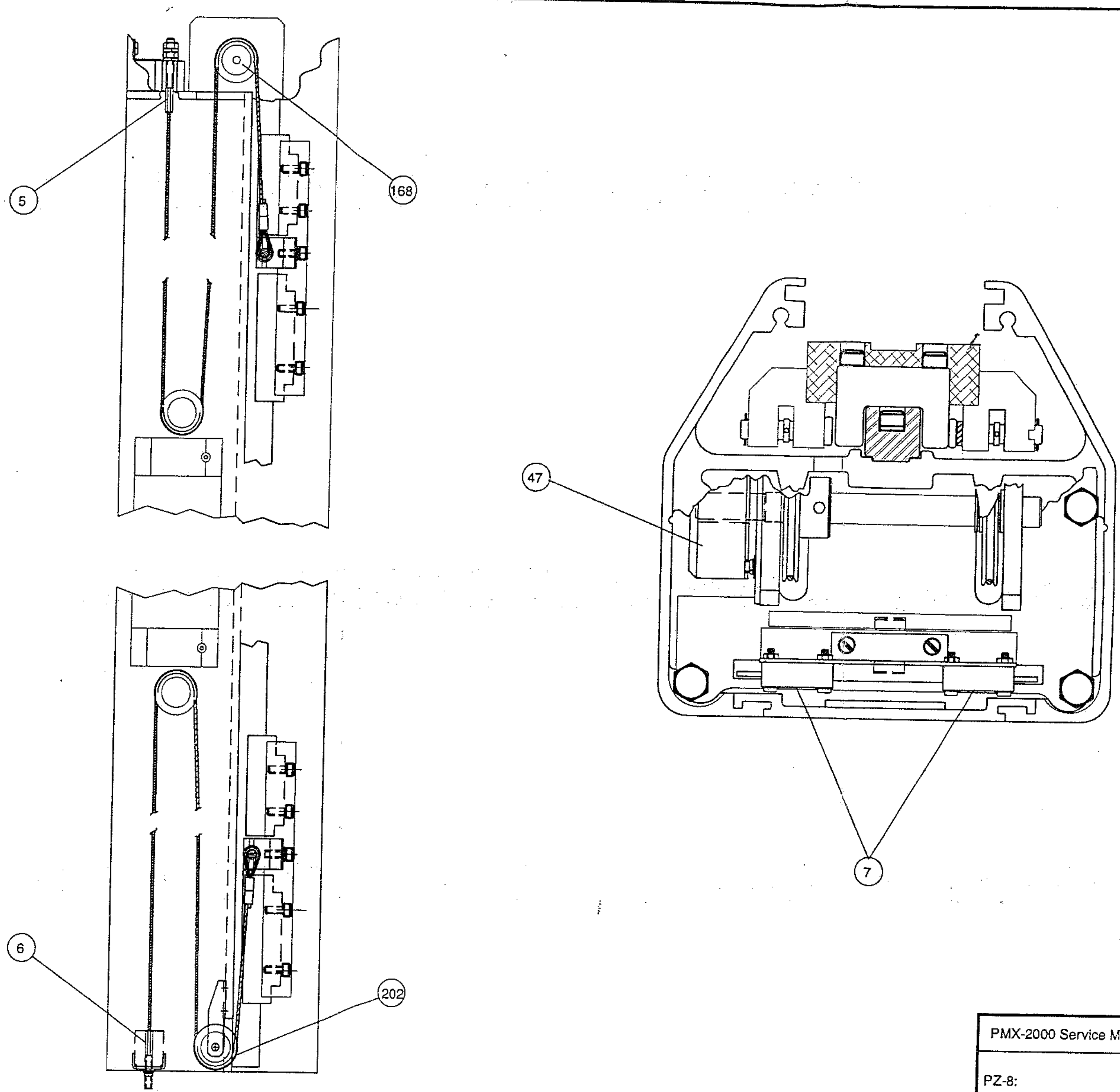


VIEW B



VIEW A-A

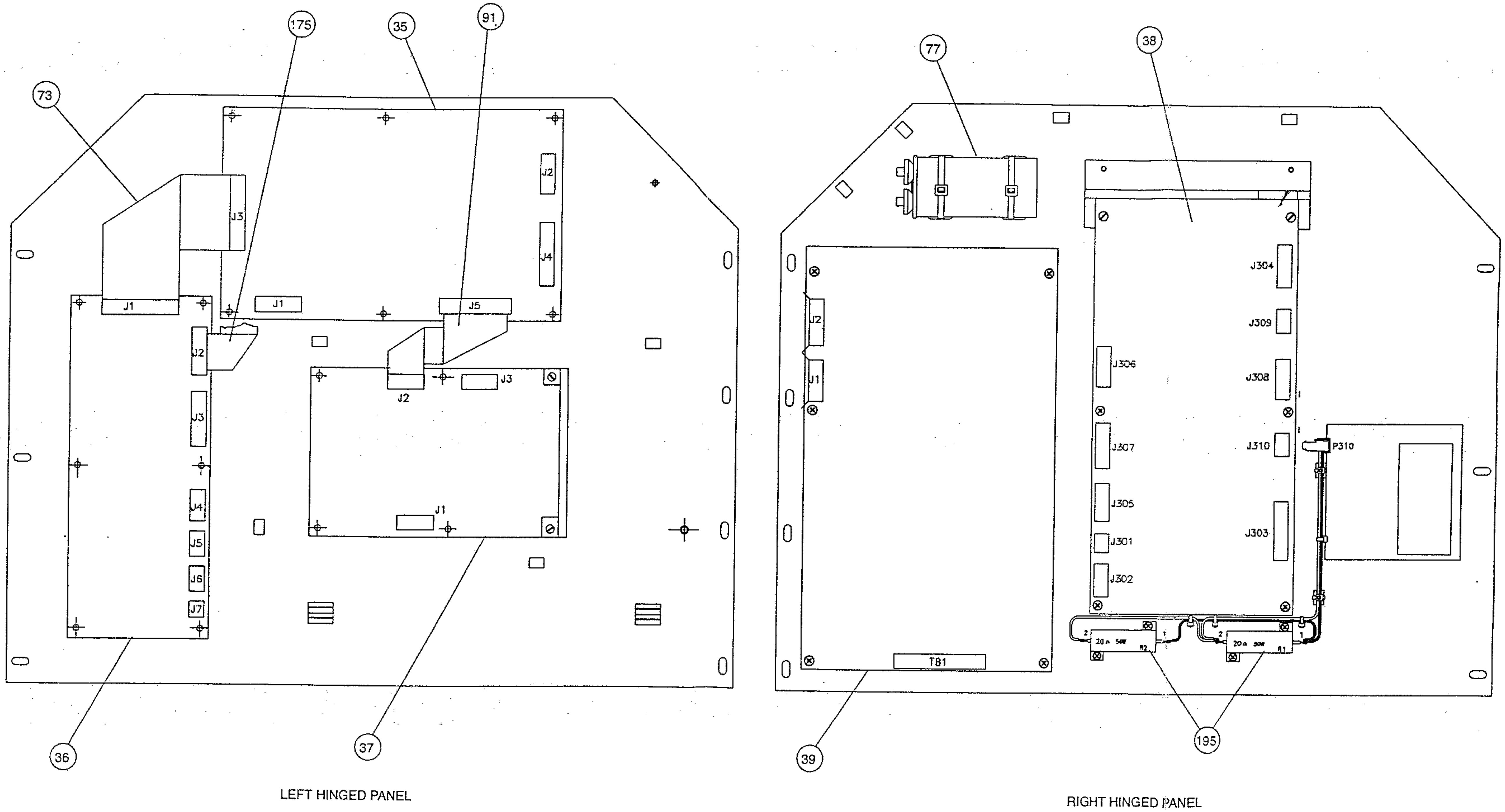
PMX-2000 Service Manual
PZ-7: BASE/FRAME ASSEMBLY



PMX-2000 Service Manual

PZ-8:
MAST ASSEMBLY

(98.0) 4535-800-28641



LEFT HINGED PANEL

RIGHT HINGED PANEL

PMX-2000 Service Manual
PZ-9: HINGED PANEL ASSEMBLIES

(98.0) 4535-800-28641

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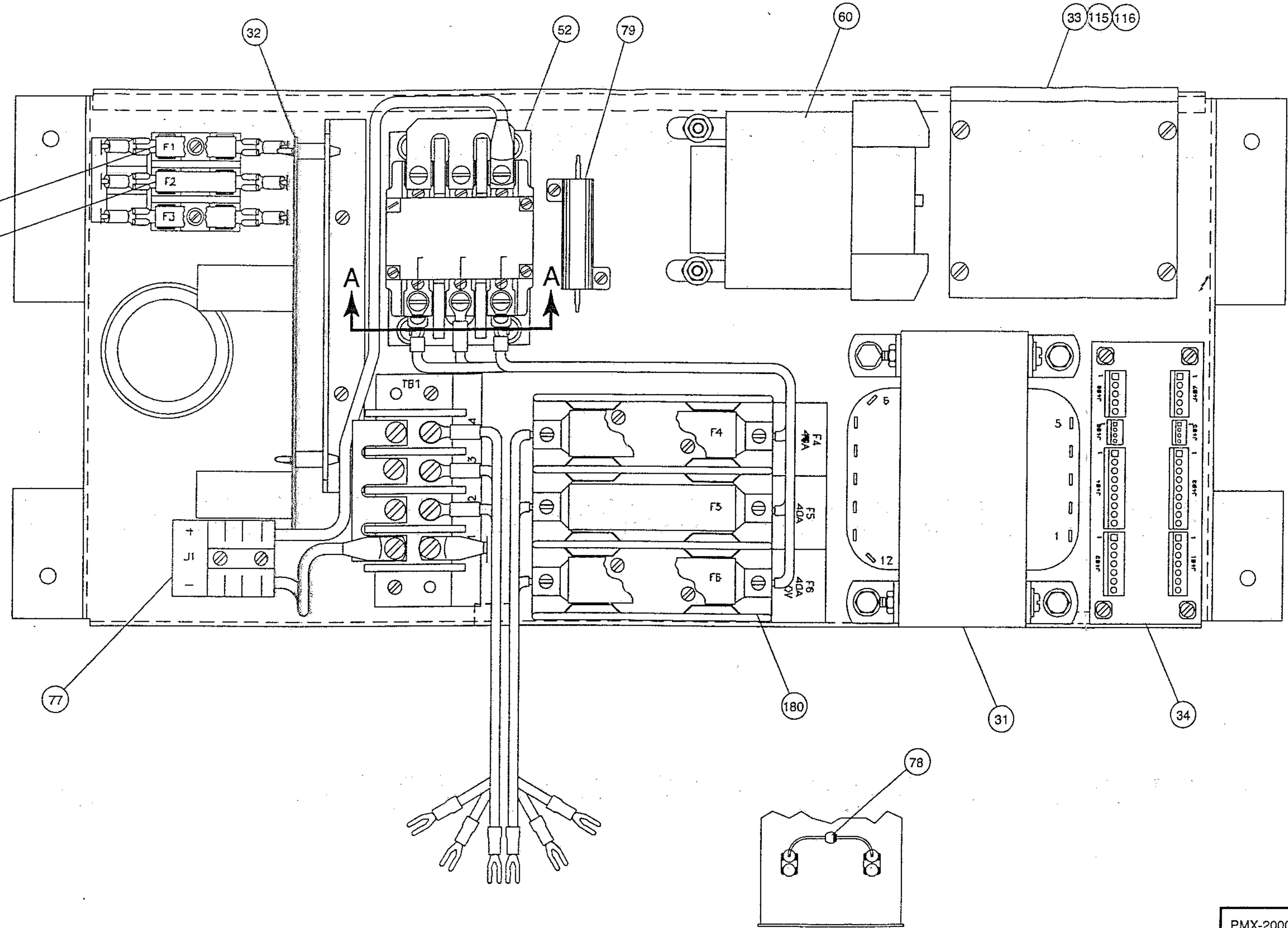
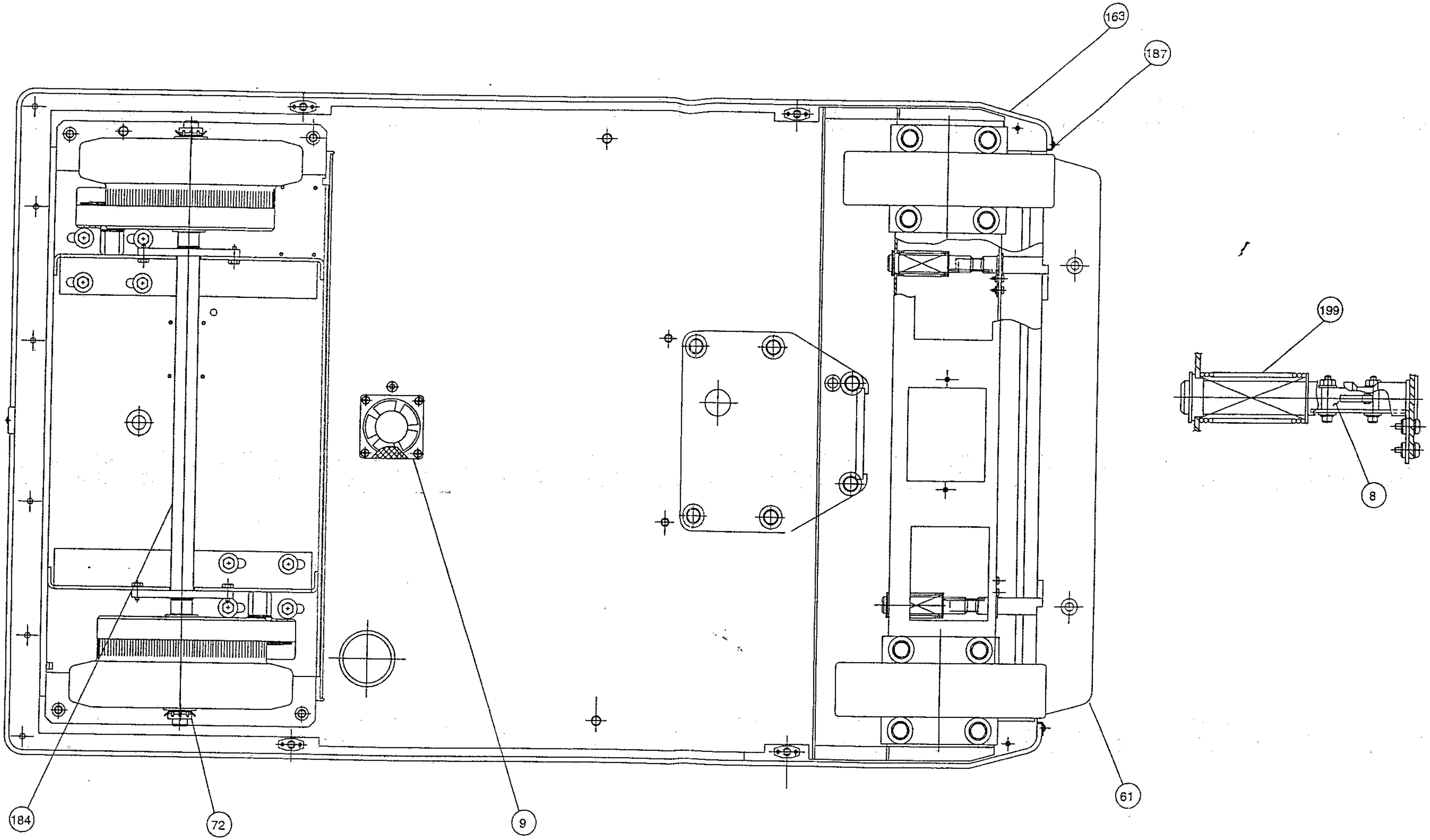


