APPENDIX A

Recommended Tools and Test Equipment

Installation and Use of Special Equipment

Dosimeter

Printer Installation

Terminal Installation and Use

Service Log

This appendix describes recommended test equipment and the installation and use of special equipment needed to calibrate the system:

DOSIMETER
DYNALYZER
FLOPPY DISK DRIVE (INCLUDED IN DXR KIT)

This appendix also contains special instructions for connecting a terminal and printer to the system, and using the terminal menus to access special software.

NOTE: *Calibration must be current on the Dynalyzer, Dynalyzer Digital Display and the Dosimeter.*

A.1 Recommended Tools and Test Equipment

In addition to common hand tools normally in any service technicians tool kit, Table A-1 lists additional tools and equipment necessary for calibration and maintenance.

TABLE A-1

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 General 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 +/- .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.

    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 30 cm (12 inches) 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 30 cm (12 inches) 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 hence open to the atmosphere, the mass of air inside will depend upon the temperature and absolute pressure of the ambient air.

Table A-2 Temperature and Pressure Correction Factors for a vented ion chamber such as the Keithley Model 96030A.

Pressure in mm Hg	Temperature (in degrees Celcius)																					
mm	20	21	22	23	23.5	24	24.5	25	25.5	26	26.5	27	27.5	28	28.5	29	29.5	30
630	1.202	1.206	1.211	1.215	1.217	1.219	1.222	1.224	1.226	1.228	1.230	1.232	1.234	1.237	1.239	1.241	1.243	1.245
631	1.200	1.205	1.209	1.213	1.215	1.217	1.220	1.222	1.224	1.226	1.228	1.230	1.232	1.235	1.237	1.239	1.241	1.243
632	1.198	1.203	1.207	1.211	1.213	1.216	1.218	1.220	1.222	1.224	1.226	1.228	1.231	1.233	1.235	1.237	1.239	1.241
633	1.196	1.201	1.205	1.209	1.211	1.214	1.216	1.218	1.220	1.222	1.224	1.226	1.229	1.231	1.233	1.235	1.237	1.239
634	1.195	1.199	1.203	1.207	1.210	1.212	1.214	1.216	1.218	1.220	1.222	1.224	1.227	1.229	1.231	1.233	1.235	1.237
635	1.193	1.197	1.201	1.205	1.208	1.210	1.212	1.214	1.216	1.218	1.220	1.223	1.225	1.227	1.229	1.231	1.233	1.235
636	1.191	1.195	1.199	1.204	1.206	1.208	1.210	1.212	1.214	1.216	1.219	1.221	1.223	1.225	1.227	1.229	1.231	1.233
637	1.189	1.193	1.197	1.202	1.204	1.206	1.208	1.210	1.212	1.214	1.217	1.219	1.221	1.223	1.225	1.227	1.229	1.232
638	1.187	1.191	1.196	1.200	1.202	1.204	1.206	1.208	1.210	1.213	1.215	1.217	1.219	1.221	1.223	1.225	1.227	1.230
639	1.185	1.189	1.194	1.198	1.200	1.202	1.204	1.206	1.209	1.211	1.213	1.215	1.217	1.219	1.221	1.223	1.226	1.228
640	1.183	1.188	1.192	1.196	1.198	1.200	1.202	1.205	1.207	1.209	1.211	1.213	1.215	1.217	1.219	1.221	1.224	1.226
641	1.182	1.186	1.190	1.194	1.196	1.198	1.201	1.203	1.205	1.207	1.209	1.211	1.213	1.215	1.217	1.220	1.222	1.224
642	1.180	1.184	1.188	1.192	1.194	1.197	1.199	1.201	1.203	1.205	1.207	1.209	1.211	1.213	1.216	1.218	1.220	1.222
643	1.178	1.182	1.186	1.190	1.193	1.195	1.197	1.199	1.201	1.203	1.205	1.207	1.209	1.212	1.214	1.216	1.218	1.220
644	1.176	1.180	1.184	1.189	1.191	1.193	1.195	1.197	1.199	1.201	1.203	1.205	1.208	1.210	1.212	1.214	1.216	1.218
645	1.174	1.178	1.183	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.202	1.204	1.206	1.208	1.210	1.212	1.214	1.216
646	1.172	1.177	1.181	1.185	1.187	1.189	1.191	1.193	1.195	1.198	1.200	1.202	1.204	1.206	1.208	1.210	1.212	1.214
647	1.171	1.175	1.179	1.183	1.185	1.187	1.189	1.192	1.194	1.196	1.198	1.200	1.202	1.204	1.206	1.208	1.210	1.212
648	1.169	1.173	1.177	1.181	1.183	1.185	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.202	1.204	1.206	1.209	1.211
649	1.167	1.171	1.175	1.179	1.182	1.184	1.186	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.202	1.205	1.207	1.209
650	1.165	1.169	1.174	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.201	1.205	1.207
651	1.163	1.168	1.172	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.193	1.195	1.197	1.199	1.201	1.203	1.205
652	1.162	1.166	1.170	1.174	1.176	1.178	1.180	1.182	1.184	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.201	1.203
653	1.160	1.164	1.168	1.172	1.174	1.176	1.178	1.181	1.183	1.185	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.201
654	1.158	1.162	1.166	1.170	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.187	1.189	1.191	1.193	1.195	1.197	1.199
655	1.156	1.160	1.165	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.187	1.189	1.191	1.194	1.196	1.198
656	1.155	1.159	1.163	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.188	1.190	1.192	1.194	1.196
657	1.153	1.157	1.161	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.180	1.182	1.184	1.186	1.188	1.190	1.192	1.194
658	1.151	1.155	1.159	1.163	1.165	1.167	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.192
659	1.149	1.153	1.157	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190
660	1.148	1.152	1.156	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.187	1.189
661	1.146	1.150	1.154	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.177	1.179	1.181	1.183	1.185	1.187
662	1.144	1.148	1.152	1.156	1.158	1.160	1.162	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185
663	1.142	1.146	1.150	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183
664	1.141	1.145	1.149	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181
665	1.139	1.143	1.147	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179
666	1.137	1.141	1.145	1.149	1.151	1.153	1.155	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178
667	1.135	1.140	1.144	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176
668	1.134	1.138	1.142	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174
669	1.132	1.136	1.140	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172
670	1.130	1.134	1.138	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171
671	1.129	1.133	1.137	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169
672	1.127	1.131	1.135	1.139	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167
673	1.125	1.129	1.133	1.137	1.139	1.141	1.143	1.145	1.147	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166
674	1.124	1.128	1.132	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164
675	1.122	1.126	1.130	1.134	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162
676	1.120	1.124	1.128	1.132	1.134	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160
677	1.119	1.123	1.127	1.131	1.133	1.135	1.137	1.139	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159

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 degrees 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 A-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 that gravity and altitude are minor corrections compared with temperature and pressure.*

A.4 Connecting A Printer to the Monitor Cart

The Report Generator Software, and also Shot Logging, can produce printed reports using any of a number of compatible printers. Contact your field service representative for more information on specific printers which can be used. The printer interface cable (OEC-Diasonics P/N 870596) will work with some of them.

The printer should have a standard parallel interface. The corresponding cable connector on the monitor cart is a 25 pin D-type which is labeled AUX.

The AUX connector on the rear of the monitor cart does not provide a standard interface. The signals provided at the pins on this connector are listed below in table A-3.

Aux Connector Printer Interface **Table A-3**

SIGNAL	CONNECTOR PIN
Strobe/	1
D0	2
D1	3
D2	4
D3	5
D4	6
D5	7
D6	8
D7	9
Ack	14
Fault/	15
Init	16
Busy	17
Ground	19,20,21,22,23,24,25
Not used	10-13 and 18

A.5 Floppy Disk Drive Installation

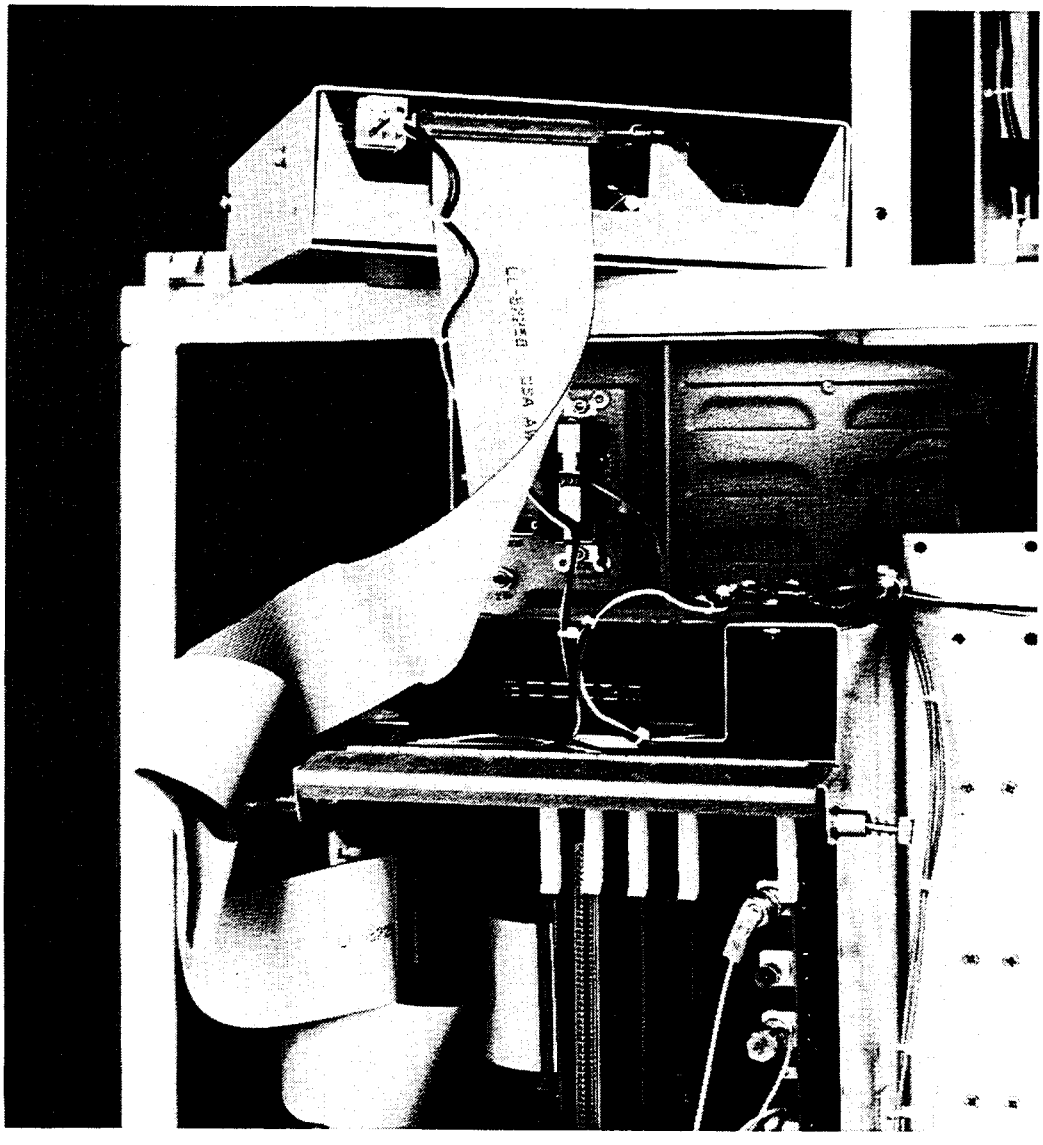
Refer to Figure 1. An 8-inch portable floppy disk drive is included in the DXR Field Kit.

The floppy drive must be installed to use diagnostic software not resident in the system, to install new versions of disk software or to add additional programs to the hard disk. The floppy drive requires an interface to the system through the Disk Controller PCB and is supplied with operating power by a molex connector.

Follow this installation procedure:

1. Unplug the monitor cart from the wall outlet.
2. Remove the left side and front panels.
3. Place the floppy drive conveniently on the left shelf top.
4. Locate the square molex connector with three wires: red, yellow, and black. This will be tied down just in front of the hard disk drive. Connect this to the mating connector on the floppy drive.
5. Connect the 50 pin ribbon cable between the floppy drive and the 50 pin connection on the OMT Adapter Board. This is a 1.5" x 3" board attached just inside the card cage on the upper left.
6. The floppy disk should be inserted into the drive with the label side facing the drive closing lever (facing up).
7. If the drive lever is closed with a floppy disk in place, the monitor cart will attempt to boot from the floppy disk when the cart power circuit breaker is turned on.

Figure 1 - *The floppy disk drive is shown connected to the monitor cart in this photo.*



A.6 External Terminal Installation and Use

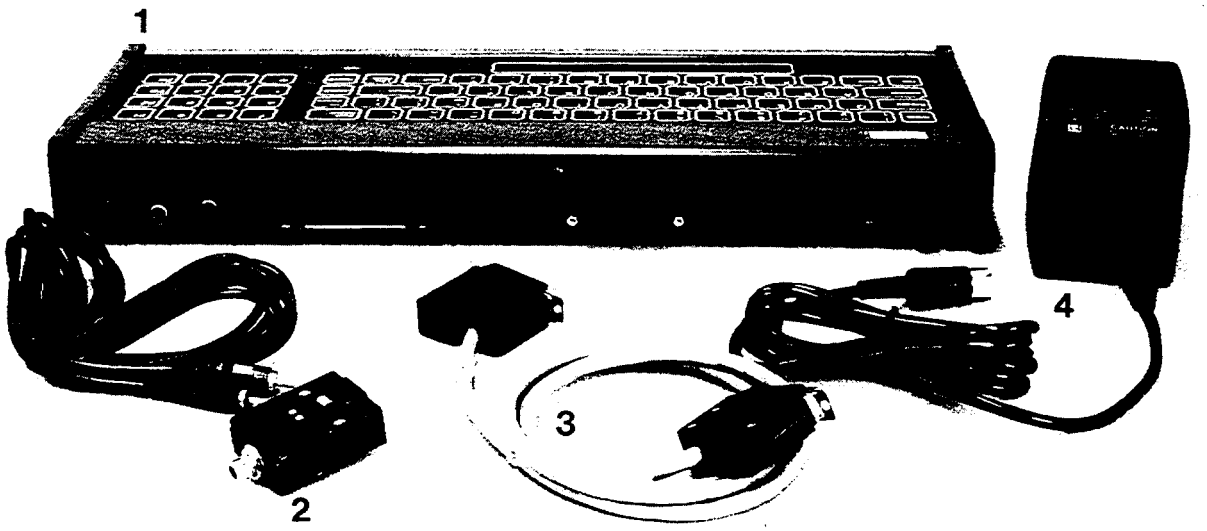
Several of the diagnostic software procedures and some of the specialized application software requires the use of an external computer terminal. If one is available on site it may be used with the proper communications protocol. This is discussed later in this section under "Installing Other Terminals".

Because of the variations in available terminals, for most field service applications it is strongly recommended that the DXR Field Service Kit is used.

The DXR Kit contains a keyboard terminal, power supply, modified RS-232 cable, and a video cable. The video jack adapter (P/N 870964), available separately, is also required. These parts are connected to the monitor cart to provide a computer terminal which uses the left monitor cart screen for the terminal monitor.

Figure 2 - *Components of the keyboard terminal are shown in this photo.*

1) Terminal/keyboard unit; 2) Video Out to VTR plug adaptor; 3) Interface cable to RS232 connector; 4) Power module.



A.6.1 Interfacing the Keyboard Terminal

1. Connect the keyboard or "RCA" labeled end of the interface cable (P/N 870257) to the keyboard terminal and the DXR labeled end to the monitor cart connector labeled "RS-232 Interface".

2. Clip the video jack adapter (P/N 870964) into the VTR connector on the rear of the monitor cart. Connect the video coax cable between the RCA-type connector on the adapter and the video out jack on the keyboard terminal.

3. Plug the power module into a 110 VAC power source and connect it to the keyboard unit.

4. Turn on the cart power and service breakers.

5. Press VTR Review to display keyboard terminal video on the left monitor.

A.6.2 Configuring the Keyboard Terminal

The keyboard will remember the communications setup for several weeks before it must be reinstalled. *Note: if the keyboard has been used within the last two weeks, skip ahead to "Activating Communications".* In the following instructions, type the keys indicated in the [ ] brackets.

1. Turn on the keyboard switch.

2. Type [2].

3. Type [3].

4. Follow the on-screen instructions to produce the following display on the monitor screen:

0 - Previous Menu	
1 - Screen Format	80
2 - TV Channel	3
3 - Cursor	Blink
4 - Line Wrap	On
5 - Auto Line End	Off
6 - Auto Screen Blank	On
7 - Status Line	On
A - Key Beep	On
B - Alpha Lock	On
C - User 1 Key	Select
D - User 2 Key	Menu

5. Once these options are correct as indicated above, type [0].

6. Type [3].

7. Another display will appear. Set it up as shown:

0 - Previous Menu	
1 - Communications Type	Direct
2 - Baud Rate	9600
3 - Data Bits	8
4 - Parity	None
5 - Stop Bits	2
6 - Duplex	Full
7 - Handshaking	Off

8. Once these options are correct type [0].

9. Type [0] again.

A.6.3 Activating communications

1. Type [3], then type [H].

2. The line at the bottom of the monitor should now read:

LINE SELECT MENU

3. After booting the system with the keyboard terminal installed, the monitor will display the line:

Press ESC to return to menu.

A.7 Service Log

The service log is found on the next pages. Enter the appropriate information when service or maintenance is performed.

OEC-DIASONICS, INC.

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

OEC-DIASONICS, INC.

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

SECTION 9
CALIBRATION

9.1 Introduction

This section contains procedures used to test and calibrate the OEC-Diasonics Series 9000 System.

The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9000 System.

9.1.1 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 have been properly installed and correctly wired. It is further assumed that all subassemblies are without defect and 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 for use before beginning the calibration.

9.1.2 Test and Calibration Outline

The calibration procedures are presented in the following order:

i. Preparation
ii. Electrical Checks
iii. Mechanical Checks
iv. Functional Checks
v. Beam alignment
vi. X-ray Calibration
vii. Dose Calibration
viii. Imaging Chain
ix. Accuracy Verification
x. Special Image Processing and Monitor Cart Tests

9.2 Safety Precautions

WARNING: **The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9000 System.**

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.

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.

9.3 Preparation and Setup

9.3.1 Record the Test Equipment Used

Record the information requested on the Worksheet.

9.3.2 Preparation and Inspection

1. To prevent the mainframe from rolling, position the front and rear wheels at right angles to each other . To keep the monitor cart from rolling, engage the monitor cart wheel locks.
2. Turn the keyswitch to OFF.
3. Unplug the power cord on the monitor cart.
4. Inspect the interconnect cable; make sure the interconnect cable is permanently attached by its bracket to the monitor cart.
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 conductive casters on both the mainframe and the monitor cart for proper pressure and freedom of movement.
8. Remove the front, rear, and left side panels from the monitor cart and the left, right and rear covers from the mainframe.
9. Connect the terminal to the mainframe as instructed in the Appendix.

9.4 Electrical Tests

9.4.1 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 100 uA (or other value specified by the user) in any of certain standard test configurations. *Leakage currents in excess of 100 uA may be recognized as unsafe in equipment of this type.*

1. Unplug the line cord.

2. Complete the measurement according to the instructions applicable to the available test device.

3. If leakage currents exceed the user's specifications during any of the preceding tests, the system under test has failed this test section. Document the fault and corrective action taken on the worksheet.

9.4.2 Ground Continuity

1. Disconnect the power cord and connect the interconnect cable between the monitor cart and the mainframe.

2. Check the continuity of the system ground between the mainframe and the monitor cart. Resistance shall be less than 0.5 ohms.

3. Measure the continuity of each power plug ground pin to its corresponding chassis. Resistance shall be less than 0.5 ohms.

9.4.3 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:

$$100\ (Vn - V1)/\ (V1)$$

where: Vn = No load voltage
V1 = 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.

9.4.4 Monitor Cart Power Supplies

1. Unplug the system power cord from the wall outlet.

2. Inspect the following power supply connections to the monitor cart electronics:

Disk Controller PCB supply	P-10
Hard disk power supply	P-3
I/O Dist.-Video Switching PCB	P-2 & P-3
Front Panel Processor PCB	J-21
Black and yellow wires	TV monitors

3. Plug the power cord into the wall. Turn on the CART POWER circuit breaker. Verify that the three cooling fans in the base of the cart are running.

4. Measure the output of the TV monitor power supply. It should measure +24 volts DC.

5. Measure the following voltages relative to DC Common (PS-1 pin 7):

PS-1 pin 12	+5 volts DC	red wire
PS-1 pin 6	+15 volts DC	gray wire
PS-1 pin 5	-15 volts DC	violet wire
PS-1 pin 4	+24 volts DC	yellow wire
PS-1 pin 3	-5 volts DC	blue wire

6. Check for the correct AC line voltage at the rear monitor cart AUX outlets.

9.4.5 Mainframe Power Supplies

1. Turn on the mainframe keyswitch.

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

WARNING: * F2 and F3 carry line voltage whenever the power cord is plugged in.

9.5 Mechanical Checks

In the steps below, check for ease of movement without excessive play.

1. Check the **foot lever and steering handle** for proper movement. Then lock the C-arm in place by setting the wheels at right angles to each other.

2. Check **Wig Wag** - horizontal swing of the C-arm from side to side.

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 proper action of 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. 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. Rotate the **L-arm** 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

9.6 Functional Checks

9.6.1 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 front panel. Refer to what these codes mean in the service sections of this manual.

3. Observe the Boot Codes on the mainframe LED panel and the Progress Codes on the monitor cart LED display as the operating software is loaded and the system is initialized.

4. If any of these codes remains on the LEDs and the system fails to complete its booting and initialization, refer to the listing of boot codes in the Mainframe Service Section or the listing of progress codes in the Monitor Cart Service Section.

9.6.2 Emergency Off and Processor Reset Test

1. With the system powered up, depress the **left** EMERGENCY OFF switch and make sure that the interlock circuit breaks and the LED display reads *INTERLKS BROKEN*.

2. Press any key, and then press the START switch to resume operation.

3. Again, with the system powered up, repeat step one using the **right** EMERGENCY OFF switch.

9.6.3 Status Mode Tests

Refer to the Mainframe 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 *LED 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).

9.6.4 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 make sure that the *NO CASSETTE* message does not appear.
5. Remove the cassette and observe that the *NO CASSETTE* does appear.
6. Rotate the C-arm to return the image intensifier below the X-ray tube.

9.6.5 Verify Operation of Mainframe Controls

WARNING: These tests produces X-rays. Take the 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 an LED 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 LARGE FIELD switch removes the 6-inch collimator by listening for the "thunk" sound produced when you press the switch.

5. Verify that the X-RAY ON lamps on the X-ray tube assembly, control panel and monitor cart light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

6. Verify operation of the footswitch.

7. Verify that early footswitch release will terminate the FILM exposure. The message *FOOT RELEASED* should appear on the control panel display.

9.6.6 Field Solenoid Position Test

This test verifies that the system can sense the position of the SMALL FIELD collimator.

1. Remove the bottom filtration plate on the collimator.

2. Place the system in the FLUORO mode and select the SMALL FIELD. Verify that the flipper returns to the 6-inch position.

3. Reach into the collimator and move the flipper (small field) collimator out of the center.

   Verify that the control panel displays the message *FLIPPER STUCK.*

4. Release the collimator and allow it to return to center.

5. Place the system in the FILM mode and select the LARGE FIELD.

   Verify that the flipper (small field) collimator moves out of the center.

6. Reach into the collimator and hold the flipper in the LARGE FIELD position. While holding the flipper in this position, select the SMALL FIELD from the front panel. The control panel should display the message *FLIPPER STUCK.*

7. Replace the filtration plate on the collimator.

9.6.7 Verify Controls in MANUAL FLUORO

1. Select MANUAL FLUORO mode.

2. Verify that kVp and mA can be controlled using the control panel knobs.

9.6.8 AUTO FLUORO Tests

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

1. Select AUTO FLUORO mode.
2. Switch to live video using the VIDEO BYPASS switch (on the monitor cart rear) and verify that true live video appears on the left monitor and that the TV monitors do not lose video sync.
3. Switch the VIDEO BYPASS switch to NORMAL.
4. Make a fluoro exposure and transfer the image to the right-hand monitor.
5. Make another exposure. The image will appear on the left monitor.
6. 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. 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 one set 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.

9. Verify operation of the left monitor's remote contrast and brightness controls on the mainframe control panel. (Set the left contrast control near the monitor screen to REMOTE).

9.6.9 Fluoro Boost Option

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

1. Enable BOOST on the control panel (if provided). Then to make the exposure, press down into the second position on the right footswitch.
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 image doesn't "burn out" or appear too dark.

9.6.10 Pulsed Operation

1. Enter the PULSE FLUORO mode.
2. Press X-ray On and verify pulsed operation when the button is pressed.

9.6.11 Verify Fluoro Timer and Timer Reset

1. In fluoro mode the accumulated exposure time is displayed in the center of the LED 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 should stop but the accumulated exposure display should not reset.
3. Press and hold the ALARM RESET for three full seconds. The accumulated timer display should reset to 0.

9.7 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

9.7.1 Preparation

1. Position the X-ray tube/image tube axis at a 45-degree angle to the floor. *Refer to Figure 9-1.*

2. Attach the beam alignment fixture and a loaded film cassette to the image intensifier assembly.

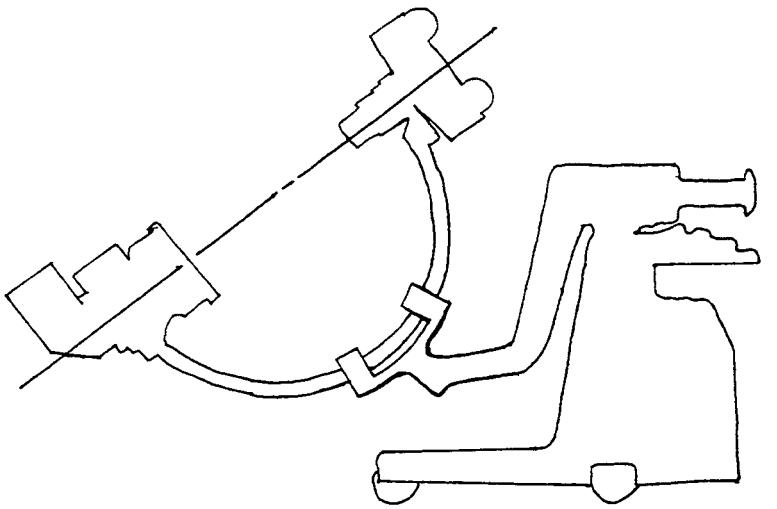


Figure 9-1 - *Position the imaging axis at a 45-degree angle to the floor.*

9.7.2 Radiographic Beam Alignment

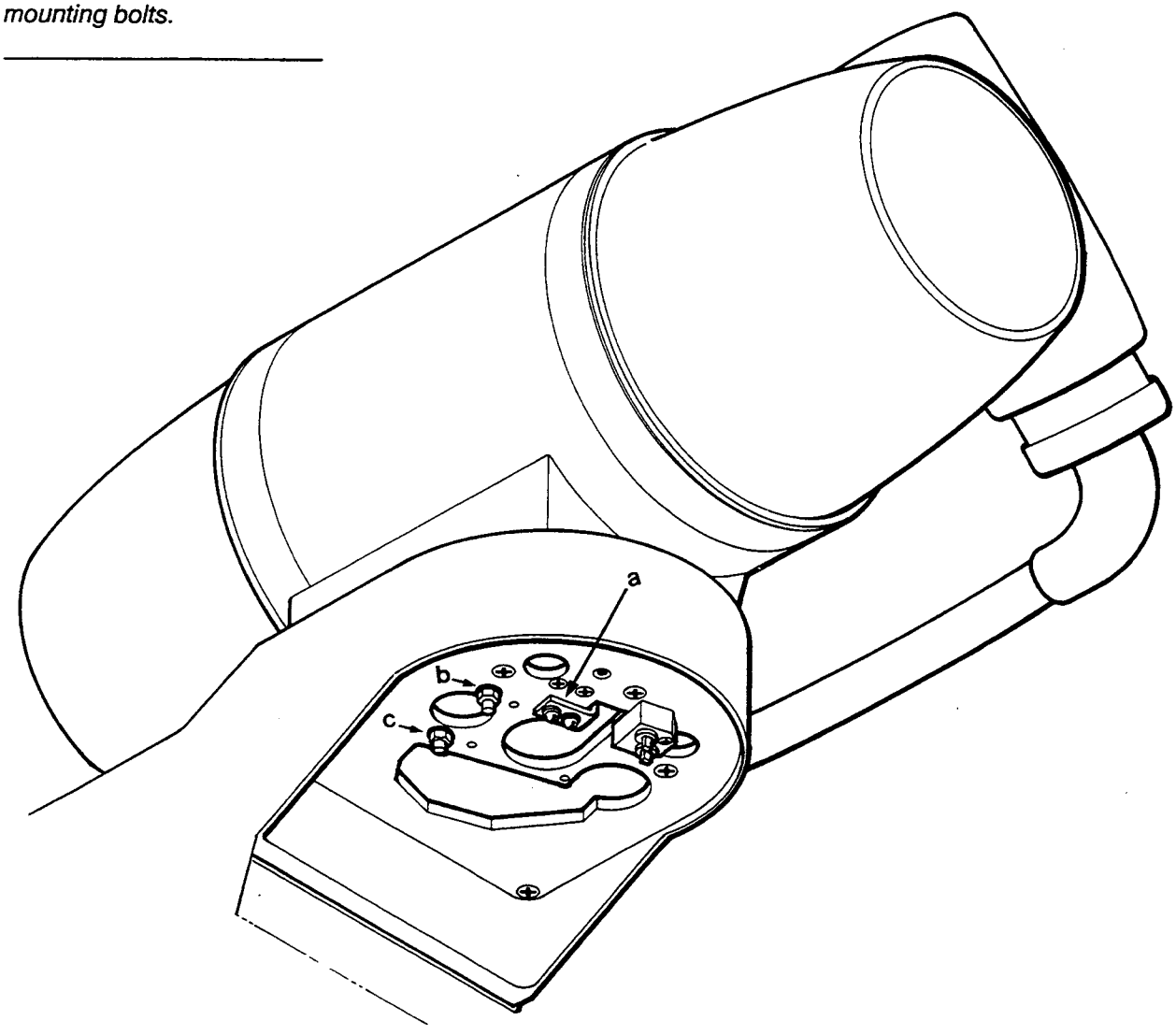
WARNING: This procedure produces X-rays. Take the appropriate precautions.

1. Set a radiographic technique of 50 kV 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 9-2 - *Adjust the shutter stop and the solenoid mounting bolts.*



4. Verify that the exposed area covers the entire large field.

5. If the beam is occluded 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:

   1. Remove the screws and cover plate from the X-ray head mounting assembly.

   2. 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.

   3. Make exposures as needed to verify the beam position.

   4. When the large field is properly centered, carefully retighten the locking screws avoiding any movement of the X-ray head as you tighten. Fine readustments may be needed as the eccentrics are tightened into place.

6. Remove the collimator assembly from the X-ray head, and select the small field.

7. Making exposures as required, adjust the 6-inch flipper stop (a) and the shutter solenoid mounting bolts (b & c) to center the 6-inch beam on the beam alignment fixture. *Refer to Figure 9-2.*

8. Check that the microswitch still functions properly.

9. Reinstall the collimator. Select the 6" field and make a radiographic exposure. Select the Large field and make another exposure on the same film.

   Check that the alignment of both fields is correct.

10. Complete the information on the film label and attach it to the upper right hand corner of the developed film.

11. Select the LARGE FIELD. Adjust the leaf collimator shutters to 6 x 6 inches and make an exposure.

12. Measure the actual size of the exposed area on the film. If necessary, loosen the set screws on the shutter adjustment knobs and adjust the collimator knobs to correspond to that size.

13. Tighten all set screws.

14. Set the radiographic technique to 50 kV and 1 mAs.

15. Make multiple exposures on a film with the shutters set to minimum, 4", 6" and 8". Label one shutter direction X and the other Y.

16. Measure the actual dimensions of the exposed areas. *The measured and actual dimensions should coincide within +/- 0.5 inch.*

    The dimensions of each field shall be as follows:

Minimum field -	less than 1.97", square *
4-inch field -	4" +/- 0.50", square
6-inch field -	6" +/- 0.50", square
8-inch field -	8" +/- 0.50", square

    * 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.

    Note: The corners of the 8" field will be clipped by the 10" collimating ring on 6" image intensifiers.

17. Record the measured values on the supplied label. Attach the label to the film.

18. On the exposed film obtained in step 15, mark each corner of the 6" area with a pen. Using a straight edge, connect the dots diagonally. *The intersection of the diagonal lines should fall within the center circle on the beam alignment fixture.*

19. Install the 0.5 mm aluminum filter on the collimator.

9.7.3 Fluoroscopic Beam Alignment

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

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. Set the video selector switch on the rear of the monitor cart to BYPASS.

5. 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 fluoroscopic test reticle should be visible around the entire input area of the image intensifier tube.

6. Return the video selector switch to NORMAL.

9.8 X-ray Calibration

9.8.1 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 is removed, disabling mA servo.
2. A series of exposures is 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.

Overview: mA/kVp Technique Calibration

1. mA servos are enabled (the mA jumper is replaced).
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.

9.8.2 Connections

Refer to Figures 9-3 and 9-4.

Connect the Dynalyzer III High Voltage Unit, Digital Display (DRO) III, Autocal Interface Box, and DVM to the mainframe electronics as shown in Figure 9-3.

NOTE: Refer to the general instructions for the Dynalyzer in the Appendix.

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.

Dynalyzer II

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.

Autocal Interface

Connect the autocal interface box to connectors J1 and J2 on the Analog Support PCB (cable part number 00-871432).

