Who should use this manual:

This manual does not contain any procedures which can be performed by the system operator.

This manual is intended for trained service engineer who perform the installation, maintenance, and calibration of the OEC-Diasonics system.

The procedures in this manual should not be attempted by anyone who is not specifically trained or authorized by OEC Diasonics to work on the 9400 system.

This manual is intended to compliment the training offered by OEC-Diasonics. Do not attempt any of the procedures in this manual unless you have received training on the 9400 System. Reading this manual does not qualify the reader to maintain or service the system.

The contents of this manual are believed accurate at the time of publication. However, changes in design and additional features may be incorporated in the hardware and software which are not reflected in this version of the manual. Contact Technical Support

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SECTION 1
INTRODUCTION

SECTION 1 INTRODUCTION

1.1. HOW TO USE THIS MANUAL

This manual does not contain any procedures which can be performed by the system operator.

This manual is intended for trained service engineers that will perform the installation, maintenance, and calibration of the OEC-Diasonics system.

The procedures in this manual should not be attempted by anyone who is not specifically trained by OEC-Diasonics to work on the 9400 Mainframe.

This manual is intended to compliment the training offered by OEC-Diasonics. Simply, reading this manual will not qualify the reader to maintain or service the system.

The contents of this manual are accurate at the time of publication. However, changes in design and additional features may be incorporated in the hardware and software which are not reflected in this version of the manual.

The manual is divided into the following sections by index divider tabs:

Section 1 .... **Introduction**

A basic overview and description of the system.

Section 2 .... **Safety**

A guide to safe practices, with warnings about hazards, emergency procedures and instructions for accident reporting.

Section 3 .... **Theory of Operation**

A description of the hardware and software is provided to facilitate an understanding of the maintenance, calibration and repair of the mainframe.

1.2. OTHER PUBLICATIONS AND REFERENCE DOCUMENTS

Service, installation, and maintenance procedures to be performed on this system are found in this manual (part number 00-873786). Other reference documents for the Model 9400 system are:

Operator Manual	9400 basic model - 00-873783
Operator Manual	9400 with E.S.P. Option - 00-873784
Operator Manual	9400 with E.S.P. & Vascular or Neuro-Vascular Option - 00-873785
Field Service	4th Gen Monitor Cart Servicing - 00-873787
Hospital	9400 Installation Procedure - 00-873788
Field Service	9400 Schematic Package - 00-873920

The system contains some equipment and assemblies manufactured by original equipment manufacturers (OEM's) and not OEC-Diasonics. These assemblies are treated as field replaceable parts. Detailed information concerning the maintenance of these are contained in manuals available from the OEM but not provided by OEC-Diasonics. Where adjustments and maintenance steps are required on OEM equipment, the procedures are described in this manual.

1.3. MAINTENANCE REQUIREMENTS

1.3.1. Responsibility for Maintenance

This service manual contains procedures by which a properly trained and qualified service technician can keep the system operating properly and repair it should it malfunction.

It is the owner's responsibility to make sure that the installation, calibration, modification, and repair of the system are performed only by qualified service technicians, such as OEC-Diasonics field service personnel, who are trained to perform all service tasks in a safe and competent manner.

Circuits inside the equipment use voltages which are capable of causing serious injury or death from electrical shock. To avoid this hazard, the operator should never be expected or allowed to perform any type of service task except as specifically instructed in the Operator's Manual.

Serious injury and property damage can result from incorrectly performed maintenance and service procedures. OEC-Diasonics does not assume responsibility or liability for the qualifications and competence of operators, technicians or engineers who are not employees or agents of OEC-Diasonics.

No unauthorized modifications should ever be made to the system. Such modifications could result in hazardous or unpredictable operation.

1.3.2. Federal Performance Standard Maintenance Schedule

The system will comply with the Federal Performance Standards for Diagnostic X-Ray Systems and their Major Components (21 CFR 1020.30-32) if calibrated annually according to the procedures for calibration given in this manual.

Annual calibration must be requested by the system owner. Calibration must be performed only by qualified service personnel.

Calibration must be verified following repairs which require replacement of the X-ray tube, High Voltage Power Supply (tank), Technique Processor PCB, Analog Support PCB, X-Ray Regulator PCB, Generator Driver PCB, or any of the high frequency components in the filament or high voltage circuits.

The imaging chain should be recalibrated whenever changes are made to the camera or image tube.

1.3.3. Record Keeping Responsibilities

Detailed records must be kept when the system is installed, calibrated, and repaired. It is the responsibility of the service technician who performs these procedures to complete the forms listed below and to direct copies of the forms to the interested parties.

TABLE 1 **RECORD KEEPING**

RECORD	WHEN REQUIRED
Service Log	When any service is performed on the system.
Calibration Worksheets	When a calibration is performed on the system.
FDA Form 2579 Report of Assembly of Diagnostic X-Ray System	When a system is installed, or when any certified component is replaced: X-Ray Tube Image Intensifier Tube Beam Limiting Assembly Film Cassette Holder High Voltage Generator X-Ray Control Unit
Four copies are provided:	1 copy to OEC or retained by assembler. 1 copy to FDA 1 copy to State 1 copy to hospital
Installation Report	When system is installed.
In Hospital Check-out	When system is installed.
Beam Alignment Films	When system is installed.

1.4. MAJOR ASSEMBLIES

There are two major assemblies, the mainframe and the monitor cart. These assemblies are connected by a 20 or 30 foot interconnect cable which carries power, video and communications signals. Figure 1-1 illustrates the mainframe (C-arm) assembly of the OEC-Diasonics Mobile C-arm X-ray System.

The principal function of the mainframe is to generate X-rays for patient imaging. The mainframe electronics control X-ray generation for both radiographic and fluoroscopic applications. The mainframe produces an image on film in the radiographic mode. In the fluoroscopic mode, an image intensifier tube converts the X-ray image into a visible light image which the TV camera converts to a video signal.

The monitor cart electronics process the video images obtained from the mainframe video camera and then displays these images on the video monitors. The monitor cart provides fluoroscopy and digital image processing capabilities. The fluoroscopic image is digitized and may be viewed live or processed to enhance the features of interest.

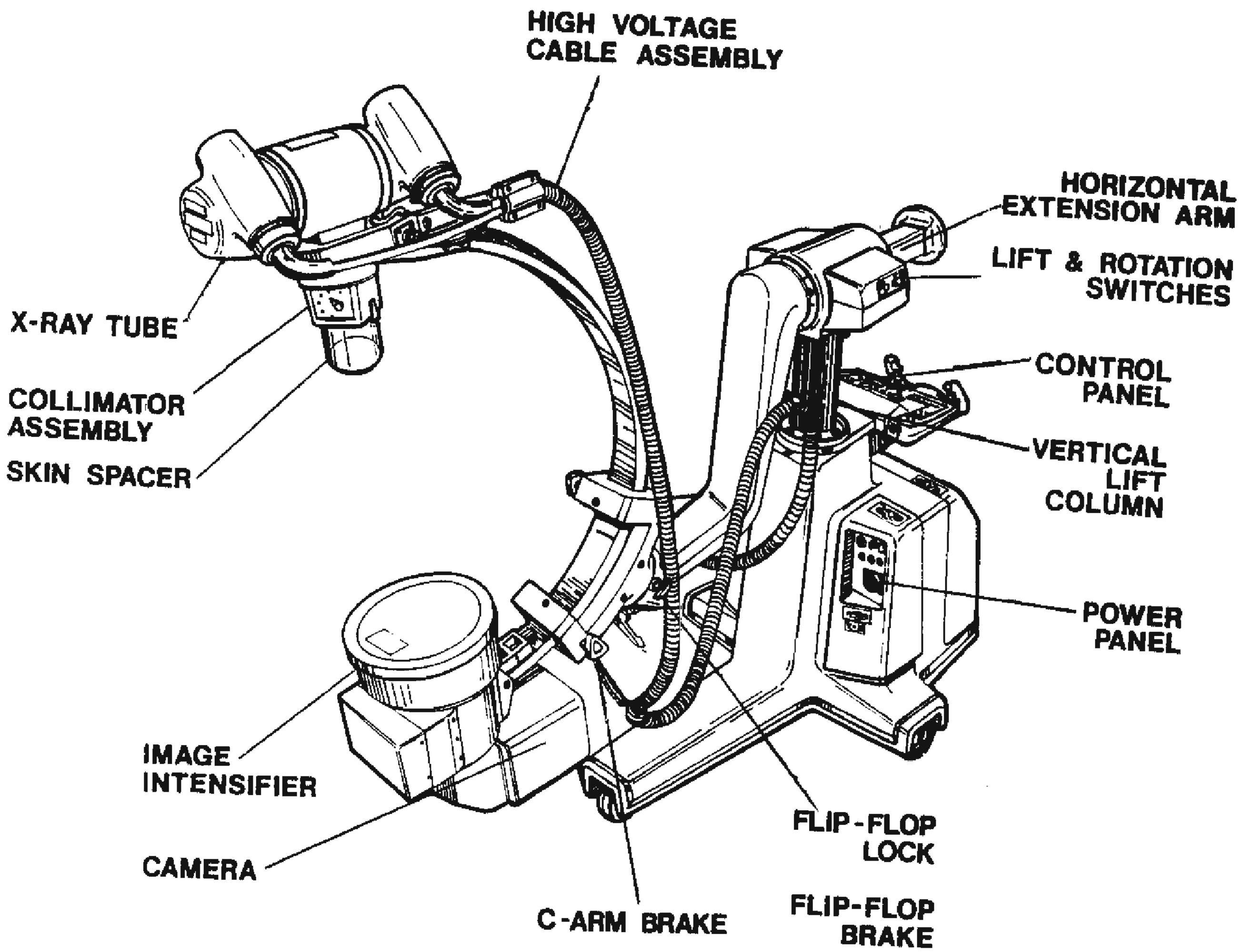
Steerable wheels or casters on each assembly allow movement of the system. Each major assembly has a conductive wheel or drag chain to provide static grounding in an operating room environment.

1.5. STANDARD EQUIPMENT

TABLE 2 **STANDARD EQUIPMENT**

ITEM	PART NUMBER
C-arm Assembly	00-873600-01
Monitor cart Assembly	00-873000-01
Collimator and Plate Assembly	
(6-inch)	00-873919-04
(4/6/9-inch)	00-873919-03
Image Intensifier Asm w/Vidicon	
(6-inch)	00-874514-01
(4/6/9-inch)	00-874515-01
Cassette Holder	
(6-inch standard)	00-861095-01
(6-inch metric)	00-871096-01
(9-inch standard)	00-871138-01
(9-inch metric)	00-871139-01
Accessory Parts Kit	00-873921-01
Foot Switch Assembly (Dual Stage)	00-874360-02
30 cm Extension Spacer	00-837201-01

Figure 1-1 - Mobile C-arm Mainframe



1.6. Equipment Required But Not Supplied

Equipment required for safe operation of the systems, but not supplied by OEC-Diasonics include the following:

- Explosion-proof connectors, where applicable
- Wall outlet connectors
- Line Circuit Breakers (20 Amp)
- Ground Fault Detection Alarm, if applicable

1.7. Feature Configuration

Various hardware and software features are provided as standard equipment on some models. Additional hardware and software features are available as options.

Generally the front panel on the monitor cart and the control panel on the mainframe will identify the major features.

Other differences in operation can be identified by the service engineer from the system hardware and system software option files. These can be viewed by accessing the Monitor Cart Service Option Screens. Refer to the 4th Gen Monitor Cart Service Manual (00-873787).

1.8. Mainframe Options

Fluoro Boost - Fluoro boost is provided on some systems. The use of boost is explained in the Operator's Manual.

Image Intensifier Tubes - The system may be equipped with either a single mode 6-inch or a tri-mode 4/6/9-inch image intensifier.

Laser Aimer Device - The laser aimer provides an opaque reference point in the X-ray image that is primarily used during orthopedic surgery. The laser aimer is optional.

SECTION 2
SAFETY

SECTION 2 SAFETY

2.1. INTRODUCTION

The information in this section is intended to help the service technician establish safe practices for installation, service and maintenance of the OEC-Diasonics X-ray system.

Potential hazards exist in the operation and service of medical electronic devices and X-ray systems. All users must understand the safety and emergency procedures, and know how to take adequate precautions to protect themselves and others from possible injury. All operators and service technicians must be familiar with and understand the safety and emergency procedures, operating instructions, and preventive maintenance schedules and procedures given in the Operator's Manual.

System users and service technicians must know how to recognize hazardous and potentially hazardous conditions, and know how to adequately protect themselves and others from possible injury.

The OEC-Diasonics X-ray system presents no hazards unusual for mobile C-arm X-ray systems and meets safety requirements applicable to medical electronic equipment of this type.

Safety Messages: This manual contains messages which are designed to inform service personnel where potential hazards may exist when servicing the equipment. These messages are defined as follows:

CAUTION: *Cautions are defined as "any hazard or unsafe practice which could result in minor personal injury and/or product or property damage".*

WARNING: **Warnings are defined as "any hazard or unsafe practices which could result in severe personal injury or death".**

2.2. RESPONSIBILITY

It is the responsibility of the owner to ensure that the system is operated only by properly trained, qualified personnel who have obtained credentials from local, state, and federal authorities where required.

If the system does not operate properly or fails to respond to the controls as described in the Operator's Manual, the owner should call the nearest OEC-Diasonics Field Service Regional Office or a qualified service technician, trained to troubleshoot and repair the 9400 Mainframe.

The owner must make certain that only properly trained, qualified service technicians undertake the installation, maintenance, calibration and repair.

OEC-Diasonics has certified that the system complies with the Radiation Control for Health and Safety Act of 1968, Title 21, Chapter 1, Subchapter J, as of the date of manufacture.

The user (hospital administration) is responsible for verifying continued compliance of entrance exposure rate, leakage radiation, alignment of useful beam, and calibration of kVp and mAs. This must be accomplished annually by qualified service personnel.

Compliance with applicable statutory and regulatory requirements is the responsibility of the user hospital administration.

Consult local, state and federal agencies regarding specific requirements and regulations applicable to the use of this type of medical electronic equipment.

All service technicians and installers of this equipment should be familiar with the contents of HHS Publication FDA 81-8144, Assembler's Guide to Diagnostic X-ray Equipment.

OEC-Diasonics assumes no responsibility or liability for after sale operating and safety practices or for personal injury or damage resulting from misuse of its systems.

Address questions and comments regarding safety to the appropriate OEC-Diasonics Service Organization. Problems still not resolved should be referred to:

Q.A. Manager
OEC-Diasonics Inc.
384 Wright Bros. Drive
Salt Lake City, Utah
84116
801-328-9300

2.3. HAZARDS

Possible hazards associated with unsafe operation of this type of equipment are described below along with the safety precautions which should be taken.

2.3.1. X-ray Tube Hazards

All persons exposed to X-ray tubes must take precautions to protect themselves against serious injury.

2.3.1.1. Overheating Hazard

Extreme heat is generated in the X-ray tube during operation. The heat is normally radiated to the dielectric oil inside the tube housing and then conducted through the housing and radiated to the air. Misuse of the tube, causing it to excessively overheat, can result in a rupture of the pressure compensating bladder in the housing. This can cause hot oil to escape, potentially resulting in scalds or burns. Take precautions to avoid such rupture and hot oil leakage.

NOTE: Draping, which covers the tube may increase the potential for tube overheating.

2.3.2. Explosion Hazard

The system must never be operated in the presence of flammable anesthetics, or other flammable or explosive liquids, vapors, or gases. Vapors and gases can be ignited by electrical arcs that can occur during the normal operation of switches, circuit breakers, pushbuttons, and other circuit components.

If flammable substances are present before the system is turned on, do not plug it in and do not turn it on.

If flammable substances are detected after the system has been turned on, do not touch any of the controls, switches, or knobs; do not turn it off; do not unplug it. Evacuate all personnel immediately, then ventilate the room to clear the air of the flammable vapor or gas. Remove any volatile liquids which are producing flammable vapors to a safe storage area.

2.3.3. Mechanical Collision Hazard

When moving the system up or down an incline, two people should be used to maintain control of the main frame assembly. Two people should also be used to maintain control of the monitor cart assembly.

The system must never be moved by one person who pushes the main frame ahead of him while pulling the monitor cart behind.

The system should not be moved up or down a ramp until all other personnel and equipment have been cleared from the base of the ramp.

Never attempt to move the system up or down any steps or on an incline of greater than 10 degrees.

Always apply the caster locks on the monitor cart and lock the wheels on the main frame when the system is in its final position. Never attempt to lock the wheels or casters in place on an incline.

2.3.4. Mechanical Movement Hazard

The arm assembly is motorized. Whenever moving the arm assembly under either motorized or manual control, observe it continuously during the motion to avoid collision with any person or object.

If either the image tube or the X-ray tube are removed from the C-arm, the imbalance of weight may cause the C-arm to slide along its cradle support. This results in a possible hazard to hospital or service personnel. To avoid this hazard, position the C-arm near the balance point it will assume after the image tube or X-ray tube has been removed.

2.3.5. Film Cassette Hazard

If the film cassette and the film cassette holder are not properly installed on the Image Intensifier Assembly, they can fall, causing injury to patient or operator. Make sure that the cassette is firmly installed in the cassette holder and that the latch is properly engaged.

Use only film cassettes of the proper size rated on the film cassette holder (10" x 12" x 5/8" nominal film cassettes in the standard cassette holder, and 24 X 30 cm film cassettes in the metric holder). Cassettes of different dimensions may not engage the latch properly in their holder. Do not use wafer or thin-line cassettes.

2.3.6. Cassette Holder Hazard

The cassette holder (on systems with 6-inch image intensifier assemblies) provides a primary protective barrier to the X-ray beam and is a registered beam limiting device. A radiation hazard may exist if any holder other than the OEC-Diasonics holder is used. Use only cassette holders supplied by OEC-Diasonics.

2.3.7. CRT Implosion Hazard

A CRT (TV screen) can shatter if struck or severely jarred. If shattered it can produce a shower of flying glass; the coating on the inside face of the CRT can produce dust or fumes which can be toxic if inhaled. To avoid this hazard do not expose the monitors to unnecessary shock or allow anything to fall against them.

To minimize the risk of injury from flying glass, wear protective long sleeved clothing such as a lab coat and gloves. Protect your eyes with approved safety goggles or eye protection.

2.3.8. Image Intensifier Implosion Hazard

Due to the high vacuum present in image intensifier tubes, they may implode if struck or subjected to severe mechanical shock. This hazard is present especially during service procedures which require the removal of image intensifier covers and the tubes themselves.

To minimize the risk of injury from flying glass, wear protective long sleeved clothing such as a lab coat and gloves. Protect your eyes with approved safety goggles or eye protection.

2.4. SAFETY PROCEDURES

2.4.1. General Safety

Under no circumstances should the safety interlocks in the system be by-passed, jumpered, or otherwise disabled.

Always unplug the AC power cable from the wall outlet before cleaning the equipment. Water, soap, or other liquids, if allowed to drip into the equipment can cause electrical short circuits leading to electric shock and fire hazards.

Do not place food or beverage containers on any part of the equipment. They can tip over and introduce conductive substances into the electrical circuitry.

The system must never be operated or stored in a location where conductive fluids such as water, saline solution, etc., can spill on any part of the equipment unless the equipment has been covered with protective waterproof draping.

NOTE: *All OEC-Diasonics systems comply with International Electrotechnical Commission safety standard IEC-601. Do not connect any external device to the system that does not meet the requirements of IEC-601. Only devices provided by or approved by OEC-Diasonics should be connected to the system.*

2.4.2. Electrical Safety

Electrical circuits inside the equipment use voltages which are capable of causing serious injury or death from electric shock.

WARNING: **When the label on the left is seen on system equipment it indicates that the equipment contains high power electrical components and should be serviced only by personnel familiar with the circuitry and its operation. At certain locations these voltages are present EVEN WHEN THE POWER CORD IS DISCONNECTED.**

Areas where hazardous voltages exist include:

High voltage generator (located in the mainframe), high voltage cable and X-ray tube assemblies - **125,000 volts.**

Image Intensifier Assembly - **25,000 - 30,000 volts.**

Transformers - **120 volts.**

Batteries (located in the C-arm) - **200 Volts DC.**

WARNING: **The batteries should be considered fully charged at all times. The battery charger circuit applies a charging current to the batteries whenever the system is plugged into a power outlet. This occurs regardless of any switch settings.**

Due to the high power capability of the batteries, the mainframe high voltage circuitry should be approached cautiously - even when the power cord is unplugged.

Several capacitors in the high voltage and battery circuits can maintain a charge after the power is off. Carefully discharge these capacitors through a safe resistance before working on circuits energized by them.

Do not remove the interconnect cable from its connector on the mainframe. Hazardous voltage (120 VAC) is present on the pins of this connector when the monitor cart is plugged into a power outlet.

If the equipment must be serviced with the covers removed, then observe the following precautions:

Observe the two person rule when working near lethal voltages. A person who is familiar with the emergency power removal procedure must be in attendance. This person must remain clear of the machine and be prepared to turn it off in an emergency.

Be familiar with the components being serviced and the locations of hazardous voltages in the assembly where work is to be performed.

High voltage cables and capacitors can retain a charge even when all power is removed from the system. Avoid touching these unless you are certain the charge has been removed (shorted to ground). Some high energy capacitors in the system should be shorted to ground through an adequate resistance to avoid a burn hazard.

2.4.2.1. Battery Hazards

WARNING: **The batteries are capable of delivering high currents at high voltage. They are capable of causing severe burns, injury or death from electrical shock. Use extreme caution when working on circuits energized by or located near the batteries.**

The battery cells have low internal resistance and are capable of delivering high currents if they are shorted. The resulting heat can cause severe burns and is a potential fire hazard.

Use caution when working near the batteries and their connections. Remove any metal rings or watchbands which may inadvertently come in contact with the battery terminals. Severe skin burns could result if such metal articles were placed across the battery terminals.

Exercise care when shipping batteries whose terminals are exposed. The terminals should be covered with an insulating material. Do not pack them in such a manner that their terminals can short out against one another. The batteries are heavy and special attention must be given to their packing.

2.4.3. Radiation Safety

The X-ray tube assembly produces X-radiation when energized. Never operate this device without X-ray shielding in place.

It is imperative that the owner designate areas suitable for safe operation and service of the system, and that the operator ensure that it is used only in these designated areas.

Radiation protection surveys and machine calibration checks must be completed by qualified experts. The radiation survey report must indicate that the installation meets the requirements of the U.S. Department of Health and Human Services and applicable local, state, and federal regulations before the system can be routinely used.

Consideration must be given to room (lead) shielding, ability of the floor, ceiling and walls to attenuate scatter radiation, choice and use of lead draping, and any other room environment conditions necessary to protect personnel.

The system must be operated only by personnel who understand the use of collimators, X-ray tube and image intensifier positioning and radiation safety procedures.

The physician in charge of the radiological procedure must ensure that all personnel in the room wear approved protective clothing and radiation monitoring devices.

2.4.4. Source - Skin Distance

The Department of Health and Human Service guidelines specify that the minimum source-to-skin distance shall be maintained at 30 cm except for specific surgical applications. In these applications, provisions have been made to allow for operation at 20 cm. By removing the collimator extension spacer from the collimator assembly, the minimum source-to-skin distance will be decreased from 30 cm to 20 cm.

Removal of the spacer should be done only on the instructions of a physician. The spacer should be reattached to the collimator assembly immediately following the procedure.

2.4.5. Image Intensifier Safety

The image intensifier uses high voltages. Its covers should never be removed. Turn off system power and discharge the image intensifier power leads before removing the image tube.

2.5. EMERGENCY PROCEDURES

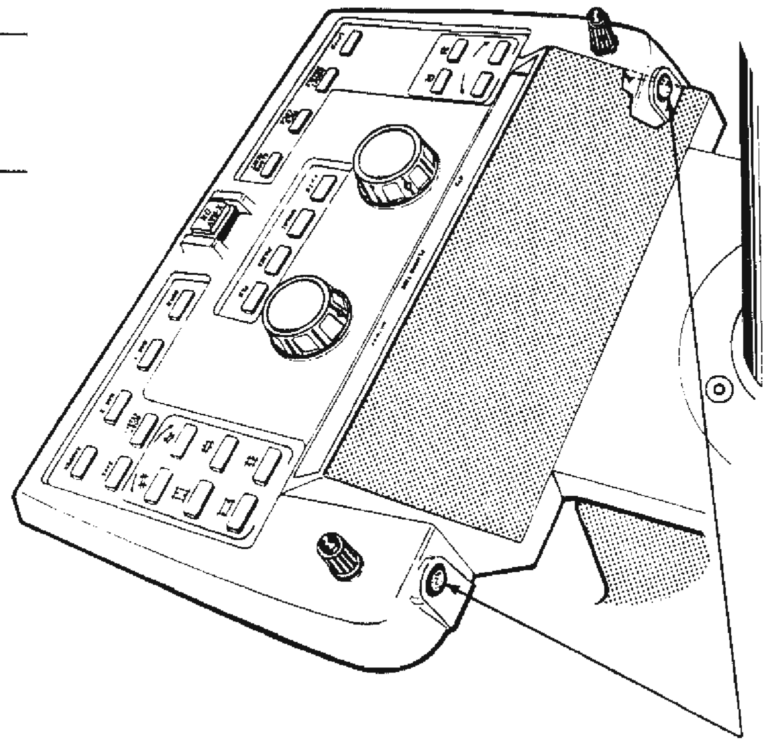
2.5.1. FAST STOP

Refer to Figure 2-1.

The C-arm has two FAST STOP buttons located on the C-arm control panel. When either button is pressed, operation of the C-arm is suspended, preventing generation of X-rays and motor powered movement. Power is not removed from the battery charger circuit nor from the control and camera electronics. This allows the microprocessor and control circuits to continue monitoring the system, and to inform the operator of its condition by a message displayed on the mainframe control panel.

In the unlikely event that a malfunction in the motor control circuitry causes a motor to drive without an operator command press one of the FAST STOP buttons.

Figure 2-1 - FAST STOP Button Locations



The battery charger circuit in the C-arm applies a charging current to the batteries whenever the system interconnect cable is in place and the monitor cart is plugged into a power outlet.

If there is any indication that the power is still being applied to any part of the system - except the battery charger circuit - after turning all switches and breakers off, remove the main power cable from the wall outlet and do not operate it again until it has been checked out.

> To turn off power to all electronics except the battery charger circuit - turn off the C-arm keyswitch and turn off the monitor cart power breaker.
>
> To remove power to all electronics - unplug the system power cord.

Remember that even when the system is unplugged, the batteries in the C-arm are a source of stored energy and are a potential hazard when the C-arm covers are removed.

2.5.2. AC Power Failure

AC power can be interrupted by overloads that blow fuses or trip circuit breakers, or by loss of power at the service outlet. The user can help avoid this problem by dedicating a properly rated line to this system. Should a power failure occur, do not plug the system into the emergency lighting circuit. Unplug the system until power is restored.

2.5.3. Electrical Fire

Execute the following emergency procedures if an electrical fire occurs.

1. Turn the system off and unplug the main power cable from the outlet.

2. Evacuate everyone from the area.

3. Call for help.

4. Use only a fire extinguisher of a type approved for electrical fires.

WARNING: **Using the wrong type of fire extinguisher presents electrical shock and burn hazards. To avoid these hazards, a fire extinguisher which has been approved by the appropriate local, state, and federal codes must be available in the room where the equipment is being used.**

2.5.4. Ground Fault Alarm Activation

If the ground fault alarm activates, a ground fault may exist in the electrical circuit supplying power to the system. Immediately unplug the system and do not attempt any further operation of the equipment until the cause of the alarm activation has been identified and corrected. Depending on the type of electrical fault, the system may present electrical shock or fire hazard if operation of the machine is attempted when supplied by a faulty circuit.

2.5.5. Accident Reporting

The Medical Device Reporting Regulation, 21 CFR Part 803, requires that the manufacturers of medical devices submit a report to the appropriate federal agency containing specific information in the event of an accident resulting in death or serious injury during the use or service of its medical devices. (In the following paragraphs, "labeling is defined to include all instructional and procedural text contained in the Operator's Manual and Maintenance Manual.)

No report is required if it can be determined that:

- o The potential for death or the type of serious injury that may result is specified in the labeling for the system.
- o The malfunction and the routine service, repair, or maintenance instructions to correct the malfunction are described in the labeling for the system.

- o The malfunction has occurred at or below its expected rate of frequency and severity.
- o The malfunction does not lead the manufacturer to undertake a remedial action involving any other systems.

In order for OEC-Diasonics to meet these reporting requirements, all users of these systems, operators, and service technicians, are required to provide the Q.A. Manager of OEC-Diasonics with the following information regarding all reportable events as soon as is practical:

1. Identify the model and the serial number.

2. Describe the event. Include whether any serious injury or death occurred, the number of people who were injured, and any publication title and dates of any articles in the scientific or medical literature describing the reported event.

3. Identify the person who is submitting the information, with his address, to OEC-Diasonics.

4. Indicate whether additional information will be submitted, and if so, when.

5. Indicate whether the event being reported has occurred with greater frequency or severity than is indicated in the labeling for the system, or is unusual for this type of system.

2.6. UNAUTHORIZED MODIFICATIONS

Unauthorized changes or modifications to any part of the system could have hazardous consequences. Changes or modifications must not be made unless specifically authorized by OEC-Diasonics.

When properly assembled with a compatible beam limiting device, this diagnostic source assembly will fully meet the Federal Performance Standards for Diagnostic X-ray Systems and Their Components (21CFR 1020.30-32) provided no components or parts are removed from the unit and no unauthorized adjustments are made in the beam limiting device or tube housing assembly. Never remove any part of the housing or beam limiting device. Never adjust any part of the beam limiting device unless under the direction of the manufacturer.

SECTION 3
THEORY OF OPERATION

SECTION 3
THEORY OF OPERATION (CONTINUED)

SECTION 3
THEORY OF OPERATION (CONTINUED)

SECTION 3 THEORY OF OPERATION

This section provides technical descriptions of the hardware and software used in the mobile C-arm mainframe. Reading this section will assist the service technician or field service engineer understand the maintenance and calibration procedures in this manual.

All printed circuit board (PCB) operation is referenced to drawings in the schematic package.

3.1. MAJOR COMPONENTS

Refer to Figure 3-1. Figure 3-1 is a block diagram showing the major components of the mainframe electronics. Further detail is found in the Mainframe Interconnect Diagram (00-873748) and the Image System Interconnect Diagram (00-873750).

3.1.1. Mainframe Electronics

The mainframe electronics consist of:

Motherboard - The motherboard interconnects several of the major data and control paths between PCBs and other components in the mainframe.

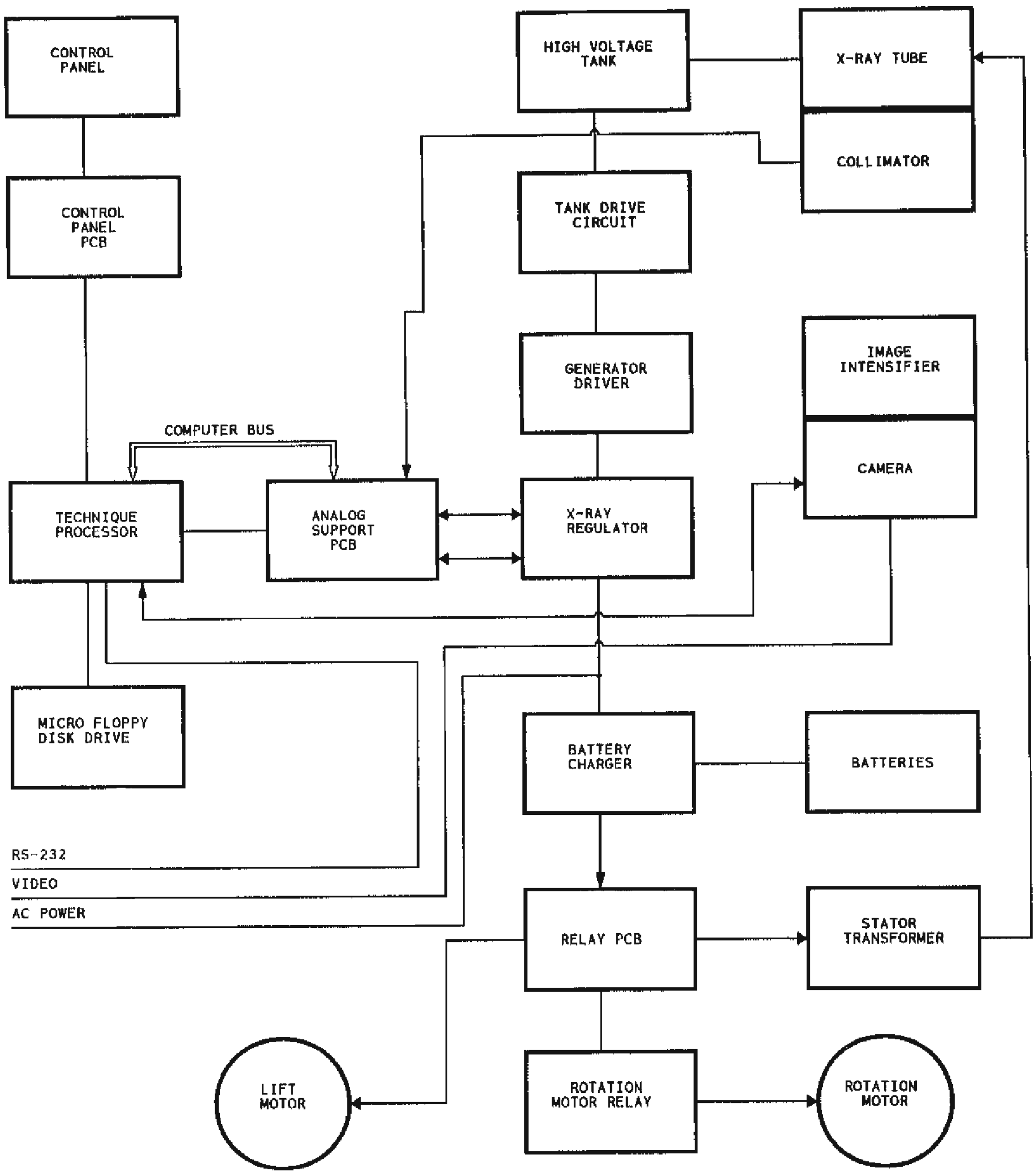
Floppy Disk Drive - Mainframe operating and application software is contained on a 3-1/2 inch floppy disk. Each time the mainframe is powered on, the software is loaded from the disk drive.

Technique Processor PCB - the 80188 processor on this board executes the operating and application software.

Control Panel Processor - reads input from the control panel, drives the display and exchanges control and display information with the Technique Processor PCB.

Generator Assembly - consists of X-Ray Regulation circuitry, Generator Driver circuitry, and Battery Charger circuitry.

Figure 3-1 - Mainframe (C-arm) Block Diagram



Analog Support PCB - interfaces the data buses from the Technique Processor with actual signal lines and analog voltages.

High Voltage Tank - contains the high voltage transformer, filament transformer, high voltage rectifier, and sensing circuits.

Batteries - buffer the energy used during an x-ray exposure.

Relay PCB - contains the interlock relay and motor control relays.

PS1 and PS2 - supply the low voltages used by the camera and the circuit boards.

Camera - converts the light image from the image intensifier tube into a video signal.

Image Intensifier - converts the latent fluoro X-ray image to a light image.

X-ray Tube - employs high voltage to accelerate electrons toward a rotating anode target. Impact with the target releases X-radiation.

Collimator assembly - Limits the size of the useful X-ray beam.

Rotation Motor Relay PCB - contains the relays which control L-arm rotation.

3.1.2. Interconnect Cable

Refer to Table 1 and Table 2

Refer to Schematic 00-873665

The mainframe and monitor cart are interconnected by either a 20 or 30 foot cable which carries power, video and communications signals. The interconnect cable is hardwired at the monitor cart and uses a 25-pin connector at the mainframe. The mainframe connector may be either of two different types. Refer to Table 1 and Table 2 for wiring connections for both cables.

TABLE 1 INTERCONNECT CABLE (ORIGINAL)

MONITOR CART PIN NO.	FUNCTION	MAINFRAME PIN NO.
P4-1	AC 01	18
P4-2	NEUTRAL	19
P4-3	CHASSIS	20
P4-4	AC 02	17
P4-5		
P4-6	SHIELD GND	
A9J7-1	CAMERA	21
A9J7-2	CAMERA-RET	22
A9J7-3	SPARE	23
A9J7-4	SPARE-RET	24
A9J7-5	REM-BRHT	11
A9J7-6	REM-CONT	12
A9J7-7	SPARE	4
A9J7-8	X-RAYINH	1
A9J7-9	VIDSTAB	2
A9J7-10	X-RAYON	5
A9J7-11	FLORO	3
A9J7-12	MECTS	9
A9J7-13	MERXD	10
A9J7-14	MERTS	7
A9J7-15	MFTXD	8
A9J7-16	GND	14

TABLE 2 INTERCONNECT CABLE (IEC 601)

MONITOR CART PIN NO.	FUNCTION	MAINFRAME PIN NO.
P4-1	AC 01	13
P4-2	NEUTRAL	22
P4-3	CHASSIS	16
P4-4	AC 02	19
P4-5		
P4-6	SHIELD GND	
A9J7-1	CAMERA	14
A9J7-2	CAMERA-RET	15
A9J7-3	SPARE	23
A9J7-4	SPARE-RET	24
A9J7-5	REM-BRHT	10
A9J7-6	REM-CONT	1
A9J7-7	SPARE	12
A9J7-8	X-RAYINH	5
A9J7-9	VIDSTAB	7
A9J7-10	X-RAYON	4
A9J7-11	FLORO	11
A9J7-12	MECTS	3
A9J7-13	MERXD	8
A9J7-14	MERTS	2
A9J7-15	MFTXD	9
A9J7-16	GND	17

3.2. POWER DISTRIBUTION

3.2.1. AC Power

Refer to the Mainframe Interconnect Diagram 00-873748.

Power is obtained from the AC line by the isolation transformer in the monitor cart and applied to the mainframe through the interconnect cable. In the mainframe, 115 VAC (optimal) is distributed to the battery charger circuit on the Generator Assembly, PS-1, PS-2 and via the Relay PCB to the stator transformer and lift motor. The Rotation Motor Relay PCB applies power to the L-arm rotation motor.

The stator and motor circuits, and the DC supplies are protected by the pop-out breakers on the mainframe power panel.

Lift and Rotation Motors

Mainframe lift and rotation motors obtain their power from the 115 VAC line. The Startup Procedure given in the Operator's Manual must be followed to complete the interlock circuit before these motors will operate. Relays which switch power to the motors are latched by the 24-volt interlock circuit. FAST STOP will open the interlock circuit, removing power from the motors.

Battery Charger Circuit

Whenever the power cord is plugged into an AC line with the interconnect cable in place, the battery charger circuit is alive and applying a charging current to the batteries. This occurs regardless of any control settings.

The Battery Charger PCB develops its own operating voltages (± 12 VDC) and charger power from the AC lines routed to this board. If a fault occurs causing excessive current to flow in the line, protection is provided by fuses on back of the power panel.

3.2.2. DC Power

Refer to the Mainframe Interconnect Diagram 00-873748.

The mainframe contains two DC power supplies:

PS1	± 15 VDC, +5 VDC
PS2	+24 VDC

Multiple DC voltages for the camera are obtained from the Camera Supply PCB located on the camera assembly. PS2 provides + 24 VDC to the Camera Supply PCB.

In the following descriptions "B+ voltage" refers to the voltage obtained across the positive and negative connections of the three 60-volt battery packs.

3.2.3. Battery Packs

Three 60 volt battery packs are located in the base of the mainframe. Their main function is to buffer the energy supplied to the X-ray tube during an exposure. This aids in high voltage regulation and also reduces the line regulation and system power requirements. The charge on the batteries is maintained by the charger circuit in the Generator Assembly which is active whenever the monitor cart is plugged in and the interconnect cable is in place.

WARNING: **Read the safety section of the manual regarding the batteries. Remember that they are a source of high voltage (180 VDC) and high current which can be hazardous even when the system is disconnected from the line voltage.**

NOTE: The three battery packs must be matched. They are installed at the factory as a matched and serialized set. When they are replaced in the field they must be replaced as a complete set - if one battery pack is replaced, they must all be replaced.

3.3. Protection Circuits

Protection circuits and software prevent runaway and overload conditions from occurring which could be hazardous or damaging.

3.3.1. 24 Volt Interlock Circuitry

Refer to Figure 3-2.

The 24 volt interlock circuitry passes through the Analog Control PCB, Relay PCB, Generator Assembly, and the Motherboard. This provides the means to halt system operation when the FAST STOP buttons are pressed or when the processor detects a major fault.

The interlock circuit begins on the Analog Control PCB where the keep-alive circuit, transistors Q1, Q2 and relay K1, provides a 15 volt interlock (also known as CPU Interlock) signal to the Relay PCB .

The CPU interlock is kept alive under software control on the Analog Support PCB - the processor supplies pulses to the keep-alive circuit via U27-PB7 (pin 25). Normally, the software will toggle U27-PB7 every 10 ms. The pulse detector, Q1 and Q2, charges C15 and latches relay K1. The processor can break the interlock by discontinuing the pulses applied to the pulse detector Q1 and Q2.

On the Relay PCB the CPU Interlock momentarily energizes relay K9 which latches relay K2. When relay K2 latches it supplies +24 volts to relays K1, K3, K4 and K5. These relays enable the lift and rotation motors, and the stator circuitry.

The +24 volts is also routed through from the Relay PCB to the Battery Charger PCB, then to the X-Ray regulator PCB. From the X-Ray PCB, +24V routs to the Generator Driver PCB. Q1 on the X-Ray regulator PCB is turned on to provide the Interlock Complete signal which routs to the motherboard, then from the motherboard to the Analog Support PCB. From the Analog Support PCB the Interlock Complete signal interfaces back to the technique processor.

If the interlock loop is broken by pressing FAST STOP, the 24 volt interlock relay (K2 on the Relay PCB) opens, interrupting power to the C-arm lift and rotation motors and the X-ray tube stator.

This 24V Interlock Circuit supplies 24VDC to the B+ (K1) charge and B+ (K2) contactor relay which mount below the X-Ray Regulator PCB. These relays (K1 and K2) are part of the Generator Controller Assembly.

3.3.2. Watchdog Timers

The Technique Processor PCB contains an automatic fail-safe circuit - a watchdog timer. The function of the watchdog timer is to interrupt the processor if the program code is not being properly executed. The watchdog timer consists of binary counters U43 and U57 which are clocked by 7.16 MHz COUT and cleared by PCS4. Software commands are imbedded at intervals in the program to "kick the dog" and prevent the counters from timing out.

If not reset every 2.3 sec, the watchdog counter issues an interrupt to the NMI input on U27, initiating a special interrupt handler routine. This routine:

1. Resets the watchdog timer (via U27-PCS4)
2. Stops pulses issued to the keep-alive relay (K1) on the Analog Support PCB, thus breaking the 24 volt interlock circuit
3. Displays an "E." error code on the Technique Processor LED digit.

If the NMI interrupt handler fails to reset the watchdog counters within another 2.3 seconds, the watchdog counters issue a RESET to the microprocessor U27-pin 24.

Figure 3-2 - Block Diagram of the Interlock Circuit

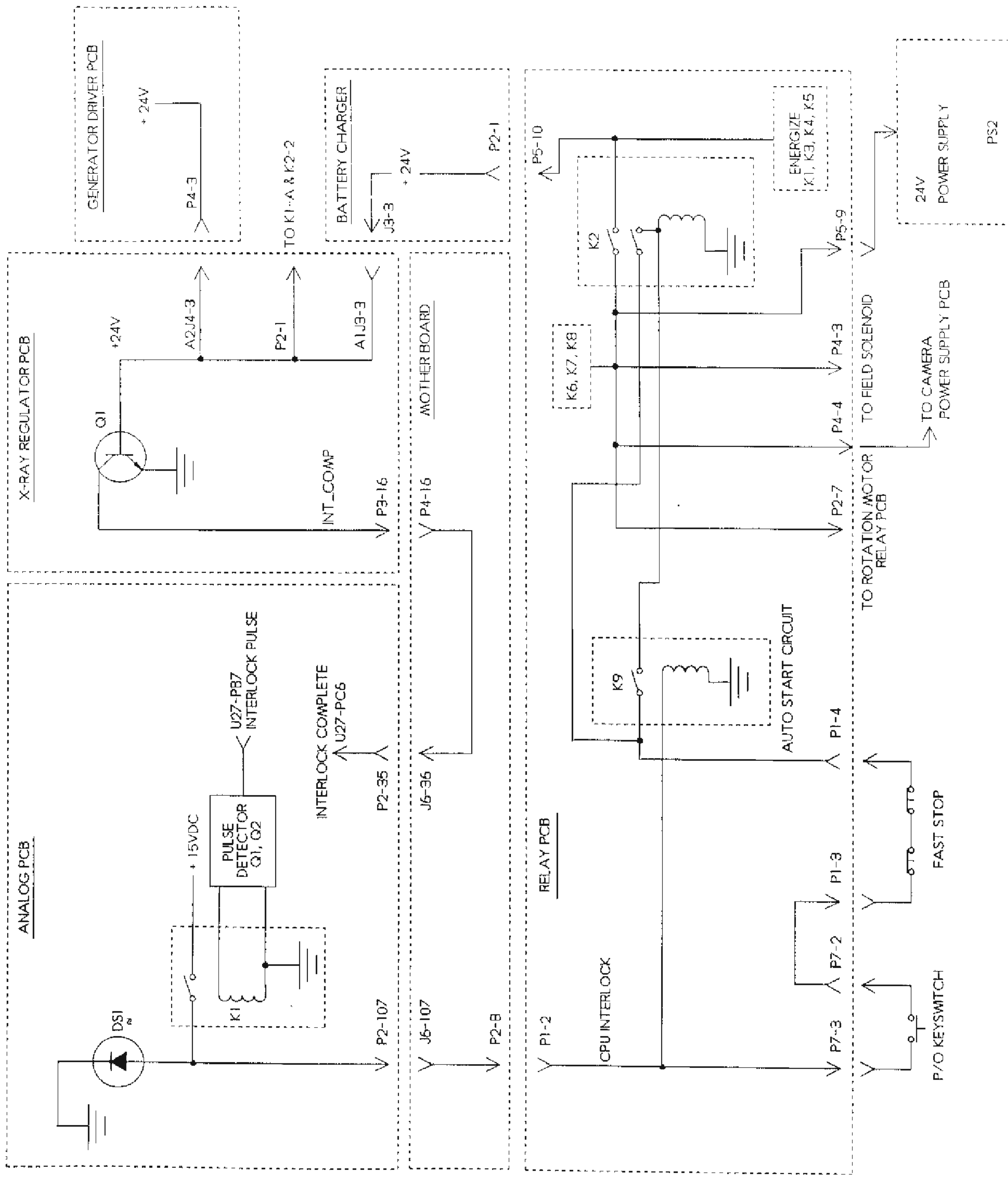
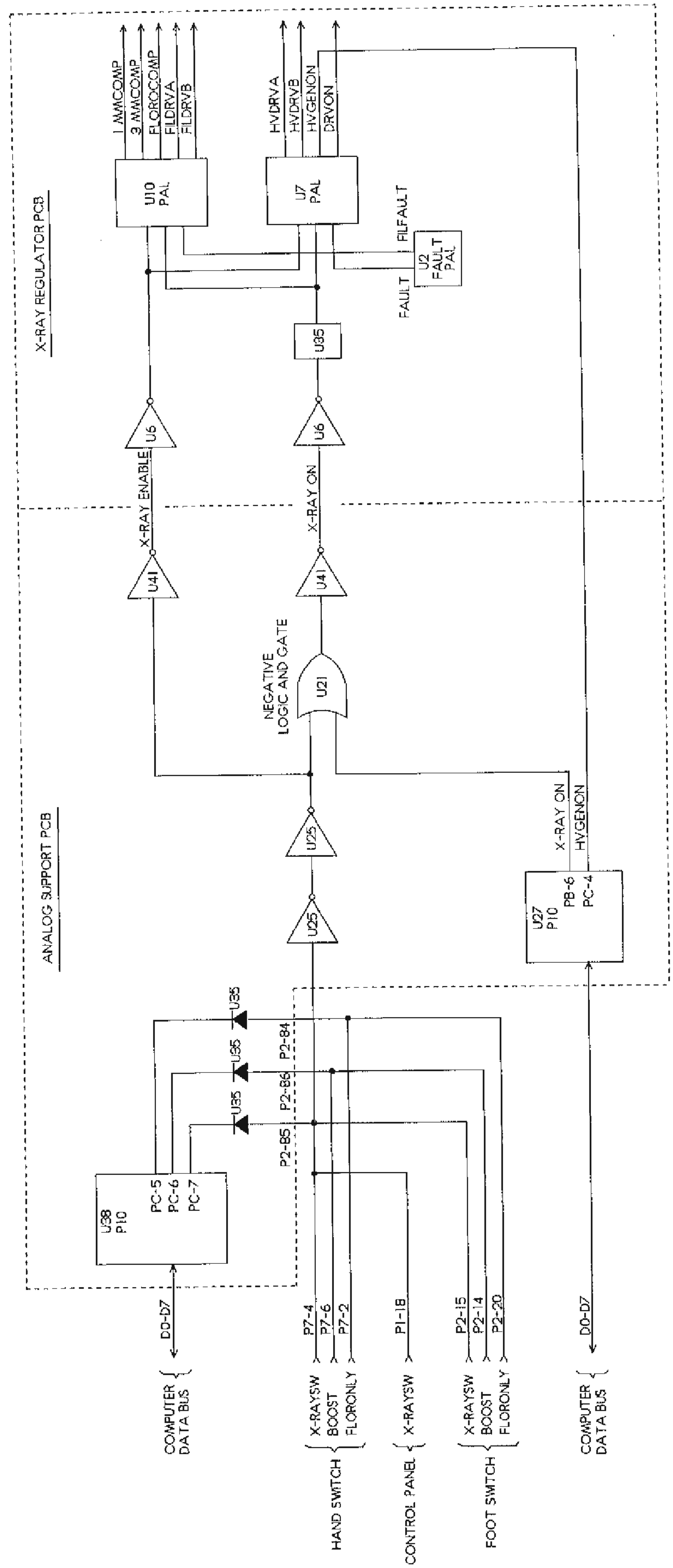


Figure 3-3 - Footswitch Logic Block Diagram



3.3.3. Footswitch Logic

Refer to Figure 3-3.

Protection logic on the Generator Assembly and Analog Support PCB requires that the processor and the footswitch logic agree before an X-ray is allowed. U27-PB6 is a processor generated X-RAY ON COMMAND.

To understand the conditions which must be met for an X-ray, trace the following logic beginning where the footswitch closure is sensed on the Analog Support PCB.

1. The kind of exposure signaled by the footswitch results in the switch qualifier signals FLUORO ONLY and BOOST. FLUORO ONLY signals that it is the left footswitch which has been pressed. All exposures are signaled by a low on the X-RAY SWITCH line.
2. X-RAY SWITCH is sensed by the processor via U38-PC7.
3. The X-RAY ON COMMAND is issued by the processor via U27-PB6 to confirm the exposure. This signal is ANDed by negative logic gate U21 - if both inputs are low, the output is low. The output is finally inverted and buffered by the "1488" driver U41 to form X-RAY ON.
4. The conditioned X-RAY SWITCH signal is inverted and buffered by U41 to form X-RAY ENABLE.
5. The two signals, X-RAY ON and X-RAY ENABLE, are connected via the motherboard to the X-Ray Regulator PCB where they are inverted by receiver U6 and input to the PAL logic at U7 and U10. The outputs from these PALs form the filament and high voltage drives.
6. Faults on the X-Ray Regulator PCB are sensed by fault PAL U2.
7. If X-RAY ON and X-RAY ENABLE are true and there are no faults reported to PAL U7-9 or PAL U10-9 from FAULT PAL U2, then U7 output HV GEN ON will be true.
8. HV GEN ON is sensed by the processor at Analog Support PCB, PIO U27-PC4.

3.3.4. Fire Protection

In the unlikely event of multiple catastrophic failures, the 30 Amp circuit breaker in the connection to the battery pack provides fire protection.

Fuses F1, F3, F4 and F5 on the Generator Driver PCB provide protection to the associated one ohm drive resistors in the event an output transistor in the high voltage driver stage should fail.

F2 interrupts the B+ supply to the Generator Assembly in the event of any other potentially destructive component failure.

The AC line for the battery charger circuit is protected by fuses on the back of the mainframe power panel.

3.4. FAULT CONDITIONS AND ERROR CHECKS

Software running on the Technique Processor PCB monitors operating conditions and hardware states. In the event of a fault, the processor suspends operation, but does not turn power off to the system. Warning messages are displayed on the control panel. These are listed and described in the Service and Diagnostics section.

Conditions which are monitored include:

- o Status of the film cassette holder sense switch (6-inch systems only)
- o X-ray tube temperature
- o Stator operation
- o Generator-regulation transistor faults
- o High voltage tank mA sense
- o High voltage kVp sense
- o Battery circuit current and Voltage

NOTE: If a fault is detected which is severe enough to cause the system to break interlocks, a complete restart of the system is required. Turn the keyswitch to the OFF position and then to the ON position.

3.4.1. KVp Overvoltage

If the voltage sensed on the SECONDARY TAPS 1 and 2 of the high voltage tank exceed 135 kVp (approximately), comparator U32 on the X-Ray Regulator will trip the OVERVOLTAGE input to PAL U2. The FAULT output from U2 disables the high voltage drives from the output of PAL U7.

3.4.2. Short Circuit Protection

A winding on the series tuning inductor L1, in the High Voltage Tank circuit input, senses the differential voltage across the inductor. This CURRENT LOOP signal is integrated on the X-Ray Regulator PCB by R124 and C71 to derive a voltage proportional to the current through L1. This voltage is rectified and filtered to provide the input to sensing comparator U37. When the comparator trips, it signals the Fault PAL U32 to interrupt the drives from PAL U21.

3.4.3. Saturation Fault Detector

This circuit is found within the Generator Assembly. The main power transistors, Q1 and Q2, each contain two darlington pairs, and drive the primary of the high voltage transformer (tank). Bridge rectifier VR1 on the Generator Driver PCB, is used to sense any excess on-state voltage across the active pair of drive transistors in Q1 and Q2.

Q9 level-shifts the high side on-state voltage sensed by R14 to the ground referenced R19. The open collector buffer U11 on the X-Ray Regulation PCB enables the input of comparator U14 only during the output stage drive period. At this time, rectifiers CR27 and CR23 can cause comparator U14 to trip the FAULT 1 line, feeding PAL U2.

Any situation which causes the output transistors to supply so much current that their on-state voltage is excessive will cause a fault to be sensed by the circuit. If this fault occurs, the message SATURATION FAULT will be displayed on the control panel.

3.5. MAINFRAME OPERATION

3.5.1. X-ray Modes

Standby Mode

The system enters a standby mode after 5 minutes have elapsed with no operator action. When the footswitch or any control on the panel is pressed, the system will resume normal operation.

The standby mode increases X-ray tube life by removing the stator and filament drives. The stator is removed after 5 minutes have elapsed with no operator interaction. The filament current is turned down after 30 minutes have elapsed with no operator interaction. The system will continue to provide motorized UP/DOWN movement of the C-arm.

Fluoro Modes

When either the X-RAY ON button or footswitch is pressed, the system begins the X-ray exposure. The actions of the system depend on which technique has been selected. The exposure is terminated if the user releases the X-RAY ON button or footswitch. The following is a general description of each major technique.

Fluoro Manual. KVp and mA are set by the operator. The camera video level is measured and camera gain is increased or decreased to optimize the video. Exposure continues until the ON button or footswitch is released.

Fluoro Manual Pulsed. Operation is the same as for Fluoro Manual except that the exposure is generated only for the duration of a pulse. The pulse rate is selectable at the monitor cart. Select 1, 2, 4, or 8 pulses per second. Four pulses per second is the default setting. The exposure is pulsed at the selected rate per second while the ON button or footswitch is pressed.