VIEW A-A

PMX-2000 Service Manual

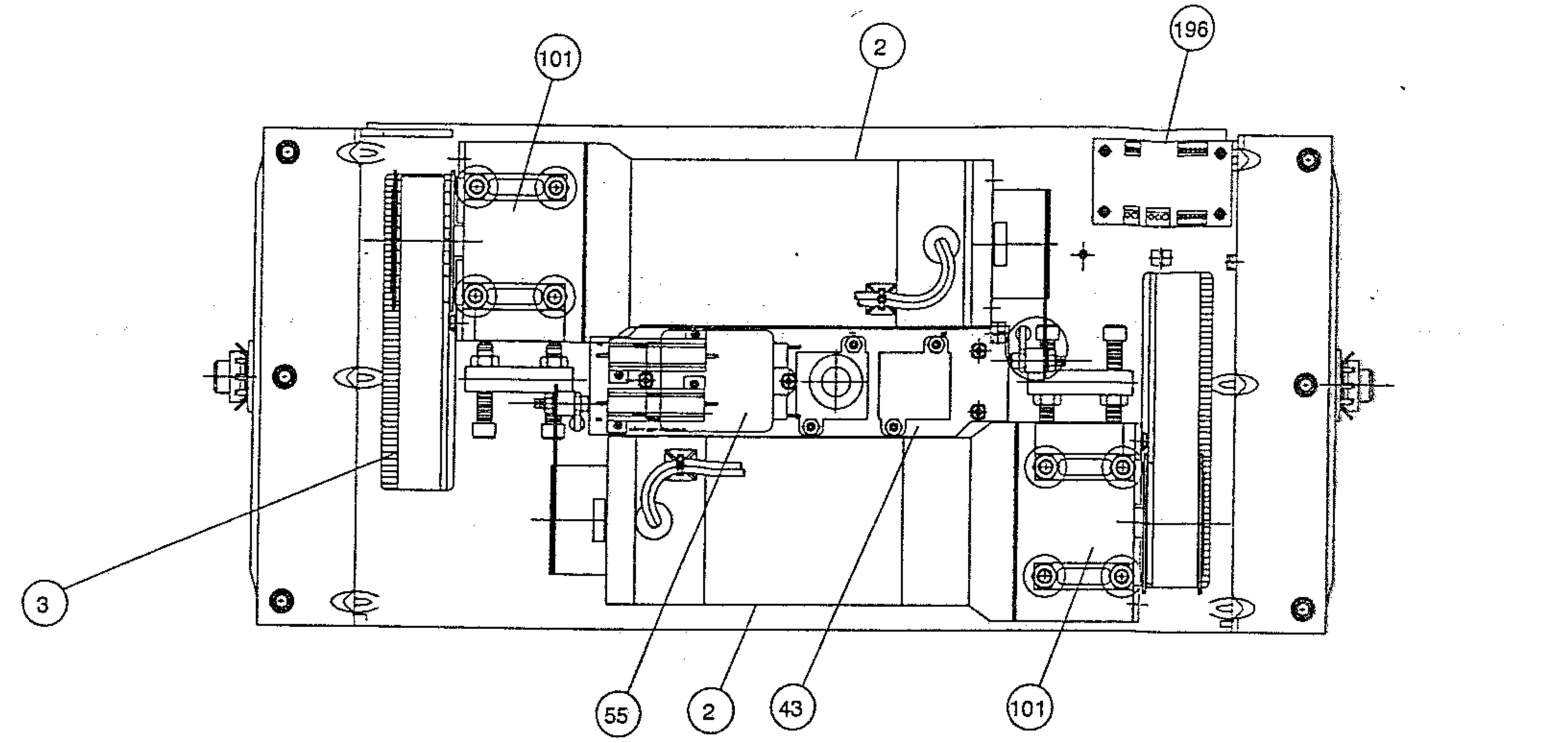
PZ-10:
POWER CONTROL ASSEMBLY

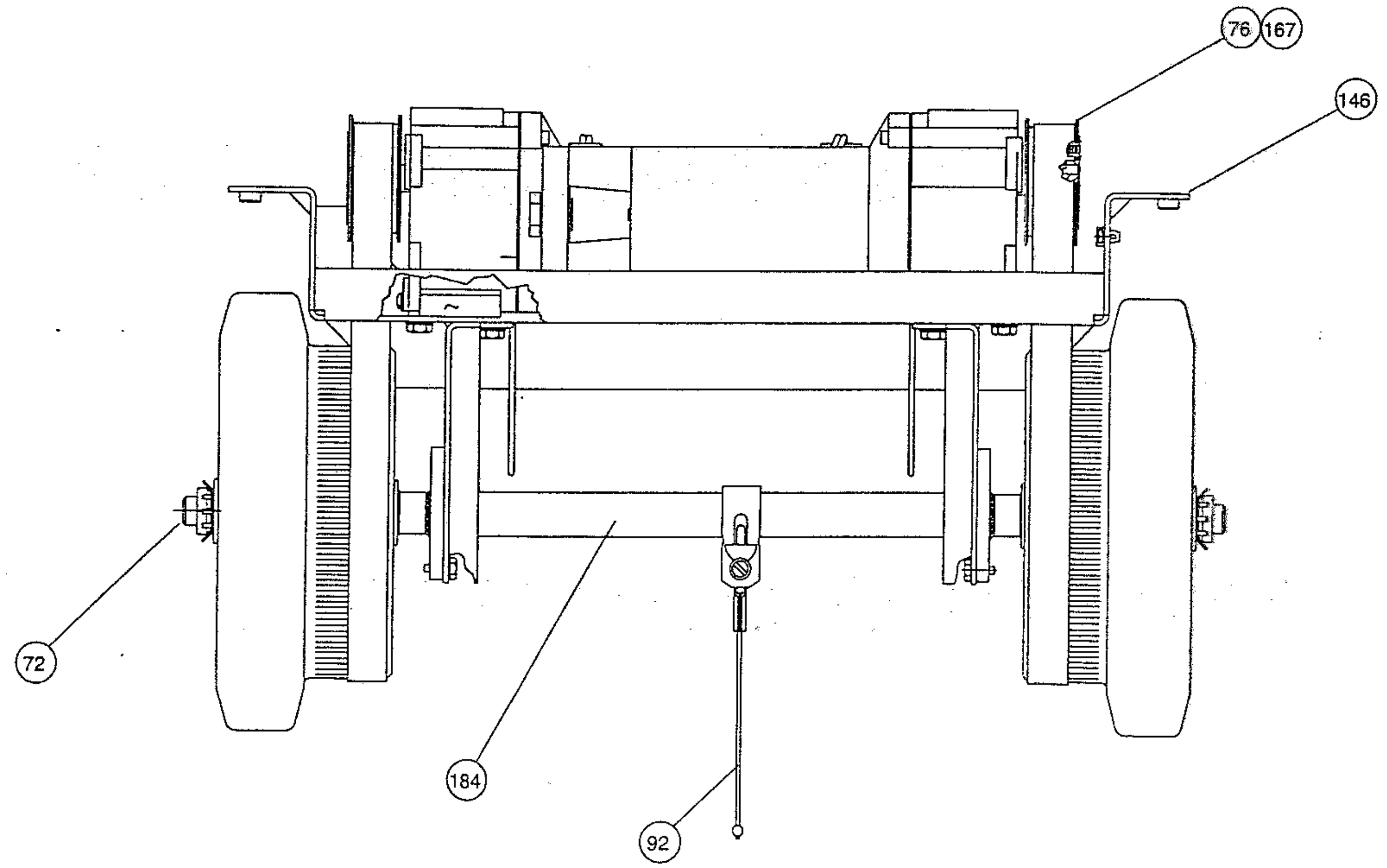


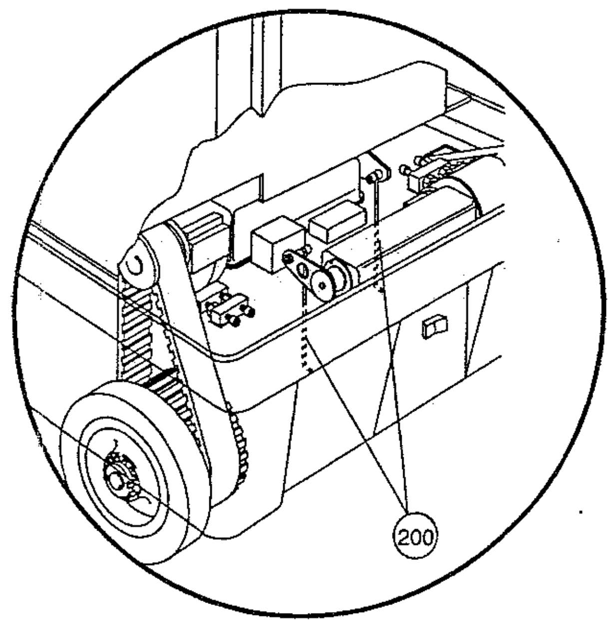
PMX-2000 Service Manual

PZ-11:
BASE SUB-ASSEMBLY

(98.0) 4535-800-28641







DETAIL VIEW

PMX-2000 Service Manual

PZ-12:
WHEEL DRIVE ASSEMBLY

DIAGRAMS

Wiring Diagram, Overall System (sheet 1 of 3) Z1-1
Wiring Diagram, Overall System (sheet 2 of 3) Z1-2
Wiring Diagram, Overall System (sheet 3 of 3) Z1-3
Wiring Diagram, Motor Relay Board Z1-4

Overall Wiring Diagrams (Z1-1 through Z1-3) use letter designations A through GG to identify the following major assemblies:

A. .... High Voltage Tank
B. .... Rotor PC Board
C. .... High Voltage Control PC Board
D. .... High Voltage Driver PC Board
E. .... Right Side Panel
F. .... Filament PC Board
G. .... Fuse PC Board
H. .... Drive Motor Control PC Board
J. .... Microprocessor PC Board
K. .... Low Voltage Power Supply
M. .... Motor Interface PC Board
P. .... Power Control Chassis
S. .... Fan Interface PC Board
T. .... Arm Nest Switch
U. .... Control Panel
X. .... Main Buss Bar
W. .... Drive Control Handle
Z. .... Circuit Breaker
AA. .... Arm Interface PC Board
CC. .... Line Filter
DD. .... Line Cord Reel
EE. .... HV Inverter/Preregulator Card Cage
GG. .... Ground Lug