Figure 9-3 - *Connections between the Analog PCB and the calibration equipment.*

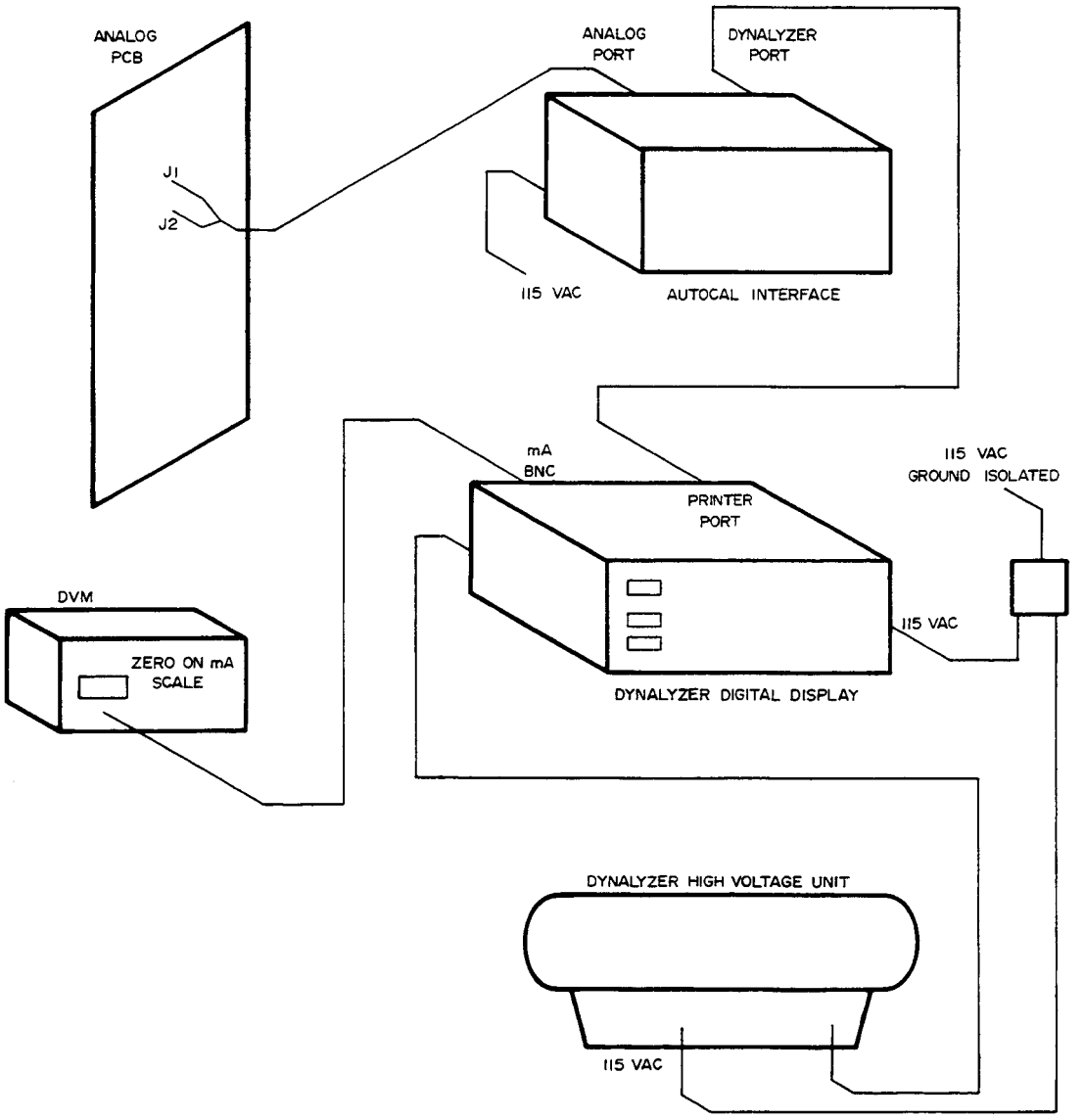


Figure 9-4 - *Connections are made between the back of the Analog PCB and the AutoCal Interface Box.*

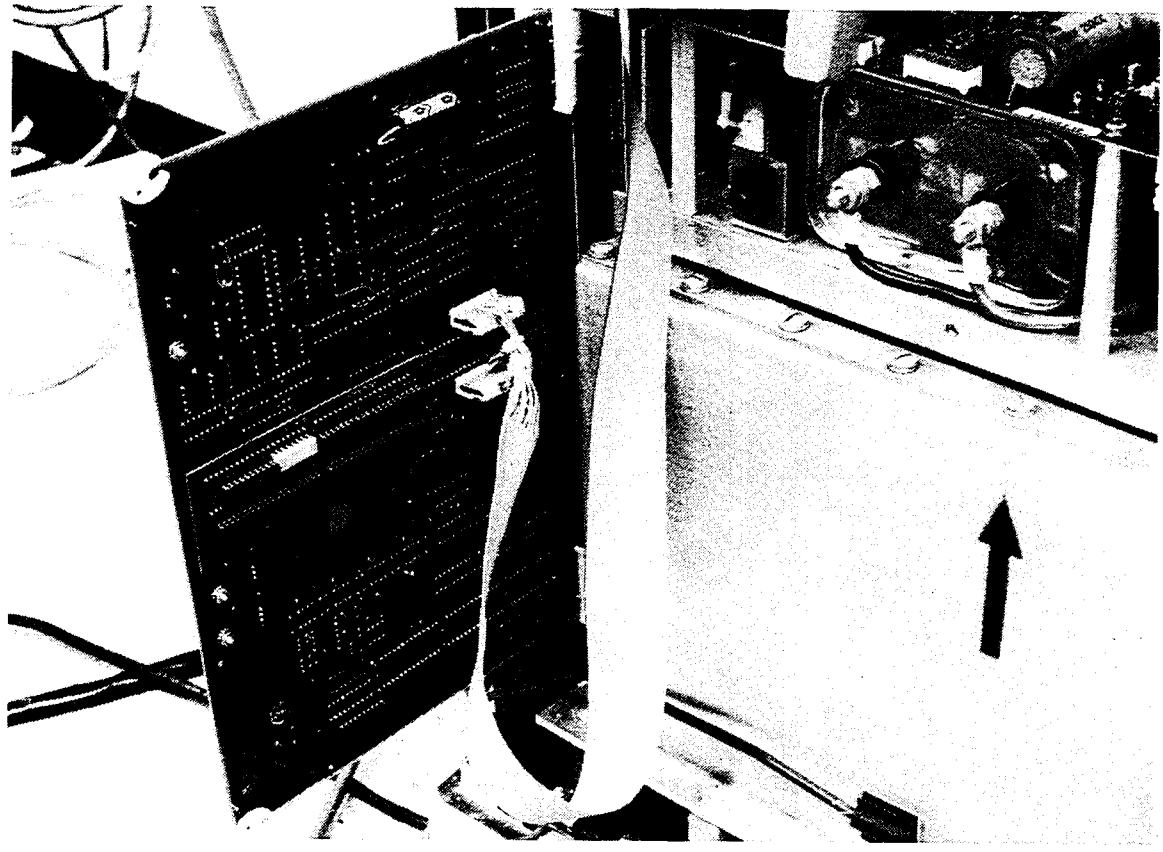
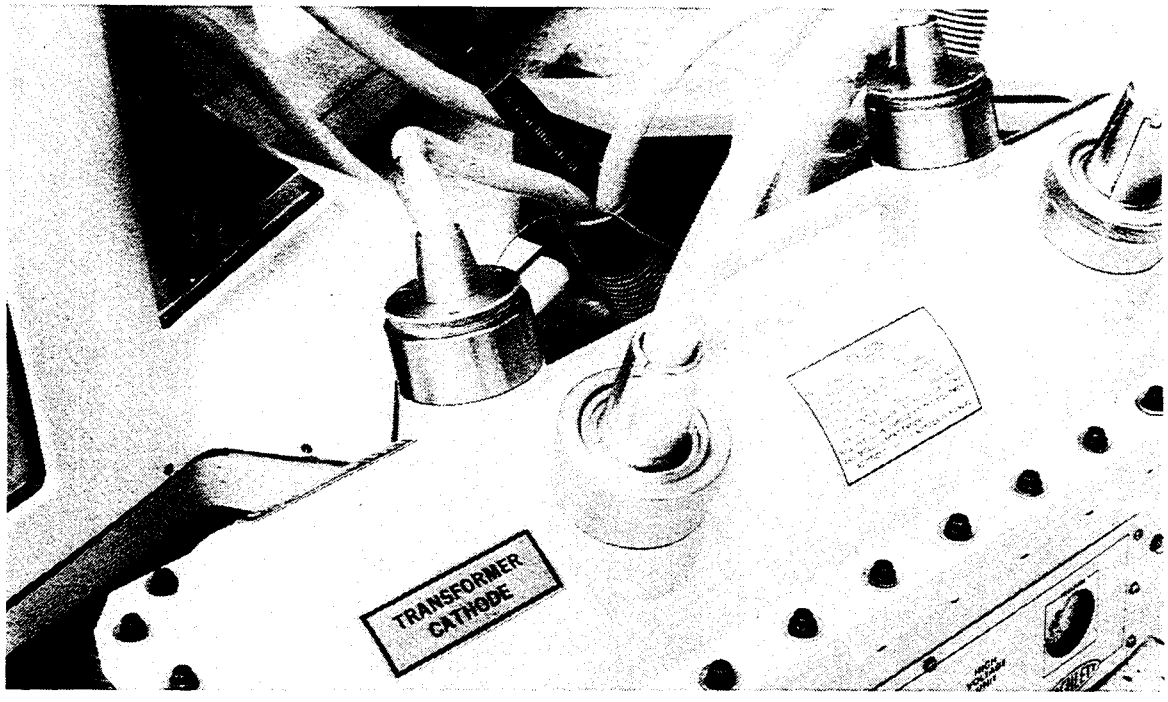


Figure 9-5 - *Refer to the Appendix for instructions on making the high voltage connections to the Dynalyzer High Voltage Unit.*



9.8.3 Setup

NOTE: Refer also to the general instructions for Dynalyzer use in the Appendix.

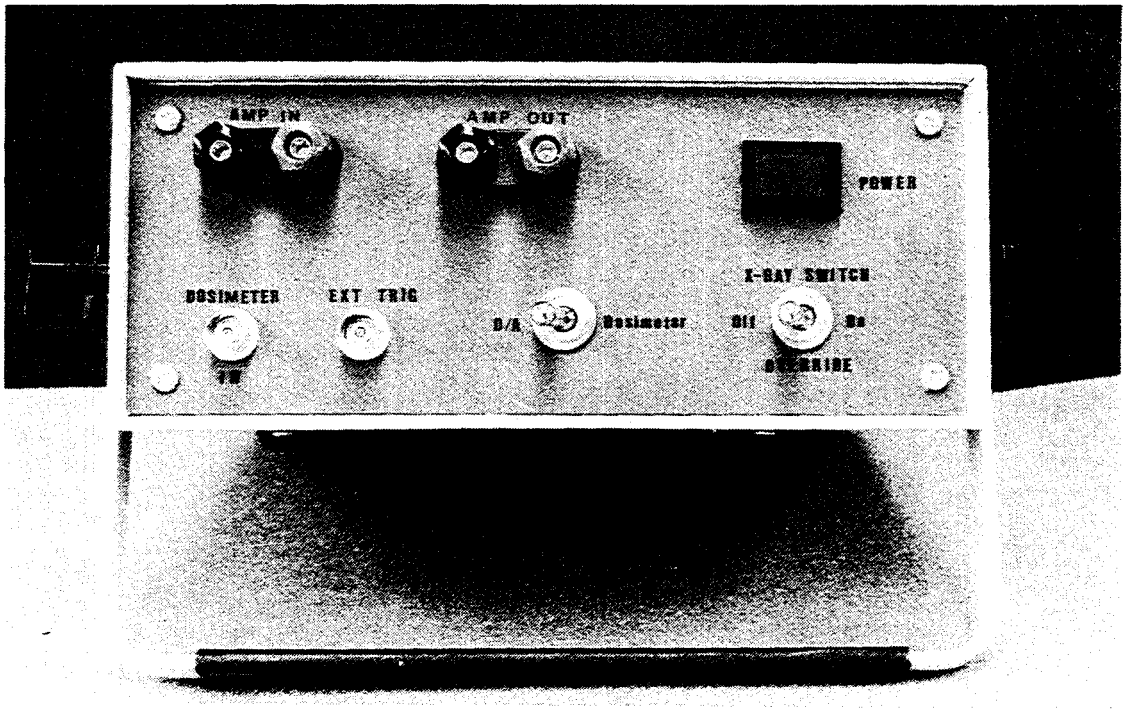
General Setup

1. Jumper across E3 on the Generator Controller PCB with a shorting plug to disable mA servo.
2. Turn on the power to all calibration equipment.

Autocal Interface Box

Refer to Figure 9-6. Turn X-ray Switch Override **ON**.

Figure 9-6 - *The AutoCal Box. Refer to the text for proper switch settings.*



Dynalyzer III High Voltage Unit

Refer to Figure 9-7. 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 9-7 - *The Dynalyzer III High Voltage Unit. Set the FLUORO/RAD switch as described in the text.*

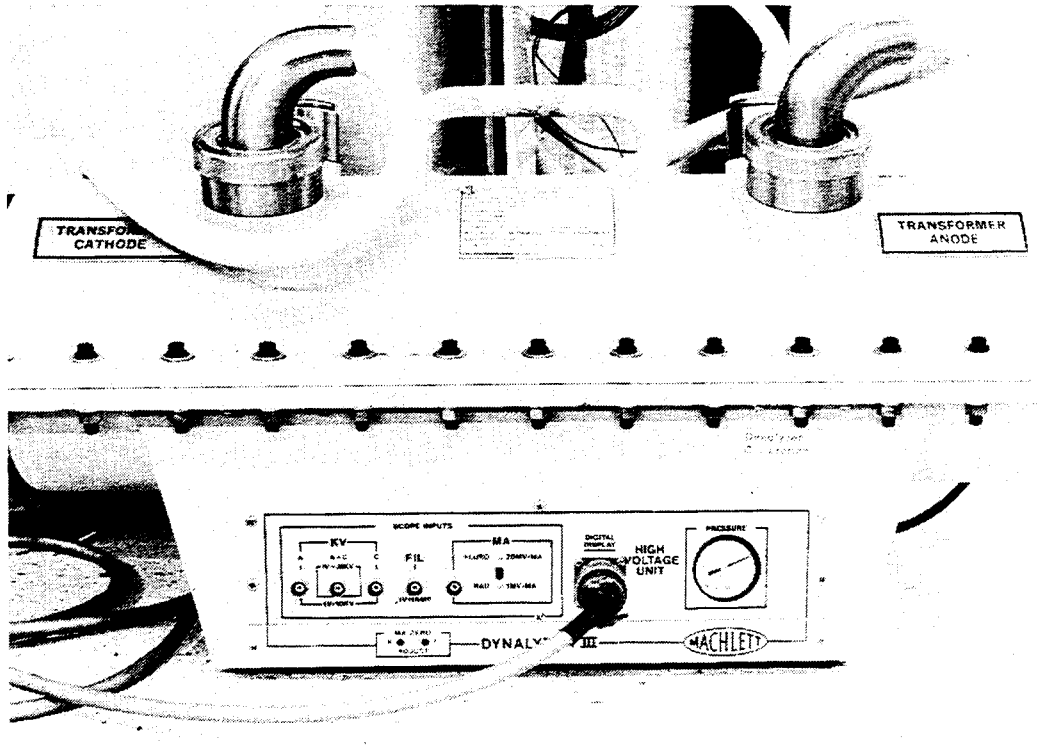
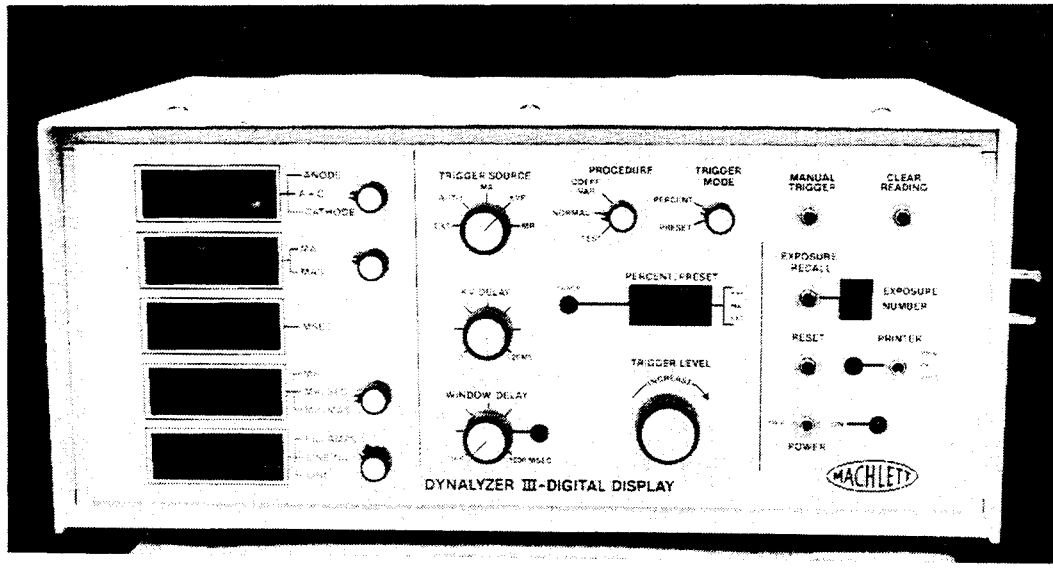


Figure 9-8 - *Dynalyzer III Digital Display*. Set the controls as described in the text.



Dynalyzer III DRO (Digital Display Unit)

Refer to Figure 9-8.

Set the controls as follows:

Displays:	**A+C,**	**mA**
Trigger Source:	**kVp**	
Procedure:	**NORMAL**	
Trigger Mode:	**PERCENT**	
kV Delay:	**20 ms**	
Window Delay:	**OFF**	
Trigger Level:	**50**	
Printer	**AUTO**	

Dynalyzer II High Voltage Unit

No special settings are required.

Dynalyzer II DRO (Digital Display Unit)

Refer to Figure 9-9.

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)		

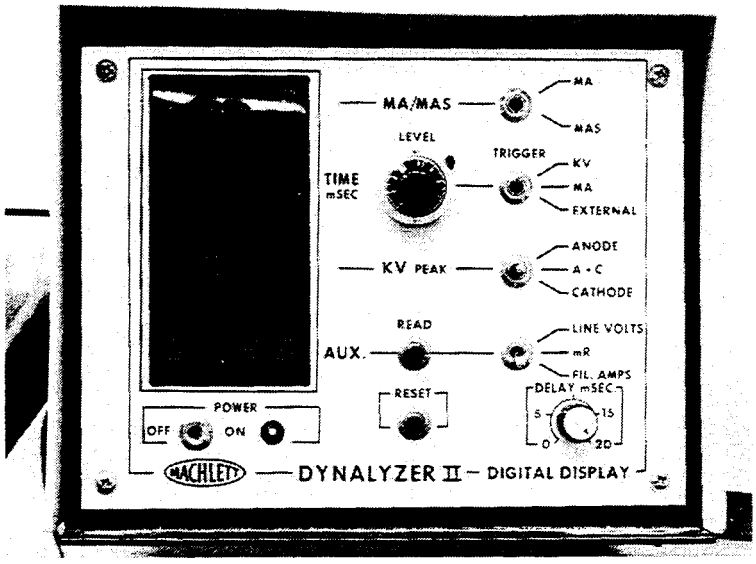
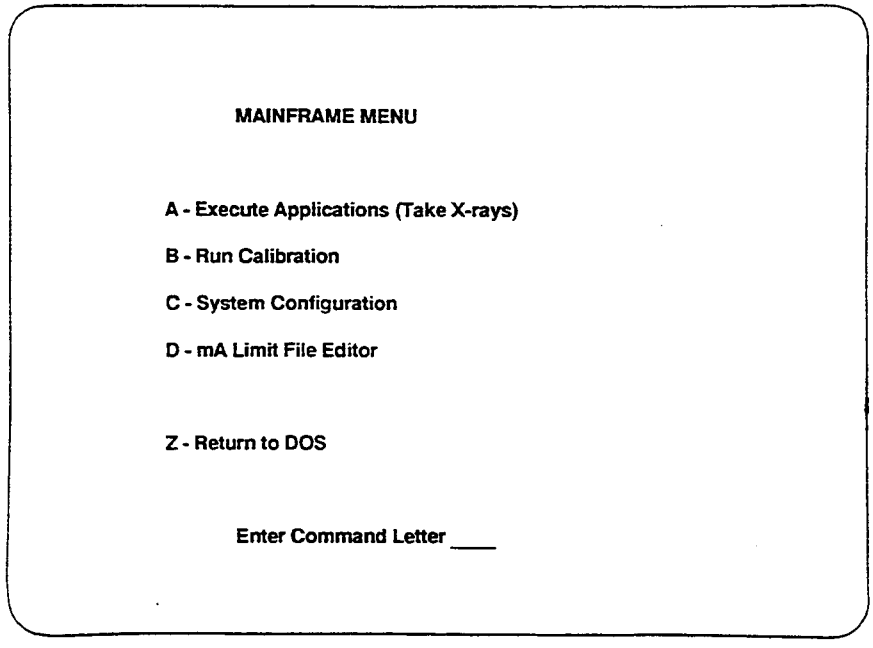


Figure 9-9 - *Dynalyzer II Digital Display. Refer to the text for the proper switch settings.*

9.8.4 Getting Started

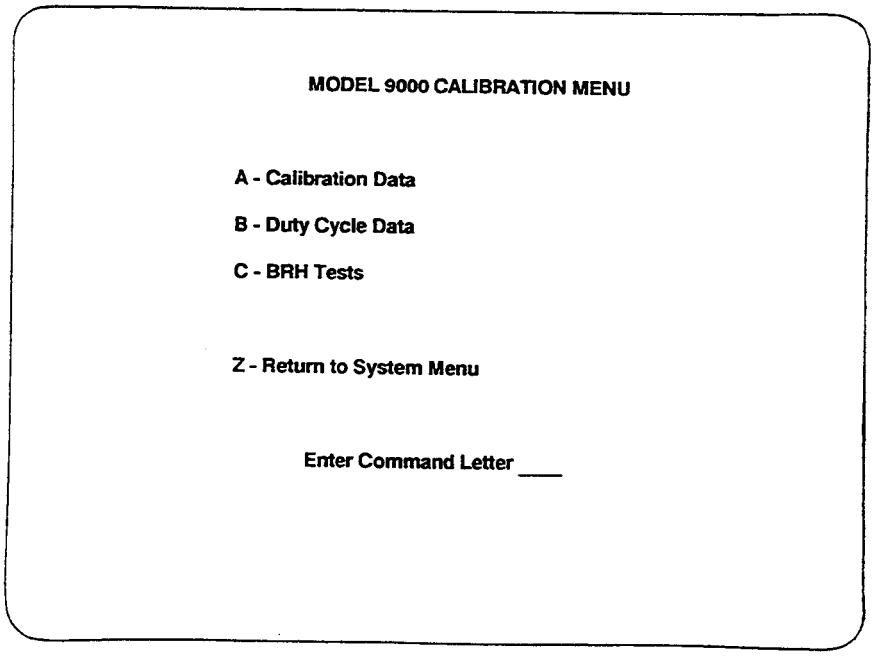
1. Connect the computer terminal to the monitor cart. Instructions for connecting and using the external computer terminal are found in the Appendix.
2. Press *[ESC]*.
3. Select: *Z - Return to main menu.*
4. Select: *Y - Access Mainframe Menu.*

   The Mainframe Menu will appear:



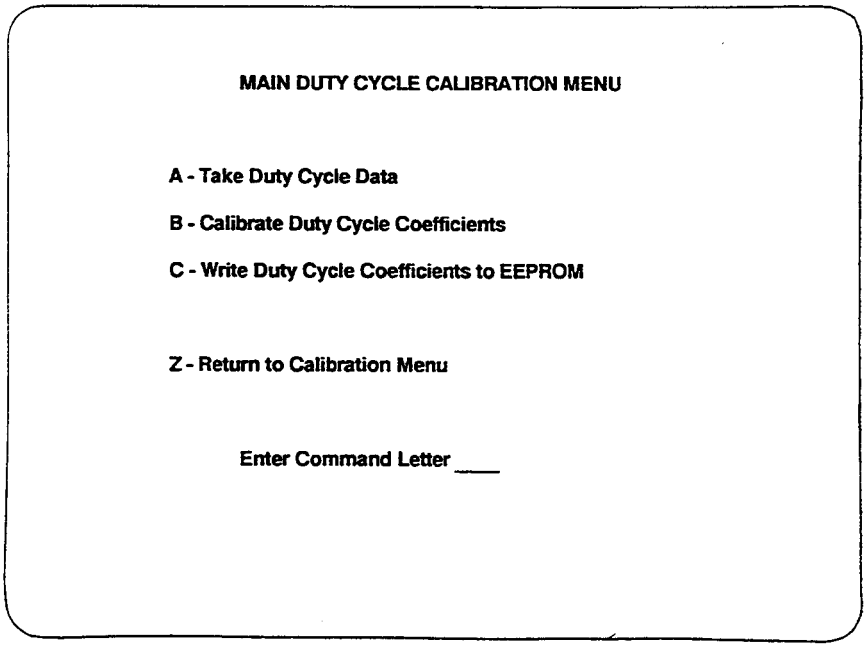
5. From the Mainframe Menu select: *B - Run Calibration.*
6. Enter your initials when prompted: *Enter initials please.*

7. From the *CALIBRATION MENU* select: *B- DUTY CYCLE DATA.*



9.8.5 Duty Cycle Calibration

The Duty Cycle Menu will next appear on the terminal screen:



9.8.5.1 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).

2. Zero the Dynalyzer high voltage unit.

Note: Zero *both* the FLUORO and RADIOGRAPHIC settings on the Model III.

3. Depress the footswitch (or X-ray On button) when ready.

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].

6. The Dynalyzer II tank must be switched between FLUORO and RAD to accommodate filament size changes during calibration. When this is required, The following prompt will appear on the terminal screen:

   *** SWITCHING FILAMENTS ***
   Change tank setting to ___ (FLUORO or RAD) for ___ (small or large) spot calibration. Press [ENTER] when ready to continue.

   When beginning the calibration procedure using a Dynalyzer III, the on-screen instructions will indicate the switch setting (FLUORO or RAD) with which to start.

9.8.5.2 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.

9.8.5.3 Write Duty Cycle Coefficients to EEPROM

1. When the calculations are complete, you will be returned to the Duty Cycle Calibration Menu.

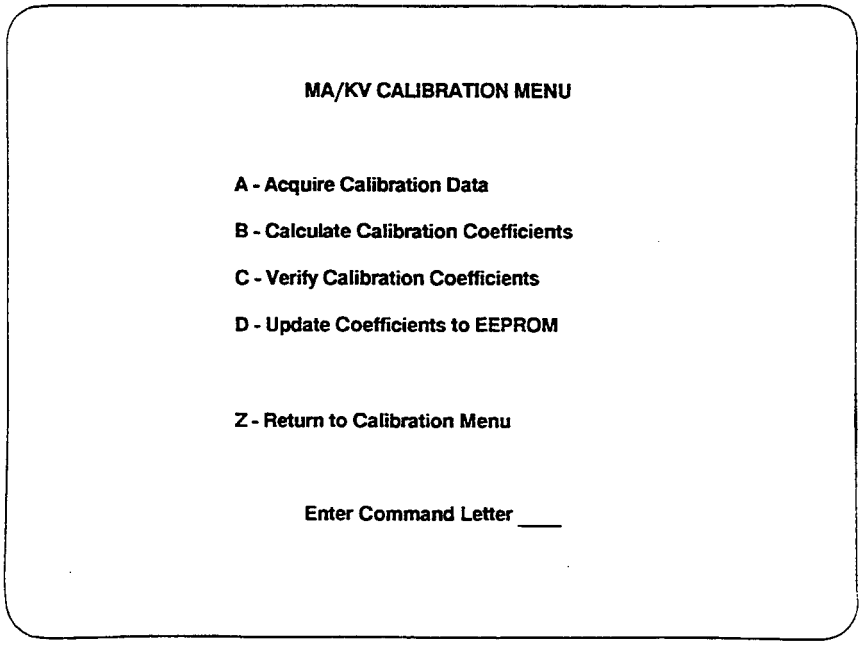
2. Select: *C - Write Duty Cycle Coefficients to EEPROM.*

3. This takes only a blink of the eye.

4. Select: *Z - Return to Calibration Menu.*

9.8.6 mA/kV Calibration

Technique calibration uses the mA/kV Calibration Menu:



9.8.6.1 Acquire Calibration Data

1. From the Main Calibration Menu select: *A - Calibration Data.*
2. From the mA/kV Calibration Menu select: *A - Acquire Calibration Data.*
3. Remove the mA servo-disable jumper E3.
4. Zero the Dynalyzer (both settings on the Model III).
5. Depress the footswitch when ready.
6. The system automatically takes 38 predefined exposures.

   The calibration software will prompt you to change the Dynalyzer setting (FLUORO/RADIOGRAPHIC) as needed.
7. Observe the results reported on the screen. The technique values should be similar to those read on the control panel and the Dynalyzer readout.
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].

9.8.6.2 Calculate Calibration Coefficients

1. Select: *B - Calculate Calibration Coefficients.*
2. The coefficients will be displayed briefly on the monitor.

9.8.6.3 Update Coefficients to EEPROM

1. Select: *D - update coefficients to EEPROM.*
2. This step is performed before the verification data is acquired.

Note: Menu item *C - Verify Calibration Coefficients* is not implemented for field use. Proceed with the manual verification procedure given below.

9.8.7 Verify Calibration

9.8.7.1 General Information

Calibration must be verified following regular calibration procedures or when any of the following components are replaced:

- X-ray Tube
- Generator Controller PCB
- High Voltage Regulator Components
- High Voltage Tank

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.*

9.8.7.2 KVP Accuracy Tests

The tests in this section are designed to measure the kVp accuracy of the system. Perform the tests indicated and 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. Slew the mA to maximum at each kVp.
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 @ 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.

9.8.7.3 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. Select the small field.
2. Take exposures at 5 mAs 50 mAs, and at 200 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. Select the SMALL field.
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.

9.8.7.4 Fluoro MA Accuracy Test

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.

9.9 Entrance Exposure Calibration

Entrance Exposure Limitation Tests

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.

Entrance Exposure Calibration

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.

Measurement Position The entrance exposure for the system is measured 30 cm (12 inches) from the input surface of the imaging assembly.

NOTE: Remove the dynalyzer prior to execution of this procedure.

Equipment Required The following equipment is required to perform the entrance exposure tests:

* Keithley Model 35050 dosimeter with Model 96030 ion chamber or equivalent (Calibration must be current).

* Metric Scale or Ruler

* Lead Apron or lead plate

* 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 such 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 4.69 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: *D - mA Limit File Editor.*

11. For each value listed by the mA Limit File Editor, select the kVp index number and enter the mA found in the steps above.

12. Enter the data obtained every five kVp (recorded in the worksheet table) and interpolate the remaining values.

13. When the table on the screen is complete, press [ENTER].

14. Follow the instructions on the screen to save the editing changes.

9.10 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.

9.10.1 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:

   1. Place the dosimeter 30 cm. (12 inches) from the input surface of the image intensifier.
   2. Adjust the technique factors to produce the required radiation level.
   3. Then LOCK the technique and remove the dosimeter for the tests.

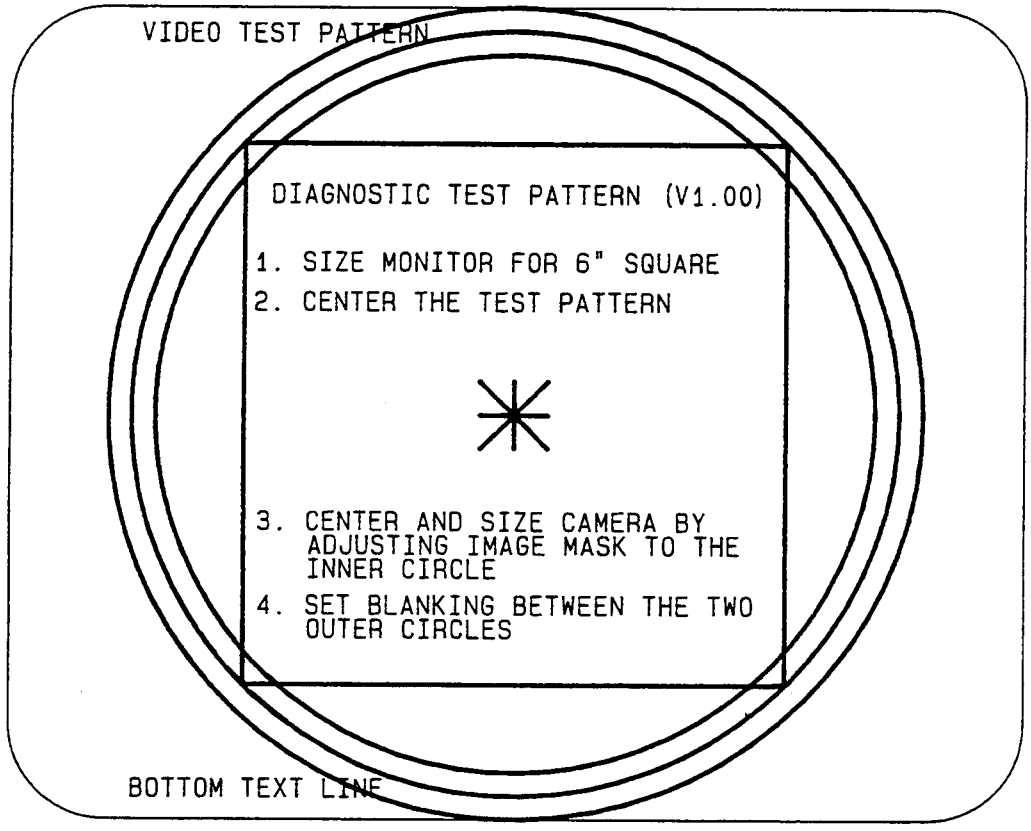
3. Unless otherwise noted, all radiation measurements are made 30 cm. (12 inches) above the input surface of the image intensifier.
4. The camera lens aperture is set to f/2.0.
5. X-ray beam alignment has been performed with satisfactory results.
6. On 6/9-inch fluoroscopy systems, all camera tests and 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.