Fluoro Auto - In this mode, kVp, mA and camera gain are automatically controlled to obtain the proper video level. The relationship between the various parameters is established by software algorithms.

Fluoro Auto Pulsed - Operation is the same as for Fluoro Auto except that the exposure is generated only for the duration of a pulse. The pulse rate is selectable at the monitor cart. Select 1, 2, 4, or 8 pulses per second. Four pulses per second is the default setting. The exposure is pulsed at the selected rate per second when either the ON button or footswitch is pressed.

Boost - Boost is available for AUTO or MANUAL FLUORO on some models. When the BOOST position of the footswitch is pressed the camera gain is reduced to minimum and the mA is allowed to increase under servo control up to a maximum of 20 mA. If the resulting image is not optimally bright, the camera gain is increased.

WARNING: Boost should not be used for general purpose imaging.

Pulsed Boost Fluorography - In this mode, mA levels as high as 60 mA are achieved during pulsed X-Rays. After a timed 30 second exposure the shot is automatically terminated.

WARNING: Pulsed Fluorography should not be used for general purpose imaging. The increase in mA is 4 - 10 times the normal rate. Exposure to these mA levels should be minimized.

Film Mode

The presence of a film cassette is required in this mode. The 6-inch, but not the 4/6/9-inch system, checks for the presence of a cassette holder. This is sensed by a proximity switch near the face of the image intensifier tube.

When the X-RAY ON button or footswitch is pressed, the system brings the rotating anode up to speed and the filament up to proper temperature, and then applies the high voltage to the X-ray tube.

The exposure is terminated when: the proper mAs (product of beam current and time) has been achieved, the user releases the X-RAY ON button or footswitch, or when a fault is detected.

Instant On

INSTANT ON allows the operator to precharge the system for radiographic exposures. Normally, after depressing the footswitch there is a 2 second delay as the anode is accelerated and the filament is heated. When the system is precharged there is no delay. Refer to the FILM section of the Operator's Manual for instructions on how INSTANT ON is used.

3.5.2. Other Factors in X-ray Operation

Stator Operation

Before an X-ray is attempted, the stator winding driving the rotating anode must be energized. The processor checks for this by monitoring the presence of stator current - the stator sense line indicates that the stator is running.

When starting rotation, the STATOR START and the STATOR RUN lines must both be active.

STATOR START remains on (120 Vac) for no longer than two seconds at a time. If it remains on after 15 seconds a circuit breaker will trip open to prevent damage to the stator.

STATOR RUN remains on (40Vac) for five minutes after an exposure or will turn off after 5 minutes if there is no exposure. When re-energizing the stator, the full start/run sequence will occur.

Dark Current Tables

Periodically, the system measures the video level without X-rays on. The dark current which occurs varies as a function of camera temperature. The measurement is used to calculate compensation for dark current.

Between exposures, the camera gain is periodically set to minimum and maximum values and the camera offset is adjusted to restore video level to the proper baseline levels.

Filament Control

Between exposures, the filament B+ is raised to about 200 VDC. After the footswitch is pressed, the filament B+ voltage is decreased to a value around 140 - 175 VDC, depending on mode and spot size. During high current exposures and film shots, when the 1-mm spot is used, filament voltage assumes the higher value to offset battery voltage cave-in.

During FILM mode shots - To prevent destructive in-rush currents to the filament driver circuits, the filament is preheated. This is done by starting at a low regulation duty cycle and then gradually increasing the duty cycle, and consequently the temperature, to the required value over a time period of at least one second.

3.6. MAINFRAME SOFTWARE

Mainframe software is loaded from microfloppy disk to Technique Processor RAM during system startup. This software remains resident in RAM until the keyswitch is turned off.

3.6.1. Startup and Software Boot

The key events which occur during startup are:

1. Power supplies come up to voltage and power is applied to all microprocessor circuits.

2. Microprocessors are reset and program control is transferred to the boot PROM on the Technique Processor PCB.

3. Boot PROM software performs critical hardware setups, executes various hardware tests, and then loads the boot sectors from the microfloppy disk.

Critical hardware setup includes initializing all DMA, memory, I/O and bus oriented devices. In detail this setup involves these steps:

a. Initialize hardware lines to a defined state
b. Initialize and test memory
c. Scroll the sign-on message
d. Check the footswitch
e. Display Boot codes

For a complete list of boot codes refer to the section in this manual: Mainframe Service.

4. Software routines in the boot PROMs load the boot sectors from the disk.

5. Boot sectors, once loaded into RAM, bootstrap load the operating system into memory. After the operating system is initialized it assumes program control.

3.6.2. Application Software is Loaded

Applications are entered from the operating system, from some other management process or a program such as the diagnostics. The key events which occur are:

1. Check EEPROM integrity.

2. Check EEPROM disk image.

3. Hardware is again initialized as a precaution.

4. The 40 kHz clock on the Analog Support PCB is started.

5. Interlocks are made.

6. The stator line is pulsed.

7. Small filament is preheated

8. B+ capacitor is charged.

9. Generator and X-ray tube control signals are initialized. After a pre-charge cycle the B+ Contactor is closed.

10. Footswitch is checked (for footswitch stuck fault).

11. Heat units are computed for the anode.

12. Tests are run to determine if the system is capable of functioning. In detail the tests are:

    a. Verify that the kVp and mA sense are near zero.
    b. Check for inadvertent presence of X-ray Activate Jumper which will appear as "Footswitch Stuck".
    c. Verify HV Generator Line OFF
    d. Turn on B+ Precharge. Check batteries during precharge.
    e. Close Main Contactor. Check B+ voltage
    f. Check flipper circuits.
    g. Check EEPROM integrity.
    h. Check EEPROM disk image.
    i. Load default parameter file.

12. Default fluoro and film parameters are loaded and the system is configured based on the contents of the default parameter file.

13. If no problems are found, operator input is accepted from the control panel.

3.6.3. Periodic Functions and Actions

These are functions executed periodically by the software program. These include control panel polling and error checking.

Items checked include:

- o Flipper collimator circuits (checked during field select and boot)
- o X-ray tube heating
- o Camera dark current compensation - dark current compensation tables are built every 5 minutes after the last fluoro exposure.
- o Monitor battery voltage and current.
- o Hardware faults - such as overloads, saturation, and filaments.

3.6.4. EEPROM Usage

The electrically-erasable PROM (EEPROM) on the Technique Processor PCB stores historical data about the system for later use by service, marketing and engineering. Associated with the EEPROM is a disk data file that contains an image of the EEPROM contents.

The EEPROM contents consist of:

- Reserved area
- Event Code array, contains the last 512 event codes
- System State array
- Highest anode heat - records highest anode heat ever produced on the system
- Anode heat conditions - Condition flags under which the highest anode heat occurred. b0=film/fluoro, b1=spot size, b2=boost normal, b3-b7=reserved
- Highest housing heat, ever recorded
- Highest housing heat conditions=as above
- Highest housing thermistor reading ever encountered
- Longest system run time - highest number of continuous hours of system power
- Highest battery voltage ever encountered
- Lowest battery voltage ever encountered
- Maximum continuous fluoro on time ever encountered
- Maximum cumulative fluoro on time ever encountered.
- Total film exposures taken on the system
- System serial number
- System calibration factors

A local event table is copied from EEPROM after system startup. A fatal event will cause the local event table to be copied to EEPROM.

3.6.5. Default Parameter File

The default parameter file contains information about the system configuration. It is accessed by using the terminal menus described in the service section.

3.7. C-ARM MECHANICS

3.7.1. C-Arm Movements

Refer to Schematic 00-870735.

The Arm Assembly consists of L-arm and C-arm mechanical assemblies. The L-arm provides approximately 360-degree motorized rotation for the C-arm. The rotation switches on the L-arm Assembly controls the direction of rotation. At the junction of the mechanical L-arm and C-arm cradle is a pivot point with a manually released friction brake allowing radial movement of the C-arm. The C-arm is capable of 111 degrees of radial movement. The centers of rotation for the motorized L-arm, flip-flop element, and radial movement are all located approximately at the same spot. Since these three elements all share this approximate center of rotation, spherical scanning is possible.

The motions possible with the L-arm and C-arm are illustrated in the following figures.

Figure 3-4 - C-arm Radial Movement

The C-arm can rotate in its cradle 111 degrees.

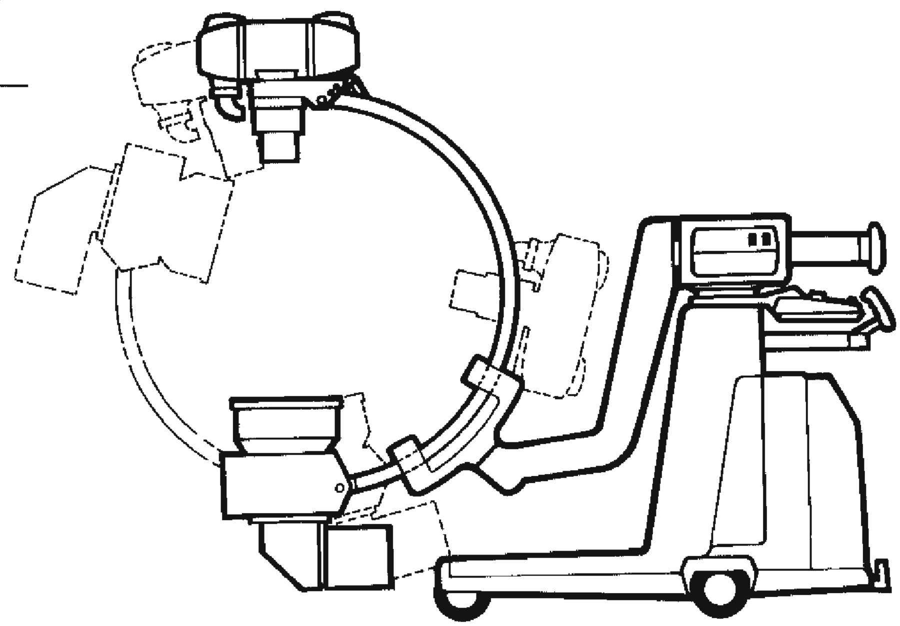


Figure 3-5 - C-arm Cradle Axis

The C-arm can pivot about the cradle axis 180 degrees to flip flop the positions of the X-ray tube and the Image intensifier.

WARNING: With its brake loosened, the C-arm may pivot out of control. Guide the C-arm carefully with both hands until the brake is retightened

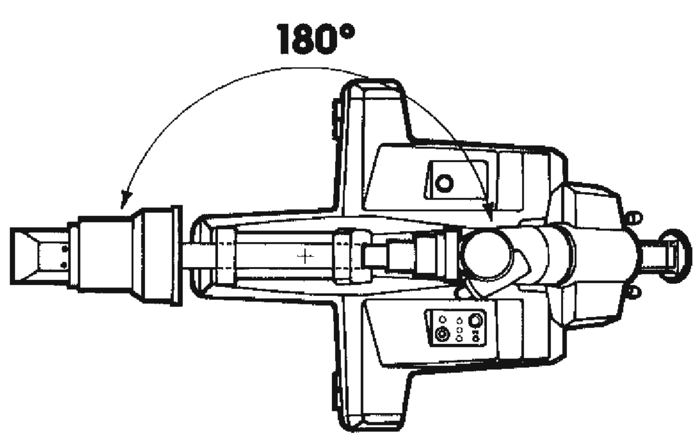


Figure 3-6 - L-arm Rotation

The L-arm can be rotated 180 degrees in either direction (for a total of 360 degrees).

1. Press up or down on the L-arm rotation switch located on the lift column head for rotation in either CW or CCW directions.

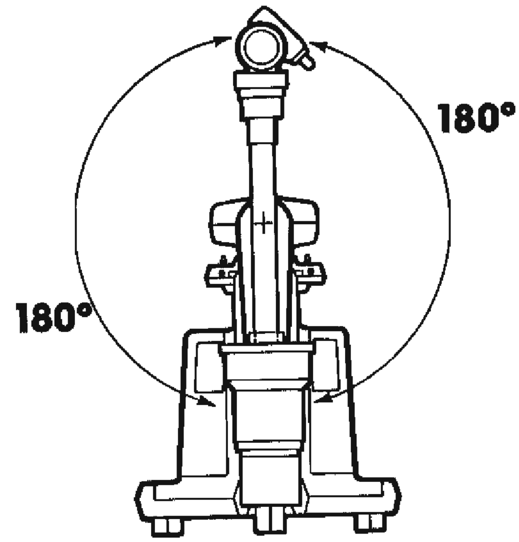


Figure 3-7 - Raising the C-arm and L-arm

The entire C-arm and L-arm assembly can be raised up to 18 inches on the central column using the following step:

1. Press the column lift switch, located on the column head, up or down.

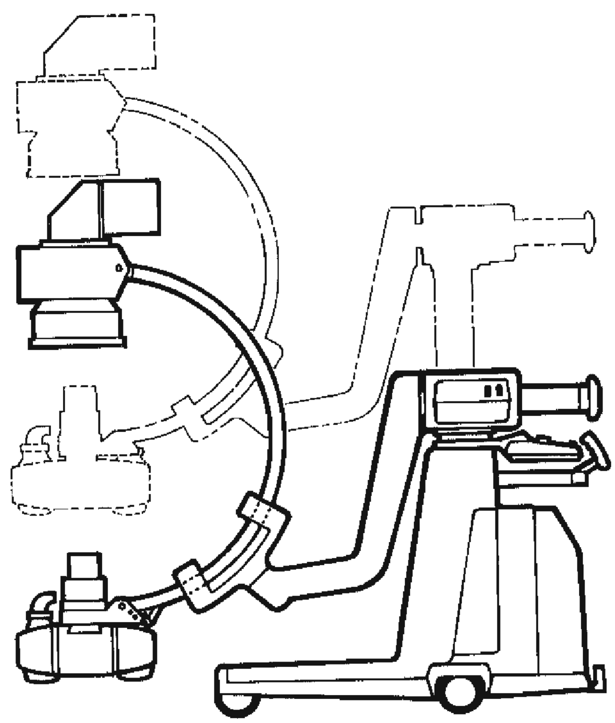


Figure 3-8 - L-arm and C-arm Horizontal Extension

Assemblies can be extended up to 8 inches horizontally using the following steps:

1. Release the locking ring by turning it counter-clockwise 15 degrees.
2. Move the extension arm to the desired position.
3. Tighten the locking ring by turning it clockwise until it is fingertight.

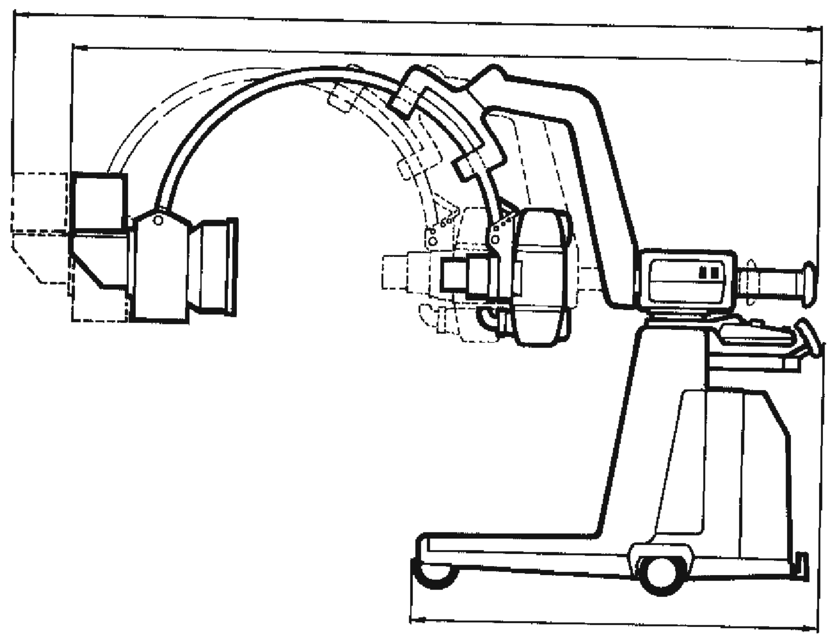


Figure 3-9 - C-arm, L-arm Wig Wag

The entire extension, L-arm, C-arm assembly can swing, or wig-wag, from side to side 11 degrees in either direction for a total of 22 degrees of motion.

1. Pull out the locking pin and turn its handle 1/4 turn to latch it open. Loosen the wig-wag brake on the column.
2. Retighten the brake handle when the desired position is reached.

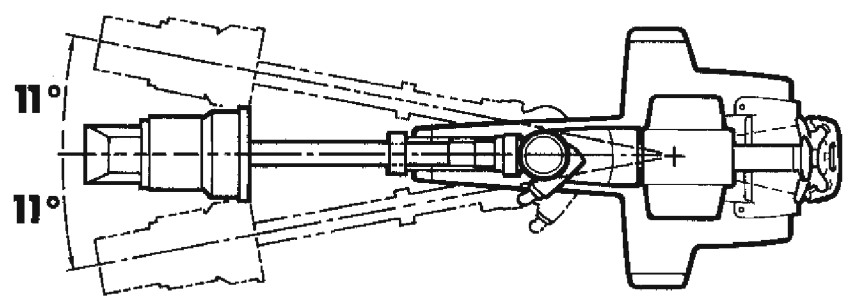


Figure 3-10 - Control Panel Movement

The control panel can be swung 58 degrees to either side, for a total of 116 degrees of movement. This provides the operator with easy access to the controls.

The control panel is not locked in position.

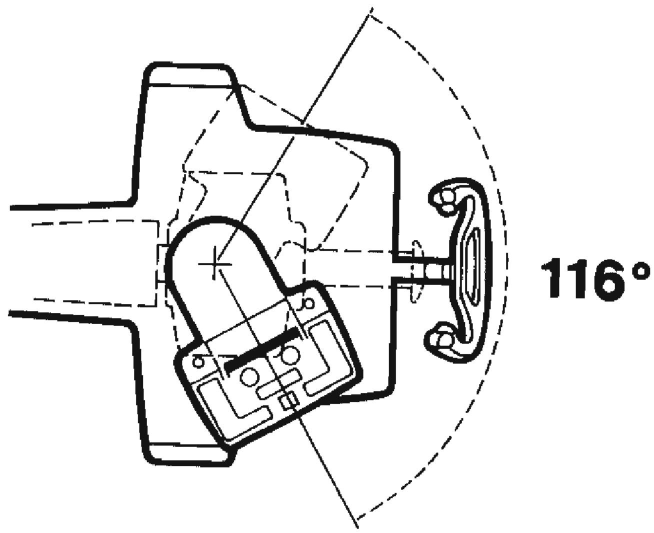
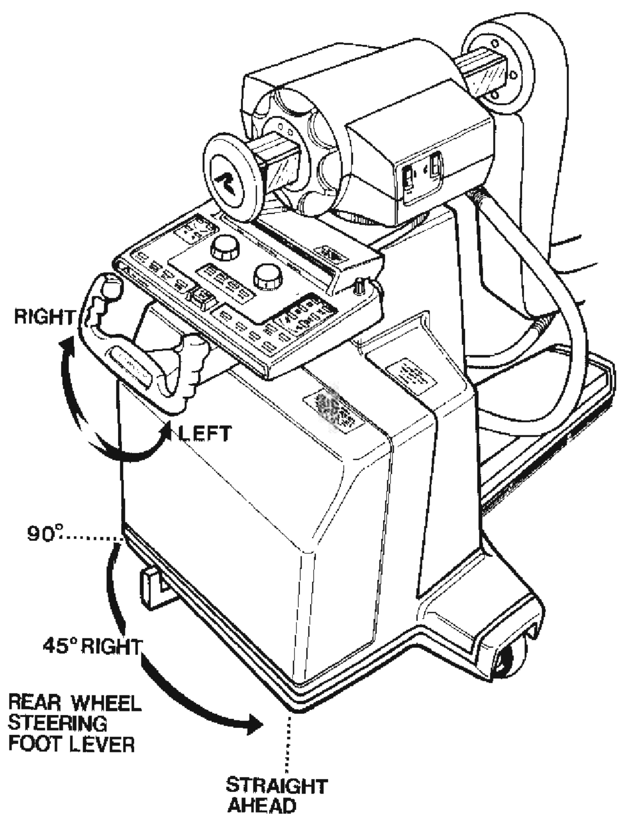


Figure 3-11 - Steering

A steering handle and foot lever are used to control the orientation of the front and rear wheels.



3.8. X-RAY TUBE

Refer to Figures 3-12 and 3-13.

The EIMAC 300 series tube uses a rotating anode and two filaments. One filament focuses the X-rays on the target in a large area (1.0 mm) and the other focuses the X-rays in a small area (0.3 mm). The rotating anode is connected to the armature of an induction motor driven by stator coils placed outside the glass envelope of the X-ray tube.

3.8.1. Stator

The stator coil is driven continuously by 40 VAC in the FLUORO mode, and with 115 VAC for a 2-second duration (the 2-second delay between the closure of the X-RAY ON switch and the actual generation of X-rays) prior to each exposure in the FILM mode.

Figure 3-12 - Cutaway View of the X-Ray Tube

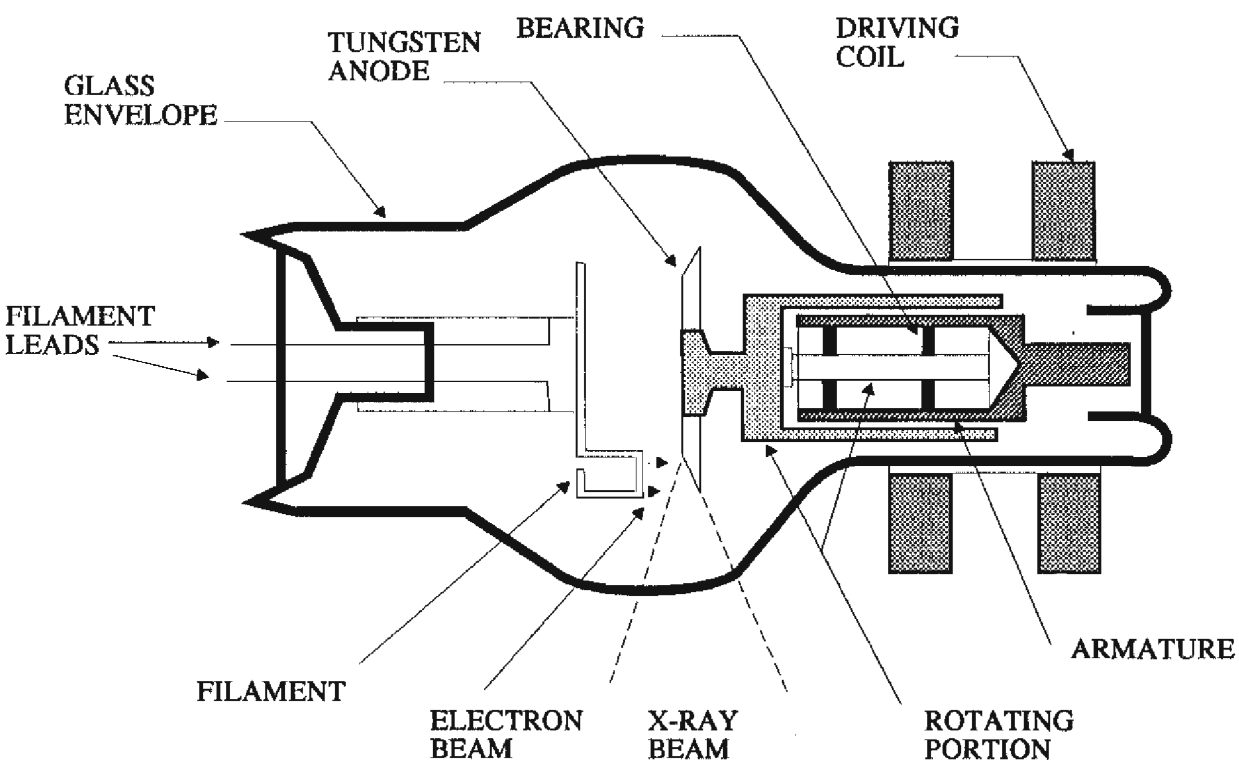
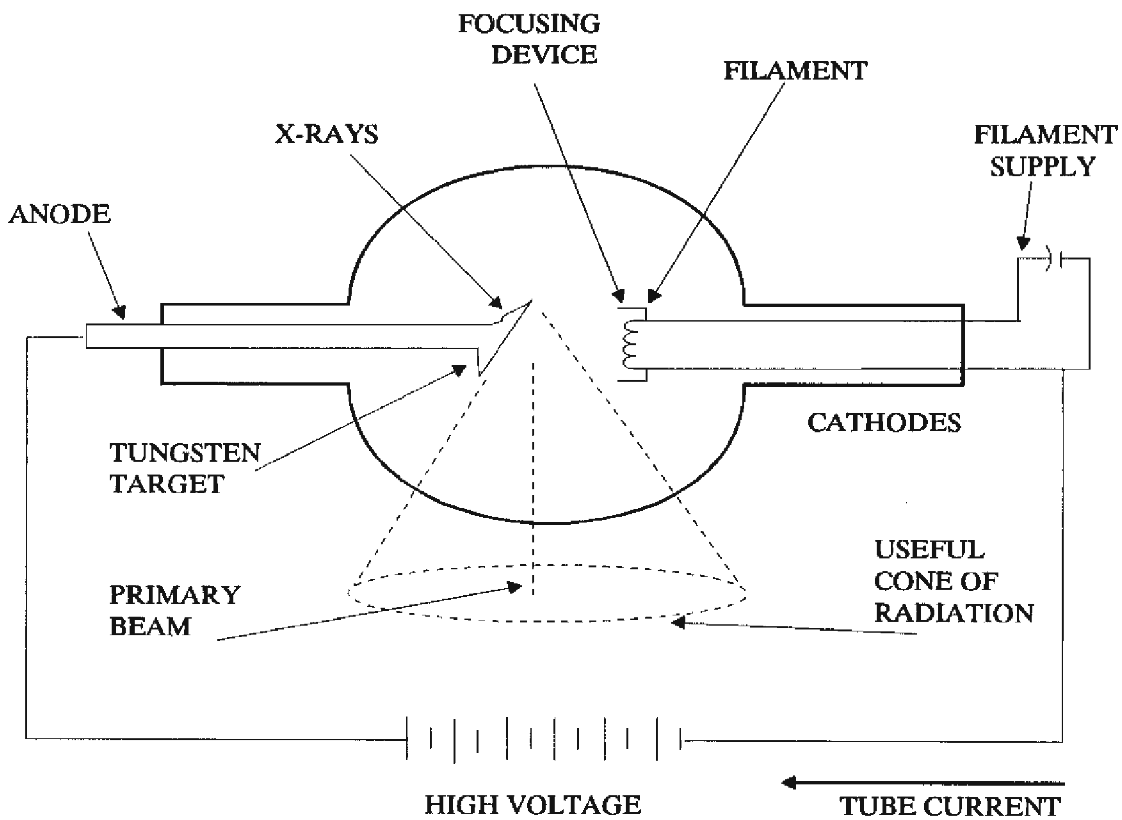


Figure 3-13 - X-Ray Tube Theory of Operation



3.8.2. Temperature Sensing

Continued heat buildup in the X-ray tube housing during long procedures can sometimes exceed the housing heat limitations. This can have potentially hazardous consequences for the tube. To avoid this situation, the operator is warned when the housing is about to exceed its safe rating.

Calculated Heat Integration

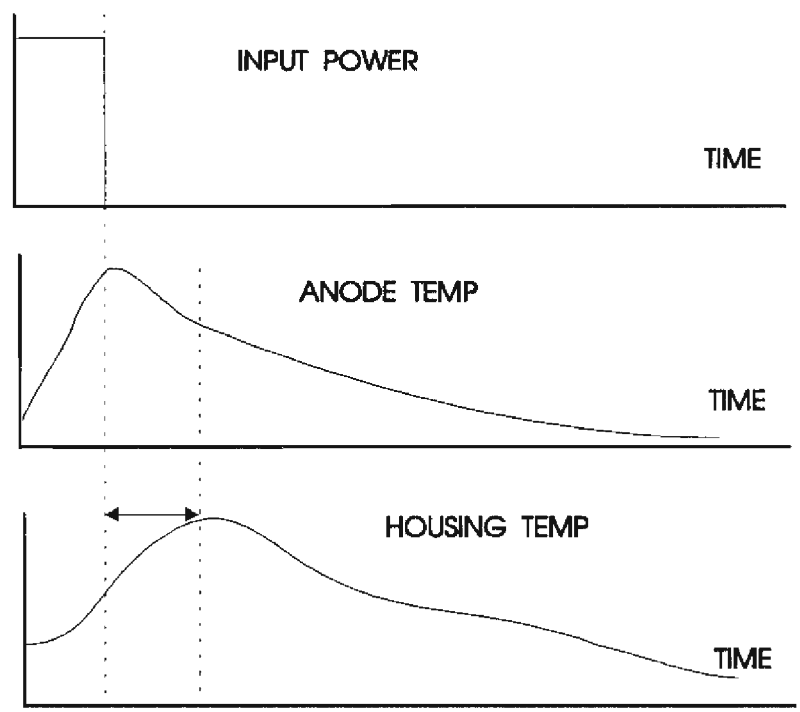
The maximum temperatures at which the tube anode and housing can be safely operated sets an upper limit on the X-ray exposure duration and power.

For short exposures, the housing temperature reaches a peak sometime after the shot. The housing temperature rise is delayed due to the time it takes to load heat from the anode. The relationship of input power, anode temperature, and housing temperature is shown in Figure 3-14.

The heat buildup in the tube before, during and after an exposure is calculated. These calculations are referenced to the actual elapsed time provided by the real time clock.

For any given temperature, a prediction of the next allowable exposure can be made assuming any given technique. The operator can be warned if the proposed shot will exceed the heat rating of the tube. For FILM shots, he is informed if the selected technique will exceed the safe temperature limits and the shot will be prevented until the tube cools or a sufficiently lower technique is selected.

Figure 3-14 - Input Power vs Anode and Housing Temperature



3.8.3. HV Cables and HV Effects

The high voltage from the high voltage generator is carried to the X-ray Tube Assembly via a flexible high voltage cable assembly. The cables have 50 pf\foot capacitance which acts as a filter capacitor on the output of the high voltage generator.

WARNING: **These cables are capable of storing a high energy charge, and must be shorted to the chassis immediately after being disconnected from the X-ray tube or high voltage generator to avoid a potentially lethal shock.**

3.9. X-RAY BEAM PATH

Refer to Figure 3-15 X-Ray Beam Path.

The primary collimator (1) is located at the X-ray tube window. Directly below this is the primary filter (2). (Filters in the beam path reduce unwanted soft radiation).

The flipper collimators (3), are located within the X-ray tube mounting head. Solenoids move the flippers in and out of the beam path, selecting between the 4" (11 cm), 6" (15 cm), and 9" (23 cm) fields. Selection is made at the control panel. With 6-inch image intensifier systems, only the small field can be used in fluoroscopy.

The beam size and shape is further controlled by the leaf collimators (4) located in the rotating collimator assembly below the tube housing.

The secondary collimator (5) limits the maximum beam size to approximately 10 inches (25.4 cm) for 6-inch only systems, and approximately 9 inches for 4/6/9-inch systems. The secondary filter (6) is immediately below the collimator opening.

The skin spacer (7) helps maintain the safe 12 " (30 cm) source to skin distance.

Beam Collimation

Collimation is used to limit the size of the usable X-ray beam. Two levels of collimation adjustment are provided.

Refer to Figure 3-16.

Continuously variable collimation is provided by a dual set of leaf collimators located in the collimator assembly below the X-ray head. The leaf collimators may be used to reduce the size and shape of the X-ray beam. With the leaf collimators the useful beam size may be reduced to less than five centimeters squared.

Figure 3-15 - X-Ray Beam Path

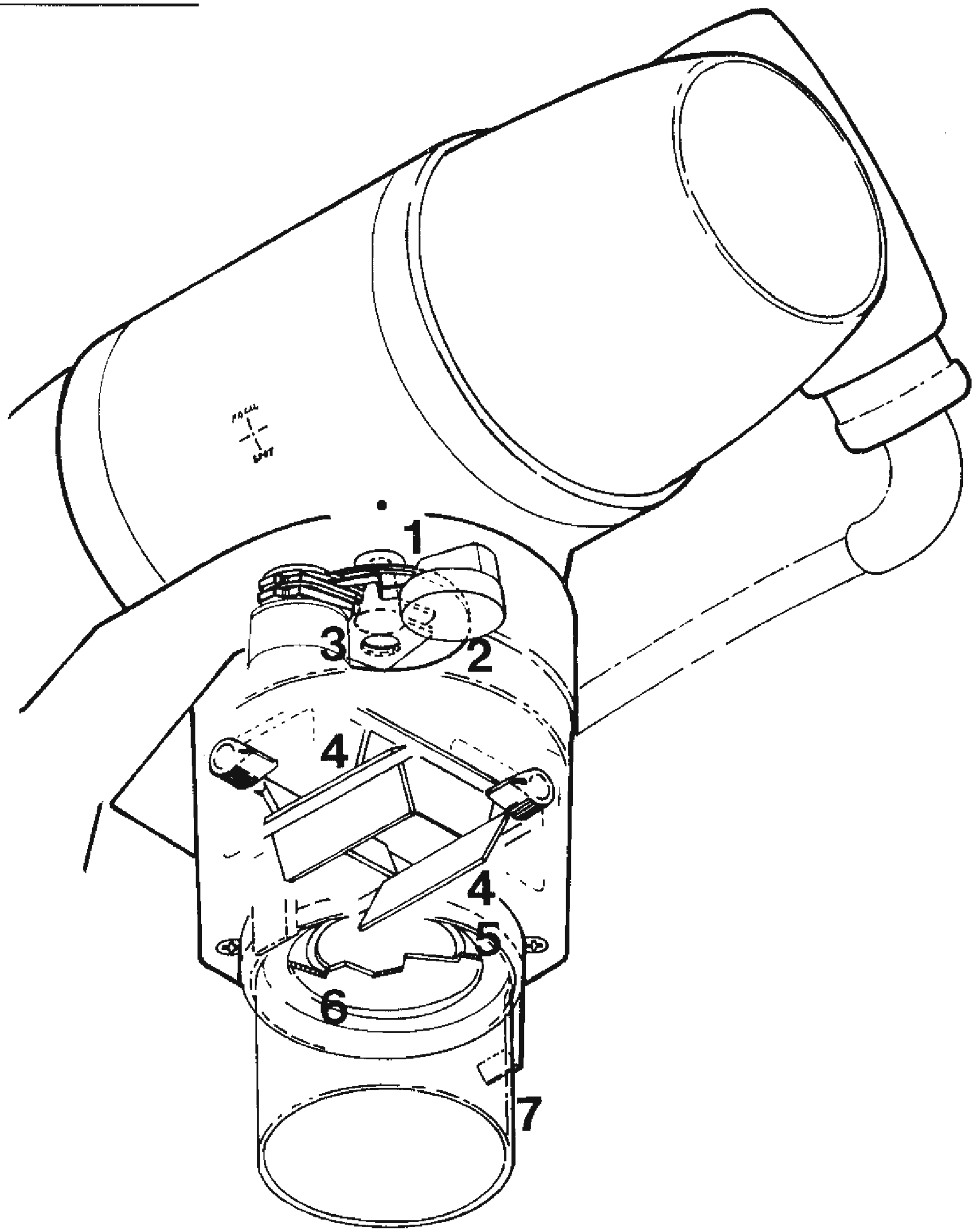
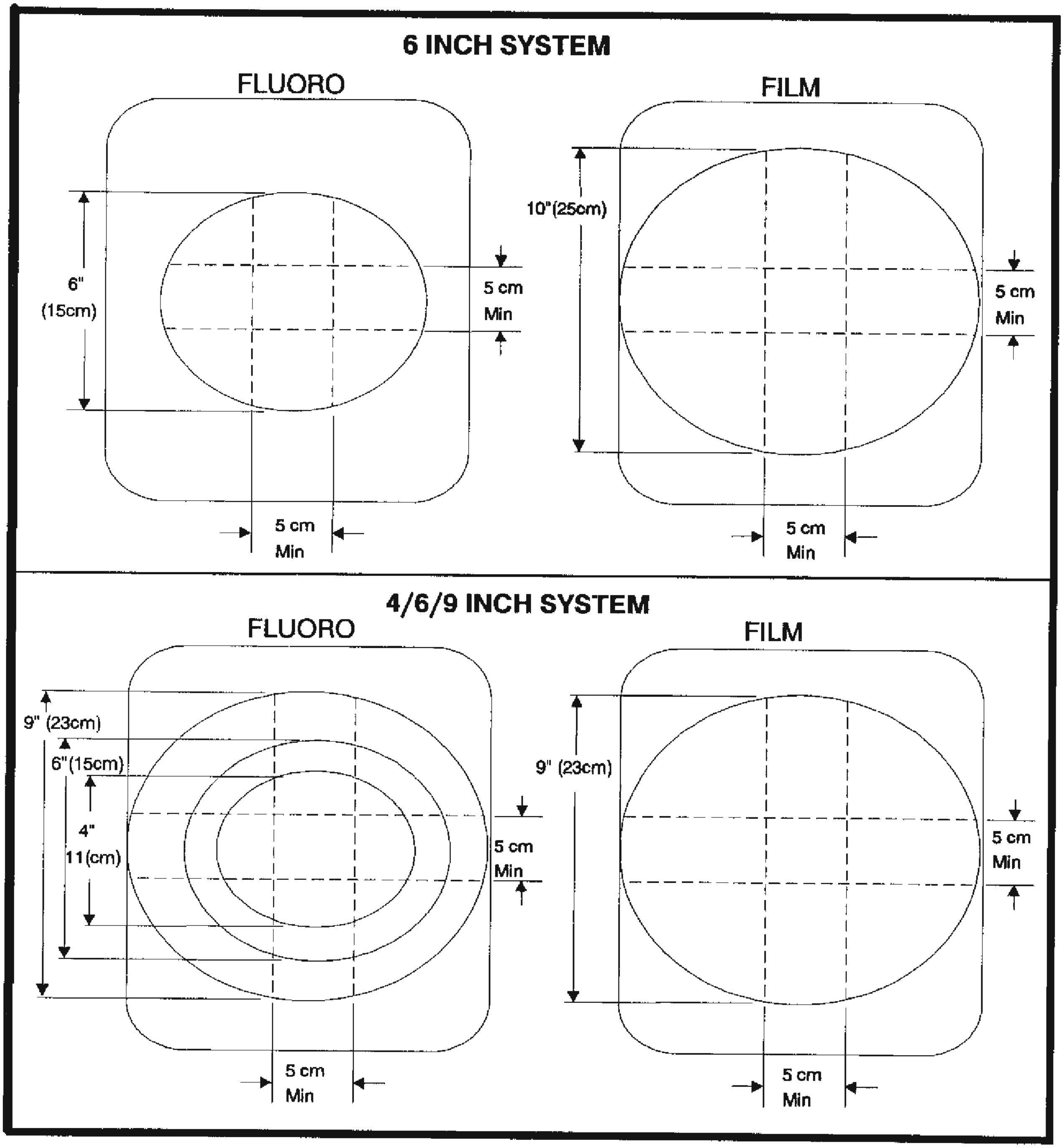


Figure 3-16 - X-Ray Fields

The X-Ray fields produced by varying degrees of collimation are different for 6-inch and 4/6/9-inch systems.



The X-ray fields produced by varying degrees of collimation are different for 6-inch and 4/ 6/9-inch (11/15/23 cm) systems. The size of these fields depends upon the configuration of the Image Intensifier:

6-inch Image Intensifier Models - When the small field collimator is in place, the field is reduced to 6 inches. Only the 6" (11 cm) field can be used in the FLUORO mode. The LARGE field on these models is approximately 10 " (25.4 cm) diameter.

4/6/9-inch Image Intensifier Models - Press the NORMAL key on the mainframe control panel to select the uncollimated 9" (23 cm) beam. Press the MAG1 key on the mainframe control panel to select the collimated 6" (15 cm) beam. Press the MAG2 key on the mainframe control panel to select the collimated 4.5" (11 cm) beam.

The last collimator in the series is a lead ring just inside the exit port of the Collimator Assembly. On a system equipped with the 6" (11 cm) image intensifier, the final collimator limits the X-ray beam size and shape to a 10-inch diameter circle when the large beam is selected. On a system equipped with the 9" (23 cm) image intensifier, the final collimator limits the X-ray beam size and shape to a 9" (23 cm) diameter circle.

Collimator rotation and closure of the upper set of lead leaves are motorized, and may be controlled from the front panel. Rotation of the collimator assembly is continuous in both CW and CCW directions. Rotation and closure of the collimator leaves can also be done manually with a switch on the collimator housing.

When the collimator control keys on the control panel are pressed an interrupt is generated which signals the control panel processor to scan the keyboard. The switches are debounced in software. The resulting scan code is passed to the technique processor PCB which controls the motor signals to the hardware. U38 on the analog support PCB provides the signals which control the motor control devices on the Image Functions PCB.

3.10. IMAGE INTENSIFIER ASSEMBLY

The image intensifier converts the fluoroscopic X-rays, incident on its input face, into a visible light image on its output screen. Image intensification employs a high voltage power supply.

3.10.1. 25 kV Power Supply

The 25 kV power supply is part of the Image Intensifier Assembly and provides approximately 25 kV to the image intensifier tube.

3.10.2. Image Intensifier Tube

The image intensifier tube is a vacuum tube device which converts X-rays into visible light. This is accomplished by the sodium-doped cesium iodide scintillator at the tube's input plane. The visible light image from the scintillator excites a photo-cathode, which emits free electrons into the space containing the focusing and accelerating electrodes. The focusing electrode accelerates the electrons to a high energy level to achieve brightness gain, demagnifies the electron image to permit optical coupling, and focuses the image onto the output image plane. Another scintillator screen produces the final intensified visible light image.

3.10.3. Optical Coupling and Right Angle Optics

Optical coupling between the image intensifier output screen and the camera vidicon consists of two lenses and a right angle mirror. The first lens converts the image to a collimated (infinity focus) image. and the second lens is focused to form the image on the input plane of the camera vidicon.

3.10.4. Cassette Proximity Switch

Six-inch image intensifier assemblies have a magnetic proximity switch mounted on the side of the tube housing. Radiographic shots are not permitted unless this switch senses that the cassette is present.

Figure 3-17 - Right Angle Optics

Right angle optics consist of a mirror , camera and image tube lenses.

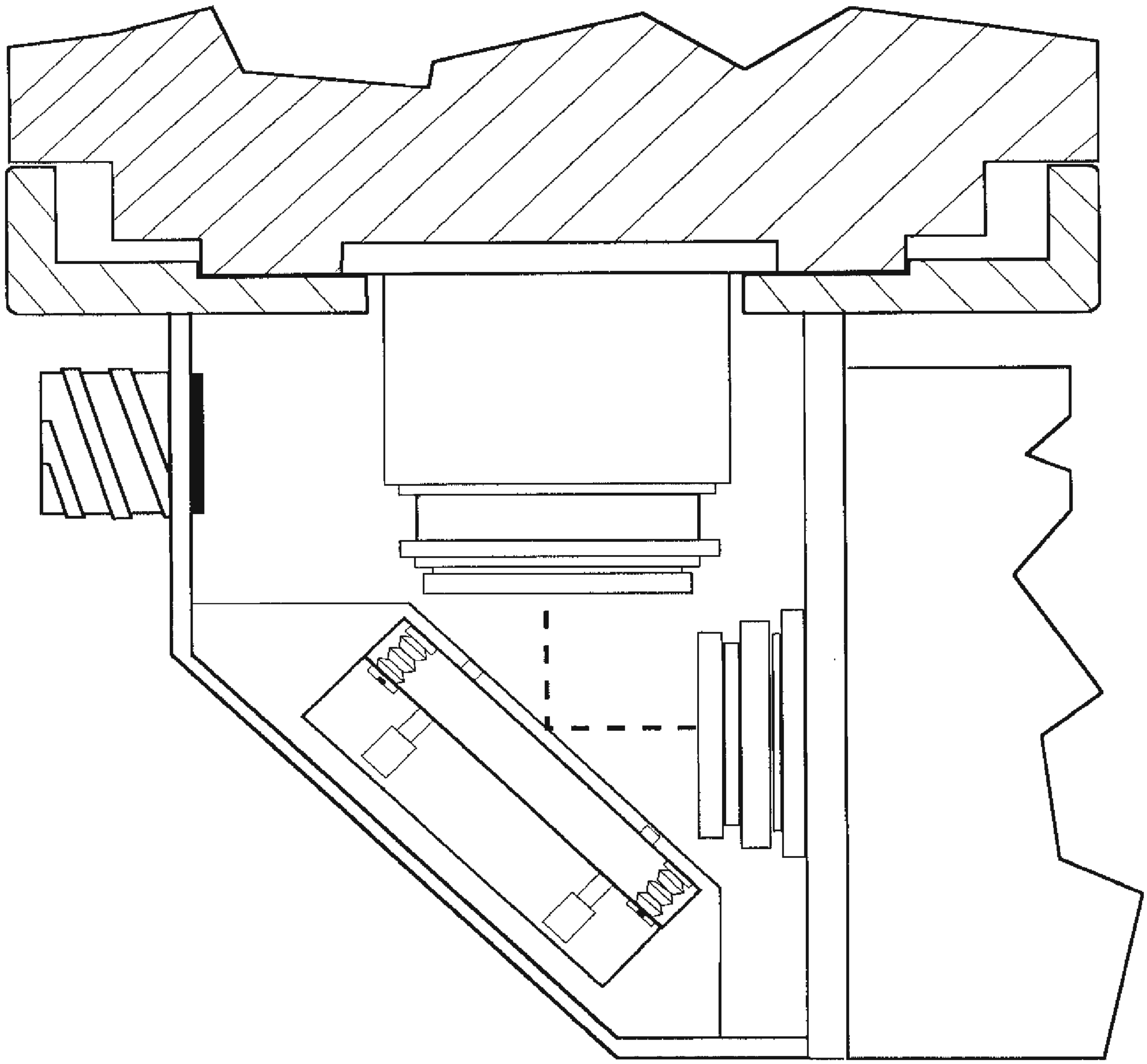
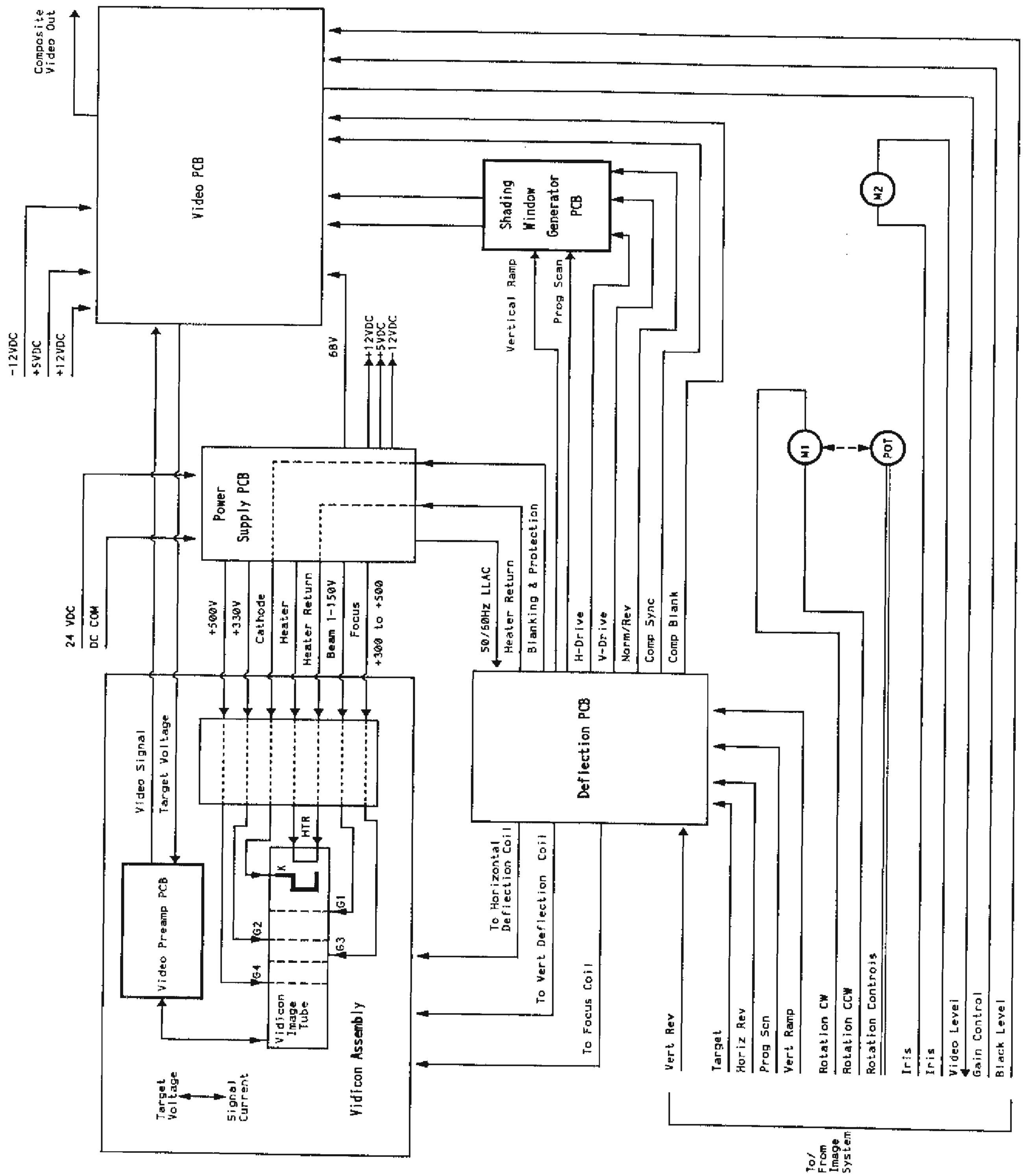


Figure 3-18 - Camera Block Diagram



3.11. VIDEO CAMERA

Refer to Schematic 00-873750 of the Imaging System.

The TV camera converts the visible light image from the image intensifier into a composite video signal.

3.11.1. Operation

Refer to Figure 3-18.

The visible light image passes through a right angle lens system and is focused on the input face of the TV vidicon. This image is converted to a composite TV signal by the camera and is available to the image processing circuitry and the video monitors in the monitor cart.

The TV camera electronics scan the image on the vidicon, optically coupled from the image intensifier, and convert the image into a composite video signal. This signal is routed to the Video Switching PCB in the monitor cart.

The camera is normally in progressive scan mode which means that the video signal is not interlaced and odd and even lines are scanned sequentially. When the camera is in interlaced mode odd fields and even fields are painted separately. The camera is automatically switched (software control) to interlaced mode when storing images to the VCR.

Another video signal, called video level, is produced which is proportional to the brightness within a sampled window area of the image. This is routed to the Analog Support PCB where it is digitized and read by the processor. Under software control, a camera gain control signal is fed back to the camera. In AUTO FLUORO mode, the video level signal is used to control exposure technique.

Circuits are included on the Window/Shading Generator PCB for correcting camera tube shading variations.

The video sweep direction can be reversed horizontally and vertically from the control panel. This results in a mirror-image reversal of the image. The camera can also be rotated to change the orientation of the image on the screen.

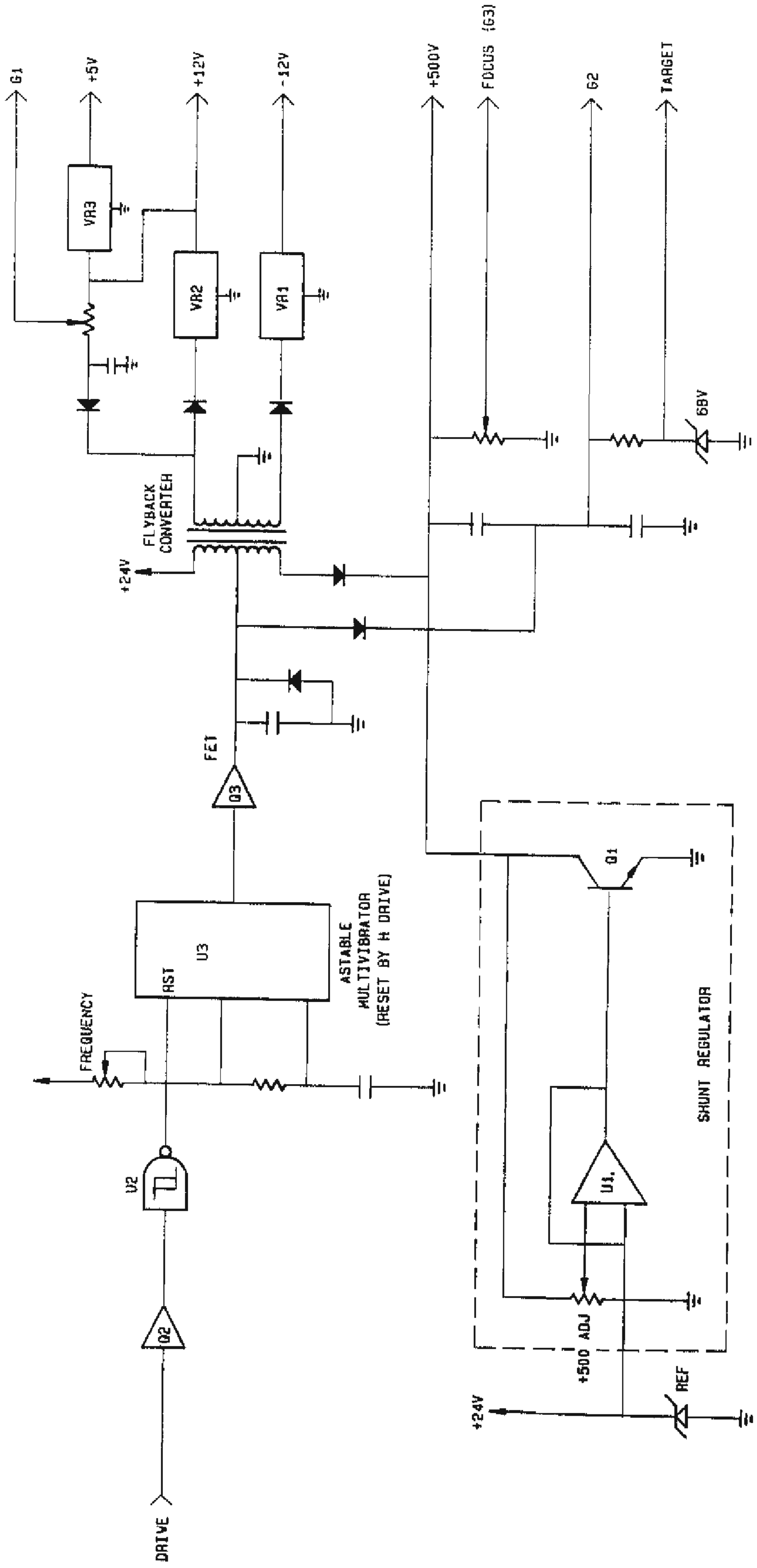
Camera rotation is controlled from the mainframe control panel. The camera yoke can be rotated a total of 360 degrees. The camera assembly does not rotate, only the yoke and tube assemblies rotate.

3.11.1.1. Pulsed Fluorography Mode

In pulsed Fluorography mode (up to 60mA), the iris motor steps the lens iris down to F-stop 4 (F/4). When pulsed fluorography mode is disabled, the motor automatically steps the lens iris back up to F-stop 2 (F/2). Insure this occurs by the following operation:

1. Enable "pulsed" and "boost enable" from the control panel.
2. Depress "boost" on the footswitch which puts the system in pulsed fluorography mode.
3. The iris motor should drive the lens iris to F/4.
4. Release "boost" on the footswitch.
5. The iris motor should drive the lens iris back to F/2.

Figure 3-19 - Block Diagram of the Camera Power Supply PCB



3.11.2. Camera Power Supply PCB

Refer to Schematic 00-870813 and Figure 3-19.

The Power Supply PCB supplies all regulated voltages used by the camera. These voltages are developed from the 24 VDC supplied from the mainframe.