111

SCHEMATICS

Schematic, Microprocessor PC Board (sheet 1 of 2) Z2-1
Schematic, Microprocessor PC Board (sheet 2 of 2) Z2-2
Schematic, Display PC Board Z2-3
Schematic, Fuse PC Board Z2-4
Schematic, Rotor PC Board (sheet 1 of 2) Z2-5
Schematic, Rotor PC Board (sheet 2 of 2) Z2-6
Schematic, H.V. Control PC Board Z2-7
Schematic, Pre-Regulator PC Board Z2-8
Schematic, H.V. Driver PC Board Z2-9
Schematic, Filament PC Board Z2-10
Schematic, L.V. Feedback PC Board Z2-11
Schematic, Mobile Interconnect PC Board Z2-12
Schematic, Diode Brake PC Board Z2-13
Schematic, Fan Interface Board Z2-14
Schematic, Arm Interface Board Z2-15
Schematic, H.V. Inverter PC Board Z2-16
Schematic, Battery Charger Board Z2-17
Schematic, Motor Relay Board Z2-18
Schematic, H.V. Tank Z2-19

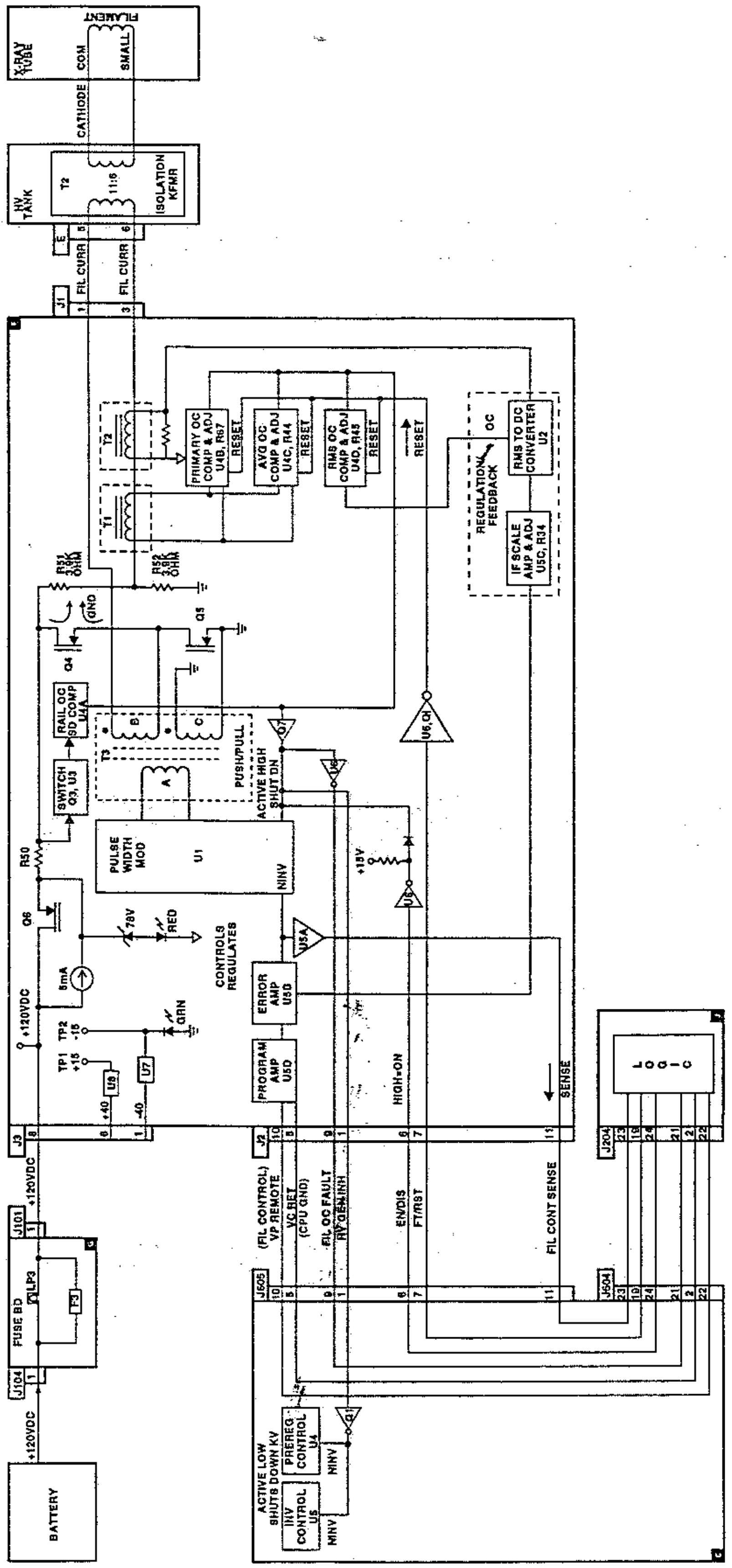


Figure GZ-5

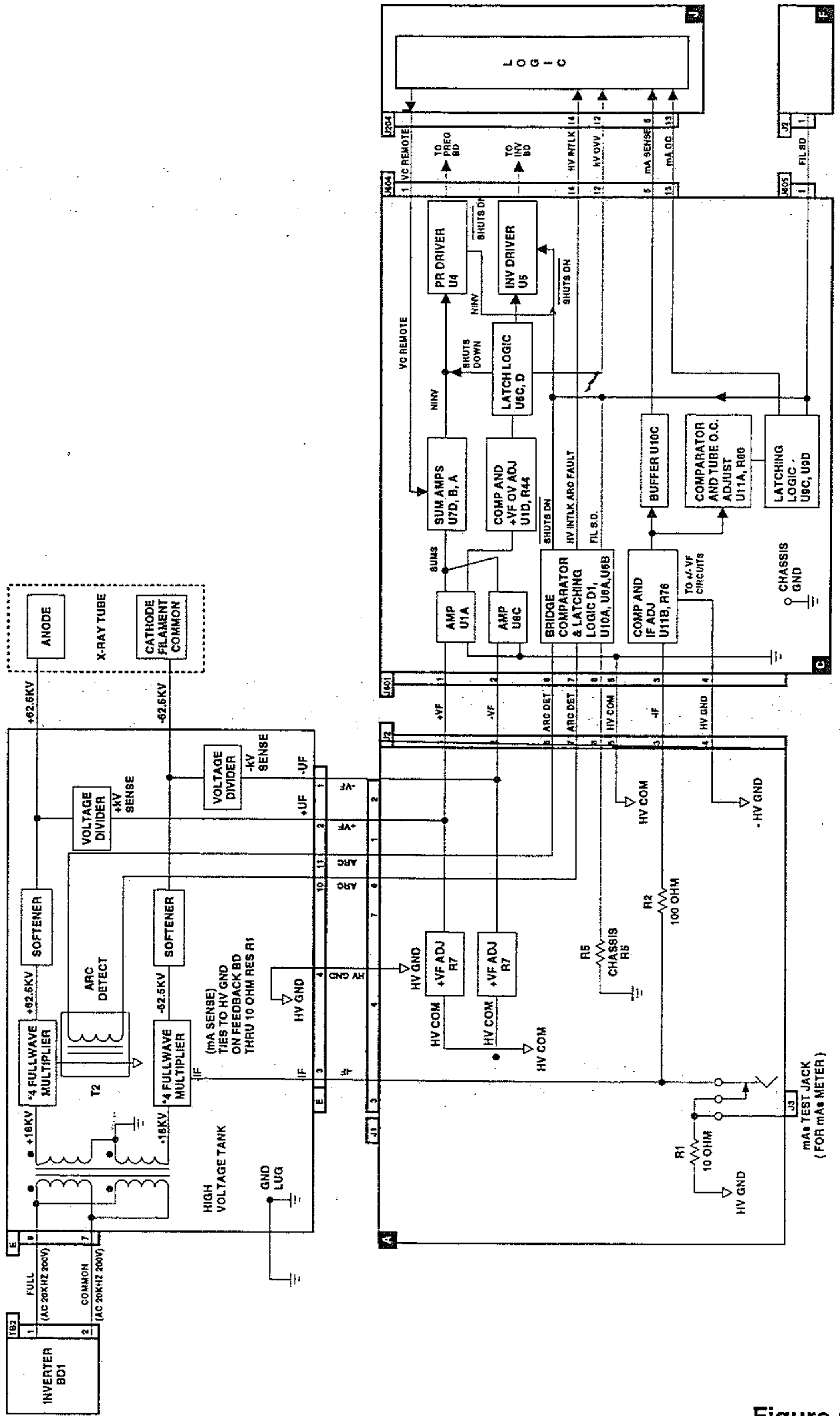
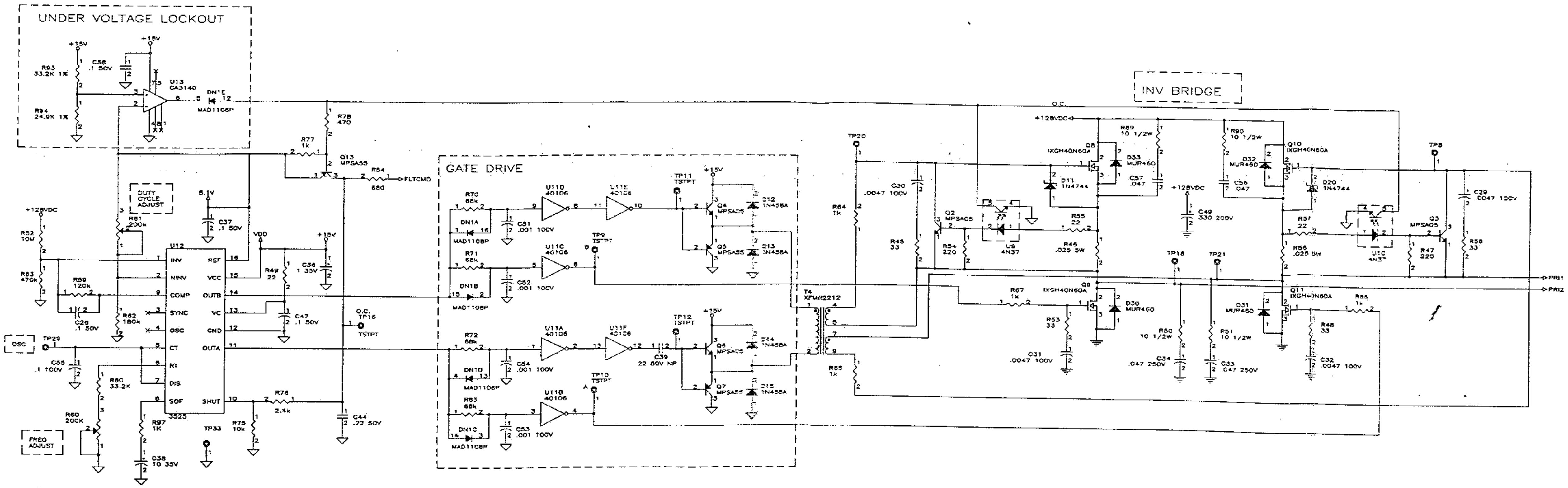
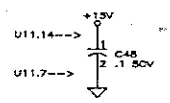
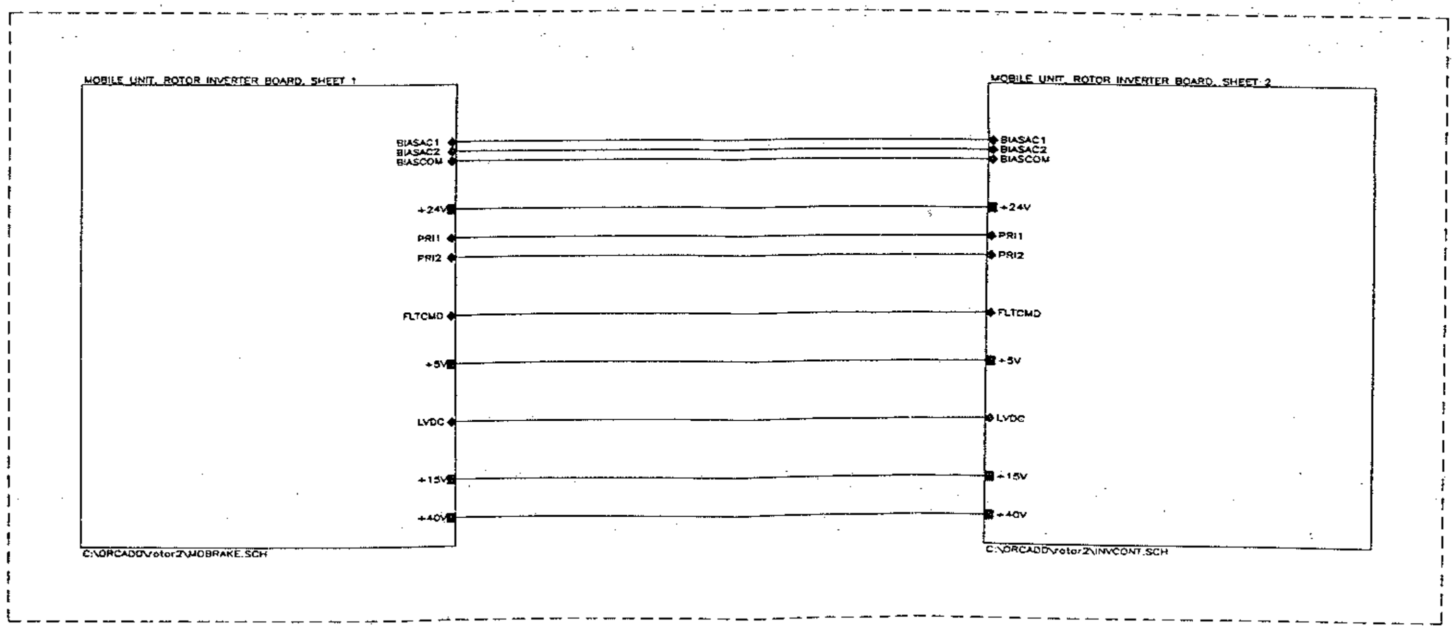