9.10.2 Monitor Raster Size Adjustment

1. Place the video selector switch on the rear of the monitor cart in the "NORMAL" position.
2. Put the monitor cart into the diagnostics mode. Follow the instructions in the Monitor Cart Service Section for using either the **Front Panel** or **Terminal Diagnostics**.
3. Select test *23 - VIDEO TEST PATTERN.*
4. While viewing the test pattern, adjust the *VERT SIZE* and the *WIDTH* controls on the left monitor to produce a 6-inch square in the center of the screen.
5. It may be necessary to adjust the centering magnets on the CRT neck to hide the raster edges, and to correctly display the text lines.
6. Repeat this procedure for the right monitor.

NOTE: Adjust the TV monitor size controls before any other size adjustments are performed.

Figure 9-10 - *TEST 23 - VIDEO TEST PATTERN is used for video alignment, sizing and centering.*



9.10.3 Camera Sizing and Optical Adjustments

9.10.3.1 Camera Rotation Axis Offset (mirror axis alignment)

Test Spec:
Less than 1/4" axis shift on the monitor as the camera is rotated through its 360 degree range.

1. Place the alignment tool on the image intensifier input surface.
2. Loosen the camera drive belt and disengage it from the drive gear. This will prevent damage to the rotation drive motor.
3. Continue using the VIDEO TEST PATTERN - Test 23, described in the previous procedure.

4. Rotate the camera to one extreme, make a fluoro exposure and with a felt-tip pen, place a mark on the monitor screen at the center of the alignment tool image.

5. Rotate the camera 90 degrees and mark the center again. Repeat this every 90 degrees throughout the 360 degree range.

6. Make a cross by connecting the diagonally opposite marks, and measure the length of the longest diagonal.

7. If this dimension is less than 1/4 inch, no further adjustment will be necessary.

8. Adjustment is made while making an exposure by varying the jackscrew settings supporting the mirror and aligning the center of the tool image with the center of the marked cross. When complete, re-check allignment.

9. Center the alignment tool crosshair in the center of the video test pattern by adjusting the horizontal and vertical centering on the camera Deflection PCB. Camera centering controls are further described in a following procedure.

NOTE: Be careful not to over-tighten the compression washers.

10. Replace the camera drive belt over the drive gear.

9.10.3.2 Camera Lens Aperture Setting

Set the camera lens aperture to f/2.0.

9.10.3.3 Active Image Size and Centering

Adjust the camera image size and centering according to the Video Test Pattern Instructions.

Spec: Diameter = 8.25 inches +/- .125

Camera Size and Centering Controls (Deflection PCB):

R-40	Hor. Size - normal
R-38	Hor. Centering - normal
R-39	Hor. Centering - reversed
R-19	Vert. Size
R-37	Vert. Centering

9.10.4 Image Circular Masking

Spec: Less than 2% of SID (.72 inch for 9-inch system, .76 inch for 6-inch system).

1. With the BYPASS switch in the "NORMAL" position, the image edges will be hidden by the circular blanking window. The blanking should cover the image edge at all points throughout a complete rotation of the camera.

2. In no case should there be more that 2% of the SID (referred to the input of the image tube) masked. This refers to areas radiated, but not imaged as a result of circular blanking or other masking.

3. Set the circular blanking on the monitor cart AD/DA PCB with the potentiometers listed below.

R45	Vertical Offset
R47	Vertical Size
R48	Horizontal Size
R50	Horizontal Offset

4. Press the *HELP* button to *exit Test 23*. Then select *Option 99 - Return to System*.

9.10.5 Camera Electrical Adjustments

Test Conditions:

1. Contrast Grid installed
2. No other filters in beam except aluminum collimator filter
3. Shading jumper out (disabled)
4. Auto gain jumper out (disabled)
5. Black level control disabled (jumper TP2 to TP7)
6. Camera input power = 24 +/- 1.0 VDC

9.10.5.1 +500 Volt Supply Adjustment.

1. Adjust R-13 to the maximum voltage extreme.

2. Reduce the "BEAM" (R-14) setting to minimum (blanked).

3. Measure the voltage at TP-6.

4. Adjust R-13 for 25 volts below the voltage measured above at TP6 or +500 VDC, whichever is less.

Figure 9-11 - *This view of the camera shows the location of the a) Video Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.*

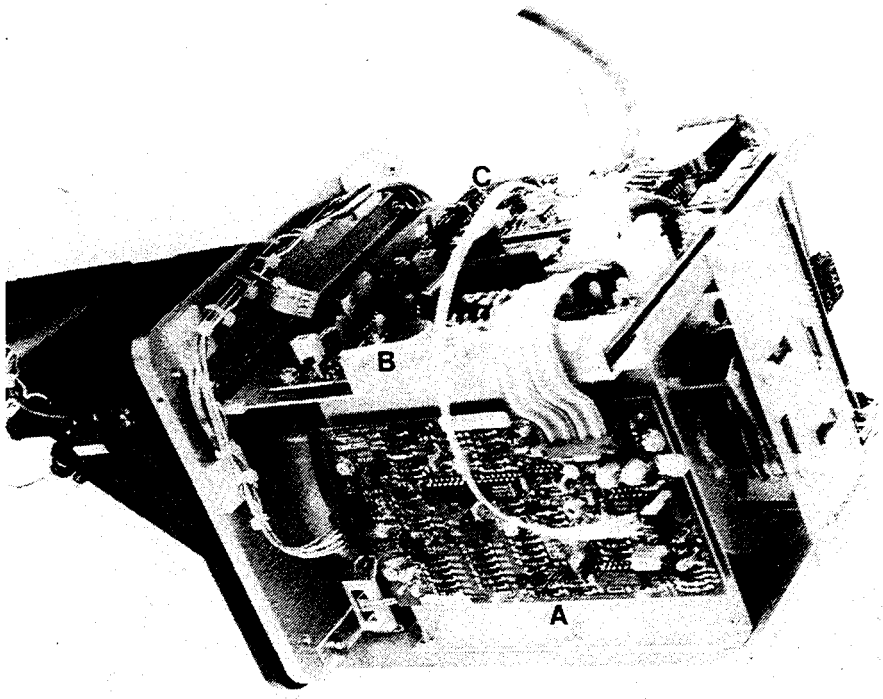
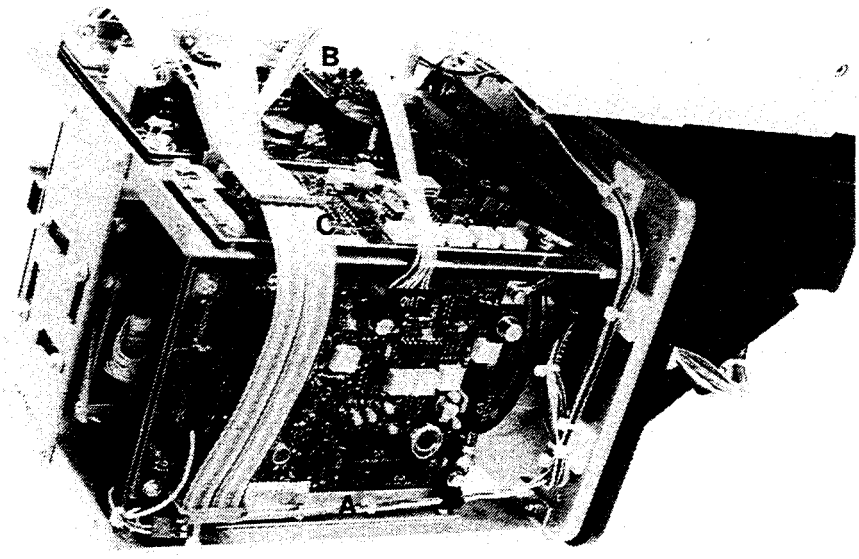


Figure 9-12 - *This view of the camera shows the a) Deflection Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.*



9.10.5.2 Beam Discharge

1. Adjust beam discharge current with the beam discharge pot R14 on the Camera Supply PCB.

2. Be sure there is sufficient beam current to discharge video amplitudes of 500 mv p-p as measured at TP-3.

3. While making an exposure and observing TP1, adjust R14 until the beam is fully discharged, then 1/8th turn beyond that point. The video level at TP3 will be observed to peak near this point.

9.10.5.3 Target Adjustment

Spec: 350 +/- 20 mv. at TP-3 on Video Processor PCB.

On the Video Processor PCB adjust the target voltage with R-43 while making an exposure to produce 350 mv p-p at TP-3.

9.10.5.4 Black Level

Spec: 75 +/- 10 mv at TP-1.

Adjust the Black Level Control (R-44) for 75mv black level as seen at TP-1 on the camera Video Processor PCB.

9.10.5.5 Camera Video Output

Spec: 850 +/- 40 mv peak video measured at J-8 of the AD/DA.

Adjust the Video Gain with R-9 on the Video Processor PCB to produce the video output measured at J8 on the AD/DA PCB.

9.10.5.6 Verify Dark Current Compensation

1. Monitor J8 on the AD/DA PCB.

2. While observing the composite video waveform during an exposure, temporarily remove the jumper between TP7 and TP2 on the camera Video PCB.

3. The black level should change, correcting to 50-150 mV above the video blanking level.

9.10.5.7 Video Output with Auto-brightness Enabled

Test conditions:
Auto-Gain enabled
Black level control enabled
Shading enabled.

Under the test conditions listed above, measure the video amplitude at J8 on the AD/DA PCB. The output video amplitude, with auto brightness enabled, should be 820 +/- 60 mv. peak.

9.10.6 Shading (Image Brightness Uniformity)

Test Conditions:
1. Contrast Grid installed
2. No other filters in beam except the aluminum collimator filter
3. * Shading jumper in (enabled)
4. Auto gain jumper out (disabled)
5. Black level control disabled (jumper TP2 to TP7)

* Shading controls adjusted for minimal shading error.

Spec:

Vertical shading component:	less than 100 mv p-p
Horizontal shading component:	Less than 100 mv p-p
Video amplitude:	850 +/- 40 mv peak (J-8 of the AD/DA)

Adjustment procedure:

1. With the horizontal sweep orientation "normal" and the scope sweep rate set to view horizontal (20 us/div) and triggered, adjust R-40 (Horiz. sawtooth) and R-42 (Horiz. parabola) for uniform amplitude across the video waveform.

Refer to Figure 9-13.

2. Restore the video amplitude with R-57 (BIAS).

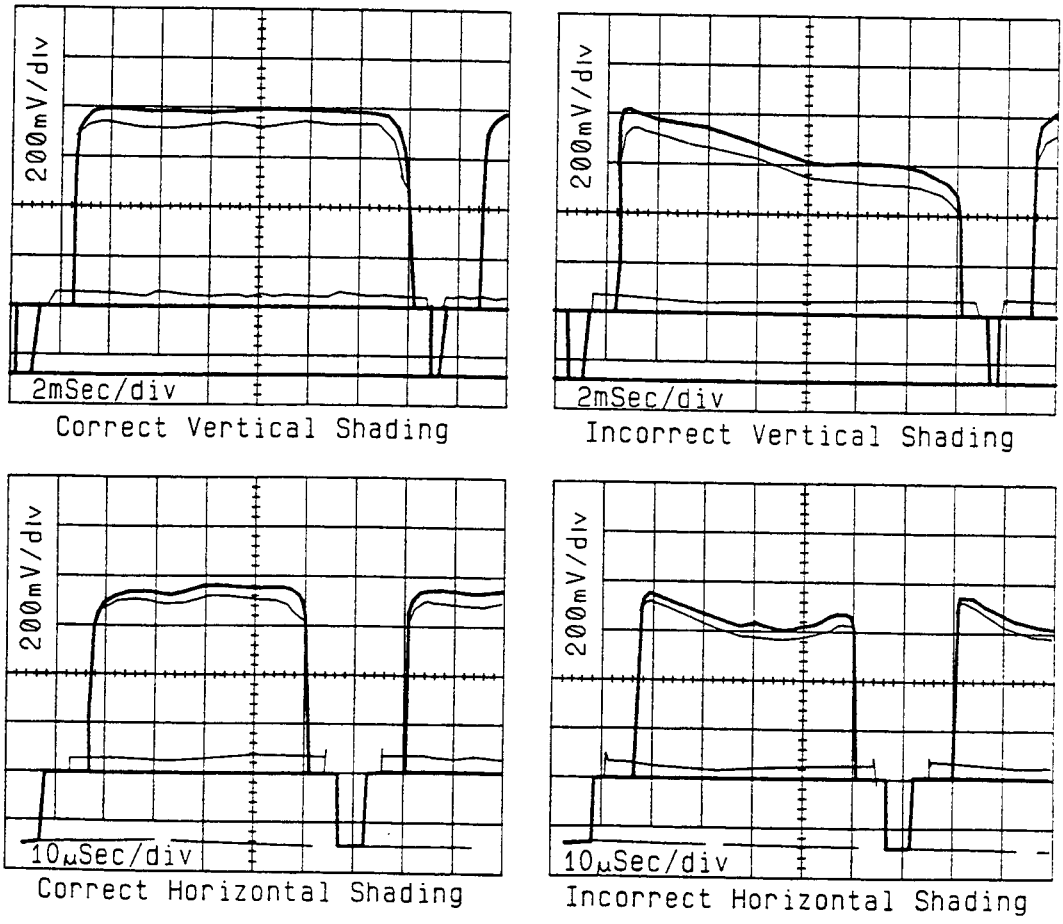
3. Change the scope sweep rate to view the vertical rate. (5 ms./div.) and adjust R-10 (Vert sawtooth) and R-15 (Vert parabola) for uniform amplitude across the video waveform.

4. Restore the video amplitude with R-57 (BIAS).

5. Repeat steps 1 and 2 with the horizontal orientation "reversed" using R-41 (horiz. sawtooth) and R-57 (BIAS) respectively.

NOTE: The shading specifications refers to the central 70% of the illuminated area in each axis. Some rounding at the edges is acceptable. It is generally helpful to "dip" the center just a little (approx. 50 mv.) to meet this specification.

Figure 9-13 - *Correct and incorrect shading waveforms are illustrated here.*



9.10.7 Resolution

Test Conditions:

1. Shading jumper in (enabled).
2. Video selector switch in the "BYPASS" position.
3. NO Contrast Grid.
4. Wisconsin Resolution Tool installed.
5. Adjust technique for 50 kVp @ 200 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 the technique for 200 +/- 10 mr./min. at 50 kVp. in "MANUAL" mode.

9.10.7.1 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.

3. Adjust C-3 (peaking capacitor) on the Preamp and Yoke assembly until the black image edges, viewed on the monitor, bleed white. Back off the adjustment of C-3 until the smearing just disappears. This will provide optimum preamp bandwidth without oscillation occurring.

Note: Use a nonmetallic adjustment tool on C-3.

9.10.7.2 Image Intensifier Focus

If this adjustment is necessary refer to the *Mainframe Service Section.*

Rotate the C-arm assembly to place the X-ray tube/image intensifier axis parallel to the floor with the X-ray tube port pointing away from the control panel.

9.10.7.3 Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

Test Specs:

(6" machine) -	40 linepairs/inch
(6/9" machine) -	40 linepairs/inch in 6" mode 35 linepairs/inch in 9" mode

9.10.8 Contrast Sensitivity Test

Test Conditions:
1. Technique factors adjusted to produce 80 kVp @ 1R/min.
2. 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 with the cart in the "NORMAL" mode and examine the stored image. Adjust the brightness and contrast controls on the monitor as necessary to optimize the image.

9.10.9 Image Noise, Correlated

Test Conditions:
1. Black level control enabled.
2. Shading jumper in (enabled).
3. Auto-gain enabled
4. Monitor Cart in BYPASS mode.

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.

9.10.10 Video Sampling Window Size and Centering

1. Connect a 2.2 Kohm resistor between TP-11 and TP-13 to see the video sampling window.

2. Put the monitor cart in "NORMAL" mode.

3. The window should now be visible when exposures are made. Adjust R-38 "H-CAL" and R-39 "V-CAL" to center this rectangular window within the viewed area.

4. 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.

9.10.11 Video Level Control and Auto Technique Tests

Test Conditions:

1. Auto-technique mode
2. Auto-gain enabled
3. Black level control enabled
4. Shading enabled
5. Contrast Grid installed.

1. Make an exposure with no filter in the beam and record the resulting kVp.

2. Make an exposure with the Aluminum filter (6" x 6" x .125") in the beam and record the resulting kVp.

3. Make an exposure with one (1) copper filter (6" x 6" x .093") in the beam and record the resulting kVp.

4. Make an exposure with two (2) copper filters (6" x 6" x .093") in the beam and record the resultant kVp.

5. The peak output video amplitude at (J8 on the AD/DA PCB) shall be 820 mv +/- 60 mv for each of the four conditions.

6. The resultant kVp readings for each of the four conditions shall be:

No filter	43+/-3 kVp
Aluminum	47+/-3 kVp
1 Copper filter	66+/-3 kVp
2 Copper filters	79+/-4 kVp

9.10.12 Camera Drive Chain Tension

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. Rotate the camera through 360 degrees and verify that the rotation motor is switched off at each limit. Verify that the chain tension allows free rotation in all positions. *Damage to the rotation motor and gear can result if the camera is rotated by hand.*

9.11 Image Processing and Monitor Cart Tests

9.11.1 AD/DA PCB Calibration

1. Place the PCB on an extender card and replace the regular daisy chain cable with the test ribbon cable (which is longer to accommodate the extender card).

2. Measure the following voltages on the AD/DA PCB:

TP-21	digital to analog reference	-1.0 VDC
TP-23	analog to digital reference	-2.0 VDC

3. Adjust R-1 (video offset adjust) so that the video baseline at P-6 (right video output) is at ground.

4. Adjust **R-2** (video offset adjust) so that the video base line at P-5 (left video output) is at ground.

5. While making a fluoro exposure observe the live video waveform, in-line, at P6 and P5 of the AD/DA PCB.

6. Verify a video amplitude of 850 mVpp +/- 50 mV and the sync portion, 400 mVpp +/- 50 mV. Observe a baseline at 0 volts.

9.11.2 Verify External Video

1. Check for the presence of an EIA RS170 composite video signal at the video output jacks on the rear of the monitor cart.

2. Verify a video amplitude of 850 mVpp +/- 50 mV and the sync portion, 400 mVpp +/- 50 mV. Observe a baseline at 0 volts.

NOTE: The video signal must be terminated with 75 ohms to correctly measure the amplitude.

9.11.3 Image Processor PCB

1. Place a scope probe on TP27 and TP5 (ground). Verify that the following TV signals are present:

TP-9	Composite sync
TP-10	Composite blanking
TP-7	Horizontal drive
TP-6	Vertical drive

2. Adjust C-6 for +2.5 VDC measured on TP27. Verify that the video is stable and displayed in the center of circular blanking.

9.11.4 Front Panel Diagnostics

1. Access the Software Diagnostic Tests from the front panel of the monitor cart by pressing the HELP key and then selecting the "Front Panel Diagnostics" from the menus. These tests can also be selected from the Terminal Controlled Diagnostics.

2. The Front Panel Diagnostics contain tests of the image/memory transfers which occur in normal operation.

   These tests are fully described in the Monitor Cart Service Section. Read the descriptions and follow the instructions for these tests.

3. There are also tests from this menu of the switches and LEDs on the Front Panel:

   Run the Front Panel LED Test to verify that all LEDs operate.

4. Generate a gray scale image from the test menu.

5. Swap the image from one monitor to the other (using the M1-M2 swap test) and examine the image for any signs of tear or jitter.

9.11.5 Monitor Cart Imaging Function Checks

A variety of image processing functions may be available on a given system. Refer to the Operator's Manual for instructions on using the available functions.

1. Enable each function on the front panel and using a suitable test image (such as the Wisconsin Copper Mesh Test Grid), evaluate the operation of the function. Camera rotation may be used to simulate motion when evaluating some functions.

2. Verify that the LIVE FLUORO (left) Footswitch generates a live fluoro image on the left monitor regardless of the status of the image processing controls.

3. Depress the PROCESS (right) Footswitch to initiate the selected image processing.

4. Enable the WINDOW and LEVEL functions and take another image. The WINDOW and LEVEL arrow buttons should change the dynamic range and brightness level of the image presented on the left-hand monitor.

5. Verify that the Negative Image (NEG) function reverses the lights and darks in the image.

6. Verify operation of both the INTEGRATE and the AVERAGE functions for all levels of averaging (number of frames).

7. Verify operation of the SHARPEN function.

9.11.6 Image Storage on Hard Disk

If the system is equipped with the option to store images on the hard disk, check its operation as follows:

1. Verify that the Manual SAVE function stores the image on the hard disc.
2. RECALL the image stored in the previous step.
3. Verify that the image counter increments and decrements, and that additional images can be recalled. "d0" error message displayed on the LED's indicates that no image was found in the specified location.
4. Enable the AUTO save function. Generate a picture on the left monitor, and press the L->R function switch. Verify that the image is auto-saved and that the LED image counter is incremented by one.
5. Time the transfer while saving an image to disk. The transfer should take less than 10 seconds, thus verifying disk transfer DMA.

9.12 Image Storage Options

Refer to Section 11, System Options.

9.12.1 AngioStor

Check out the operation of the AngioStor videodisk recorder described in the Options Section.

9.12.2 VTR

1. Verify VTR control operation as described in the operator's manual.
2. Check that the playback level is correct.

   Level adjustment instructions are found in the Options Section of the Service Manual.

CALIBRATION WORKSHEETS

Series 9000 - Serial Number _____

Calibration Performed By: _____

Location _____ *Date:* _____

Introduction

These worksheets accompany the Series 9000 system calibration procedures found in Section 9 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.

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 9000 System.

9.3 Preparation and Setup

9.3.1 Record the Test Equipment Used

Dynalyzer Model _____ S/N _____

Dynalyzer Display Model _____ S/N _____

Autocal Interface Box S/N _____

DVM/DMM Model _____ S/N _____

Oscilloscope Model _____ S/N _____

Dosimeter Model _____ S/N _____

Ion Chamber Model _____ S/N _____

9.3.2 Preparation and Inspection

___ *Steps 1 thru 9 completed.*

9.4 Electrical Tests

9.4.1 Leakage Current Testing

Leakage Current _____ Pass/Fail _____

9.4.2 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 = _____

9.4.3 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

9.4.4 Monitor Cart Power Supplies

___ *Steps 1 thru 3 completed.*

AC voltage at the AUX outlets _____ VAC

Measure the following voltages relative to DC Common (PS-1 pin 7):

PS-1 pin 12	red wire	_____ VDC
PS-1 pin 6	gray wire	_____ VDC
PS-1 pin 5	violet wire	_____ VDC
PS-1 pin 4	yellow wire	_____ VDC
PS-1 pin 3	blue wire	_____ VDC
TV monitor power supply		_____ VDC

9.4.5 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.

9.5 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

9.6 Functional Checks

9.6.1 Self-tests

___ Self-tests during powerup successfully completed.

9.6.2 Emergency Off and Processor Reset Test

___ Left Emergency Off breaks interlock circuit
___ Processor resets and runs.
___ Right Emergency Off breaks interlock circuit

9.6.3 Status Mode Tests

Refer to the Mainframe Service Section for instructions on using the Status Mode.

___ LED Test
___ Panel key test
___ Panel knob test

Date and initials listed for last calibration _____

Total RAM _____ Total disk space _____

9.6.4 Film Cassette Test (6-inch systems only)

___ *Steps 1 thru 6 completed.*

9.6.5 Verify Operation of Mainframe Controls

___ *Steps 1 thru 7 completed.*

9.6.6 Field Solenoid Position Test

___ *Steps 1 thru 7 completed.*

9.6.7 Verify Controls in MANUAL FLUORO

___ *Steps 1 thru 2 completed.*

9.6.8 AUTO FLUORO Tests

___ *Steps 1 thru 9 completed.*

9.6.9 Fluoro Boost Option

___ *Steps 1 thru 4 completed.*

9.6.10 Pulsed Operation

___ *Steps 1 thru 2 completed.*

9.6.11 Verify Fluoro Timer and Timer Reset

___ *Steps 1 thru 3 completed.*

9.7 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

9.7.1 Preparation

___ *Steps 1 thru 2 completed.*

9.7.2 Radiographic Beam Alignment

___ *Steps 1 thru 19 completed.*

Measure the dimensions of each field:

Minimum field - less than 1.97" square * _____
4-inch field - 4" +/- 0.50" square _____
6-inch field - 6" +/- 0.50" square _____
8-inch field - 8" +/- 0.50" square _____

* 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.

Note: The corners of the 8" field will be clipped by the 10" collimating ring on 6" image intensifiers.

9.7.3 Fluoroscopic Beam Alignment

___ *Steps 1 thru 6 completed.*

9.8 X-ray Calibration

9.8.2 Connections

___ The Dynalyzer, digital display, and autocal interface box are connected according to the instructions in this section.

9.8.3 Setup

___ General Setup

___ Autocal Interface Box

___ Dynalyzer High Voltage Unit

___ Dynalyzer DRO (Digital Display Unit)

9.8.4 Getting Started

___ *Steps 1 thru 7 completed.*

9.8.5 Duty Cycle Calibration

___ (9.8.5.1) Take Duty Cycle Data

___ (9.8.5.2) Calculate Duty Cycle Coefficients

___ (9.8.5.3) Write Duty Cycle Coefficients to EEPROM

9.8.6 Calibration Data

___ (9.8.6.1) Acquire Calibration Data

___ (9.8.6.2) Calculate Calibration Coefficients

___ (9.8.6.3) Update Coefficients to EEPROM

9.8.7 Verify Calibration

The following tests for kVp, mA and mAs accuracy require installation of a dynalyzer; the Autocal Interface Box is not required. *Refer to the Dynalyzer Instructions in the Appendix.*

Perform the tests indicated and record the results on the calibration worksheet. Verify that the system meets the specifications given with the tables below.

9.8.7.2 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 @ 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

9.8.7.3 MAS Accuracy Tests

mAs Accuracy @ 50 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp
200 mA	_____ mA (+/-10.0 mAs)	_____ kVp

---

mAs Accuracy @ 90 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp
200 mA	_____ mA (+/-10.0 mAs)	_____ kVp

---

mAs Accuracy @ 120 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp

9.8.7.4 Fluoro mA Accuracy Test

Fluoro mA Accuracy @ 50 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

Fluoro mA Accuracy @ 90 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

Fluoro mA Accuracy @ 120 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

9.9 Entrance Exposure Calibration

Fill in the worksheet table by determining the mA needed to produce 4.69 R/minute at increments of every five kVp. Do this across the range from 40 to 120 kVp.

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.

9.10 Imaging System Calibration

9.10.1 General Test conditions:

___ Conditions 1 thru 8 are being observed for the tests in this section.

9.10.2 Monitor Raster Size Adjustment

___ *Steps 1 thru 6 completed.*

9.10.3 Camera Sizing and Optical Adjustments

9.10.3.1 Camera Rotation Axis Offset (mirror axis alignment)

___ *Steps 1 thru 10 completed.*

9.10.3.2 Camera Lens Aperture Setting

___ Camera lens aperture set to f/2.0.

9.10.3.3 Active Image Size (camera size adjustments)

___ Adjust the camera image size according to the Video Test Pattern Instructions.

9.10.4 Image Circular Masking

___ *Steps 1 thru 4 completed.*

9.10.5 Camera Electrical Adjustments

___ Conditions 1 thru 6 are being observed for the tests in this section.

9.10.5.1 500 Volt Supply Adjustment

___ *Steps 1 thru 4 completed.*

9.10.5.2 Beam Discharge

___ *Steps 1 thru 3 completed.*

9.10.5.3 Target adjustment

___ Target voltage adjusted.

9.10.5.4 Black Level

___ Black Level Control adjusted.

9.10.5.5 Camera Video Output

Video output measured at J8 = _____ mVp

9.10.5.6 Verify Dark Current Compensation

___ *Steps 1 thru 3 completed.*

9.10.5.7 Video Output with Auto-brightness Enabled

Video output measured at J8 with Auto brightness enabled = _____ mVp.

9.10.6 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.

9.10.7 Resolution

___ Conditions 1 thru 5 are being observed for the tests in this section.

9.10.7.1 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.

9.10.7.2 Image Intensifier Focus

Adjustment **was/was not** neccessary (circle one).

9.10.7.3 Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

(6-inch machine) - _____ linepairs/inch

(6/9-inch machine) - _____ linepairs/inch in 6" mode
_____ linepairs/inch in 9" mode

9.10.8 Contrast Sensitivity Test

___ Conditions 1 thru 2 are being observed for the tests in this section.

# of penetrometer spots discernible = _____

9.10.9 Image Noise, Correlated

___ Conditions 1 thru 4 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.

9.10.10 Auto Brightness

9.10.10.1 Video Sampling Window Size and Centering

___ *Steps 1 thru 4 completed.*

9.10.11 Video Level Control and Auto Technique Tests

___ Conditions 1 thru 5 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
Aluminum	_____ kVp	_____ mVp
1 Copper filter	_____ kVp	_____ mVp
2 Copper filter	_____ kVp	_____ mVp

9.10.12 Camera Drive Chain Tension

___ *Steps 1 thru 3 completed.*

9.11 Image Processing and Monitor Cart Tests

9.11.1 AD/DA PCB Calibration

___ *Steps 1 thru 6 completed.*

9.11.2 Verify External Video

___ *Steps 1 thru 2 completed.*

9.11.3 Image Processor PCB

___ *Steps 1 thru 2 completed.*

9.11.4 Front Panel Diagnostics

___ *Steps 1 thru 5 completed.*

9.11.5 Monitor Cart Imaging Function Checks

___ *Steps 1 thru 7 completed.*

9.11.6 Image Storage on Hard Disk

___ *Steps 1 thru 5 completed.*

9.12 Image Storage Options

Refer to Section 11, System Options.

9.12.1 AngioStor

Check out the operation of the AngioStor videodisk recorder described in the Options Section.

9.12.2 VTR

___ *Steps 1 thru 2 completed.*

SERVICE MANUAL

00-870820-01

SERIES 9000

X-RAY IMAGING SYSTEM

Effectivity:

This manual contains descriptions, instructions and procedures which apply only to Series 9000 systems with serial numbers in the 96-000 and 99-000 series.

Date of Issue: September 1987

OEC-DIASONICS

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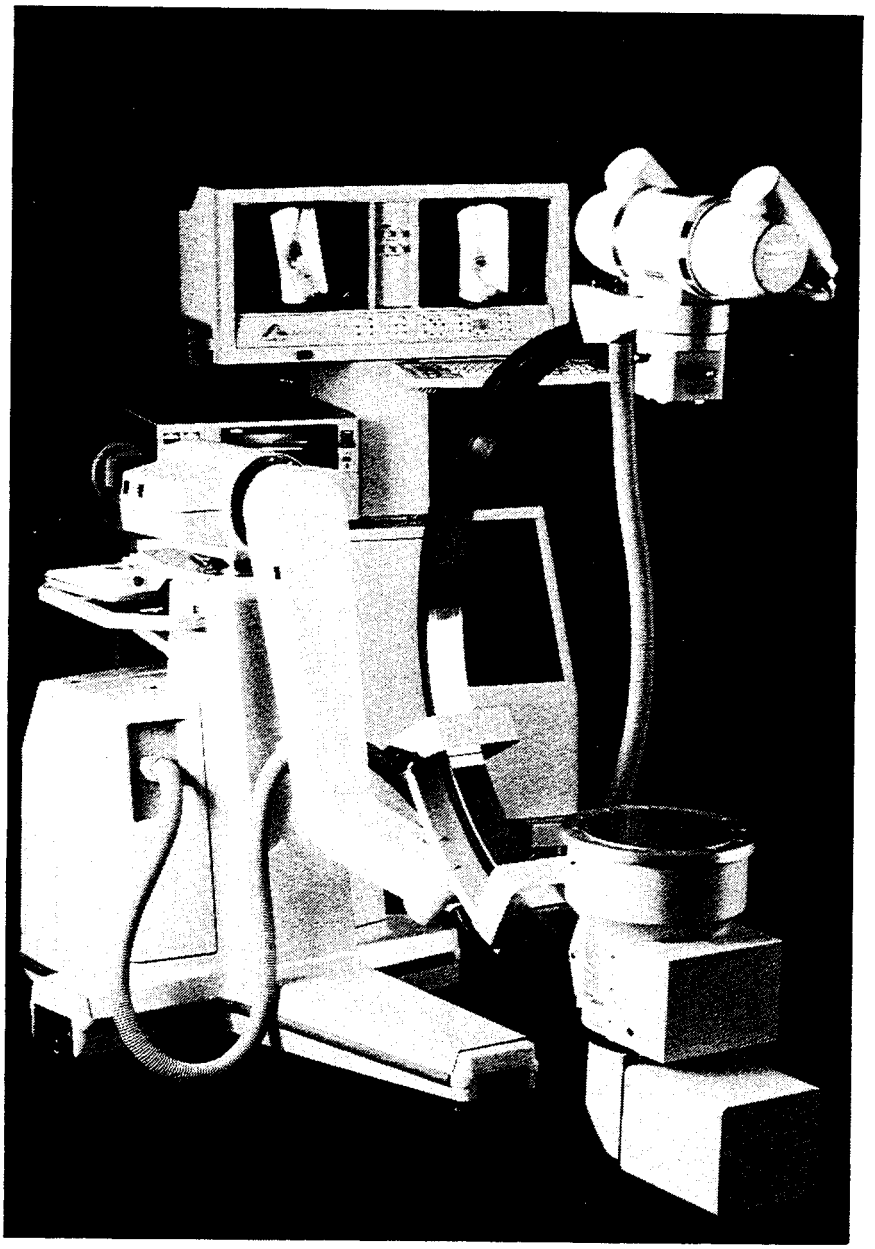
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SERIES 9000 X-RAY IMAGING SYSTEM (Details of this photograph may vary depending on options).

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 the properly trained service engineer who 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 Series 9000 system.

This manual is intended to compliment the training offered by OEC-Diasonics. You should not attempt any of the procedures in this manual unless you have received this training on the Series 9000 System. Reading this manual does not alone 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.

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SECTION 10
UNPACKING AND INSTALLATION

This section describes the installation of the OEC-Diasonics mobile C-arm system. Included are instructions for unloading and unpacking, startup after long term storage, and guidelines for moving the system.

Site requirements and the Installation Checkout Procedure are found at the end of this section.

10.1 Responsibility

The customer must provide the labor and equipment necessary to unload the system from the transport vehicle and move it to the final location. The customer is responsible for obtaining all permits and for meeting all other requirements of state and local codes, regulations, and ordinances with respect to the installation and operation of the system.