24 volts is applied to one end of the primary of flyback transformer T1. The center tap of this transformer is switched to ground by transistor Q3. The base of Q3 is driven by astable multivibrator U3 which is synchronized to the horizontal drive (H drive) rate.

Potentiometer R5 controls this synchronization. Monitor TP14 and TP13 and adjust R5 to synchronize U3 with the H drive.

Both halves of the T1 primary are flyback inductors which develop high voltage AC waveforms when the centertap switches from ground through Q3.

During the flyback cycle, CR3 rectifies the AC voltage across the lower half of the primary to provide 350 VDC for G2. The target supply voltage is also obtained from this point and then regulated down to 68 VDC by zener diode CR4. CR2 rectifies the high voltage AC across the entire primary inductance to form 500 VDC applied to the voltage divider R7-R11-R10. R11 adjusts the G3 (focus) voltage. The 500 VDC rectified by CR2 is regulated by shunt regulator circuit U1, Q1 and adjusted by pot R13.*

During the non-flyback part of the cycle the secondary of T1 provides the G1, +5, and ± 12 VDC voltages.

3.11.3. Camera Deflection PCB

Refer to Schematic No. 00-873455 and Figure 3-20.

The Deflection PCB supplies the synchronized scan signals to the yoke assembly. This PCB contains:

- o Sync generator
- o Horizontal deflection coil driver
- o Vertical deflection coil driver
- o Vidicon blanking and protection
- o Focus coil voltage regulator

Sync Generator

The sync generator, U2, generates all the necessary pulses for operation of the deflection and composite video signals. The sync generator is operated in two modes; progressive scan, and interlaced video.

During progressive scan programmable counter U3 is programmed to count at a slightly longer period than mid-line. This output sets U8, which is used to inhibit the mid-line counts in the sync generator by holding U3-11 low. This causes the sync generator to generate vertical timing signals at ½ the normal rate.

During interlaced video mode the programmable counter U3, is programmed to count at a slightly shorter period than mid-line. This shorter period does not interfere with the mid-line counter in the sync generator.

The video sync generator is clocked by crystal Y1 for 60 Hz operation and Y2 for operation in 50 Hz systems.

Horizontal Deflection

A switched flyback style yoke driver is comprised of Q5, Q6 and associated circuitry. The waveform generated is a short half-sinusoidal, high voltage pulse, followed by a long level segment. This waveform is AC coupled to the horizontal winding of the yoke, resulting in an average voltage of zero. A sawtooth shaped current waveform then results in the yoke due to its inductance. R39, R38, selector U4, op-amp U1, and associated components provide a "sum-in" DC current, used to center the deflection beam. The slight linearity error caused by the L/R time constant of the yoke is corrected by damped resonant circuit L4, C5, and R56.

Horizontal Sweep Reversal

Horizontal sweep reversal is accomplished by energizing relay K1, which swaps the yoke leads. The same signal also causes selector U4 to select the H CENT REV potentiometer R38.

Vertical Deflection

The vertical deflection coil driver consists of U6 and Q3. Integrator U6 generates a sawtooth waveform. During vertical retrace Q3 is turned on which shorts out the integrating capacitor C13. The resulting sawtooth is applied to amplifier U6 which produces a sawtooth current waveform in the vertical deflection coil.

Vertical Sweep Reversal

K2 provides vertical sweep reversal. Centering adjustments R29 and R37 are provided for reversed and normal mode.

Tube Blanking

The camera tube blanking and protection circuit consists of Transistors Q8, Q9, Q10, and Q11. Q4 buffers a voltage waveform from the vertical deflection coil to drive Q9 which operates as a switch. Transistor Q10 is a switch driven by the flyback pulse across the horizontal deflection coil. The two transistors Q9, and Q10 drive emitter-follower Q8, whose output is applied to the cathode of the camera tube. When Q9 and Q10 are biased to cutoff, the potential at the emitter of Q8 is approximately 110 VDC. This negative voltage applied to the cathode turns on the beam in the camera tube. Q10 switches on at the start of horizontal retrace or if the horizontal deflection waveform fails. Q9 switches on at the start of vertical retrace or if the vertical deflection waveform fails. With either transistor turned on, +12 VDC will be applied to the cathode by Q8, which biases the beam to cutoff.

The beam can be blanked externally by applying a low to P109-1 the BEAM BLANK input. When the function is not asserted the beam current resumes at the next vertical drive time.

Focus Coil Regulator

The focus coil regulator consists of current regulator circuit Q1, U1, and zener diode CR3. The diode biases the collector of Q1 at a potential 6.2 volts more positive than the -12 VDC supply. U1 is a voltage to current converter.

Zener diode CR3 also supplies 6.2 VDC to the tube filament.

Figure 3-20 - Block Diagram of the Deflection PCB

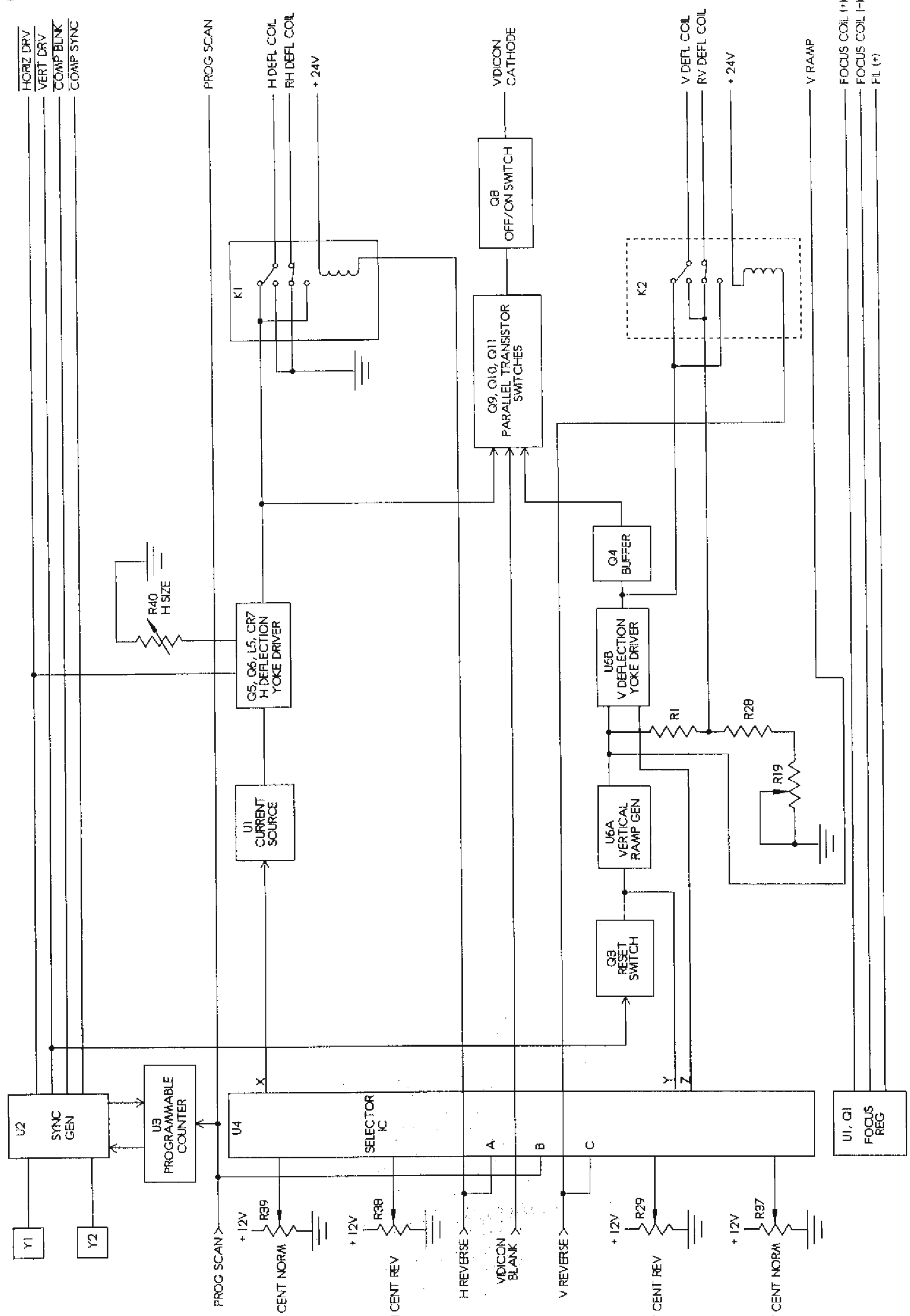
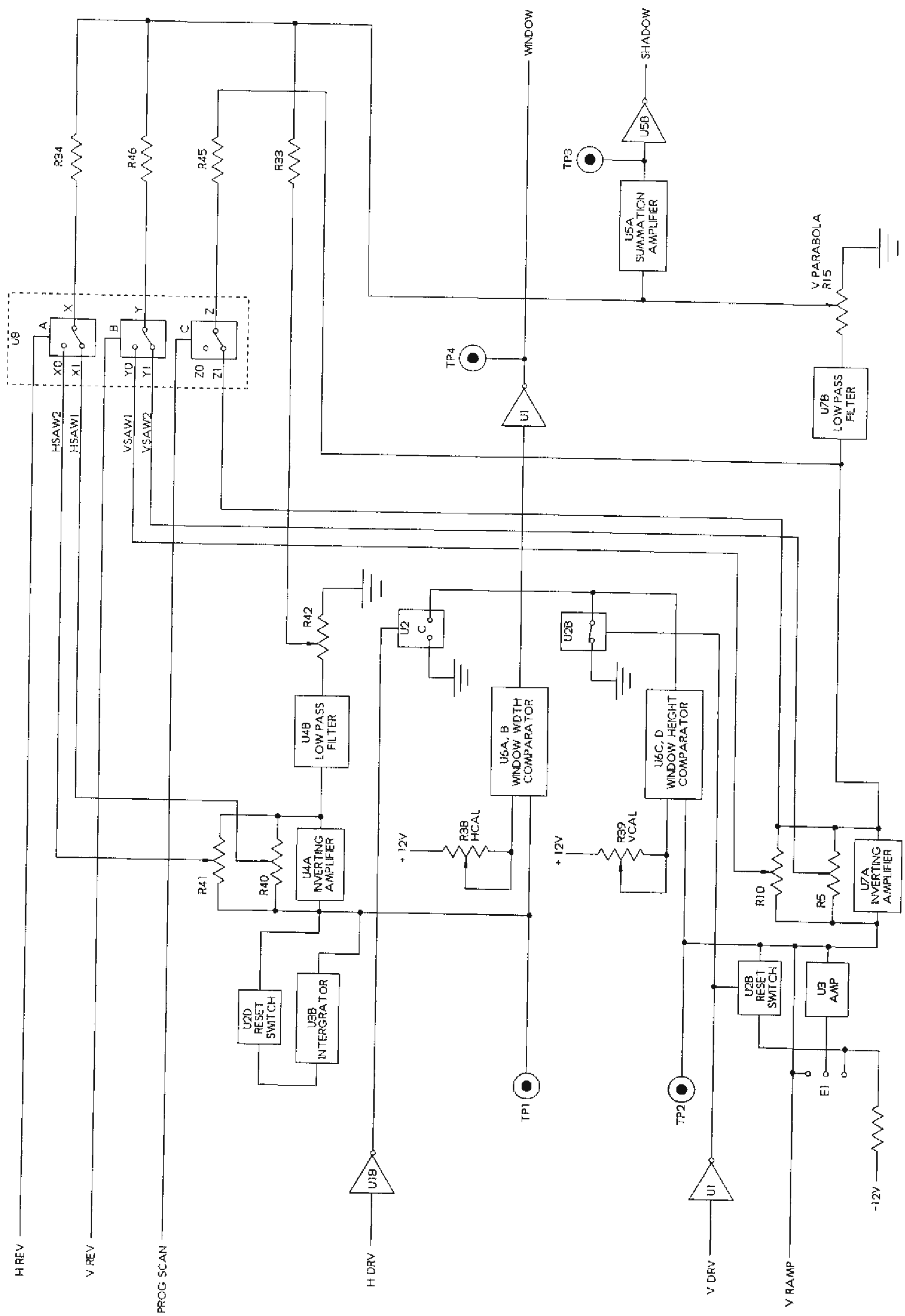


Figure 3-21 - Block diagram of the Window Shading PCB



3.11.4. Shading/Window Generator PCB

Refer to Schematic No. 00-873471 and Figure 3-21.

The Shading/Window Generator PCB provides the signals necessary for the shading modulator on the video board to compensate for vidicon shading, and optics vignetting.

This PCB also generates the ABS (Auto Brightness) sample window waveform. Its purpose is to sample the amplitude of the video winthin a centrally located square of the image. This sample is used in the ABS function in the X-Ray Generator

Vertical Shading Circuit

The shading function utilizes both the horizontal and vertical ramps. Shading is a video gain correction that varies over the image plane. Shading corrects for optical vignetting, image intensifier variations and beam landing and target quality variations in the vidicon.

The gain correction curve is parabolic with less gain correction required at the center than at the edges of the image plane. To apply this function, a parabolic waveform is added to a ramp to result in the proper correction. Both horizontal and vertical shading circuits are the same.

The vertical ramp originates in the Deflection PCB and is routed to P111-2 on the Shading/Window Generator PCB. After routing through amplifier U3 for amplitude scaling it is applied to inverting amplifier U7 to generate an inverted ramp. Both the input and the output of U7A are applied across R10 (V SAW1) and R5 (V SAW2) the VERT SAWTOOTH adjustment potentiometers. These signals are summed at the summing junction of U5 via multiplexor/switch U8.

At the same time the output of U7A is applied to the input of U7B. The resulting parabolic waveform is applied to R15, the V PARABOLA potentiometer. The wiper of R15 provides another waveform to be summed by U5. The combination of V PARABOLA, V SAW1 and V SAW2, form the vertical shading waveform.

Horizontal Shading Circuit

The horizontal shading circuit operates similarly, except the horizontal ramp is generated on the Shading/Window PCB by integrator U3B. The horizontal drive input at P104-15 is fed to analog switch at U2-12 to reset the ramp each horizontal line.

This ramp signal is applied to inverting amplifier U4A to generate an inverted ramp. Both the input and the output of U4A are applied across R40 (H SAW1) and R41 (H SAW2) HORIZONTAL SAWTOOTH adjustment potentiometers. These signals are summed at the summing junction of U5 via multiplexor/switch U8.

The output of amplifier U4A is also fed to integrating amplifier U4B where the parabolic waveform is generated. The output of U4B is also fed to the summing amplifier.

Shading Signal

The output of U5A is inverted by U5B, resulting in the shading waveform at P104-13. The signal at this point is a combination of the vertical shading waveforms and the horizontal shading waveforms. This signal adjusts the gain on the Video PCB.

Video Level Sampling Window

The window gates a selected area of the video signal to a peak detector which generates the video level indicator voltage. The video level is sent to the Technique Processor PCB where it is used to control camera gain and fluoro technique. The window approximately covers the active image area.

Four comparators, U6A-U6D perform the windowing function. These comparators sense when the scanning beam is within the window limits. When all four open collector outputs are high, inverter U1 produces a negative-going pulse at P104-14. Centering can be adjusted by adjusting HCAL and VCAL adjustments. The window signal enables the video level output from the Video PCB.

3.11.5. Vidicon/Yoke Assembly

This assembly contains the vidicon, the yoke assembly with focus, vertical, and horizontal deflection coils, and the vidicon connector board and video preamplifier.

The vidicon/yoke assembly is rotated by a motor sprocket and drive chain mounted in the camera assembly.

3.11.6. Video Preamp PCB

Refer to Schematic No. 00-860378.

The Video Preamp is located near the front of the yoke shield to minimize the target wire length. Target currents are amplified and fed to the Video Board. The target supply voltage id derived by potentiometer R43 on the Video PCB. The target signal current is converted to a voltage signal by fixed-gain video preamplifier Q1-Q5. The target signal current is AC coupled through C1 to the gates of low-noise FET cascode input stage Q2 and Q3. The signal current through Q1 and through the drain connections of Q2 and Q3 is direct coupled to Q4.

The signal is amplified by Q4 and its output is DC coupled to the base of Q5. Negative feedback from the output of Q5 is applied through R3 to the peaking capacitor C3.

The gain of the preamplifier is fixed; the output of Q5 is 250 millivolts when the target current is 300 nanoamperes. The peaking control C3 compensates for high-frequency rolloff and provides a uniform frequency response from the preamplifier.

3.11.7. Video PCB

Refer to Figure 3-22 and Schematic No. 00-860381

The Video PCB provides the final amplification of the video signal. The video from the preamp is applied to U2, a four quadrant multiplier. The gain control voltage is applied to U2-4. As the control voltage is increased more gain results. The output is applied to the base of transistor Q2 and the collector current is passed to the summing node of op amp U1, a wide bandwidth amplifier. U1 is the injection point for black level and dark current compensation. The amount of compensation is controlled by the Technique Processor PCB and Analog Support PCB through the input at P107-3. Once every five minutes, while X-rays are off, the software reduces the camera gain to minimum and measures the video level to determine the dark current. The camera gain is then increased to maximum and the dark-current compensation is changed until the video level equals that measured at low gain. For camera gain settings between these two extremes the dark-current compensation is interpolated.

Black Level

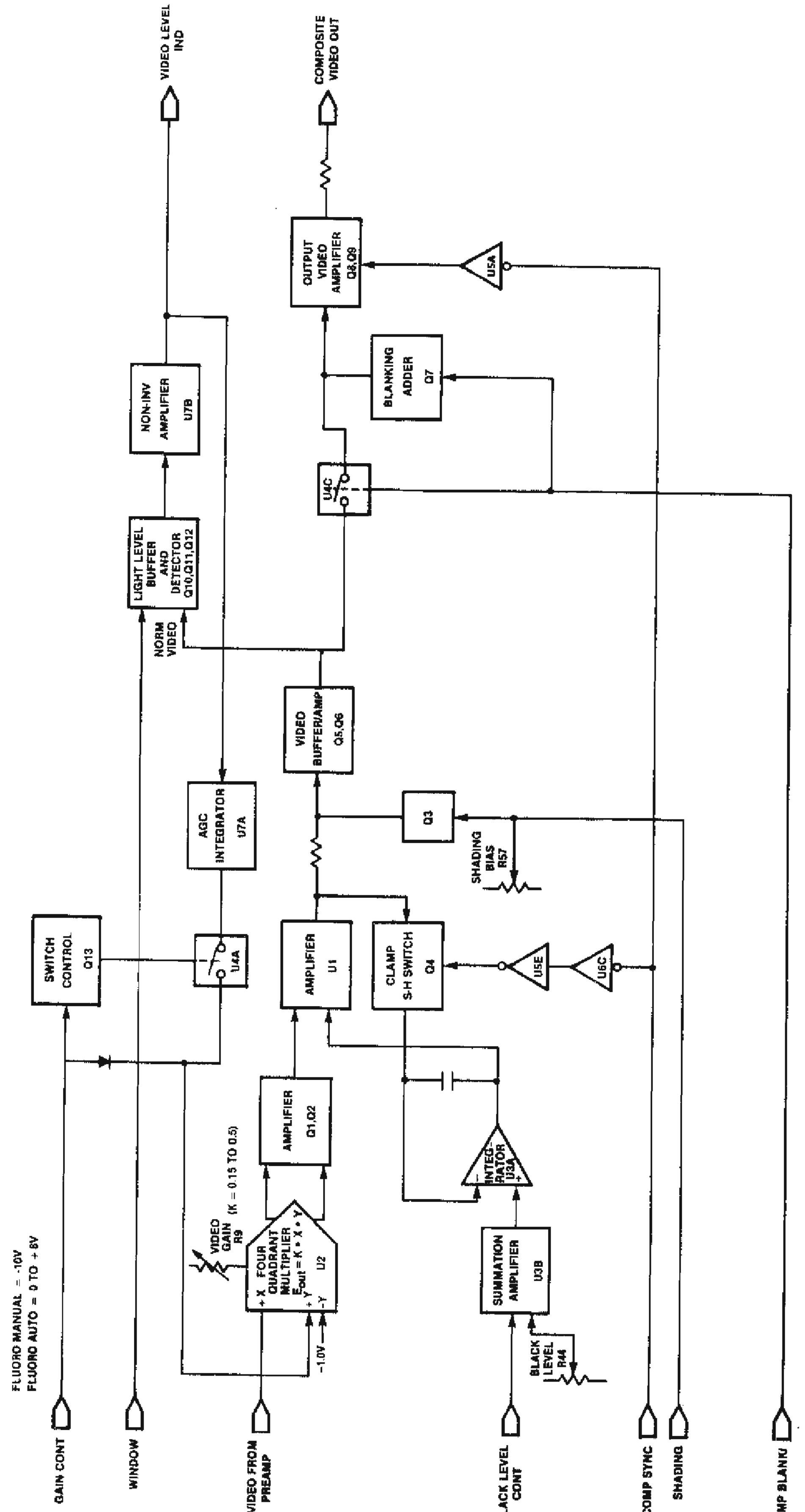
A black level adjustment is provided by R44. The output of U3 combines both black level adjustment and dark-current compensation. If the shading jumper is in place, a bias adjustment, set by R57, enables gain control through Q3. The input to Q3 is received from the Shading PCB.

Transistors Q5 and Q6 provide either an inverted or noninverted video signal. Analog switch U4 selects the output from Q5 or Q6. The output is connected to the emitter of Q7 which adds blanking to the video signal. The signal is then applied to noninverting amplifier Q9-Q8, which has a gain of approximately 2. The output of the amplifier is taken from the collector of Q8 and is connected to the output of the board.

The Video Board also generates a *video indicator level* which is used by the Technique Processor to control kVp, camera gain and mA. This function is provided by Q12, Q10, and U7. The gain control voltage is proportional to the peak video signal in the window interval at the junction between Q12 and Q10.

Automatic gain is controlled by the Technique Processor PCB and Analog Support PCB. The video AGC controls camera gain by varying the signal at P107-2. The gain control voltage is applied to the Y input of multiplier U2 to control video gain.

Figure 3-22 - Block Diagram of the Video PCB



3.11.8. Image Functions PCB

Refer to Schematic 00-873556

The Image Functions PCB decodes signals that control the motors in the imaging end of the 9400 system.

Control Signals

Inputs from the Analog Support PCB are supplied at ±10V logic levels to provide an extra measure against noise and to prevent the occurance of false modes in the coded/latched signals used to provide non-momentary or mode controls needed. These signals are received and shifted to TTL logic levels by RS232 receivers U9 and U10. GALs U6 and U7 decode the signals and provide control to the imaging end of the 9400 system.

Combinatorial Outputs

Reference Table 3

Motor select bits S0 thru S2 are decoded in GAL U6 and gated with the MOTOR EN input to provide the "ENABLE" input for each of the motor driver chips U1 thru U5. The MOTOR DIR signal is also routed through GAL U6 to provide the "PHASE" bit for the motor driver chips.

Motor Drivers

U1 thru U5 are H-bridge Drivers. The ENABLE bit turns the output stage on, and the PHASE bit determines the polarity or direction of the motor.

The motor control bit patterns are defined as:

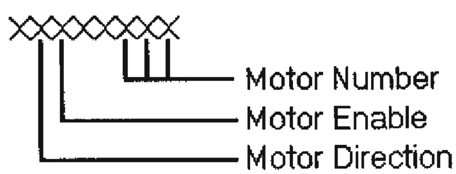


TABLE 3 **MOTOR SIGNALS**

		Bit Pattern	
Function	**Motor No.**	I md me s4 s3 s2 s1 s0	**Output**
Camera Rotation CW	0	0 0 1 X X 0 0 0	P1-1 LO
Camera Rotation CCW	0	0 1 1 X X 0 0 0	P1-2 HI
Iris open	1	0 0 1 X X 0 0 1	P1-3 LO
Iris close	1	0 1 1 X X 0 0 1	P1-4 HI
Collimator Longitude Open	2	0 0 1 X X 0 1 0	P2-15 LO
Collimator Longitude Close	2	0 1 1 X X 0 1 0	P2-6 HI
Collimator Latitude Open	3	0 0 1 X X 0 1 1	P2-14 LO
Collimator Latitude Close	3	0 1 1 X X 0 1 1	P2-7 HI
Collimator Rotate CW	4	0 0 1 X X 1 0 0	P2-13 LO
Collimator Rotate CCW	4	0 1 1 X X 1 0 0	P2-8 HI

Encoded/Latched Controls

Reference Table 4

Bits S0 thru S4 are used to select function states. Once a function is selected and is present (a particular combination of bits S0 thru S4) a "LATCH" pulse (10 usec) latches the function in. The function latched in will remain until another function state is latched in. This means only one function can be set or latched in at a time but that state is remembered and the decoder can be used for another purpose such as running a motor or setting a different channel state. For example while running a motor, the collimator could be changed to the small field, (shutting the motor off for a few microseconds) then go back to running the motor. The brief time the motor is without drive would not be noticed.

The encoded/latched bit patterns are defined as:

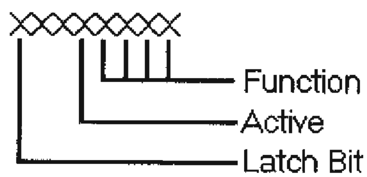


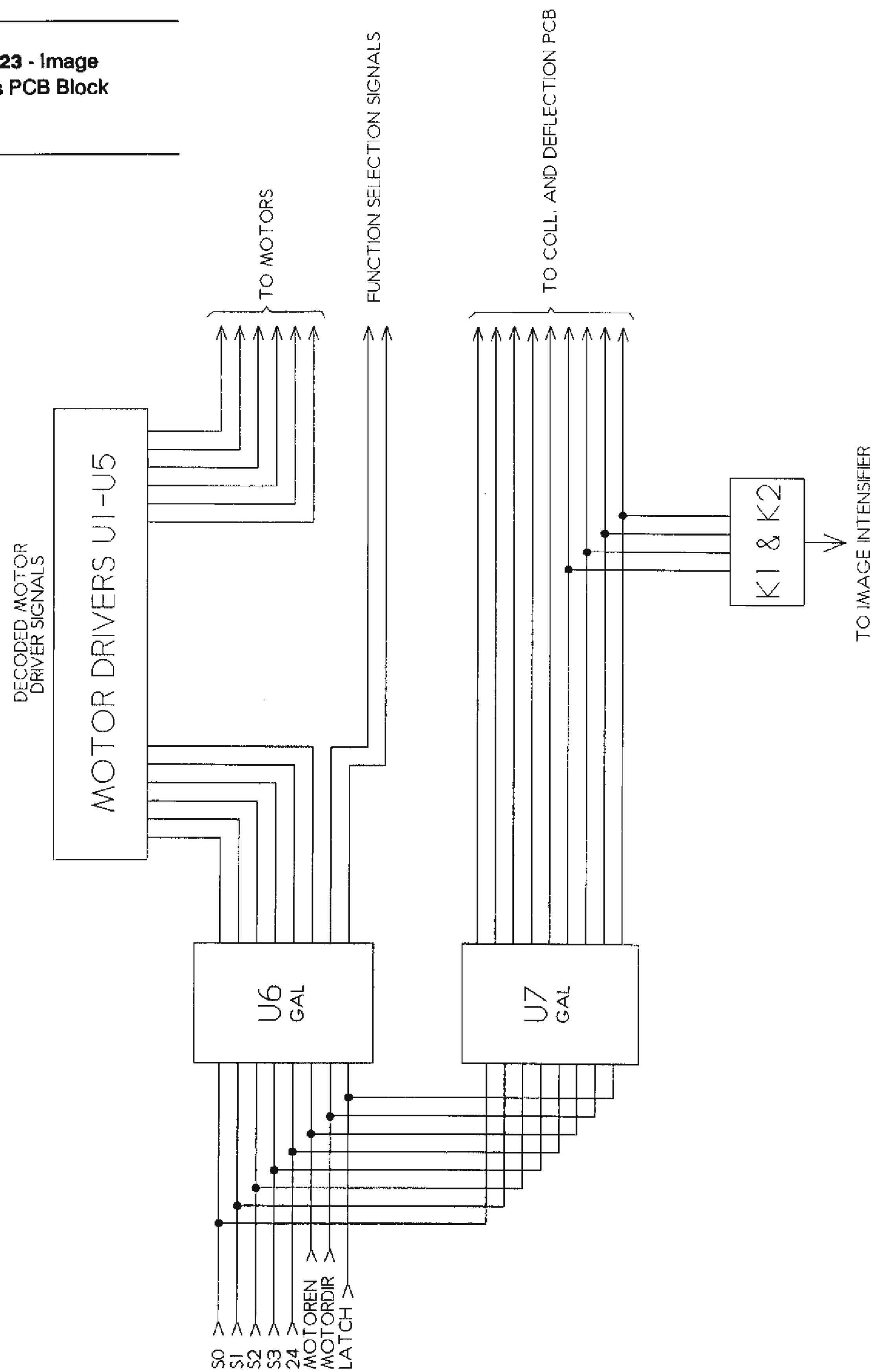
TABLE 4 **MODE SIGNALS**

Function	Bit Pattern	Output
	l md me s4 s3 s2 s1 s0	
Unused	0 0 0 0 0 0 0 0	not used
Reset	0 0 0 1 0 0 0 0	not used
Horiz Rev	0 0 0 0 0 0 0 1	P1-13 LO
Horiz Norm	0 0 0 1 0 0 0 1	P1-13 OPEN**
Vert Norm	0 0 0 0 0 0 1 0	P1-14 LO
Vert Rev	0 0 0 1 0 0 1 0	P1-14 OPEN**
Small Field Off	0 0 0 0 0 0 1 1	P2-12 HI
Small Field ON	0 0 0 1 0 0 1 1	P2-12 LO
		P1-17 ON *
Med Field Off	0 0 0 0 0 1 0 0	P2-9 HI
Med field ON	0 0 0 1 0 1 0 0	P2-9 LO
		P1-15 ON
Progressive Scan ON	0 0 0 0 0 1 0 1	P1-6 LO
Progressive Scan OFF	0 0 0 1 0 1 0 1	P1-6 HI
Beam Blank Assert (beam off)	0 0 0 1 0 1 1 0	P1-17 LO
Beam Blank Unassert (beam on)	0 0 0 0 0 1 1 0	P1-17 OPEN**

* ON means the relay has made the connection between the output indicated and P1-11.

** OPEN refers to the output state of an open collector output.
LO refers to a logic condition within 1 volt of ground potential.
HI means +24VDC ± 1VDC

Figure 3-23 - Image Functions PCB Block Diagram



3.12. X-RAY GENERATION AND CONTROL ELECTRONICS

General description

The X-ray generator is a high frequency inverter operating at 2500 Hz. It converts a stable DC supply into alternating current that is applied to the primary of a high voltage transformer. The transformer steps up the primary voltage from about 200 VAC to the kilovoltage levels required at the X-ray tube. The output of the transformer is full-wave rectified.

The relatively high frequency currents applied to the cable/X-ray tube combination results in very low ripple voltages compared to traditional single-phase systems. At fluoroscopic current levels, the performance surpasses that of three phase systems. This results in improved beam quality with a corresponding reduction in dose absorbed by the patient.

3.12.1. Control Panel Processor PCB

Overview

Refer to Schematic 00-872858 and Figure 3-24.

The Control Panel Processor is a single board computer used as an intelligent controller and interface to the Technique Processor. The Control Panel Processor drives a 20 character dot matrix type fluorescent indicator module, and obtains inputs from the control panel switch matrix and the digital encoder "pots" for kV and mA. Switch scan codes and digital encoder data is passed to the Technique Processor PCB.

All control panel display characteristics are determined by software running on this board.

The Control Panel Processor uses an 80188 processor running at 8 MHz, with 128k of dynamic RAM, 16k of EPROM, a dual UART and two 8255 PIOs (U13 and U18) connected to the panel switch matrix.

Memory

The dynamic RAM on the board uses the 4500A controller chip to handle refresh and memory access arbitration (by the 80188's SRDY line). The 128k of DRAM consists of 64k x 4-bit chips (4464) located at the bottom of the processor's address space and selected by the LCS chip select signal. The DRAM receives the main operating code for the Control Panel Processor, downloaded from the Technique Processor.

The 16k of EPROM (27128) is a 16k x 8-bit chip located at the top of the processor's address space and selected by the UCS chip select signal. The EPROM contains the initialization and boot code used to transfer the main program from the Technique Processor to the Control Panel Processor (via the UART).

Dual UART

The dual UART (WD 2123) is accessed as a peripheral chip by the 80188, using PCS0, PCS1, and PCS2 chip select signals. Data transfer is performed under program I/O control; the UART generates an interrupt whenever either of the two transmitting registers is empty, or when either of the two receiving registers is full. The determination of the source of the interrupt is handled by the software. One of these two UART channels is connected to the Technique Processor (without RS-232 drivers/ receivers), and the other UART channel is used as a remote terminal connection. This channel uses RS-232 drivers and receivers.

Accumulated Exposure Timer

This timer accumulates fluoro exposure time. The display for fluoro exposure time is updated any time the seconds value changes. When 5 minutes of accumulated fluoro time has elapsed, the alarm turns on and is not reset until the alarm reset key is pressed.

Digital Encoder Interface

The kV and mA encoders (knobs) are not variable resistors but actually small optical encoders which generate a phase quadrature output signal, with 16 counts per complete revolution of the knob. Each encoder is connected to a circuit on the board which generates an interrupt for each count. The kV interrupt is connected to INT1, and the mA interrupt is connected to INT2 on the 80188. The direction of the encoders revolution is determined by reading a bit in a register accessed by PCS6 chip select signal.

A full 360 degree turn of the encoder knob generates 24 interrupts; with each interrupt the direction of rotation is read and a counter is incremented. Every 100 ms the accumulated count is read. A function call is issued to the Technique Processor which provides the number of interrupts accumulated over the 100 ms period.

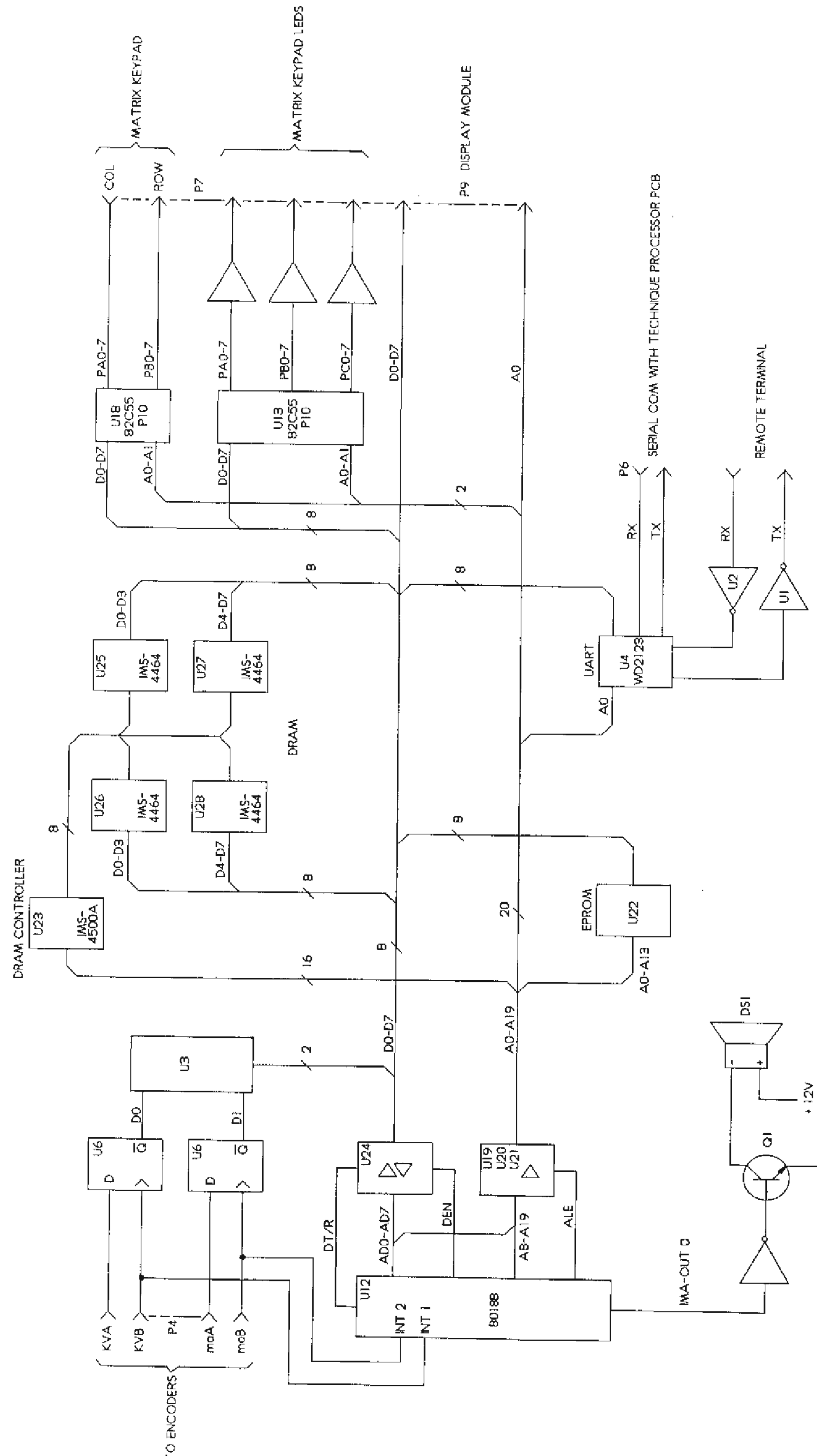
Switch Matrix Interface

The panel switches are interfaced to the processor by two interface chips (82C55). U13 uses all three of its ports to drive the LED's in the base of those switches which illuminate when they are pressed. U18 scans the columns and rows of the switch matrix. PB0-PB5 drives the matrix rows and PA0-PA5 reads the switch closures in the columns where they intersect with the rows. The processor determines the key which has been pressed by selecting one of the rows (outputs), and then scanning the column port (inputs) to see which line has been brought to ground by switch closure. U13 is accessed by the 80188 PCS5 chip select signal, and U18 is accessed by the 80188 PCS4 chip select.

Audio Indicator

A small speaker is located on the Control Panel PCB to sound a "beep" when the matrix switches are pressed. This speaker also acts as an alarm when signaled by the fluoro timer. The speaker is driven by the collector leg of transistor Q1 which in turn is driven by the 80188's timer output (TMR-OUT-0).

Figure 3-24 - Block Diagram of the Control Panel Processor PCB



Communicating with the Technique Processor

When a technique request is received by the Technique Processor, the operating system buffers the request until it is acted on.

To make sure that the state of the Technique Processor is the same as that displayed on the control panel switch LEDs, the processor echoes the LED display commands to the control panel.

A similar sequence of actions occurs when technique is selected. The control panel sends the number of digital encoder interrupts and a direction (for plus or minus). The Technique Processor calculates the new technique value, translates it to ASCII format, then sends it to the control panel for display.

3.12.2. Display Module

Refer to Schematic 00-900242

The Display Module provides twenty 5 x 7 (dot matrix), alphanumeric characters with multiplexed text and decimal points. Two modes of operation are possible:

Technique Display - "KV/FLUORO TIME/MA" in fluoro and "KV/ /MAS" in film mode.

Text mode - error messages, prompts, warning messages, data, etc. Under software control the display can alternate messages with technique, display a constant message, blink a message, scroll a message, or step through a series of messages.

The display module is interfaced directly to the Control Panel Processor PCB through a 36-pin cable. The display is equipped with a DC/DC, AC converter, a character generator, and an 8-bit microcomputer.

3.12.3. Technique Processor PCB

Overview

The Technique Processor loads and runs the operating system and application software.

Refer to Schematic 00-870591 and Figure 3-25.

The Technique Processor is a single board computer located in the mainframe card cage. The board has two edge connectors; one is the internal computer bus connector, while the other connector interfaces signals to the Analog Support PCB and other circuits.

The Technique Processor is based on the 80188 microprocessor, which combines an 8088 with several support functions normally found on separate chips. The board contains DRAM, EPROM, and EEPROM (electrically erasable PROM), a floppy disc controller, a dual UART, a real time clock. A dual port RAM receives data from the analog board.

Microprocessor

The microprocessor on the board is an 80188, running at 7.16 MHz. Its instruction set is essentially identical to that of the 8088.

The data bus (D0-D7) and the lower half of the address bus (A0-A7) are multiplexed on the same microprocessor bus. Demultiplexing is controlled by ALE (address line enable), DEN (data enable) and DT/R (data transmit/receive).

The main difference between the 8088 and the 80188 is the inclusion of several support functions on the chip itself. These support functions are: programmable chip selects for memory (six) and peripheral chip devices (six), a programmable interrupt controller, two DMA channels, and three programmable timers. The chip also has two READY lines used for automatic insertion of WAIT states when required by peripheral devices.

Memory

The processor has three types of system memory DRAM, EPROM, and EEPROM. The DRAM is a 256k x 8 block of 64k x 4 memory chips (TMS 4464), located at the bottom of the processor address space and selected by the processors LCS chip select signal. The refresh and row and column addressing of the memory is handled by a DRAM controller, the TMS 4500A. With this controller, the DRAM looks like static RAM to the processor; access arbitration during refresh cycles is handled by inhibiting the processor's READY line (which inserts WAIT states). The DRAM is intended to hold the MS-DOS operating system and the main technique processor program.

The EPROM (TMS 27128) is a 16k x 8 chip located at the top of the processor's address space and selected by the processor's UCS chip select signal. The EPROM is intended to carry the boot code to load MS-DOS from disk, and to provide a debug monitor.

The EEPROM (TMS 2817) is a 2k x 8 chip located in the mid-range of the processor address space and selected by the processors MSC2 chip select signal. The EEPROM only requires a 5 VDC supply for programming, so it can be programmed in-circuit. The time required to program a single byte is 10 msec. The EEPROM generates an interrupt to the processor when it is ready to program another byte.

The dual-port RAM is discussed below under "A/D Interface."

Interrupt Controller

Interrupt controller U26 (8259A) is provided in addition to the internal 80188 interrupt controller. U26 has eight interrupt inputs; two of the inputs are connected to the computer bus for future expansion. The other six inputs are used to signal interrupts by the Dual UART U24 and the real time clock U79. Two U26 outputs are connected to two of the four interrupt lines on the 80188 processor. These two lines are configured as an interrupt input and acknowledge pair.

Floppy Disk Controller

The floppy disc controller U22 (WD 2797) is accessed as a peripheral chip by the 80188. Data transfer, typically between the Dynamic RAM and the floppy, is handled by one of the 80188's DMA channels. The floppy controller is connected to the microfloppy disc drive via a connector on the motherboard. Adjustments for the controller's read pulse width, write pulse width, and oscillator center frequency are located on the outer edge of the Technique Processor PCB.

Dual UART

The dual UART U24 (WD2123) is accessed as a peripheral chip by the 80188. Data transfer is performed via programmed I/O, rather than DMA. Four interrupt lines from the UART alert the processor when either of the receiver registers are full, or when either of the transmitter registers are empty.

UART channel A is dedicated for communications with the Control Panel Processor PCB. Channel B is dedicated for communications with the monitor cart. Channel B employs RS-232 drivers due to the cable length between this PCB and the monitor cart.

A/D Interface

The A/D interface is comprised of two static RAMs:

The sequencer RAM - is used to control the sixteen channel analog multiplexer (located on the Analog Support PCB)

The dual-port RAM - stores the data digitized on the Analog Support PCB until it can be read out by the processor.

The sequencer RAM U37 (AM9122) is a 256 x 4 chip located in the mid-range of the processors address space and selected by the processors MSC1 chip select signal.

The sequencer RAM contents are written by the 80188. When being read, the sequencer RAM's address bus is connected to a counter which sequences thru the addresses. This counter also controls the address lines on one port of the dual port RAM, so that as a different mux channel is selected, the memory location for the A/D data is incremented.

Since the A/D data is ten bits wide, each mux channel which is digitized occupies two memory locations in the dual port RAM. The timing signals for controlling the sample/hold, A/D, and A/D RAM port write are generated by PAL U77.

The Dual Port RAM U75 (IDT 7130) is a 1k x 8, static RAM chip located in the mid-range of the processor's address space and selected by the MSC0 chip select signal. This chip has two independent ports to access the RAM array, each with its own address bus, data bus, and control lines. One port is connected to the 80188 for read/write access by the processor, and the other port has the data bus connected to the A/D converter, with the address bus connected to the addressing counter (along with the mux RAM).

Each port can simultaneously access the RAM array, with the only contention occurring when both ports attempt to access the same memory location. This contention is handled by giving the A/D port priority, with WAIT states inserted in the 80188's bus cycle until the A/D port is done. The dual port RAM generates an interrupt to the 80188 when the A/D port writes a byte to the last memory location of the RAM. This interrupt is used by the processor to synchronize reading RAM and to read the most recent A/D data. The processor can also reset the A/D port addressing counters through peripheral chip select PCS6.

Ancillary Circuits

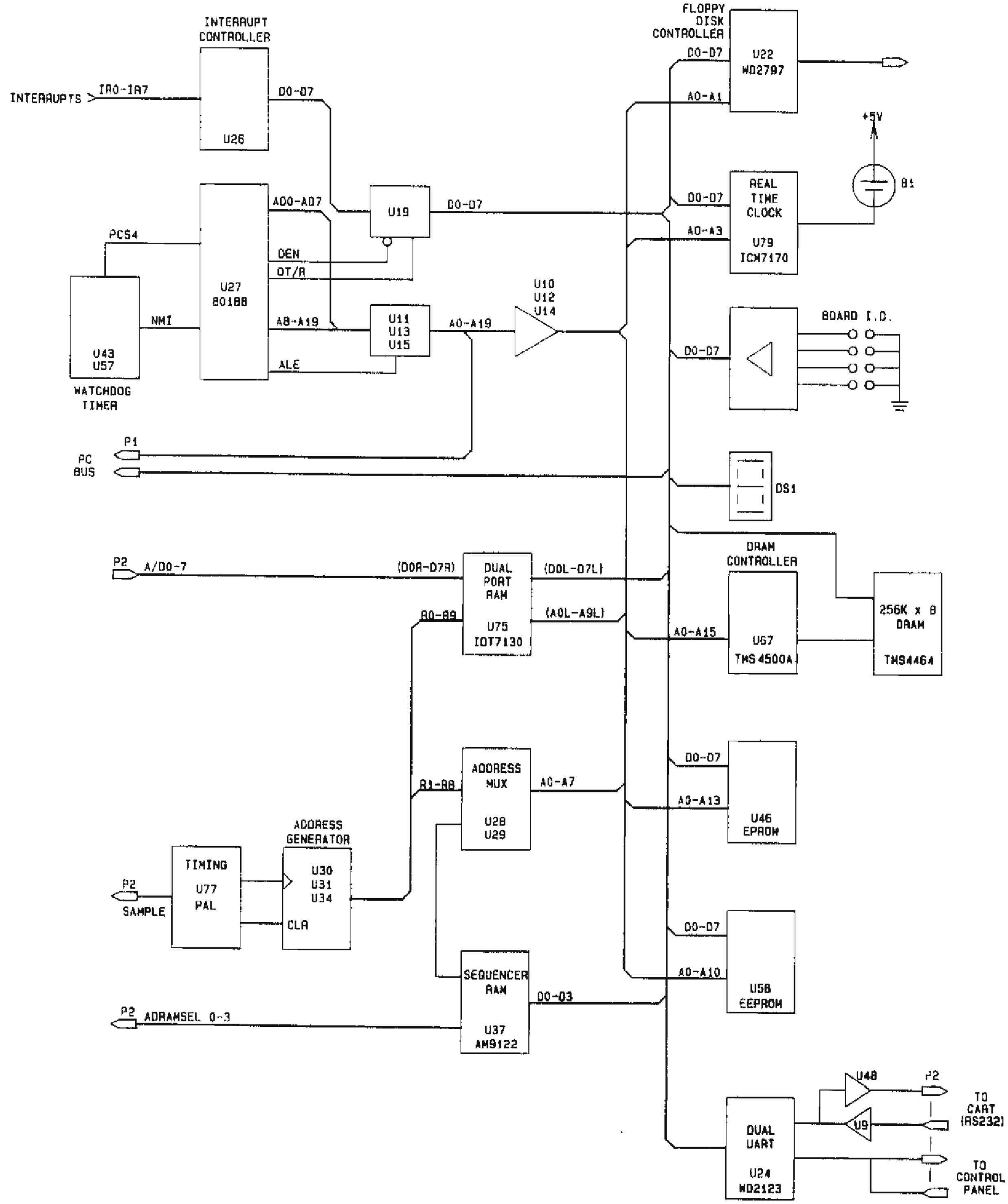
The Technique Processor contains a watchdog timer which generates an NMI (non-maskable interrupt) and under some conditions, a processor reset, if it is not cleared by the processor every two seconds. This is meant to pull the processor out of endless loops or major software failures.

The Technique Processor contains a real time clock U79 (ICM 7170) with a battery backup to keep track of the correct date and time-of-day. The processor accesses U79 as a peripheral chip, using the PCS5 chip select signal. The clock also generates an interrupt to the processor at programmable intervals for timekeeping functions.

The processor reads a revision block, accessed as a peripheral, using the PCS1 chip select signal. The bottom half of the 8-bit REV block has a DIP switch to encode the software revision level, while the top half of the REV block has jumpers to encode the circuit board revision level.

The Technique Processor also contains a single alphanumeric digit LED accessed as a peripheral by the PCS1 chip select signal. The LED digit is meant to assist in troubleshooting, as it displays some of the boot and error codes. Refer to the Mainframe Service Section of the manual for an explanation of the codes.

Figure 3-25 - Technique Processor PCB Block Diagram



3.12.3.1. Memory

TABLE 5 MEMORY PERIPHERAL CHIP DECODING

Chip Select	Size	Function	R/W
LCS	256k	RAM	R/W
MSC0	2k	A/D RAM	R/W
MSC1	256x4	A/D Mux Select RAM	W
MSC	22k	EEPROM	R/W
MSC3			Not Used
UCS	16k	EPROM	R

3.12.3.2. Peripherals

TABLE 6 MEMORY PERIPHERAL CHIP DECODING

Chip Select	Addr (A0-A3)	Function	R/W
PCS0	0	Floppy Controller Status	R
PCS0	0	Floppy Controller Command	W
PCS0	1	Floppy Controller Track	R/W
PCS0	2	Floppy Controller Sector	R/W
PCS0	3	Floppy Controller Data	R/W
PCS1	0	UART Channel A Receive	R
PCS1	0	UART Channel A Transmit	W
PCS1	1	UART Channel A Status	R
PCS1	1	UART Channel A Command	W
PCS1	2	UART Channel B Receive	R
PCS1	2	UART Channel B Transmit	W
PCS1	3	UART Channel B Status	R
PCS1	3	UART Channel B Command	W
PCS1	4	Channel A Rate	W
PCS1	5	Channel B Rate	W
PCS1	C or D	LED Indicator (D0-D4)	W
PCS1	E or F	Revision Block	R
PCS2	0,1	Interrupt Controller	R/W
PCS3			Not Used
PCS4	X	Watchdog Timer Reset	W
PCS5	0 - 1F	RealTimeClock	R/W
PCS6	0 - FF	A/D RAM Address	
		Counter Clear	R/W

TABLE 6 (CONTINUED) **INTERRUPT CHANNELS**

Chip Select	Addr (A0-A3)	Function
80188	INT0	8259A Interrupt Request (Cascade Mode)
80188	INT2	8259A Interrupt Acknowledge (Cascade Mode)
80188	INT1	A/D RAM Interrupt (after 512 samples)
80188	INT3	EEPROM Interrupt; active when ready for next byte
80188	NMI	Watchdog Timer Interrupt
8259A	IR0	UART Interrupt; active when CH A transmitter is ready (buffer empty
8259A	IR1	Real Time Clock Interrupt
8259A	IR2	IRQ2 on IBM Bus
8259A	IR3	UART Interrupt; active when CH B receiver is ready (character in buffer)
8259A	IR4	UART Interrupt; active when CH B transmitter is ready (buffer empty)
8259A	IR5	UART Interrupt; active when CH A receiver is ready (character in buffer)
8259A	IR6	Floppy Disc Controller Interrupt
8259A	IR7	IRQ7 on IBM Bus

3.12.3.3. DMA Channels

TABLE 7 **MEMORY PERIPHERAL CHIP DECODING**

80188	DRQ0	Floppy Disc Controller DMA
80188	DRQ1	DRQ1 on IBM Bus

3.12.4. Analog Support PCB

Overview

Refer to Schematic 00-870771 and Figures 3-26 and 3-27.

The Analog Support PCB converts data into hardware control signals and samples and digitizes voltages to be read by the technique processor.

The Analog Support PCB performs the following functions:

- Sample and digitize signals from the X-Ray Regulator PCB to be read by the Technique Processor PCB.
- Convert data bytes from the Technique Processor into analog signals for such functions as camera gain control, kVp control, and filament control.
- Generate the high voltage drive and filament drive signals.
- Provide a digital interface between the Technique Processor and discrete digital signals such as *STORE* and *B+ CONTACTOR*.
- Control the camera and collimator motors.
- Interface the processor's interlock keep-alive signal with the relay controlled interlock circuits.

The major hardware lines and signals on the Analog Support PCB interface with the software via the following ICs:

U22	PIO	Intel 82C55A
U38	PIO	Intel 82C55A
U27	PIO	Intel 82C55A
U31	DAC	DAC 8408
U18	DAC	DAC 8408
U7	ADC	AD573
U12	Counter/Timer	Intel 8253

Transistors Q3 - Q10 drive individual control lines.