Figure GZ-4

113





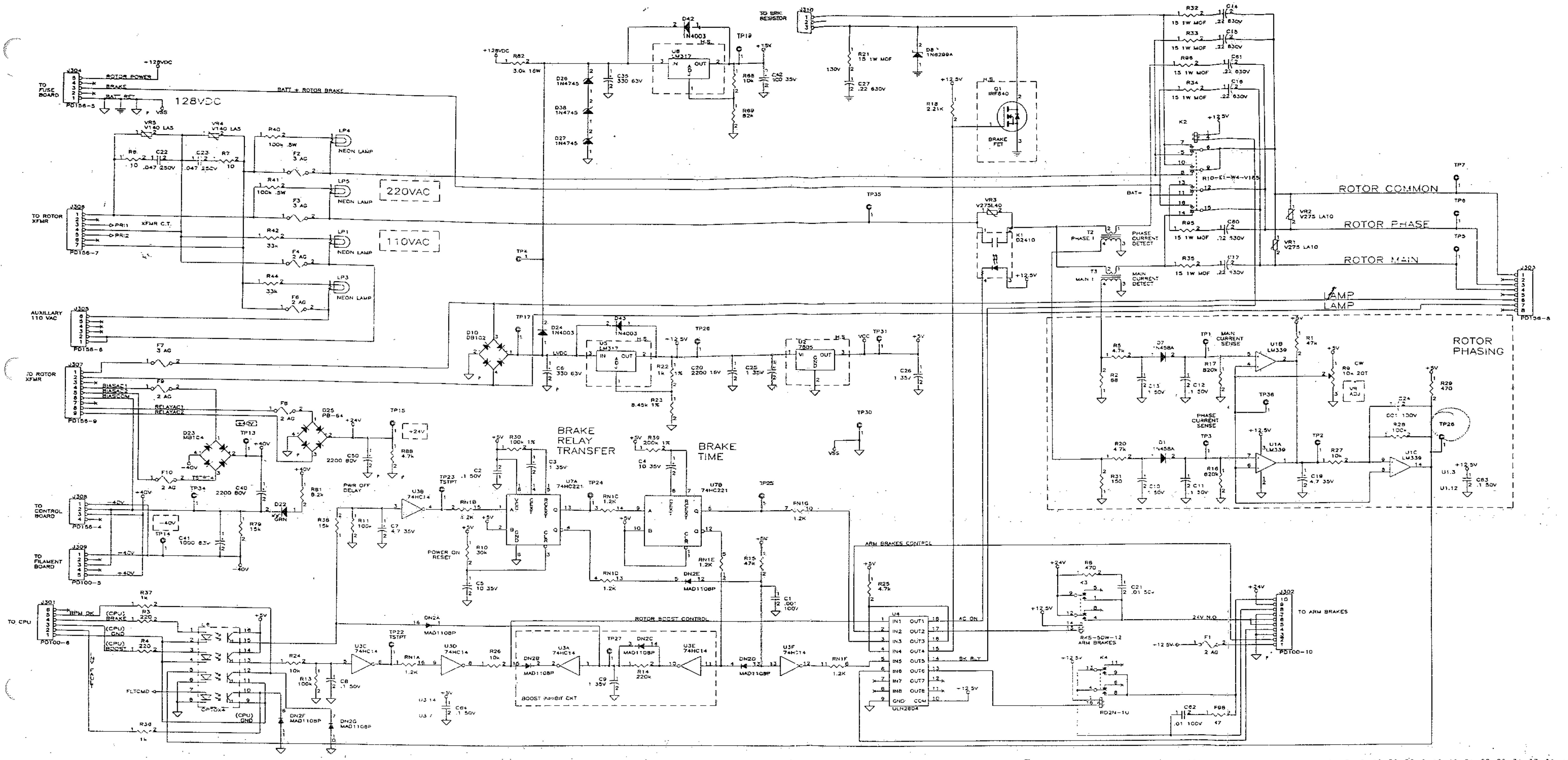


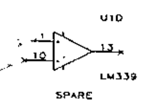
SHEET REFERENCE CHART

✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000
SCHEMATIC, ROTOR PC BOARD (Sheet 2 of 2)
(98.0) Z2-6

1-004-0223-R2





IC	LOCATION	#PINS	VCC	GND
LM339	U1	14	3	12
7805	U2	3	3	2
74HC14	U3	14		
ULN2804	U4	10	10	9
LM317	U5 8 13	3		
74HC221	U7	16	2 10	8
4N37	U9 10			
40106	U11	14		
3525	U12	16	15	12

and

12,5
1

3
7

5. REFERENCE DESIGNATIONS NOT USED: C18, 43, 45–48, 59, D2–6, 16–19, 21, 28, 29, 34–37, 39–41, F5, LP2, Q14, R12, 19, 43, 58, 73, 74, 85–87, 89–92, TP32, T1.

4 REPLACES 1-004A-0189.

3. HIGHEST REFERENCE DESIGNATION USED: C62, D43, F10, J310, K4, LP5, Q14, R98, T4, TP36, U12, VR5

2 ALL CAPACITANCE IS IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS ARE 1/4W 5% AND RESISTANCE IS IN OHMS UNLESS OTHERWISE SPECIFIED

NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

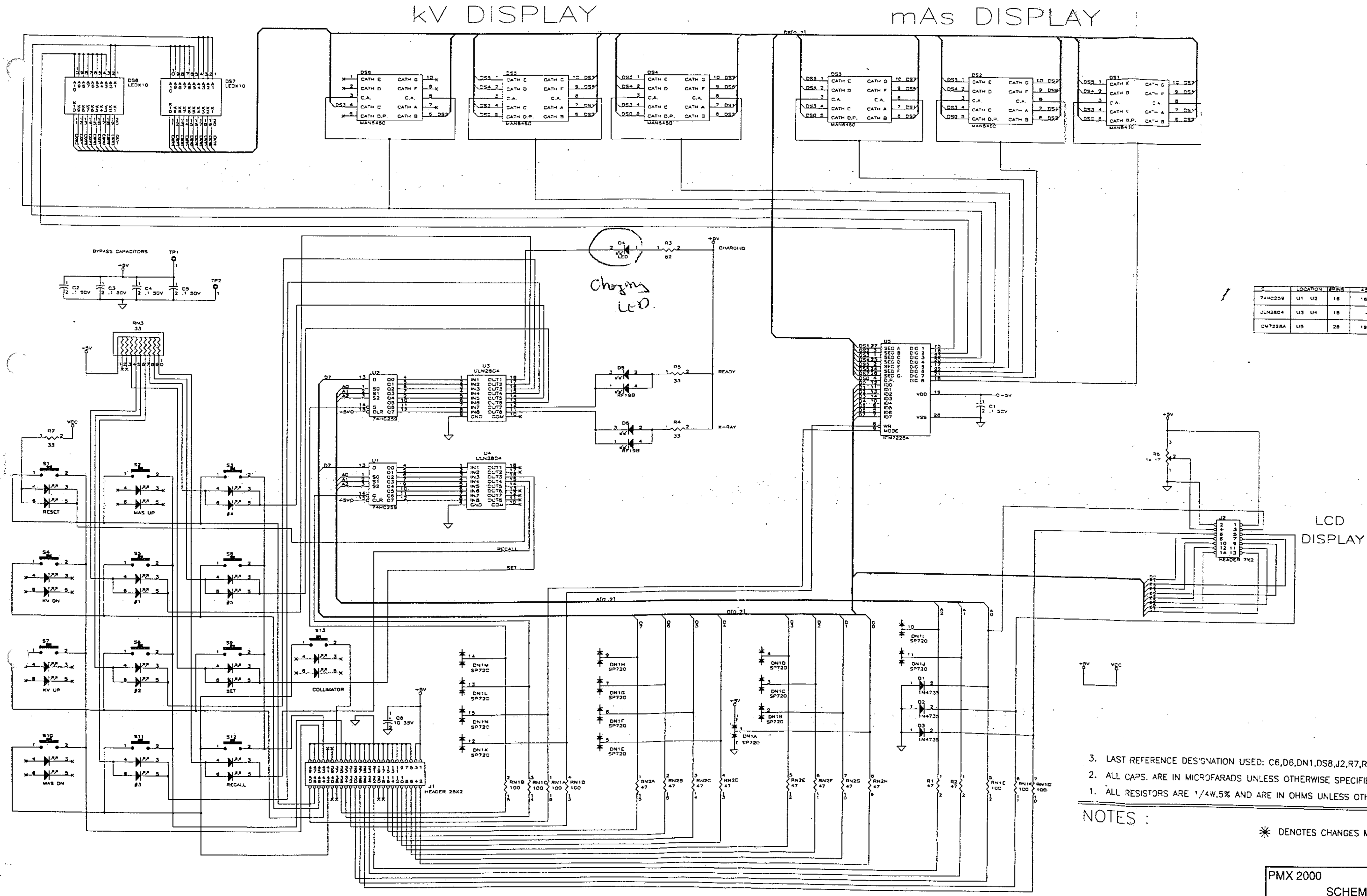
PMX 2000

SCHEMATIC,
ROTOR PC BOARD
(Sheet 1 of 2)

(98.0) Z2-5

1-004-0223-R2

115



	LOCATION	#PINS	+5V	GND
74HC259	U1 U2	16	16	8
ULN2804	U3 U4	18	–	9
ICM7228A	U5	28	19	26

3. LAST REFERENCE DESIGNATION USED: C6,D6,DN1,DS8,J2,R7,RN3,S13,TP2,U5.
2. ALL CAPS. ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS ARE 1/4W,5% AND ARE IN OHMS UNLESS OTHERWISE SPECIFIED.

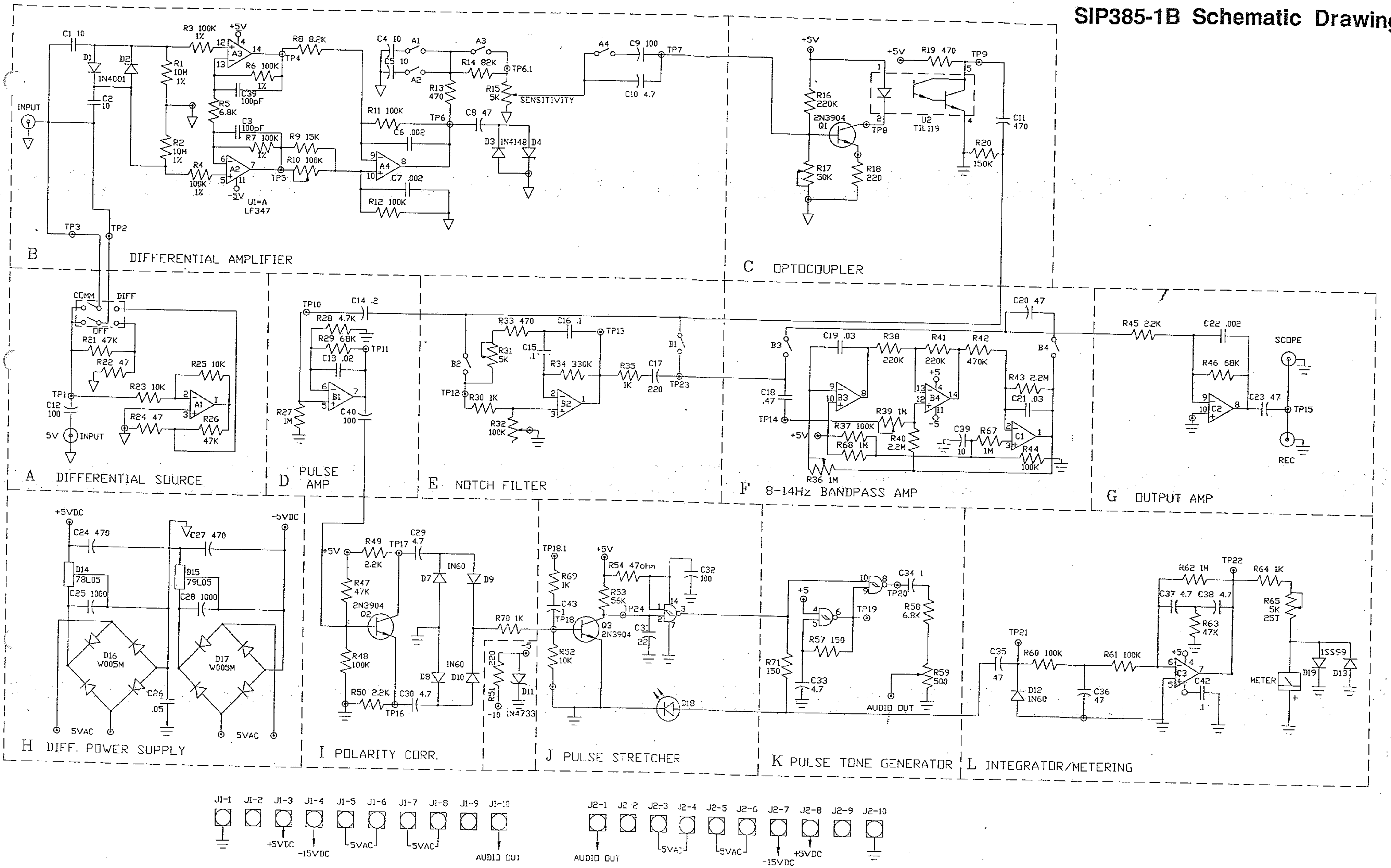
NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