The Installation Checkout Procedure should be performed only by a qualified service technician.

10.2 Unloading and Inspecting the Shipment

Before unpacking, the customer should inspect the shipping containers and exposed system components for any apparent damage. Any shipping container that appears damaged should be unpacked with the carrier's agent present. The customer should also ensure that all equipment specified in the purchase order has been delivered.

If any part of the shipment is damaged or missing, immediately notify the carrier and the nearest OEC-Diasonics regional service office or representative. Retain the shipping container and packing material for the carrier's inspection.

10.3 Domestic Unpacking Instructions

10.3.1 Unpacking the Mainframe Assembly

1. Remove the plywood ramp and place it at the rear of the palette base. *(Refer to Figure 10-1).*

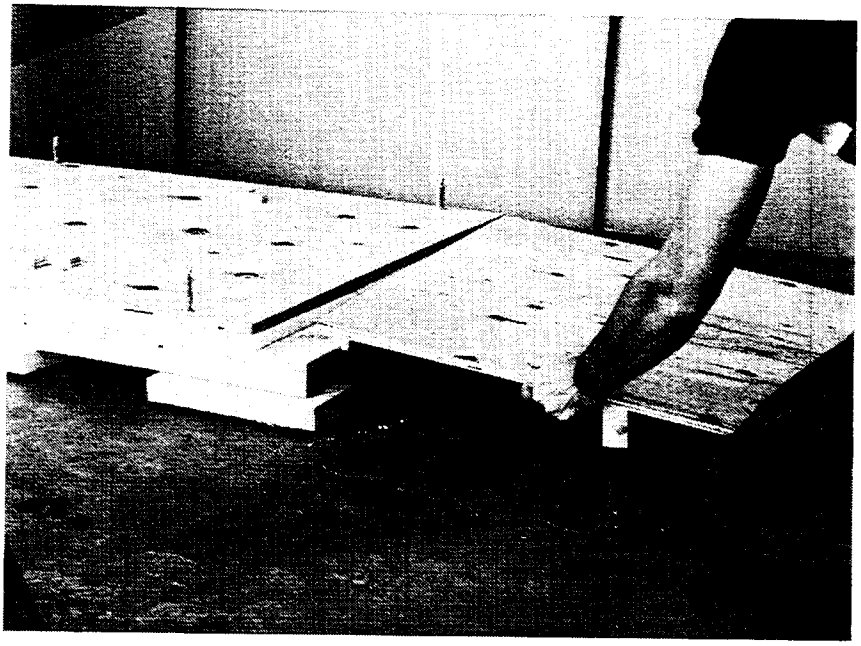


Figure 10-1 - *Place the plywood ramp at the rear of the palette base.*

2. Remove the image intensifier assembly from the palette and place it out of the way for now.

3. Remove the bolts and strap holding down the X-ray tube assembly.

4. Remove the metal straps holding the front and rear wheels in place. *(Refer to Figures 10-2 and 10-3).*

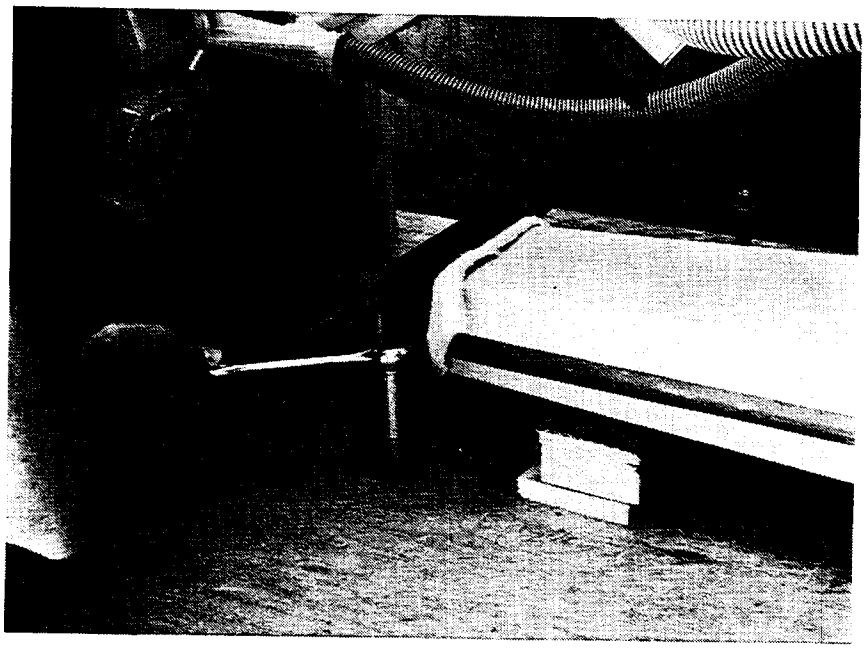


Figure 10-2 - *Remove the metal strap holding the front wheel in place.*

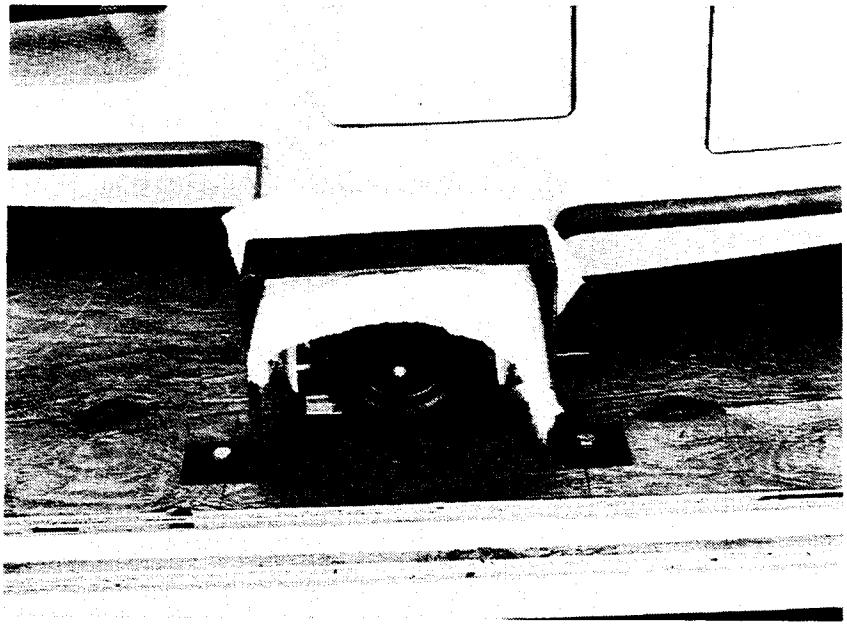


Figure 10-3 - *Remove the metal straps holding the rear wheels in place.*

5. Using the 3-ft. length of 2x4 as a lever, carefully lift up the front wheel and remove the support blocks. *(Refer to Figure 10-4)*.

6. Again using the 2X4 as a lever, lift up each rear wheel and remove the support blocks on both sides. *(Refer to Figure 10-5)*.

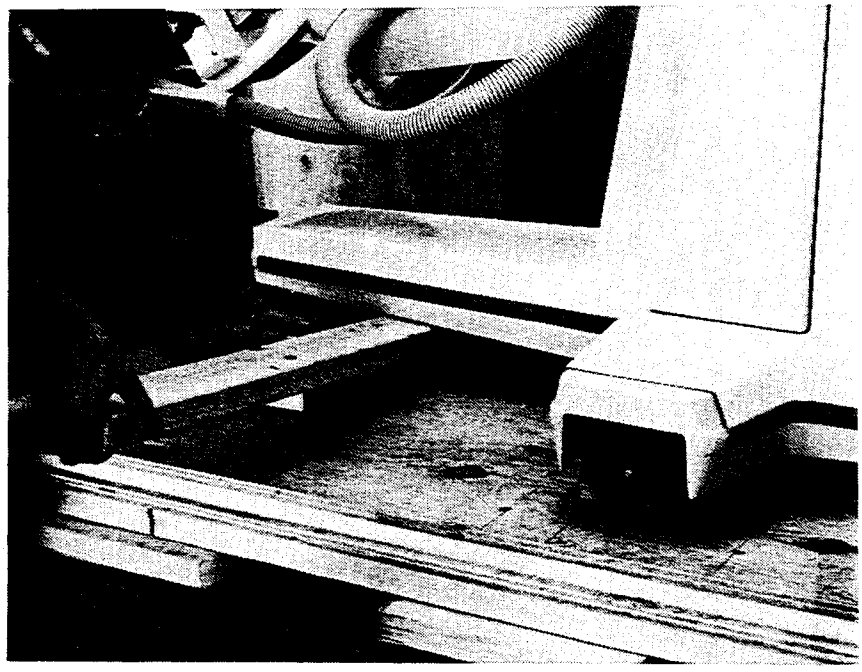


Figure 10-4 - *Use the length of 2x4 as a lever.*

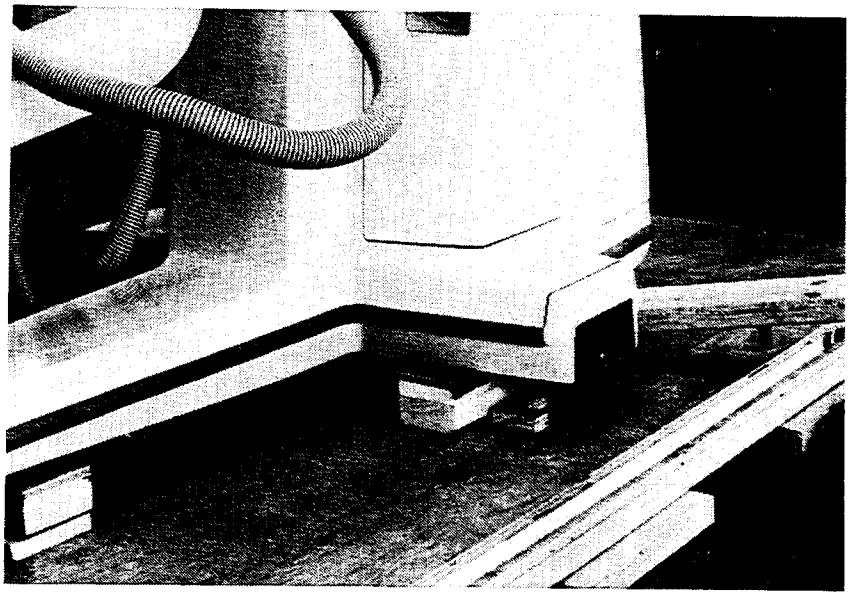


Figure 10-5 - *Use the length of 2x4 as a lever under each rear wheel to remove the blocks.*

7. Position the front and rear wheels in a straight line using the foot lever and the steering handle.

8. Pull the mainframe gently down the ramp. *(Refer to Figure 10-6).*

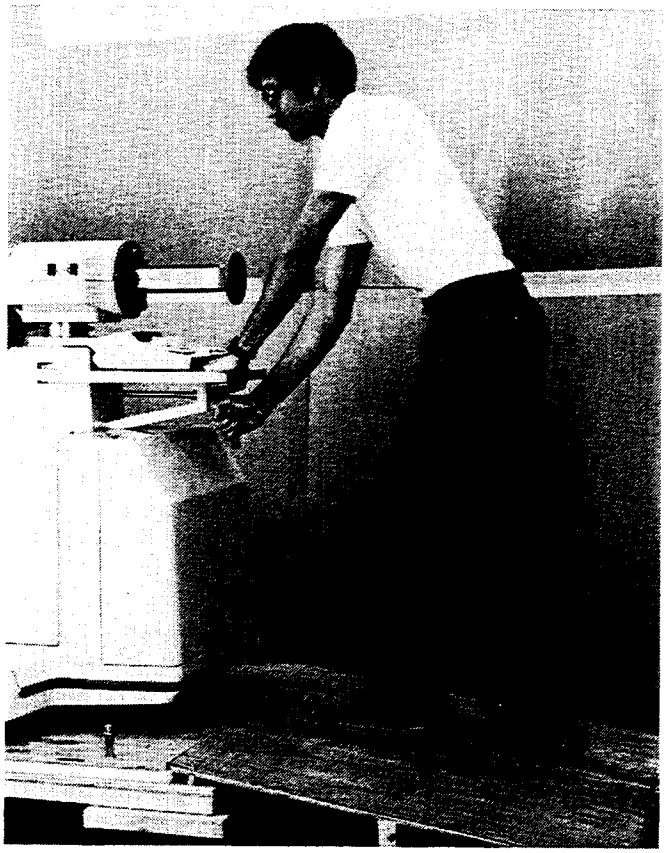


Figure 10-6 - *Carefully back the mainframe down the ramp.*

CAUTION: *Don't let the C-arm roll down the ramp too fast. Keep it in a straight line aimed straight back to avoid rolling off the side of the ramp.*

CAUTION: *Keep the base of the ramp clear of obstacles.*

9. After leaving the ramp, lock the C-arm wheels at right angles to each other to prevent the C-arm rolling.

10. Rotate the C-arm to place the imaging axis vertically with the image tube mount on the bottom.

CAUTION: *When the C-arm brakes are loosened the C-arm may pivot out of balance. Be sure the brakes are tight before attaching the weight of the image tube assembly to the C-arm.*

11. Locate the four Nylock screws in the shipping kit. Place the image intensifier assembly on the C-arm mount and insert and tighten the four Nylock screws.

12. Remove the protective bubble pack from the high voltage cable assembly, extension arm, and control panel. *(Refer to Figure 10-7).*

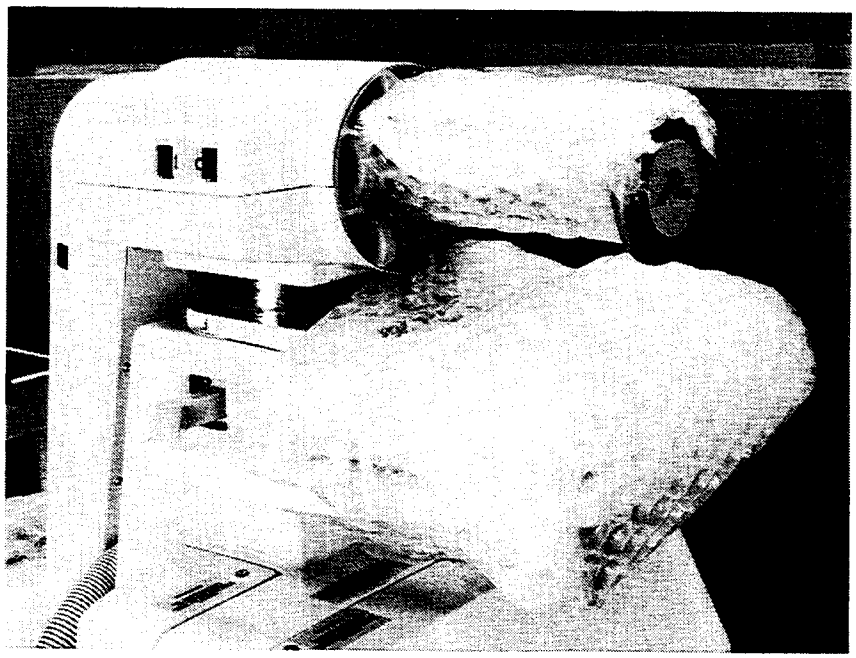


Figure 10-7 - *Remove the bubble packing.*

13. Remove the wood brace from the extension arm. *(Refer to Figure 10-8).*

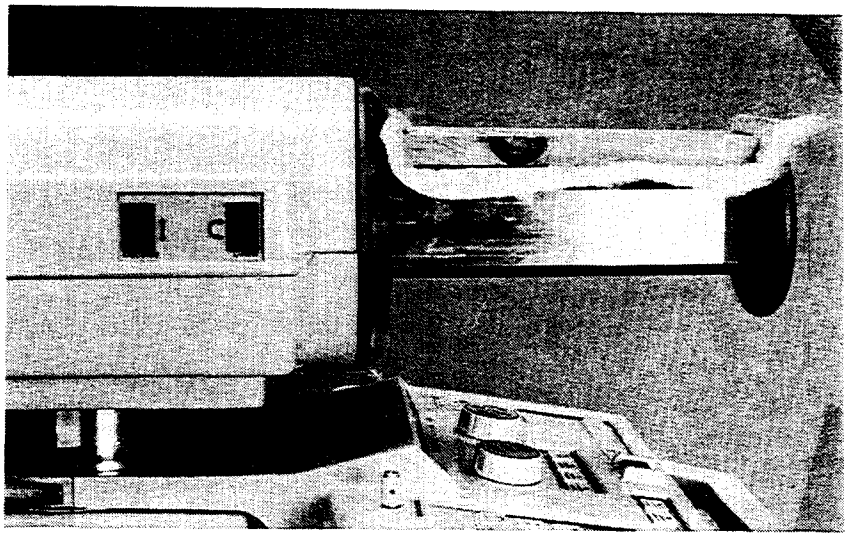


Figure 10-8 - *Remove the wooden brace.*

10.3.2 Repacking the Mainframe

Reverse the order of the above steps.

NOTE: *When placing the wood blocks under the three wheel assemblies, note that the front wheel block is higher than the two rear wheel blocks.*

WARNING: When removing the image intensifier, do not let the C-arm pivot unbalanced - make sure the C-arm brakes are tight.

10.3.3 Unpacking the Monitor Cart Assembly

1. Carefully cut away the shrink wrap covering the monitor cart. *(Refer to Figure 10-9).*

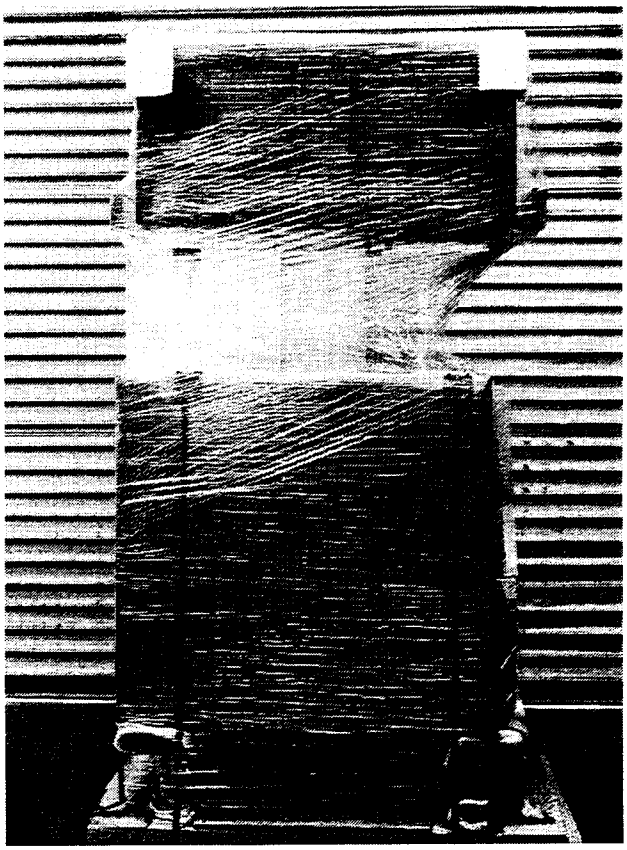
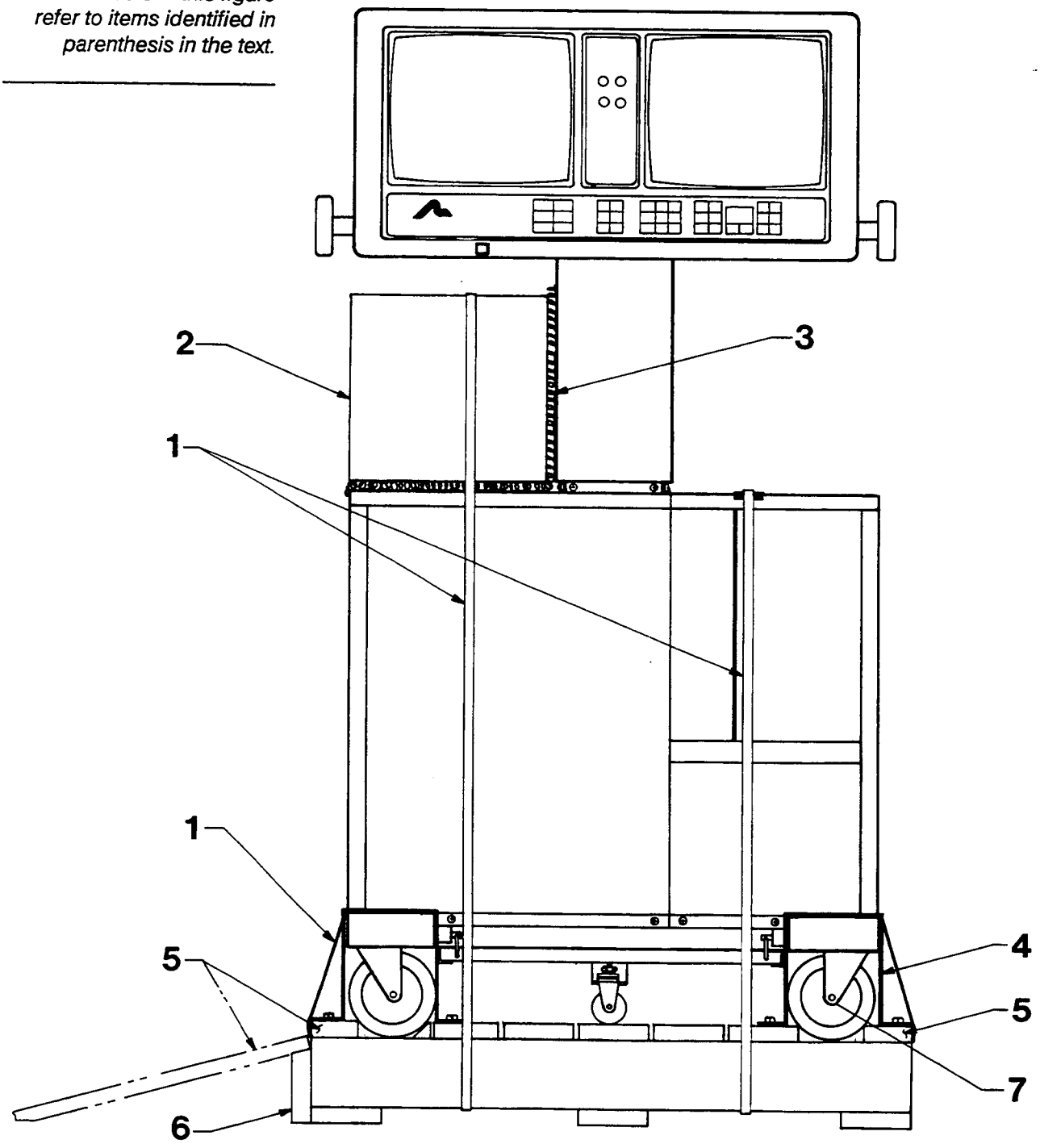


Figure 10-9 - *Remove the shrink wrap plastic covering the monitor cart.*

2. Cut the plastic straps secured around the monitor cart and the cardboard shipping box.

   If the cart has been shipped on a palette, follow steps 3 thru 7. *(Refer to Figure 10-10).*

Figure 10-10 - *Remove the monitor cart from the palette. The numbers in this figure refer to items identified in parenthesis in the text.*



3. Remove the shipping (accessory) kit (2) from the shelf top. Cut the nylon reinforced tape and remove the protective covering (3) from the shelf top.

4. Remove the two lag screws, metal strap and felt pad from each of the front wheels (4). *(Refer to Figure 10-11).*

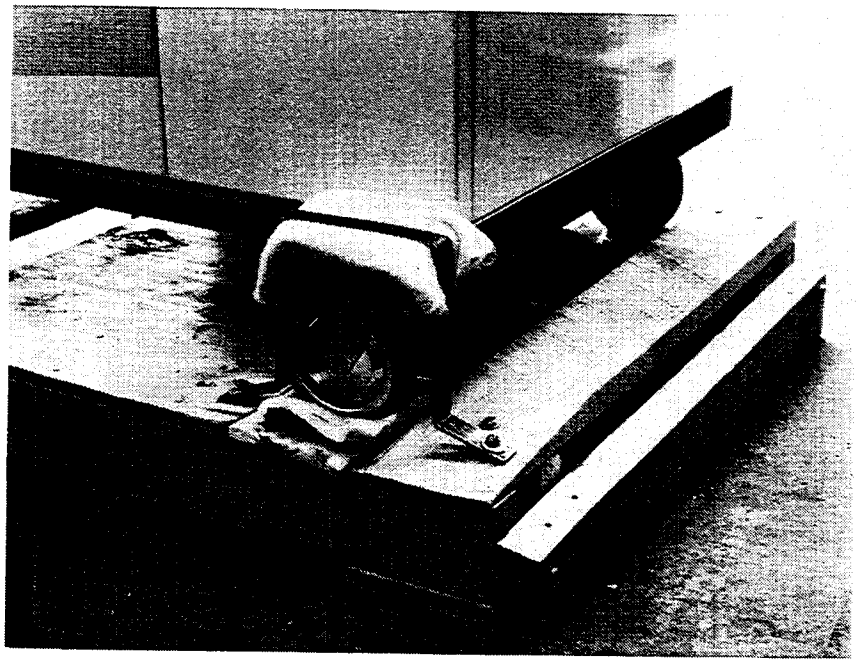


Figure 10-11 - *Remove the metal straps from each of the front wheels.*

5. Remove the lag screws and ramp planks (5), reposition the ramps on the ramp support (6), and secure in place using the 4 lag screws obtained during plank removal.

6. Unlock the rear wheel brakes. Unlock the caster swivel lock on the front wheel furthest from the ramp (7). Turn the caster 180 degrees and relock its swivel.

CAUTION: *The following steps require two strong people capable of controlling the cart as it is rolled out of its retension groove and down the ramp (the monitor cart weighs approximately 360 lbs.). Care must be taken to prevent the cart from rolling off the pallet and ramps.*

7. Roll the monitor cart up and over the center pallet planking and down the ramps to the floor.

8. Check for any unremoved packing materials on the cabinet. Unpack the accessory kit and the optional accessories.

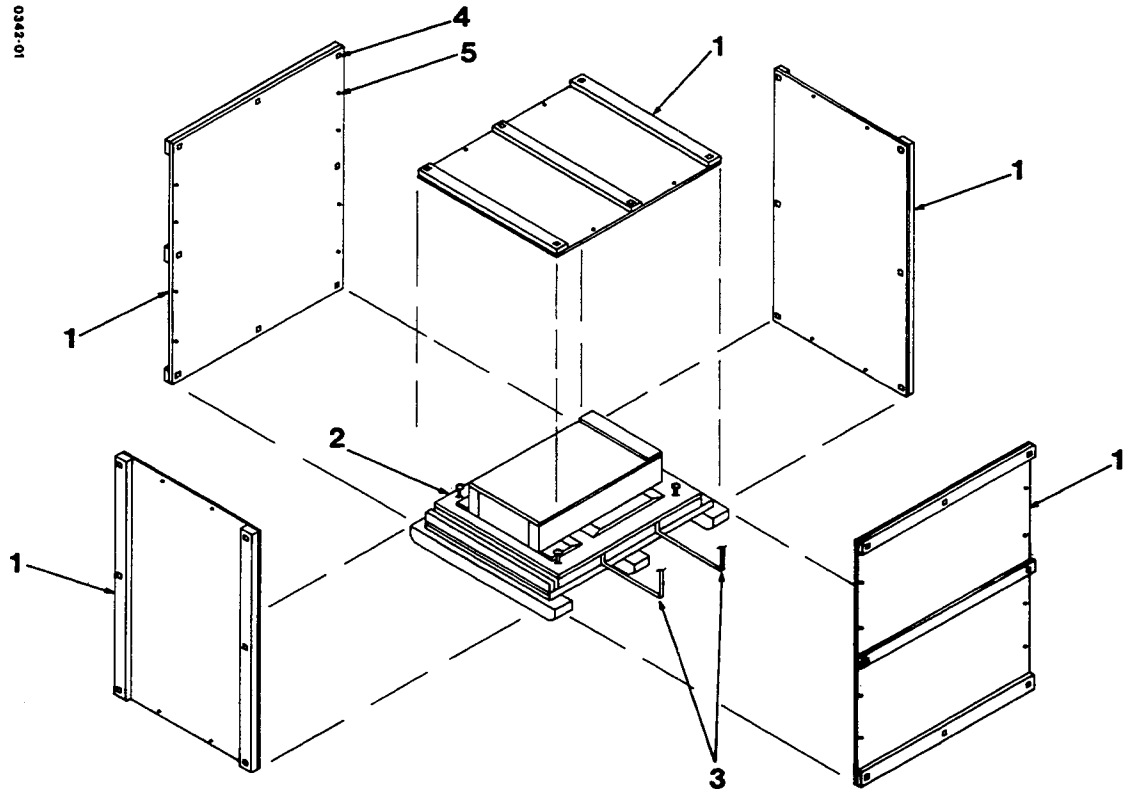
9. Install the top covers. Refer to the Assembly/Disassembly section in the Service Manual for instructions.

10. The monitor cart can now be moved to the installation site.

10.4 Foreign Export Unpacking Instructions, Mainframe and Monitor Cart Assemblies

The shipping containers consist of side and top pieces secured to the shipping palette with lag screws. *(Refer to Figure 10-12).*

Figure 10-12 - *Foreign export packing.*



1. Remove the lag screws which secure each panel to the wooden shipping palette.

2. As each panel is freed by removing the lag screws, lift the panel out of the way.

3. Follow the instructions previously given in this section for removing the equipment from the palettes and removing protective wrapping materials.

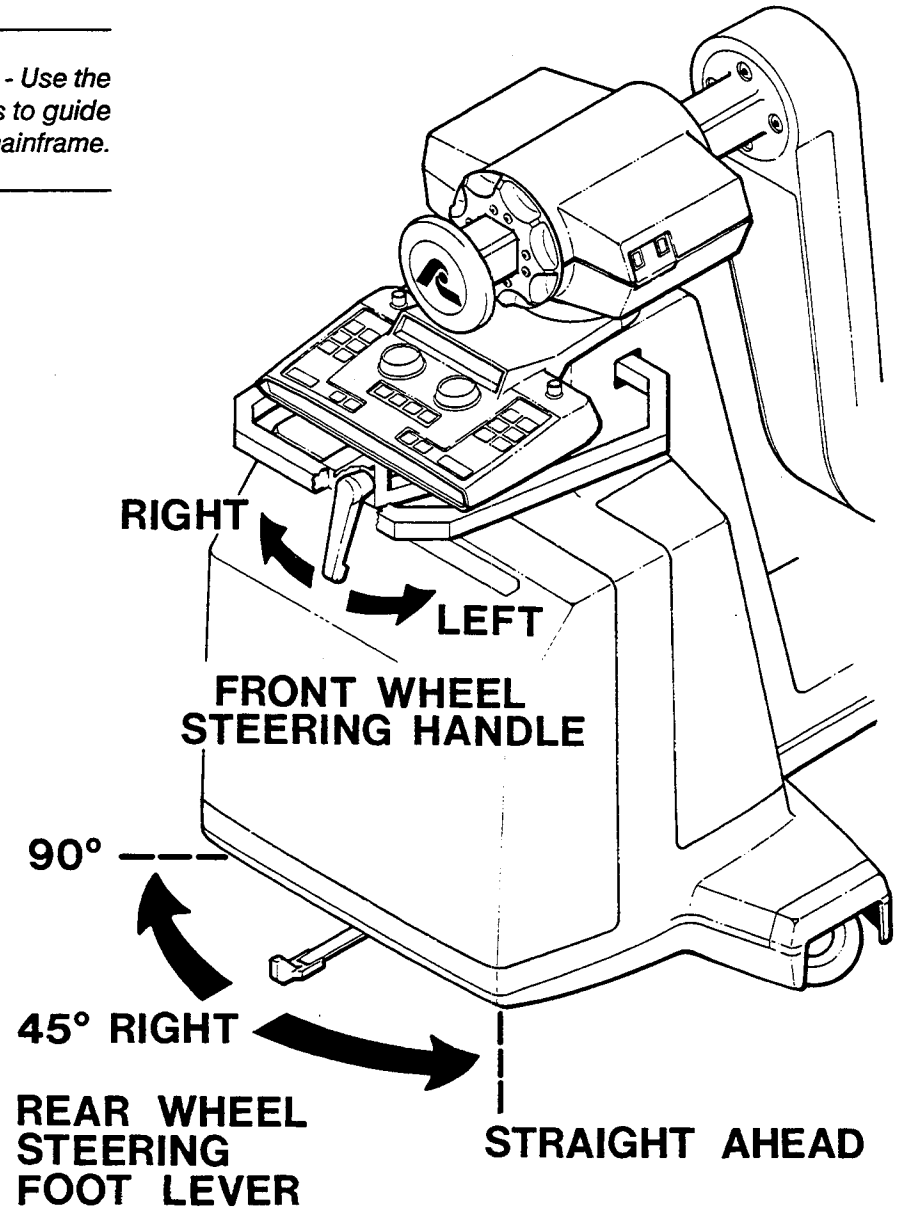
10.5 Moving the System

1. Place the C-arm and L-arm in their most compact positions. If the system has just been unpacked it is already in this configuration.