Figure 3-26 - Block Diagram of the Analog Support PCB

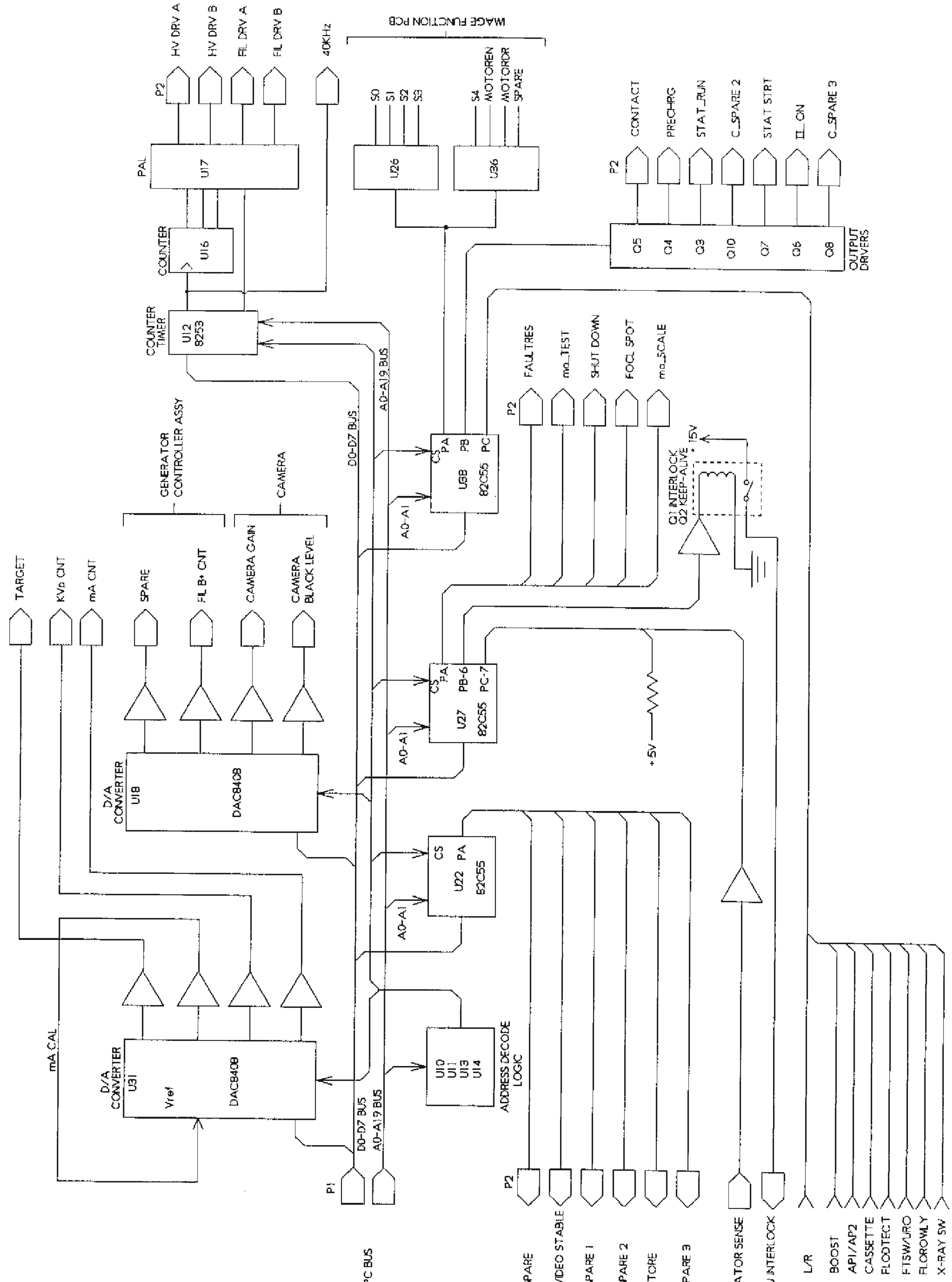
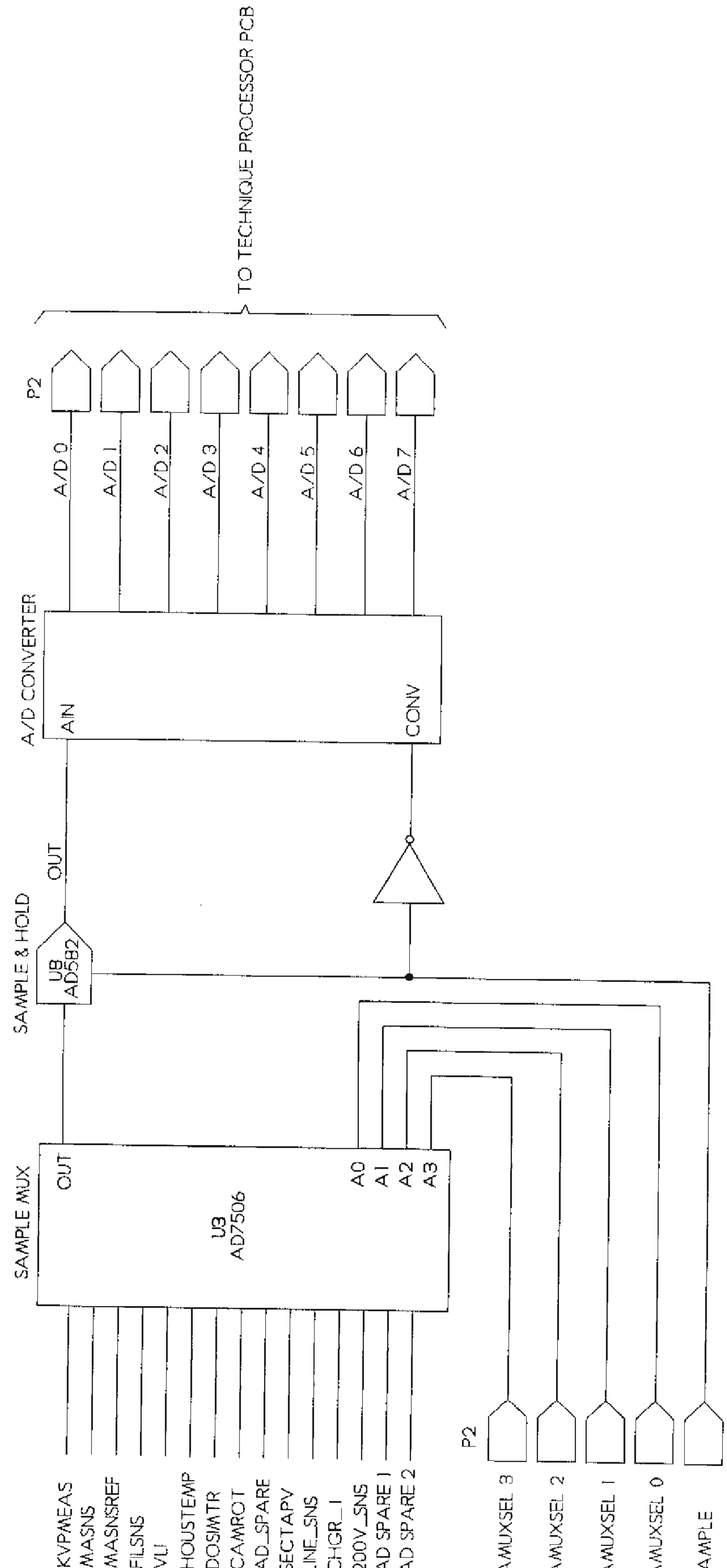


Figure 3-27 - Block Diagram of the A/D Portion of the Analog Support PCB



HV DRIVE A, HV DRIVE B, FIL DRIVE A, and FIL DRIVE B are produced by PAL U17. Counter/Timer U12 and counter circuit U15, U16 generate the input signals for PAL U17. Counter/Timer U12 obtains its clock from the 80188 CLK OUT (7.16 MHz) on the Technique Processor PCB.

Filament duty cycle is determined by the FIL DRIVE A and FIL DRIVE B outputs from the circuit described above.

D/A converter U31 generates the mA and kVp control voltages. U18 generates the control signals for filament B+ control, camera gain, and camera black level.

Transistors Q3, 4, 5, 6, 7, 8, and 10 buffer control bits for on/off control of a number of functions.

Board Revision Indicator

This is jumpered according to the revision number of the board and is read by the processor.

Sample Mux

Refer to Figure 3-27.

Sample mux U3 is addressed by the AMUXSEL lines generated by the sequencer RAM on the Technique Processor PCB. Sample MUX OUT is fed to the sample and hold amp U8. A/D converter U7 digitizes the signal for the technique processor.

3.12.4.1. Analog Support PCB Summary

Refer to Tables 3, 4, 5 and 6.

The following digital and analog signals are monitored or generated on the Analog Support PCB. They are listed briefly in the following tables and then described in more detail in the text that follows.

A/D Inputs

These A/D channels are selected by the data selector U3 as they are addressed by the AMUXSEL0 through AMUXSEL3 lines. The output of U3 is fed to the sample and hold circuit U8. The sampled level is converted to an 8-bit data byte by A/D U7. This byte is then passed on the 8-bit A/D bus, A/D-0 through A/D-7, via the motherboard to the dual port RAM U75 on the Technique Processor PCB.

TABLE 8 **A/D SENSE LINES**

SCHEMATIC LABEL	A/D CHANNEL	FUNCTION
U3-S1	0	kVp measured
U3-S2	1	mA sense
U3-S3	2	filament B+ sense
U3-S4	3	video level
U3-S5	4	housing temperature
U3-S6	5	dosimeter
U3-S7	6	camera rotation
U3-S8	7	spare
U3-S9	8	secondary tap voltage
U3-S10	9	line voltage sense
U3-S11	10	charger current
U3-S12	11	200V sense
U3-S13	12	adspare1
U3-S14	13	adspare2
U3-S15	14	spare
U3-S16	15	spare

TABLE 9 **PIO 1, U38 SUMMARY**

BIT	PIN	FUNCTION	COMMENT
PA0	4	S0	motor and encoded/latch ed signal
PA1	3	S1	motor and encoded/latch ed signal
PA2	2	S2	motor and encoded/latch ed signal
PA3	1	S3	motor and encoded/latch ed signal
PA4	40	S4	motor and encoded/latch ed signal
PA5	39	motor enable	motor and encoded/latch ed signal
PA6	38	motor direction	motor signal
PA7	37	latch	encoded/latch ed signal
PB0	18	B+ contactor	active hi
PB1	19	B+ charge	
PB2	20	stator run	

PB3	21	C_spare2	not used
PB4	22		
PB5	23	stator start	hi for 2 sec
PB6	24	II power	used in fluoro
PB7	25	C_spare3	
PC0	14	ap/lat2	sense
PC1	15	ftsw/uro	sense
PC2	16	cassette detect	sense
PC3	17	field detect	sense
PC4	13	L/R	
PC5	12	fluoro only	left footswitch sense
PC6	11	boost	boost sense
PC7	10	X-ray switch	switch or footswitch sense

TABLE 10 **PIO 2, U27 SUMMARY**

BIT	PIN	FUNCTION	COMMENT
PA0	4	mA scale factor	low=film
PA1	3	focal spot	low=1 mm
PA2	2	high power mode	active high
PA3	1	shutdown cmnd	active high
PA4	40	mA test	active low
PA5	39	TP15	not used
PA6	38	TP14	not used
PA7	37	fault reset	active high
PB0	18	charger disable	for battery test
PB1	19	camera mode	not used
PB2	20	TP30	
PB3	21	TP7	
PB4	22	TP8	
PB5	23		
PB6	24	X-ray on command	
PB7	25	interlock keep-alive	toggles every 10 ms.
PC0	14	overload fault	active hi
PC1	15	saturation fault	active hi
PC2	16	filament fault	active high
PC3	17	fault	active hi
PC4	13	HV generator on	hi when generator is on
PC5	12	X-ray disable	active high
PC6	11	interlock complete	active low
PC7	10	stator sense	active low

TABLE 11 **PIO 3, U22 SUMMARY**

BIT	PIN	FUNCTION	COMMENT
PA0	4	spare	cart
PA1	3	video stable	cart
PA2	2	spare1	cart
PA3	1	spare2	cart
PA4	40	store	cart, active low
PA5	39	spare3	
PA6	38	TP5	
PA7	37	TP6	
PB0	18	not used	
through			
PC7	10	not used	

3.12.4.2. Signal Descriptions

Charger Control

Charger Disable;.. U27-PB
when high: causes the charger to stop charging the batteries. On the Generator Assembly this line is connected to the shutdown pin on U22, a current mode PWM controller.

X-ray Tube Control

Stator Start U38-PB
applied to the base of Q7. Q7 collector drives the line "Stator Start" which is applied to K3 on the Relay PCB. Causes 120VAC to be applied to the stator for 2 seconds

Stator Run U38-PB
applied to the base of Q3. Q3 collector drives the line "Stator Run" which is applied to the relay K1 on the Relay PCB. Causes 40VAC to be applied to the stator.

NOTE: *X-Ray tube failure will result if Stator Power remains on for > 10 minutes.*

Stator Sense.. U27-PC
Inductor L1 on the Relay PCB detects the flow of stator drive current. The circuit formed by U19 and part of U24 amplifies and translates the current signal to a TTL level and applies it to U27-PC7.

NOTE: *This sensor determines only that the stator is energized and not how much voltage is being applied. this sensor is monitored by the software.*

3.12.4.3. Generator Control

B+ Charge..U38-PB
When active, a high is applied to the base of Q4. Q4 collector (B+ Charge) is looped through the Generator Assembly and routed to the charging relay K1 mounted below the Generator Assembly. This causes the relay K1 to close precharging the B+ capacitor through a resistor. This precharge prevents high in-rush currents from occurring when the B+ Contactor is energized.

B+ Contactor..U38-PB
When active, a high is applied to the base of Q5. Q5 collector (B+ Contactor) is looped thru the Generator Assembly and routed to the relay K2 located under the Generator Assembly. When active, "B+ Contactor" causes the contactor to close, connecting the battery circuit to the B+ capacitor.

NOTE: The contactor must not be energized until the precharge to the B+ capacitor has been completed.

Fault Reset..U27-PA
When high, resets the generator fault protection logic. This line must be low during normal operation. The reset pulse is inverted by U4 on the Generator Assembly and applied to the fault protection logic PAL U32.

KVP Control..U31-CH
U31-CH3 is a DAC output which delivers a control voltage to the generator. Measure this voltage at TP19 on the Analog Support PCB. *Refer to the KVP control circuitry on the Generator Assembly.*

KVP Reference (kVp Cal)..U31-CH
U31-CH1 sets the reference voltage for the DAC used to generate KVP CONTROL. Measure this voltage at TP17.

mA Control...U31-CH
Delivers a control voltage to the filament regulator circuit. Measure this voltage at TP18. *Refer to the filament control circuit on the Generator Assembly.*

mA Reference (mA Cal)..U31-CH
Sets the reference voltage for the DAC used to generate mA CONTROL. Measure this voltage at TP16.

Filament B+ Control..U18-CH
Filament B+ Control delivers a control voltage to the generator as a reference for the filament B+ servo circuitry. Measure the signal at TP10. *Refer to the filament control circuit on the Generator Assembly.*

Focal Spot U27-PA
The state of this line selects the focal spot size.

1 = 0.3 mm spot
0 = 1.0 mm spot

On the Generator Assembly - This line is inverted by part of U4 and applied to PAL U8. When the output U8-14 goes high this turns on Q7 which causes relay K1 to close, thus selecting the 1.0 mm filament. When K1 is open, the 0.3 mm filament is selected.

NOTE: PAL U8 requires other inputs and provides other outputs in addition to focal spot selection. Reference the Generator Assembly

Generator Shutdown (Shutdown Command) U27-PA
When this bit is high it turns off the drives to transistors Q14, Q15, Q16 and Q17 in the output stage of the generator circuitry. When this bit is low it turns on the drives to the output stage. On the Generator Assembly this line is inverted by p/o U13 and applied to one of the inputs of PAL U21. *Refer to the HV drive circuitry on the Generator Assembly.*

mA Scale Factor U27-PA
Selects the mA scale factor for film or fluoro - 1 = Fluoro, 0 = Film.

HV Drive U1
Counter/Timer Chip U12 OUT0 & OUT1, in conjunction with flip flop U15, counter U16 and PAL U17, generate timing pulses for HV DRV A and HV DRV B. On the Generator Assembly, Drive A and Drive B are inverted by U25 and applied to inputs on PALs U33 and U21. *Refer to the HV drive circuitry on the Generator Assembly.*

HV Generator On U27-PC
When high, indicates that the footswitch and X-RAY CONFIRM lines are requesting X-rays. X-rays are being generated if all other control parameters are set correctly. When low, indicates that generator has not been commanded to make X-rays. This line originates on the Generator Assembly at PAL U21, which monitors the states of the HV Drives, X-ray On, X-ray Enable, and other lines.

Generator Fault U27-PC
Indicates that one of the fault conditions has been detected and the generator has been shut down. Originates on the Generator Assembly at PAL U32.

Overload Fault U27-PC
Indicates that the generator has detected an overload and shutdown. Originates on the Generator Assembly at PAL U32.

Saturation Fault U27-PC
Indicates that the generator has detected a saturation fault and shut down. Originates on the Generator Assembly at PAL U32.

Filament Fault U27-PC
Indicates that a filament fault has been detected and the generator has been shutdown. Originates on the Generator Assembly at PAL U32.

mA Test U27-PA
Turns on the mA test circuitry in the generator. When this line goes low, it turns off the mA test circuitry and restores normal operation. This line is inverted by p/o U25 and forms one of the inputs to the FAULT PAL U32, on the Generator Assembly.

Camera/Image Intensifier Control

Camera Horizontal Sweep Control U38-PB
When high, the horizontal sweep is in the normal direction. When low, the horizontal sweep direction is reversed. This signal is applied to Q8 and Q9. From there it is routed to the camera Deflection PCB.

S0.. U38-PA
Encoded motor and mode control signals.

S1.. U38-PA
Encoded motor and mode control signals.

S2.. U38-PA
Provides the encoded motor and mode control signals that are decoded by GAL U6 on the Image Functions PCB.

S3.. U38-PA
Provides the encoded motor and mode control signals that are decoded by GAL U6 on the Image Functions PCB.

S4.. U38-PA
Provides the encoded motor and mode control signals that are decoded by GAL U6 on the Image Functions PCB.

Motor Enable.. U38-PA
Provides the "enable" input for each of the motor driver chips U1 through U5 on the Image Functions PCB.

Motor Direction.. U38-PA
Provides the "motor direction" input for each of the motor driver chips U1 through U5 on the Image Functions PCB.

Latch U38-PA
A 10μS pulse width latches in S0 - S4 when selecting a mode; see section 3.11.8.

Camera Mode U27-PB
Not currently used, should be set low.

Camera Gain... U18-CH
An analog voltage control signal obtained at the CH3 output of DAC U18. This signal is buffered by U29 and may be measured at TP13. This signal controls the camera gain.

Camera Offset (Dark Current Compensation)............................ U18-CH
An analog voltage control signal obtained at the CH4 output of DAC U18. Controls camera video level offset to correct for vidicon dark current.

II (Image Intensifier) Power.. U38-PB
When this line is high it turns on the II power supply. The supply should remain on in all modes except FILM. The line is applied to Q6. The collector of Q6 is connected to the II tube power supply on the C-arm.

Camera/Image Intensifier Sensing

Film Cassette U38-PC
Senses the presence of a film cassette. Line is high when film cassette is present.

Collimator Control

Collimator rotation directions are defined such that when viewing a fluoro image in the normal sweep mode, the image of the collimator appears to rotate in the direction indicated. No compensation is made for camera sweep direction.

Field Select .... U38-PA0 thru PA
Encoded field select signals which are routed to the Image Functions PCB through P2. The signals are decoded on the Image Functions PCB. Selects either the small field or medium field collimator flippers.

Field Detect U38-PC
PIO input from a microswitch at the flipper. Detects if either of the flippers have been engaged but does not differentiate between the flippers.

Cart Control and Sensing

Store U22-PA
When low, informs the image processor that an exposure is being made.

Video Stable U22-PA
This line is low when the software servos are active and the video level has not stabilized. When high the software servos are stabile and the techniques are no longer slewing.

X-ray Disable U27-PC
The cart uses this PIO input to request termination of an exposure. When this line is high X-rays are inhibited.

System Sensing

Interlock Pulse U27-PB
This line must toggle about every 10 ms. Missing pulses will cause the interlock circuit to shut down the system and force a restart. *See the Interlock Circuit on the Analog Support PCB.*

Interlock Complete U27-PC
When this line is high, indicates the interlock circuit is energized. When low, indicates that the interlock circuit has been broken and the interlock relay is de-energized.

X-ray Switch U38-PC
When this PIO input is active, indicates that the X-RAY ON switch or either right or left footswitches have been pressed. This signal may be monitored at TP20. X-rays are not generated unless software confirms the exposure.

Boost U38-PC
PIO Input. Signals that the boost position of the footswitch has been pressed.

Fluoro Only U38-PC
PIO Input. Signals that the left side of the footswitch, FLUORO ONLY, has been pressed.

3.12.5. Battery Charger PCB

Refer to Schematic 00-873617

The battery charger PCB provides the following functions:

- o Battery charging and voltage regulation
- o Over voltage protection
- o Low voltage cutout
- o Current limiting
- o Voltage and current indicators
- o Power supply voltages

NOTE: *Components located within the Generator Assembly carry high dc currents. Control circuit grounds are isolated from transients generated while switching high currents by using three separate grounds on the board. The grounds are distinguished on the schematic as:*

- *o Ground A: Battery minus (B-) and 115 VAC Neutral*
- *o Ground B: ground for the driver stage Q5-Q8*
- *o DC Common: ground for most low voltages, and forms the PCB ground plane*

Verify that voltage measurements are referenced to the correct ground.

Overview

The battery charger PCB uses a boost regulator which provides controlled current and voltage to the battery circuit. Inductor L2 (located on the generator assembly), FET Q1, CR2, and output filter capacitors C10 and C11 comprise the boost regulator circuit.

When the system is first plugged into the AC power line the charger begins to apply 211 VDC to the battery circuit. Under low charger current demand the boost regulator output to the battery circuit is constant at about 211 VDC.

When the battery voltage is sensed caving-in during an X-ray exposure, the battery charger will supply the extra current needed for the shot, within the safe limits set by the protection circuitry.

If the charger current reaches its maximum output limit (current-limit condition) during battery charging or during an X-ray shot, the charger voltage is stepped up from 211 VDC to 230 VDC. This improves battery recovery after high current demands.

When the battery charger current-limits, as sensed by comparator U5, Q7 is turned on, placing R26 in parallel in the voltage feedback loop with R9 and R10. This raises the charging voltage to 230 VDC. The battery charger remains in this mode until the charge demand falls below about 0.5 Amp.

When the charging current falls below 400-600 mA, Q7 turns off and regulates the charging voltage back to the 211 VDC level. Hysteresis is biased into the op-amp circuit of U4 causing this transition to occur suddenly so that an oscillating condition does not occur.

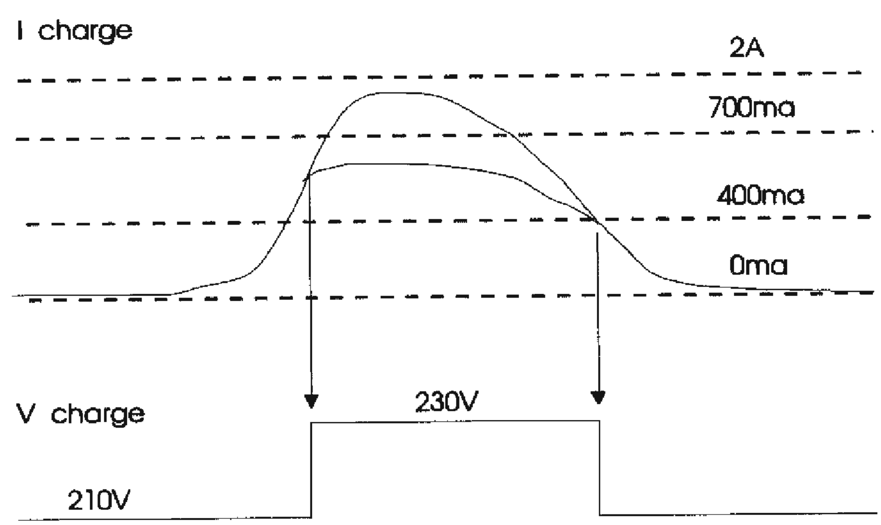


Figure 3-28 - The Current and Voltage Output During Low and High Charge

Pulse Width Modulator

U2 (UC3846) is a current mode, pulse width modulator with a built in 5.1 volt reference. The reference is accessible on pin 2 (Vr). U2 controls the duty cycle applied to the gate of FET Q1. The oscillation frequency is determined by R23 and C19. Voltage feedback is provided by voltage divider network R6, R9 and R10. Loop feedback compensation is provided by R31 and C10.

Resistor network R6/R9/R10 provides feedback to the inverting voltage sense input of U2. R10 is adjusted to produce 211 VDC output at CRG_OUT or 5.1 VDC at TP1, Voltage Feedback.

Voltage is sensed for the charging voltage bar graph display by resistor network R11/R28/R29/R32. R132 is adjusted for the correct display of the charging voltage on the bargraph.

Charging Current Sense

Current transformer T2, U4, Q9 and associated components comprise an output current sensor. U4, CR8, Q9 and associated components comprise an ideal diode. DC response is derived from the fact that the core of T2 is reset to zero during the off time of CR2, which also coincide with the off time of the ideal diode. The voltage across R19, the sense resistor, is then averaged by low-pass filter U4 and its associated components, whose output is then used to control the current bar graph indicator U7, and the CHGISNS (charger I sense) output to the analog support PCB.

Overvoltage Shutdown

To guard against battery damage and/or venting, an overvoltage protection circuit is provided. If the last indicator, (240 VDC) indicator of the voltage indicator lights, U1 is set, turning Q6 on. This both activates the shutdown control of the PWM chip and shunts the Q1 drive to ground. Stopping Q1 from switching.

If the overvoltage condition is sensed, protection is provided in two steps: apply a high to the SHTDN pin of the PWM U2, and ground the U2 drive output through transistor Q6.

U1 can be reset by either resetting AC power or by clocking the CHGDISAB (charger disable) input of the board; high and then low.

The CHARGER DISABLE line from the processor (via the Analog Support PCB) is attached to the U2 pin-SHTDN. When held high by the processor, this disables the pulse width modulator.

Low Voltage Cutout

A low voltage cutout circuit is provided to prevent over-current conditions in the event the battery voltage becomes discharged to below 160 VDC. Transistor Q10 turns off under this condition, turning Q2 off, removing DC power to the power switching circuit.

Current Limiting

Current sense resistor R1 provides an indication of the instantaneous current through FET Q1, to the PWM control chip U2. The drive to Q1 is removed on a pulse-by-pulse basis for current limit control. The current limit is set for approximately 3.5 amps DC at Q1, this corresponds to 2.5 amps DC at the output.

Indicators

Charging current is indicated on the LED bar graph display U7. U7 is driven by the charger CURRENT SENSE line. Charging current is indicated in logarithmic 3 dB steps from 25 mA to 625 mA.

The charging voltage indicator, U6, is driven by the VOLTAGE SENSE line. The indicator reads in 10 linear steps from 150 VDC to 240 VDC.

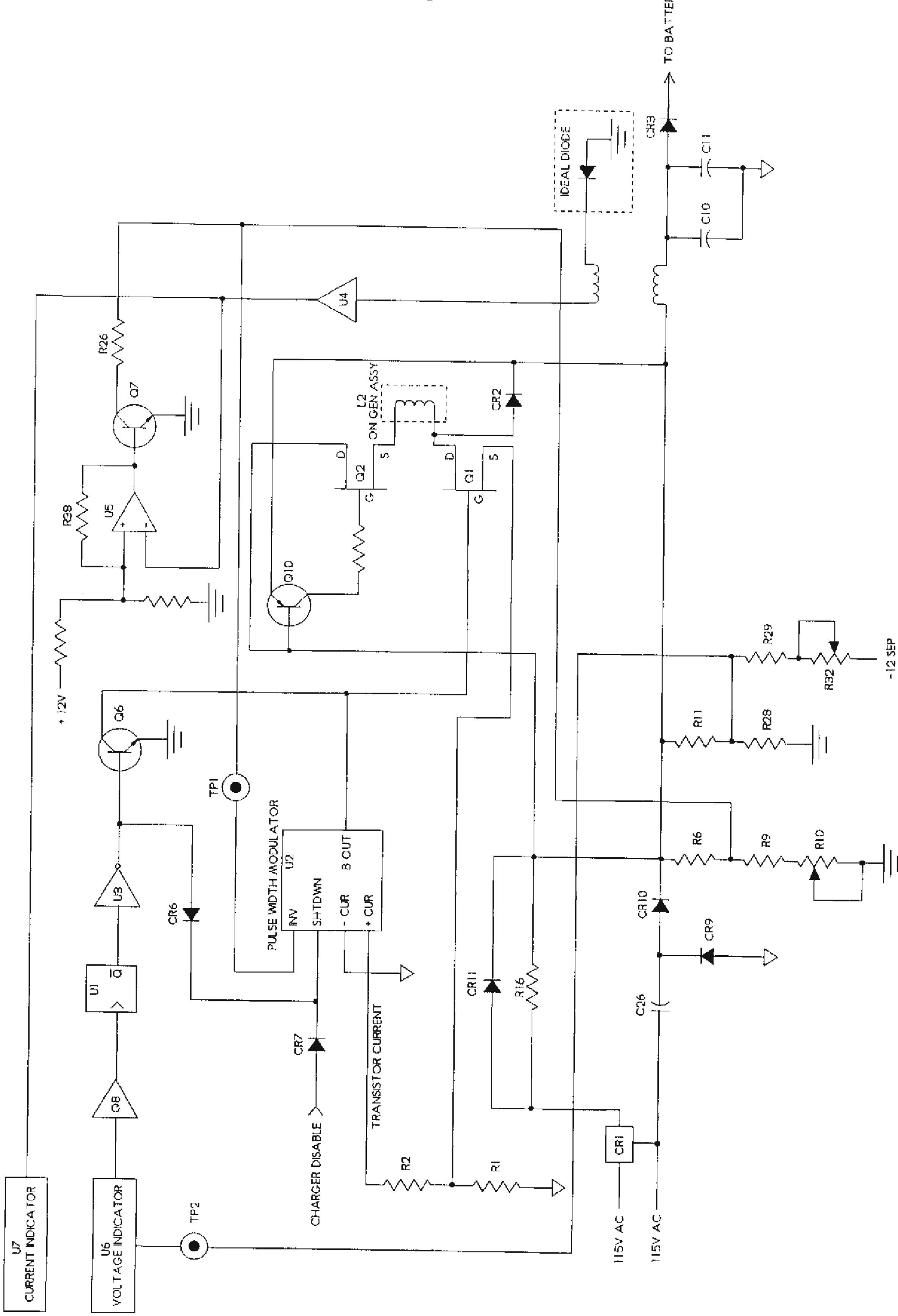
R11, R28, R29, and R32 comprise a voltage scaling/offset divider to control the voltage indicator. This circuit scales the voltage from 150 - 240 VDC to 0 - 5 VDC for use by the bar-graph indicator control chip U6. R32 is used to calibrate the voltage indicator readout range.

PCB Power Supplies

The battery charger circuit must be able to charge the batteries when the system is not in use. When the system is plugged into the AC line, and the interconnect cable is in place, 115 VAC is applied to the battery charger portion of this board independently of other circuits.

Connector P6 supplies phase-1, phase-2 and neutral lines. The phase-1 and neutral lines are applied to the input of bridge rectifier VR3. The rectified voltage is regulated by VR1 and VR2 to provide ± 12 VDC. These are identified as ± 12SEP and they power the battery charger circuits separately from the other voltages on the board.

Figure 3-29 - Block Diagram of the Battery Charger PCB



3.12.6. X-Ray Regulator PCB

3.12.6.1. Overview

Refer to Schematic 00-873614

The major functions of the X-Ray Regulator PCB are:

- o. Regulate Filament Current
- o. Regulate X-ray tube high voltage
- o. Buffer energy during the x-ray*

* The energy required by the X-ray tube during an exposure is provided by a combination of the batteries and the charger circuit. The batteries do not supply all of the energy for an exposure, but act as a buffer to minimize the line requirements and maintain a constant supply level.

NOTE: *The Generator Assembly carries high dc currents. Control circuit grounds are isolated from transients generated while switching high currents by using three separate grounds on the board. The grounds are distinguished on the schematic as:*

- *o Ground A: Battery minus (B-) and 115 VAC Neutral*
- *o Ground B: ground for the driver stage Q5-Q8 on the Generator Driver PCB*
- *o DC Common: ground for most low voltages, and forms the PCB ground plane*

Verify that voltage measurements are referenced to the correct ground.

3.12.6.2. Filament Regulation

Overview

Tube current (or mA) is controlled by varying the temperature of the x-ray tube filament.

Filament Preheat

At the beginning of a fluoro shot, or in the 2 seconds just before a film shot, the filament is preheated to an approximate temperature for the selected technique. The preheat temperature is controlled by varying the duty cycle of the filament drive.

The two means for controlling the filament under software and hardware (servo loop) control are:

1. Vary the duty cycle of the output switcher stage comprised of transistors Q3 and Q4 on the Generator Driver PCB (P/N 873613). This is the means the processor uses to preadjust the filament temperature, prior to a film shot and at the beginning of a fluoro shot, to an approximate value for the technique selected.

The processor calculates the initial duty cycle, for the desired technique, and programs the counter-timer chip (CTC) U12 on the Analog Support PCB. The CTC, with flip-flop U15 and counter U16, provides the logic inputs to PAL U17. This PAL produces the HV DRIVE A, HV DRIVE B and FILAMENT DRIVE A and B. The duty cycle of the filament drives determines the filament preheat value.

2. Vary the B+ voltage applied to the filament driver stage. This is the means used by the hardware servo loop to control the filament current during the X-ray shot.

The servo loop "fine adjusts" the value during the exposure in order to reduce the error between mA SENSE and mA CONTROL. (To optimize the image in Auto Fluoro mode, the processor adjusts the filament current by varying the MA CONTROL signal applied to the error amplifier).

Filament Regulation During the shot.

As the shot begins, the software turns over control to the hardware regulation loop which dynamically regulates the filament current (temperature) to the desired value. The hardware loop regulates filament current by controlling filament B+ voltage.

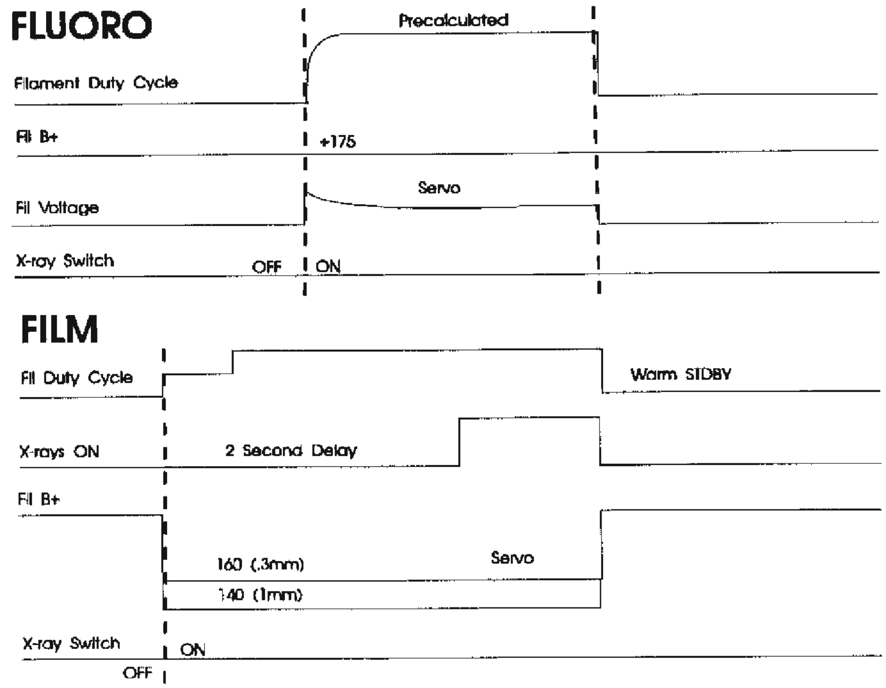


Figure 3-30 - Filament Duty Cycle and Filament B+ Regulation

The filament B+ voltage is initially set to a low value by the processor: 140 volts for large filament in film mode and 175 volts for the small filament in either film mode or fluoro mode. As the shot begins the B+ is servoed by the hardware loop to produce the desired filament current.

NOTE: *The processor increases B+ during film standby mode in order to reduce the dissipation of the series pass transistor in the regulator.*

The mA Sense Circuit

The X-ray tube current (mA) is sensed by a 100 turn toroidal transformer wound around the anode connector inside the high voltage tank. The anode lead, passing through the toroid, acts as the transformer primary.

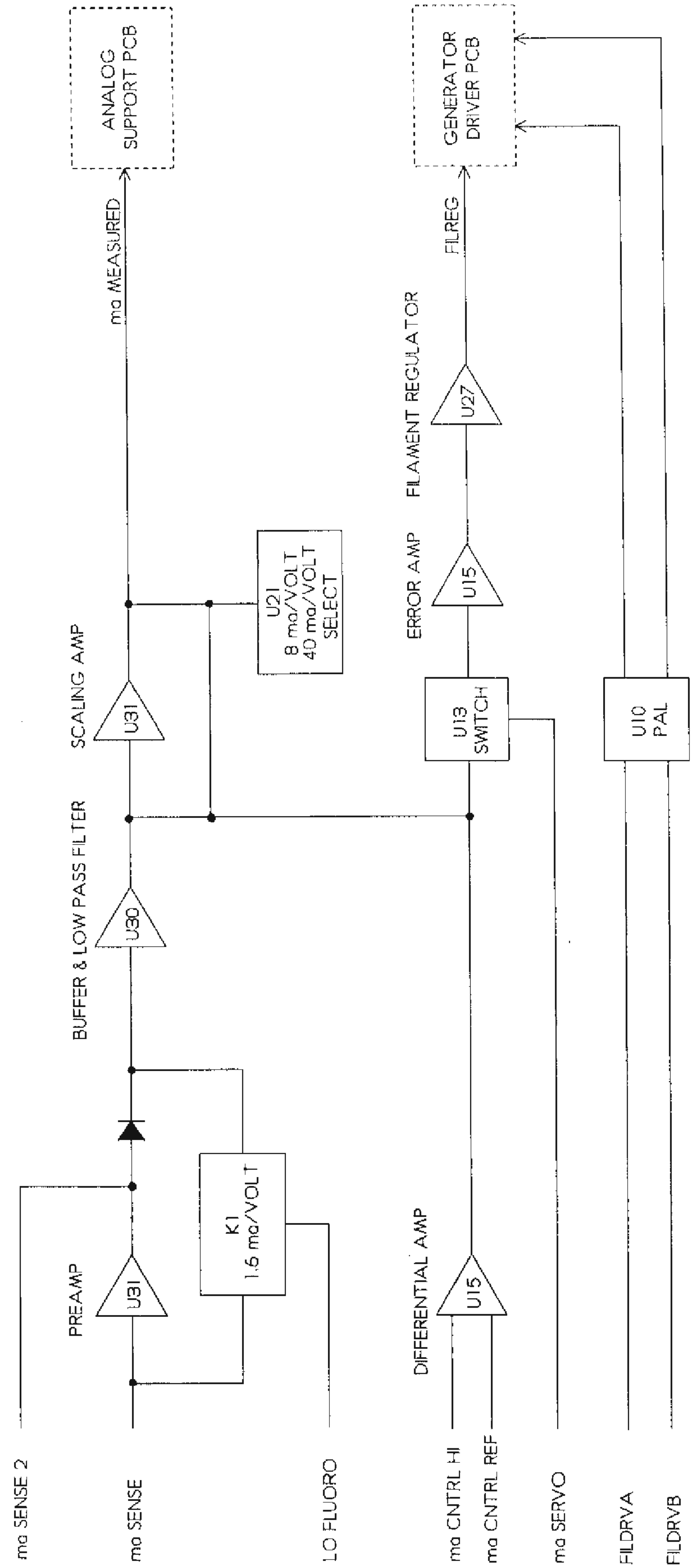
The voltage seen at the anode is DC with high frequency ripple. (At the far end of the high voltage cables the ripple is greatly reduced due to the filtering action of the distributed cable capacitance). The voltage ripple seen at the anode provides the means for current sensing by transformer action. The ripple induces an alternating current in the secondary winding of the 100 turn sensing transformer that allows tube current to be measured.

The high voltage rectifier in the tank prevents the current in the anode lead from reversing. The transformer can be used to measure the d.c. current as long as the secondary winding current is prevented from reversing. This is done by self-clamping transimpedance amplifier U31, resulting in d.c. restoration. U31 acts as a current to voltage converter.

The two stages of U30 form a low pass filter. The output of U30 is applied to film/fluoro scaling amplifier U31. U21 is an analog switch which selects the resistors used for scaling the sense voltage. The scaled voltage - MA MEASURED - is fed to the analog support PCB and read by the processor.

Note that Figure 3-31 shows the LOFLUORO signal to the K1 relay. This hardware is designed to improve low mA resolution, from 0 to 5mA, with U31 yielding 1.6mA/volt. However, the software for LOFLUORO - K1 is not yet implemented, thus K1 - LOFLUORO is not used.

Figure 3-31 - Block Diagram of mA Regulation Circuit



Filament Preheat

Filament preheat values are calculated by the software. Corrections to the algorithm are obtained during calibration.

Preheat Curve Self-adjustment Leading Edge Calibration

The mA at the start of a shot may need recalibration as the tube ages. If excessive servoing during the shot is needed, the formula which determines duty cycle is corrected automatically.

mAS Integrator

In the film mode, mAS is determined by integrating mA with respect to time. If the elapsed exposure time exceeds 10% of the expected time, the shot will be terminated.

Details of the Filament Regulation loop. Refer to Figure 3-33.

Prior to an exposure, the FIL DRIVE A and B duty cycle is set and FILAMENT B+ CONTROL applies an initial voltage to the linear regulation loop at the inverting input of U38.

Without mA SERVO enabled (by opening the analog switch U39), the input to the linear regulator circuit is provided solely by FILAMENT B+ CONTROL. This signal is developed as an output of DAC U18 on the Analog Support PCB.

To begin the shot, the kVp line from U19 triggers comparator U44, closing analog switch U13 (pins 6 & 7). As the shot begins, switch U13 (pins 10 & 11) opens, enabling error amplifier U15. U15 compares the MA CONTROL voltage with the mA sense voltage obtained from op amp U10.

Between pulses (in pulse mode) U13 pins 6 & 7 open, and U13 pins 10 & 11 remain open, causing the error amplifier to behave as a sample hold circuit. This allows subsequent pulses to begin with corrected filament voltage.

The difference, or error voltage, is applied to error amplifier U38 whose output controls the voltage on the base of transistor Q10.

The signal applied to the base of Q10 regulates the B+ voltage applied to the filament driver stage Q3 and Q4.

The linear regulator circuit, Q1 and Q2, controls the battery B+ voltage applied to the push-pull filament driver circuit Q5, Q4 on the Generator Driver PCB.

The final output is applied through L4 and C77 to relay K1. According to the state of the mm mode line, the relay applies the filament voltage to either the small or large filament.

NOTE: The initial filament voltage fed to the output stage depends on the selection of focal spot size. It is not varied as a function of mA or other technique factors which don't cause a change of focal spot size.

mA Test Circuit

A ten turn winding on the current sense transformer in the tank provides a means to verify accurate operation of the mA sense circuit.

A test signal is applied to this winding to simulate actual current in the cables. The signal MA PULSES enables analog switch U21 and applies the MA TEST CONTROL VOLTAGE to op amp U24.

U23 and Q3 are a current source whose output is proportional to the mA TEST CONTROL VOLTAGE. This applies a known calibration current to the 10 turn test winding in the tank. This is used to test the mA sense circuit at system boot.

Figure 3-32 - The mA Test Circuit

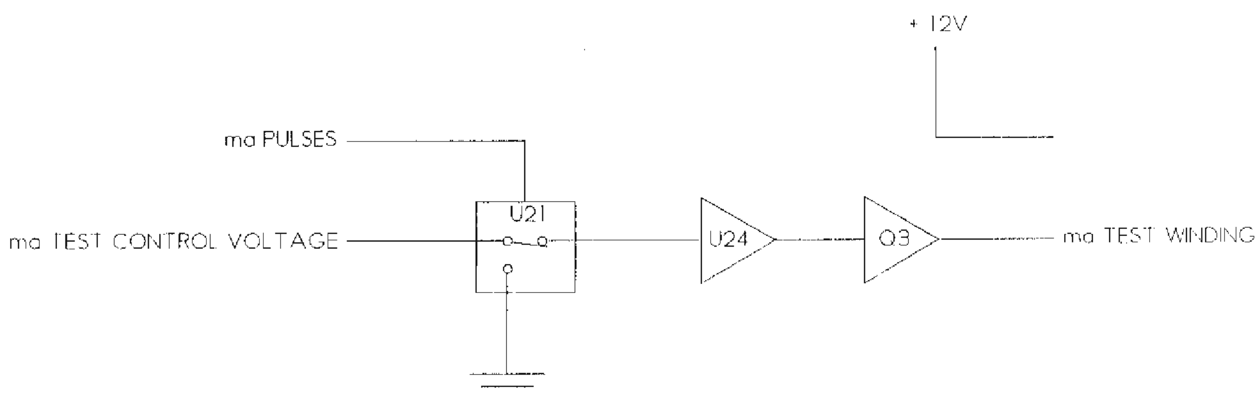
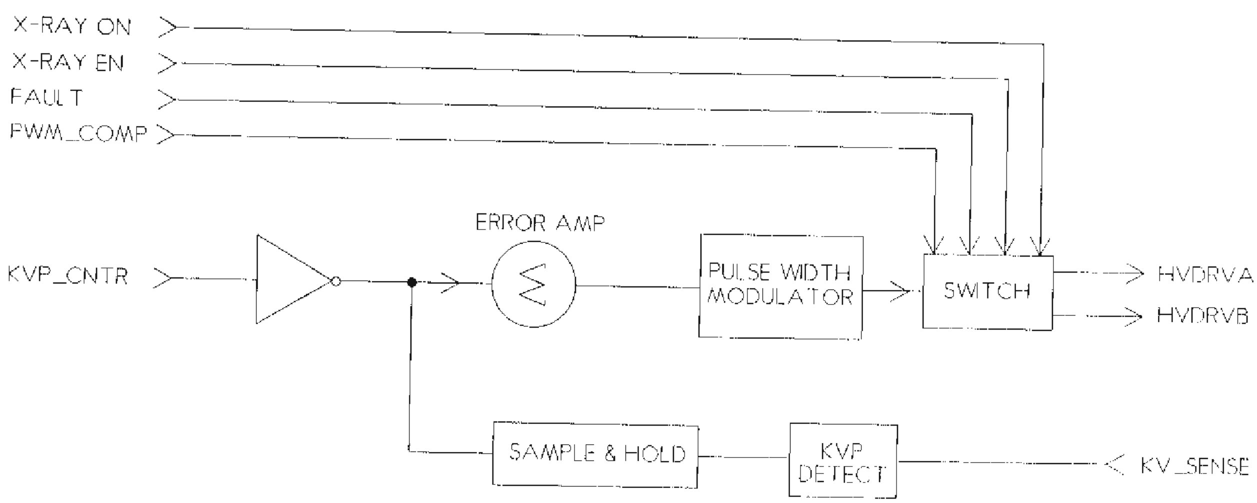


Figure 3-33 - KVp Regulation Loop



3.12.6.3. High Voltage Regulation

KV is dynamically regulated by varying the duty cycle applied to the high voltage driver circuit.

The kv regulation is accomplished in the hardware by a closed-loop regulation system consisting of a kv sensing circuit, peak detector, sample and hold circuit, error amplifier, and a pulse-width-modulator.

KV Sense

The KV sense voltage is obtained from a capacitive voltage divider (10,000:1) located in the high voltage tank. On the Generator Assembly KV SENSE is applied across R78. The positive peaks of the KV SENSE waveform are buffered by U16 and peak detected by U22/U26. The negative peaks of the waveform are inverted by U16, and detected by U25/U26.

Both peaks are sampled and held by U18, then combined and filtered by C37 and U20. The result is KVP MEASURED. This signal is then sampled and digitized on the Analog Support PCB.

Analog switch U17 provides feedback frequency compensation for the three mA operation (shot) ranges (refer to schematic 873614, sheet 2). The three RC circuits switch on as needed, as shown in the following:

Signal	mA range	U17 RC circuit enabled
FLROCOMP (fluoro & fluoro boost)	0 - 20 mA	U17A (C45, R81)
.3MMCOMP	20 - 60mA	U17B (C71, R117)
.1MMCOMP	60 - 100mA	U17C (C72, R118)

Error Amplifier

The error amplifier compares the measured kVp (from the capacitive divider and related peak detection circuitry) to the KVP CONTROL signal arising from the processor via DAC U31 on the Analog Support PCB. The output of the error amplifier controls the PWM (pulse width modulator) circuit of U34, U12, and Q6. The PWM output PWM COMPARATOR forms a logic input to PAL U7, along with the signals HV DRIVE A and B, an X-RAY ON and X-RAY ENABLE. PAL U7 produces the signals HV DRV A and HV DRV B which determine the duty cycle of the switcher drives.

The kVp control signal, an analog level used to proportionally control the kilovoltage, is fed to P3-28, inverted by U20B and fed to error amplifier U23A. It is then compared to the KVP_MEAS signal to generate the control signal for the pulse width modulator, which is used to control the pulse width of the drive signals fed to the output inverter.

Comparator U34 transistor Q6, and flip-flop U12 form a pulse width modulator controlled by the output of the error amplifier. The variable pulse width which results is input to programed logic array (PAL) U7. HV DRV A and HV DRV B are output by U7, buffered and inverted by U8. U36 and U40 provide current gain before applying the drive signals to Q5/Q6/Q7/Q8 on the Generator Driver PCB.

Secondary Tap Voltage Sense

The SEC TAP voltage provides a redundant measurement of the tank high voltage output to verify the voltage indicated by the capacitive divider, but it is not used for regulation.

The purpose for the secondary tap voltage is to provide a means for kilovoltage determination independent of the kv sense circuit responsible for regulation. Its failure could result in errors that would go undetected by the processor, or overvoltage conditions which could damage the tank, X-ray tube cables or the X-ray tube itself.

Taps on the secondary windings in the high voltage tank provide the inputs to this circuit: TAP 1 and TAP 2. Signals from these taps are fed to comparitor U32 and peak detector U33. If the voltage at U32 exceeds 30 vpp (corresponds to 140 kvp) an overvoltage fault is fed to U2, setting a latch, and removing the drives while setting the FAULT line leading to the CPU. U33 is a peak detector whose output, SECTAP, is also proportional to the kVp voltage from the tank. This signal is digitized on the Analog Support PCB and read by the processor.

Figure 3-34 - Secondary Tap Voltage Sense

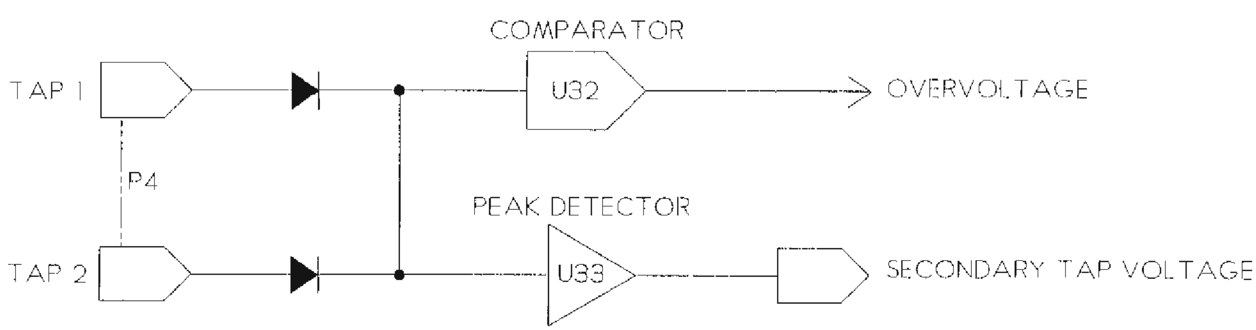
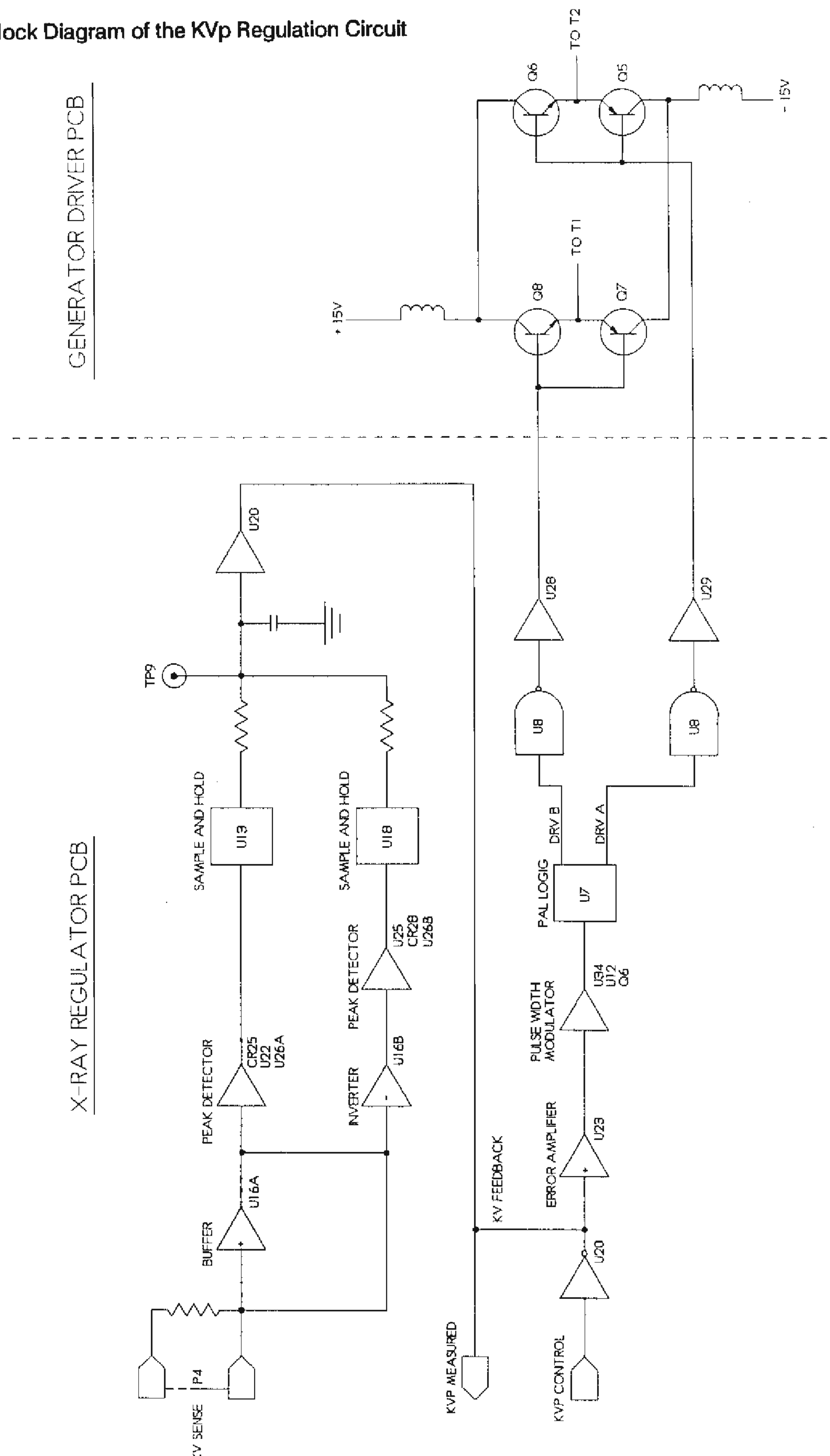


Figure 3-35 - Block Diagram of the KVp Regulation Circuit



Calibration

Refer to the calibration section in this manual for detailed information on calibration.

Closed loop regulation of the filament and high voltage power supplies allows dynamic regulation of kVp and mA. Calibration involves adjusting the transfer functions of these control circuits to bring them within the limits of accuracy. The transfer functions are adjusted by changing the reference voltages of the D/A converters on the analog support PCB which generate the control voltages.

3.12.7. Generator Driver PCB

NOTE: *Components located within the Generator Assembly carry high dc currents. Control circuit grounds are isolated from transients generated while switching high currents by using three separate grounds on the board. The grounds are distinguished on the schematic as:*

- *Ground A: Battery minus (B-) and 115 VAC Neutral*
- *Ground B: ground for the driver stage Q5-Q8*
- *DC Common: ground for most low voltages, and forms the PCB ground plane*

Verify that voltage measurements are referenced to the correct ground.

3.12.7.1. Overview

NOTE: *The initial filament voltage fed to the output stage depends on the selection of focal spot size. It is not varied as a function of mA or other technique factors which don't cause a change of focal spot size.*

Reference Schematic 00-873611 and Figure 3-36

Transistors Q5/Q6 and Q7/Q8 form a bridge circuit. Their emitters are coupled via C1 and C4 to transformers T1 and T3. The return path for each transformer primary is connected to ground through interlock relay K2. If the interlock circuit opens, the ground return path is opened by this relay.

Filament Inverter Supply Regulator

Q10, Q1 and Q2 comprise the high voltage portion of the filament inverter supply regulator. Q1 and Q2 share the voltage drop equally. Q10 controls Q1 and Q2 in response to the output of the error amplifier in the filament regulator section of the X-Ray Regulator PCB

Filament Inverter

Inverter drive signals are applied to P3-4 and P3-5, then routed to transformer T2 primary. The secondary drives the bases of the half bridge inverter, consisting of Q3 and Q4. The duty cycle is varied by the software control as a function of desired X-Ray technique. This varies the power fed to the filaments, and ultimately the mA of the exposure. DC blocking capacitor C13 prevents DC currents in the filament transformers, causing the average voltage to be at 0 VDC, . L3 aids in reducing EMI and noise problems by blocking high frequency currents.