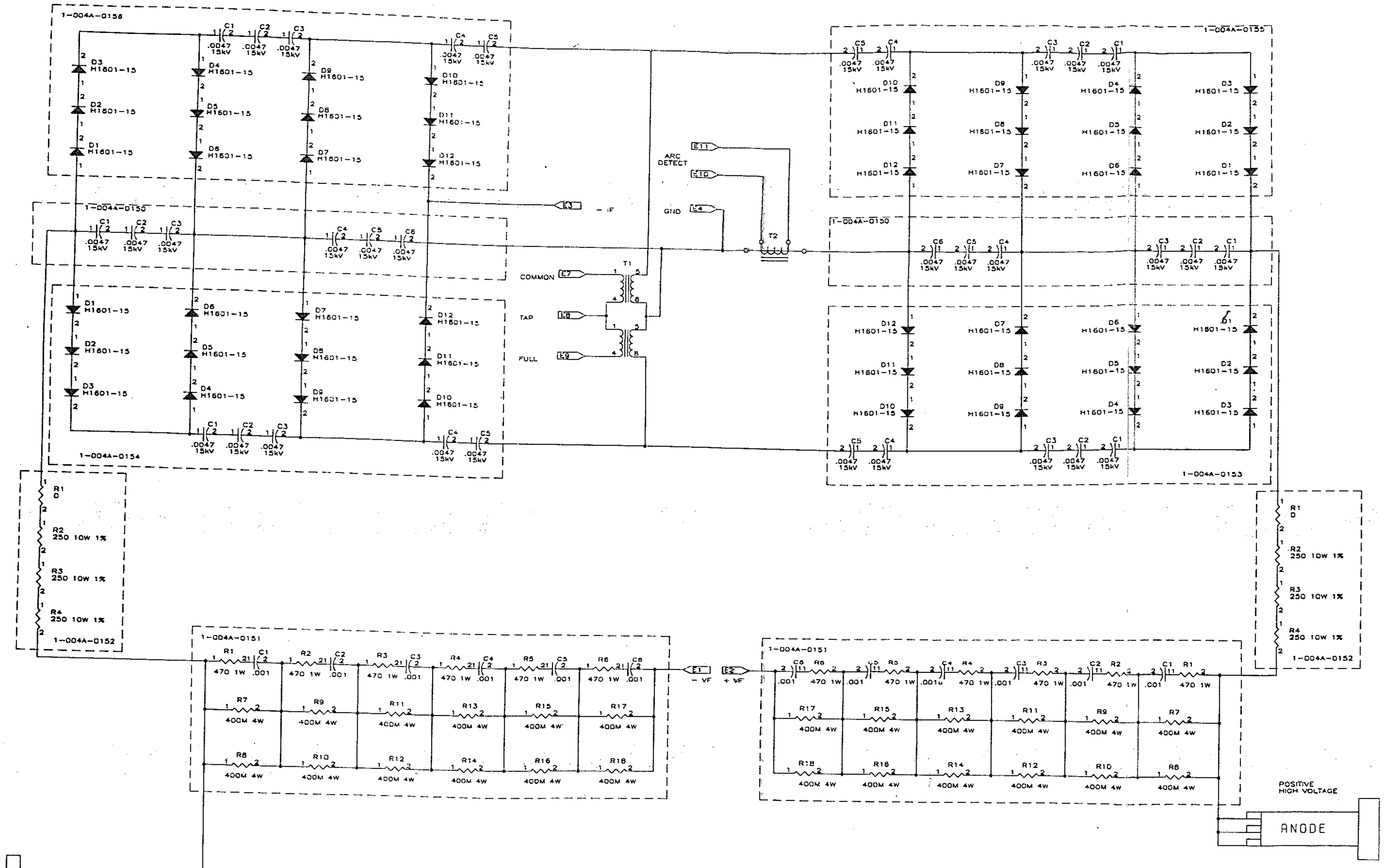
PMX 2000
SCHEMATIC,
DISPLAY PC BOARD
(Sheet 1 of 1)
(98.0) Z2-3

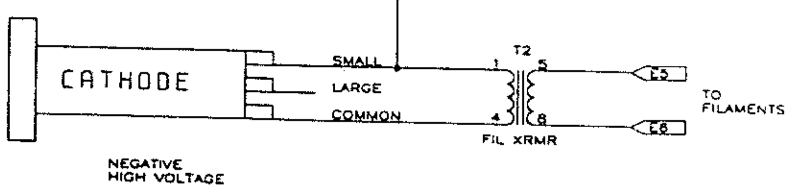
1-004-0234-R2

SIP385-1B Schematic Drawings



117





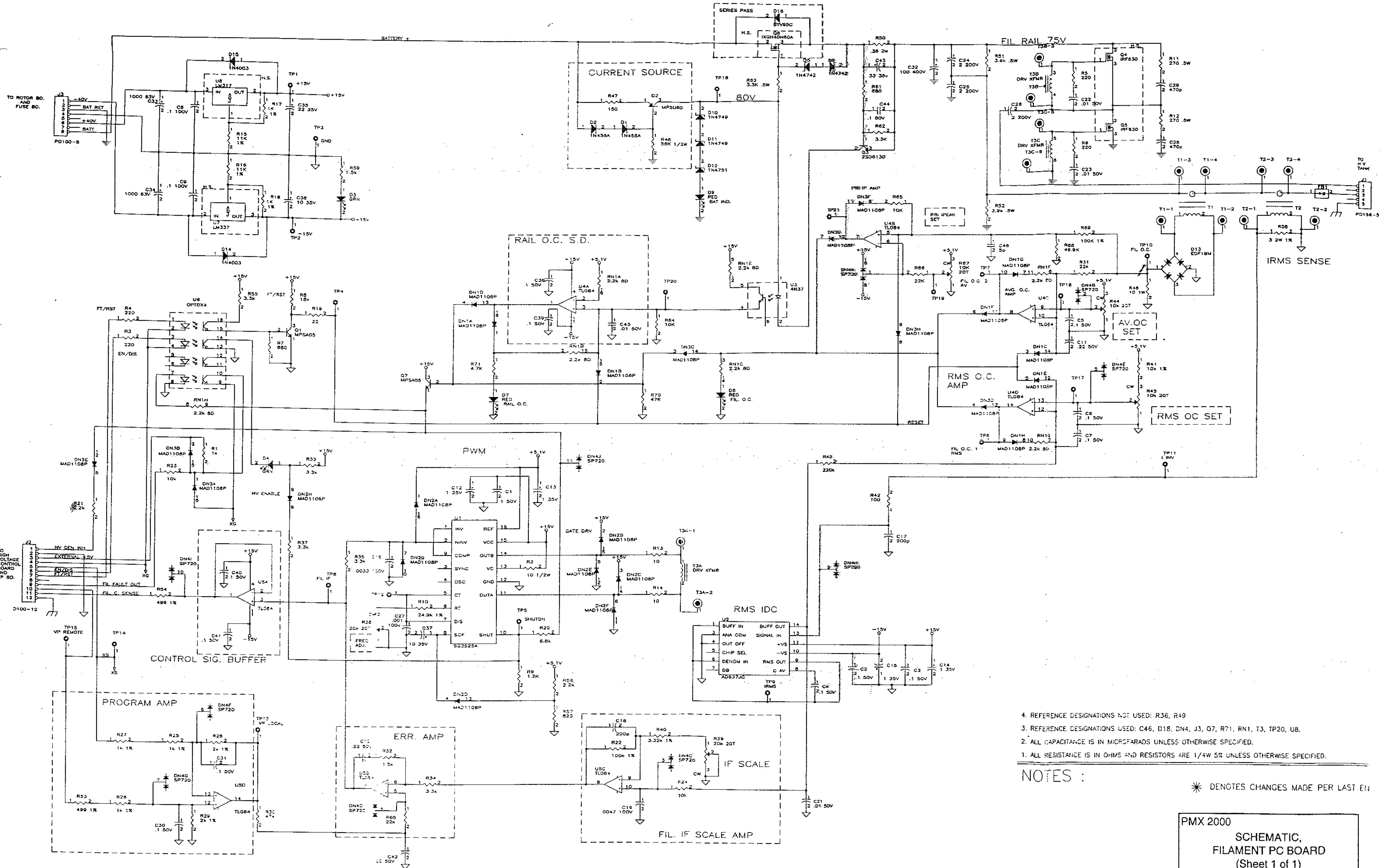
2. ALL CAPACITANCE IS IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS ARE 1/4W, 5% AND ARE IN OHMS UNLESS OTHERWISE SPECIFIED.

NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000	
	SCHEMATIC, H.V. TANK (Sheet 1 of 1)
(98.0)	Z2-19

1-041-0048-R1



4. REFERENCE DESIGNATIONS NOT USED: R36, R49
3. REFERENCE DESIGNATIONS USED: C46, D18, DN4, J3, Q7, R71, RN1, T3, TP20, U8.
2. ALL CAPACITANCE IS IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTANCE IS IN OHMS AND RESISTORS ARE 1/4W 5% UNLESS OTHERWISE SPECIFIED.

NOTES :

✳ DENOTES CHANGES MADE PER LAST EN

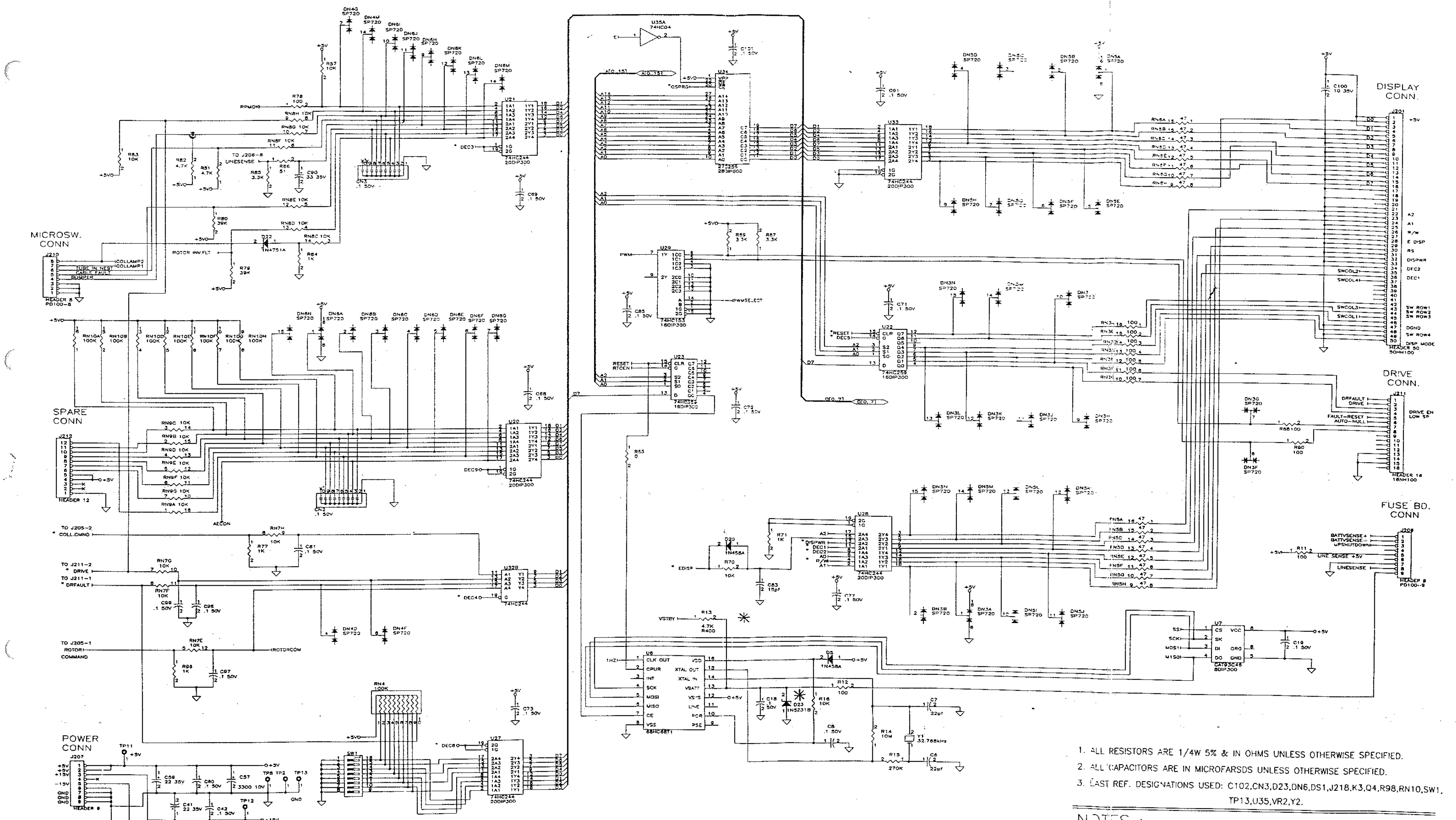
PMX 2000

SCHEMATIC,
FILAMENT PC BOARD
(Sheet 1 of 1)