2. Lock all movable mechanical assemblies, such as the extension arm, in place. Tighten all locking handles.

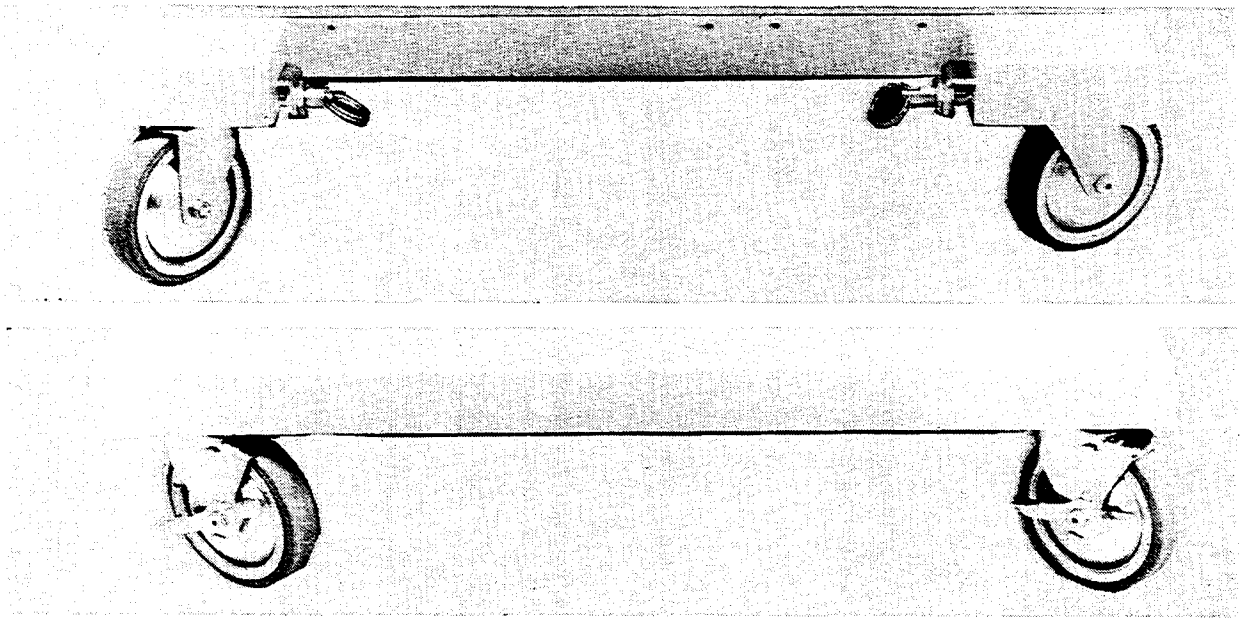
3. Steer the mainframe with the controls. The operation of the steering controls is demonstrated in Figure 10-13.

Figure 10-13 - *Use the steering controls to guide the mainframe.*



4. Unlock the monitor cart wheels and guide it carefully as you push. *(Refer to Figure 10-14).*

Figure 10-14 - *The front and rear wheel locks.*



5. When the system is finally in place, apply the friction wheel locks on the monitor cart and lock the mainframe front and rear wheels at right angles to each other.

Take These Precautions When Moving the System

- Two people should guide the mainframe and then return to guide the monitor cart when moving up or down an incline.

- Never move the system by pushing the mainframe ahead of you while pulling the monitor cart behind.

- Clear all hazards (this may mean both people and equipment) from the base of a ramp before moving the system along the incline.

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

- Never lock the mainframe or cart in place on an incline. It may roll out of control.

- Always apply the friction locks on the monitor cart and lock the front and rear wheels on the mainframe at right angles to each other when the system is in its final location.

10.6 Startup After Long Term Storage

Follow these steps if the system has been in storage for more than 60 days:

1. Plug in the system.
2. Follow the normal setup procedure.
3. Leave the system powered up in the FLUORO mode for at least four hours. (This allows for proper ion removal from the image intensifier tube).

If the system has been in storage for more than six months, condition the batteries and ensure their full charge before use:

1. Connect the interconnect cable between the mainframe and the monitor cart.
2. Plug in the monitor cart power cord. (The battery charger circuit will apply the charging current to the batteries in the mainframe).
3. Allow the batteries to charge in this manner for 24 hours.
4. Follow the normal setup procedure.
5. Leave the system in the FLUORO mode for at least four hours. (This allows for proper ion removal from the image intensifier tube).

10.7 Site Requirements

The major considerations for installation of the system are:

1) electrical power requirements,
2) environmental conditions, and
3) safety precautions.

The system power and operating environment requirements are listed in the *System Specifications*.

To satisfy its electrical requirements the system requires an input power source capable of providing:

115 VAC, 20 Amps or
230 VAC, 10 Amps.

Line voltage regulation requirements must be met as described in the Installation Checkout Procedure.

The customer is responsible for preparing the building, equipment environment and services required to install and operate the system.

10.8 Installation Checkout Procedure

As the steps in this procedure are performed, check them off on the Installation Checklist at the end of this section. You should make a photocopy of this checklist for use and save the original for reference.

10.8.1 Verify the Contents of the Accessory Kit

Verify that the following materials have been included in the System Accessory Kit (part # 870729). Note any shortages on the Checklist.

Two Operator's Manuals
Two Service Manuals
Two schematic Packages
Two mainframe keys
Footswitch assembly
Cassette holder (OEC-Diasonics metric or standard)
30 cm. skin spacer assembly
Eight socket-head Nylock screws
Copy of Configuration Sheet

Field Service Documentation Package:

- FDA form 2579
- Installation report (QAI 1003)
- Film identification stickers
- Various envelopes
- X-ray installation documentation instructions
- Instructions for Installation (QAI 1006)

10.8.2 Inspection and Setup

1. Install the skin spacer on the collimator assembly.

   Verify the presence of an aluminum filter at the bottom surface of the collimator and another aluminum filter located between the X-ray tube and the X-ray tube mounting bracket. The second filter can be seen after removing the aluminum filter from the bottom surface of the collimator. Look into the collimator and up toward the X-ray tube window.

2. Check the conductive casters on both the mainframe and the monitor cart for proper pressure and freedom of movement.

3. Inspect the interconnect cable; make sure the interconnect cable is permanently attached by its bracket to the monitor cart.

4. Remove the front, rear, and left side panels from the monitor cart and the left, right and rear covers from the mainframe. Inspect for loose hardware and shipping damage.

5. Inspect both the monitor cart card rack and the mainframe card rack. Verify that the extender board is present and that the retaining bars are screwed in place.

6. Replace all covers on the mainframe.

7. 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.*

10.8.3 Line Voltage Compatibility Check

The line voltage must be checked in each room where the equipment is to be used. Do not assume the line voltage will be constant throughout the hospital.

Verify voltage compatibility in all rooms where this machine will be used in the hospital. If a particular room is unavailable, write "NOT KNOWN" in the line voltage blank and put "NK" in the voltage and plug compatibility blanks on the checklist. A room is not plug compatible if it requires an adapter to be used. If any rooms are not voltage compatible, the hospital must be made aware of it.

10.8.4 Wiring the Isolation Transformer

1. The secondary voltage, measured on each leg referenced to neutral, should fall within the range 110-120 VAC. Wire the transformer to obtain a voltage as close to 115 VAC as possible.

   If the AC voltage range is:

94-102 VAC	wire T1 for 98 VAC
100-108 VAC	wire T1 for 104 VAC
105-115 VAC	wire T1 for 110 VAC
115-125 VAC	wire T1 for 120 VAC
122-134 VAC	wire T1 for 128 VAC

   If the AC voltage range is:

186-206 VAC	wire T1 for 196 VAC
200-218 VAC	wire T1 for 208 VAC
209-232 VAC	wire T1 for 220 VAC
228-252 VAC	wire T1 for 240 VAC
243-269 VAC	wire T1 for 256 VAC

2. Connect the interconnect cable to the mainframe and plug the power cord into the wall outlet. Check and record the voltages at the primary and secondary of the isolation transformer (T1).

3. Replace the covers on the monitor cart.

10.8.5 Basic Setup Checks

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 front panel. Refer to what these codes mean in the Service Section of this manual.

   Observe the Boot Codes on the mainframe LED panel and the Progress Codes on the monitor cart LED display as the operating software is loaded and the system is initialized.

   If any of these codes remains on the LEDs and the system fails to complete its booting and initialization, refer to the listing of boot codes in the Mainframe Service section or the listing of progress codes in the Monitor Cart Service section.

3. Check for correct AC voltage at the rear monitor cart AUX outlets.

10.8.6 Mechanical Checks

In the steps below, check for ease of movement without excessive play.

1. Check the **foot lever and steering handle** for proper movement. Then lock the C-arm in place by setting the wheels at right angles to each other.

2. Check **Wig Wag** - horizontal swing of the C-arm from side to side.

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 proper action of the pivot lock.

5. Check radial movement of the C-arm on the **cradle bearings** with proper holding action of the brakes.

6. Raise and lower the **L-arm.** The switch is located on either side of the extension arm assembly.

7. Rotate the **L-arm** 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

10.8.7 Verify Operation of Mainframe Controls

Warning: This procedure produces X-rays. Take the 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 an LED or beep response), indicating that the microprocessor is responding to the input.

3. Verify that the LARGE field switch removes the 6-inch collimator by listening for the "thunk" sound produced.

4. Select FILM mode and enter a low power technique.

5. Verify that the X-RAY ON lamps on the X-ray tube assembly, control panel and monitor cart light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

6. Verify operation of the footswitch.

7. 6-inch Machine only - Verify that in FILM mode, X-ray operation only occurs when the film cassette is in place.

8. Verify that the EMERGENCY OFF buttons on the control panel break the interlock circuit and prevent X-ray operation. (The message *INTLCKS BROKEN* will be displayed on the LED panel).

10.8.8 Verify Controls in MANUAL FLUORO

1. Select MANUAL FLUORO mode.

2. Verify that kVp and mA can be controlled with the control panel knobs.

10.8.9 AUTO FLUORO Tests

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Select AUTO FLUORO mode.

2. Using different thicknesses of copper filters, verify that the kV tracks up and down during X-rays as material thickness is increased and decreased.

3. Remove the copper filters.

4. Switch to live video using the VIDEO BYPASS switch (on the monitor cart rear) and verify that true live video appears on the left monitor and that the system does not lose synchronization.

5. Place the Wisconsin Copper Mesh Test Tool on the image intensifier assembly. Check image resolution during live imaging (video bypass mode). Minimum acceptable resolution is 35 line pairs per inch in the live mode.

6. Switch the VIDEO BYPASS switch to NORMAL. Check for proper operation of these mainframe controls:

   a. Left to right sweep reversal
   b. L -> R memory swap
   c. SHARPEN (if provided)

7. Verify operation of the motorized collimator and camera controls with the control panel switches.

8. Verify operation of the left monitor's remote contrast and brightness controls on the control panel. (Set the control on the monitor cart to REMOTE).

10.8.10 Verify Image Processing and Storage Features.

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Switch the VIDEO BYPASS switch to NORMAL.

2. Make a fluoro exposure and transfer the image to the right-hand monitor.

3. Make another exposure. The image will appear on the left monitor.

4. Enable the WINDOW and LEVEL functions and take another image. The WINDOW and LEVEL arrow buttons should change the dynamic range and brightness level of the image presented on the left-hand monitor.

5. Verify that the Negative Image (NEG) function reverses the lights and darks in the image.

6. Verify operation of both the Integration and the Averaging functions for all levels of averaging (number of frames).

7. Verify operation of the SHARPEN function.

8. 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.

9. *On systems equipped with hard disk image storage*, verify that the Manual SAVE function stores the image on the hard disc.

10. RECALL the image stored in the previous step.

11. *On systems equipped with hard disk image storage*, verify that the image counter increments and decrements, and that additional images can be recalled. "d0" error message displayed on the LED's indicates that no image was found in the specified location.

12. *On systems equipped with hard disk image storage*, enable the AUTO save function. Generate a picture on the left monitor, and press the L->R function switch. Verify that the image is auto-saved and that the LED image counter is incremented by one.

13. Time the transfer while saving an image to disk. The transfer should take less than 10 seconds, thus verifying disk transfer DMA.

14. Verify that the LEFT Fluoro footswitch generates a live fluoro image on the left monitor regardless of the status of the image processing controls.

15. Select an image processing mode (such as integrate). Press the RIGHT footswitch and verify that the selected image processing occurs.

16. Verify that the circular blanking is set as close as possible to the actual image edges throughout a full rotation in both normal and reversed image modes.

17. Check for presence of an EIA RS170 composite video signal at the video output jacks on the rear of the monitor cart.

NOTE: The video signal must be terminated with 75 ohms to correctly measure the amplitude.

10.8.11 Additional Image Processing Tests

An extensive set of tests are available through the Front Panel HELP function. These tests are described under Calibration and Diagnostic Software in the Monitor Cart Service section of this manual.

10.8.12 Fluoro Boost Option

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Enable boost on the control panel. Press down into the second position on the right footswitch.

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 image doesn't "burn out" or appear too dark.

10.8.13 Radiographic Beam Alignment Check

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Attach the beam alignment fixture to the face of the image intensifier assembly. Rotate the C-arm until the beam axis is perpendicular to the floor.

   On 6-inch models only: Verify that the cassette interlock switch is activated .

2. Make an exposure with the collimators fully open and the LARGE FIELD switch activated. Use 50 kV and 5 mAs. (The technique may vary depending on the type of film used.)

3. Close the collimators to their minimum field. Align the collimator assembly parallel to the cassette holder and repeat the exposure.

4. Develop the film.

5. Verify that the minimum field is contained within the target square (this must be less than 4.7 cm in each dimension measured on the film), that all of the innermost ring can be seen in the large field and none of the outer ring is visible.

6. Press the SMALL FIELD switch.

7. Install a new film cassette and repeat steps 2 thru 5 using the same technique.

8. Develop the film.

9. Verify that all the inner 6-inch ring is visible, and that none of the outer 6-inch ring is visible.

   The films are to be returned to the OEC-Diasonics Compliance Department per the instructions provided in the Field Service Documentation Package.

10.8.14 Fluoroscopic Beam Alignment Check

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. With the beam alignment fixture in place, select MANUAL FLUORO and set the technique at 45 kVp and 1 mA.

2. Bring up the Video Test Pattern on the monitor using the Monitor Cart Diagnostics described in the Monitor Cart Service section.

3. Make a fluoroscopic exposure and examine the test pattern image on the monitor. There should be no distortion of the image field and the inner circle of the beam alignment fixture reticle should be visible throughout its circumference.

10.8.15 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 check list:

   100 (Vn - V1)/ (V1)

   where: Vn = No load voltage
   V1 = 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.

10.8.16 Install and Verify System Options

Options provided may include:

Video Tape Recorder
AngioStor Video Disk
Hard Disk Image Storage (installed at the factory)
Patient Annotation (installed at the factory)

The installation of these options is described in Section 12 - Options.

10.8.17 Reporting

1. Return the assembler's copy of the Report of Assembly of Diagnostic X-ray (FDA form 2579), the Beam Alignment Radiographs (films), the completed Installation Report, and the Installation Checklist to OEC/Diasonics, Attention: Compliance Department, in the stamped, manila envelope provided in the Field Service Documentation Package.

2. Distribute the various remaining copies of the Report of Assembly of Diagnostic X-ray (FDA form 2579), per the documentation instructions included in the Field Service Documentation Package.

3. Verify the serial and model numbers listed and the control numbers on the Main Frame and Collimator. These should agree with those listed on FDA form 2579.

4. Record the installation in the service log.

   The OEC Representative MUST sign the last page of the Installation and Checkout Checklist, verifying acceptance of the unit. If, for any reason, installation can not be completed, the OEC Representative MUST be notified that unit is not yet ready for use. (A copy of the Installation and Checkout Procedure Checklist is found at the end of this section).

INSTALLATION CHECKLIST

Check off these steps as you perform the Installation Checkout Procedure in the service manual. Paragraph numbers are provided to make it easier to correlate the checklist to the procedure. Fill in specific data where requested.

Date - _____ S/N - _____

10.8.1 Verify the Contents of the Accessory Kit

Verify that the following materials have been included in the System Accessory Kit (part # 870729). Note any shortages below.

___ Two Operator's Manuals
___ Two Service Manuals
___ Two schematic packages
___ Two C-arm keys (inside ring binders)
___ Footswitch assembly
___ Cassette holder
___ 30 cm. skin spacer assembly
___ Eight Nylock socket-head screws
___ Copy of Configuration Sheet

___ Field Service Documentation Package:
___ FDA form 2579
___ Installation report (QAI 1003)
___ Film identification stickers
___ Various envelopes
___ X-ray Installation documentation instructions
___ Instructions for Installation (QAI 1006)

10.8.2 Inspection

___ 1. Check skin spacer, primary and secondary filters.
___ 2. Check conductive casters on cart and mainframe.
___ 3. Check interconnect cable attached to monitor cart with bracket.
___ 4. Remove panels and covers; inspect the interior of mainframe and cart.
___ 5. Inspect the card racks in monitor cart and mainframe.
___ 6. Replace all covers.
___ 7. Inspect AC power cable and the high voltage cable.

10.8.3 Line Voltage Compatibility Check

Verify voltage compatibility in all individual rooms where this machine is intended to be used in the hospital. If a particular room is unavailable, write "NOT KNOWN" in the line voltage blank and put "NK " in the voltage and plug compatibility blanks. A room is not plug compatible if it requires an adapter to be used. If any rooms are found not voltage compatible, the hospital must be made aware of it.

Location	Compatible ?	
	Voltage	Plug
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___

10.8.4 Wiring the Isolation Transformer

Primary _____ VAC

Secondary _____ VAC

___ 1. The secondary voltage measured on each leg should fall within the range of 110-120 VAC referenced to neutral.
___ 2. Replace the monitor cart covers.

10.8.5 Basic Setup

___ 1. Power up the system as usual.
___ 2. Monitor cart and mainframe complete their software boot and initialization with no self-test errors reported on the displays.
___ 3. Check for AC voltage at the rear monitor cart AUX outlets (110-120 VAC).

10.8.6 Mainframe Mechanical Checks

___ 1. Footlever and steering handle.
___ 2. Inspect the wig-wag.
___ 3. Inspect the extension arm
___ 4. Inspect the flip-flop and C-arm pivot point.
___ 5. Check C-arm movement in the cradle.
___ 6. Check L-arm lift movement.
___ 7. Check L-arm rotation.

10.8.7 Verify Operation of Mainframe Controls

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

___ 1. Verify that the anode is rotating.
___ 2. Check all control switches.
___ 3. Verify that the LARGE field switch removes the 6-inch collimator - listen for the "thunk" sound produced.
___ 4. Select FILM mode.
___ 5. Verify that the X-RAY ON lights on the X-ray Head, Control Panel and Monitor Cart light when the X-RAY ON button is pressed. The audible beep should also be heard.
___ 6. Verify operation of the footswitch.
___ 7. 6-inch Machine only - Verify that FILM Mode operation only occurs when the film cassette is in place.
___ 8. Verify that the EMERGENCY OFF buttons break the interlock circuit.

10.8.8 Verify Controls in MANUAL FLUORO

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

___ 1. Select MANUAL FLUORO mode.
___ 2. Verify control with the control panel knobs.
___ 3. Observe fluoro image on the left monitor.

10.8.9 Auto Fluoro Tests

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

___ 1. Select AUTO FLUORO mode.
___ 2. Verify that the kV tracks up and down as material thickness is increased and decreased.
___ 3. Remove copper filters.
___ 4. Verify operation of VIDEO BYPASS switch.
5. Check resolution during video bypass.

_____ line pairs per inch.

6. Check operation of mainframe video controls.

___ a. Left to right reversal
___ b. L->R Swap
___ c. SHARPEN (if provided)

___ 7. Check operation of the motorized collimator and camera controls.
___ 8. Check remote contrast and brightness controls.

10.8.10 Verify Image Processing and Storage Features

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

___ 1. Set video bypass switch to normal.

___ 2. Make an exposure and transfer image to right monitor.
___ 3. Make another exposure.
___ 4. Check operation of WINDOW and LEVEL.
___ 5. Check NEG function.
___ 6. Verify operation of INTEGRATION and AVERAGING.
___ 7. Check operation of SHARPEN.
___ 8. Check operation of L->R function from the monitor cart front panel.
___ 9. *On systems equipped with hard disk image storage*, verify operation of SAVE.
___ 10. *On systems equipped with hard disk image storage*, verify operation of RECALL.
___ 11. *On systems equipped with hard disk image storage*, verify operation that the image counter increments and decrements.
___ 12. *On systems equipped with hard disk image storage*, verify operation of AUTO.
___ 13. *On systems equipped with hard disk image storage*, verify operation of DMA.
___ 14. Verify operation of the FLUORO ONLY footswitch.
___ 15. Verify operation of the PROCESS footswitch.
___ 16. Check circular blanking.
___ 17. Verify proper video signal on the video output jacks (when terminated with 75 ohms).

10.8.11 Additional Image Processing Tests

___ As required.

10.8.12 Fluoro Boost Option

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

___ 1. Enable BOOST on the control panel.
___ 2. Alarm beeps at twice the normal rate.
___ 3. Verify that boost works in both auto and manual X-ray modes.
___ 4. Image doesn't "burn out" or appear to dark.

10.8.13 Radiographic Beam Alignment Checks

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

___ 1. On the first film - Verify that the minimum field is contained within the target square (this must be less than 4.7 cm in each dimension measured on the film), that all of the innermost ring can be seen in the large field and none of the outer ring is visible.

___ 2. On the second film - Verify that all the inner 6-inch ring is visible, and that none of the outer 6-inch ring is visible.

The films are to be returned to the OEC-Diasonics Compliance Department per the instructions provided in the Field Service Documentation Package.

10.8.14 Fluoroscopic Beam Alignment Check

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

___ 1. Bring up the Video Test Pattern, make a fluoroscopic exposure, and examine the image within the video test pattern.
___ 2. Circular blanking is correct.
___ 3. Image size is correct.

10.8.15 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. Calculate the percentage line voltage regulation and record the results below.

   100 (Vn - V1)/ (V1)

   where: Vn = No load voltage
   V1 = Max load voltage

   Vn=_____
   V1=_____

   Regulation = _____%

   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.

2. Measure the voltage on the isolation transformer secondary under maximum radiographic load. It must not fall below 100 VAC.

   Secondary voltage under max. load = _____ VAC

10.8.16 Install and Verify System Options

___ Install and verify options. The installation of options is described in Section 12, Options.

10.8.17 Reporting

___ 1. Return the assembler's copy of the Report of Assembly of Diagnostic X-ray (FDA form 2579), the Beam Alignment Radiographs (films), the completed Installation Report, and the Installation Checklist to OEC-Diasonics, attention: Compliance Department, in the stamped, manila envelope provided in the Field Service Documentation Package.

___ 2. Distribute the various remaining copies of the Report of Assembly of Diagnostic X-ray (FDA form 2579), per the documentation instructions included in the Field Service Documentation Package.

___ 3. Verify the serial and model numbers listed and the control numbers on the Main Frame and Collimator. These should agree with those listed on FDA form 2579.

___ 4. Record the installation in the service log.

___ 5. OEC Representative and hospital representative MUST sign last page of Installation Checklist, verifying acceptance of unit. If, for any reason, installation could not be completed, both OEC Representative and hospital representatives MUST be notified that unit is not yet ready for use.

This system is now installed and is operating in a satisfactory manner. The hospital representative acknowledges any limitations due to voltage incompatibilities between different areas of projected use.

OEC-DIASONICS Field Service Representative

_____

OEC Applications Representative

_____

Hospital Representative

_____

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 the properly trained service engineer who 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 Series 9000 System.

This manual is intended to compliment the training offered by OEC-Diasonics. Reading this manual does not alone 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.

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 certain hazards, emergency procedures and instructions for accident reporting.

Section 3
Mainframe 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.

Section 4
Monitor Cart Theory of Operation
A description of the hardware and software is provided to facilitate an understanding of the maintenance, calibration and repair of the monitor cart. Optional patient annotation and hard disk image storage are covered.

Section 5
Mainframe Parts, Disassembly and Replacement
Step by step instructions for removing and replacing field serviceable parts.

The major field replaceable parts are pictured and identified with their OEC-Diasonics part numbers.

Section 6
Monitor Cart Parts, Disassembly and Replacement
Step by step instructions for removing and replacing field serviceable parts.

The major field replaceable parts are pictured and identified with their OEC-Diasonics part numbers.

Section 7
Mainframe Service and Diagnostics
Mainframe boot and error codes, event codes and warning messages. Using the control panel Status Mode. Tables of adjustments, switches and jumpers.

Section 8
Monitor Cart Service and Diagnostics
How to change the monitor cart option configuration. Front Panel error messages. Built-in test and diagnostic software. Shot logging.

Section 9
Mainframe Calibration
Calibration procedures for the system are provided. A calibration worksheet is included.

Section 10
Installation
Unpacking, repacking, installation and on-site checkout instructions are provided.

Section 11
Options
Installation of options, interfaces, special troubleshooting and maintenance notes. Options include: VTR, AngioStor, multiformat camera.

Appendix
Recommended tools and test equipment. Installation and Use of Special Equipment. Printer Installation. Terminal installation and use. Test Log.

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 00-870820-01). Operating instructions for the system are contained in the Operator's Manuals for each member of the Series 9000 family:

9000 basic model - 00-871352
9000 with E.S.P. Option - 00-871353
9000 with E.S.P. and Vascular or Neuro-Vascular Option - 00-871354

Schematic diagrams for the system are contained in the schematic package, part number 00-870822.

The system contains some equipment and assemblies manufactured by original equipment manufacturers (OEM's) and not OEC-Diasonics. 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 maintenance 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 (21CFR 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, Generator Controller 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

Figures 1, 2, and 3 illustrate the major assemblies of the OEC-Diasonics Mobile C-arm X-ray System. The two major assemblies, the mainframe and the monitor cart, are connected by an 18 foot interconnect cable which carries power, video and communications signals.

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 to provide static grounding in an operating room environment.

1.5 Standard Equipment

Table 2 Standard Equipment

ITEM	*PART NUMBER*
C-arm Assembly	00-870724
Monitor Cart Assembly	00-870727
Collimator and Plate Assembly	
(6-inch)	00-870472
(6/9-inch)	00-870472
Image Intensifier Asm w/ Vidicon	
(6-inch)	00-870725
(6/9-inch)	00-870817
Cassette Holder	
(6-inch standard)	00-861095
(6-inch metric)	00-871096
(9-inch standard)	00-871138
(9-inch metric)	00-871139
Accessory Parts Kit	00-870729
Conductive Caster Asm	00-860092
Foot Switch Assembly (Dual Stage)	00-900012
30 cm Extension Spacer	00-837201

Figure 1 - *The mainframe is shown in this drawing.*

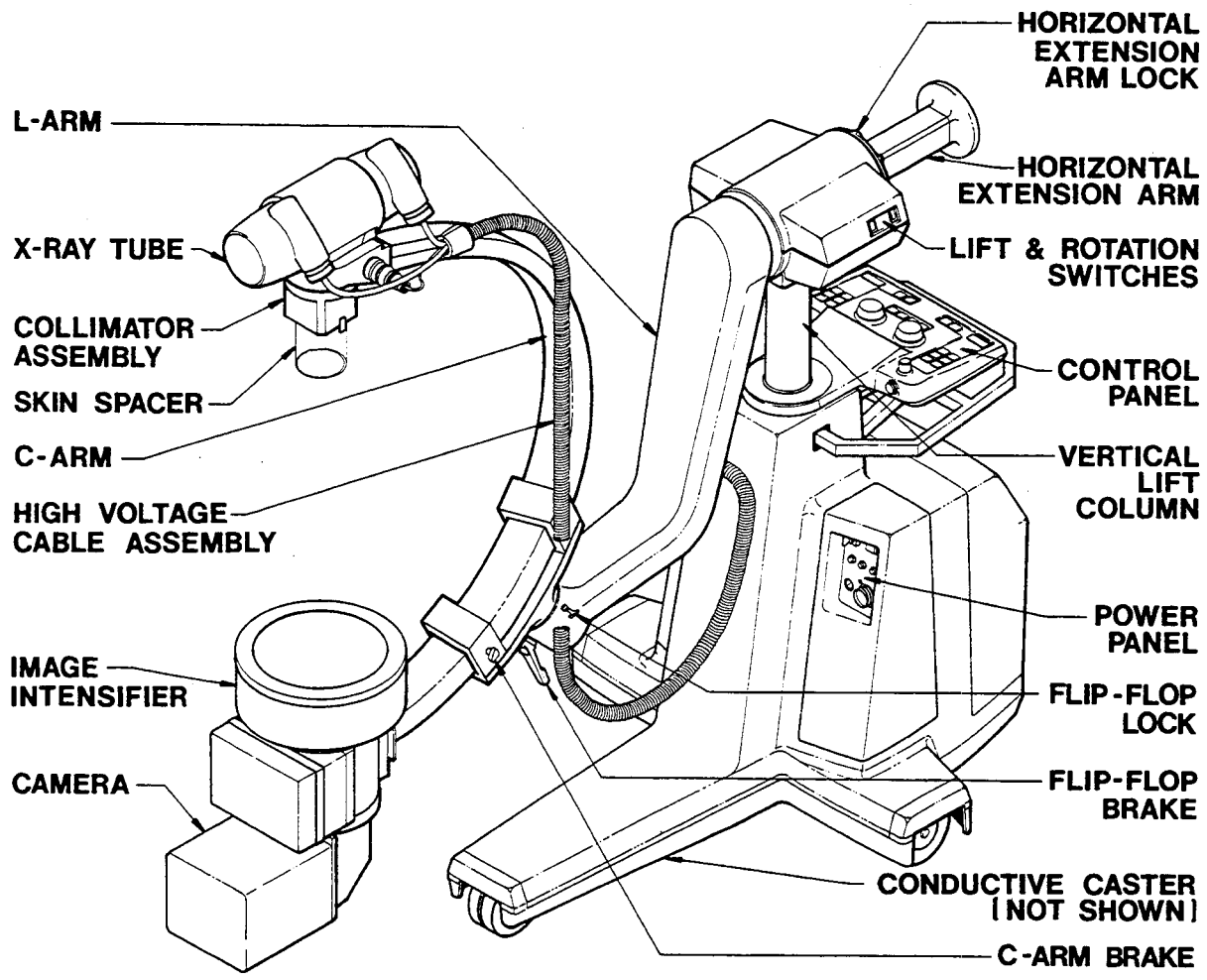


Figure 2 - *Front view of the monitor cart.*

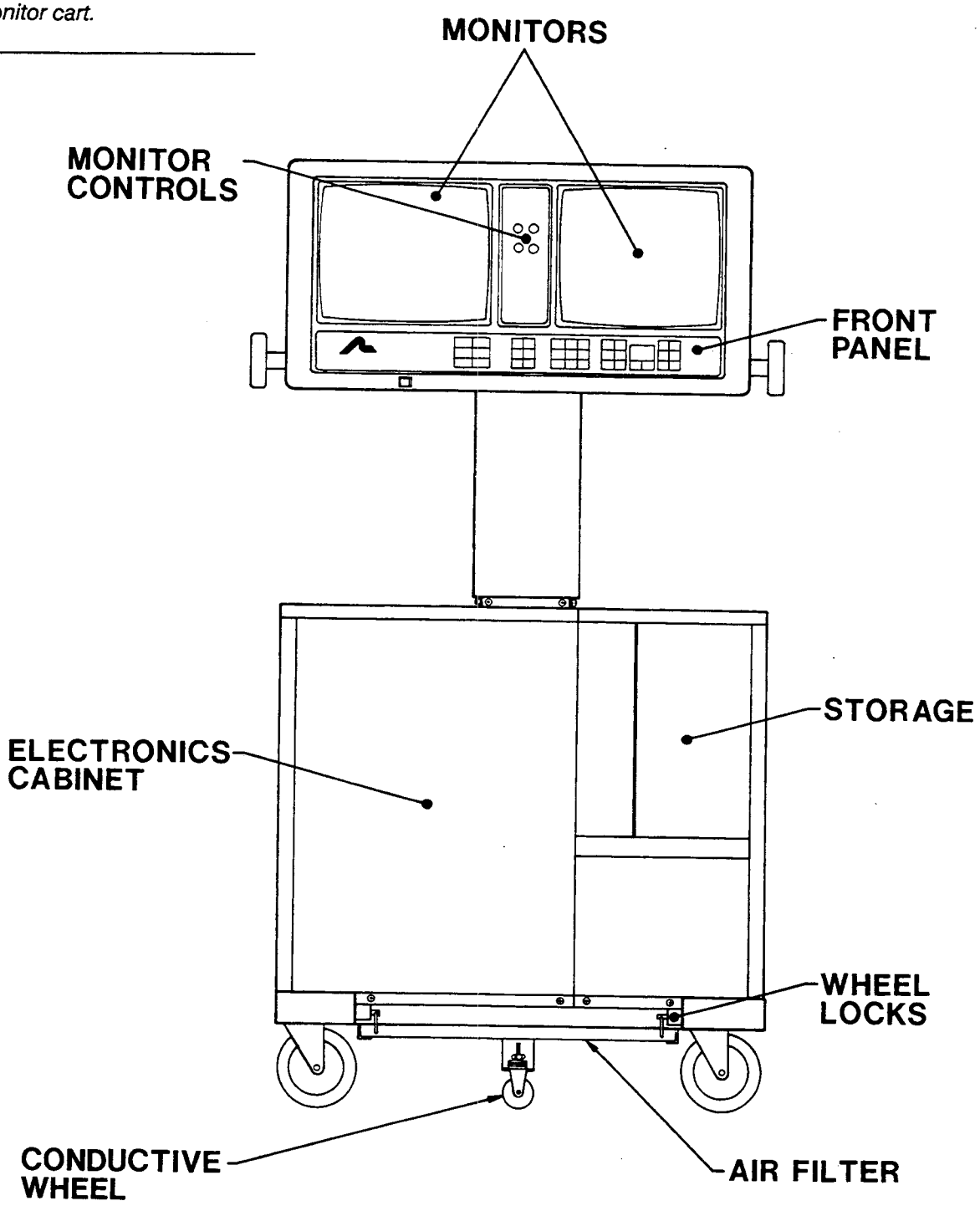
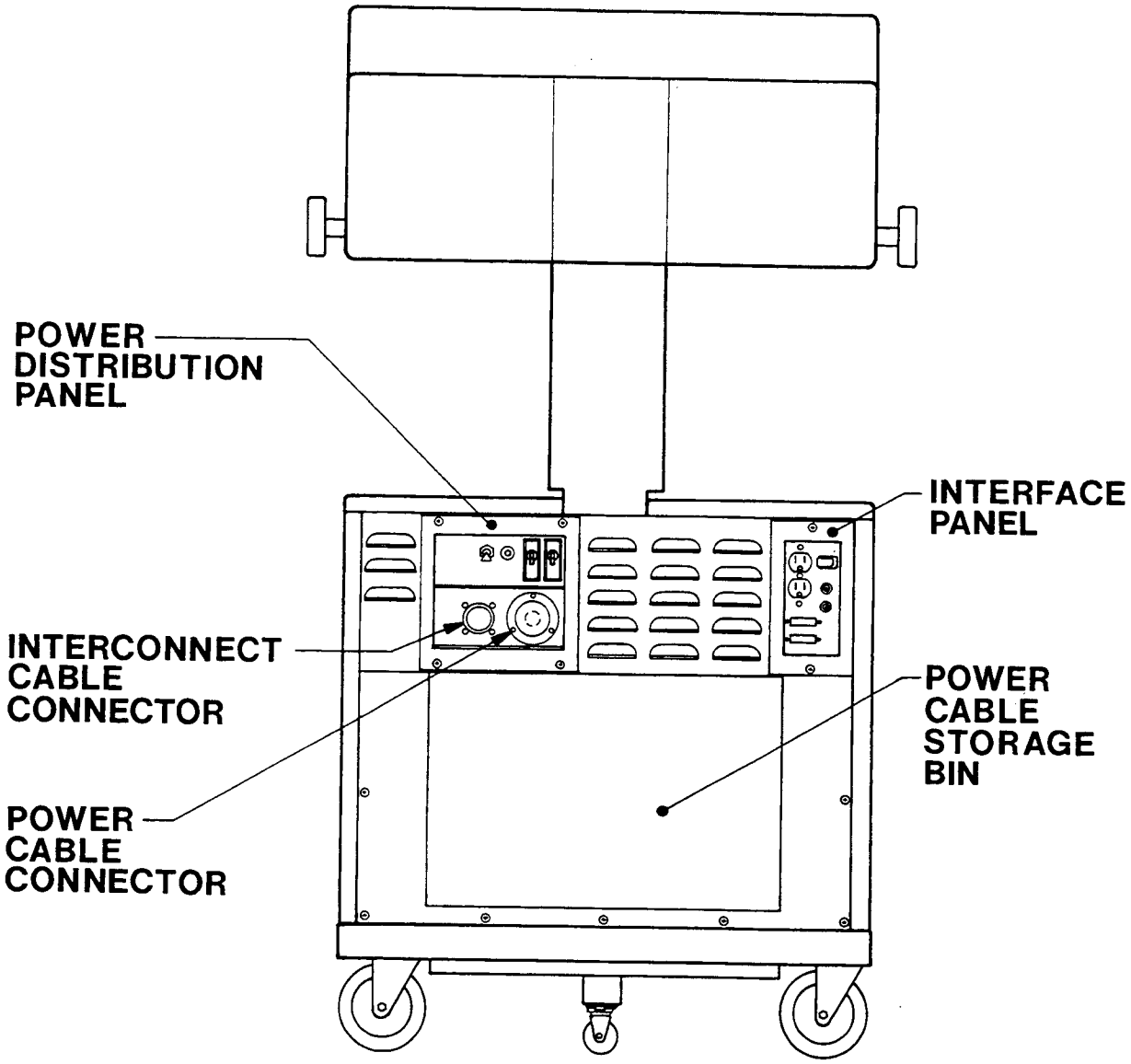


Figure 3 - *Rear view of the monitor cart.*



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 connecting an external terminal. The option files are described in the sections of this manual: "Mainframe Service" and "Monitor Cart Service."