Filament Selection

The filament select control signal is fed to the base of Q11 which drives the filament selector relay, K1. K1 then routes the filament drive power to the selected filament transformer in the high voltage tank. When Q11 is on, the large filament is selected.

Saturation Voltage Sampler

VR1, Q9 and associated components sample the voltage drop across Q7, or Q8. Whichever is currently ON. The voltage across R19 represents the voltage across the darlington power transistor. This voltage is fed through CR23 and then to the saturation fault detector circuit on the X-Ray Regulator PCB.

VR1's negative output samples the drop on Q5 and Q6, for the same purpose. If either of these voltage drops exceed 5 volts, the fault is indicated and the drives are shut down on the X-Ray Regulator PCB

3.12.7.2. Generator Driver Output Stage

Refer to Figure 3-36

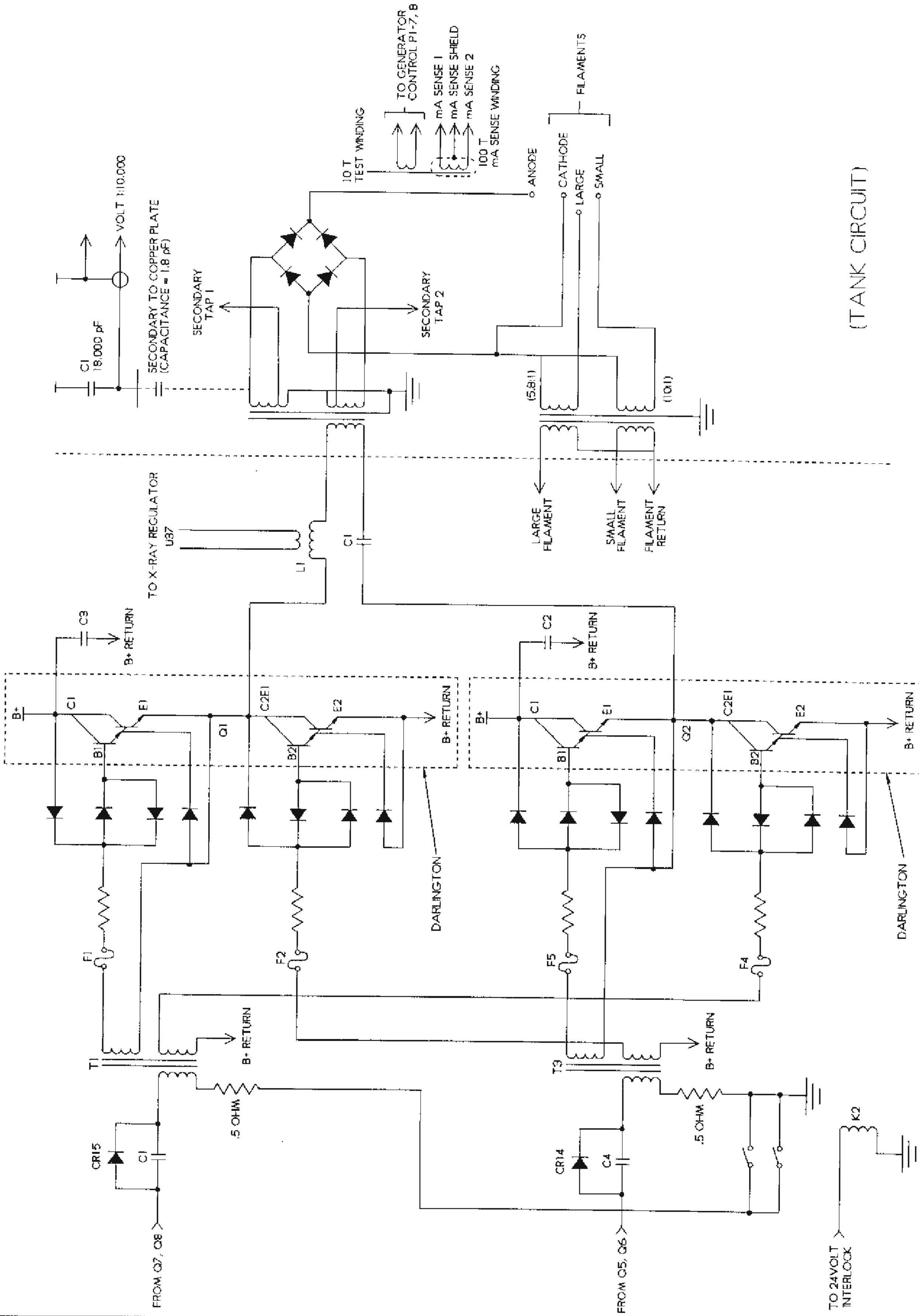
The two transformers, T1 and T3, located on the Generator Driver PCB, each have two individually fused secondary windings, which drive the high power transistors Q1 and Q2 (located on the Generator Assembly).

The main power transistors, Q1 and Q2, each contain two darlington pairs and drive the primary of the high voltage transformer (tank) in a bridged configuration, alternately connecting each of its input leads (through a series tuned circuit) to common and then to 200 volts in reverse phase, effectively doubling the drive voltage. Baker clamping diodes enhance the switching speeds of these transistors. Baker clamping diodes and fuses F1, F2, F4, and F5 are located on the Generator Driver PCB in the secondary circuits of T1 and T3.

The large switching transistors Q1 and Q2 each contain two internally wired Darlington pairs. These form an H-bridge switching regulator. C1 and L1 (High Voltage Tank) form a series resonant filter to improve the input impedance characteristics of the tank circuit to the high frequency generator output.

The tuned circuit formed by L1 and C1 has the effect of converting the square wave output to a sinusoidal current waveform at the transformer primary.

Figure 3-36 - Block Diagram of the High Voltage Drive and Tank Circuits



3.12.8. High Voltage Circuit (Tank)

Refer to Figure 3-36

The tank primary circuit, Inductor L1, capacitor C1, and the lumped tank inductance and capacitance presents a tuned load with a sinusoidal response to the high voltage driver stage at the switching frequency of 2500 Hz. Due to the sinusoidal response of the circuit, longer pulse widths, controlled by the PWM, result in higher currents in the tank primary circuit.

The oil filled tank is a sealed assembly which contains:

- o Filament transformer with secondary windings for both filaments.
- o High voltage transformer
- o High voltage rectifier
- o Capacitive voltage divider for voltage sensing with a divider ratio of 1:10,000 volts.
- o Current sensing inductor for anode current. This is a 100 turn winding through which the anode lead passes as it exits the tank. A 10 turn test winding is used to inject a current into the mA sense winding for calibration.
- o Secondary winding taps for voltage sensing.

NOTE: *The Cathode connection is also the common filament return.*

3.12.9. Battery Circuit

Refer to Figure 3-37

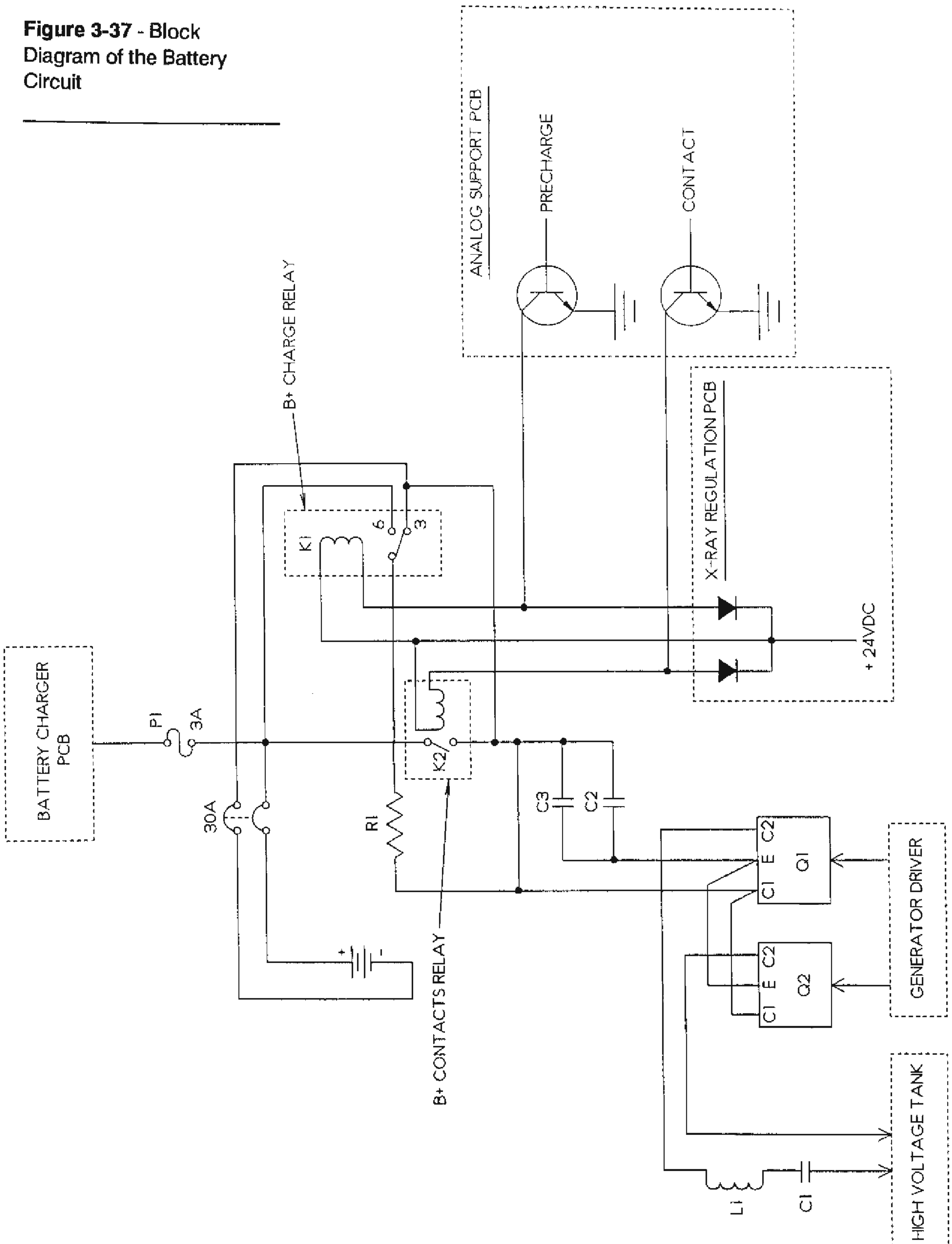
The battery circuit is comprised of:

- o Three 60 volt battery packs
- o Charging resistor R1
- o 30 Amp contact closure fuse
- o 3 Amp charger fuse
- o B+ charge relay
- o B+ contactor

The internal batteries buffer the power line during high current exposures. The batteries are 5 Amp-hour sealed lead-acid gel cells in a 180 VDC stack. Each exposure draws from this energy source. The end result is that the system is capable of high power exposures while being operated from a 115 VAC, 20 Amp line.

The battery charger circuit, and the batteries provide energy for the X-ray shot.

Figure 3-37 - Block Diagram of the Battery Circuit



The Battery Charger circuit is connected through a 3 Amp fuse to the positive side of the battery pack. The battery pack is constantly being charged with 211 VDC.

When K1, the PRECHARGE relay, is closed, by the PRECHARGE circuit on the Analog Support PCB, the B+ voltage is applied through R1 to precharge capacitors C2 and C3.

After the circuit has been precharged, the B+ CONTACTOR relay K2 is closed, connecting the battery, and the battery charger up to the emitter of Q1 and Q2, supplying B+ current for the shot.

3.13. OTHER MAINFRAME COMPONENTS

3.13.1. Motherboard

Refer to Schematic 00-870776

The motherboard forms the back of the card cage. It provides a 62 pin computer bus common to all boards plugged into the card rack. The other backplane connectors are specific for each PCB.

3.13.2. Floppy Disk Drive

Refer to Drawing 00-900103

The operating system and application software are loaded from floppy disk to RAM when the system is booted. The floppy is a 3-1/2" microfloppy installed in the microfloppy disk drive mounted in the mainframe. The disk drive operates on +5 and +12 VDC.

3.13.3. Rotation Motor Relay PCB

Refer to Schematic 00-871214

This PCB contains the relays used to control the C-arm rotation and lift motors.

3.13.4. Relay PCB

Refer to Schematic 00-871112 and Figure 3-2

The 24 volt interlock line and the FAST STOP switches are connected through this PCB. Relays supply power to and control the motion of lift and rotation motors. Power is supplied to the image intensifier via this board. Stator start and stator run relays are located on this PCB.

The CPU INTERLOCK CIRCUIT supplies +15 VDC to the auto start circuit on the Relay PCB, which engages relay K9. The auto start circuit is comprised of CR14, R9, C5, CR12 and K9. Once K9 has been engaged +15 VDC engages relay K2, and providing the +24V Interlock and the 24V to relays K1, K3, K4, and K5. If the POWER ON KEYSWITCH has been turned to the ON position, the +24 VDC from PS2 is applied to the contacts of relays K6, K7 and K8.

SECTION 4
REMOVAL AND REPLACEMENT

SECTION 4
REMOVAL
REPLACEMENT

4.1. SAFETY

WARNING **Circuits inside the equipment use voltages which are capable of causing serious injury or death from electrical shock. There are no procedures in this section of the manual which should be attempted by anyone other than a properly trained service technician.**

Remember that even when the mainframe is disconnected from the monitor cart and the wall outlet there are still hazardous voltages present due to the high energy capacitors and the battery packs.

Read the Safety section of this manual. In addition to the guidelines and warnings given in that section, follow these specific precautions when working around the mainframe electronics.

1. Always unplug the AC power cable before opening or removing equipment covers.

2. Disconnect the red battery lead to interrupt the battery current path.

3 After removing the monitor cart power cord from the outlet and disconnecting the battery lead, wait at least ten minutes to allow the B+ storage capacitor to discharge, or then discharge the B+ capacitor through a 200 ohm, 100 watt resistor.

4. Use extreme care if you must perform adjustment procedures when power is applied to the electronics.

5. The large metal tank is at ground potential. Do not accidentally place any conductor or part of your body between the tank and any voltage above ground potential.

6. Use caution when working near the batteries and their connections. Remove any metal rings or watchbands which might inadvertently come in contact with the battery terminals. Severe burns could result if such metal articles are placed across the battery terminals.

4.2. Removal Replacement Procedures

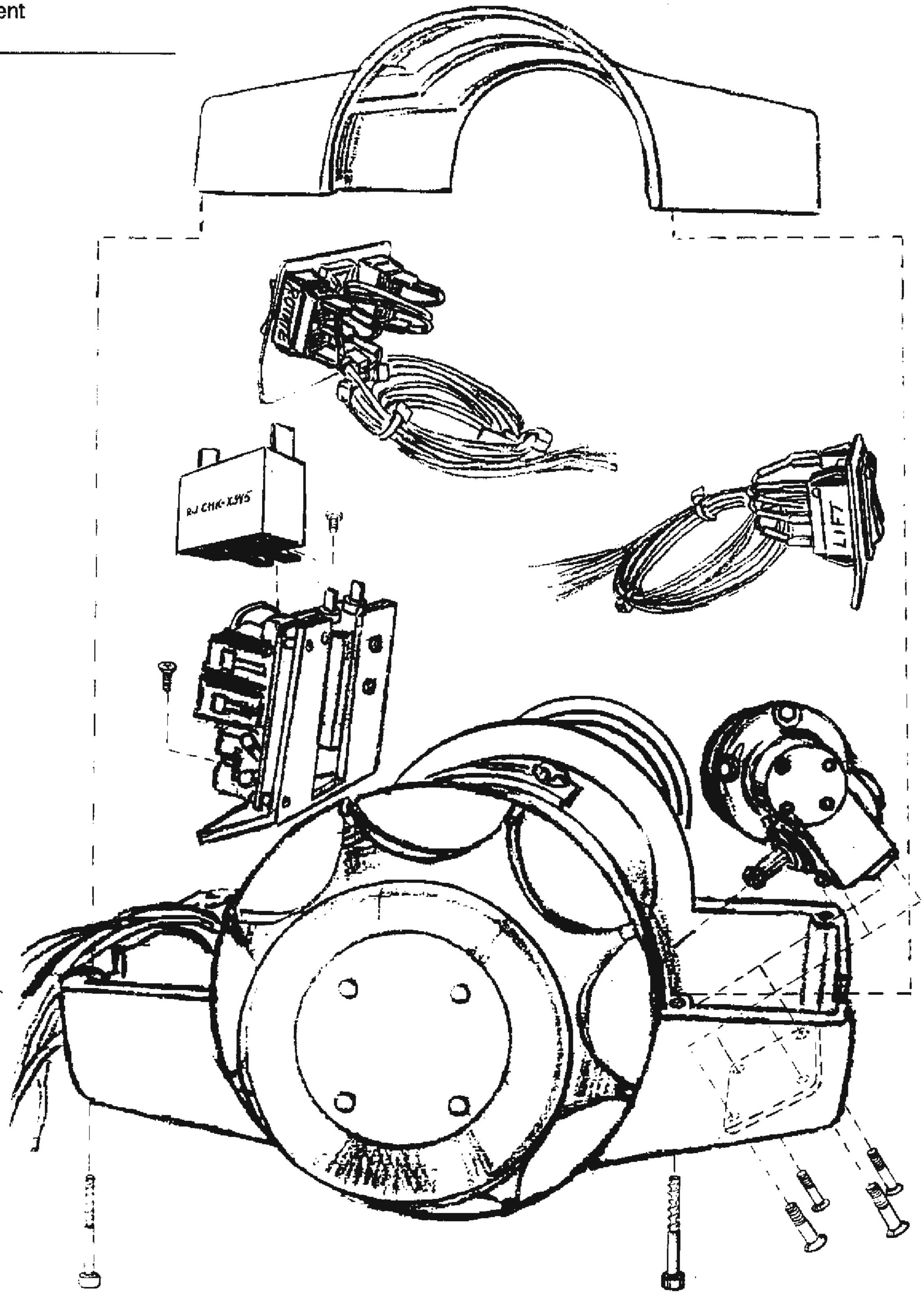
4.2.1. L-Arm Rotation Motor Removal Replacement

Refer to Figure 4-1 to remove the L-Arm Rotation Motor

1. Remove the monitor cart power cord from the outlet.
2. Remove the four hex bolts that secure the cross arm housing cover and remove the cover. Move the panel that holds the Rotation and Lift motor switches.
3. Disconnect the J2 connector on the Rotation Motor Relay PCB and then loosen the bracket which secures the Rotation Motor Relay PCB and the capacitor.
4. Carefully cut the ties that secure the motor wires.
5. Remove the four hex bolts from the bottom of the cross arm housing that secure the rotation motor to the housing.
6. Pull the motor away from the worm gear coupling.
7. Secure the new motor in the cross arm housing with the four hex bolts. Use loctite 242 on these bolts.
8. Reroute the motor wires and reconnect them to the J2 connector on the Rotation Motor Relay PCB as follows:

Rotation Motor Wires	Crimped Wire	J2 Connector
Black	Black	Pin 5
Yellow	Yellow	Pin 2
Red	Red	Pin 3
Blue	Blue	Pin 4
Black/Yellow	Gray	Pin 1

Figure 4-1 - L-Arm Rotation Motor Removal Replacement



4.2.2. High Voltage Tank Removal Replacement

Refer to Figure 4-2 to remove the High Voltage Tank

1. Remove the monitor cart power cord from the outlet.

2. Disconnect the red battery lead to interrupt the battery current path.

3. After removing the power cord from the outlet and disconnecting the battery lead, wait at least ten minutes to allow the B+ storage capacitor to discharge, or discharge the B+ capacitor through a 200 ohm 100 watt resistor.

NOTE: The card rack, generator control assembly, and the tank are removed as one assembly.

4. Disconnect the high voltage cables from the tank.

5. Disconnect the black twist-on control cable.

WARNING: These cables retain a high voltage charge. Ground the pins of the connector to the chassis immediately after removing a cable from its connection in order to discharge the cable capacitance.

6. Remove the two hex head screws securing the base of the tank to the frame.

7. Remove the two screws at the back of the Generator Control Assembly that secure the assembly to the center column.

8. Slide the High Voltage Tank and the Generator Controller Assembly back toward you about 4 inches.

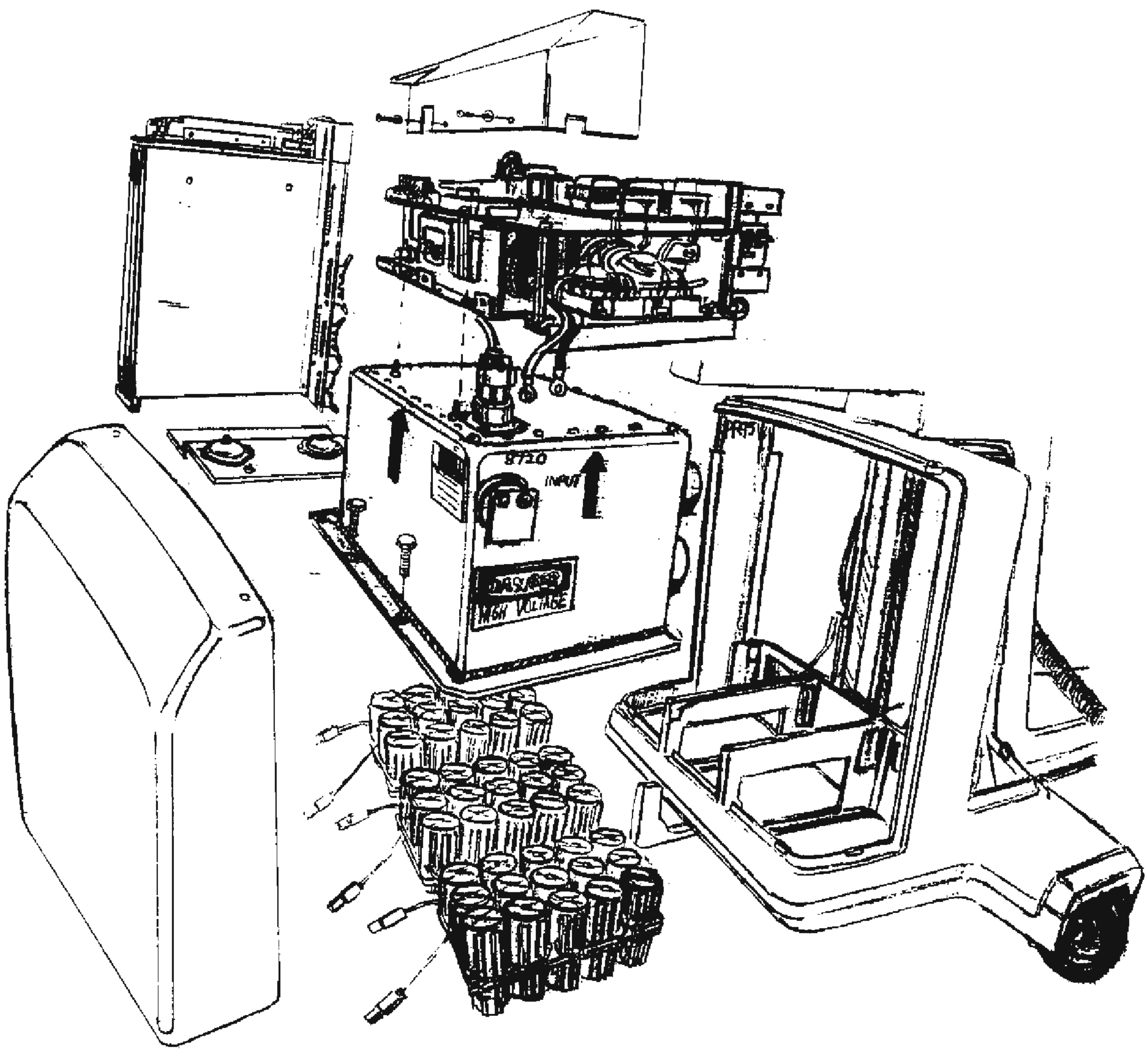
9. Disconnect the cables attached to the X-ray Regulator PCB.

10. Unplug the motherboard connectors and the stator transformer wires.

WARNING: The tank weighs about 80 pounds. To avoid injury, get help lifting the tank.

11. Slide the tank assembly out and lift it away from the frame.

Figure 4-2 - High Voltage Tank Removal Replacement



4.2.3. Battery Pack Removal Replacement

WARNING: **Use caution when working near the batteries and their connections. Remove any metal rings or watchbands which might inadvertently come in contact with the battery terminals. Severe burns could result if such metal articles are placed across the battery terminals.**

The batteries have low internal resistance and are capable of delivering high currents if they are shorted.

NOTE: *The battery packs must be replaced as a complete unit. Partial replacement of batteries is not recommended. For optimal performance and best overall battery life all batteries should have the same usage history. The batteries are serialized by the manufacturer and these numbers are used to keep sets of three battery packs together.*

1. Disconnect all of the battery connectors and cut the cable ties.

Refer to Figure 4-2 to remove the batteries

2. Use the preceding procedure to remove the High Voltage Tank
3. Lift the battery packs out of the cabinet frame. Note how the battery cables are routed through the frame.
4. Replace the battery packs in the battery compartments from right to left. Route battery cables as noted in step 3.

4.2.4. Floppy Drive Removal Replacement

1. Remove the cables attached to the rear of the floppy drive. Note the cable polarity for correct reattachment.

2. Remove the four screws securing the floppy drive to the top of the card rack and remove the drive.

4.2.5. Card Rack PCB Removal Replacement

1. The PCBs must occupy these slots:

LEFT SLOT	RIGHT SLOT
Technique Processor PCB	Analog Support PCB

4.2.6. Camera and Vidicon Removal Replacement

1. Remove the four phillips head screws securing the cover near the front of the camera.

2. Remove the four bolts holding the camera to the 45° angle bracket.

3. Remove the camera. Save the rubber gasket which seals the camera to the optics assembly.

4. With the camera lens facing up loosen the phillips head screw that secures the brass slide ring.

5. Slide the brass slide ring up the lens

6. Remove the camera lens and the lens mount from the camera frame by rotating the mount CCW.

7. Remove the brush plate and spring plate from the bottom of the camera.

8. Remove the filter board and the socket from the vidicon tube.

9. Slide the Vidicon out through the front of the yoke assembly by pushing against the pin end of the tube.

7. Slide the new Vidicon into the yoke and orient the tube so that the short index pin is adjacent to the wires leaving the yoke assembly. Be sure the Vidicon is firmly seated in the yoke.

8. Reconnect the filter board and socket on the rear of the vidicon. Reattach the brush plate and spring plate.

9. Reattach the lens mounting ring, and camera lens.

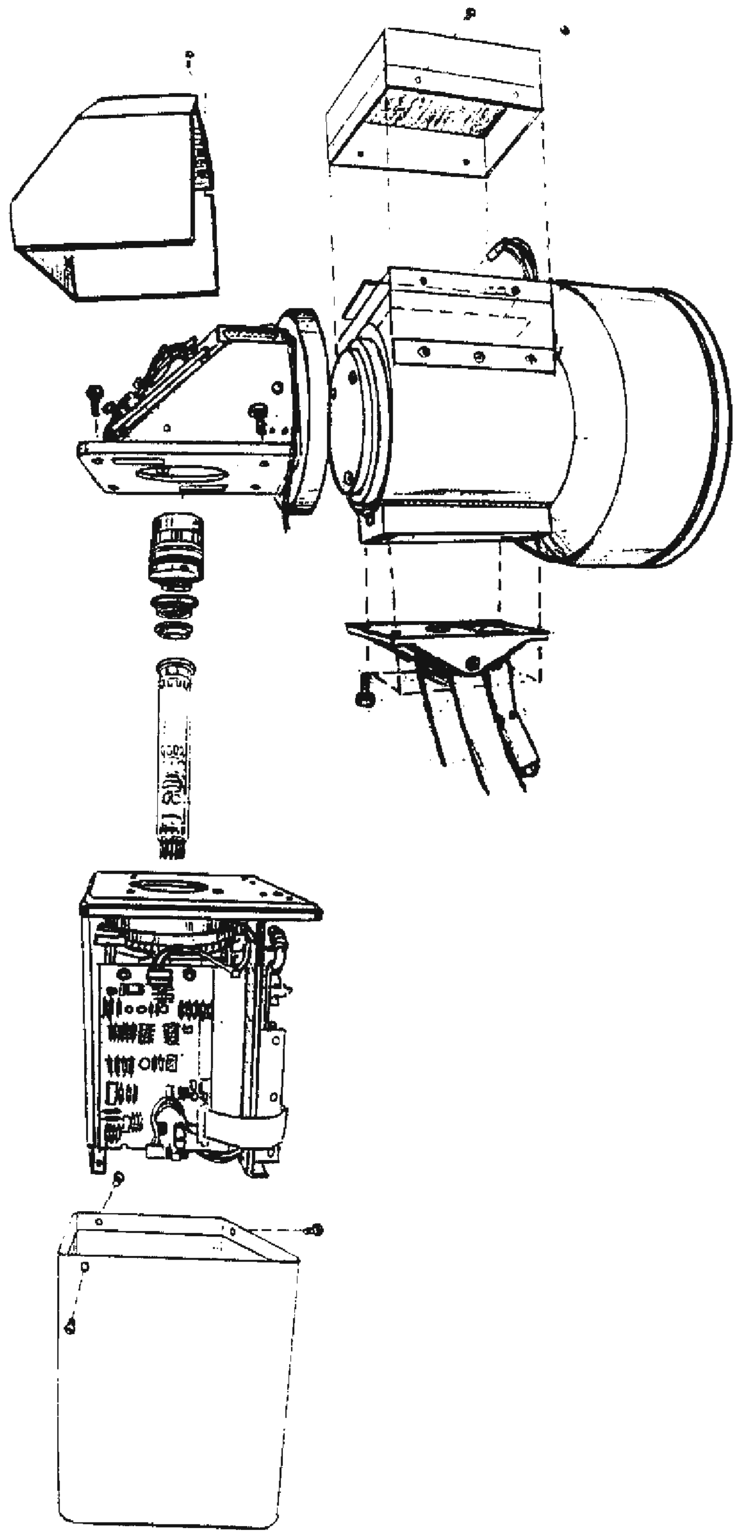
NOTE: *Carefully clean the mirror of any dust or fingerprints before replacing it on the camera.*

10. Reinstall the camera. When replacing the camera, make sure the 25-pin D-connector lines up with the mating plug on the camera.

Refer to the Calibration Section

11. Perform the camera alignment procedure.

Figure 4-3 - Camera, Image Intensifier and Vidicon, Removal Replacement



4.2.7. Image Intensifier Removal Replacement

Use this procedure to remove either the 6" or 9" Image Intensifier.

WARNING: **The image intensifier tube can implode if struck or jarred. Use care when handling. To avoid injury from flying glass, wear protective clothing and approved safety eye protection.**

When the image tube is removed the C-arm becomes unbalanced and may pivot out of control. Make sure that the brake is tight and remove the weight of the image tube slowly.

1. Remove the monitor cart power cord from the outlet.
2. Remove the plastic mirror cover.
3. Disconnect the J12 connector (2 screws).
4. Remove the Image Intensifier power supply cover. Disconnect the wiring to the image tube Power Supply PCB at CN11.

NOTE: When removing a 6" Image intensifier, disconnect the wires connected to the cassette sense switch.

5. Disconnect the two connectors from the Image Functions PCB and then remove the Image Functions PCB by removing three screws.
6. Disconnect the J13 connector below the Image Functions PCB location.
7. Remove the six screws on the mounting hub that secure the 45° angle bracket to the Image Intensifier.
8. Separate the camera assembly from the Image Intensifier.
9. Remove the four bolts that secure the Image Intensifier to the chrome C-arm and remove the Image Intensifier.
10. Replace the Image Intensifier and reassemble.

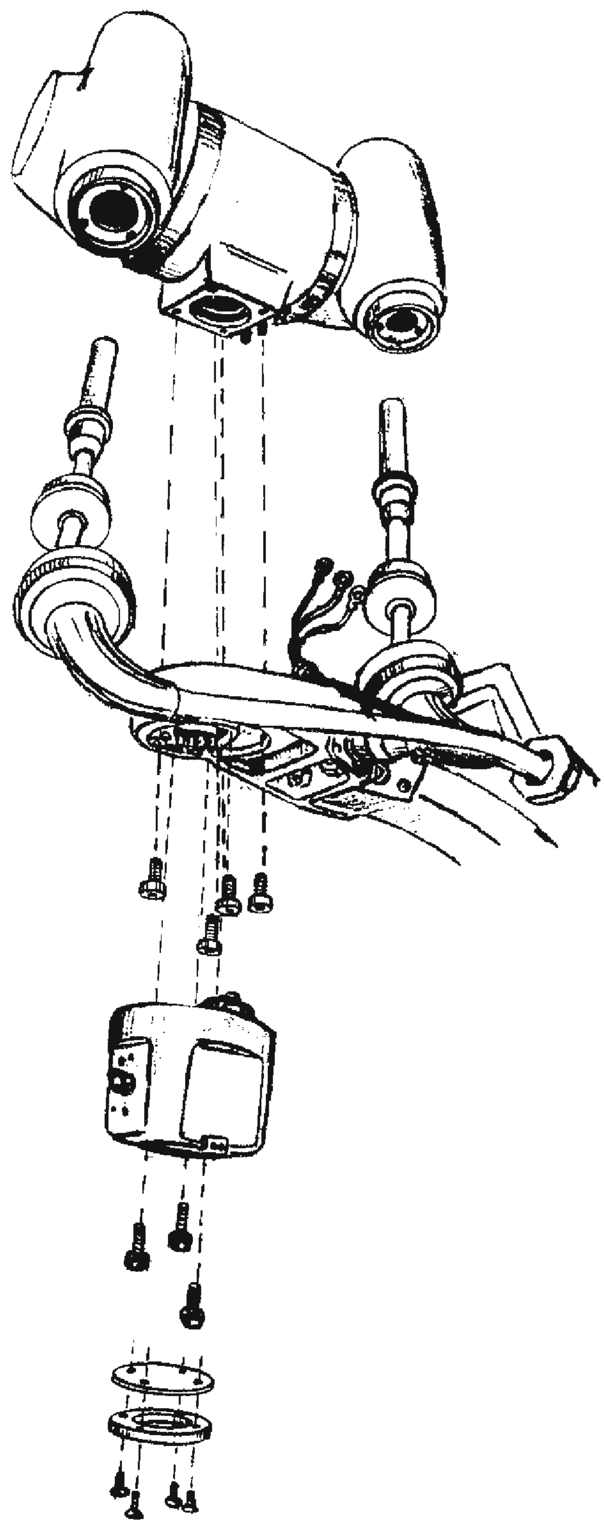
4.2.8. Collimator Assembly Removal Replacement

CAUTION: **Do not bend, scratch, or otherwise mark the lead collimator leaves. Such damage can be visible on the X-ray image.**

Refer to Figure 4-4 to remove the Collimator

1. Remove the monitor cart power cord from the outlet.
2. Orient the C-arm perpendicular to the floor, with the collimator pointed towards the ceiling. This position will allow access to the four screws at the back of the assembly which secure the lower aluminum filter.
3. Remove the four screws that secure the aluminum filter.
4. Remove the three hex bolts securing the collimator to the mounting plate.
5. Lift the collimator straight-up avoiding contact with the brushes and unplug the rotation motor cable.
6. There are no field serviceable parts or adjustments inside the collimator. Replace the collimator as a complete assembly.
7. The brush assemblies consist of two spring loaded soft metal projections, held in a mounting block on the collimator mounting plate. The brushes may be replaced by removing their holding screws on the inside of the collimator mounting plate.

Figure 4-4 - Collimator and X-Ray Tube Removal Replacement



4.2.9. X-ray Tube Removal Replacement

WARNING: **When the X-ray tube is removed the C-arm becomes unbalanced and may pivot out of control. Make sure that the brake is tight and remove the weight of the X-ray tube slowly.**

Refer to Figure 4-4 to remove the X-ray Tube

1. Use the vertical column to lower the tube assembly until it rests approximately 6" above a padded chair. This will prevent the tube from accidentally falling to the floor during the removal procedure.

2. Remove the monitor cart power cord from the outlet.

3. Complete the collimator removal procedure.

WARNING: **The high voltage cables retain a high voltage charge. Ground the pins of the connector to the chassis immediately after removing a cable from its connection in order to discharge the cable capacitance.**

4. Remove the anode and cathode high voltage cables. Verify that the cables are labeled correctly (anode, cathode). Protect the connectors from dust and dirt contamination.

5. Remove the two phillips head screws on the mounting bracket that secure the black twist on control cable. Disconnect the black twist-on control cable.

6. Remove the four hex bolts in the collimator mounting plate that secure the tube to the C-arm. Lower the tube until it rests upon the chair.

7. Replace the X-ray tube and reassemble.

Refer to the Calibration Section

8. Take beam alignment films and make adjustments if necessary.

9. Complete FDA form 2579.

4.2.10. Wig Wag Brake Removal Replacement

1. Remove the allen set-screw located in the brake stud.
2. Remove the stud and brake handle assembly from the C-arm by turning the stud clockwise.

NOTE: *A bolt would normally be turned clockwise to tighten but this stud has reverse threads so the clockwise motion will actually loosen the stud.*

3. Remove the washers from the stud and unscrew the stud from the brake handle.
4. Insert the new stud into the brake handle and place the washers on the stud.
5. Insert the stud and brake handle assembly into the C-arm flange and turn Counter-Clockwise to tighten. Position the brake handle to the far left.
6. Using a 1/8" drill bit, at least 6" in length, drill a 1/8" deep hole into the stud through the vacant set screw hole.
7. Tighten the set-screw into the brake stud.

4.2.11. Control Panel Removal Replacement

1. Loosen the four black hex bolts that are located in the chrome ring that encircles the vertical column.
2. Remove the two hex bolts that hold the control panel ring around the vertical column.
3. Pull the control panel towards the steering handle.
4. Turn the control panel upside down and remove four screws that secure the bottom pan of the control panel.
5. Disconnect connector and ground wire connected to the Control Panel Processor PCB and verify that they are labeled correctly.
6. Remove the screws that secure the Control Panel Processor PCB.

4.2.12. Steering Handle Removal Replacement

1. Remove the four hex cap screws (if installed) in the bottom of the steering handle. Remove allen set screws from the same holes.

2. Pull the handle away.

4.2.13. Wheel Removal Replacement

1. Use the snap ring tool to remove the spring clip on the end of the axle.

2. Slide the axle through the wheel yoke and wheel.

SECTION 5
SERVICE AND DIAGNOSTICS

SECTION 5
SERVICE AND DIAGNOSTICS (CONTINUED)

SECTION 5 SERVICE AND DIAGNOSTICS

5.1. SAFETY PROCEDURES DURING SERVICE

WARNING: **When the mainframe is disconnected from the monitor cart and wall power outlet there are still hazardous voltages present due to the large capacitors and battery packs.**

Circuits inside the mainframe use voltages which are capable of causing serious injury or death from electrical shock.

Use the following safety precautions to minimize your potential risk:

- Remove rings, watches and other jewelry before performing any servicing operation.
- Unplug the AC power cable before opening or removing equipment covers.
- Disconnect the red battery lead to interrupt the battery current path.
- After removing the monitor cart power cord from the outlet and disconnecting the battery lead, wait at least ten minutes to allow the B+ storage capacitor to discharge.
- Use extreme care performing adjustments when power is applied to the electronics.
- Use caution when working near the batteries and their connections.

5.2. MAINFRAME BOOT AND ERROR CODES

During startup, boot codes are issued as software is loaded and hardware is initialized. These progressive codes are displayed briefly on the mainframe LED display. If any of these messages persist on the display and the system fails to complete the startup sequence, a fault is indicated. Note the code letter and refer to the lists below.

5.2.1. Control Panel Boot Codes

C0	Initialize variables
C1	Begin ROM checksum test
C2	Begin RAM read/write test
C3	Not used
C4	Control Panel Boot is completed

5.2.2. Technique Processor Boot Codes

(Also displayed on the Technique Processor LED as numbers 0-8.)

B0	Setting PIOs - (will halt here if Technique Processor does not come up)
B1	Beginning ROM check on Technique Processor
B2	RAM check on Technique Processor
B3	Entering monitor mode (will halt here if S4 on Technique Processor PCB is not set properly)
B4	Loading boot-sector from disk to memory
B5	Loading DOS, boot sector is OK, then loading IO.SYS and MSDOS.SYS
B6	Running I/O system
B7	DOS re-initialization
B8	Initializing stack pointers

5.2.3. Applications Software Boot Sequence Codes

A0	Starting Technique Processor initialization.
A1	Initializing PIOs and front panel
A2	Loading MUXRAM
A3	Reading EEPROM
A4	Loading servo tables
A5	Initializing software defaults and flags
A6	Checking hardware integrity
A7	Starting interlocks and BPLUS charge

5.2.4. Disk Error Codes

These codes appear on the Technique Processor LED with a decimal point to identify them as disk error codes.

E1	Invalid command error (bad software)
E2	Drive not ready
E3	Write protect error
E4	Track seek error
E5	ID mark CRC error
E6	Data CRC error
E7	Data overrun error, possible DMA error
E8	Record not found error
E9	Not Used

5.2.5. Miscellaneous Error Codes

In the following codes, nnnn is the error address and HH is a hex number.

ERROR nnnn HH
This error code indicates a fatal disk error and could possibly occur at any time. The cause may be a DOS media problem.

RT FAIL HH nnnn
Indicates a run-time software fatal error.

IO FAIL HH nnnn
Indicates an I/O software fatal error.

5.3. EVENT CODES AND WARNING MESSAGES

5.3.1. Event Codes

The software executed on the Technique Processor PCB monitors operating conditions and hardware states. Transitions in conditions and states are signaled by software event codes. The most recent 128 event codes are stored in a buffer to provide a record of the events leading up to a failure. The event buffer can be examined using the status mode described in section 5.4.

Refer to Table 1 Event Code Table

The Hexadecimal number in the left column indicates the two right digits of the event code. These two hexadecimal digits indicate the specific event. Most event codes signal events which occur during normal operation. Event codes signaling fatal errors, which terminate system operation, are indicated by an asterisk (*) in the table.

TABLE 1 EVENT CODE LISTING

CODE	EVENT	DESCRIPTION
01	NOT USED	
02	NOT USED	
03	NOT USED	
04	*X-RAY JUMPER ON	jumper left in after calibration
05	FOOTSWITCH STUCK	x-ray switch is sensed improper
06	*PRECHARGE FAIL	precharge cycle has failed
07	*HV INVERTER ON	high voltage generator is on
08	30 MINUTES	time marker groups events
09	MAIN PRGM LOADED	main program is loaded to RAM
0A	INIT COMPLETE	hardware initialization complete
0B	NO DARK CURRENT NEC	dark current comp not needed
0C	AD CHANNEL-0 FAILED	kVp measure out of range
0D	AD CHANNEL-1 FAILED	mA measure out of range
0E	AD CHANNEL-2 FAILED	fil B+ sense out of range

0F	AD CHANNEL-3 FAILED	video level out of range
10	MAIN.TXT	error while opening text file
11	FLUORO - XRAY	indicates software state
12	DO NOT ROTATE CAMERA	c-arm calibrated for C-lith operations
13	FLUORO - XOFF	indicates software state
14	FLUORO - DIAG	indicates software state
15	FLUORO BOOST	indicates software state
16	FLUOROX - FILM	indicates transition; fluoro to film
17	NO AEC FILE	error while opening AEC data file
18	MAS LIMITED	AEC exposure terminated by gen
19	FLUOROS - FILM	transition; standby to film
1A	FP DEAD	80188 on control panel inoperable
1B	BAD THERMISTOR	data from thermistor out of range
1C	SET TOMO SWEEP	set tomo sweep
1D	RESTART CART	monitor cart not running
1E	BOOST OVERTIME	boost terminated at 30 seconds
1F	HOUSING IS WARM	heat integrator warning
20	HOUSING IS HOT	heat integrator warning
21	ANODE IS WARM	heat integrator warning
22	ANODE IS HOT	heat integrator warning
23	ANODE OVERHEATED	heat integrator warning
24	HOUSING OVERHEATED	heat integrator warning
25	WILL OVERHEAT	film mode warning
26	TUBE IS HOT	not used
27	NO BOOST - HOT	boost not allowed due to heat
28	INSTANT ON - TO	instant on prearm has timed out
29	INSTANT ON - FP	prearm terminated from front panel
2A	SELECT FIELD	AEC chamber not selected
2B	NO MAPPING FILE	error opening mapping file
2C	ARM NOT READY	urotable arm not in x-ray position
2D	PRESS START	9000 c-arm only
2E	FILMX - FLUORO	transition; film to fluoro
2F	PLEASE WAIT	generator loading software
30	NOT USED	not used
31	BATTERY DISCONNECTED	batteries not connected
32	FILMS - FLUORO	transition; standby to fluoro
33	STANDBY MODE	gen not used for 30 minutes
34	STANDBY OVER	standby over
35	FILM - XOFF	indicates software state
36	XRAY COMPLETE	exposure has ended
37	RELEASED EARLY	film shot not complete
38	XRAY OVERTIME	film mAs integration error occurred
39	TABLE NOT READY	not ready to take x-rays
3A	COLLIMATOR HOLD	not ready to take x-rays

3B	NO OPTION FILE	no default parameters
3C	NO TOMOGRAPHY FILE	error opening tomography file
3D	HIGH FILM KV	calibration error has occurred
3E	LOW FILM KV	calibration error has occurred
3F	HIGH FLUORO MA	not used
40	MA ERROR	mA detected out of range
41	GENERATOR FAULT	not used
42	*FLIPPER STUCK	collimator flipper is stuck
43	MA ON IN ERROR	improper generator operation
44	REGULATOR FAIL	fil voltage out of range
45	KV ON IN ERROR	improper generator operation
46	*STATOR NOT ON	rotating target stator not running
47	*OVERLOAD FAULT	generator fault detected
48	*SATURATION FAULT	generator saturation fault detected
49	*FILAMENT FAULT	generator fault detected
4A	*INTERLOCKS BROKEN	interlock circuit was broken
4B	HV INVERTOR OFF	high voltage generator is on
4C	NO RANGE FILE	error opening cal range file
4D	*OVERVOLTAGE FAULT	generator overvoltage fault
4E	*NO SERVO TABLE	disk software failure
4F	*NO MUXRAM DATA	disk software failure
50	CHARGER FAILED	gen charger failed
51	USER END	user terminated application code
52	EXIT PROGRAM	exit program from terminal
53	NO CASSETTE	cassette not in place
54	LOADING STATUS	control panel entering status mode
55	NO SYSTEM FILE	disk software failure
56	NO MA LIMITS	disk software failure
57	HIGH FLUORO KV	not used
58	KV ERROR	kv detected out of range

5.3.2. Warning Messages During Operation

The following recommendations can be used to remedy the indicated conditions. If the messages persist, further trouble-shooting is required.

NO CASSETTE The film cassette holder is not in place. To use the system in film mode, this must be properly attached (applies only to 6-inch image intensifier systems).

BOOST OVERTIME The boost exposure has been terminated after 30 seconds even though the footswitch was still depressed.

FOOT RELEASED During a film exposure, the footswitch was released early, before the desired mAs (mA x time product) was reached.

5.3.3. Heat Warning Messages

Heat warning messages will appear on the control panel display to alert the operator when a potential X-Ray tube overheat condition will occur. Remedy this condition by allowing the X-Ray tube to cool. These messages alternate with the normal information displayed on the LED panel.

5.3.4. Fluoro Mode Warnings

HOUSING IS WARM Housing temperature is at approximately 75% of its rated heat capacity. You may continue with fluoroscopy, but discretion is advised.

HOUSING IS HOT The housing temperature is at 90% of its rated heat capacity. Continued use without cooling may damage the X-ray tube. You should wait for the tube to cool before making another exposure, but fluoroscopy is not prevented.

ANODE IS WARM Anode temperature is at approximately 75% of its rated heat capacity. You may continue with fluoroscopy, but discretion is advised.

ANODE IS HOT The anode temperature is at 90% of its rated heat capacity. Continued use without cooling may damage the X-ray tube. You should wait for the tube to cool before making another exposure, but fluoroscopy is not prevented.

NO BOOST - HOT The X-ray tube anode or housing is at 90% of its rated heat capacity. Continued use in fluoro boost, without cooling, may damage the tube. When NO BOOST - HOT is displayed, the BOOST ENABLE LED turns off. To re-enable BOOST and continue a fluoro boost procedure, regardless of the tube temperature, press BOOST ENABLE.

5.3.5. Film Mode Warnings

WILL OVERHEAT The tube anode or housing is at 90% of its rated heat capacity. Continued use in FILM mode, without allowing the tube to cool may damage the tube. You must wait for the tube to cool before the next FILM exposure is allowed, or select a sufficiently lower technique. The display will also present the message WAIT.

WAIT This message is displayed in the center of the FILM mode technique display when projected overheat would occur at this technique during the next exposure. The exposure is not allowed until the tube has cooled or a sufficiently lower technique is selected.

5.3.6. Low Battery Charge Messages

Under most circumstances the battery condition is never a problem. It is possible however, that during periods of heavy use some consideration must be made to allow adequate recharging time.

70 PCT CHARGE

When the batteries are reduced to 70 percent of their effective charge a warning message will appear on the control panel LED display.

The message **70 PCT CHARGE** will alternate with the displayed technique.

The first action to take if this message appears is to try to allow more time between X-ray exposures. Both FLUORO and FILM exposures are still allowed.

When the current procedure is done, leave the system plugged in with the interconnect cable in place. This will allow the batteries to recharge. The system does not need to be turned on. Normally only a few hours is required to fully recharge the batteries.

If the batteries are further discharged, without adequate time to recharge, the 70 percent number may drop lower.

50 PCT CHARGE

If the effective charge drops to 50 percent, the display will alternate the message **50 PCT CHARGE**. In FILM mode, the message **WAIT** will appear in the center of the technique display and FILM shots are not allowed until the battery charge recovers.

In FLUORO mode, exposures are still allowed. To allow the batteries to recharge leave the system plugged into the wall outlet for 24 hours, with the interconnect cable connected to the mainframe.

5.3.7. Error Messages During Operation

Error messages are displayed when a condition occurs which results in automatic system shutdown. When any of these messages listed below appear, the operator must call for service.

X-RAY JUMPER ON
The jumper used during calibration on the X-ray Regulator PCB has been left in place, disabling regulation. Results in automatic shutdown.

FOOTSWITCH STUCK
The footswitch, the X-RAY ON switch or the associated switch sensing electronics has a fault. Results in automatic shutdown.

PRECHARGE FAIL
The precharge cycle has failed which may indicate that the batteries are weak. Results in automatic shutdown.

X-RAY OVERTIME
The film shot has continued beyond the time required to achieve the correct mAs product.

KV ON IN ERROR
KV was sensed without an X-ray requested. This indicates a fault with the high voltage generator.

FLIPPER STUCK
The trimode flipper is stuck. Results in automatic shutdown.

MA ON IN ERROR
MA was sensed without an X-ray requested. This indicates a fault with the high voltage generator.

STATOR NOT ON
The stator is not running. Operation of the system without the stator rotating would be destructive to the tube. Results in automatic shutdown.

OVERLOAD FAULT
An overload fault probably indicates a fault in the high voltage regulator circuit. Results in automatic shutdown.

SATURATION FAULT
A saturation fault probably indicates a high voltage regulator fault. Results in automatic shutdown.

FILAMENT FAULT
There is a fault in the filament circuit. Results in automatic shutdown.

INTRLOCKS BROKEN
The interlock circuit has been broken. This could be due to a fault sensed by software or a direct hardware failure. Results in automatic shutdown.

OVERVOLTAGE FAULT
X-ray generator failure was detected. Results in automatic shutdown.

5.4. Control Panel Status Mode

Refer to Figure 5-1 for status mode hierarchy

The control panel status mode is used to set time and date, check battery condition and alter some default parameters. Several ABS tables along with the method of camera gain control (fixed, image controlled, or kVp controlled) can be selected in the status mode.

The status mode is useful for performing some service tests from the control panel and does not require connecting an external terminal.

5.4.1. To Enter the Status Mode

1. PRESS and HOLD the FILM button until the message "LOADING STATUS" appears on the control panel display.

2. The message STATUS V n.nn indicates that you have entered the status mode. Once in this mode, turn either the kVp or mA knobs to scroll through the status menus.

3. When the desired menu title appears on the LED display, select it by pressing any key on the control panel.

4. Scroll through the choices listed within this menu by turning either the kVp or mA knobs.

5. To read the information or value contained under a menu item, display the item name and press any control panel key.

6. To return to the level of the status menus, select EXIT THIS MENU and press any control panel key.

7. To exit from the status menu mode and return to normal operation, scroll the message EXIT TO SYSTEM onto the display and press any control panel key.

When returning to normal system operation the LED panel will display the message: LOADING SYSTEM.

5.4.1.1. DATE/TIME SET

SET TIME
SET DATE
EXIT THIS MENU

Select SET TIME, press any key. Select 12 or 24 hour format. The display format should be HH_MM_SS. To begin changes, turn kVp or mA knob to the desired value. Press any key to move to the next field. Changes can be made in the following order: HH, MM, SS. When all changes are complete, press any key.

Select SET DATE, press any key. The display format should be MM/DD/YY. To begin changes, turn kVp or mA knob to the desired value. Press any key to move to the next field. Changes can be made in the following order: YY, DD, MM. When all changes are complete, press any key.

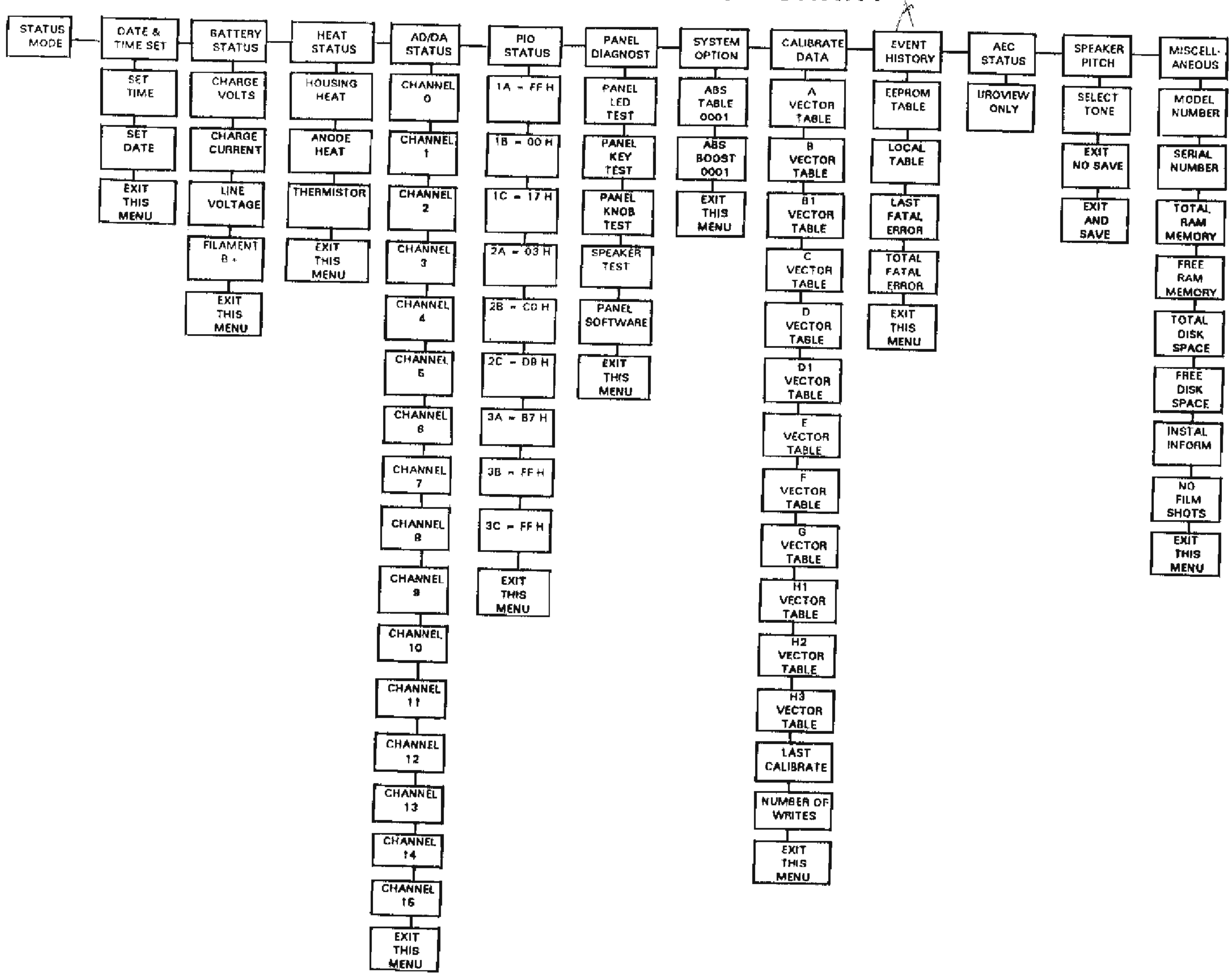
Select EXIT THIS MENU and press any key to exit.