(98.0) Z2-10

1-004-0196-R2

119



1. ALL RESISTORS ARE 1/4W 5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARSDS UNLESS OTHERWISE SPECIFIED.
3. LAST REF. DESIGNATIONS USED: C102,CN3,D23,DN6,DS1,J218,K3,Q4,R98,RN10,SW1, TP13,U35,VR2,Y2.

NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

IC	LOCATION	#PINS	+15V	−15V	GND
AD7237JN	U15	24	21	23	12
DG301A	U5	14	14	8	7
LF412CN	U2	8	8	4	–
OP177	U3,4,9,10, 11,12	8	7	4	–

IC	LOCATION	#PINS	+5V	GND
74HC259	U8,22,23	16	16	8
74HC244	U1,20,21, 27,28,32	20	20	10
68HC11F1	U18	68	34	1
CS5012	U17	40	11	10
74HC04	U30,35	14	14	7
NE555	U24	8	8	1

IC	LOCATION	#PINS	+5V	GND
74HC20	U31	14	14	7
MC34064	U19	3	2	3
MAX233	U13	20	7	6,9
74HC74	U25	14	14	7
74HC154	U14	24	24	12

IC	LOCATION	#PINS	+5V	GND
74HC00	U26	14	14	7
74HC153	U29	16	16	8
93C46	U7	8	8	5,6
27C256	U34	28	28	14
74LS244	U33	20	20	10
68HC68T1	U6	16	16	8

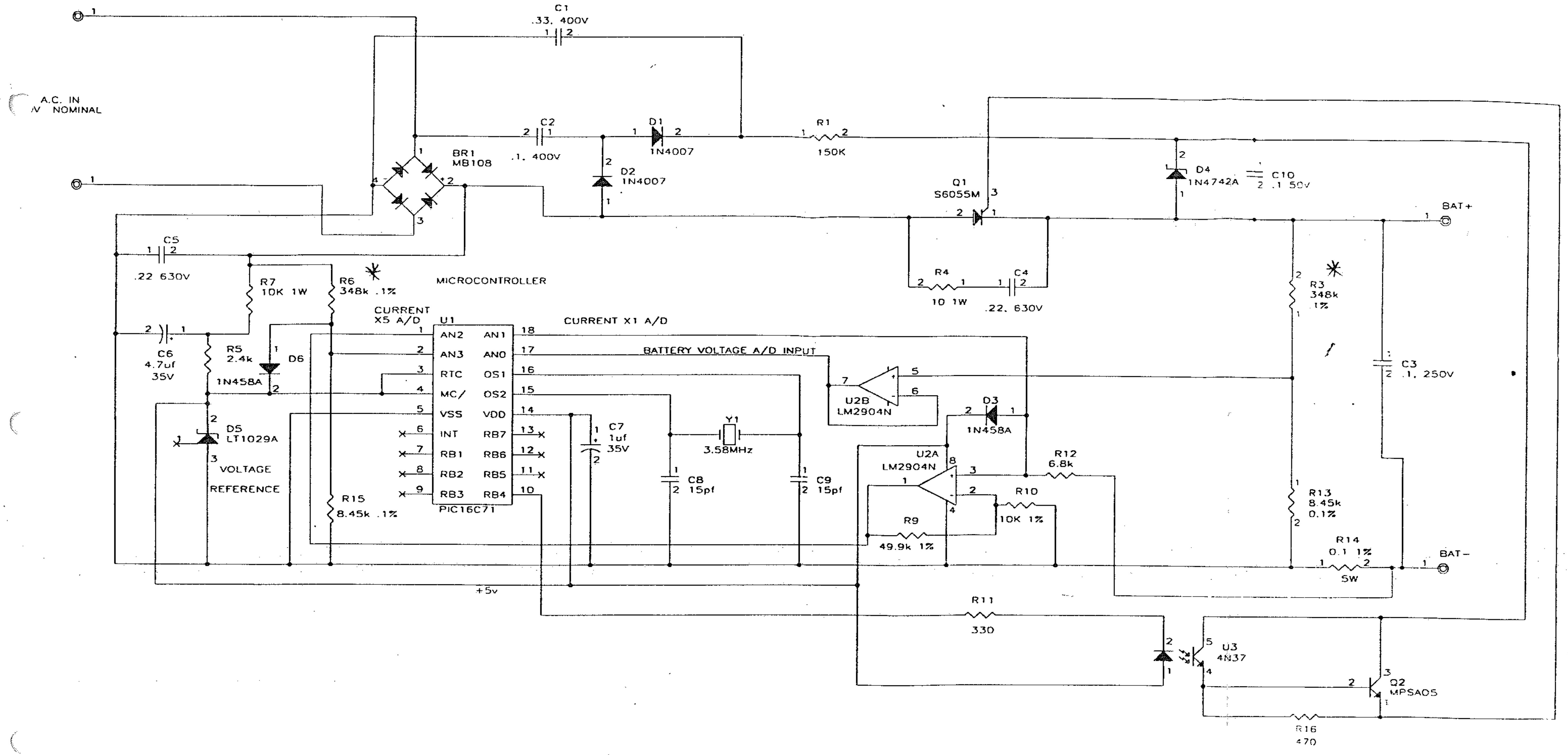
PMX 2000

SCHEMATIC, MICROPROCESSOR PC BOARD (Sheet 2 of 2)

(98.0) Z2-2

1-004-0208-R5

120



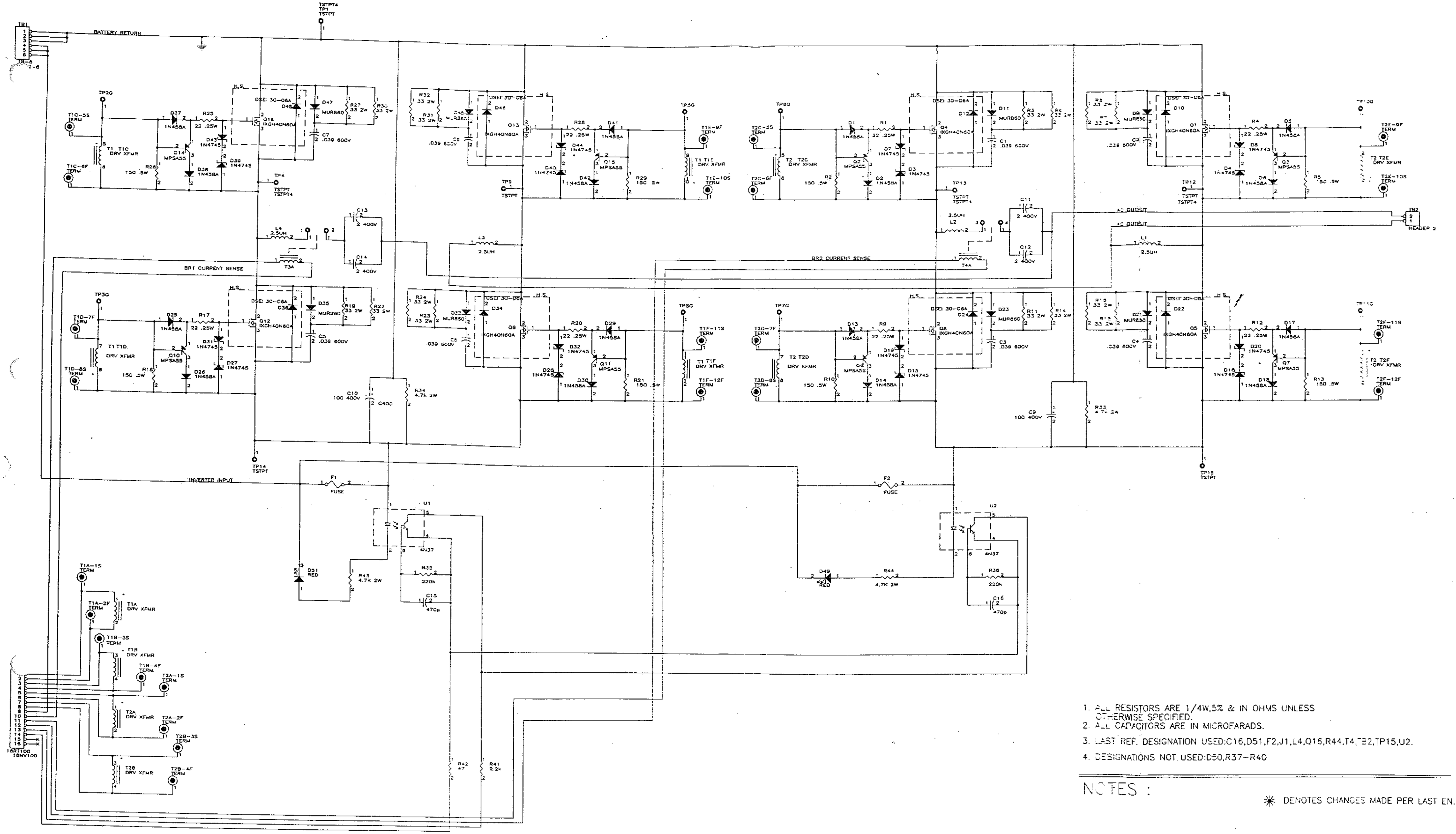
1. ALL RESISTORS ARE 1/4W,5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARADS.

NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000
SCHEMATIC, BATTERY CHARGER BOARD (Sheet 1 of 1)
(93.0) Z2-17

1-004-0263 R2



1. ALL RESISTORS ARE 1/4W,5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARADS.
3. LAST REF. DESIGNATION USED:C16,D51,F2,J1,L4,Q16,R44,T4,TB2,TP15,U2.
4. DESIGNATIONS NOT USED:D50,R37–R40

NOTES :

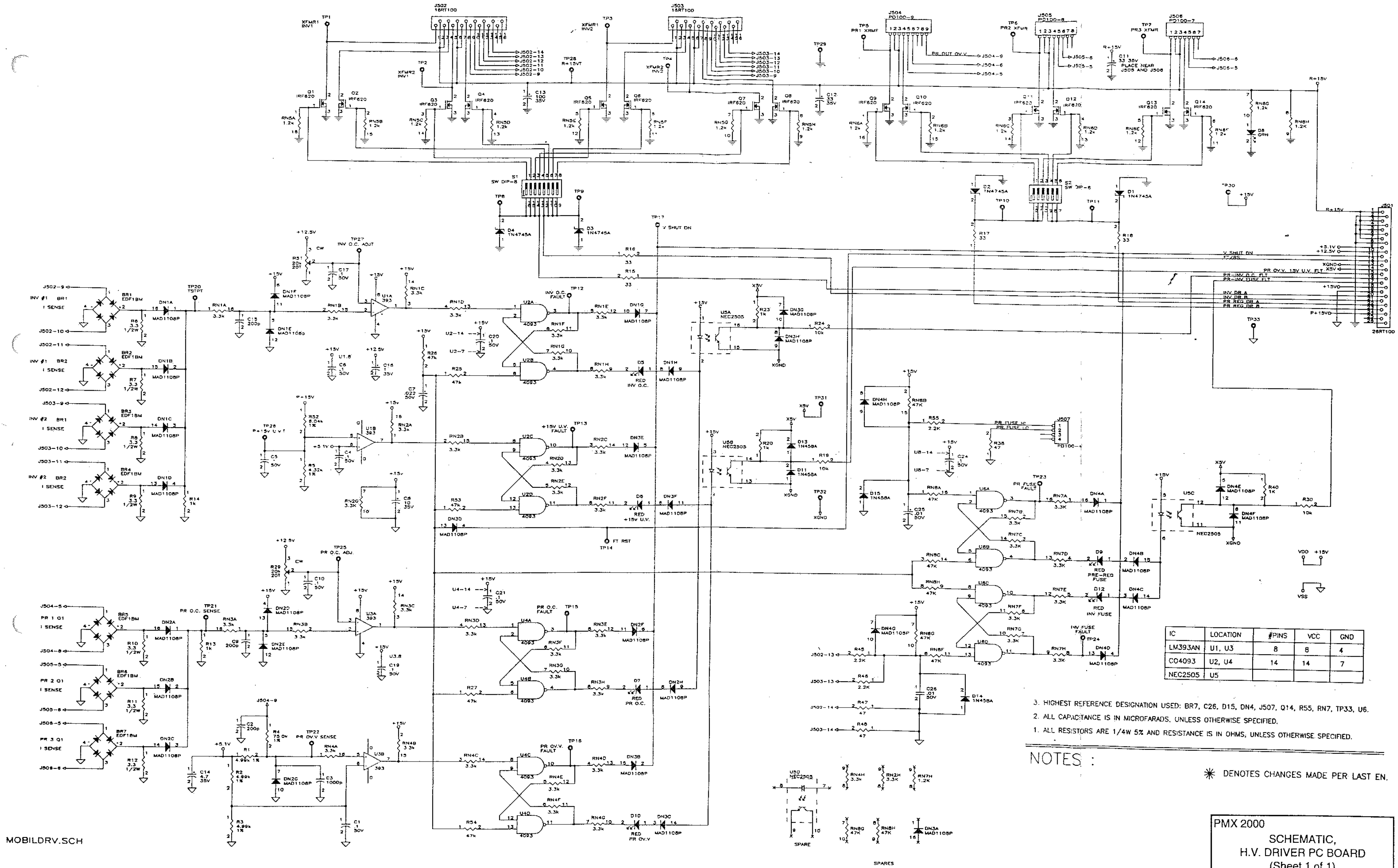
✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000

SCHEMATIC,
H.V. INVERTER PC BOARD
(Sheet 1 of 1)

(98.0) Z2-16

1-004-0180-R0



IC	LOCATION	#PINS	VCC	GND
LM393AN	U1, U3	8	8	4
CO4093	U2, U4	14	14	7
NEC2505	U5			

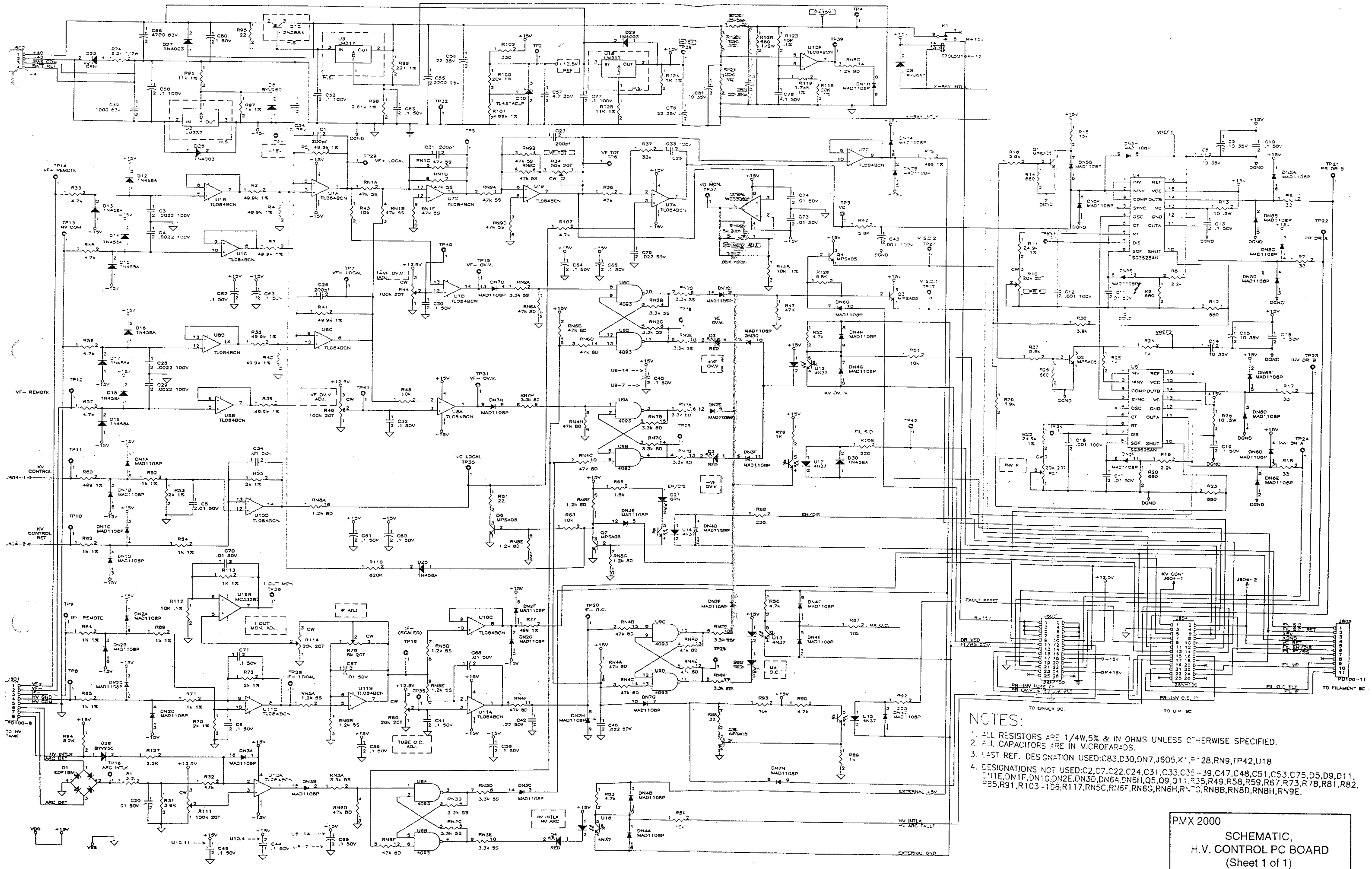
3. HIGHEST REFERENCE DESIGNATION USED: BR7, C26, D15, DN4, J507, Q14, R55, RN7, TP33, U6.
2. ALL CAPACITANCE IS IN MICROFARADS, UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS ARE 1/4W 5% AND RESISTANCE IS IN OHMS, UNLESS OTHERWISE SPECIFIED.

NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000
SCHEMATIC,
H.V. DRIVER PC BOARD
(Sheet 1 of 1)
(98.0) Z2-9

1-004-0214-R3



NOTES:

1. ALL RESISTORS ARE 1/4W,5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARADS.
3. LAST REF. DESIGNATION USED:C83,D30,DN7,J605,K1,R128,RN9,TP42,U18
4. DESIGNATIONS NOT USED:C2,C7,C22,C24,C31,C33,C35-39,C47,C48,C51,C53,C75,D5,D9,D11, DN1E,DN1F,DN1G,DN2E,DN3D,DN6A,DN6H,Q5,Q9,Q11,R35,R49,R58,R59,R67,R73,R78,R81,R82, R85,R91,R103-106,R117,RN5C,RN6F,RN6G,RN6H,RN7G,RN8B,RN8D,RN8H,RN9E.

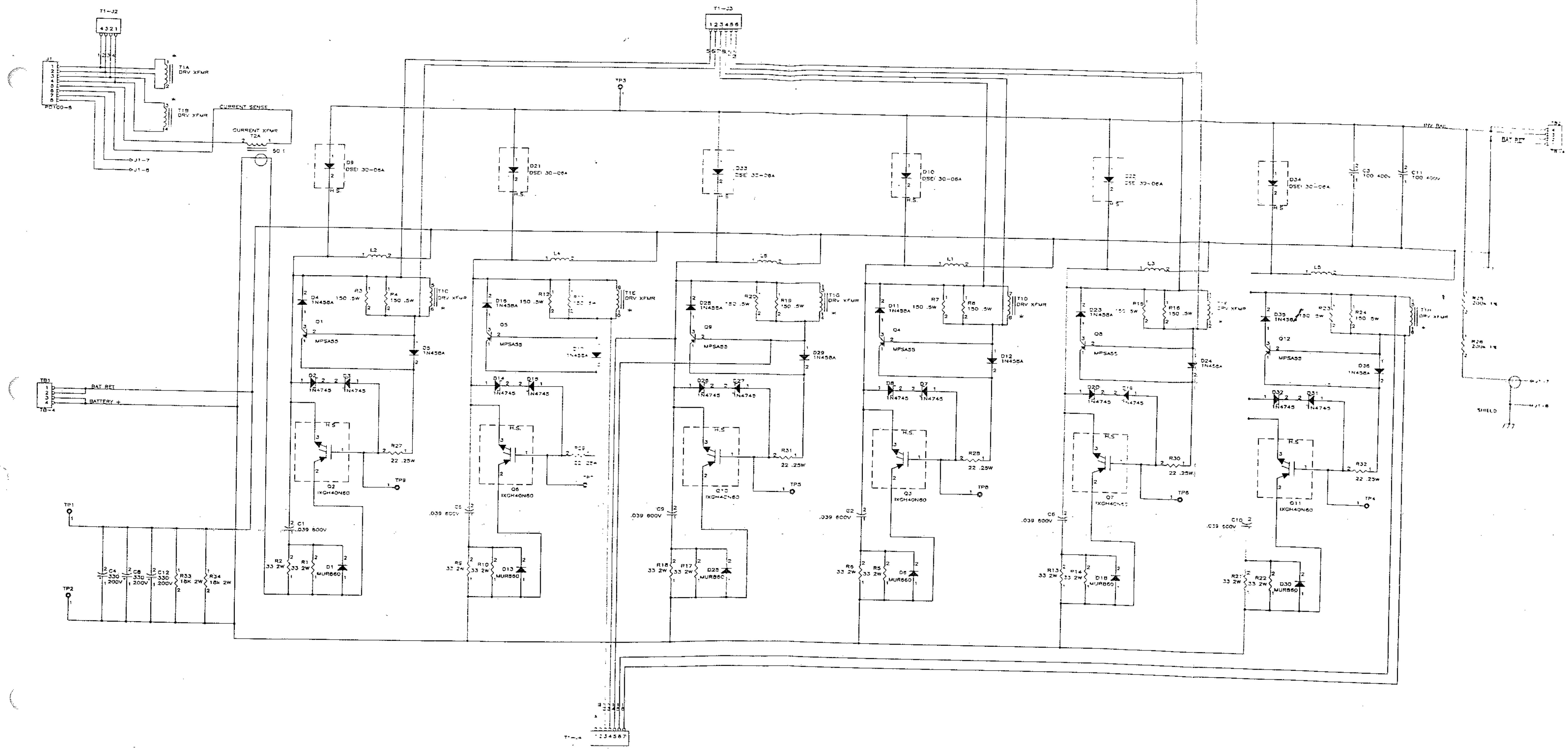
PMX 2000

SCHEMATIC,
H.V. CONTROL PC BOARD
(Sheet 1 of 1)

(98.0) Z2-7

1-004-0219-R3

DENOTES CHANGES MADE PER LAST EN.