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 dual mode 6/9-inch image intensifier. Serial numbers in the 63-000 range identify systems equipped with 6-inch image tubes. Serial numbers in the 93-000 range identify those equipped with 6/9-inch image tubes.

1.9 Monitor Cart Options

Image Storage

Images may be stored by several means, in analog or digital format, depending upon the system configuration.

Internal Hard Disk Image Storage - a hard disk memory system capable of storing sixty 512 x 512 x 8 bit matrix images. The digitized image can be saved on the hard disk and later recalled.

Video Tape Recorder - The undigitized image is available for storage on a video tape recorder or AngioStor.

AngioStor - Up to 20 seconds of high resolution video can be stored and reviewed. Playback can be continuous or stepped a single frame at a time.

Multi-format Camera - Several models are available to make hard copy films of fluoro images.

Patient Annotation - Images can be annotated with identifying information on the screen or on hard disc. A swing out keyboard is used with special software.

Image Processing

The circuits and software in the monitor cart perform image processing on the video signal. The specific operations, which may include frame integration, frame averaging, image subtractions, and "window" and "level" control of the gray scale, are selected from the monitor cart front panel.

Most image processing options can be identified by examining the monitor cart front panel.

SECTION 7
MAINFRAME
SERVICE AND DIAGNOSTICS

7.1 Safety Procedures During Service

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 adjustments 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 can result if such metal articles are placed across the battery terminals.

7.2 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 however, 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.

7.2.1 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

7.2.2 Technique Processor Boot Codes

These codes are 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

7.2.3 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

7.2.4 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

7.2.5 Misc 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.

7.3 Event Codes and Warning Messages

7.3.1 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 7.4.

Event Code Table

Refer to Table 1; 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 a * in the table.

Table 1 Event Code Listing

01	not used	
02	not used	
03	not used	
04*	X-RAY JUMPER ON	jumper left in after calibration
05	SWITCH STUCK	x-ray switch is sensed as on improperly
06*	PRECHARGE FAIL	precharge cycle has failed
07*	HV INVERTER ON	high voltage generator is on
08	not used	
09	MAIN PGM LOAD	main program is loaded to RAM
0A	INIT COMPLETE	hardware initialization is complete
0B	not used	
0C	D CURRENT FAIL	dark current cannot be calculated
0D	not used	
0E	FLUORO-PREP	indicates software state
0F	FLUORO-INIT	indicates software state
10	FLUORO-READY	indicates software state
11	FLUORO-XRAY	indicates software state
12	not used	
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	not used	
18	not used	
19	FLUOROS FILM	indicates transition: standby to film
1A	not used	
1B	not used	
1C	not used	
1D	BOOST FOOT UP	boost switch released
1E	BOOST OVERTIME	boost terminated at 30 seconds
1F	HOUSING 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 OVERHEAT	heat integrator warning
24	HOUSE OVERHEAT	heat integrator warning
25	WILL OVERHEAT	film mode warning
26	CP DEAD	control panel dead
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 was terminated from front panel
2A	not used	
2B	X-RAY ARMED	instant on is prearmed
2C	FILM - PREP	indicates software state
2D	FILM - INIT	indicates software state
2E	FILMX - FLUORO	indicates software state

Table 1 (continued) Event Code Listing

2F	FILM - READY	indicates software state
30	not used	
31	FILM - WARMUP	indicates software state
32	FILMS - FLUORO	indicates software state
33	FILM - XRAY	indicates software state
34	FILM - INST ON	indicates software state
35	FILM XOFF	indicates software state
36	XRAY COMPLETE	exposure has ended
37	FOOT RELEASED	x-ray switch released early in film mode
38	XRAY OVERTIME	film mAs integration error has occurred
39	not used	
3A	not used	
3B	not used	
3C	not used	
3D	EXCESS FILM KVP	a calibration error has occurred
3E	LOW FILM KVP	a calibration error has occurred
3F	EXCESS FILM MA	a calibration error has occurred
40	LOW FILM MA	a calibration error has occurred
41	not used	
42*	FLIPPER STUCK	the flipper collimator is stuck
43	MA ON IN ERROR	improper generator operation
44	not used	
45	KV ON IN ERROR	improper generator operation
46*	STATOR NOT ON	rotating target stator is not running
47*	OVERLOAD FAULT	generator fault detected
48*	SATURATION FLT	generator saturation fault detected
49*	FILAMENT FAULT	generator fault detected
4A*	INTRLKS BROKEN	interlock circuit was interrupted
4B*	HV INVERTER OFF	high voltage generator is on
4C	not used	
4D*	OVERVOLTGE FLT	generator overvoltage fault
4E*	NO SERVO TABLE	disk software failure
4F*	NO MUXRAM DATA	disk software failure
50	NO OPTIONS FILE	no default parameters
51	USER END	normal operation has been interrupted
52	EXIT PROGRAM	exit program from terminal
53	NO CASSETTE	
54	LOADING STATUS	control panel is entering the status mode
55	NO SYSTEM FILE	disk software failure
56	NO MA LIMITS	disk software failure

* Fatal Errors

7.3.2 Warning Messages During Operation

Follow the recommendations below for remedying 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.

7.3.3 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. These conditions can be remedied by allowing time for the X-ray tube to cool. These messages alternate with the normal information displayed on the LED panel.

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.

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.

7.3.4 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 provide additional recharging time, leave the system plugged in with the interconnect cable in place overnight.

7.3.5 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 Generator Controller PCB has been left in place, disabling regulation. Results in automatic shutdown.

SWITCH 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.

BPLUS FAULT
The battery voltage is low; the batteries may be weak. Results in automatic shutdown.

SHOT TOO LONG
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.

LG FIELD STUCK
The collimator is stuck in the large field position. 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 FLT
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.

INTRLKS 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.

7.4 Control Panel Status Mode

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.

If the mainframe fails at the "Press Start" prompt during startup, the Status Mode can still be entered in the manner described below.

7.4.1 To Enter the Status Mode:

1. PRESS and HOLD the unlabeled button below the image reversal button for five seconds.
2. The message *STATUS V n.n* indicates that you have entered the status mode. Once in this mode, turn either the right or left knob 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 knob.
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, scroll the menu item *EXIT THIS MENU* onto the display 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*.

7.4.2 Status Menus

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

7.4.2.1 Battery Status

When this menu is entered, you are instructed to press START. This completes the interlock circuit and allows battery measurement. If no action is taken within ten seconds, the message PRESS START is replaced by INTERLOCK TIMEOUT, and you are returned to the the status menu level.

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

7.4.2.2 Camera Status

VIDEO LEVEL
DARK CURRENT
CAMERA GAIN
EXIT THIS MENU

7.4.2.3 Heat Status

HOUSING HEAT
ANODE HEAT
THERMISTOR
EXIT THIS MENU

7.4.2.4 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 NUMBER	
0	*MEASURED KVP*
1	*MEASURED MA*
2	*FILAMENT B+*
3	*VIDEO LEVEL*
4	*HOUSING TEMPERATURE*
5	*DOSIMETER*
6	*SPARE*
7	*SPARE*
8	*TAP VOLTAGE*
9	*LINE VOLTS*
10	*CHARGE CURRENT*
11	*CHARGE VOLT*
12	*FIL CURRENT*
13	*SPARE*
14	*SPARE*
15	*SPARE*

EXIT THIS MENU

7.4.2.5 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 and 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

7.4.2.6 Control Panel Diagnostics

PANEL LED TEST
PANEL KEY TEST
PANEL KNOB TEST
PANEL CLOCK TEST
SPEAKER TEST
CLOCK TEST
REMOTE BAUD CHECK
EXIT THIS MENU

7.4.2.7 Date/Time Set

SET TIME
SET DATE
EXIT THIS MENU

7.4.2.8 System Options

(XXXX below indicates the current option setting).

ABS TABLE XXXX
ABS BOOT XXXX
CAM GAIN XXXX
LENGTH OF PULSED MODE PULSE
EXIT THIS MENU

7.4.2.9 Examine Calibration Parameters

TABLE A	*TABLE B*
TABLE C	*TABLE D*
TABLE E	*TABLE F*
TABLE G	*TABLE H*
TABLE I	*TABLE J*
TABLE K	*TABLE L*

LAST CAL DATE and TECHNICIAN
NUMBER OF CALIBRATIONS

7.4.2.10 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 - (last 128, beginning with most recent stored in EEPROM. This table is only updated when a fatal system error occurs.)

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

NUMBER OF FATAL EVENTS (accumulated number of fatal event occurances).

DATE AND TIME OF LAST FATAL ERROR

7.4.2.11 Miscellaneous

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

MODEL NUMBER
SERIAL NUMBER
TOTAL RAM
FREE RAM SPACE
TOTAL DISK SPACE
FREE DISK SPACE
INSTALLATION DATE AND TECH
NUMBER OF FILM EXPOSURES
EXIT THIS MENU

7.5 Internal LED indicators

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

The Technique Processor LED digit - This LED echos 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 interlock circuit is complete. 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 Generator Controller PCB.

7.6 Video Camera - Jumpers and Adjustments

7.6.1 Video PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1	IN	Shading
E2	IN	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

7.6.2 Preamp and Yoke ASM

FUNCTION	*ADJUSTMENT*
Peaking	C3

7.6.3 Power Supply PCB

FUNCTION	*ADJUSTMENT*
Beam Discharge	R14
+500 VDC	R13
Focus	R11
H-drive Sync	R25

Adjustment **H-Drive Sync Frequency**

1. Disconnect the H-drive.
2. Adjust R25 to obtain 14.5 kHz at TP14.

7.6.4 Shading/Window PCB

FUNCTION	*ADJUSTMENT*
H- Sawtooth #1	R40
H- Sawtooth #2	R41
H- Parabola	R42
H- Window Cal.	R38
V- Sawtooth	R10
V- Parabola	R16
V- Window Cal.	R39

7.6.5 Deflection PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1	AFC	line Lock/Auto Freq Cntl
E2	525 (60 Hz)	line rate select
	625 (50 Hz)	line rate select
E3		unused
E4		unused
E5-E6	OUT	U2 clock source
E7-E8-E9	E7-E8	50 HZ
	E8-E9	60 HZ
E10-E11-E12	E11-E12	Clock
E16-E17-E18	E16-E17	Horiz reversal

FUNCTION	*ADJUSTMENT*
H- Size	R40
H- Normal Centering	R38
H- Reverse Centering	R39
V- Size	R19
V- Centering	R37
AFC Tuning	L1

7.7 Image Intensifier Adjustments

7.7.1 6-inch Image Intensifier

ELECTROSTATIC FOCUS ADJUSTMENT

Refer to figure 7-1 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.

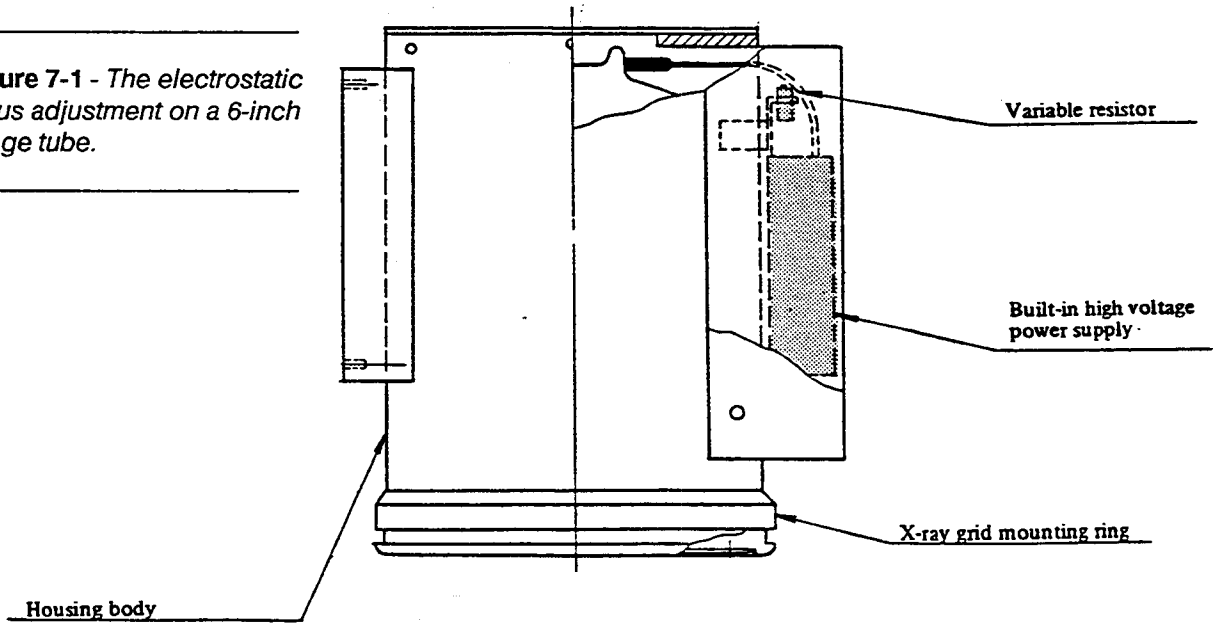


Figure 7-1 - *The electrostatic focus adjustment on a 6-inch image tube.*

7.7.2 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. Refer to Table 2.

Table 2 6/9-inch Image Tube Adjustments

The 6-inch mode adjustments are made to the pots labeled M1; 9-inch mode adjustments are made to the pots labeled N. The M2 adjustments are not applicable.

MODE	*OVERALL SIZE*	*OVERALL FOCUS*	*EDGE FOCUS*
6-INCH	G3	G2	G1
9-INCH	G3	G2	G1

Note: G3 (overall size) may only need adjustment in the 9-inch mode to make the image slightly smaller.

7.8 High Voltage Generator and Generator Controller PCB

These procedures are recommended if the Generator Controller PCB or any High Voltage Generator major component is replaced. Follow these procedures in order.

WARNING: This equipment contains very high power electrical components and should be serviced only by personnel intimately familiar with the circuitry and its operation. The voltages and power levels attainable are capable of causing serious injury, burns, and electrocution. At certain locations, these voltages are present EVEN WITH POWER CORD DISCONNECTED.

WARNING: Due to the high power delivery capability of the battery, and the hazardous voltages present, the mainframe high voltage circuitry should be approached in a cautious and orderly manner.

When energizing a system for the first time following a major repair of the high power or control circuitry, it is important that power limiting techniques be applied until proper functioning can be determined.

7.8.1 Checkout Preparation:

CAUTION: **These checkout tests are to be conducted with the battery and the battery charger disconnected. Do not reconnect the battery or power the charger until directed to do so in these procedures.**

1. Unplug the system from the wall outlet.
2. Disconnect the red connector to the positive lead of the battery, and remove the fuses F2 and F3 in the A.C. power path of the battery charger circuit (these fuses are located on the front of the power panel).

7.8.2 High Power Driver Stage Tests

1. With the high voltage supplies disconnected (as described above) boot the system by running "MAIN 0 " from the external terminal according to the instructions in Section 7.12. The "0 " argument allows the software to operate with no high voltage present.

2. Press START to engage the interlock circuit when prompted on the control panel.

3. Press the "X-RAY ON" switch; with an oscilloscope, the drive pulses at R139 and R156 (ungrounded end) should measure 2.6 +/- .3 volts peak.

4. Measure the turn-off pulse at the trailing edge of the drive pulses seen at R139 and R156. This should be a negative going spike, greater than -1.0 volt in amplitude, and greater than 5 usec. in duration.

5. Disable kV servo by installing jumper E5 on the Generator Controller PCB.

6. Measure the duration of the on-pulses. The duration should be approximately 20 usec.

7. Check that the on-pulse duration can be varied by turning the kVp Knob on the control panel.

8. Remove the jumper from E5.

7.8.3 Power Limited Functional Test

1. Disable the kVp servo by installing a jumper at E5 on the Generator Controller PCB.

2. Set the fluoro technique to: 50 kVp and 0.5 mA.

3. Connect one battery (60 VDC) into the circuit with a 12 ohm 100 watt resistor wired in series with the positive battery lead. (Bypass the other two battery packs).

4. Boot the system by running "MAIN 40 " from the external terminal according to the instructions in Section 7.12. The "40 " argument allows the software to operate with a lower battery voltage present.

5. Make an exposure while observing the following:

   There should be no fault messages on the control panel display and a sinewave should appear at P1-4 and P1-5 of the Generator Controller PCB.

6. Make a fluoro exposure and observe the waveform at TP-13 on the Generator PCB for the following:

kVp Sensor Functional Test A sinewave equal to 42 to 48 percent of the amplitude seen in step 5 should be present during the exposure.

7. Remove the jumper at E5.

8. Make an exposure and observe the following:

kVp Regulation Test The amplitude of the waveform at TP-13 should be 5.0 +/- .20 Vpp, and its amplitude should be adjustable by varying the "KV" knob on the control panel.

NOTE: *It will not be possible to obtain more than about 6 volts p-p with only one battery connected.*

9. Verify the waveform at P1-12 (small filament output) without making an exposure.

Filament Drivers

There should be no signal at P1-11 (large filament) in this mode.

10. Put the system in "FILM" mode and arm for "instant on". This is done by pressing the X-RAY ON switch and releasing it before the exposure actually occurs.

11. Verify the waveform at P1-11 without making an exposure.

Filament Drivers There should not be a signal at P1-12 (small filament) in this mode.

7.8.4 High Voltage Application

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

1. Open the interlock circuit by pressing EMERGENCY OFF. Wait one minute to discharge the filter capacitance. Reconnect all batteries but leave the 12 ohm 100 watt resistor in series.

2. Jumper E5 should be removed and Jumper E3 installed. Set the technique for FLUORO and 50 kVp, 0.5 mA.

3. Reboot the system by typing MAIN at the terminal. (Refer to the instructions in Section 7.12).

CAUTION: *Do not use the "0 NOCAL" argument this time, as this will close the large contactor prematurely, resulting in very large inrush currents.*

4. Make a fluoro exposure and observe that no fault messages appear on the control panel display.

5. Turn off the keyswitch. Disconnect the power cord from the wall outlet. Wait one minute to discharge the filter capacitance. Remove the series 12 ohm resistor, reconnecting the batteries in their normal configuration.

6. Remove both jumpers E3 and E5 from the Generator Controller PCB.

7.8.5 Adjusting Charger Output Voltage

1. The batteries are connected in their normal configuration prior to this procedure (see step 5 of the previous procedure).
2. Unplug the power cord. Install F-2 and F-3 to provide A.C. power to the charger circuit.
3. Remove the panel mount fuse below the Generator Controller PCB.
4. Plug in the power cord. Leave the interlocks disengaged - DO NOT PRESS START.
5. Adjust R-108 for 211 +/- 3 VDC at C-63(+).

7.8.6 Adjusting Charger Voltage Readout (Bargraph)

1. Adjust R109 clockwise until the bargraph reads below 210 volts.
2. Then turn R109 counter-clockwise until the 210 volt LED just turns on.

7.8.7 Generator Controller PCB Jumpers

JUMPER	*SHOULD BE*	*FUNCTION*
E3	IN only for calibration	disables mA servo
E5	IN only for test	disables kV servo

7.9 Analog Support PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Counter Timer Clock-Input
E4-E11	TBA	Board Rev

7.10 Technique Processor PCB

Switch Settings

SWITCH	*SHOULD BE*	*FUNCTION*
S1		reserved
S2		reserved
S3	OFF	real time clock disable
S4	ON	autoboot switch, if off mainframe will boot in monitor program
E0-E3		Board Rev
E9, E10	IN, IN	Real Time Clock Oscillator

Adjustment

Disk Drive Interface - Read/Write Pulses

Use this procedure to adjust the read/write data pulse widths. Measure frequency and pulse widths at the test points indicated using an oscilloscope. To obtain proper accuracy in this measurement, set the horizontal scale as indicated in [brackets] below.

1. Connect the 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 [set scope on 100 ns/div].

7.11 Control Panel Processor PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E3	IN	Dual UART Oscillator Circuit

Switch Settings

SW8	*SW7*	*BAUD RATE*
off	off	9600 baud (normal)
off	on	4800 baud
on	off	2400 baud
on	on	1200 baud

SW5	SW4	COMMUNICATION DIAGNOSTICS
off	off	disabled (normal)
off	on	echo key request to terminal
on	off	echo T.P. commands to terminal
on	on	undefined

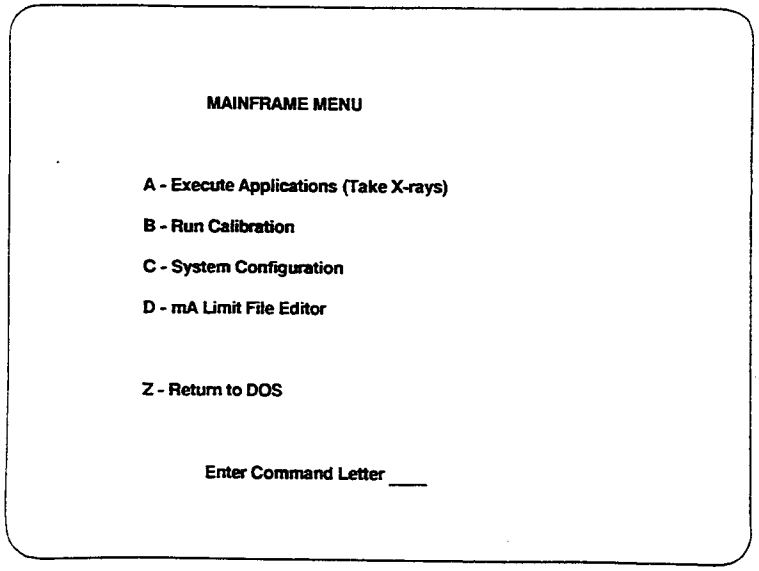
SW3	SW2	SW1	DIAGNOSTIC MODES
off	off	off	normal operation
off	off	on	segment & LED check
off	on	off	keyboard diagnostics
off	on	on	clock & speaker checks
on	off	off	UART loop test
on	off	on	memory test
on	on	off	undefined
on	on	on	undefined

7.12 Accessing the Mainframe with the External Terminal

7.12.1 Mainframe Terminal Menus

Mainframe software menus are accessed from the monitor cart MAIN MENU by selecting "Access Mainframe Menu".

This Mainframe Menu will appear.



Refer also to Section 8.6.3 in *Monitor Cart Service* for a summary of the selections available from the monitor cart Main Menu.

7.12.2 To Access Mainframe DOS (MSDOS$_{TM}$)

1. Connect the external terminal by following the instructions given in the Appendix: *External Terminal Use*.
2. Press [ESC] to view the Program Access Menu.
3. From the Program Access Menu select: *Z-Return to Main Menu.*
4. From the Main Menu select: *Y-Access Mainframe Menu.*
5. From the Mainframe Main Menu select: *Z-Exit to DOS.*

7.12.3 Booting From the External Terminal

1. The system can be booted from the external terminal for certain test procedures. Do this only when specifically told to do so in the test procedure.
2. Enter the command line desired after performing step 5 in Section 7.12.2 above:

   Type *MAIN* to invoke the Main Program.

   Type *MAIN 0* when required by certain test procedures.

7.12.4 Exit Applications Software

If the mainframe fails at the "Press Start" prompt during startup, the Main Menu can be accessed by pressing [ESC] and typing END.

7.13 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 Generator Controller PCB.
3. The bargraph may indicate 160 or 170 volts during the exposure. If the voltage drops to 150 volts, there could be a problem with the batteries.

7.14 Evaluating the Battery Charger

The battery charger circuit on the Generator Controller 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 measured at E1 should be about 210 VDC.
2. Above 625 mA the voltage measured at E1 should rise to approximately 230 VDC.
3. Above about 2 amps charger current, the charger current limits and the charger voltage at E1 will decrease.
4. Overvoltage shutdown should occur above approximately 240 VDC, indicated by a sudden drop in output voltage at E1.
5. During mainframe boot, the charger output is shutdown momentarily; the output voltage should briefly drop to about 150 VDC.

7.15 Resetting the Battery Circuit Breaker

The 50 Amp battery circuit breaker will trip in the event of a major overload in the battery circuit. Determine the cause before resetting. *Refer to Figure 7-2.*

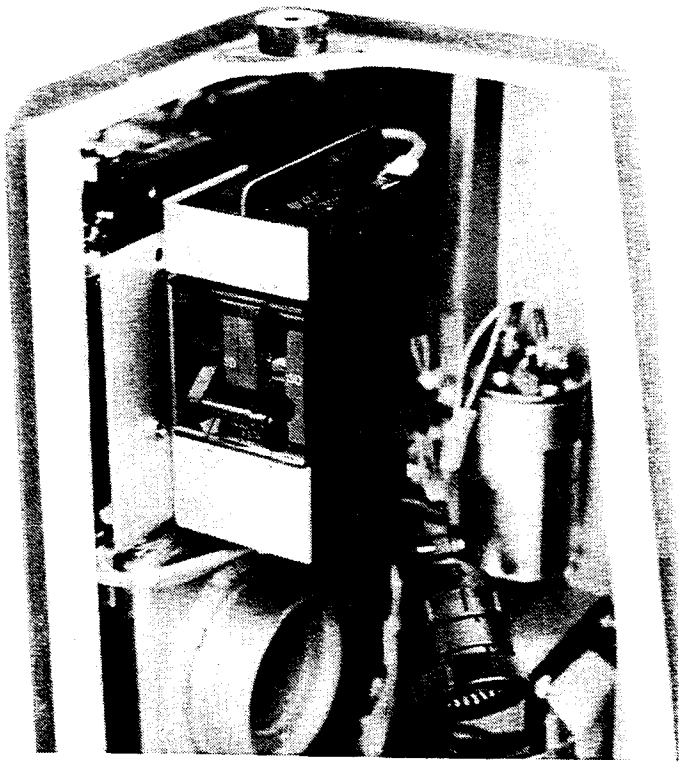


Figure 7-2 - *The battery circuit breaker is shown in this photo.*

7.16 Mainframe Mechanical Adjustments

7.16.1 Loosening a Stuck Lift Shaft

If either of the limit switches on the lift column are badly misadjusted, the column may bind at the top or bottom of its travel.

1. Directly above the top of the shaft, there is an access hole through which to insert a hex wrench.
2. Reach the wrench into the hole and onto the hex head at the top of the shaft. Turn the shaft in the direction opposite to the bind.

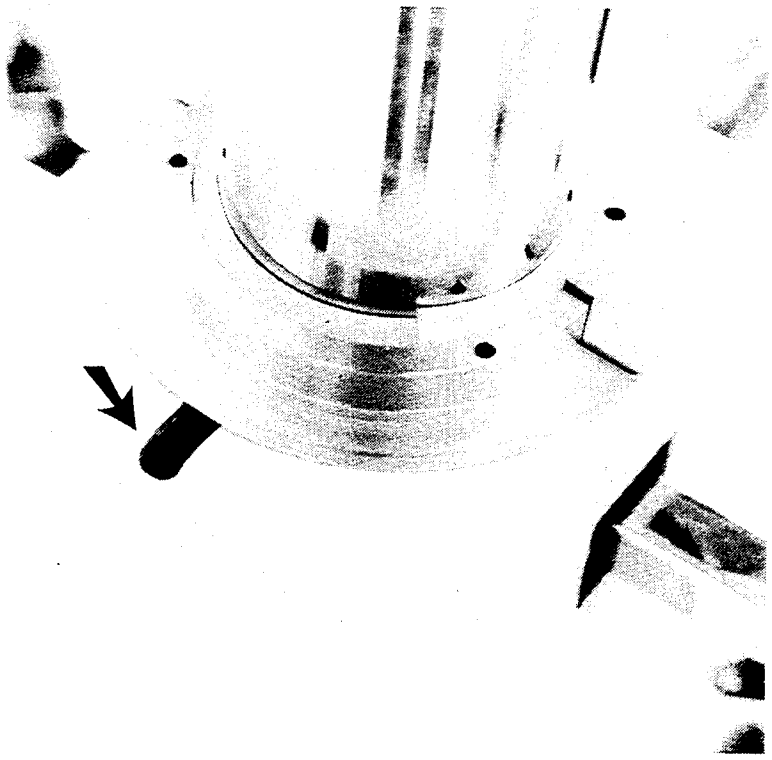


Figure 7-3 - *The lift shaft can be turned with a hex wrench inserted through this hole.*

7.16.2 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 blade screwdriver rotate each bearing to minimize sloppy, loose or irregular movement of the the C-arm within the cradle. Do not adjust these to cause overtight bearing contact.
3. Test the bearing contact through the full range of movement.
4. Tighten the set screws.

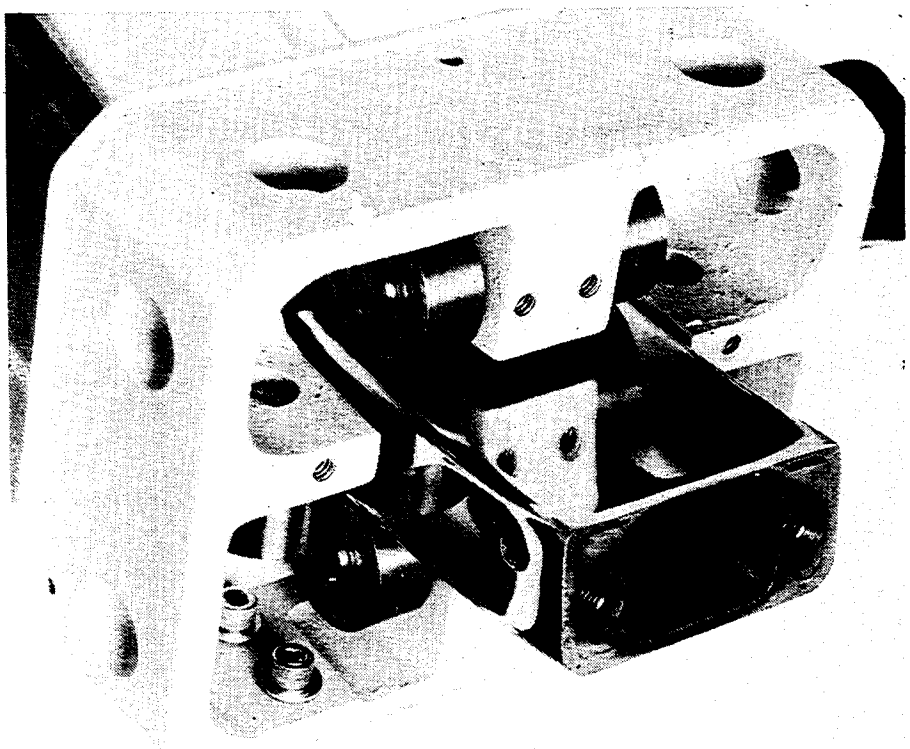


Figure 7-4 - *The cradle bearings can be exposed in the bearing blocks.*

SECTION 3
MAINFRAME
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 in understanding the maintenance and calibration procedures in this manual.

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

The software plays a central role in the operation of the system. Therefore discussion of software is combined with the hardware theory of operation.

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 (00-870735) and the Image System Interconnect Diagram (00-871059).

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. The connectors J1, J2, J3 and J4 provide the internal computer bus.