5.4.2. Status Menus

The status menus and the items contained under each are listed below.

Figure 5-1 - Status Menu Tree

STATUS MODE FLOWCHART



5.4.2.1. Battery Status

Select the Battery Status Menu and press any key .The following selections are available:

CHARGE VOLTS
CHARGE CURRENT
LINE VOLTAGE
FILAMENT B+
EXIT THIS MENU

5.4.2.2. Heat Status

Select the Heat Status Menu and press any key. The following selection are available:

HOUSING HEAT
ANODE HEAT
THERMISTOR
EXIT THIS MENU

5.4.2.3. AD/DA Status

Use this menu to read the AD/DA channel designation and the voltage measured on each channel. After selecting this menu, scroll through the AD/DA channels listed below. To read the voltage measured on the channel, press any key. The display will change to show the channel number and the voltage. Press any key again to return to the channel list. You may also scroll through the number/voltage list, returning to the channel list at any time by pressing any key.

CHANNEL	SIGNAL
0	MEASURED KVP
1	MEASURED MA
2	FILAMENT B+
3	VIDEO LEVEL
4	HOUSING THER
5	DOSIMETER
6	CAMERA ROTATION
7	SPARE
8	TAP VOLTAGE
9	LINE VOLTAGE
10	CHARGE CURRENT
11	CHARGE VOLTS
12	FILAMENT CURRENT
13	SPARE
14	SPARE
15	SPARE

5.4.2.4. PIO Status

Read the status of a signal line, the IC name, and the PIO designation.

There are three PIOs on the Analog PCB, each with three ports: A ,B and C. Refer to the PIO table in the Theory of operation section of this manual for definitions of these PIO lines on the Analog PCB.

Select the PIO Status Menu, press any key and scroll through the PIO ports:

1A	1B	1C
2A	2B	2C
3A	3B	3C

The hexadecimal content of each port is indicated.

With any PIO port displayed, press any key. You may now scroll through the individual lines within each port to examine their state - high or low. The name of the signal line is given along with the port designation.

Press any key again to display the IC number and the actual IC pin number along with the line state - high or low. You may toggle back and forth between this mode and the mode above by pressing any key.

For example - PIO PORT:	HEX CONTENTS:
PIO 1B	FF H

Individual lines can be read by signal name:

B2 STATOR RUN = LO

Individual lines can also be read by pin number:

U38 PIN 20 = LO

5.4.2.5. Panel Diagnostics

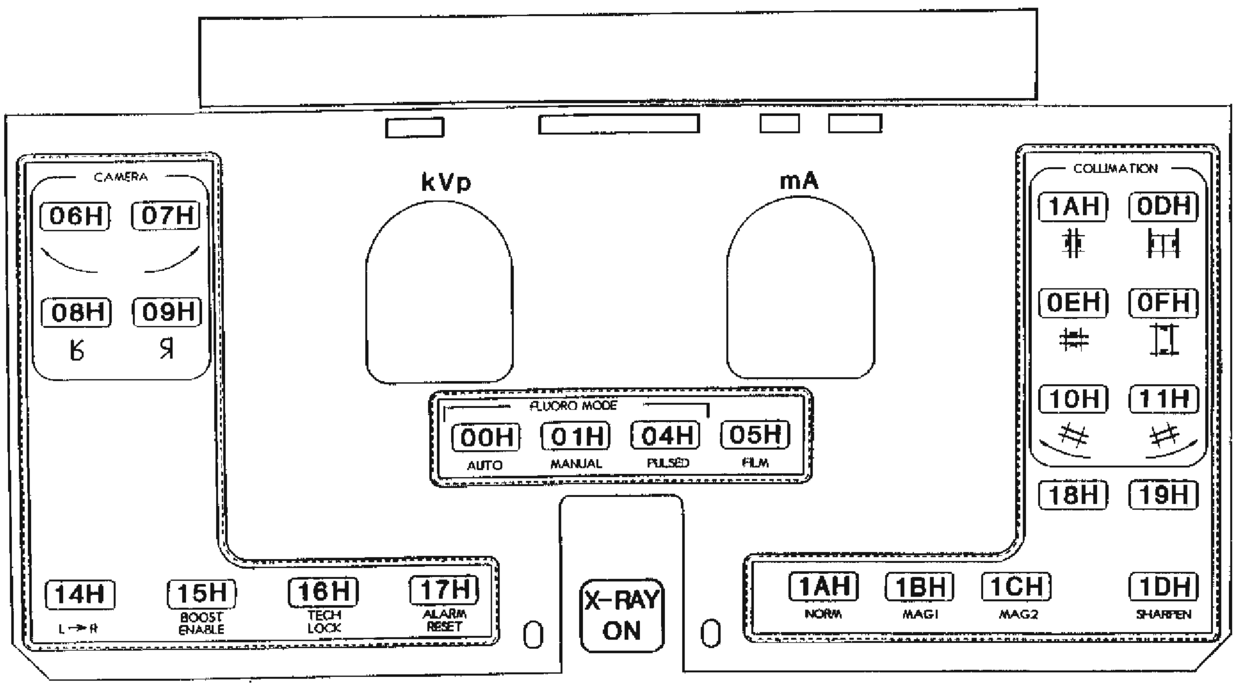
DISPLAY PANEL TEST
PANEL KEY TEST
PANEL KNB TEST
SPEAKER TEST
PANEL SOFTWARE
EXIT THIS MENU

Select DISPLAY PANEL TEST, press any key. The mainframe display panel should blink displaying a solid block of squares lighting every pixel. All display panel matrices on the mainframe control panel light except X-RAY ON. Press any key to exit.

Select PANEL KEY TEST, press any key. The mainframe display panel clears, displaying a message "PRESS KEYS". When pressing any key the associated value should be displayed. Press the key several times to verify that the return value is consistent. Refer to Figure 5-2 for hexadecimal key codes.

NOTE: *The Alarm Reset button displays two hexadecimal key code; 17H and 57H.*

Figure 5-2 - Key Test Codes



Select PANEL KNB TEST, press any key. The mainframe display panel clears and displays the message "TURN KNOBS". The rate at which the indicated values change is determined by how fast the knob is turned. Turning kVp knob clockwise will increment from STEP 01 to STEP 06. Turning the kVp knob counter clockwise will decrement from STEP 06 to STEP 01.

Select SPEAKER TEST, press any key. The mainframe display panel will clear and display the message "SPEAKER ON" and an audible tone will be heard.

Select PANEL SOFTWARE, press any key. The mainframe display panel clears, and displays the software version number and release date.

Select EXIT THIS MENU to exit.

5.4.2.6. System Options

ABS TABLE 0001
ABS BOOST 0001
EXIT THIS MENU

Select ABS TABLE 0001; this is the current ABS table used by the system.

Select ABS BOOST 0001; this is the current boost value used by the system.

Select EXIT THIS MENU to exit.

5.4.2.7. Calibrate Data

TABLE A
TABLE B
TABLE B1
TABLE C
TABLE D
TABLE D1
TABLE E
TABLE F
TABLE G
TABLE H1
TABLE H2
TABLE H3
TABLE K
TABLE L
LAST CALIBRATE
NUMBER OF WRITES
EXIT THIS MENU

Select a vector from the table. Press any key to display the selected vector value.

Select LAST CALIBRATE, press any key. The last calibration date with the technicians initials will be displayed on the mainframe display panel.

Select NUMBER OF WRITES, press any key. The mainframe display panel will clear and then display the number of writes.

Select EXIT THIS MENU and press any key to exit.

5.4.2.8. Event History

Events codes are reported in reverse order, with the most recent event first. The events are stored in the EEPROM TABLE and the LOCAL TABLE. The local table resides in RAM.

The format for event code reporting is:

E - NN = HHHH

Where:

NN = event count (1-128)
HHHH = identifies the event code.
(refer to Table 1)

Select EVENT HISTORY, press any key, and scroll through the items listed below.

EEPROM TABLE - E1 to E128 will be displayed. Select an error number and press any key to toggle the display to the event code

LOCAL TABLE (last 128, beginning with most recent stored in RAM).

LAST FATAL ERR - Displays the date and time of the last fatal error.

TOTAL FATAL ERR - Displays the total fatal error count.

Select Exit This Menu and press any key to exit.

5.4.2.9. AEC Status

Used only for UroView.

5.4.2.10. Speaker Pitch

SELECT TONE
EXIT NO SAVE
EXIT AND SAVE

Select SELECT TONE, and press any key. Use the kVp or mA knobs to vary the pitch value.

Select EXIT NO SAVE to exit without saving the selected tone value.

Select EXIT AND SAVE to exit and save the selected tone value.

5.4.2.11. Miscellaneous

Scroll through this menu of miscellaneous data and press any key to read the item.

MODEL NUMBER
SERIAL NUMBER
TOTAL RAM MEMORY
FREE RAM SPACE
TOTAL DISK SPACE
FREE DISK SPACE
INSTAL. INFORM.
NO FILM SHOTS
EXIT THIS MENU

5.5. INTERNAL LED INDICATORS

LEDs located on circuit boards in the mainframe electronics can be viewed after the covers are removed.

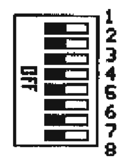
The Technique Processor LED digit - This LED echoes the system boot codes 0-8. In addition, the Miscellaneous Error Codes - E, F and D will be indicated on this digit if they occur.

The interlock-complete LED (Analog PCB) - Signals that the + 15 VDC CPU Interlock Circuit is complete and the 9400 is capable of producing X-rays. Refer to the diagram of this circuit in the Theory of Operation Section.

Battery Charger LEDs - The charger current and voltage are indicated on these bar segment LEDs located on the edge of the Battery Charger PCB.

5.6. STRAPPING

The following illustrations are used to represent switchblocks. The switch position is denoted by the black portion of the illustration.

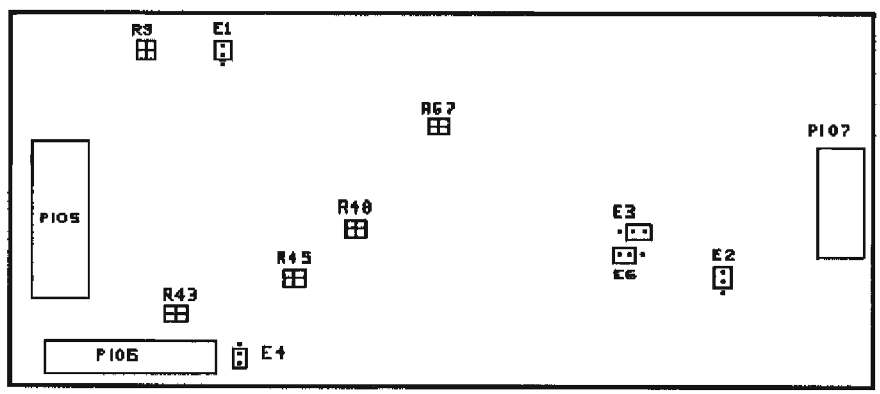


OFF = OPEN

ON = CLOSED

Potentiometers, variable capacitors, and jumpered pins are represented using the following:

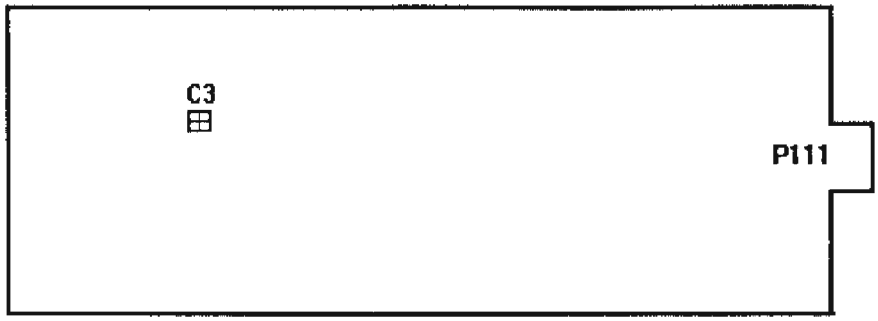
5.6.1. Video PCB



JUMPER	POSITION	FUNCTION
E1	1 - 2	Shading
E2	2 - 3	Auto Gain
E3	902	Composite Sync
E4	902	Composite Sync
E5	902	Composite Sync

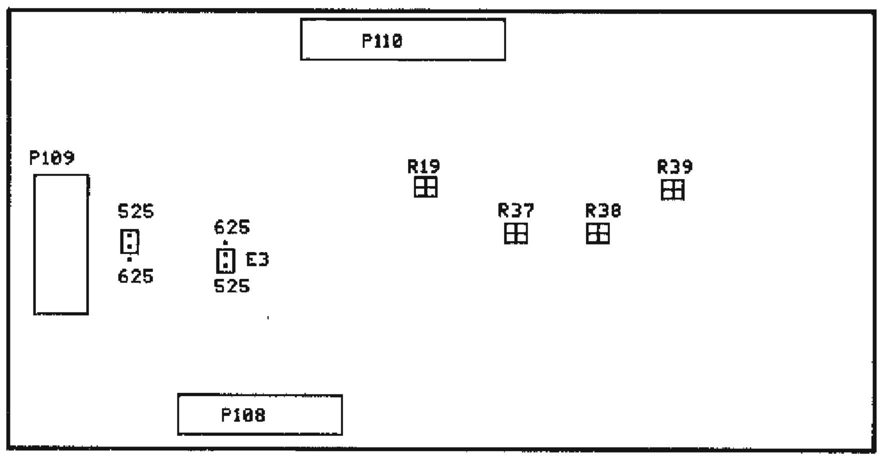
FUNCTION	ADJUSTMENT
Video Gain	R9
Dark Current Compensation	R48
Target Voltage	R43
Black Level	R44
Shading Level	R57

5.6.2. Preamp



FUNCTION	ADJUSTMENT
Peaking	C3

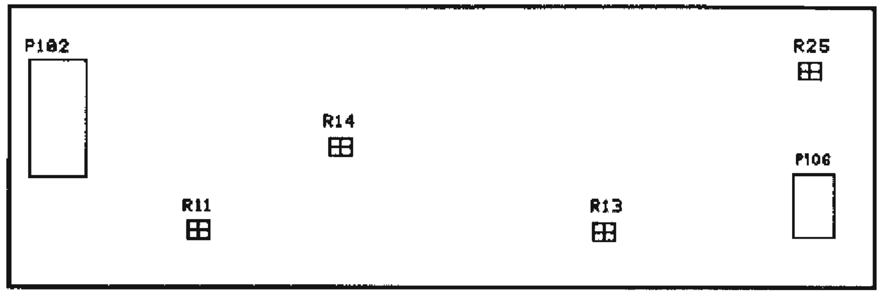
5.6.3. Deflection PCB



JUMPER	POSITION	FUNCTION
E3	1 - 2	525 (60 Hz)
E3	2 - 3	625 (50 Hz)

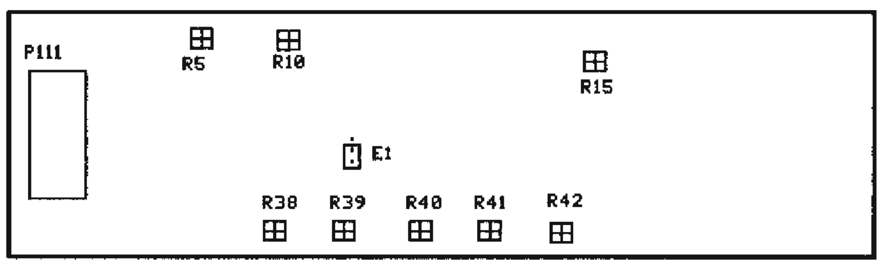
FUNCTION	ADJUSTMENT
H- Size	R40
H- Normal Centering	R39
H- Reverse Centering	R38
V- Size	R19
V-Centering Rev	R29
V- Centering Norm	R37

5.6.4. Power Supply PCB



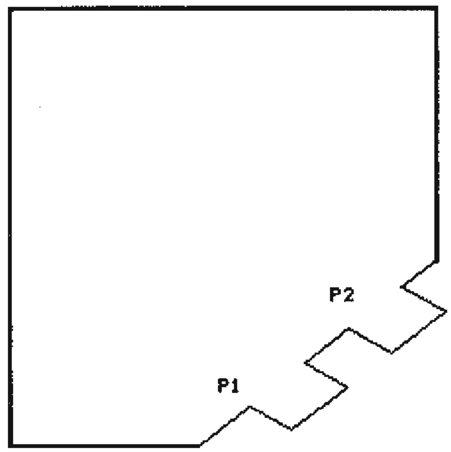
FUNCTION	ADJUSTMENT
Beam Discharge	R14
+500 VDC	R13
Focus	R11
H-drive Sync	R25 (14.5 kHz at TP14)

5.6.5. Shading/Window PCB



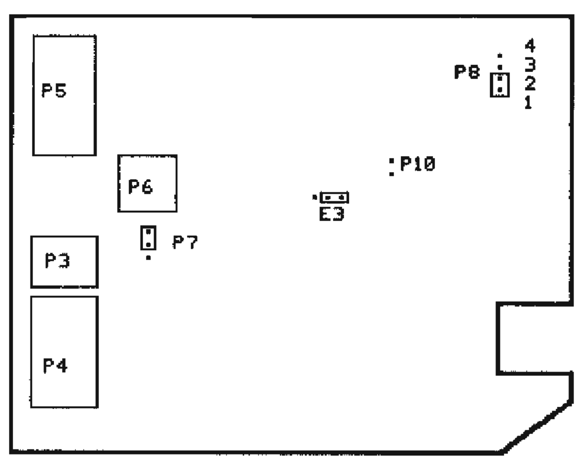
FUNCTION	ADJUSTMENT
H- Sawtooth #1	R40
H- Sawtooth #2	R41
H- Parabola	R42
H- Window Cal.	R38
V-Sawtooth #1	R10
V- Sawtooth #2	R5
V- Parabola	R15
V- Window Cal.	R39

5.6.6. Image Function PCB



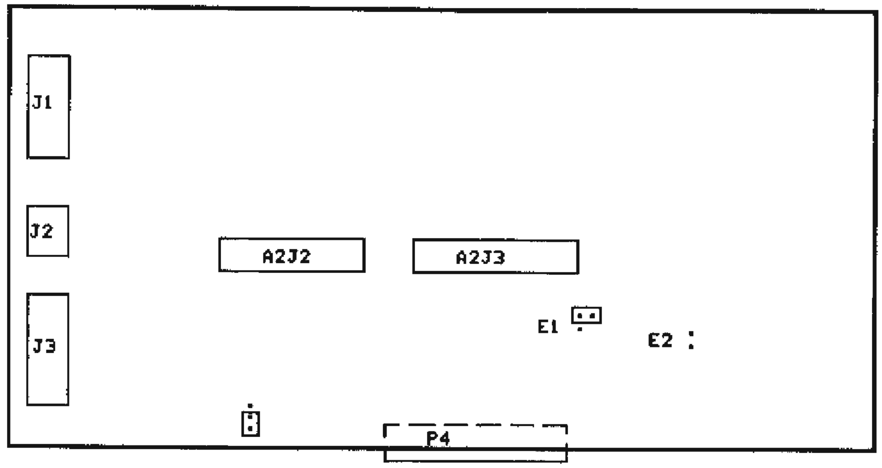
No adjustments or jumpers

5.6.7. Relay PCB



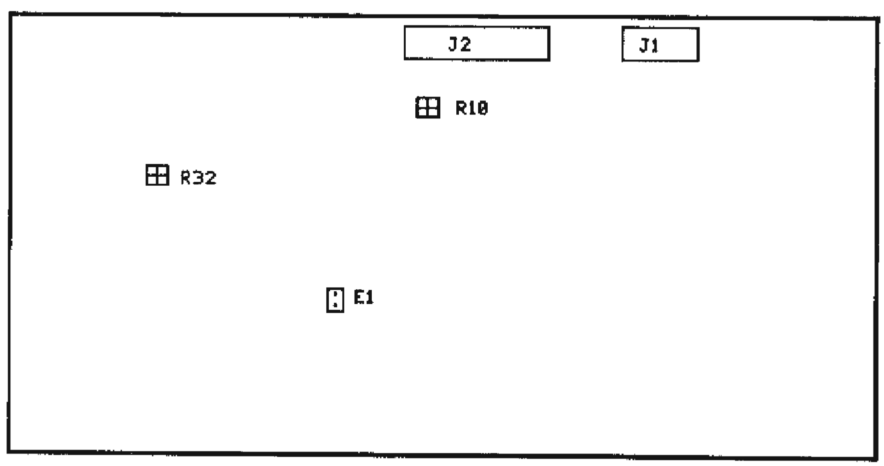
JUMPER	POSITION	FUNCTION
E3	2 - 3	
P7	2 - 3	
P8	1 - 2	Rotation Motor
P10	no jumper	

5.6.8. X-Ray Regulator PCB



JUMPER	POSITION	FUNCTION
E1 1 - 2	Closed	
E2	Open	
E3 2 - 3	Closed	

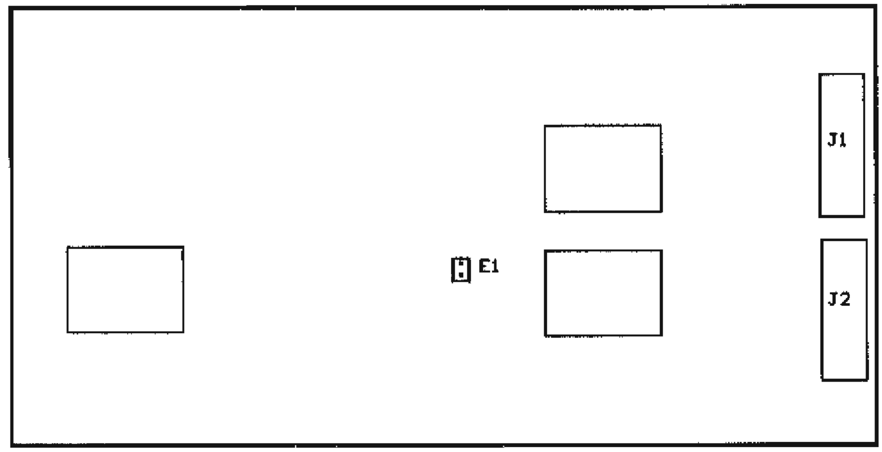
5.6.9. Battery Charger PCB



JUMPER	SHOULD BE	FUNCTION
E1	Closed	Ground Isolation

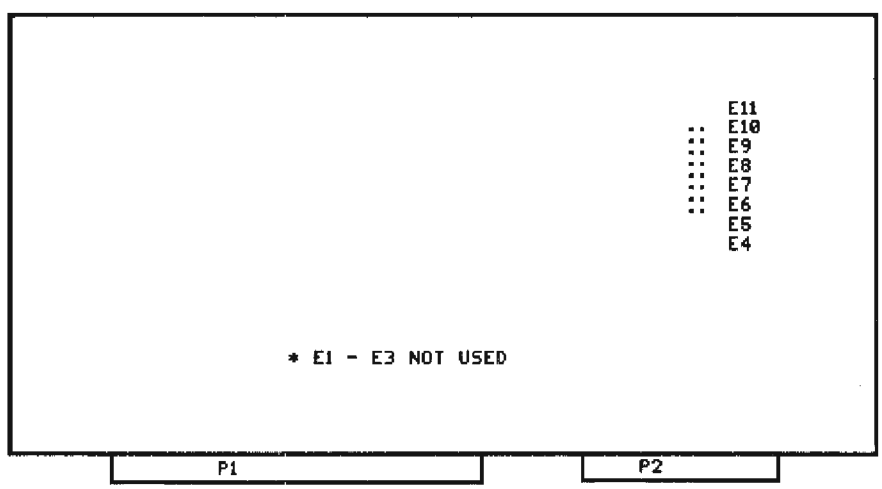
FUNCTION	ADJUSTMENT
Charger Output Adjust	R10
Volts Display Adjust	R32

5.6.10. Generator Driver PCB



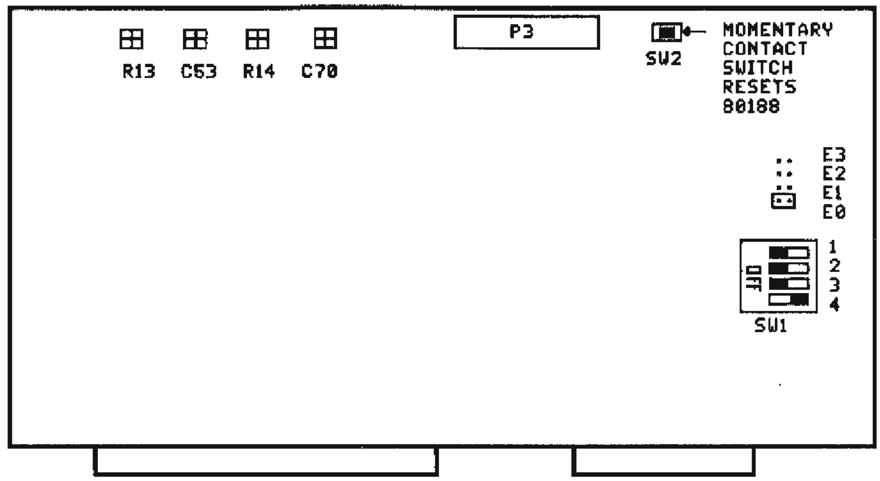
JUMPER	POSITION	FUNCTION
E1	Open	

5.6.11. Analog Support PCB



JUMPER	POSITION	FUNCTION
E1-E2-E3	Unused	
E4-E11	TBA	Board Rev

5.6.12. Technique Processor PCB



FUNCTION	ADJUSTMENT
	R14
	R13
	R70
Frequency Adjust	C53

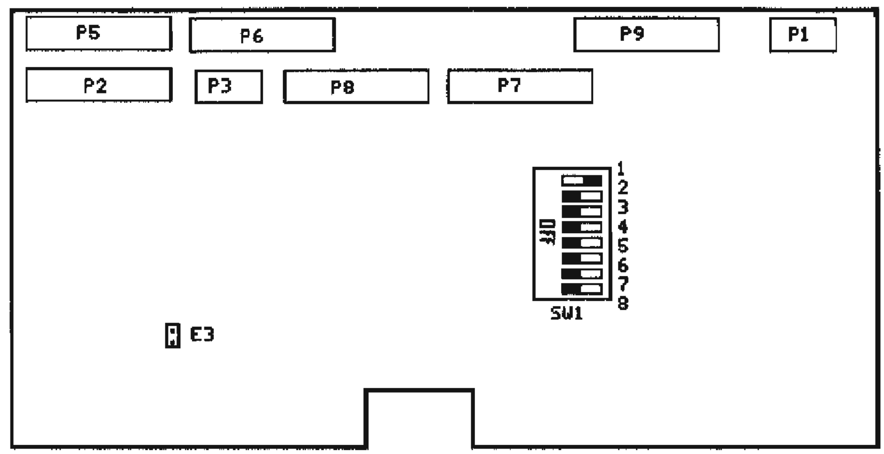
SWITCH	POSITION	FUNCTION
SW1-1		reserved
SW1-2		reserved
SW1-3	OFF	real time clock disable
SW1-4	ON	autoboot switch, if off
		mainframe will boot
		in monitor program
SW2	NORMALLY OPEN	resets 80188
E1-E4		Board Rev

5.6.12.1. Disk Drive Interface - Read/Write Pulses

Use this procedure to adjust the read/write data pulse widths on the Technique Processor PCB. Measure frequency and pulse widths at the test points indicated using an o-scope.

1. Connect a jumper between TP3 and GND.
2. Adjust C53 - FREQUENCY ADJUST, to obtain 250 kHz at TP10 [set scope on .5 us/div].
3. Adjust R14 to obtain a 250 ns pulse width at TP15 [set scope on 50 ns/div].
4. Adjust R13 to obtain a 500 ns pulse width at TP33 [100 ns/div].

5.6.13. Control Panel Processor PCB



JUMPER	POSITION	FUNCTION
E3	IN	Dual UART Oscillator Circuit

SW1-8	SW1-7	BAUD RATE
off	off	9600 baud (normal)
off	on	4800 baud
on	off	2400 baud
on	on	1200 baud

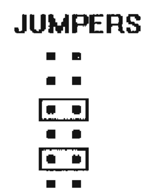
SW1-1	DIAGNOSTIC MODES
off	Selects old display
on	Selects new large fluorescent display (normal)

SW1-2 thru SW1-6 not used

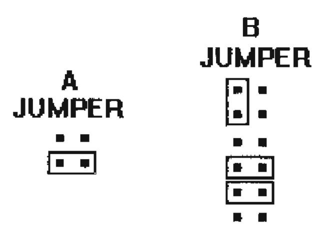
5.6.14. Toshiba 3.5" Floppy Disk ND-352TH-A

5.6.15. Toshiba 3.5" Floppy Disk ND-3521BR

5.6.16. Teac 3.5" Floppy Disk FD-235F-112-U



5.6.17 Mitsubishi 3.5" Floppy Disk MF353C-51VJ



5.7. EVALUATING BATTERY CONDITION

WARNING: This procedure produces high level X-rays. Take the appropriate precautions.

This procedure can be used to verify that a fully charged set of battery packs is performing adequately.

1. In FILM mode set the technique for about 75 kVp and 200 mAs.
2. Make an exposure and observe the battery charger voltage LED bargraph on the Battery Charger PCB.
3. If being measured by a meter, the values may indicate 160 or 170 volts during the exposure. If the voltage drops to 150 volts, there could be a problem with the batteries.

5.8. EVALUATING THE BATTERY CHARGER

The battery charger circuit on the Battery Charger PCB provides different charging currents at several voltages. A problem with this circuit exists if the following relationships are not observed:

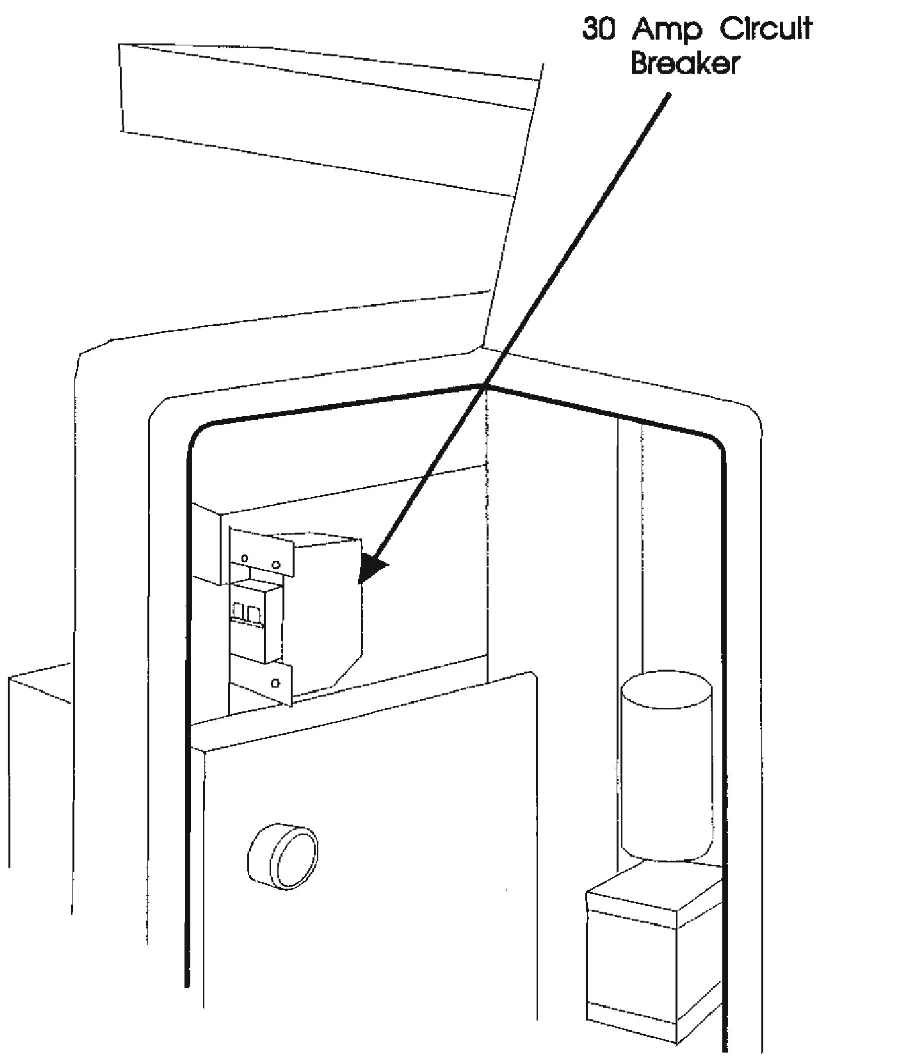
1. Between 20 mA and 600 mA the charger output should be approximately 210 VDC.
2. Above 625 mA the voltage output should rise to approximately 230 VDC.
3. Above 24 Amps charger current, the charger current limits and the charger voltage will decrease.
4. Overvoltage shutdown will occur above 240 VDC, indicated by a sudden drop in output voltage.

5.9. RESETTING THE BATTERY CIRCUIT BREAKER

Refer to Figure 5-3.

The 30 Amp battery circuit breaker will trip in the event of a major overload in the battery circuit. Determine the cause before resetting.

Figure 5-3 - Battery Circuit Breaker



5.10. MAINFRAME MECHANICAL ADJUSTMENTS

5.10.1. Loosening a Stuck Lift Shaft

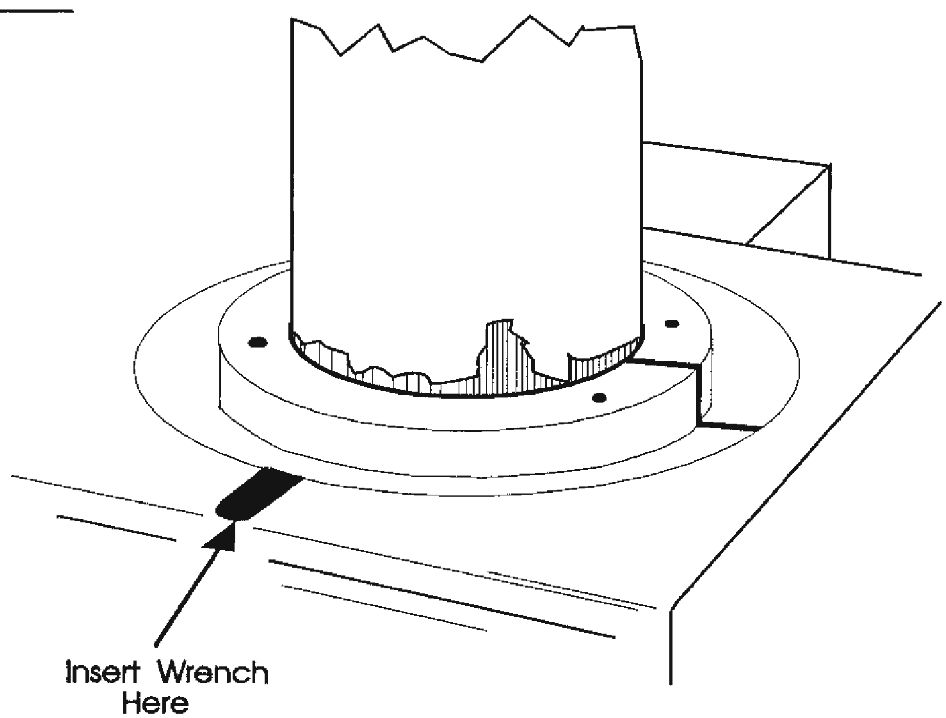
If either of the limit switches on the lift column are misadjusted, the column may not move in one direction of travel.

1. Directly above the top of the shaft, there is an access hole where a hex wrench can be inserted.

2. Insert the wrench into the hole and into the hex head at the top of the shaft. Turn the shaft in the opposite direction of the bind.

Figure 5-4 - Stuck Lift Shaft

The lift shaft can be turned with a hex wrench inserted through this hole.



5.10.2. Adjusting the Cradle Bearings

To access the cradle bearings supporting the C-arm, remove the bearing block cover plates which are each secured by three screws.

1. Loosen the set screws which lock the eccentric screws through the bearings.

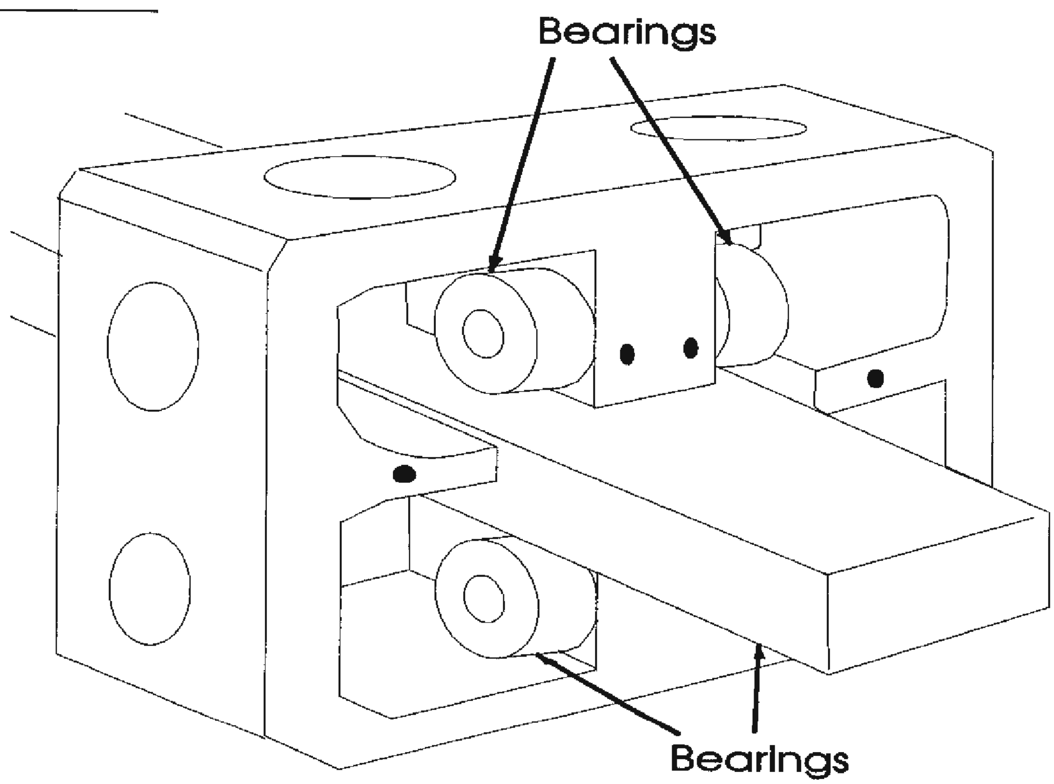
2. With a large standard blade screwdriver rotate each bearing to minimize sloppy, loose or irregular movement of the C-arm within the cradle. Do not adjust these to cause overtight bearing contact.

3. Verify that all of the bearings make contact through the full range of movement.

4. Tighten the set screws.

Figure 5-5 - Adjusting Cradle Bearings

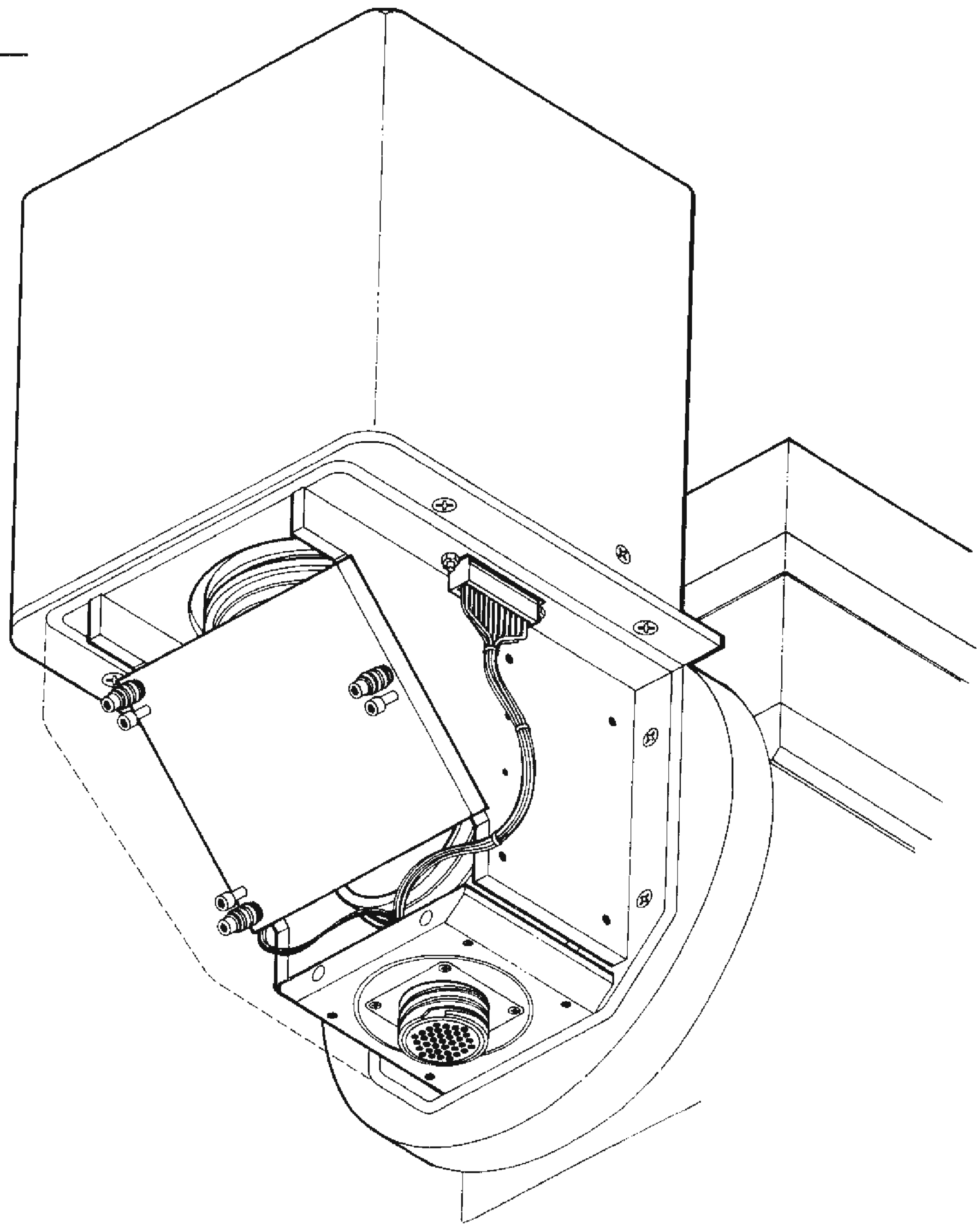
The cradle bearings can be exposed in the bearing blocks.



5.10.3. Right Angle Optics

A first-surface mirror forms a right-angle light path between the image tube and camera optics. Three screw adjustments on the mirror mounting plate align the mirror.

Figure 5-6 - Mirror Mounting Plate Adjustment Points



SECTION 6
CALIBRATION

SECTION 6
CALIBRATION (CONTINUED)

SECTION 6
CALIBRATION (CONTINUED)

SECTION 6 CALIBRATION

6.1. INTRODUCTION

This section contains procedures used to test and calibrate the OEC-Diasonics Series 9400 mainframe.

WARNING: **The procedures in this section should be performed by service engineers specifically trained to calibrate the 9400 mainframe.**

6.1.1. Overview

These procedures begin at the basic electrical and mechanical level and progress through system calibration and imaging chain tests and alignment.

Before You Begin

These procedures assume that all parts are installed and are wired correctly. It is also assumed that all subassemblies are either known to be operational or were previously tested at the factory.

If any component or circuit board is not operational, it must be repaired before proceeding with the calibration.

Further settings and adjustments are described in the mainframe and monitor cart service sections. If there is any question about whether circuit boards are operational or properly adjusted, turn to the service section before beginning the calibration.

Test Specs

Test specifications used during calibration take into account measurement limitations of the test equipment. When calibrated using these practical values, the system will meet its performance specifications.

Tools and Test Equipment

Tools and test equipment which are required, along with their special instructions, are described in the Appendix. References and special reporting forms required are listed in the Introduction of this manual.

Calibration Worksheet

A Calibration Worksheet is included at the end of this section. This worksheet must be filled out during the calibration. Make a photocopy of the worksheet and complete the steps during the calibration.

6.2. SAFETY PRECAUTIONS

WARNING: Read and understand the following precautions before you begin:

Serious injury and property damage can result from incorrectly performed service procedures. Observe all operating and safety procedures in this section and the Safety Section of this manual.

This system is capable of generating lethal voltages and injurious levels of radiation. Care must be taken when testing the system to observe safe electrical testing procedures and to observe safe practices concerning radiation protection.

Exposures must never be made with the high voltage cables removed from the high voltage transformer, Dynalyzer, or X-ray tube. Never remove a high voltage cable connector with the power on the system. Ground the pins of the connector to the chassis immediately after removing a connector from its connection in order to discharge the cable capacitance.

WARNING: The high voltage cables can retain a lethal charge after X-ray exposures have been taken, even if the system has been powered down. High voltages can arc several inches from their terminals if the cables are removed from the connector wells. Use caution when disconnecting high voltage cables even when the power is turned off.

If these connections are removed, immediately discharge their contacts against the high voltage tank case (ground). Discharge them independently and then touch them simultaneously against the tank case.

The C-arm is never to be energized in an area which is not approved for X-ray procedures. Failure to observe C-arm safety procedures may result in a serious radiation hazard to personnel in the immediate area.

Radiation monitors must be worn at all times during testing. Lead aprons and appropriate radiation shields must be utilized by personnel performing testing. At no time is living human anatomy to be used as a phantom or demonstration aid. Only designated personnel are to enter the test area during testing.

CAUTION: Many of the PCB's in this system contain components which are sensitive to Electro-Static Discharge (ESD). To prevent component damage, follow all ESD protection procedures outlined in the SAFETY section.

6.3. PREPARATION AND SETUP

6.3.1. Record the Test Equipment Used

Record the information requested on the Worksheet.

6.3.2. Preparation and Inspection

1. To prevent the mainframe from rolling, position the front and rear wheels at right angles to each other .
2. Turn the key switch to OFF.
3. Unplug the system power cord from the wall outlet.
4. Inspect the interconnect cable; verify that the cable, mainframe connector and pins have not been damaged in any way.
5. Inspect the AC power cable; inspect the high voltage cable assembly for any damage during shipping. Look for any signs of damage or abrasion to the cable jackets. Inspect the plugs for loose pins.
6. Verify that the skin spacer is attached to the collimator assembly.
7. Check the drag chains on the mainframe and the monitor cart for proper pressure and freedom of movement.

6.4. ELECTRICAL TESTS

6.4.1. Leakage Current Testing

The tests in this section are designed to measure the compliance of the system with hospital current leakage limitations. The procedure used depends on the leakage measurement device employed at the hospital.

The objective of the current leakage test is to establish that the X-ray system does not have fault currents in excess of the maximums listed below.. Leakage currents exceeding these maximums are unsafe in equipment of this type.

Voltage	Maximum leakage current
120 VAC	100 uA
220 VAC	500 uA

1. Unplug the system power cord from the wall outlet.

2. Complete the leakage current measurements complying with the instructions provided by the test device.

3. If leakage currents exceed the maximums specified the system under test has failed this test section. Document the fault and corrective action taken on the worksheet.

6.4.2. Ground Continuity

1. Disconnect the system power cord and connect the interconnect cable to the mainframe.

2. Check the continuity of the system ground between the mainframe chassis and the system power plugs ground pin. Resistance shall be less than 0.5 ohms.

3. Check the continuity of the system ground between the monitor cart chassis and the system power plugs ground pin. Resistance shall be less than 0.5 ohms.

6.4.3. Line Voltage Regulation

WARNING: This procedure produces high energy X-rays. Take the appropriate precautions. Because of the high radiation output produced, personnel should not be present in the room during the following test.

1. Measure the line voltage on the input of the isolation transformer.

2. Measure the line voltage on the input of the transformer again while making a maximum radiographic exposure (500 mAs @ 100 kVp).

3. Calculate the percentage line voltage regulation using the following formula and record the results on the worksheet:

$$100\,(V_n - V_1)/\,(V_1)$$

where: V_n = No load voltage
V_1 = Max load voltage

4. If the results above do not fall within the range of 0 to 15 percent, the hospital should be informed that an in-house wiring problem exists and should be corrected as soon as possible. (This problem results in a violation of a provision of the Federal Performance Standards 21CFR 1030-32.)

5. Perform a maximum radiographic exposure and measure the voltage on the isolation transformer secondary. (Under no

conditions should the loaded voltage fall below 100 VAC measured on the isolation transformer secondary.)

6.4.4. Mainframe Power Supplies

1. Turn on the mainframe key switch.

2. Measure these voltages on the power panel fuse strip:

F7	+24 VDC	yellow wire
F6	+5 VDC	red wire
F5	+15 VDC	grey wire
F4	- 15 VDC	violet wire
F3*	115 VAC	black wire
F2*	115 VAC	red wire
F18	115VACBlack wire	

WARNING: * F2 and F3 carry line voltage whenever the power cord is plugged in.

6.5. MECHANICAL CHECKS

In the steps below, check for ease of movement without excessive play.

1. Check the foot lever and steering handle movement. Set the wheels at right angles to each other to stop C-arm movement.

2. Check Wig Wag - horizontal swing of the C-arm.

3. Check back and forth movement of the extension arm.

4. Check flip-flop repositioning of the C-arm and integrity of the C-arm pivot point. Check the pivot brake and lock.

5. Check radial movement of the C-arm on the cradle bearings. The C-arm should slide smoothly without binding. Check for proper holding action of the brakes.

6. With power applied to the mainframe, raise and lower the L-arm. The switch is located on either side of the extension arm assembly. Verify smooth switch action. Verify that the lift motor stops at the extreme top and bottom of its range when the switch is held on. Verify that the L-arm stops moving down when the switch is released with 1/4-inch or less drift.

7. With power applied to the mainframe, rotate the L-arm 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

6.6. FUNCTIONAL CHECKS

6.6.1. Self-tests

1. Power up the system as usual - follow the Basic Setup procedure given in the Operator's Manual.

2. The system performs various self-tests during power up. If any of these tests fail they will be indicated by error codes or messages on the mainframe control panel or the monitor cart screen. Refer to the service sections of this manual for code definitions.

6.6.2. FAST STOP and Processor Reset Test

1. With the system powered up, press the left FAST STOP switch and verify that the mainframe front panel display reads "INTERLKS BROKEN", and that the motors and X-rays are disabled.

2. Press any key on the control panel, to resume operation.

3. Repeat step 1 using the right FAST STOP switch.

6.6.3. Status Mode Tests

Refer to the Service Section for instructions on using the Status Mode.

1. Enter the Status Mode on the mainframe control panel.

2. Scroll to the CONTROL PANEL DIAGNOSTICS.

3. Run the DISPLAY PANEL TEST, PANEL KEY TEST, and PANEL KNOB TEST.

4. Exit this menu and enter the menu heading - EXAMINE CALIBRATION PARAMETERS.

5. Read the date and initials entered at the last calibration.

6. Enter the MISCELLANEOUS menu.

7. Verify that the total RAM is 262144 and the total disk space is 730112. (Actual numbers may vary depending upon software version).

6.6.4. Film Cassette Test (6-inch systems only)

This test verifies that the radiographic mode will not operate unless the film cassette (beam limiting device) is in place. This test applies to 6-inch systems only.

1. Rotate the C-arm to place the image intensifier above the X-ray tube.

2. Set the system in FILM mode and enter a low technique (50 kVp, 5 mAs).

3. Attach a film cassette to the image intensifier assembly.

4. Rotate the cassette in place and verify that the *NO CASSETTE* message does not appear.

5. Remove the cassette and verify that the *NO CASSETTE* message does appear.

6. Rotate the C-arm to return the image intensifier below the X-ray tube.

6.6.5. Verify Operation of Mainframe Controls

WARNING: **These tests produce X-rays. Take appropriate precautions.**

1. Verify that the anode is rotating by listening for the "whirring" sound of the anode motor. Do not operate the system if anode rotation cannot be heard.

2. Press all control panel switches in turn. Verify responses for each (may be a front panel display or beep response), indicating that the microprocessor is responding to the input.

3. Select FILM mode and enter a low power technique.

4. Verify that the X-RAY ON lamps on the X-ray tube assembly, and control panel, light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

5. Verify operation of the footswitch.

6. Verify that early footswitch release will terminate the FILM exposure. The message *RELEASED EARLY* should appear on the control panel display.

6.6.6. Field Solenoid Position Test

This test verifies that the system can sense the position of both the 4" and 6" flippers (MAG1 and MAG2 respectively).

NOTE: This test is for 9" systems only.

1. Remove the aluminum filter plate on the collimator.
2. Place the system in FLUORO mode and select the MAG1 field. Verify that the 6" flipper moves to the center of the collimator.
3. Select the MAG2 FIELD. Verify that the 4" flipper moves to the center of the collimator.
4. Select the NORMAL field. Verify that both the 4" and 6" flippers move out of the center of the collimator.
5. Place the system in the FILM mode and select the NORMAL field.
   - Verify that neither the 4" or 6" flipper is in the center of the collimator..
6. Reach into the collimator and hold the flippers in the NORMAL position. While holding the flipper in this position, select MAG1 from the front panel. The control panel should display the message FLIPPER STUCK.
7. Select the NORMAL field position.
8. Reach into the collimator and hold the flippers in the NORMAL position. While holding the flipper in this position, select MAG2 from the front panel. The control panel should display the message FLIPPER STUCK.
9. Replace the filtration plate on the collimator.

6.6.7. MANUAL FLUORO

1. Select MANUAL FLUORO mode.
2. Verify that kVp and mA can be controlled using the control panel knobs.

6.6.8. AUTO FLUORO Tests

WARNING: This procedure produces X-rays. Take the appropriate precautions.

1. Select AUTO FLUORO mode.

2. Verify that live video appears on the left monitor and that the TV monitors do not lose video sync.

3. Make a fluoro exposure and transfer the image to the right-hand monitor.

4. Make another exposure. The image will appear on the left monitor.

5. Verify that an image can be transferred from the left to the right monitor by the use of the L->R function key from both the mainframe and monitor cart panels.

7. Check for proper operation of the following mainframe controls:

   a. Horizontal sweep reversal
   b. Vertical sweep reversal
   b. SHARPEN (if provided)

8. Verify operation of the motorized collimator and camera controls using the control panel switches.

The motorized collimator allows collimator rotation and opening/closure of two sets of leaves to be controlled from the front panel. Collimator rotation is continuous in both directions, clockwise and counter-clockwise.

Rotation time is approximately 30 seconds for 360 degrees. The time for complete opening or closure of the leaves is about 5 seconds. Note that this rotation is not continuous; it times out at 540 degrees.

9. Verify operation of the left monitor's remote contrast and brightness controls on the mainframe control panel. (Set the left contrast control to REMOTE).

6.6.9. Fluoro Boost Option

WARNING: **This procedure produces X-rays. Take the appropriate precautions.**

1. Enable BOOST on the control panel (if provided) by pressing the boost key for five seconds. Then make an exposure by pressing the right footswitch down to the second position.