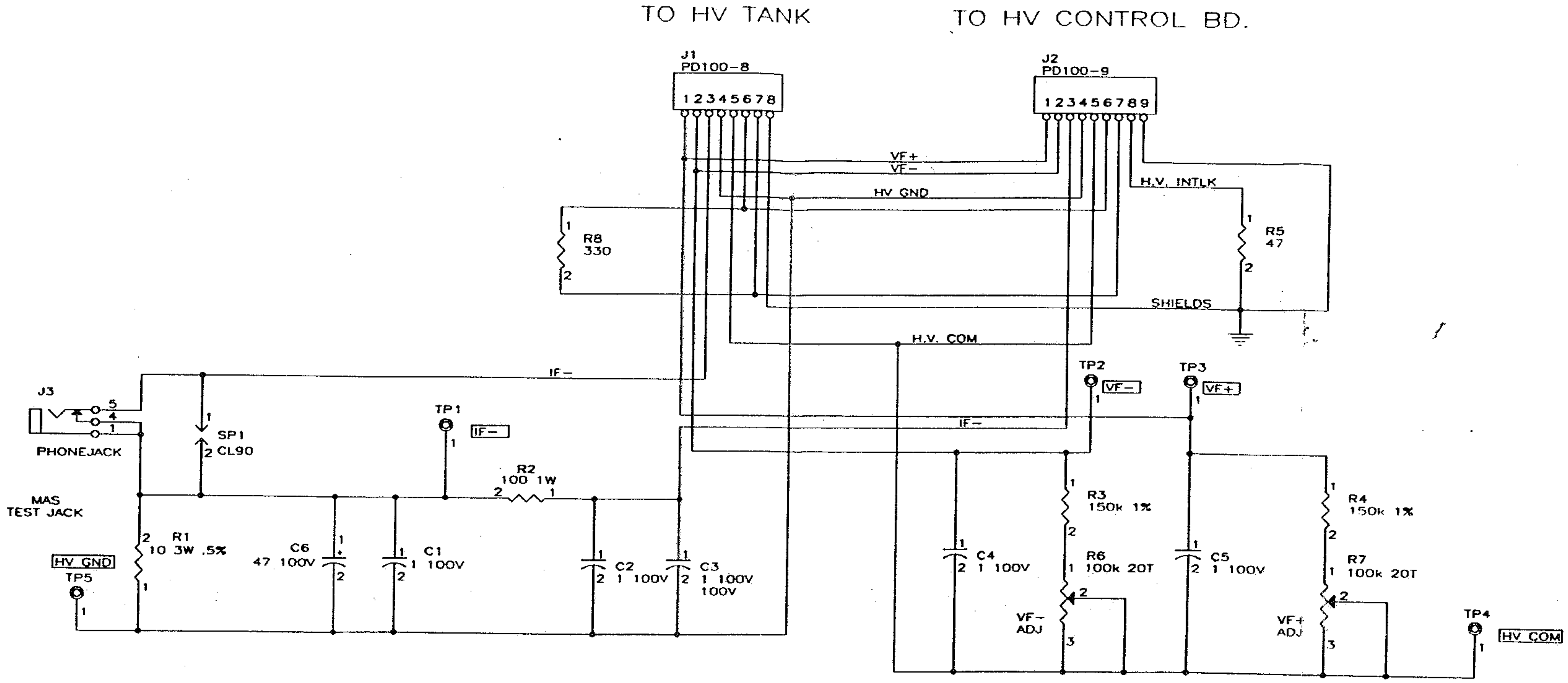


1. ALL RESISTORS ARE 1/4W,5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARADS.
3. LAST REF. DESIGNATION USED:C12,D36,J4,L6,Q12,R34,T2,TB2
4. DESIGNATIONS NOT USED:C7

NOTES :

✻ DENOTES CHANGES MADE PER LAST EN

PMX 2000
SCHEMATIC,
PRE-REGULATOR PC BOARD
(Sheet 1 of 1)
(98.0) Z2-8

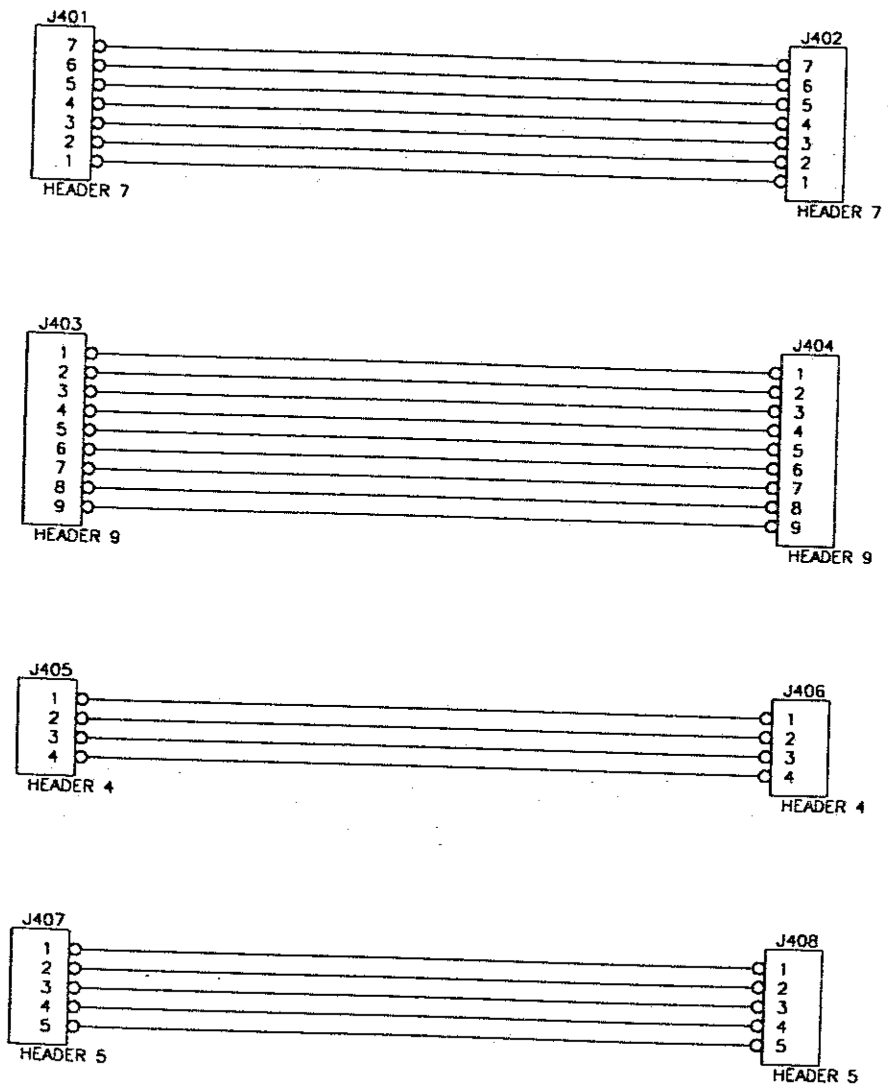


1. ALL RESISTORS ARE 1/4W,5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARDS UNLESS OTHERWISE SPECIFIED.
3. LAST REFERENCE DESIGNATION USED: R8,C6,J3,SP1,TP4.

NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000
SCHEMATIC,
L.V. FEEDBACK BOARD
(Sheet 1 of 1)
(98.0) Z2-11
1-004-0178-R3



1. ALL RESISTORS ARE 1/4W,5% & IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARADS.

NOTES :

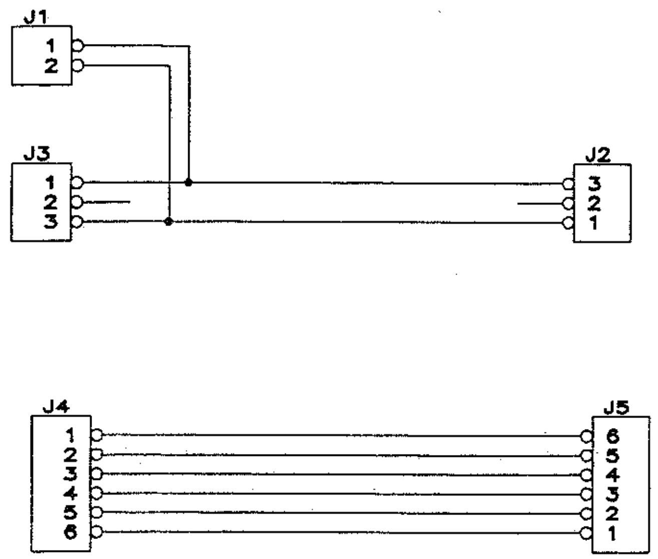
✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000

SCHEMATIC,
MOBILE INTERCONNECT BOARD
(Sheet 1 of 1)

(98.0) Z2-12

1-004-0198-RA



NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

128

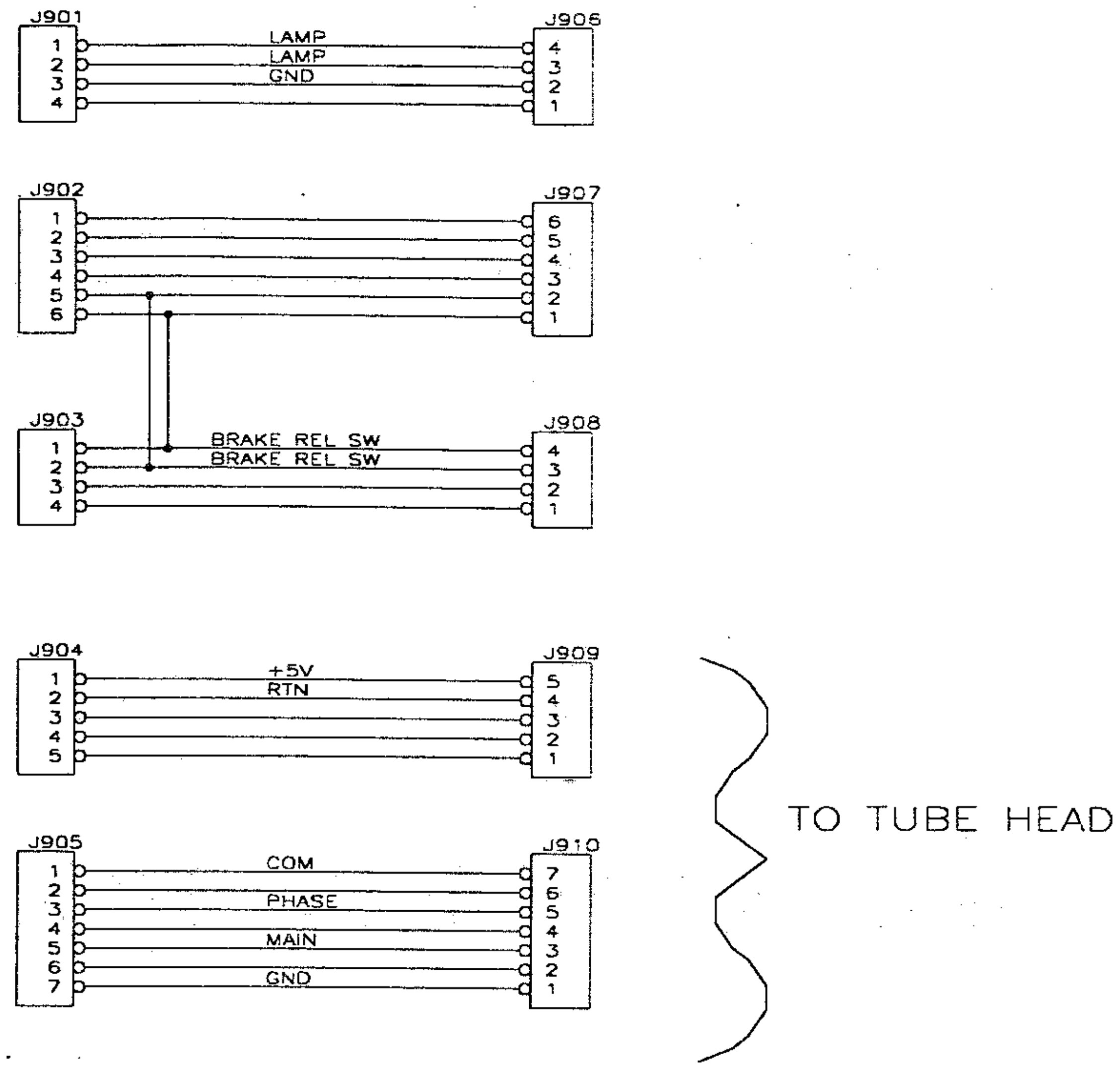
PMX 2000

SCHEMATIC,
FAN INTERFACE BOARD
(Sheet 1 of 1)

(98.0)

Z2-14

1-004-0221-RA



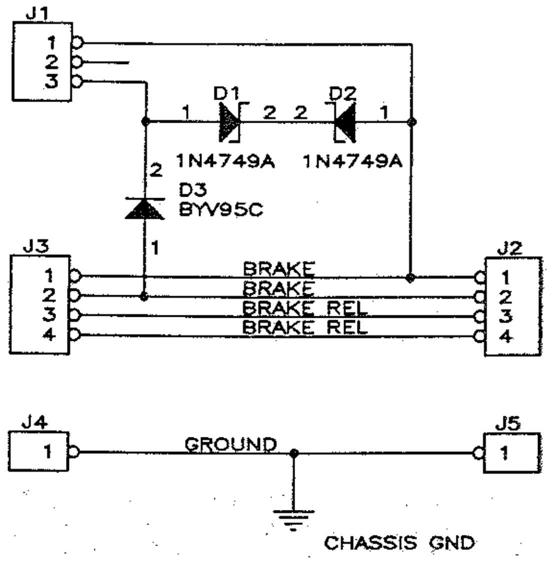
1. HIGHEST REFERENCE DESIGNATION USED: J910.

NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000
SCHEMATIC,
ARM INTERFACE BOARD
(Sheet 1 of 1)
(98.0) Z2-15
1-004-0206-R1

130



NOTES :

✳ DENOTES CHANGES MADE PER LAST EN.

PMX 2000
SCHEMATIC,
DIODE BRAKE PC BOARD
(Sheet 1 of 1)
(98.0) Z2-13

1-004-0237-RB

131