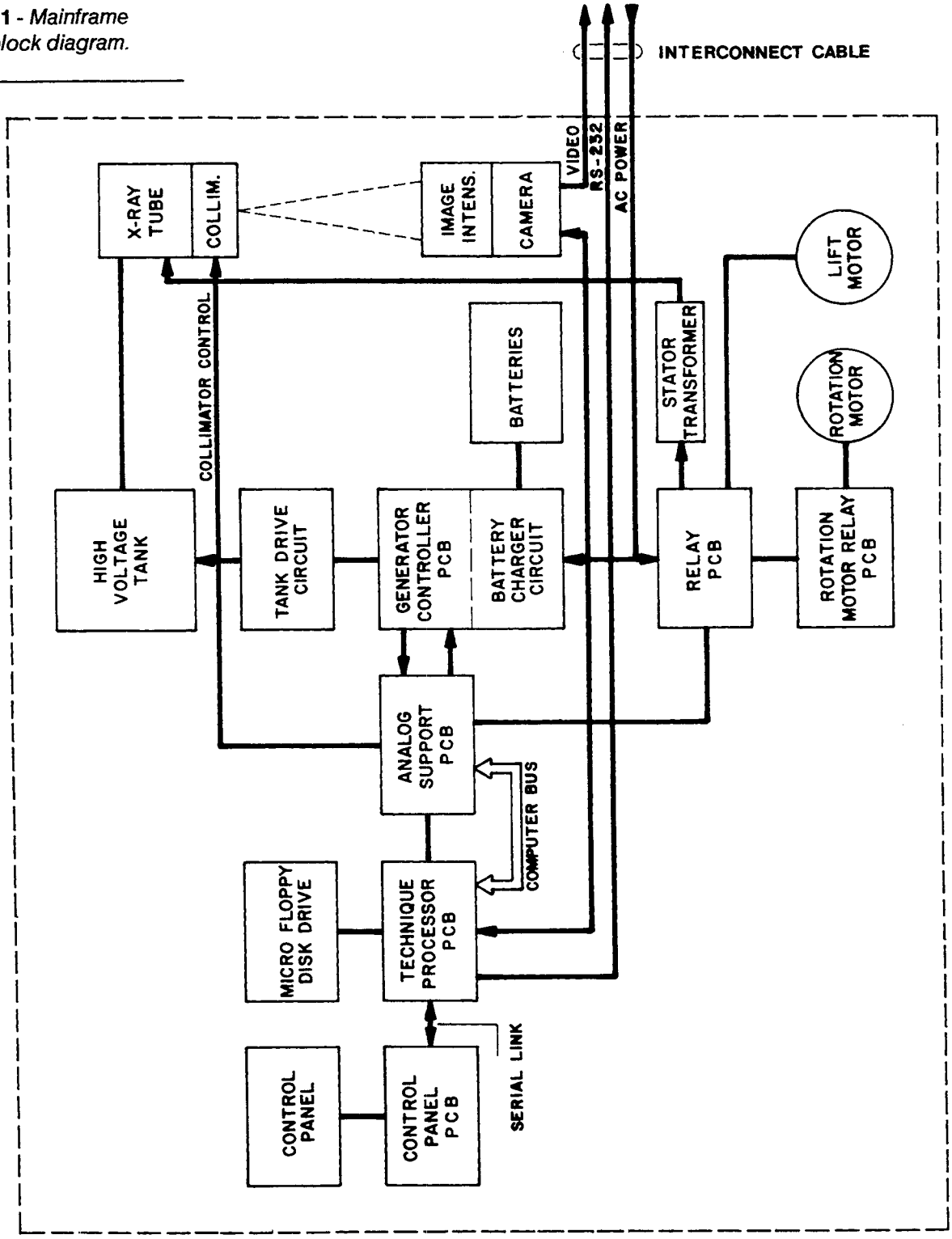
Floppy Disk Drive - Mainframe operating and application software is contained on a 3 1/2-inch microfloppy disk. Each time the system is started, the software is loaded from the disk drive.

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 Controller PCB - the filament control, high voltage control, mA and kVp sensing and battery charger are combined on this board.

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.

The mainframe and monitor cart are interconnected by an 18-foot cable which carries power, video and communications signals. Both ends are interchangeable. The monitor cart end is normally locked in place to prevent the electrical shock hazard that could result from accidentally contacting the line voltage pins on the connector. A stand-alone adapter is not required to operate the monitor cart for post-processing without the mainframe attached.

3.2 Power Distribution

3.2.1 AC Power

Refer to the Mainframe Interconnect Diagram 00-870735.

Power is obtained from the AC line by the isolation transformer in the monitor cart and applied to the mainframe through an 18-foot interconnect cable. In the mainframe, 115 VAC (optimal) is distributed to the battery charger circuit on the Generator Controller PCB, 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.

Table 1 Interconnect Cable Wiring List

PIN	*FUNCTION*
1	X-ray disable
2	video stable
3	L>R
4	spare
5	store
6	spare
7	RTS cart
8	TXD cart
9	CTS cart
10	RXD cart
11	brightness
12	contrast
13	X-ray lamp 3
14	n.a.
15	n.a.
16	n.a.
17	n.a.
18	n.a.
19	n.a.
20	n.a.
21	n.a.
22	n.a.
23	n.a.
24	n.a.

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. EMERGENCY OFF 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 portion of the Generator Controller 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 00-870735.

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 to the six 30-volt battery packs.

3.2.3 Battery Packs

Six 30 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 on the Generator Controller PCB 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 these batteries. Remember that they are a source of high voltage (180 VDC) and high current which can be hazardous even when the system is not plugged in.

NOTE: The condition of the six 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. Many of these circuits provide redundant protection.

3.3.1 24 Volt Interlock

Refer to Figure 3-2.

The 24 volt interlock circuit passes through the Relay PCB, Technique Processor PCB, Analog Control PCB, and the motherboard. This provides the means to halt system operation when the EMERGENCY OFF 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 signal to the Relay PCB.

The 15 volt 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 15 volt interlock passes through both EMERGENCY OFF switches and the START switch.

When the START switch is pressed, relay K2 latches, supplying +24 volts to relays K1, K3, K4 and K5. If the interlock loop is broken, 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 same 24 volts is also supplied to the *Generator Controller PCB* where it latches relay K2. If this relay opens, it disables the high voltage generator by disconnecting the 15 volt return path from transistors Q14-Q17.

The B+ charge and B+ contactor relays, mounted below the Generator Controller PCB, also obtain 24 VDC from this 24 volt interlock circuit.

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 imbeded 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.*

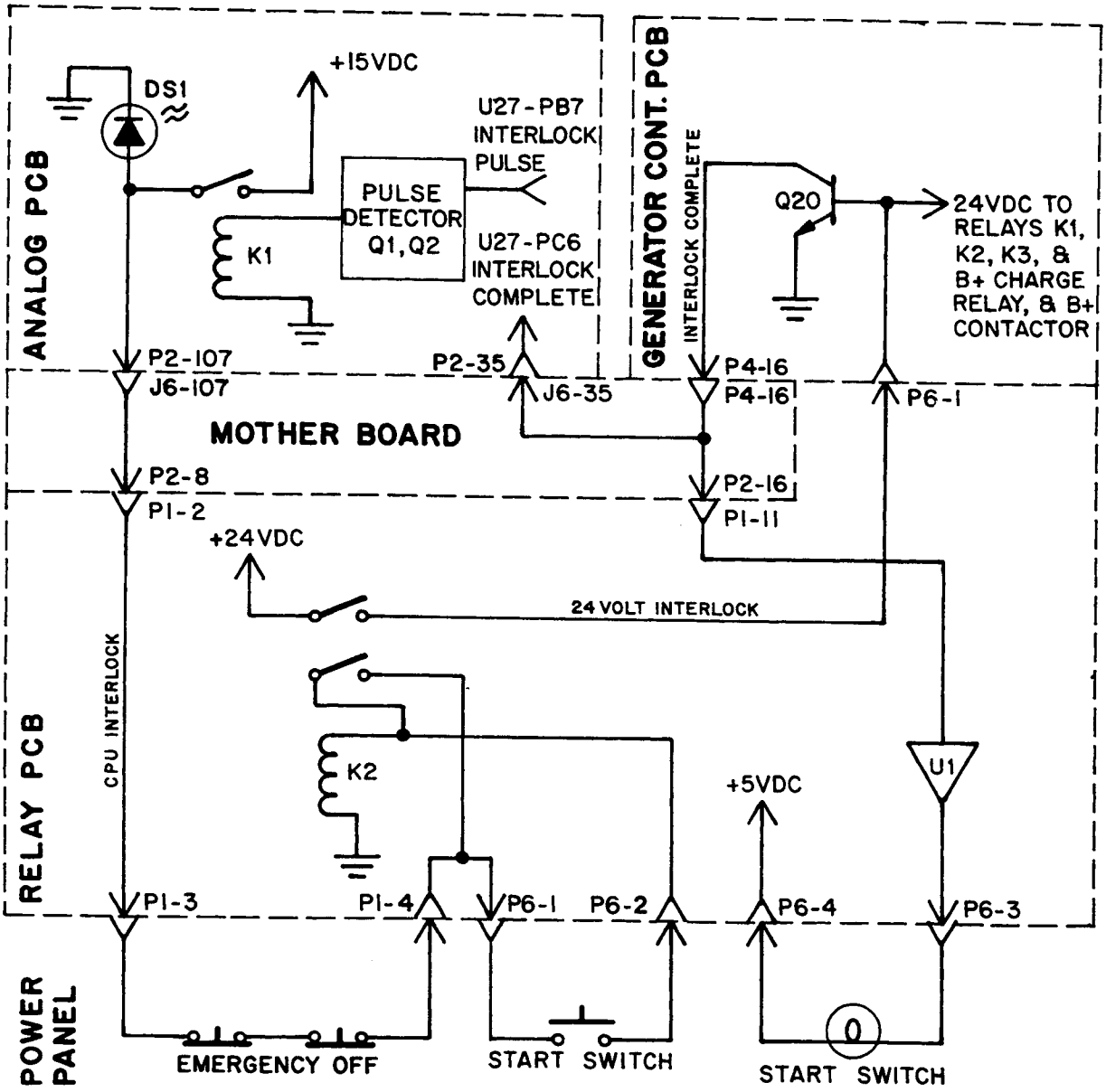
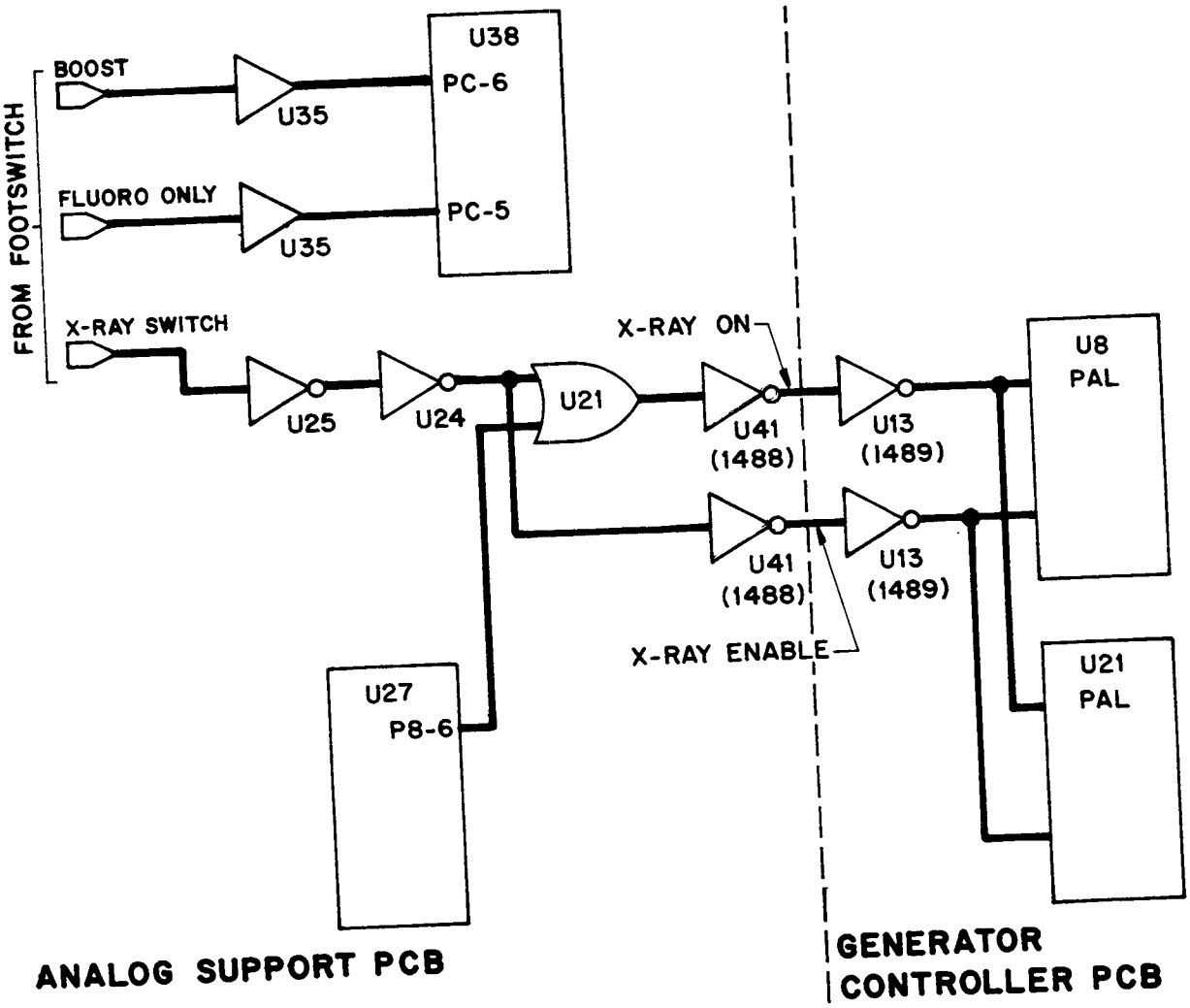


Figure 3-3 - *Block diagram of the footswitch logic.*



3.3.3 Footswitch Logic

Refer to Figure 3-3.

Protection logic on the Generator Controller PCB 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 Generator Controller PCB where they are inverted and input to the PAL logic at U21 and U8. The outputs from these PALs form the filament and high voltage drives.

6. Faults on the Generator Controller PCB are sensed by fault PAL U32.

7. If X-RAY ON and X-RAY ENABLE are true and there are no faults reported to PAL U21 pin-9 from the FAULT output of U32, then U21 output HV GEN ON will be true.

8. HV INV ON is sensed by the processor at Analog Support PCB, PIO U27-PC4.

3.3.4 Fuse Protection

In the unlikely event of multiple catastrophic failures, the 50 Amp circuit breaker in the connection to the battery pack provides fire protection.

Fuses F1, F3, F4 and F5 on the Generator Controller 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 Controller PCB 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 bring the system to a de-energized stand still. Warning messages are displayed on the control panel. These are listed and described in the section Mainframe Service and Repair.

Conditions which are monitored include:

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

When a fault is detected severe enough to cause the system to shut down, a complete restart of the system is required.

3.4.1 KVp Overvoltage

If the voltage sensed on the SECONDARY TAPS 1 and 2 of the high voltage tank exceeds about 135 kVp, comparator U3 on the Generator Controller PCB will trip the OVERVOLTAGE input to PAL U32. The FAULT output from U32 disables the high voltage drives from the output of PAL U21.

NOTE: If the secondary tap 1 and 2 signals carried through P1 on the Generator Controller PCB are disconnected, pullup resistors R1 and R3 will cause comparator U3 to trip the the OVERVOLTAGE line. This is an important safety factor; all signals on connector P1 must be connected for the generator to operate without damage.

3.4.2 Short Circuit Protection

A winding on the series tuning inductor L1, in the tank circuit input, senses the differential voltage across the inductor. This CURRENT LOOP signal is integrated on the Generator Controller 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 Output Transistor On-State C-E Voltage Fault

This circuit, also known as the saturation fault detector, is found on the Generator Controller PCB. The main power transistors, Q1 and Q2, each contain two darlington pairs, and drive the primary of the high voltage transformer (tank). Bridge rectifier VR2 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 R147 to the ground referenced R149. The open collector buffer U6 enables the input of comparator U42 only during the output stage drive period. At this time, rectifiers CR50 and CR53 can cause comparator U42 to trip the FAULT 1 line, feeding PAL U32.

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 10 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 high voltage, filament current and anode rotation are turned off and the collimator is returned to the small field position. 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 are dependent upon which technique has been selected. In all cases, 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 Manual Continuous except that the exposure is generated only for the duration of a pulse. The pulse is repeated each second with the ON button or footswitch depressed.

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 is repeated each second with the ON button or footswitch depressed.

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.

Film Mode

The presence of a film cassette is required in this mode. The 6-inch, but not the 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 prearm 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 prearmed, however, exposures are immediate, 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 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 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 for the first several seconds, then gradually increasing the duty cycle, and consequently the temperature, to the required value over 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. Hardware is again initialized as a precaution.
2. The 40 kHz clock on the Analog Support PCB is started.
3. Interlocks are made.
4. The stator line is pulsed.
5. Small filament is preheated
6. B+ capacitor is charged.
7. Generator and X-ray tube control signals are initialized. After a pre-charge cycle the B+ Contactor is closed.
8. EEPROM is checked.
9. Footswitch is checked (for footswitch stuck fault).
10. Heat units are computed for the anode.
11. Tests are run to determine if the system is capable of functioning. In detail the tests are:
    a. Scroll sign on message
    b. Verify that the kVp and mA sense are near zero.
    c. Check for inadvertent presence of X-ray Activate Jumper which will appear as "Stuck Footswitch".
    d. Verify HV Generator Line OFF
    e. Start interlock pulses and scroll message "PRESS START." Operator presses START SWITCH.
    f. Turn on B+ Precharge. Check batteries during precharge.
    g. Close Main Contactor. Check B+ voltage
    h. Check flipper circuits.
    i. Check EEPROM integrity.
    j. Check EEPROM disk image.
    k. 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:

1. Small field flipper
2. X-ray tube heating
3. Camera dark current compensation - dark current compensation tables are built every 120 seconds after the last fluoro exposure.
4. Monitor battery voltage and current.
5. 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:

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

15. System serial number

16. 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

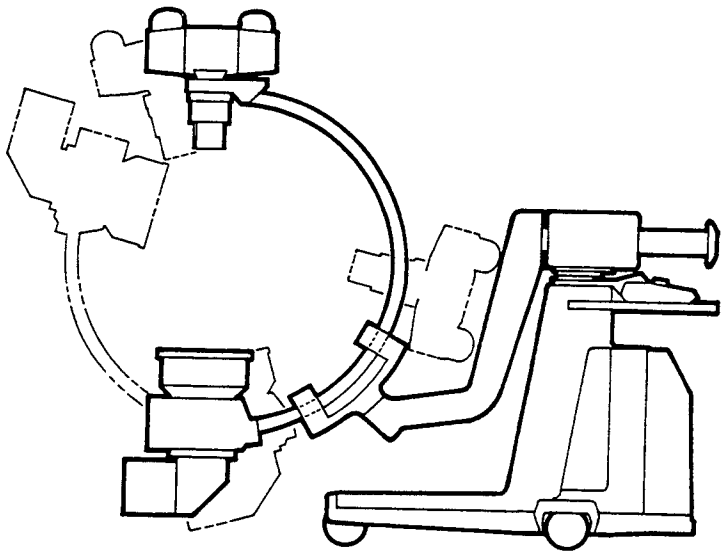
Refer to Schematic 00-870735.

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.

C-arm Radial Movement

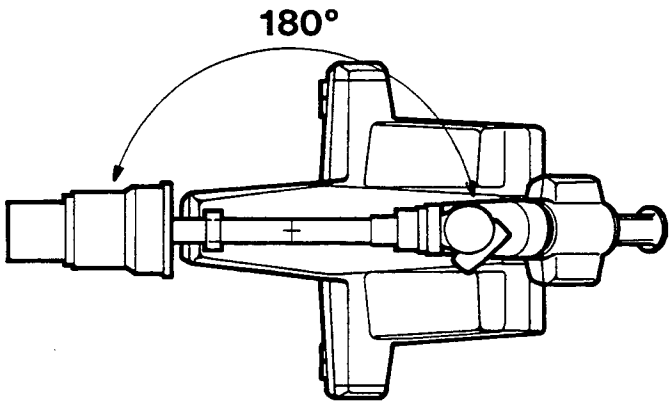
Figure 3-4 - *The C-arm can rotate in its cradle 111 degrees.*



C-arm Flip-Flop Positioning

Figure 3-5 - *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.*



L-arm Rotation

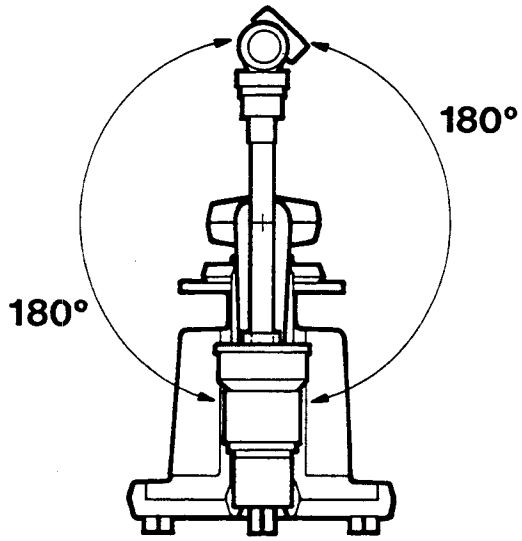


Figure 3-6 - *The L-arm can be rotated 180 degrees in either direction (for a total of 360 degrees).*

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

Vertical Lift Travel

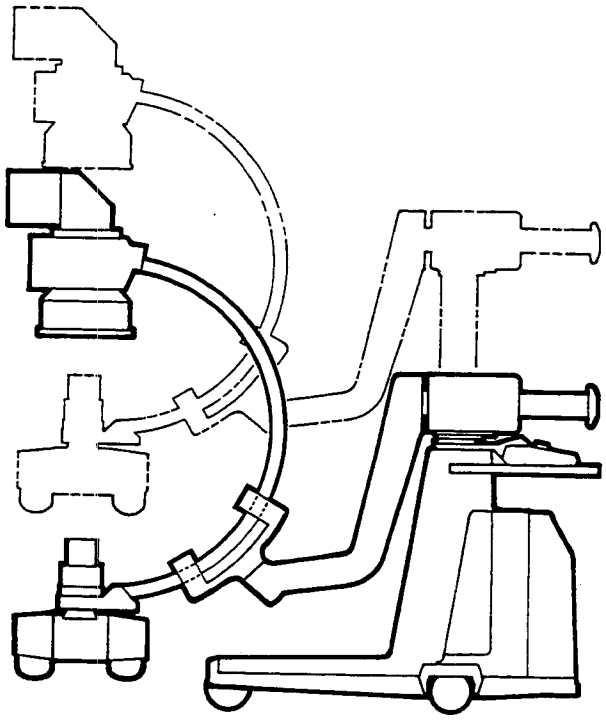


Figure 3-7 - *The entire C-arm and L-arm assembly can be raised up to 18 inches on the central column.*

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

Horizontal Travel (Extension)

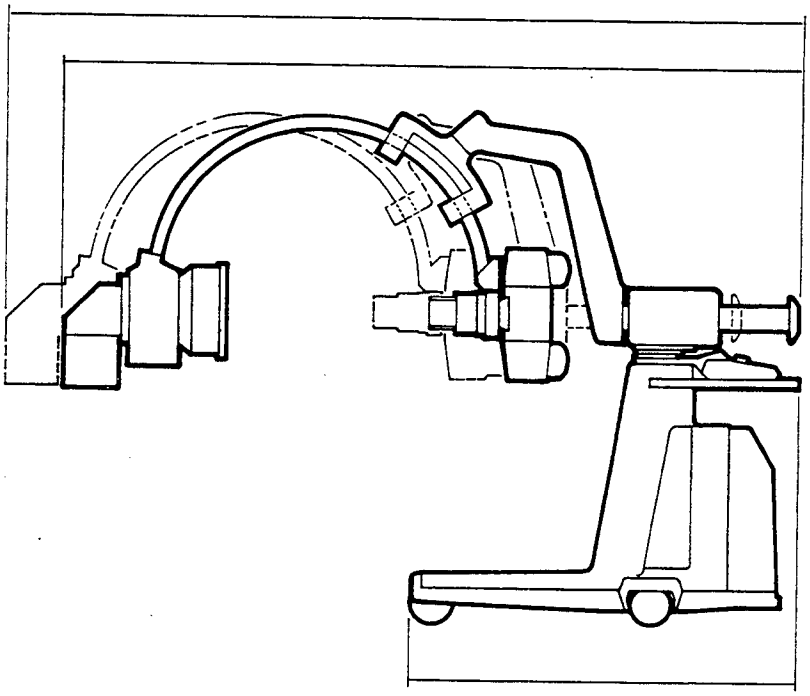


Figure 3-8 - *The L-arm and C-arm assemblies can be extended horizontally up to 8 inches.*

Release the locking ring by turning it counter-clockwise about 15 degrees.

Push or pull on the extension arm to the desired position,

then retighten the locking ring by turning it clockwise until it is fingertight.

Wig-Wag (side-to-side swing)

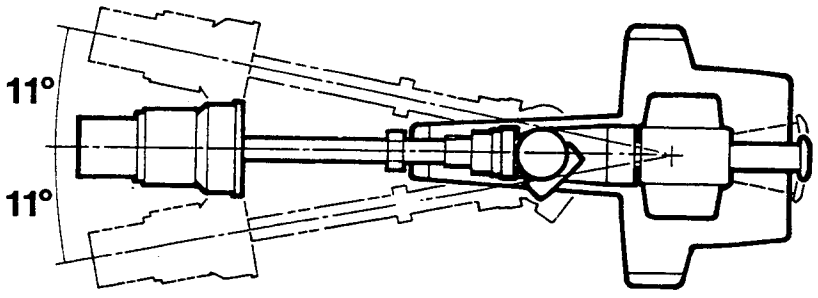


Figure 3-9 - *The entire extension, L-arm, C-arm assembly can swing, or wig-wag, from side to side 11 degrees in either direction for a total of 22 degrees of motion.*

Pull out the locking pin and turn its handle 1/4 turn to latch it open. Loosen the wig-wag brake on the column.

Retighten the brake handle when the desired position is reached.

Control Panel Positioning

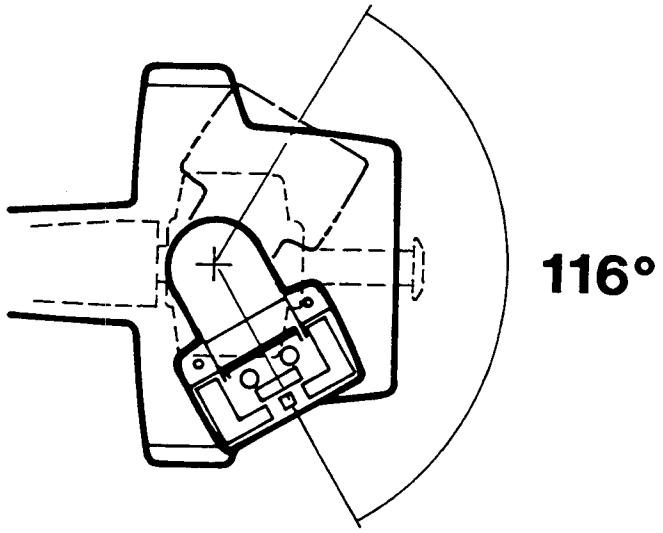


Figure 3-10 - *The control panel can be swung 58 degrees to either side, for a total of 116 degrees of movement. This provides the operator with easy access to the controls.*

The control panel is not locked in position, move it freely as needed.

Steering Control

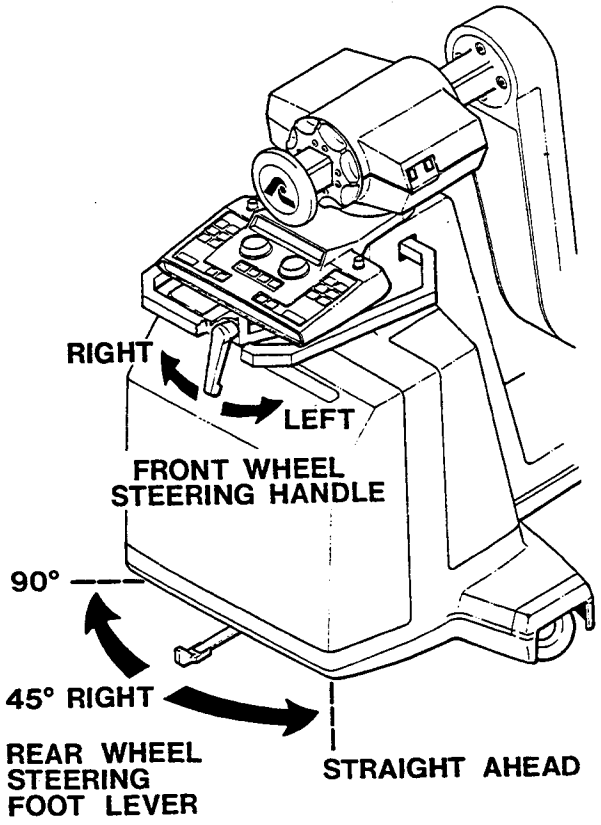
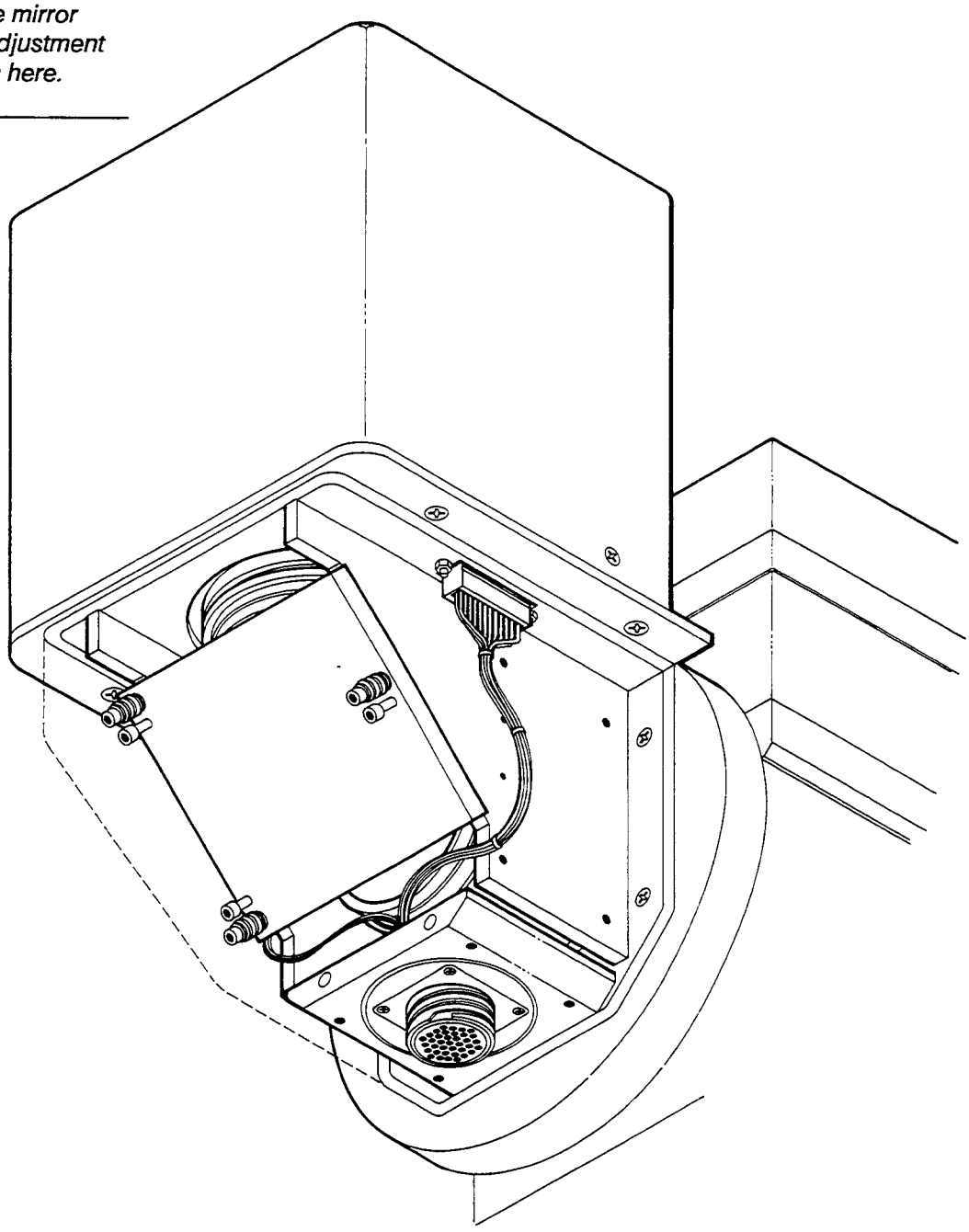


Figure 3-11 - *A steering handle and foot lever are used to control the orientation of the front and rear wheels.*

3.7.2 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 3-12 - *The mirror mounting plate adjustment points are shown here.*



3.8 X-ray Tube

Refer to Figures 3-13 and 3-14.