2. Verify that the audible alarm beeps at twice the normal rate.

3. Verify that BOOST works in both AUTO, and MANUAL X-ray modes.

4. Observe that the image doesn't "burn out" or appear too dark.

6.6.10. Pulsed Fluoro Operation

1. Enter the PULSED FLUORO mode. Press X-ray On and verify pulsed operation when the button is pressed.

2. Enable BOOST on the control panel (if provided) by pressing the boost key for five seconds. Then make an exposure by pressing the right footswitch down to the second position.

3. Verify that the audible alarm beeps at twice the normal rate.

6.6.11. Verify Fluoro Timer and Timer Reset

1. In fluoro mode the accumulated exposure time is displayed in the center of the display panel. After five minutes of accumulated fluoro X-rays the timer alarm will sound.

2. Press ALARM RESET to reset the alarm. The alarm will stop but the accumulated exposure display will not reset.

3. Press and hold the ALARM RESET for five seconds. The accumulated timer display will reset to 0.

6.7. X-RAY CALIBRATION

6.7.1. Theory of Calibration

Measurements are made during calibration and are automatically recorded by the software. Equations are then derived in software which pre-distort the generator control parameters to cause correct exposures during subsequent use.

The coefficients of the calibration equations are called vectors:

A-vector = Relates measured kV and mA to the kV control voltage.

B-vector = Relates measured kV and mA to the mA control voltage.

C-vector = Relates the internal sensors to the measured kV.

D-vector = Relates the internal sensors to the measured mA.

E-vector = Relates internal secondary sensors to measured kV.

F-vector = Relates dose and camera gain to VLI.

G-vector = Relates measured kV and mA to dose rate.

H-vector = Relates filament voltage and current to filament duty cycle.

The filament and high voltage supplies are calibrated in two stages: Filament Duty Cycle Calibration and Technique Calibration. These will be followed by an accuracy verification procedure.

Overview: Filament Duty Cycle Calibration

1. The mA servo jumper, E1 is installed on the X-ray Regulator PCB, disabling mA servo.
2. A series of exposures are taken at 10 kVp intervals between 40 kVp and 120 kVp at duty cycle values that yield mA from 0 mA to 100 mA.
3. Data is written to a disk file for later analysis.
4. The H-Vector is calculated from the data.
5. The coefficients are written to the EEPROM for use by the main system software.

NOTE: This aspect of calibration is independent of mA/kVp calibration and only characterizes the X-ray tube.

mA/kVp Technique Calibration

1. mA servos are enabled (mA jumper E1 is removed from the X-ray Regulator PCB).
2. A sequence of exposures is taken at 20 kVp intervals from 40 kVp to 120 kVp at mA values from 1.0 mA to 100 mA for both filaments.
3. Data obtained from the system and from the Dynalyzer are written to a disk file for later analysis.
4. The software performs a least squares analysis and calculates the A-Vector, B-Vector, C-Vector, D-Vector and E-Vector.
5. The vectors are written to the EEPROM for use by the main system software. At this point the system is calibrated for mA, mAs and kVp.

Verification

Finally the resulting calibration is verified by a series of independent exposures.

6.7.2. Calibration Equipment Connections

Refer to Figures 6-1 and 6-2.

1. Open all system circuit breakers, including the battery charger circuit breaker and then remove the outer covers from the X-ray Generator Assembly.

2. Connect the Dynalyzer Tank, Digital Display Unit (DRO), AutoCal Interface Unit, and DVM to the Generator electronics as shown in Figure 6-1.

6.7.2.1. Dynalyzer III

The autocal interface box is connected to the printer port on the back of the Model III digital display using a 15-pin D-type connector (cable part number 00-871434).

NOTE: The power cord ground pin must be isolated from electrical ground.

6.7.2.2. Dynalyzer II

NOTE: It is recommended that the Dynalyzer III be used in place of the Dynalyzer II whenever possible due to the ease of use.

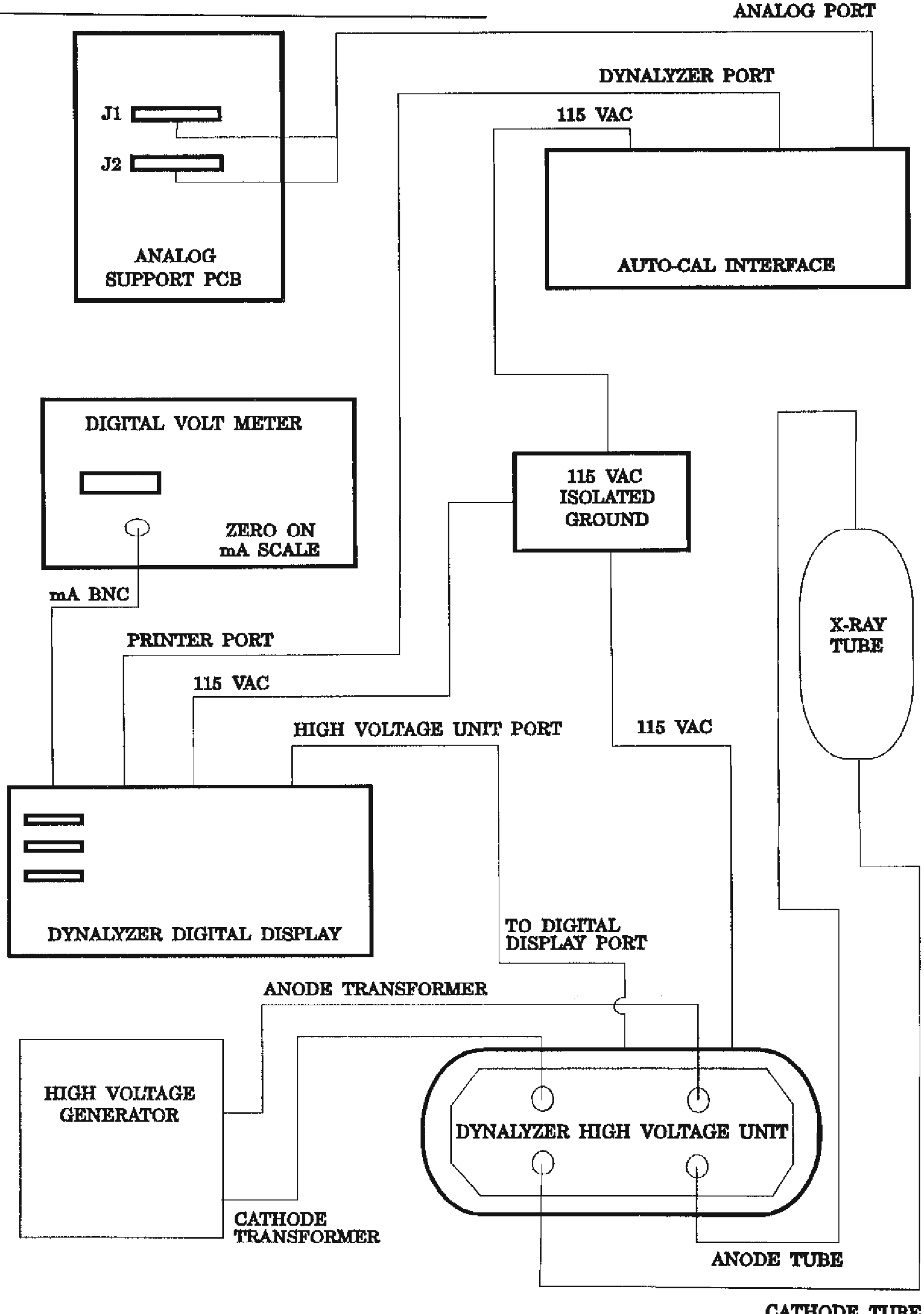
The autocal interface box is connected to the printer port on the back of the Model II digital display using a 15-pin circular Mil-type connector (cable part number 00-871433).

NOTE: The power cord ground pin must be isolated from electrical ground.

6.7.2.3. Autocal Interface

Connect the autocal interface box to connectors J1 and J2 on the Analog Support PCB (cable part number 00-871432).

Figure 6-1 - Calibration Equipment Connection Diagram



6.7.3. Setup

NOTE: Refer also to the general instructions for Dynalyzer use in the Appendix.

6.7.3.1. General Setup

1. Jumper across E1 on the X-ray Regulator PCB with a shorting plug to disable mA servo.

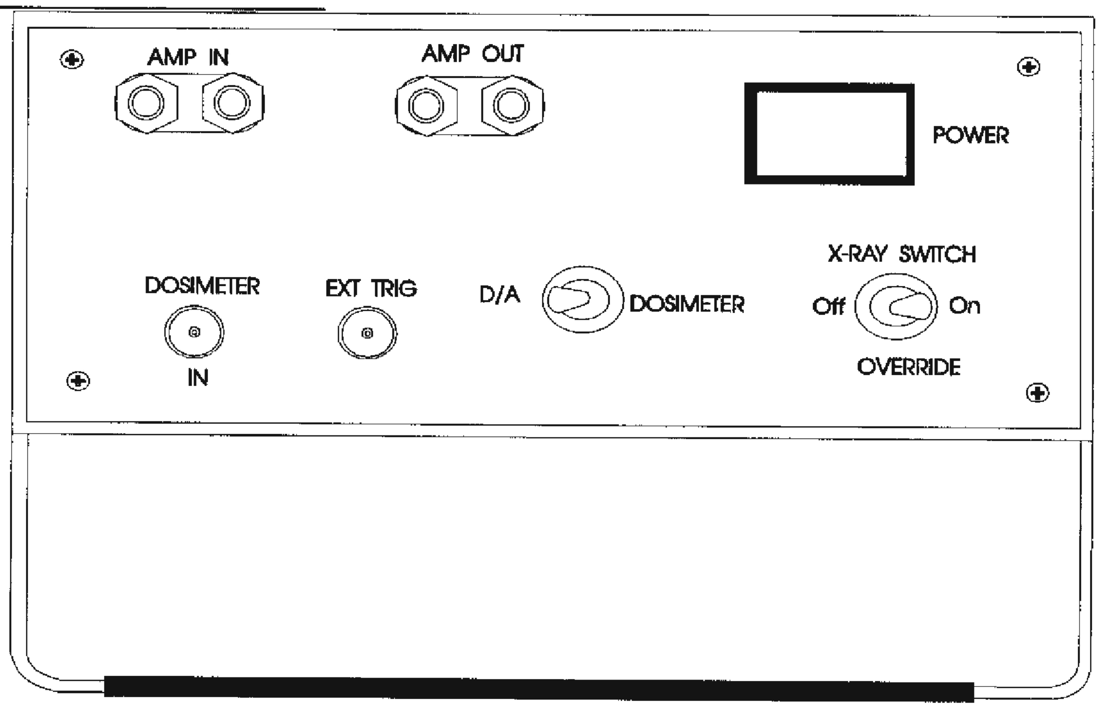
2. Turn on the power to all calibration equipment.

6.7.3.2. Autocal Interface Box

Refer to Figure 6-2 Turn X-ray Switch Override **ON**.

Figure 6-2 - The AutoCal Box

Refer to the text for proper switch settings.



6.7.3.3. Dynalyzer III High Voltage Unit

Refer to Figure 6-3. The calibration software will indicate on the terminal screen which mA switch setting (RADIOGRAPHIC/FLUORO) must be used during different stages of the calibration.

Set the mA switch accordingly, changing the setting when requested.

Figure 6-3 - The Dynalyzer III High Voltage Unit. *Set the FLUORO/RAD switch as described in the text.*

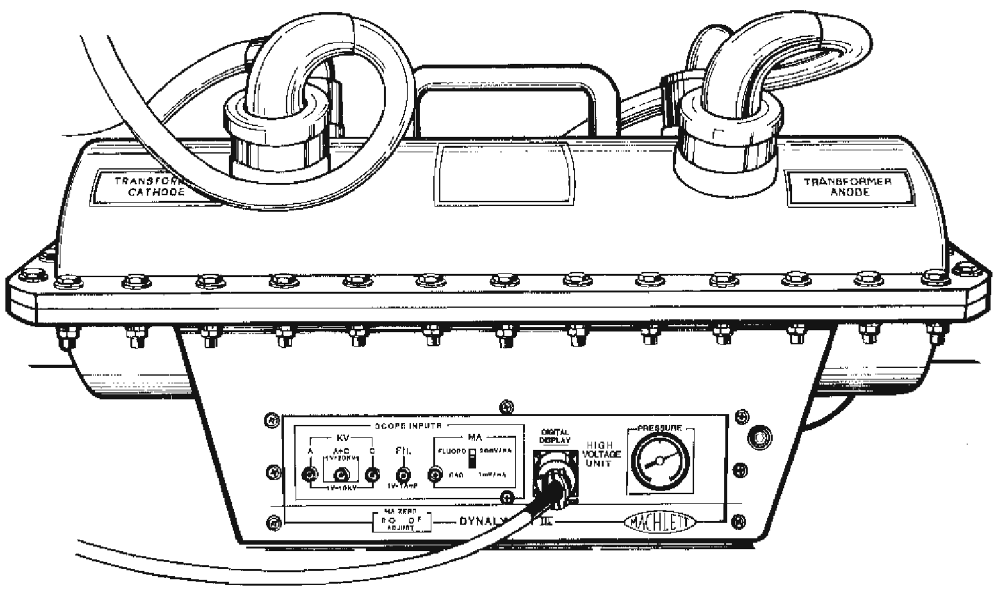
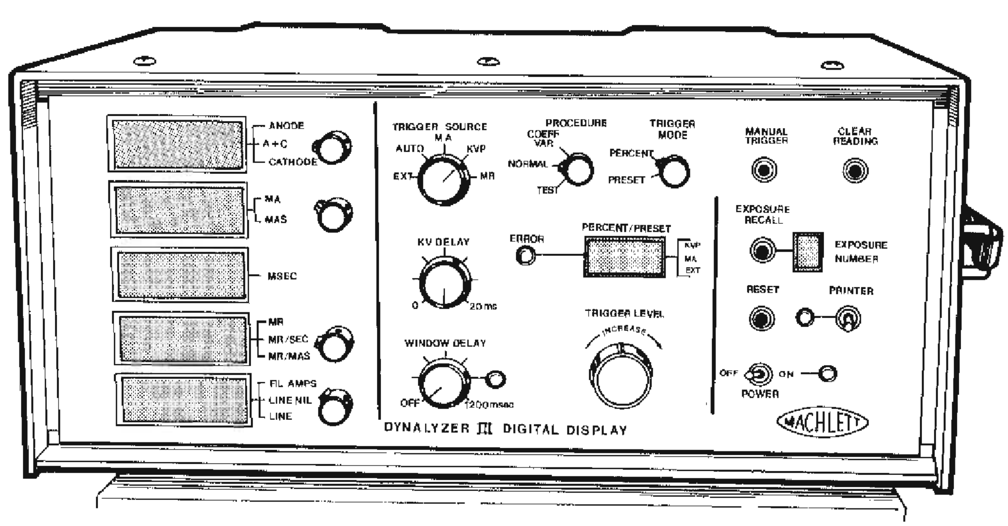


Figure 6-4 - Dynalyzer III Digital Display. *Set the controls as described in the text.*



6.7.3.4. Dynalyzer III DRO (Digital Display Unit)

Refer to Figure 6-4. Set the controls as follows:

Displays:	A+C,	mA
Trigger Source:		kVp
Procedure		NORMAL
Trigger Mode:		PRESET
kV Delay:		20 ms
Window Delay:		OFF
Trigger Level:		30
Printer		AUTO

6.7.3.5. Dynalyzer II High Voltage Unit

No special settings are required.

6.7.3.6. Dynalyzer II DRO (Digital Display Unit)

Refer to Figure 6-5. The Dynalyzer II DRO must be modified to conform to Altered Item Drawing 00-871587.

Set the controls as follows:

mA/mAs:	mA		
Trigger:	kV	Level:	50
kV peak:	A+C		
Delay:	20 ms		
Delay Switch:	ON (see back of DRO)		

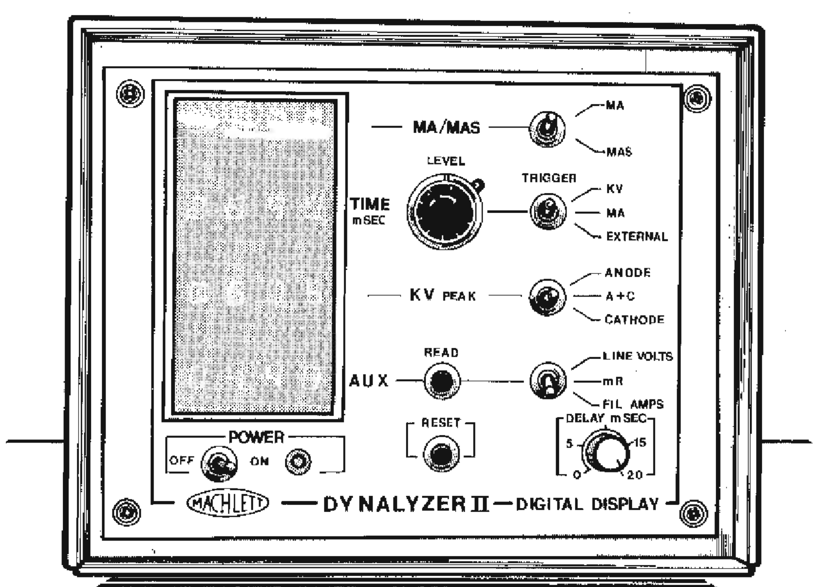


Figure 6-5 - Dynalyzer II Digital Display

Refer to the text for the proper switch settings.

6.7.4. Getting Started

1. Press F10 function key on the monitor cart. The *SETUP OPTIONS* screen will appear.

2. Select *ACCESS LEVEL 2* and press RETURN key.

3. Enter Pass Code.

4. Select: *ACCESS MAINFRAME MENU* and press RETURN key.

The Mainframe Menu will appear:

```
MAINFRAME MENU

A - Run Applications (Take X-rays)
B - Run Calibration With Parameters
C - Run Calibration
D - System Configuration
E - mA Limit File Editor
F - Set Date and Time
G - Examine Event file
H - Run Status

<ESC> - Return to DOS

    Enter Command Letter :
```

5. From the Mainframe Menu select: *C - RUN CALIBRATION.*

6. Enter your initials when prompted: *ENTER INITIALS PLEASE.*

7. Answer the following questions when they appear on the monitor:

```
Is your Dynalyzer (if any) wired internally for automatic reset?

Enter (Y/N): Y
```

```
Is this a C-Arm Generator or a Urology Generator?

Enter (9/U): 9
```

8. The *CALIBRATION MENU* will appear

```
                    Calibration MENU
                    Version - 12

The following commands are available:

        *Duty Cycle Calibration Options*

A - Take Duty Cycle Data
B - Calculate Duty Cycle Coefficients
C - Write Duty Cycle Coefficients to EEPROM
        *kV/mA Calibration Options*
D - Acquire Calibration Data
E - Calculate Calibration Coefficients
F - Update Coefficients to EEPROM
        *Verification Option*
G - Acquire Data for Calibration Verification
        *BRH Test Option*
H - Take BRH Data
I - Return to main menu and merge existing data files


<ESC> - To abort without change


        Enter Command Letter ___
```

6.7.5. Duty Cycle Calibration

The Duty Cycle Menu will appear next on the terminal screen:

6.7.5.1. Take Duty Cycle Data

1. Enter command letter: *A - TAKE DUTY CYCLE DATA.*

A screen of instructions will appear for either the Model II or III Dynalyzer. (The model is automatically sensed by the software). Ensure that each instruction on the list has been performed before continuing.

2. Zero the Dynalyzer high voltage unit.

NOTE: *Zero both the FLUORO and RADIOGRAPHIC settings on the Model III. Do this by monitoring the mA jack on the DRO and zeroing the reading (±0.2mV) with the appropriate mA Zero Adjust pot on the tank (F=fluoro; R=radiographic).*

3. Depress the footswitch (or X-ray On button) to select AUTO mode.

4. The system will automatically acquire a series of shots. Observe the shots reported on the monitor.

5. If the Dynalyzer fails to trigger, the calibration software will prompt you to press the RESET button on the DRO and then press [ENTER]. The trigger level on the DRO may need to be adjusted to trigger.

6. The Generator automatically switches filaments during duty cycle calibration. When this happens, the following message will appear on the monitor cart screen.

```
***SWITCHING FILAMENTS - 1 MINUTE DELAY ***
```

When beginning the calibration procedure using a Dynalyzer III, the on-screen instructions will indicate the initial switch setting (FLUORO or RAD).

6.7.5.2. Calculate Duty Cycle Coefficients

1. When the data acquisition run is complete, you will be returned to the Duty Cycle Calibration Menu.

2. Select: *B - CALCULATE DUTY CYCLE COEFFICIENTS.*

3. The coefficients are calculated and briefly displayed on the screen.

6.7.5.3. Write Duty Cycle Coefficients to EEPROM

1. When the calculations are complete, you will be returned to the Duty Cycle Calibration Menu.

2. Select: *C - WRITE DUTY CYCLE COEFFICIENTS TO EEPROM.*

3. The following message will appear briefly and then the software returns to the Calibration Menu.

```
Writing duty cycle coefficients to EEPROM.

Duty cycle coefficients have been written to EEPROM.
```

6.7.6. mA/kVp Technique Calibration

6.7.6.1. Acquire Calibration Data

1. From the Calibration Menu select: *D - ACQUIRE CALIBRATION DATA.*

2. Remove the mA SERVO-DISABLE jumper E1 on the X-ray Regulator PCB and change the tank setting to Radiographic mode for large spot calibration.

4. Zero the Dynalyzer (FLUORO and RAD on the Model III).

5. Depress the footswitch (or X-ray ON) to select AUTO mode and begin acquisition run.

6. The system automatically begins acquiring data.

> *** SWITCHING FILAMENTS ***
>
> Change tank setting to Fluoro mode for small spot calibration.
>
> Press {ENTER} on keyboard to continue.

7. Observe the results reported on the screen.

8. If the Dynalyzer DRO does not trigger, the calibration software will prompt you to press the RESET button on the DRO and then press [ENTER].

6.7.6.2. Calculate Calibration Coefficients

1. After completion of the acquisition run, the Calibration Menu is displayed; select *E - CALCULATE CALIBRATION COEFFICIENTS.*

2. The coefficients will be displayed briefly and then the Calibration Menu is displayed.

6.7.6.3. Update Coefficients to EEPROM

1. From the Calibration Menu select: *F - UPDATE COEFFICIENTS TO EEPROM.*

2. When step one is completed the Calibration menu is displayed.

6.7.7. Verify Calibration

6.7.7.1. General Information

Calibration must be verified following regular calibration procedures or when any of the following components are replaced:

- o X-ray Tube
- o X-ray Regulator PCB
- o High Voltage Regulator Components
- o High Voltage Tank
- o Generator Driver PCB

The measurement values used for these tests are not the design specifications. The test specifications used here take into account measurement limitations; their use will ensure that the design specifications are met. All reference to specifications below are to these TEST specifications.

The data collected from the tests in this section should be recorded on the Calibration Worksheets included at the end of this section and then stored with the system log sheet (found in the Appendix). Make photocopies of the Calibration Worksheets for this purpose as needed.

The following tests for kVp and mAs accuracy require installation of a Dynalyzer; the Autocal Interface Unit is not required. **Refer to the Dynalyzer instructions in the Appendix.**

6.7.7.2. Acquire Data for Calibration Verification

1. From the Calibration Menu select G - *ACQUIRE DATA FOR CALIBRATION VERIFICATION.*

2. Follow the menu instructions which appear on the computer terminal before continuing with the procedure.

3. Zero the Dynalyzer (in both FLUORO and RAD on the model III). Set the Dynalyzer tank to RAD.

4. Depress the footswitch (or X-RAY ON switch) to select AUTO mode and begin acquisition run.

5. The system automatically begins acquiring data. When necessary, the software will prompt you to change the Dynalyzer III setting with the following message:

```
*** SWITCHING FILAMENTS ***

Change Tank Setting to Fluoro Mode For Small Spot Calibration.

Press {ENTER} on Keyboard to Continue.
```

6. When the acquisition run is complete, you will be returned to the Calibration Menu.

6.7.7.3. Merge Existing Data Files

1. From the Calibration Menu, select *I - RETURN TO MAIN MENU AND MERGE EXISTING DATA FILES.*

2. After several minutes, the message "Merging files, recreated ALLDAT" will be displayed followed by a message stating that the EEPROM. DAT file has been updated. The software then returns you to the Mainframe Menu.

3. Make two backup copies of the mainframe disk. Place one backup diskette with the mainframe and return the other to the Technical Support office for evaluation and archiving.

4. Turn the key switch to the OFF position.

5. Next, turn the keyswitch to ON and allow the mainframe to completely run through the boot procedure.

6. From the Main Menu, select *A - RUN APPLICATIONS (Take X-rays).*

6.7.7.4. kVp Accuracy Tests

The tests in this section are designed to measure the kVp accuracy of the system. Record the results on the calibration worksheets.

Fluoroscopic kVp Accuracy @ 1 mA

1. Set the system to FLUORO MANUAL mode.

2. Enter 1.0 mA beam current. Take exposures at 50, 90 and 120 kVp.

3. Record the kVp and mA values on the worksheet and verify that the system meets test specifications.

Fluoroscopic kVp Accuracy @ maximum mA

1. Set the system to FLUORO MANUAL mode.
2. Take exposures at 50, 90 and 120 kVp. Set the mA technique to the maximum possible setting for each kVp value.
3. Record the kVp and mA values on the worksheet and verify that the system meets specifications.

Radiographic kVp Accuracy @ 5 mAs

1. Set the system to FILM mode.
2. Enter 5 mAs exposure. Take exposures at 50, 90 and 120 kVp.
3. Record the kVp and mAs values on the worksheet and verify that the system meets specifications.

Radiographic kVp Accuracy @ 10 mAs

1. Set the system to FILM mode.
2. Enter 10 mAs exposure. Take exposures at 50, and 100 kVp.
3. Record the kVp and mAs values on the worksheet and verify that the system meets specifications.

Radiographic kVp Accuracy @ 50 mAs

1. Set the system to FILM mode.
2. Enter 50 mAs exposure. Take exposures at 50, 90 and 120 kVp.
3. Record the kVp and mAs values on the worksheet and verify that the system meets specifications.

Radiographic kVp Accuracy @ 200 mAs

1. Set the system to FILM mode.
2. Enter 200 mAs exposure. Take exposures at 50, and 90 kVp.
3. Record the kVp and mAs values on the worksheet and verify that the system meets specifications.

6.7.7.5. Film mAs Accuracy Tests

The tests in this section are designed to measure the mAs accuracy of the system in FILM mode. Perform the tests indicated and record the results on the calibration worksheets.

mAs Accuracy @ 50 kVp

1. Set the system to FILM mode.
2. Take exposures at 5 mAs 50 mAs, and at 100 mAs using 50 KVp.
3. Record the kVp and mAs values on the worksheet and verify that the system meets specifications.

mAs Accuracy @ 120 kVp

1. Set the system to FILM mode.
2. Take exposures at 5 mAs and at 50 mAs using 120 kVp.
3. Record the kVp and mAs values on the worksheet and verify that the system meets specifications.

mAs Accuracy @ 50 kVp

1. Set the system to FILM mode. Select the large field.
2. Take exposures at 10 mAs 50 mAs, and at 100 mAs using 50 KVp.
3. Record the kVp and mAs values on the worksheet and verify that the system meets specifications.

mAs Accuracy @ 100 kVp

1. Set the system to FILM mode. Select the large field.
2. Take exposures at 10 mAs and 50 mAs using 100 KVp.
3. Record the kVp and mAs values on the worksheet and verify that the system meets specifications.

6.7.7.6. Fluoro mA Accuracy Tests

The tests in this section are designed to measure the mA accuracy of the system in FLUORO mode. Perform the tests indicated and record the results on the X-ray Calibration Worksheet.

Fluoro mA Accuracy @ 50 kVp

1. Set the system to FLUORO MANUAL mode.
2. Take exposures at 1 mA and at maximum mA using 50 kVp.
3. Record the kVp and mA values on the worksheet and verify that the system meets specifications.

Fluoro mA Accuracy @ 90 kVp

1. Set the system to FLUORO MANUAL mode.
2 Take exposures at 1 mA and at maximum mA using 90 kVp.
3. Record the kVp and mA values on the worksheet and verify that the system meets specifications.

Fluoro mA Accuracy @ 120 kVp

1. Set the system to FLUORO MANUAL mode.
2. Take exposures at 1 mA and at maximum mA using 120 kVp.
3. Record the kVp and mA values on the worksheet and verify that the system meets specifications.

6.8. X-RAY TUBE AND COLLIMATOR ALIGNMENT

This section provides instructions for the mechanical alignment of the X-ray tube and collimator assembly. All films generated in the field by this procedure shall be returned to:

Q.A. Manager, Compliance Dept.
OEC-DIASONICS
384 Wright Brothers Drive
Salt Lake City, Utah 84116
(801) 328-9300

6.8.1. Preparation

Refer to Figure 6-6.

1. Position the X-ray tube/image tube axis at a 45° angle to the floor.

2. Attach the beam alignment fixture and a loaded film cassette to the image intensifier assembly.

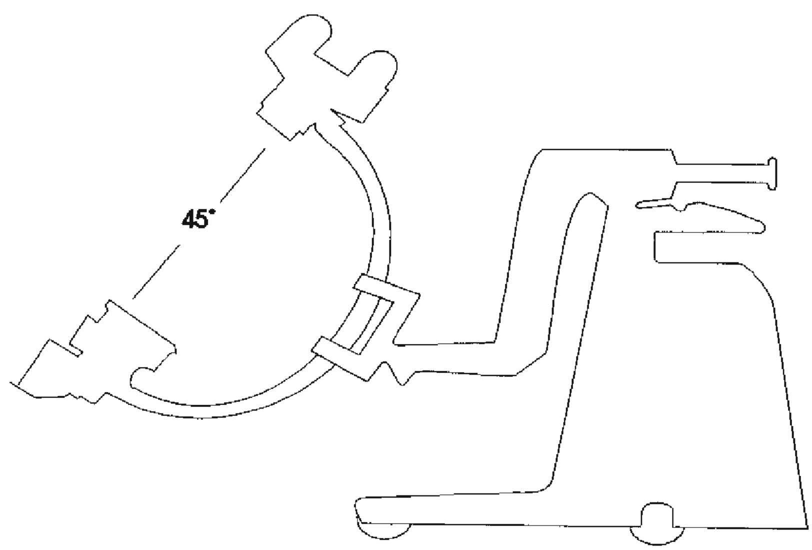


Figure 6-6 - Beam Alignment Position

Position the imaging axis at a 45-degree angle to the floor

6.8.2. 4/6/9" Radiographic Beam Alignment

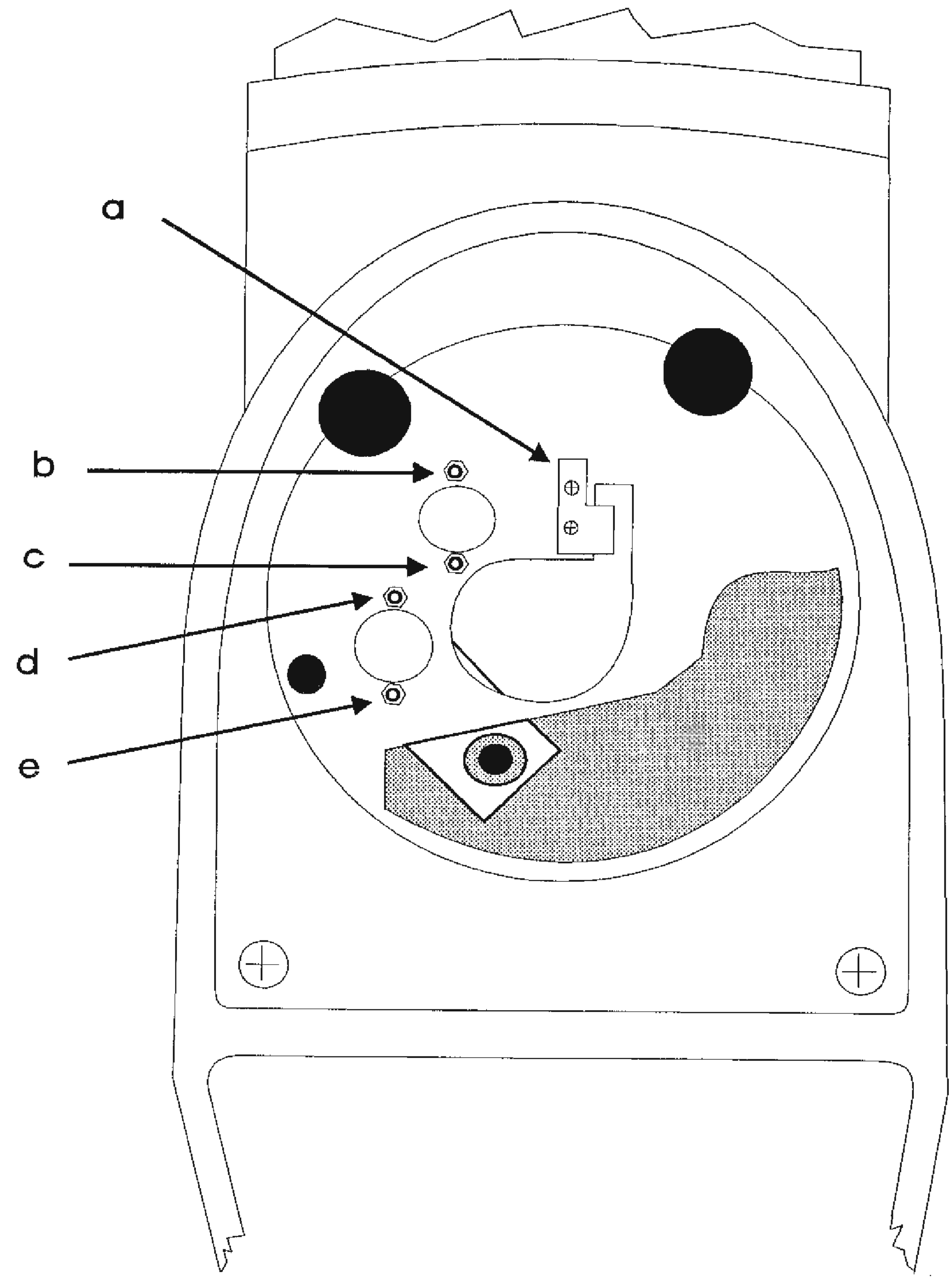
WARNING: **This procedure produces X-rays. Take appropriate precautions.**

1. Set a radiographic technique of 50 kVp and 1 mAs. Select the LARGE FIELD.

2. Make an exposure and develop the film. Reload the cassette.

3. Replace the cassette in the beam alignment fixture and lay the developed film over the top of the alignment fixture. Observe the proper alignment of the film with the alignment pattern.

Figure 6-7 - Adjust Shutter Stop and Solenoid Mounting Bolts



4. Verify that the exposed area covers the entire large field.

5. If the beam is blocked and clipping occurs in the image, reposition the X-ray tube on the head assembly and repeat the procedure of comparing the developed film with the alignment fixture pattern.

To align the X-ray tube on the head assembly:

A. Remove the screws and cover plate from the X-ray head mounting assembly.
B. Loosen the inset socket-head (locking) screws and adjust the eccentric bolts with a box wrench. Adjust the eccentrics to center the large field on the alignment fixture.
C. Take exposures as needed to verify the beam position.
D. When the large field is properly centered, carefully retighten the locking screws avoiding any movement of the X-ray head as you tighten. Fine readjustments may be needed as the eccentrics are tightened into place.

NOTE: The 4" and 6" fields cannot be selected while in Radiographic mode.

Refer to the Removal and Replacement Section

6. Remove the collimator assembly from the X-ray head, and select the 6" field. You need to take the short in Fluoro mode.

7. Taking exposures as required, in fluoro mode, adjust the 6-inch flipper stop (a) and the shutter solenoid mounting bolts (b, c, d, & e). **Refer to Figure 6-7.** Center the 6-inch beam on the beam alignment fixture.

8. Check that the microswitch still functions properly.

9. Engage the 4" flipper and take an exposure.

10. Engage the 6" flipper and take an exposure:

11. Verify that the 4" field is centered within the 6" field. If not return to step seven.

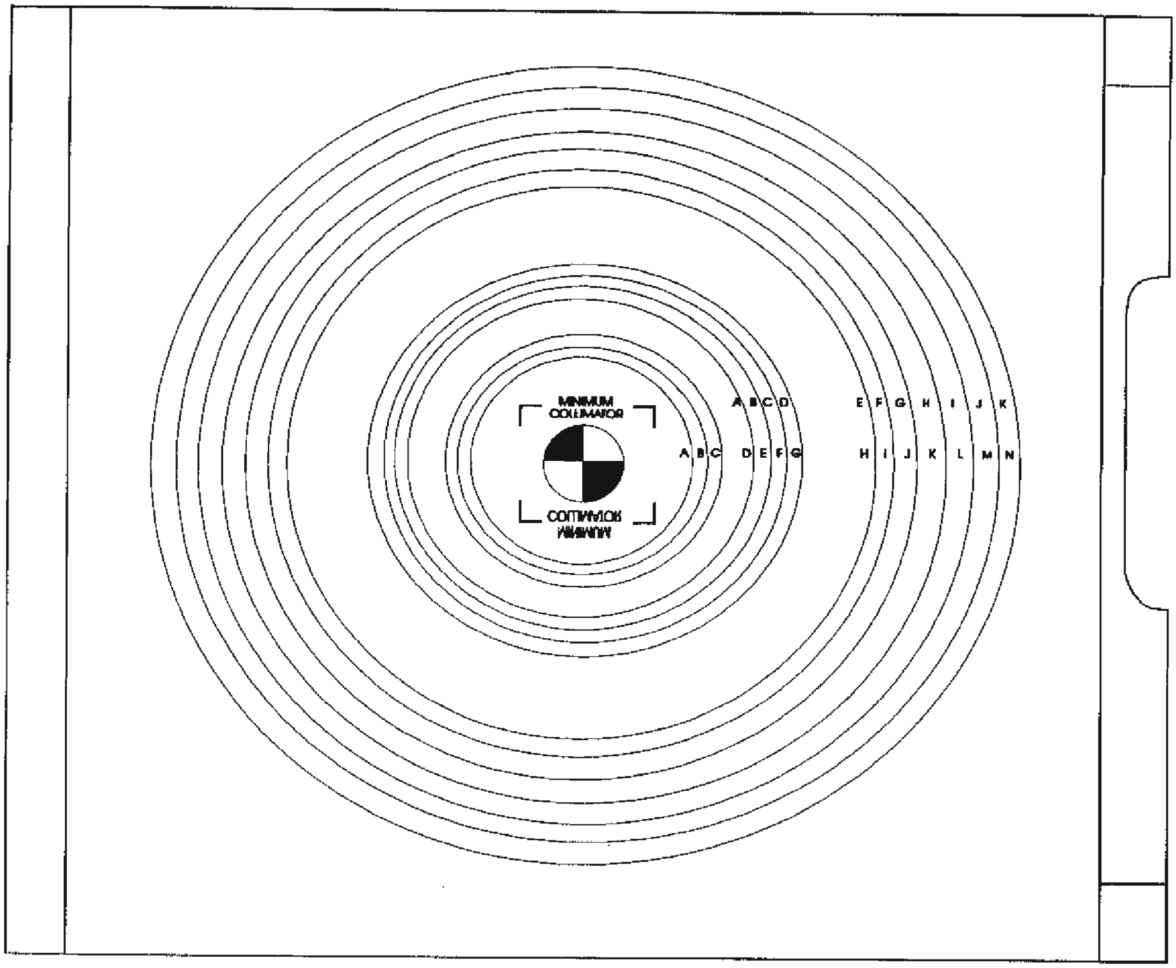
12 Reinstall the collimator. Verify that the beam alignment tool is on the Image Intensifier. **Refer to Figure 6-7 and 6-8.**

NOTE: If the beam alignment tool you are using does not have rings for the 4" field, center the 4" exposure within the 6" rings.

13. In Fluoro Mode set the technique to 40kVp, 1mA, and take a 3 second shot for the 4", 6", and 9" fields. Include a 2 x 2 inch collimation shot.

Verify that the field alignments are all correct.

Figure 6-8 - Beam Alignment Tool and Beam Alignment Specifications



ALIGNMENT TOOL	FIELD SIZE	TOLERANCE MIN	NOMINAL SPOT DIA	TOLERANCE MAX
Old Tool	9" Image Intensifier 4" Beam	Center Within 6" Field		
Old Tool	9" Image Intensifier 6" Beam	B	C	D
Old Tool	9" Image Intensifier 9" Beam	E	G	H
Old Tool	6" Image Intensifier 6" Beam	A	B	C
Old Tool	6" Image Intensifier 10" Beam	I	J	K
New Tool	9" Image Intensifier 4" Beam	A	B	C
New Tool	9" Image Intensifier 6" Beam	D	E-F	G
New Tool	9" Image Intensifier 9" Beam	H	I	J
New Tool	6" Image Intensifier 6" Beam	D	E-F	G
New Tool	6" Image Intensifier 10" Beam	L	M	N

14. Complete the information on the film label and attach it to the upper right hand corner of the developed film.

6.8.3. 6" Radiographic Beam Alignment

WARNING: This procedure produces X-rays. Take the appropriate precautions.

1. Set a radiographic technique of 50 kVp and 1 mAs. Select the NORMAL FIELD.

2. Make an exposure and develop the film. Reload the cassette.

3. Replace the cassette in the beam alignment fixture and lay the developed film over the top of the alignment fixture. Observe the proper alignment of the film with the alignment pattern.

4. Verify that the exposed area covers the entire large field.

5. If film exposure isn't concentric (round) or something is in the path of the beam, reposition the X-ray tube on the head assembly and repeat the procedure of comparing the developed film with the alignment fixture pattern.

To align the X-ray tube on the head assembly:

a. Remove the screws and cover plate from the X-ray head mounting assembly.
b. Loosen the inset socket-head (locking) screws and adjust the eccentric bolts with a box wrench. Adjust the eccentrics to center the large field on the alignment fixture.
c. Take exposures as needed to verify the beam position.
d. When the large field is properly centered, carefully retighten the locking screws avoiding any movement of the X-ray head as you tighten. Fine readjustments may be needed as the eccentrics are tightened into place.

NOTE: The 6" field cannot be selected while in radiographic mode.

6. Remove the collimator assembly from the X-ray head, and select the 6" field.

7. Taking fluoro exposures as required, adjust the 6-inch flipper stop (a) and the shutter solenoid mounting bolts (b, c, d, & e) to center the 6-inch beam on the beam alignment fixture. **Refer to Figure 6-7 and 6-8.**

8 Reinstall the collimator. Select Fluoro Mode and switch to the 6" field. Set the technique to 40 kVp, 1 mA and take a 3 second exposure. Switch back to Radiographic mode and select the Large field. Take another exposure using the same film.

   Verify that the field alignments are correct.

9. Complete the information on the film label and attach it to the

upper right hand corner of the developed film.

6.8.4. Fluoroscopic Beam Alignment

WARNING: This procedure produces X-rays. Take the appropriate precautions.

NOTE: Use this procedure for both the 9" and 6" Image Intensifiers.

1. Mount the beam alignment fixture on the image intensifier assembly.
2. Rotate the C-arm until the X-ray tube/image tube axis is at a 45-degree angle to the floor.
3. Select FLUORO MANUAL, PULSED mode. Set the technique for 45 kVp and 1 mA.
4. Make a fluoroscopic exposure and observe the image through the output lens of the Image Intensifier tube. It should be circular with no distortion of the field (collimator clipping) and the inner circle of the beam alignment tool pattern should be visible around the entire input area of the image intensifier tube.

6.9. ENTRANCE EXPOSURE CALIBRATION

The tests in this section are designed to ensure compliance with the 5.0 R/minute entrance exposure limitation set by BRH. Perform the tests indicated and record the results on the calibration worksheet.

The software routines used to control the entrance exposure rates are the same in all FLUORO modes of operation. For this reason, testing in the MANUAL CONTINUOUS mode ensures compliance in all modes.

The procedure outlined in this section is performed to ensure that the entrance exposure rate to the patient provided by fluoroscopic X-ray equipment is limited such that it will not be possible to operate the X-ray system at any tube potential or tube current which will produce an entrance exposure rate above 5 Roentgens/minute at the point where the center of the useful beam enters the patient.

6.9.1. Set-up

Measurement Position

The entrance exposure for the system is measured 30 cm (12 inches) from the input surface of the imaging assembly.

NOTE: The Dynalyzer should not be connected during this procedure.

Equipment Required

The following equipment is required to perform the entrance exposure tests:

- o Keithley Model 35050 dosimeter with Model 96030 ion chamber or equivalent (Calibration must be current).
- o Metric Scale or Ruler
- o Lead Apron or lead plate
- o Probe Holding Fixture

Test Procedure

The following procedures shall be performed to ensure compliance with the requirements of HHS Publication (FDA) 80- 8035, Section 1020.32, part (d)(2), "Equipment without automatic exposure rate control."

1. Select the FLUORO MANUAL mode.

2. Place the probe holding fixture on the image intensifier faceplate and place the ion chamber in the fixture.

NOTE: To protect the image intensifier from being over driven, place a lead plate or several folds of lead apron over the faceplate, under the holding fixture.

3. Adjust the chamber so that its flat plane is parallel to the face of the image assembly and adjust to a distance 30 cm (12 inches) from the input surface of the image intensifier.

4. Verify the aluminum collimator filtration plate is installed. Adjust the manual collimator controls to maximum open positions.

5. Make a fluoro exposure of sufficient duration to allow positioning of the active volume of the chamber in the center of the useful beam.

6. Set the Fluoro kVp to maximum. Set the mA control to maximum. Verify that the kVp indicates 120 kVp.

7. Make an exposure of at least 10 seconds to measure the exposure rate with the dosimeter.

8. Calculate the actual exposure using the correction formulas for barometric pressure, temperature and gravity.

Refer to the section in the Appendix on Dose Rate Calculations for information on the calculations to perform.

9. Determine the mA needed to produce 4.63 R/minute at increments of every five kVp. Do this across the range from 40 to 120 kVp and record the results in the worksheet table.

10. Using the terminal, access the *MAINFRAME MENU*.
    From here, select: *E - mA LIMIT FILE EDITOR*. The softlock mA Limit File menu below should appear. (Softlock is a proprietary software editor which, in this case, allows the user to make changes to the maximum mA values allowed for each kVp value in order to keep the exposure level under the calculated dose rate.)

```
___ SOFTLOCK mA LIMIT FILE EDITOR ___
malimit.dat Coefficients are: > <R/W>)

kVp    Maximum mA
40     5.0          A. Fill with constant
41     5.0          B. Clear mA to zero
42     5.0          C. Interpolate Table
43     5.0
44     5.0          E. Restore Original
45     5.0          F. Edit mA Table
46     5.0
47     5.0          ESC - QUIT
48     5.0
49     5.0          ENTER CHOICE (A,B,..):
50     5.0
```

12. Select B - CLEAR mA TO ZERO to clear the mA values from the mA Limit file.

NOTE: *Only upper case letters are recognized as valid menu choices.*

13. Select F - EDIT mA TABLE to bring up the mA Table Submenu.

14. Scroll through the mA Table and enter the data obtained every five kVp (from the Worksheet).

15. Select C - INTERPOLATE TABLE to interpolate the remaining values in the mA limit file between the values entered above. (See following example.)

Sample portion of the mA limit file:

kVp	max mA
75	5.0
76	4.9 (interpolated)
77	4.9 (interpolated)
78	4.8 (interpolated)
79	4.7 (interpolated)
80	4.6
81	4.5 (interpolated)
82	4.3 (interpolated)
83	4.2 (interpolated)
84	4.1 (interpolated)
85	4.0

NOTE: *The mA Table can be interpolated in its entirety or for a selected range of kVp values only. When entering values prior to interpolation, remember the following guidelines:*

A. No two entries can have the same mA values. If two or more of the readings obtained are the same, enter only the first reading and then skip down to the next kVp entry that has a different mA value. (Select ranges rather than interpolating the entire table at once.)

B. Two adjacent entries cannot both contain a value. (This problem is avoided since mA values are entered in 5kVp increments.)

C. A minimum of three values must be entered into the Table.

D. The very last entry in the Table must contain a value.

16. When the mA Limit Table is interpolated, press ESC to exit the program.

17. Follow the instructions on the screen to save the editing changes.

6.9.2. Backup Generator Software

Whenever a new Generator and/or Entrance Exposure calibration is performed, the associated Generator software changes must be backed up on diskette.

Two backup diskettes should be made: one diskette is to stay with the UroView system, the other should be returned to the Technical Support department at OEC for evaluation and archiving.

1. Turn off the power to the X-ray Generator and remove the floppy diskette from the Generator Disk Drive.

2. Create two backup copies of the Generator software diskette.

3. Place the customer's backup diskette in the pouch provided with the UroView system. Return the other backup diskette to OEC's Technical Support office at the address below.

   OEC-Diasonics
   Attn. Technical support
   384 Wright Brothers Drive
   Salt Lake City, UT. 84116

6.10. IMAGING SYSTEM CALIBRATION

WARNING: **In certain procedures that follow, fluoroscopic exposures are made. Observe all radiation safety measures including wearing protective lead aprons while making adjustments to the camera during X-ray exposures.**

6.10.1. General Test conditions:

Except where noted, the following test conditions apply to all of the video performance tests.

1. Contrast Grid is installed.

2. Technique factors are adjusted to produce 270 mR/min ± 5% at 50 kVp using this procedure:

    A. Place the dosimeter 30 cm. (12 inches) from the input surface of the image intensifier.
    B. Adjust the technique factors to produce the required radiation level.
    C. Press the TECH LOCK key on the control panel to lock in the technique setting. Remove the dosimeter for the remainder of the tests.

3. Unless otherwise noted, all radiation measurements are made 30 cm. (12 inches) above the input surface of the image intensifier.

4. The camera lens aperture is set to f/2.0.

5. X-ray beam alignment has been performed with satisfactory results.

6. On 4/6/9-inch fluoroscopy systems, all camera tests and alignments are to be done in the 9-inch mode.

7. All dosimeter radiation measurements are corrected for temperature and pressure. Refer to the section in the Appendix: *Using the Dosimeter.*

8. Rotate the imaging axis parallel to the floor.

6.10.2. Monitor Raster Size Adjustment

1. Press F10 (SETUP OPTIONS) and access Level 2 (SERVICE).

2. Select Video Calibration and Monitor/Camera Alignment (respectively) from the sub-menu screens.

3. The Video Test Pattern (**Refer to Figure 6-9**) will appear on both monitors (superimposed over the existing images).

4. While viewing the test pattern, adjust the horizontal size coil (L1) and the vertical size pot (R5) on the left monitor to produce a 10" square (25.4 cm squared).

5. If necessary, adjust the horizontal linearity coil (L2) and the vertical linearity pot (R9) to obtain a symmetrical pattern.

NOTE: *It may be necessary to repeat the adjustments in steps 4 and 5 due to the interaction between the sizing and linearity controls.*

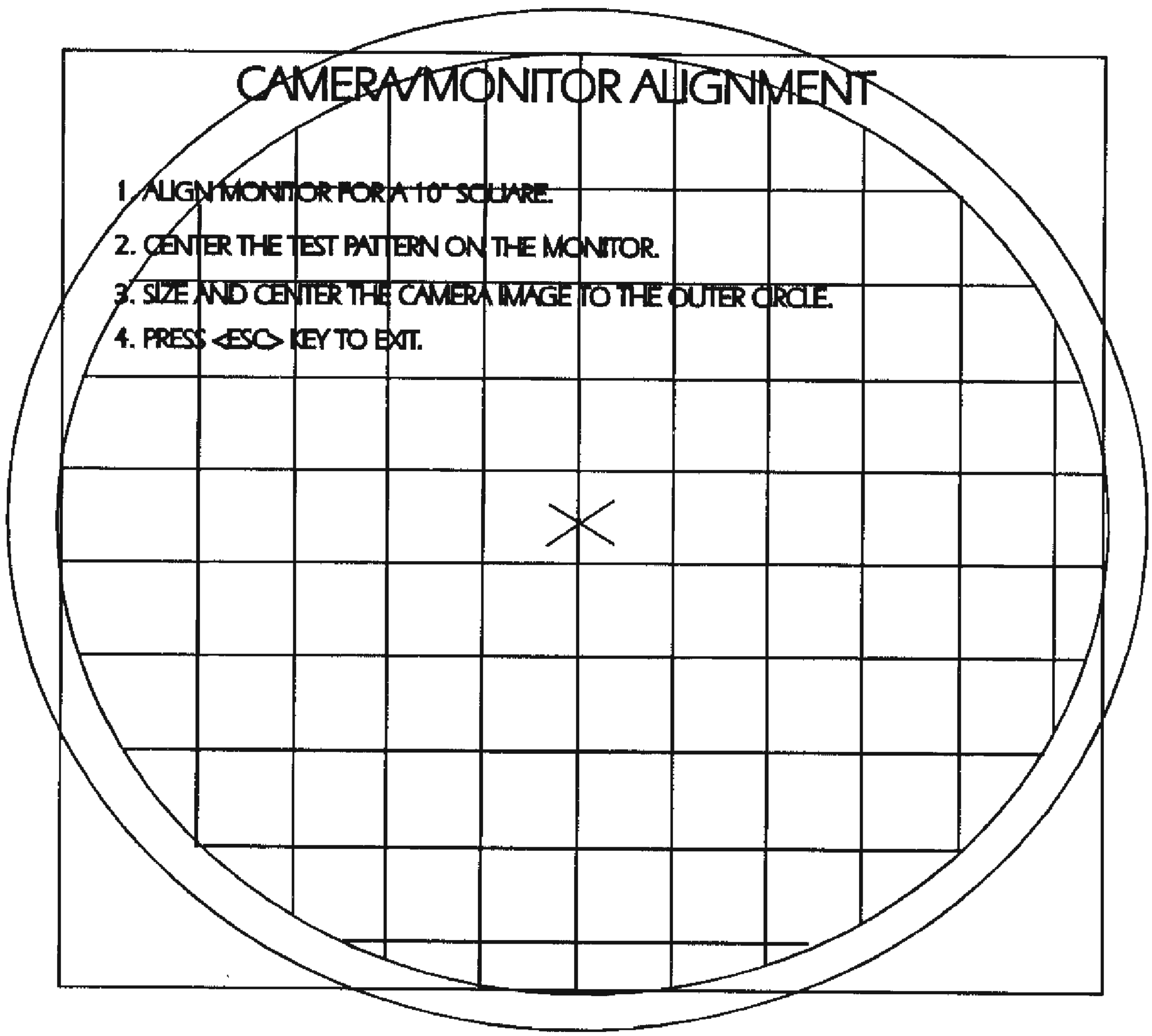
6. Center the test pattern horizontally using the horizontal phase pot (R33). Center the pattern vertically, if required, by adjusting the monitor yoke rings.

7. Repeat this procedure for the right monitor.

NOTE: *Adjust the video monitor image sizing controls (on both monitors) before any other size adjustments are performed.*

Figure 6-9. - Video Test Pattern

Appears when Monitor/ Camera Alignment is selected from the Video Calibration Menu



11. ALIGN MONITOR FOR A 10" SQUARE.

2. CENTER THE TEST PATTERN ON THE MONITOR.

3. SIZE AND CENTER THE CAMERA IMAGE TO THE OUTER CIRCLE.

4. PRESS <ESC> KEY TO EXIT.

6.10.3. Camera Set-Up and Alignment

SET-UP:

Adjust the C-arm to position the x-ray beam axis on the horizontal plane. Position the protective lead barriers around the I.I. tube. Install the alignment fixture on the I.I. tube (use the adapter rings for a 6" system). Connect a clip lead from TP7 to TP2 on the Video PCB. Set the system in MANUAL FLUORO mode, 50 kVp @ 1.0 mA, and NORMAL field. (unless otherwise specified). Jumper removed 6.10.3.8 (pg 43)

6.10.3.1. Clean Lenses / Set Aperture

Disconnect **P101** from the Camera Power Supply PCB. Remove the camera from the image intensifier assembly.

Inspect the camera lens, I.I. tube lens, and mirror assembly. Remove dust from lens surfaces with canned air and carefully clean with lens paper.

Re-install the camera on the image intensifier and connect P101 to the Power Supply PCB.

Auto Iris

Manually force the lens aperture counter-clockwise until it hits its mechanical stop at a setting of 4.0. Reboot mainframe and verify that the Iris will automatically rotate to the 2.0 setting when the mainframe is all the way up and running.

6.10.3.2. Adjust Camera Power Supply

NOTE: In tests below, test point references and adjustments apply to the Power Supply PCB **(refer to figure 6-11)**, unless otherwise specified.

Verify that the voltage at TP12 is 24 Vdc (±1 Vdc). If necessary, adjust the mainframe 24 volt power supply.

TP6 to gnd TP3 Pwr Supply 500 vdc

Adjust **R14** (beam) fully counter-clockwise and **R13** (500 V) fully clockwise. Measure the supply at TP6. If the voltage is 525Vdc or greater, adjust **R13** to obtain 500Vdc. If the voltage at TP6 is below 525Vdc, adjust **R13** to set the supply 25 volts below the maximum. The final voltage must be greater than 475 Vdc.

Monitor TP3 (preamp out) on the Video PCB **(refer to Figure 6-10)** during fluoro exposure and adjust **R14** (beam) on the Power Supply PCB to obtain maximum video level at TP3.

6.10.3.3. Adjust Sizing and Centering

On the Video PCB, position the jumpers **E1** (shading) and **E2** (auto gain) in the OUT position.

Load the *Camera/Monitor Alignment* test pattern as in section 6.10.2.

During fluoro exposure, adjust the camera sizing and centering controls (listed below) on the Deflection PCB **(refer to figure 6-11)** to align the image with the outer ring of the test pattern.

R40	horizontal sizing	**R19**	vertical sizing
R39	horizontal centering	**R37**	vertical centering
***R38**	horizontal reverse centering	****R29**	vertical reverse centering

*select horizontal reverse mode on control panel

**select vertical reverse mode on control panel

Adjust the contrast control of the left monitor until the image begins to bloom out. During fluoro exposure, adjust the camera yoke rings until the contrast bloom is centered on the screen. When adjusting one ring, make sure the other does not move. Readjust the camera centering if necessary.

6.10.3.4. Align Right Angle Optics

Rotate the camera either direction to one of the limit switches.

During fluoro exposure, use a marker to make a dot on the monitor screen in the center of the alignment pattern image.

Repeat this process at 90, 180, and 270 degrees of camera rotation. Use the marker to draw an intersection between the 4 diagonally opposed dots.

During fluoro exposure, observe the alignment pattern on the monitor. Adjust the jackscrews in the mirror assembly to align the center of the pattern with the intersection of the 4 dots.

During fluoro exposure, observe the alignment pattern on the monitor and rotate the camera from stop to stop. Verify that the center of the image deviates less than 1/8 of an inch from the intersection of the 4 dots.

When the mirror adjustments are complete, repeat the image centering adjustments on the Deflection PCB as in section 6.10.3.2.

(9" systems only) Select the *MAG 1* field on the control panel. Make a fluoro exposure and verify that the image is centered and sized as in section 6.10.3.2. If necessary, make minor adjustments.

(9" systems only) Select the *MAG 2* field on the control panel. Make a fluoro exposure and verify that the image is centered and sized as in section 6.10.3.2. If necessary, make minor adjustments.

6.10.3.5. Adjust Focus

Return the monitor cart to normal operation.

During fluoro exposure, adjust the mechanical focus of the camera lens and **R11** (electrostatic focus) on the Power Supply PCB for optimum focus.

6.10.3.6. Adjust Video Levels

Monitor TP3 on the Video PCB during fluoro exposure and adjust **R43** (target voltage) to obtain a preamp output of 300mV.

Set technique to 70 kVp and 3.0 mA. Monitor TP3 (Preamp Out) on video PCB during FLUORO exposure and adjust **R14** (Beam) on the Power Supply PCB to obtain 500mV of video at TP3.

Return technique to 50 kVp and 1.0 mA. Monitor TP3 on the Video PCB and readjust **R43** on the Video PCB for 300mV if necessary.

Set the bandwidth on the oscilloscope to 20MHz. Connect the scope ground probe to TP23 and monitor TP10 on the Video Switching PCB during fluoro exposure. Adjust **R9** (gain) on the Video PCB to obtain a video amplitude of 700mV.

On the Video PCB, move the **E1** (shading) jumper to the IN position.

Monitor TP10 on the Video Switching PCB and adjust **R44** on the Video PCB to obtain a black level of 75mV.

Select the Horizontal Reverse video mode and adjust **R44** again. Switch between reverse and normal video. Verify that the black level shift between the two modes is no more than 30mV.

Monitor TP10 on the Video Switching PCB during fluoro exposure and adjust **R57** (bias) on the Video PCB to obtain a video amplitude of ~~700~~mV. 800 - 850

6.10.3.7. Adjust Shading Uniformity

Monitor the horizontal video signal at TP10 on the Video Switching PCB during fluoro exposure. Adjust **R40** (horizontal sawtooth) and **R42** (horizontal parabola) on the Shading/Window PCB **(refer to figure 6-11)** to obtain a uniform video level. If necessary, adjust **R57** (bias) on the Video PCB to reset the video amplitude to 700mV.

Select the Horizontal Reverse video mode on the control panel. Adjust **R41** (horizontal reverse sawtooth) as described above. When adjustments are complete, select the normal video mode.

Monitor the vertical video signal at TP10 on the Video Switching PCB during fluoro exposure. Adjust **R10** (vertical sawtooth) and **R15** (vertical parabola) on the Shading/Window PCB to obtain a uniform video level. If necessary, adjust **R57** (bias) on the Video PCB to reset the video amplitude to 700mV.

Select the Vertical Reverse video mode on the control panel. Adjust **R5** (vertical reverse sawtooth) as described above. When adjustments are complete, select the normal video mode.

Due to the interaction between the horizontal and vertical shading adjustments, it may be necessary to repeat steps above.

Rotate the camera from stop to stop during fluoro exposure. Verify that the image shading is uniform throughout rotation in normal, horizontal reverse, and vertical reverse video modes.

6.10.3.8. Adjust Window Sizing

Connect a 2.2 K-ohm resistor between TP11 and TP13 on the Video PCB.

During fluoro exposure, adjust **R38** (H-cal) and **R39** (V-cal) on the Shading/Window PCB to center and size the video sampling window visible on the left monitor.

Disconnect the 2.2 K-ohm resistor and the clip lead from TP2 to TP7 on the Video PCB.

Re-adjust the video levels if needed.

6.10.3.9. Adjust Focus and Peaking

Place the resolution mesh tool on the I.I. grid. Repeat the focus adjustments as in 6.10.3.4.

Verify that the imaging system complies with the following specifications for minimum acceptable resolution. Repeat focus adjustments as described in Section 6.10.3.4 if needed.

SYSTEM TYPE	FIELD	VISIBLE LP/INCH
6"	Normal	35
9"	Normal	30
9"	Mag 1	40
9"	Mag 2	50

During fluoro exposure, adjust **C3** (peaking capacitor) on the Preamp

PCB until the black edges in the image begin to bleed white. Back-off the adjustment until the white smearing just barely disappears.

Remove the resolution mesh tool from the I.I. During fluoro exposure, observe the flat image on the monitor and verify that the Vidicon camera tube complies with the specification for blemishes. (Refer to Specification Control Drawing 860093.)

6.10.3.10. Adjust Auto Gain

Adjust the C-arm to the vertical beam axis position.

Set the camera rotation potentiometer at the mid-point of its range (5 turns from one end). Rotate the camera 180 degrees from the stop position. Connect and adjust the camera chain drive. Move the **E2** (auto gain) jumper to the IN position on the Video PCB.

Select the AUTO FLUORO mode and NORMAL field. Adjust the collimator shutters to a 6"x 6" or 15cm x 15cm field.

Place the resolution mesh tool on the I.I. grid. During an exposure, rotate the collimator to align the field with the edges of the mesh tool.

Place 3 copper filters on top of the mesh tool. Make an exposure and verify that the kVp tracks to 93 (±4). If the auto fluoro kVp is slightly low, monitor TP4 on the Video PCB and adjust **R43** to decrease the target voltage in 0.5 volt increments. If the auto fluoro kVp is slightly high, increase target voltage in 0.5 volt increments. Repeat adjustments and exposures as needed to verify compliance.

6.10.3.11. Calibrate Rotation Indicator

Access the system *Service Options* menu from the *Access Level 2 (Service)* through the *Setup Options*, F10. Enter the *Video Calibration* sub-menu and run the *Camera Rotation Calibration* program. This program will automatically calibrate the camera rotation indicator displayed on the left monitor to the actual degree of rotation from the stop position.

When the program is complete, return the system to normal operation. Place the resolution mesh tool on the I.I. grid.

During fluoro exposure, rotate the camera and verify that the simulated stop position displayed on the monitor coincides with the actual stop position.

Make an exposure and note the vertical and horizontal orientation of the image, then discontinue the exposure. Rotate the camera and observe the indicator arrow as it rotates around the perimeter of the image.

Discontinue rotation and the note where the arrow is pointing toward image. Make another exposure and verify that the point indicated in the previous image is now at the top of the monitor in the new image.

Figure 6-10 - Camera PCB Locations

This view of the camera shows the location of the a) Video Board

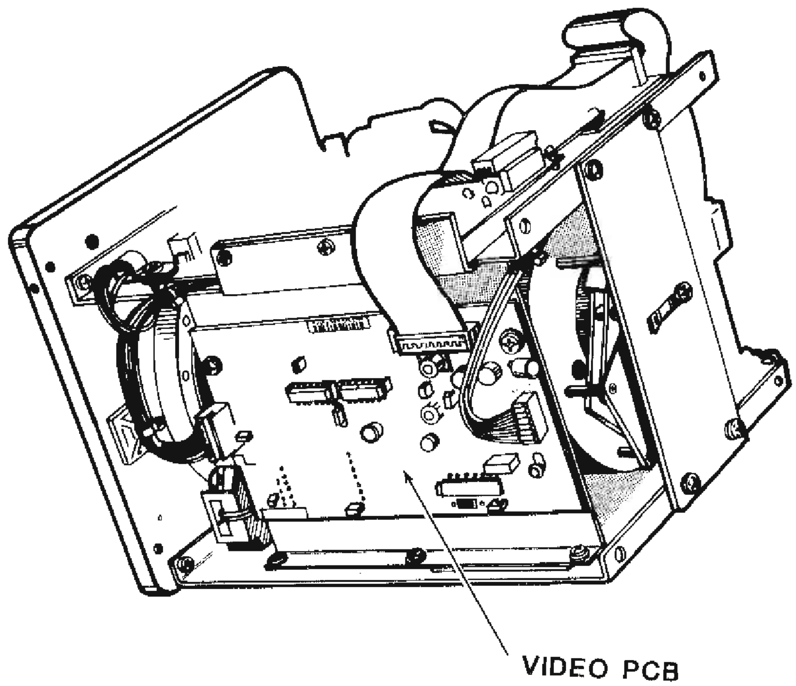


Figure 6-11 - Camera PCB Locations

This view of the camera shows the a) Deflection Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.

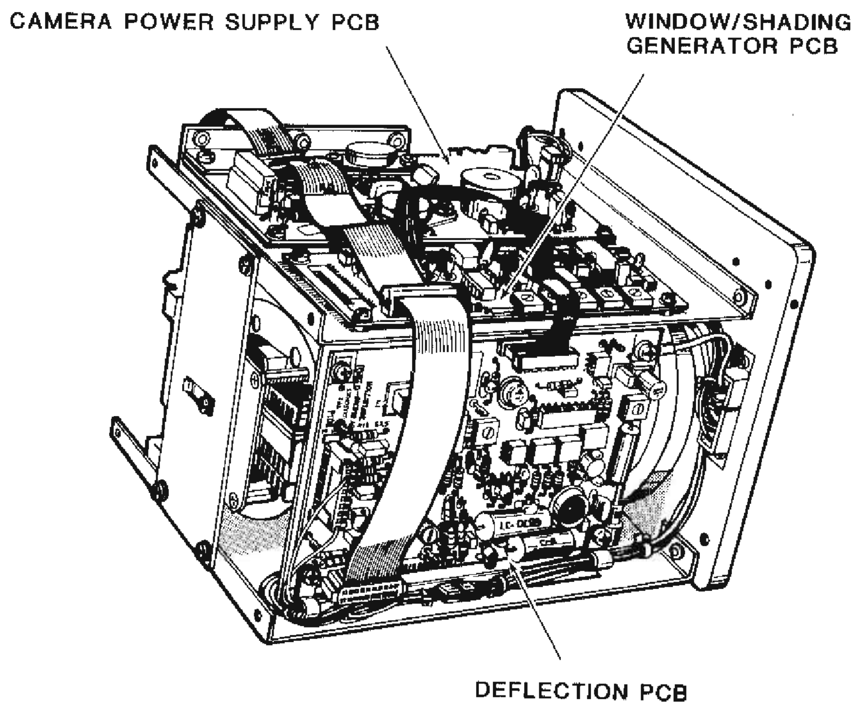
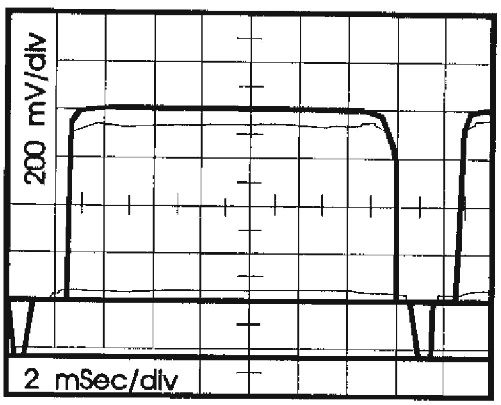
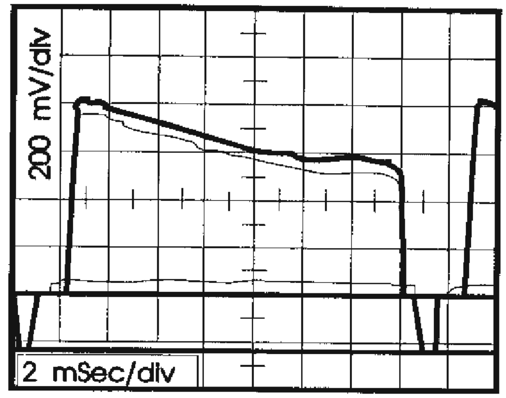


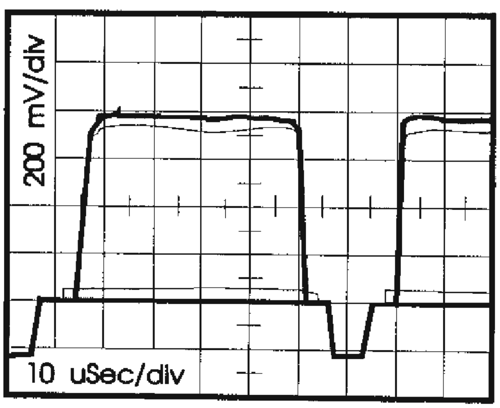
Figure 6-12- Correct and Incorrect Shading Waveform Illustrations



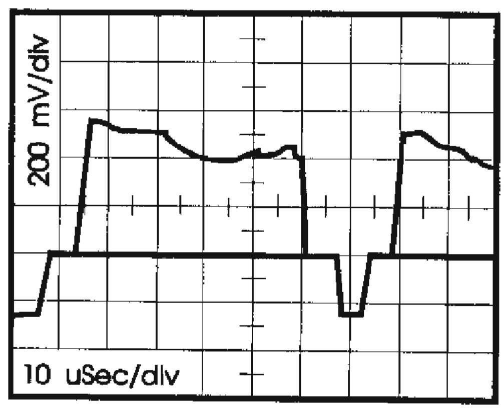
Correct Vertical Shading



Incorrect Vertical Shading



Correct Horizontal Shading



Incorrect Horizontal Shading

6.10.4. Resolution

TEST CONDITIONS:

A. Shading jumper in (enabled).
B. NO Contrast Grid.
C. Wisconsin Resolution Tool installed.
D. Adjust technique for 60 kVp @ 270 mR/min. (in manual mode)

1. Remove the Contrast Grid, install the Wisconsin Resolution Test Tool on the input surface of the image intensifier and orient it so the mesh pattern is at a 45 degree angle to the horizontal.

2. Adjust technique for 270 ±10 mr./min. at 60 kVp. in MANUAL FLUORO mode.

6.10.4.1. Camera Focus and Peaking Adjustment

1. Adjust the optical focus of the camera lens.

2. Adjust the electrostatic focus R11 on the camera Power Supply PCB for the best possible focus.

NOTE: Use a nonmetallic adjustment tool on C3.

3. Adjust C3 (peaking capacitor) on the Preamp and Yoke assembly until the black image edges, viewed on the monitor, bleed white. Back off the adjustment of C3 until the smearing just disappears. This will provide optimum preamp bandwidth without oscillation occurring.

6.10.4.2. ELECTROSTATIC FOCUS ADJUSTMENT

Refer to figure 6-13 for location of the focus adjustment.

Adjustment is extremely sensitive and *may not be required*. A telescope should be used when checking or adjusting the image tube focus.

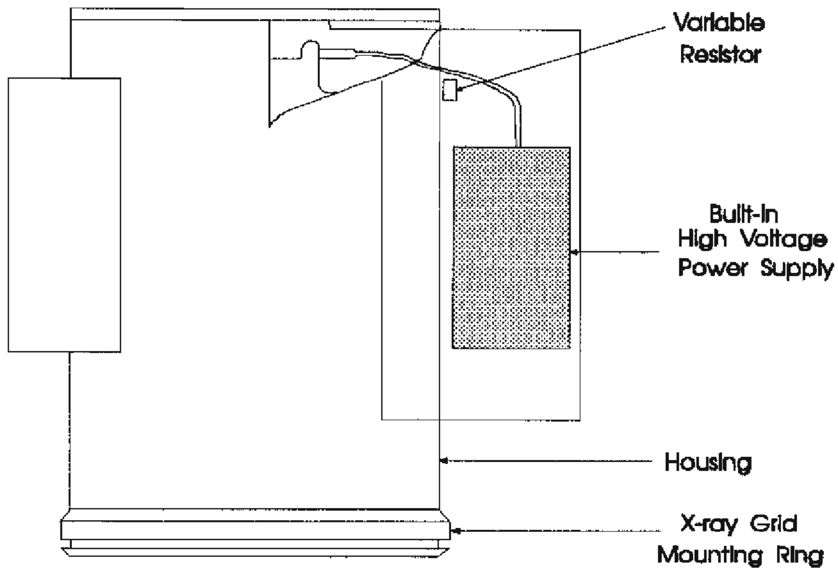


Figure 6-13 - Electrostatic Focus Adjustment on a 6-inch Image Tube

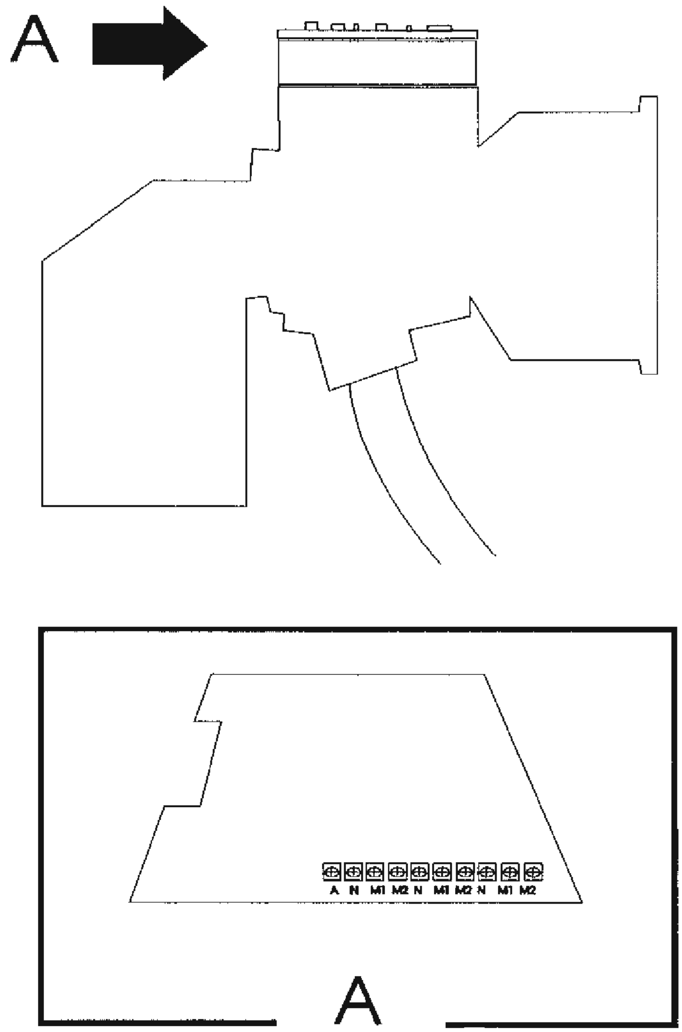
6.10.4.3. 4/6/9-inch Image Intensifier

Adjustments to the high voltage power supply may not be required. Any adjustment should only be attempted *as a last resort* to obtain the necessary image resolution.

The 4-inch mode adjustments are made to the pots labeled M2. The 6-inch mode adjustments are made to the pots labeled M1; 9-inch mode adjustments are made to the pots labeled N. **Refer to Figure 6-14 for location.**

MODE	OVERALL SIZE	OVERALL FOCUS	EDGE FOCUS
4-INCH	G3	G2	G1
6-INCH	G3	G2	G1
9-INCH	G3	G2	G1

Figure 6-14 - Adjustment Locations



6.10.4.4. Measure Imaging Resolution

Make an exposure and measure (line pairs/inch) resolution using the Wisconsin Resolution Test Tool.

4" mode- (MAG2)	50 line pairs/inch
6" mode (MAG1)	40 line pairs/inch
9" mode (NORMAL)	35 line pairs/inch

6.10.5. Contrast Sensitivity Test

TEST CONDITIONS:

A. Technique factors adjusted to produce 80 kVp @ 1R/min.
B. Contrast Grid installed.

Test Spec: Contrast Sensitivity: 8 Spots minimum should be discernible.

1. Center the standard penetrometer and shield on the input screen of the image intensifier.

2. Make an exposure and examine the stored image. Adjust the brightness and contrast controls on the monitor as necessary to optimize the image.

6.10.6. Image Noise, Correlated

TEST CONDITIONS:

A. Black level control enabled.
B. Shading jumper in (enabled).
C. Auto-gain jumper in (enabled)

1. Make an exposure in the MANUAL mode at 40kVp and 0.5 mA with a lead shield over the intensifier. Allow time for the camera gain to increase to maximum.

2. Observe the live image for noise.

3. There should be no discernible correlated noise patterns. This refers to system generated noise rather than "random" or thermal noise.

4. Make an exposure at 120kVp and maximum mA.

5. There should be no discernible correlated noise patterns. This refers to system generated noise rather than "random" or thermal noise.

6.10.6.1. Video Sampling Window Size and Centering

1. Connect a 2.2 Kohm resistor between TP11 and TP13 to see the video sampling window.

2. The window should now be visible when exposures are made. Adjust R38 "H-CAL" and R39 "V-CAL" to center this rectangular window within the viewed area.

3. With window centered, the size of the window as measured at the monitor shall be:

   4.0 ± .5 in. (vertical)
   4.0 ± .5 in. (horizontal)

The window shall be centered within the circular display area within .25" relative to active image center viewed on the monitor.

6.10.7. Video Level Control and Auto Technique Tests

TEST CONDITIONS:

A. AUTO FLUORO technique mode
B. Auto-gain enabled
C. Black level control enabled
D. Shading enabled
E. Collimate down to size of filters
F. NORMAL field size selected

1. Place the Wisconsin Resolution Test Tool on the image intensifier and make an exposure with no filters in the beam. Record the resulting kVp value on the X-ray Calibration Worksheet.

2. Make exposures with one, two, three and four copper filters added in the beam path and verify that the kVp and visible line pairs/inch (resolution) track as indicated in the list below. Record the resulting kVp values on the Worksheet.

Number of Filters	kVp ± 4	Resolution
none	46	24
one	67	20
two	81	20
three	96	16
four	108	16

3. The peak output video amplitude at VIDEO 1 on the Monitor Cart must remain between 760 - 880 mV peak for each exposure. Record the video level for each exposure on the Worksheet.

6.10.8. Camera Drive Chain Adjustment

1. Check the camera rotation drive chain.

2. Adjust the drive chain tension to allow 1/4" of slack in the middle of the chain when moderate pressure is applied.

3. Press F10 and enter the SETUP OPTIONS screen.

4. Select ACCESS LEVEL 2 and press RETURN.

5. Enter pass code.

6. From the SERVICE OPTIONS screen select VIDEO CALIBRATION and press RETURN.

7. From the VIDEO CALIBRATION screen select CAMERA ROTATION CALIBRATION and press RETURN (Calibration is automatically performed).

8. The following screen will appear on the screen

```
Calibration Complete

Min =      Max =
Range =

Valid Range Between 665 - 670
```

9. Verify that the Range falls within the parameters 665 - 670.

   A. If the range does not fall between these parameters, remove the chain and rotate the camera so that it is in the middle of it's 360° rotation.

   B. Turn the camera potentiometer in either direction until it stops and then place a small mark on the pot with a felt tip marker. Rotate the pot in the opposite direction until the mark has completed 5 turns.

NOTE: *Steps 9A and 9B should be done* **whenever** *the chain is removed..*

Reinstall the chain and return to step 2

Calibration Worksheets

Calibration Worksheets (continued)

CALIBRATION WORKSHEETS

Series 9400 - Serial Number ______________________

Calibration Performed By: ______________________

Location ________________ Date: ____________

6.1. INTRODUCTION

These worksheets accompany the Series 9400 system calibration procedures found in Section 6 of the Service Manual. Fill out these worksheets during the calibration. Calibration Worksheets may be photocopied as needed. You should keep the original as a master copy.

The section numbers used in this worksheet refer to the actual calibration procedure sections. This will allow you to cross-reference the procedure with the worksheet.

6.2 WARNING

Read all safety precautions and warnings given in the Calibration Section of the manual. Also read the Safety Section of the manual.

The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9400 System.

6.3. PREPARATION AND SETUP

6.3.1 Record the Test Equipment Used

Dynalyzer Model ______________ S/N ________________
Calibration Date _______

Dynalyzer Display Model ___________ S/N ______________
Calibration Date _______

Autocal Interface Box ______________ S/N ______________________
Calibration Date__________

DVM/DMM Model ________________________ S/N ________________
Calibration Date__________

Oscilloscope Model _______________________ S/N ________________
Calibration Date__________

Dosimeter Model ____________________ S/N _____________________
Calibration Date__________

Ion Chamber Model __________________ S/N _____________________
Calibration Date__________

6.3.2 Preparation and Inspection

___ Steps 1 thru 7 completed.

6.4 ELECTRICAL TESTS

6.4.1 Leakage Current Testing

Leakage Current ___________________ Pass/Fail __________________

6.4.2 Ground Continuity

System ground continuity between the mainframe and the monitor cart.
Resistance = ______________

Continuity of each power plug ground pin to its corresponding chassis.
Resistance = _________________

6.4.3 Line Voltage Regulation

Calculate the percentage line voltage regulation using the following formula and record the results:

100 (Vn - V1)/ (V1)

where: Vn = No load voltage
V1 = Max load voltage

Vn = ________________ V1 = _________________

Regulation % = _________________

Perform a maximum radiographic exposure and measure the voltage on the isolation transformer secondary = _________________________ VAC

6.4.4 Mainframe Power Supplies

Measure these voltages on the power panel fuse strip:

F7	yellow wire	________	VDC
F6	red wire	________	VDC
F5	grey wire	________	VDC
F4	violet wire	________	VDC
F3 *	black wire	________	VAC
F2 *	red wire	________	VAC

WARNING: *** F2 and F3 carry line voltage whenever the power cord is plugged in.**

6.5 MECHANICAL CHECKS

___ Foot lever and steering handle
___ Wig-wag
___ Extension arm
___ Flip-flop and C-arm pivot point
___ Cradle bearings and radial movement
___ L-arm lift
___ L-arm rotation

6.6. FUNCTIONAL CHECKS

6.6.1 Self-tests

___ Self-tests during powerup successfully completed.

6.6.2. Fast Stop and Processor Reset Test

___ Left Fast Stop breaks interlock circuit
___ Processor resets and runs.
___ Right Fast Stop breaks interlock circuit

6.6.3. Status Mode Tests

Refer to the Service Section for detailed information about the status mode.

___ Display Panel Test

___ Panel key test

___ Panel knob test

Date and initials listed for last calibration ____________________

Total RAM ____________ Total disk space ____________

6.6.4. Film Cassette Test (6-inch systems only)

___ Steps 1 thru 6 completed.

6.6.5. Verify Operation of Mainframe Controls

___ Steps 1 thru 6 completed.

6.6.6 Field Solenoid Position Test

___ Steps 1 thru 7 completed.

6.6.7. Verify Controls in MANUAL FLUORO

___ Steps 1 thru 2 completed.

6.6.8. AUTO FLUORO Tests

___ Steps 1 thru 9 completed.

6.6.9. Fluoro Boost Option

___ Steps 1 thru 4 completed.

6.6.10. Pulsed Fluoro Operation

___ Steps 1 thru 3 completed.

6.6.11. Verify Fluoro Timer and Timer Reset

___ Steps 1 thru 3 completed.

6.7. X-RAY CALIBRATION

6.7.1. Connections

___ The Dynalyzer, digital display, and autocal interface box are connected according to the instructions in this section.

6.7.2. Setup

___ (6.7.3.1.) General Setup

___ (6.7.3.2.) Autocal Interface Box

___ (6.7.3.3. or 6.7.3.5.) Dynalyzer High Voltage Unit

___ (6.7.3.4. or 6.7.3.6.) Dynalyzer DRO (Digital Display Unit)

6.7.3. Getting Started

___ Steps 1 thru 8 completed.

6.7.4. Duty Cycle Calibration

___ (6.7.5.1) Take Duty Cycle Data

___ (6.7.5.2) Calculate Duty Cycle Coefficients

___ (6.7.5.3) Write Duty Cycle Coefficients to EEPROM

6.7.5. mA/kVp Technique Calibration

___ (6.7.6.1) Acquire Calibration Data

___ (6.7.6.2) Calculate Calibration Coefficients

___ (6.7.6.3) Update Coefficients to EEPROM

6.7.6. Verify Calibration

Refer to the Dynalyzer Instructions in the Appendix.

The following tests for kVp, mA and mAs accuracy require installation of a dynalyzer; the Autocal Interface Box is not required.

Perform the tests indicated and record the results on the calibration worksheet. Verify that the system meets the specifications given with the tables below.

6.7.6.1. Acquire Data for Calibration Verification

___ Steps 1 thru 6 completed.

6.7.6.2. Merge Existing Data Files

___ Steps 1 thru 7 completed.

6.7.6.3. KVP Accuracy Tests

Fluoroscopic kVp Accuracy @ 1 mA

Test Spec: ± 5 % or ± 2 kVp, whichever is greater.

kVp Required	kVp Measured	mA Measured
50 kVp	________ kVp (±2.5 KvP)	________ mA
90 kVp	________ kVp (±4.5 KvP)	________ mA
120 kVp	________ kVp (±6.0 KvP)	________ mA

Fluoroscopic kVp Accuracy @ maximum mA

Test Spec: ±5 % or ±2 kVp, whichever is greater.

kVp Required	kVp Measured	mA Measured
50 kVp	________ kVp (±2.5 KvP)	________ mA
90 kVp	________ kVp (±4.5 KvP)	________ mA
120 kVp	________ kVp (±6.0 KvP)	________ mA

Radiographic kVp Accuracy @ 5 mAs

Test Spec: ±5 % or ±2 kVp, whichever is greater.

kVp Required	kVp Measured	mAs Measured
50 kVp	________ kVp (±2.5 KvP)	________ mAs
90 kVp	________ kVp (±4.5 KvP)	________ mAs
120 kVp	________ kVp (±6.0 KvP)	________ mAs

Radiographic kVp Accuracy @ 10 mAs

Test Spec: ±5 % or ±2 kVp, whichever is greater.

kVp Required	kVp Measured	mAs Measured
50 kVp	________ kVp (±2.5.0 KvP)	________ mAs
100 kVp	________ kVp (±5.0 KvP)	________ mAs

Radiographic kVp Accuracy @ 50 mAs

Test Spec: ±5 % or ±2 kVp, whichever is greater.

kVp Required	kVp Measured	mAs Measured
50 kVp	________ kVp (±2.5 KvP)	________ mAs
90 kVp	________ kVp (±4.5 KvP)	________ mAs
120 kVp	________ kVp (±6.0 KvP)	________ mAs

Radiographic kVp Accuracy @ 200 mAs

Test Spec: ± 5% or ± 2 kVp, whichever is greater.

kVp Required	kVp Measured	mAs Measured
50 kVp	________ kVp (±2.5 KvP)	________ mAs
90 kVp	________ kVp (±4.5 KvP)	________ mAs

6.7.6.4 Film MAS Accuracy Tests

The tests in this section are designed to measure the mAs accuracy of the system in FILM mode. Perform the tests indicated and record the results on the calibration worksheets.

Film mAs Accuracy @ 50 kVp

Test Spec: ± 5% or ± 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	________ mA (± 0.25 mAs)	________ kVp
50 mA	________ mA (± 25 mAs)	________ kVp
100 mA	________ mA (±10.0 mAs)	________ kVp

Film mAs Accuracy @ 100 kVp

Test Spec: ± 5 % or ± 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
10 mA	________ mA (±.5 mAs)	________ kVp
50 mA	________ mA (±2.5 mAs)	________ kVp
100 mA	________ mA (±5.0 mAs)	________ kVp

Film mAs Accuracy @ 120 kVp

Test Spec: ± 5 % or ± 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5mA	________ mA (±.25 mAs)	________ kVp
50 mA	________ mA (±2.5 mAs)	________ kVp
120 mA	________ mA (±6.0 mAs)	________ kVp

6.7.6.5. Fluoro mA Accuracy Tests

Fluoro mAs Accuracy @ 50 kVp

Test Spec: ± 5 % or ± 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
1 mA	________ mA (±.05 mAs)	________ kVp

Fluoro mAs Accuracy @ 90 kVp

Test Spec: ± 5 % or ± 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
1 mA	________ mA (±.05 mAs)	________ kVp

Fluoro mAs Accuracy @ 120 kVp

Test Spec: ± 5 % or ± 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
1 mA	________ mA (±.05 mAs)	________ kVp

6.8. X-RAY TUBE AND COLLIMATOR ALIGNMENT

This section provides instructions for the mechanical alignment of the X-ray tube and collimator assembly. All films generated in the field by this procedure shall be returned to:

Q.A. Manager, Compliance Dept.
OEC-DIASONICS
2341 South 2300 West
Salt Lake City, Utah 84119
(801) 973-6800

6.8.1. Preparation

___ Steps 1 thru 2 completed.

6.8.2. 4/6/9" Radiographic Beam Alignment

___ Steps 1 thru 14 completed.

* The exposed area when the shutters are set to the minimum field size must be within the square outline in the center of the alignment tool.

6.8.3. 6" Radiographic Beam Alignment

___ Steps 1 thru 9 completed.

* The exposed area when the shutters are set to the minimum field size must be within the square outline in the center of the alignment tool.

6.8.4. Fluoroscopic Beam Alignment

___ Steps 1 thru 4 completed.

6.9. ENTRANCE EXPOSURE CALIBRATION

6.9.1. Set-up

____ Steps 1 thru 8 completed.

____ Step 9 completed.

kVp	mA	kVp	mA
40	______	85	______
45	______	90	______
50	______	95	______
55	______	100	______
60	______	105	______
65	______	110	______
70	______	115	______
75	______	120	______
80	______		

Using the mA Limit File Editor, for each value listed in the Limit File enter the kVp index and then the mA. Enter the data obtained every five kVp from the worksheet table and then interpolate the remaining values.

When the mA Limit File Table is complete, press [ENTER]. Follow the instructions on the screen to save the editing changes.

____ Steps 10 thru 17 completed.

6.10. IMAGING SYSTEM CALIBRATION

6.10.1. General Test conditions:

__ Conditions 1 thru 8 are being observed for the tests in this section.

6.10.2. Monitor Raster Size Adjustment

__ Steps 1 thru 7 completed.

6.10.3. Camera Sizing and Optical Adjustments

6.10.3.1. Camera Rotation Axis Offset (mirror axis alignment)

__ Steps 1 thru 10 completed.

6.10.3.2. Camera Lens Aperture Setting

___ Camera lens aperture set to f/2.0.

6.10.3.3. Active Image Size (camera size adjustments)

___ Adjust the camera image size according to the Video Test Pattern Instructions.

6.10.4. Image Circular Masking

___ Steps 1 thru 3 completed.

6.10.5. Camera Electrical Adjustments

___ Conditions 1 thru 6 are being observed for the tests in this section.

6.10.5.1. 500 Volt Supply Adjustment

___ Steps 1 thru 4 completed.

6.10.5.2. Beam Discharge

___ Steps 1 thru 3 completed.

6.10.5.3. Target adjustment

___ Target voltage adjusted.

6.10.5.4. Black Level

___ Black Level Control adjusted.

6.10.5.5. Camera Video Output

Video output measured at VIDEO 1 = ________ mVp

6.10.5.6. Verify Dark Current Compensation

___ Steps 1 thru 3 completed.

6.10.5.7. Video Output with Auto-brightness Enabled

Video output measured at VIDEO 1 with Auto brightness enabled = ________ mVp.

6.10.5.8. Shading (Image Brightness Uniformity)

___ Conditions 1 thru 5 are being observed for the tests in this section.

___ Adjusted for uniform amplitude across the video waveform with horizontal sweeps normal and reversed.

6.10.6. Resolution

___ Conditions A thru D are being observed for the tests in this section.

___ Steps 1 and 2 completed.

6.10.6.1. Camera Focus and Peaking Adjustment

___ Adjust the optical focus of the camera lens.

___ Adjust the electrostatic focus R11 on the camera Power Supply PCB.

___ Adjust C-3 (peaking capacitor) on the Preamp and Yoke Assembly.

6.10.6.2. Electrostatic Focus Adjustment

Refer to Figure 6-14 for location of the focus adjustment

Adjustment is extremely sensitive and may not be required. A telescope should be used when checking or adjusting the image tube focus.

6.10.6.3. Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

(6-inch machine) - ________ linepairs/inch

(4/6/9-inch machine) - ________ linepairs/inch in 4" mode
________ linepairs/inch in 6" mode
________ linepairs/inch in 9" mode

6.10.7. Contrast Sensitivity Test

___ Conditions A and B are being observed for the tests in this section.

# of penetrometer spots discernible = ________

6.10.8. Image Noise, Correlated

___ Conditions A thru C are being observed for the tests in this section.

___ There are no discernible correlated noise patterns. This refers to system generated noise rather than "random" or thermal noise.

6.10.8.1. Video Sampling Window Size and Centering

___ Steps 1 thru 3 completed.

6.10.9. Video Level Control and Auto Technique Tests

___ Conditions A thru F are being observed for the tests in this section.

The resulting kVp readings for each of the four conditions are:

Condition	*kVp*	*Video Amplitude*
No filter	______ kVp	______ mVp
1 Copper filter	______ kVp	______ mVp
2 Copper filter	______ kVp	______ mVp
3 Copper filter	______ kVp	______ mVp
4 Copper filter	______ kVp	______ mVp

Peak output video amplitude at Video 1 + ______ (760-880mV pk each)

6.10.10. Camera Drive Chain Tension

___ Steps 1 thru 9 completed.

APPENDIX A

APPENDIX A

This appendix describes recommended test equipment and the installation and use of special equipment needed to calibrate the system:

DOSIMETER
DYNALYZER

A.1. RECOMMENDED TOOLS AND TEST EQUIPMENT

In addition to common hand tools normally in any service technicians tool kit, Table 1 lists additional tools and equipment necessary for calibration and maintenance.

TABLE 1 **TOOLS AND EQUIPMENT**

ITEM	MFR AND PART NUMBER
BNC Connectors: barrel, T, 75 ohm Terminator	as required
BNC to clip lead adapters	as required
Coax Cables	as required
BNC to Phono coax cable	as required
Pin Extractors	AMP 457445A
Oscilloscope, dual trace	Tektronix 465 or equivalent
DVM or DMM	Fluke 8020A or equivalent
Dosimeter	Keithley 35050
Dosimeter ionization chamber	Keithley 96030
High Voltage Divider (with readout)	Machlett Dynalyzer II or III
Alignment Tool	OEC 00-860368
Copper mesh tool (RMI 141)	OEC 00-900040
Telescope	Edmund Scient. 60941
Ground leakage test circuit	as required
Clock with sweep second hand	as required
Aluminum filtration tool (60 kVp)	OEC 00-860752
Copper filtration tool (80 kVp) (Qty of 2)	OEC 00-860751
DXR Kit (contains terminal and floppy drive with cables	OEC 00-870258)
Video Adapter Jack Assembly	OEC 00-870964
High voltage probe (Beckman HV-211-22 or HV-231-22)	OEC 00-900021
Daisy chain extender cable	OEC 00-870023
Spare parts kit	OEC FS-Spares-Kit
Image Diagnostics Kit	OEC 00-870598

Contains: phantom	OEC 00-870595
Printer Interface Cable Asm	OEC 00-870596
Lead Blocks	as required
12 ohm 100 watt resistor	as required
2.2 kohm resistor	as required
Penetrometer	as required
Autocalibration Interface Box	OEC 00-871350
Autocal Box/DRO III cable	OEC 00-871434
Autocal Box/DRO II cable	OEC 00-871433
Autocal Box/Analog PCB cable	OEC 00-871432

A.2. INSTRUCTIONS FOR DYNALYZER USE

This section describes the installation of the Machlett II and III Dynalyzers. For more information refer to the Calibration section of this manual.

WARNING: **When working with X-ray high voltage connections, make certain the X-ray generator is de-energized and disconnected from the ac outlet. Always ground the cable tip to chassis after removal from the connector well. Unless discharged, the cable capacitance can give a lethal shock.**

1. Prior to use, check the Dynalyzer pressure gauge for a reading of 10-15 psig.

2. Plug the Dynalyzer tank into a 120 VAC outlet and allow one hour for warmup.

NOTE: The Dynalyzer tank and digital readout must both be isolated from line ground.

3. After stabilization, check the voltages at the Dynalyzer BNC connectors. All voltages should be 0 vdc $\pm$ 0.002 vdc. The mA value can be zeroed by adjusting the MA ZERO trimpot. If not, do not attempt to use the Dynalyzer.

4. Clean the Dynalyzer wells with clean paper towels and Freon. To avoid contaminating the wells, be careful not to touch their surfaces with your fingers.

NOTE: The 5 ft H.V. jumper cables should always be stored installed on the Dynalyzer to keep the connectors clean.

5. Flip-flop the C-arm to place the X-ray tube near the Dynalyzer. Loosen the cable clamp to move the high voltage cable assembly as needed.

Remove the anode and cathode cables from the X-ray tube connections. Check the cables for polarity markings prior to removal and mark them if necessary.

6. Thoroughly clean the cable ends with Freon (if available) to remove all silicone compound. The cable connectors must not be touched after cleaning or contamination will occur.

7. Coat the cable ends with a thin layer of silicone compound. Approximately one-half teaspoon of compound should be applied to the cable connector and pins at the end of the connector. Use a clean straight edge, not your fingers, to spread the silicone compound evenly over the surface of the high voltage connector.

8. Insert the cable ends into the proper wells of the Dynalyzer. Observe proper polarity when making these connections or serious damage will occur.

9. Clean the H.V. jumper cables and apply silicone compound. Install the connectors in the wells of the X-ray tube. Check for proper polarity of the cables.

10. Check the threaded retaining rings for tightness.

NOTE: *Due to the size of the cable rings and the fineness of the thread, some care must be taken not to cross-thread the cable rings. Never force the ring if it feels jammed.*

11. Connect the Dynalyzer digital display to the Dynalyzer.

    Plug the Dynalyzer display unit into a wall outlet and turn it on. Allow at least 15-30 minutes for the instrument to thermally stabilize.

NOTE: *The Dynalyzer tank and digital readout must both be isolated from line ground.*

12. Press the reset button - all digits should display 0.

13. Connect the DVM to the BNC connector on the rear of the digital display unit. During the calibration procedure the Dynalyzer is zeroed by measuring this point.

14. Instructions for connecting the Autocal Interface Box are found in the Calibration section.

NOTE: *Use of the Dynalyzer III is generally preferred over the less accurate Model II. There are also some differences in connections and use which are discussed in the Calibration Section.*

A.3. USING THE DOSIMETER

The following equipment is needed to perform dose measurements as required in the calibration procedure:

- Keithley Model 35050 dosimeter with Model 96030 ion chamber or equivalent.
- Metric Scale
- Lead Apron
- Probe Holding Fixture

Measurement Position

The entrance exposure for the system is measured 12" (30 cm) from the input surface of the imaging assembly.

1. Place the holding fixture on the image intensifier assembly faceplate and place the ion chamber in the fixture.

NOTE: *To protect the image intensifier from being over driven, place a lead sheet or several folds of lead apron over the faceplate, under the holding fixture.*

2. Adjust the chamber such that its flat plane is parallel to the face of the image assembly and adjust to 12" (30 cm) from the input surface of the image intensifier.
3. Verify the aluminum collimator filtration plate is installed.
4. Make a fluoro exposure of sufficient duration to allow positioning of the active volume of the chamber in the center of the useful beam.
5. Adjust the collimator manual controls to maximum open positions.
6. Determine the barometric pressure and temperature, and record these on the worksheet. If "Station Pressure" is not available, calculate the absolute pressure and record on the worksheet. Record the altitude used for the absolute pressure calculation.
7. Make an exposure of at least 10 seconds when measuring the exposure rate with the dosimeter.
8. Calculate the actual dose using the correction formulas for the barometric pressure, temperature and gravity corrections.
9. Some dosimeters require that a correction factor be applied. Refer to the manufacturer's operating instructions.

A.3.1. Dose Rate Calculations

The measurement of an exposure in roentgens usually requires the determination of the mass of air in a known volume. Since the Model 96030A is a vented ion chamber and open to the atmosphere, the mass of air inside will depend upon the temperature and absolute pressure of the ambient air.

The Model 96030A transfer function is specified at a temperature of 22 degrees C and a pressure of 760 mm of mercury. The basic accuracy of the 96030A/35050 system is thus ± 5 percent at 22° C and 760 mm of mercury (sea level).

The sum of the dosimeter accuracy plus an anticipated ± 2 percent setup accuracy requires that the upper limit of dose rate be set at 4.63 R/minute. This assures that, under worst case conditions, the actual dose is less than 5.0 R/minute.

To further compensate for temperature and pressure variations, the output reading of the Model 35050 must be corrected by multiplying the measured dose rate by a correction factor. Find the correction factor in Table 2.

Actual Dose Rate = Measured Dose Rate X Correction Factor

If you cannot find the correct temperature and pressure in the table, then use the following formula:

$$\text{Actual Dose Rate} = \frac{760}{P} \times \frac{273.15 + T}{295.15} \times \text{Measured Dose Rate}$$

where:

P = Absolute Pressure in Millimeters of Mercury.
T = Temperature in Degrees C.

The "Absolute Pressure" in the above equation refers to the "Station Pressure" obtained from the local airport. Most airports and barometers report or indicate barometric pressure corrected to Sea Level ("Corrected Barometric Pressure"). The technician must specifically ask for and be sure that the Absolute Pressure is obtained. If the Station Pressure is not available from the local weather bureau, the Corrected Barometric Pressure may be used and corrected backwards to Absolute Pressure. This requires a knowledge of the local altitude. Refer to the specific instructions on any barometers used.

NOTE: Gravity and altitude are minor corrections compared with temperature and pressure.

A.4. SERVICE LOG

The service log is found on the following pages. Enter the appropriate information when service or maintenance is performed.

Operator/Field Service System Log

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

UPDATE

1. X-RAY HAND CONTROL UPGRADE, FILTER PCBs

To correct potential noise problems, small filter PCBs, 876457-01 & -02, were added to the X-ray and Footswitch cables just inside the Power Panel Assembly (see Figure 1 and Figure 2). The Hand Control uses -01, and the Footswitch uses -02.

Further wiring and cable modifications were also implemented such as heat shrink tubing, a new power panel harness, spiral wrapping, protective grommets, and (for the Hand Control Cable) increased cable length and shield removal. Refer to FSB #93-004 and the Field Service X-Ray Cabling Upgrade Kit , PN 00-876517-01.

Figure 1 - CONN Filter PCB's, Interconnect Diagram, Zone C-1, D-2

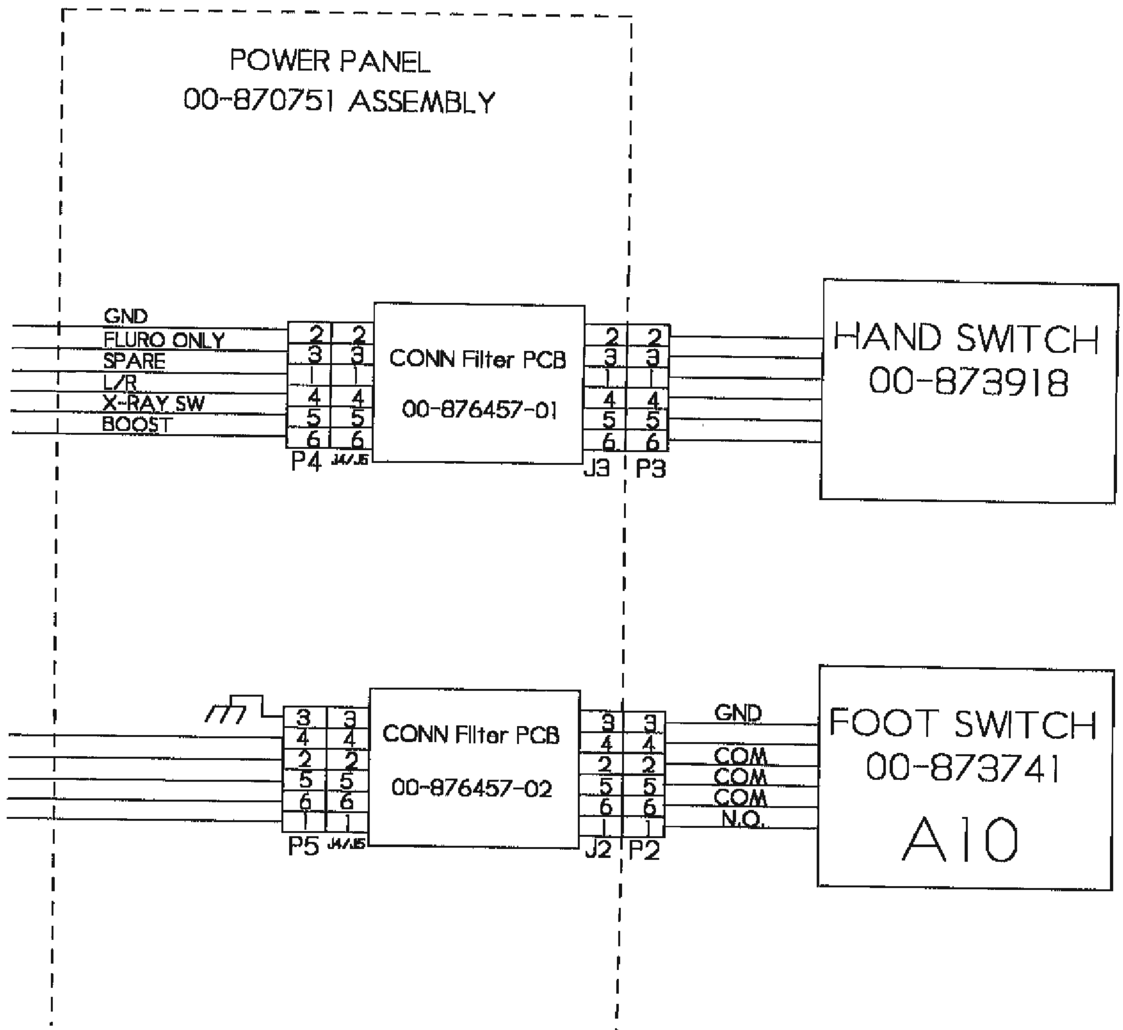
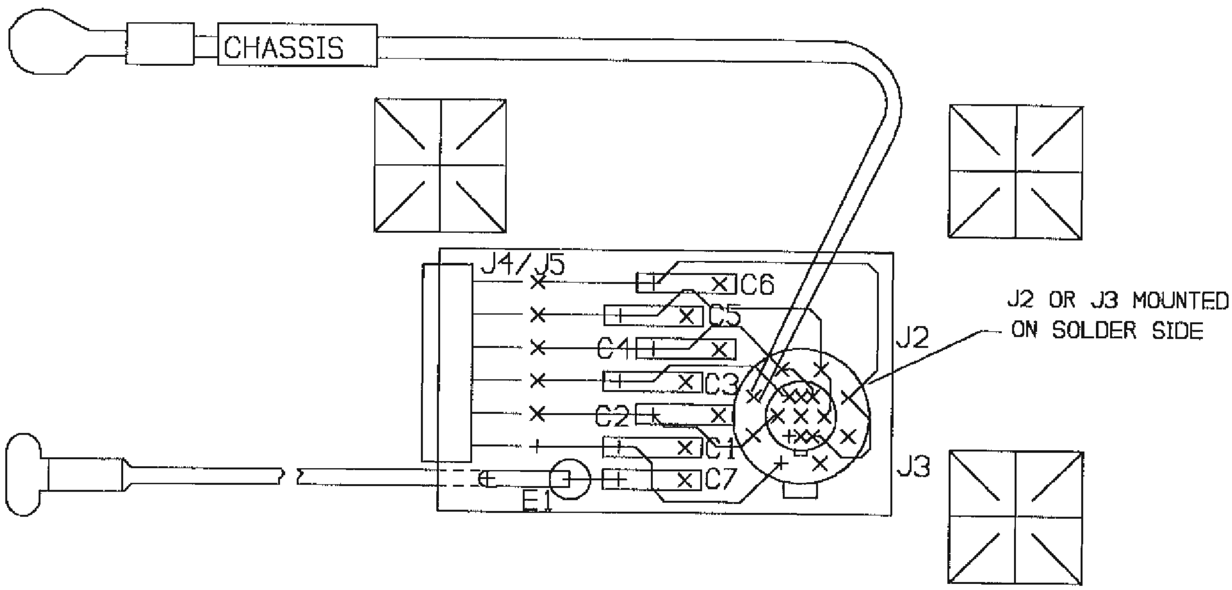


Figure 2 - CONN Filter PCB Assembly



00-876457-01 & -02

2. Standard Equipment

The table below supersedes the Standard Equipment table on p. 6, *Introduction*, of the 9400 Service Manual.

ITEM	PART NUMBER*
C-arm Assembly	00-873600-01
Monitor cart Assembly	00-873000-01
Collimator and Plate Assembly (6-inch) (4/6/9-inch)	 00-873919-04 00-873919-03
Image Intensifier Asm w/Vidicon (6-inch) (4/6/9-inch)	 00-874514-01 00-874515-01
Accessory Parts Kit	00-873921-01
Foot Switch Assembly (Dual Stage)	00-874360-02
30 cm Extension Spacer	00-837201-01

*The system being serviced may have a different part number than what is listed here. Call service support for latest part numbers.

2.1 Optional Cassette Holder

Note that the Cassette Holder is now optional; it is *not* standard equipment with the 9400 (sizes listed below).

ITEM	PART NUMBER
Cassette Holder (6-inch standard) (6-inch metric) (9-inch standard) (9-inch metric)	 00-861095-03 00-871096-03 00-871138-03 00-871139-03