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 40VAC 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 3-13 - *Cutaway view of the X-ray tube.*

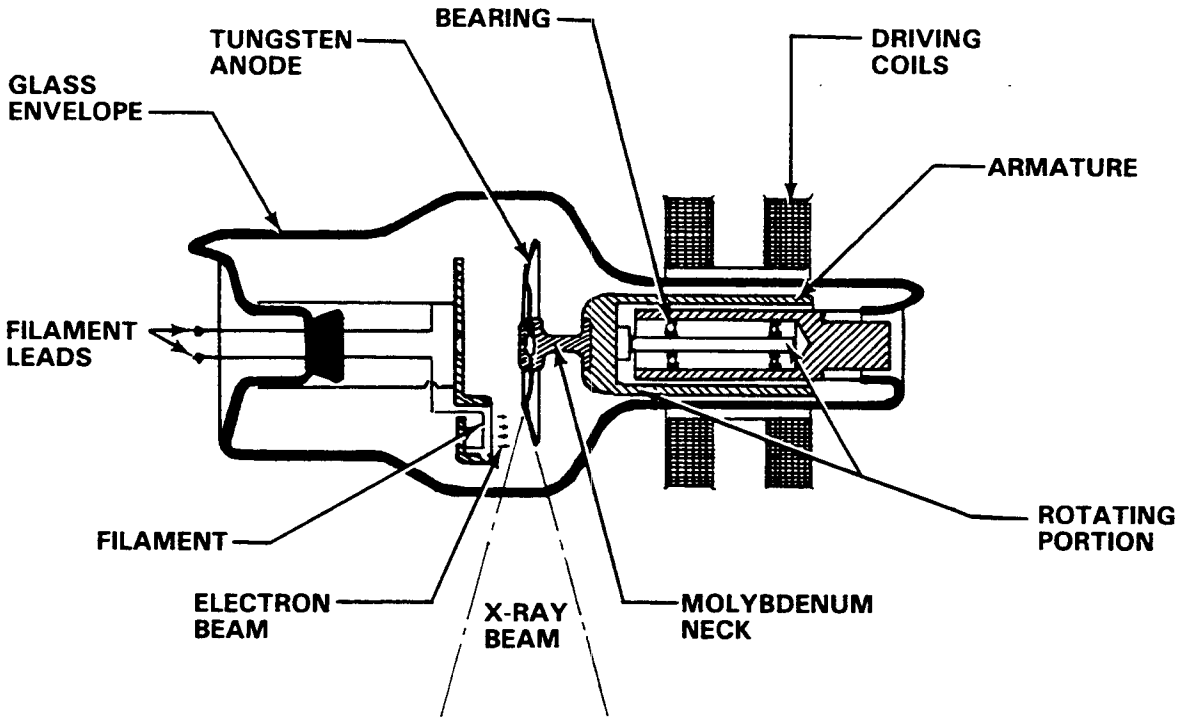
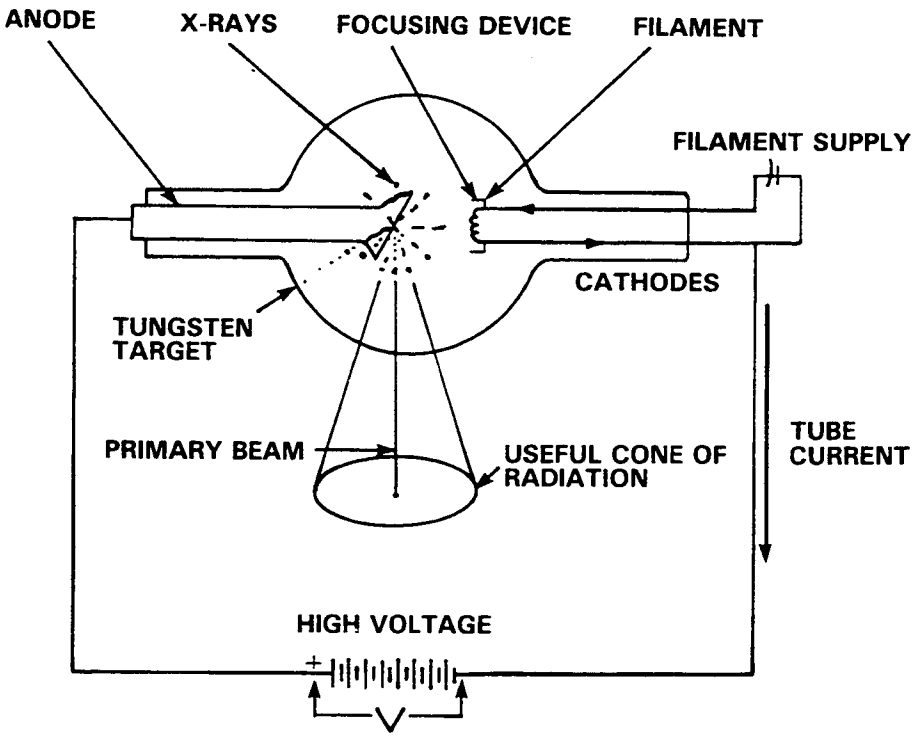


Figure 3-14 - *Schematic of the X-ray tube.*



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 3-15.

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.

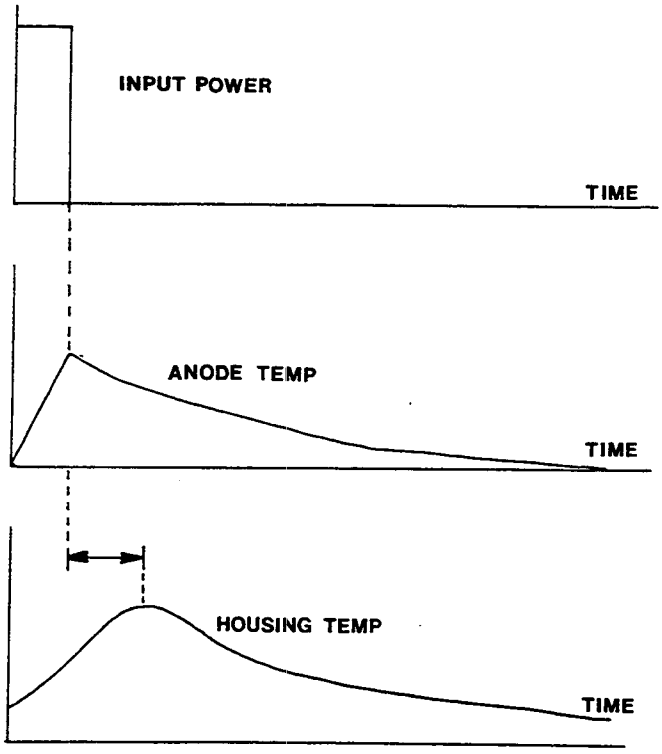


Figure 3-15 - *The relationship of input power, anode and housing temperatures is shown in these graphs.*

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 75 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 3-16 to trace this 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 collimator (3), located within the X-ray tube mounting head, is moved in or out of the beam path to switch between large and small beam diameters. 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 X-ray tube housing.

The minimum beam size of less than 5 X 5 cm square is measured at the source to image receptor distance (SID). The face of the fluoro image intensifier lies slightly outside the film SID and this factor is accounted for at calibration.

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

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

Beam Collimation
Refer to Figure 3-17.

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

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 a five x five centimeter square.

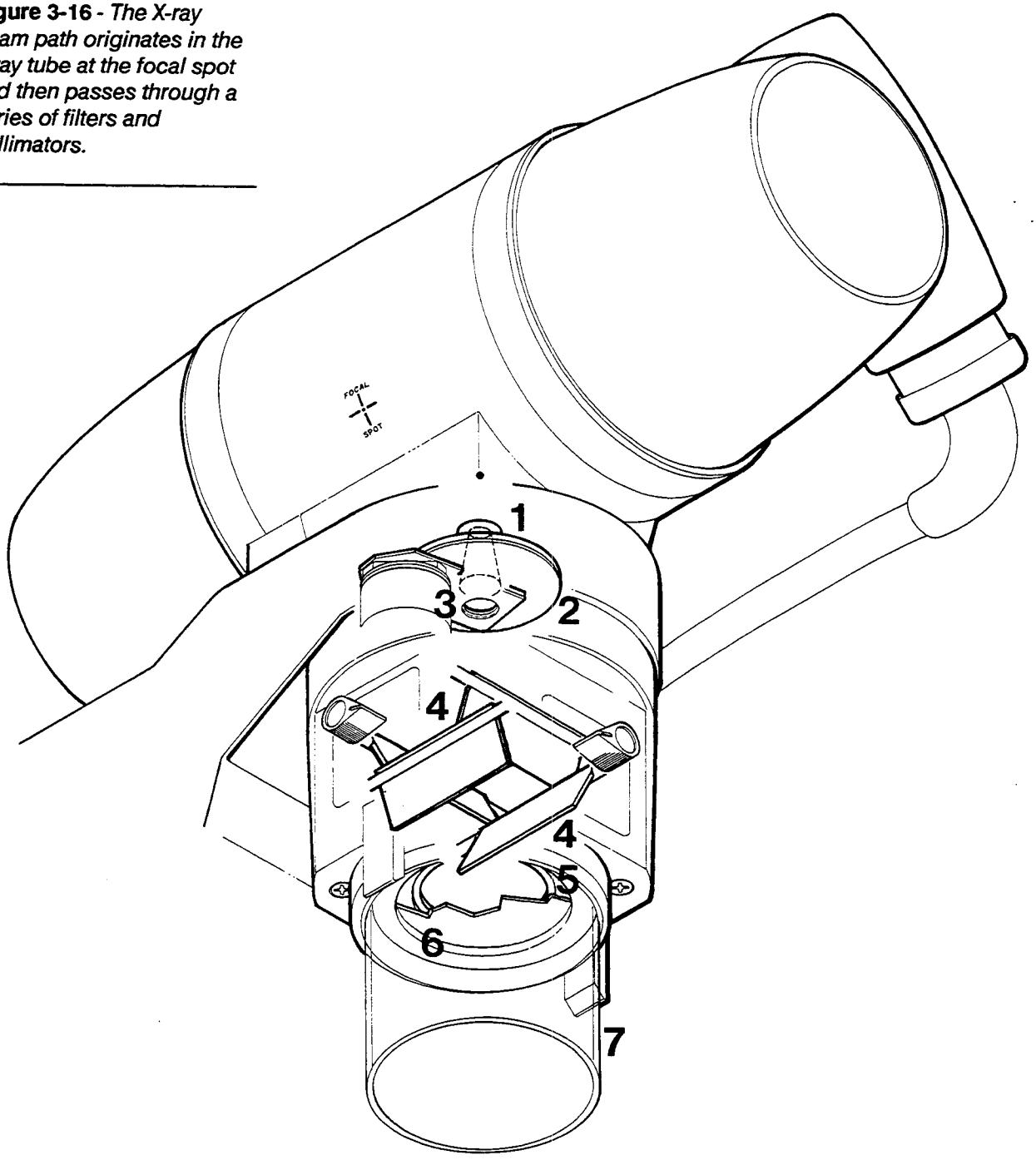
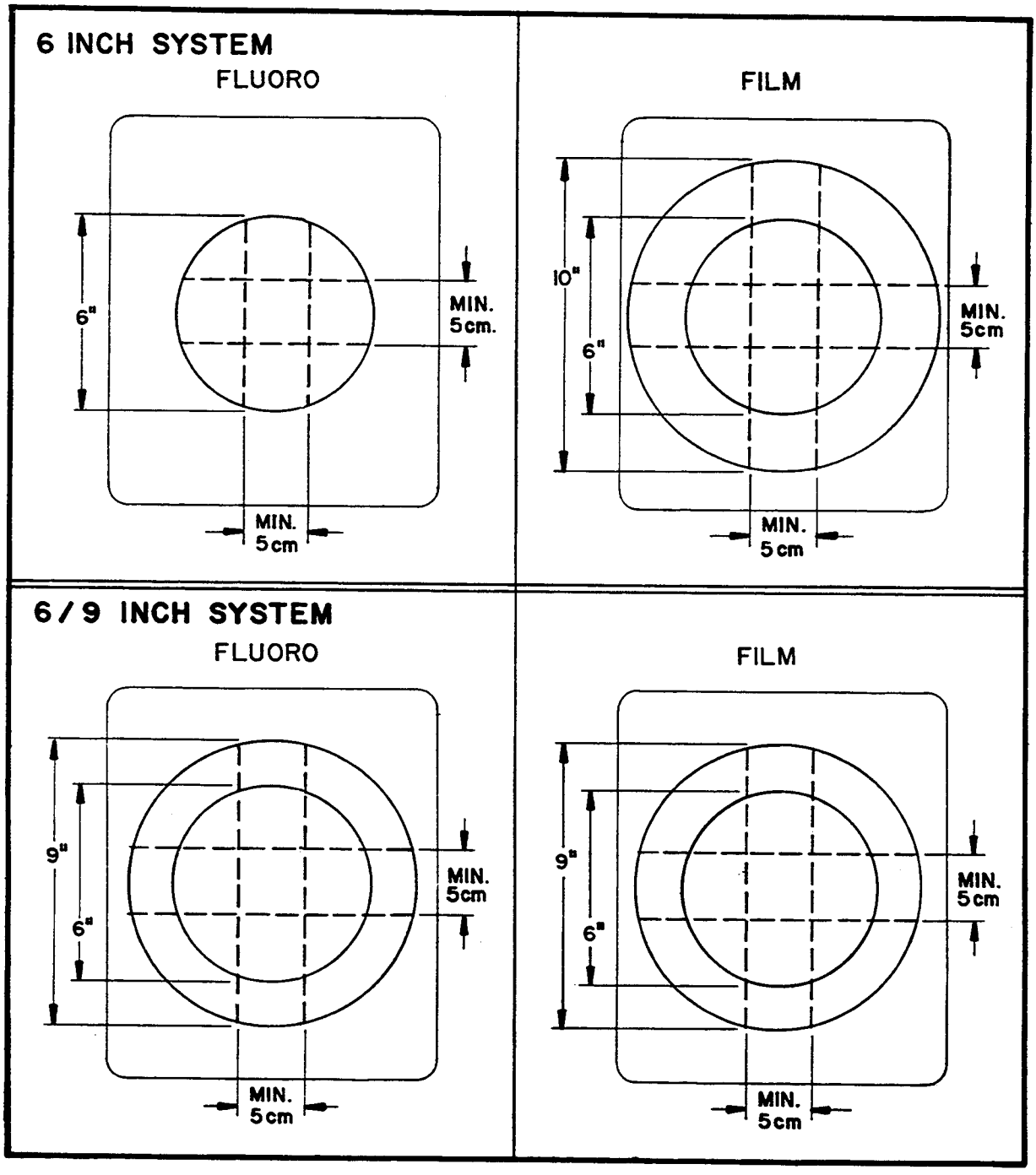


Figure 3-16 - *The X-ray beam path originates in the X-ray tube at the focal spot and then passes through a series of filters and collimators.*

Figure 3-17 - *The X-ray fields produced by varying degrees of collimation are different for 6-inch and 6/9-inch systems.*



The X-ray fields produced by varying degrees of collimation are different for 6-inch and 6/9-inch 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-inch field can be used in the FLUORO mode. The LARGE field on these models is approximately 10 inches in diameter.

6/9-inch Image Intensifier Models - the uncollimated beam is 9 inches in diameter when the small field collimator is retracted. When the small field collimator is in place, the beam is reduced to 6 inches.

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-inch 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-inch image intensifier, the final collimator limits the X-ray beam size and shape to a 9-inch 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 can also be done manually.

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 U26, U36, U37. These devices are integrated motor controllers.

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 low light level lenses and a right angle mirror. The first lens is focused at infinity and the camera 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 3-18 - *The right angle optics consist of a mirror and the camera and image tube lenses.*

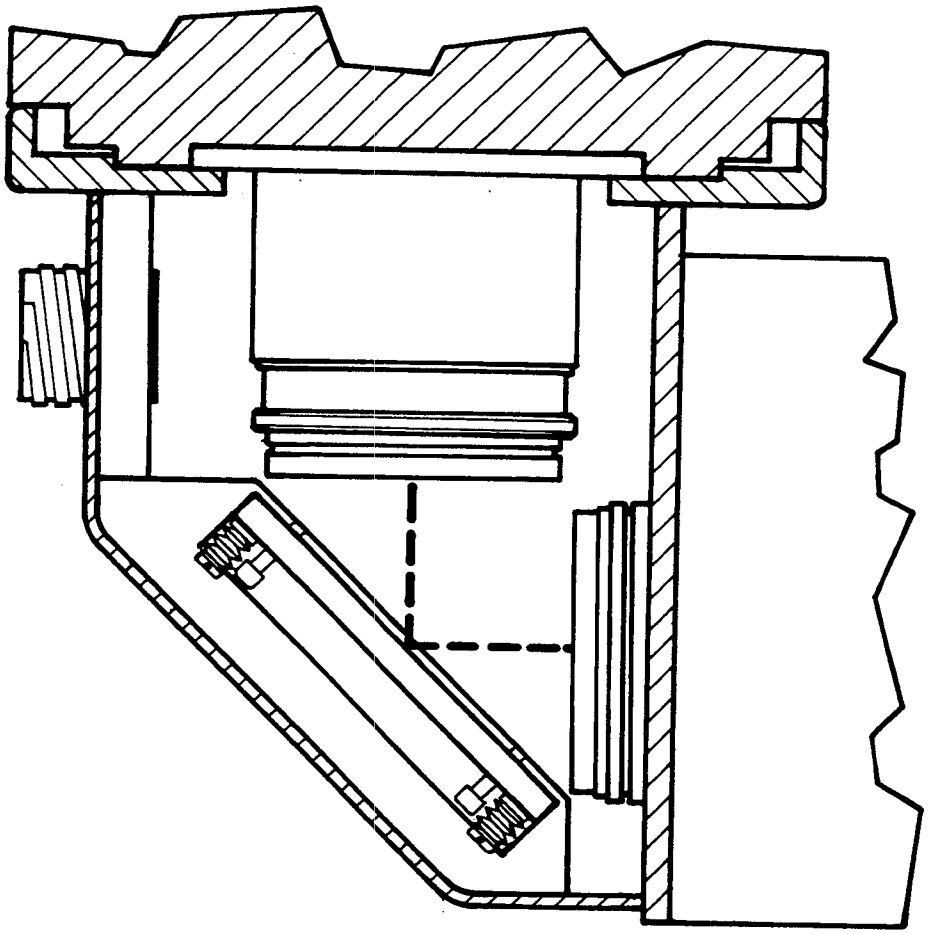
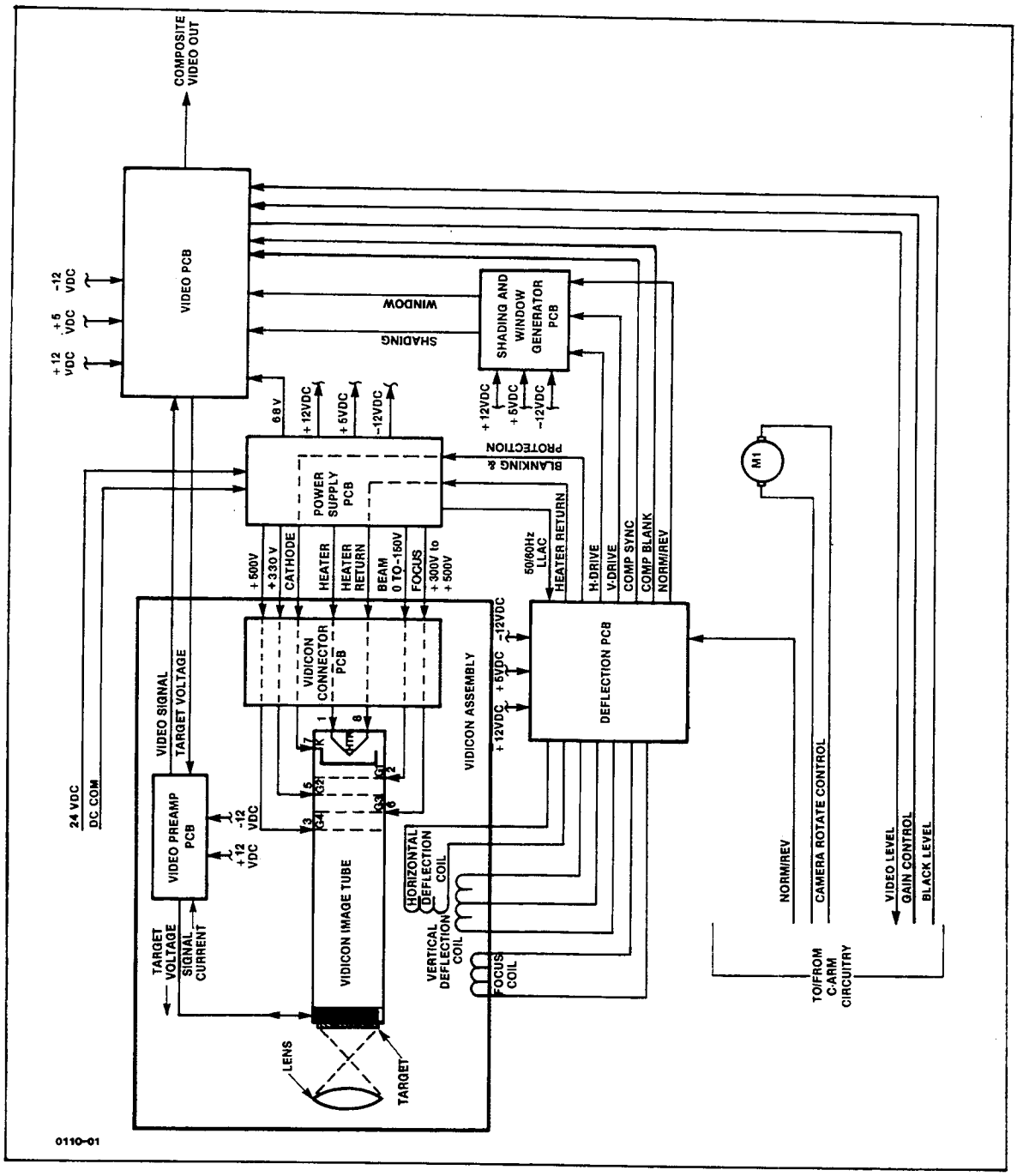


Figure 3-19 - *Camera Block Diagram.*



3.11 Video Camera

Refer to Schematic 00-871059 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 3-19.

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 I\O Distribution\Video Switch PCB in the monitor cart.

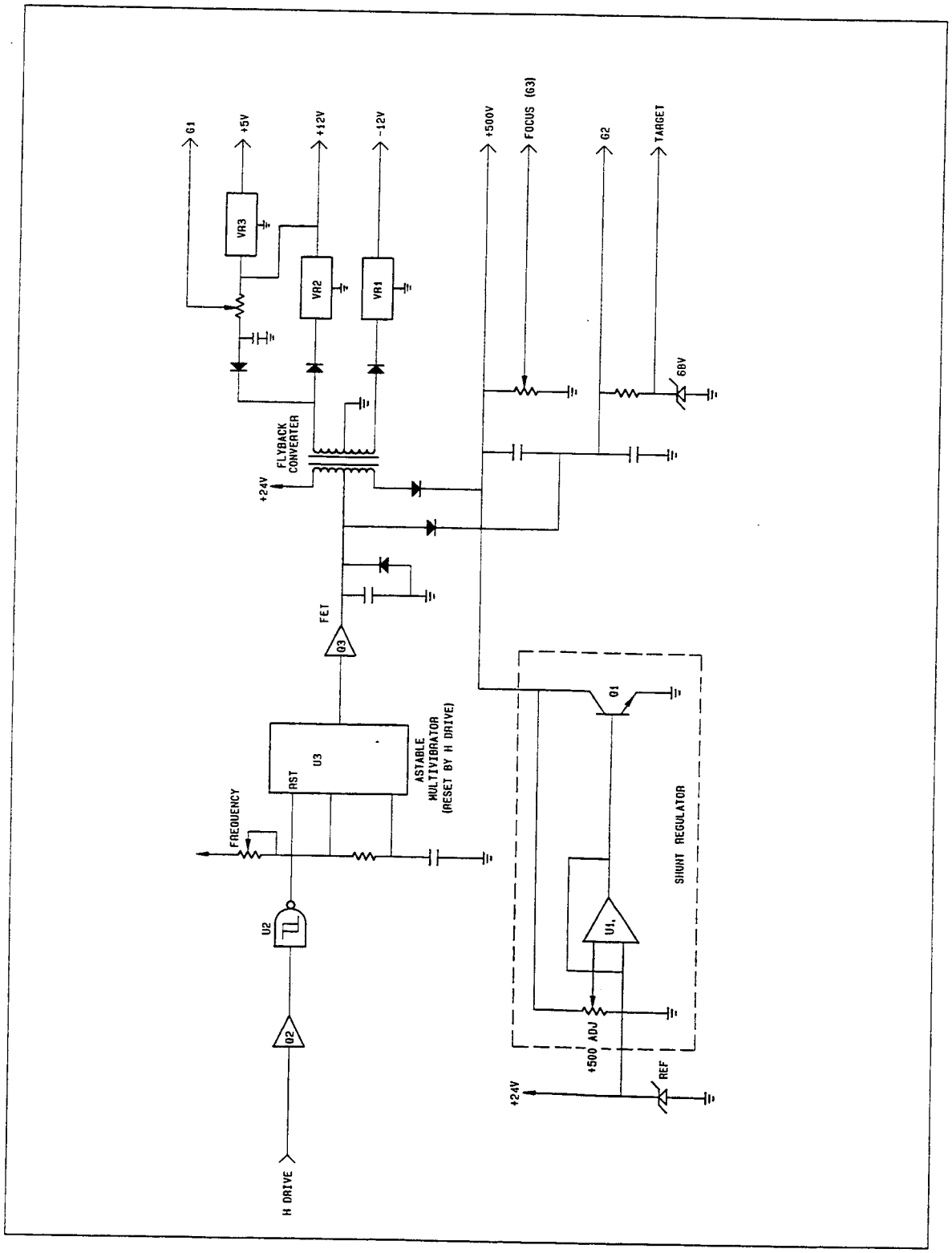
Another video signal, called video level, is produced which is proportional to the brightness within a sampled window area of the image. This is routed to the Analog Support PCB where it is digitized and read by the processor. Under software control, a camera gain control signal is fed back to the camera. 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 which would otherwise detract from the image.

The video sweep direction can be reversed 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.

Figure 3-20 - *Block diagram of the camera Power Supply PCB.*



3.11.2 Camera Power Supply PCB

Refer to Schematic 00-870813 and Figure 3-20.

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

Flyback Regulator

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 H drive rate. Both halves of the T1 primary are flyback inductors which develop high voltage AC waveforms when the centertap switches to 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. 00-860387 and Figure 3-21.

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

1. Sync generator
2. Horizontal deflection coil driver
3. Vertical deflection coil driver
4. Vidicon blanking and protection
5. Focus coil voltage regulator

Sync Generator Section

The video sync generator U2 is clocked by crystal Y1 for 60 Hz operation and Y2 for operation in 50 Hz systems.

Horizontal Deflection

The horizontal deflection driver consists of Q5, Q6, and U1. When the camera beam is scanning horizontally, Q5 is turned off and Q6 is turned on - a linearly increasing current flows in the horizontal deflection coil. When HOR DRV/ occurs, at the start of horizontal retrace, Q5 is turned on and Q6 is turned off. The width of the horizontal scan is proportional to the current supplied to the deflection coil by Q6. This current depends on the Q6 collector voltage set by L5 and the H SIZE potentiometer R40. The horizontal position of the scan is set by the level of the sawtooth current waveform in the deflection coil. The DC current is supplied by L3 and is determined by the setting of the H CENT potentiometers R38 and R39.

Sweep Reversal

Horizontal sweep reversal is accomplished by reversing the direction of the current through the deflection coils. The HORIZ REV control line selects the reverse direction of sweep.

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.

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.

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 3-21 - *Block diagram of the Deflection PCB.*

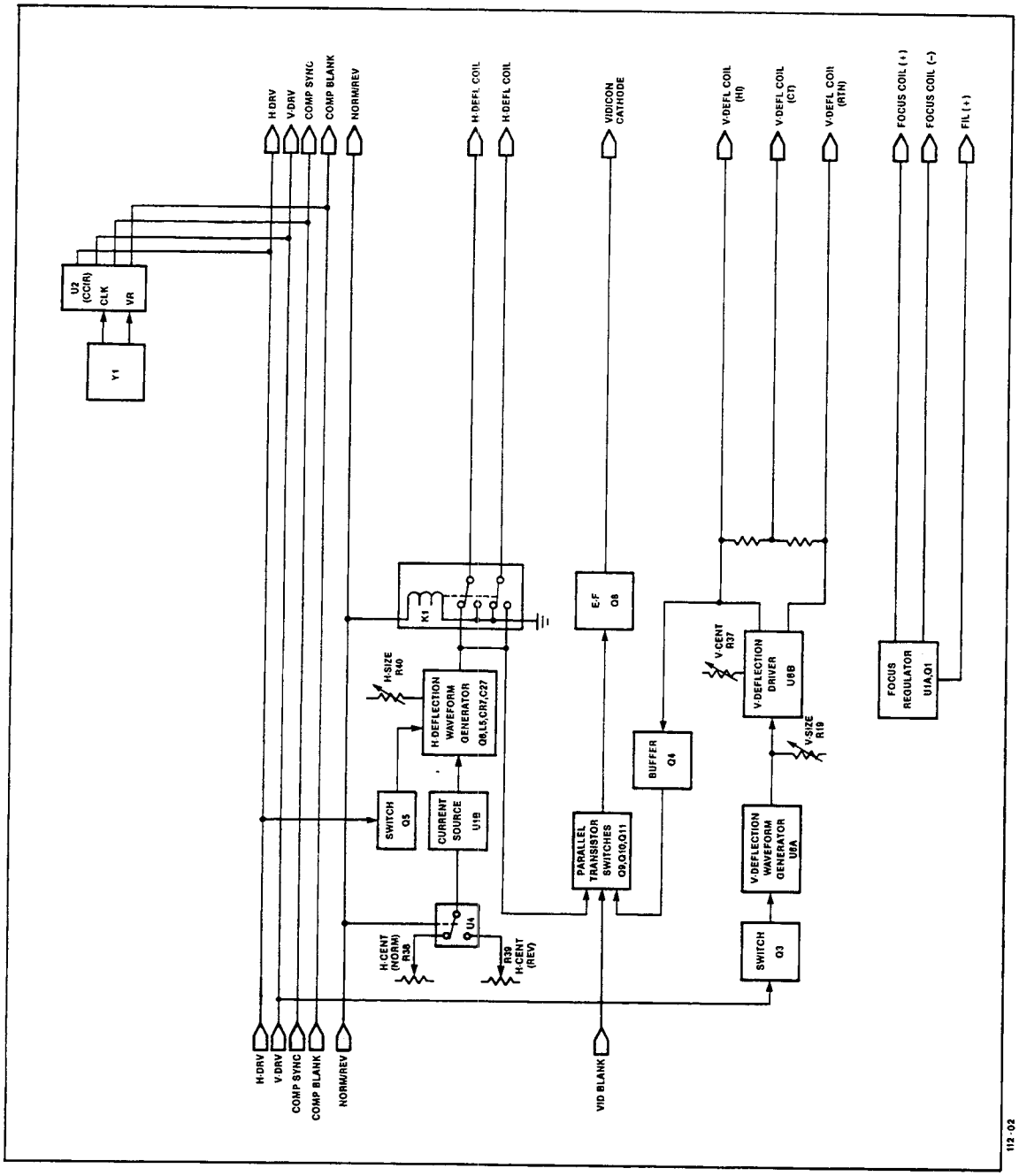
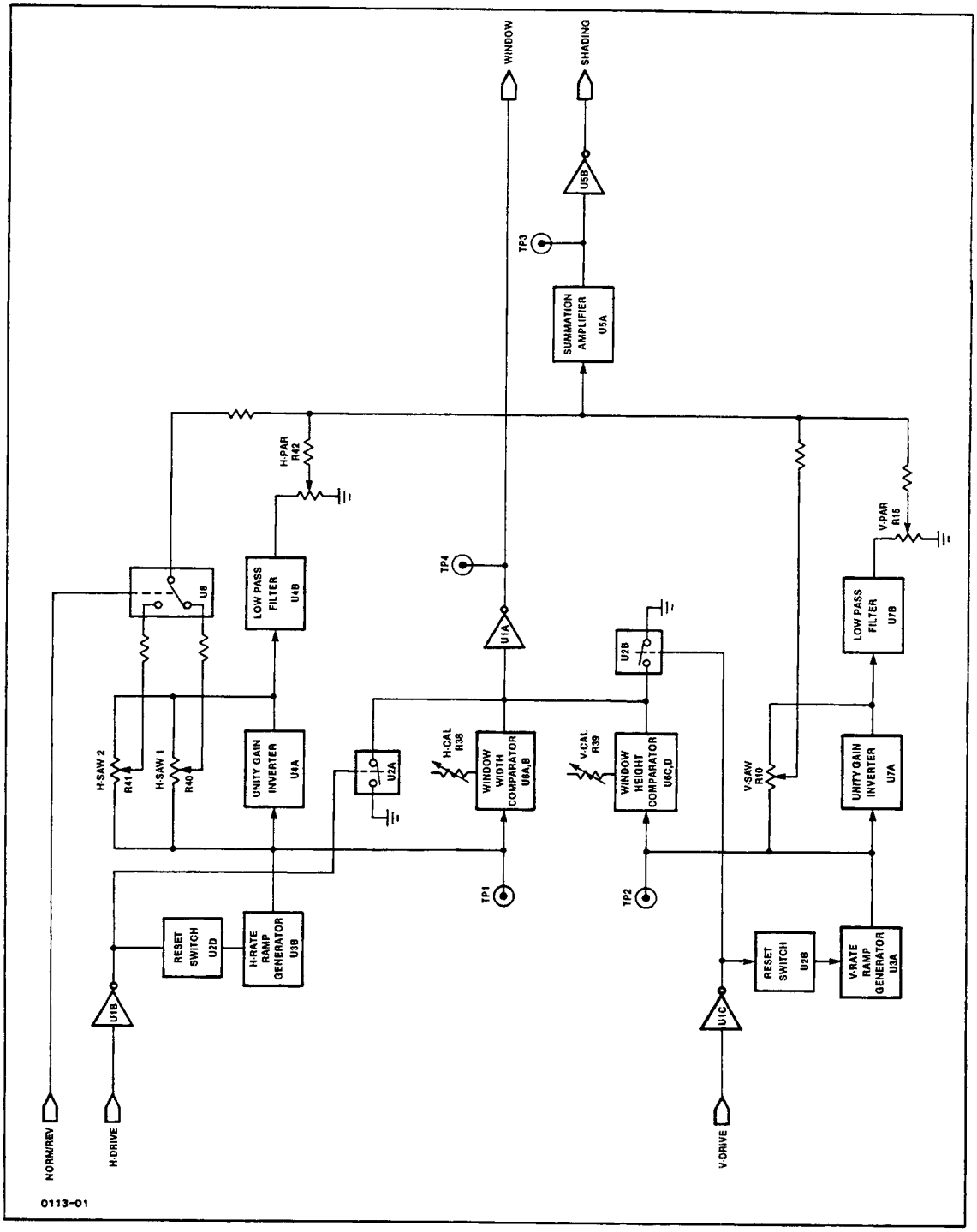


Figure 3-22 - *Block diagram of the Window Shading PCB.*



3.11.4 Shading/Window Generator PCB

Refer to Schematic No. 00-860384 and Figure 3-22.

The Shading/Window Generator PCB provides two functions required for fluoroscopy:

Correction for aberational brightness variations across the image plane (shading).

Generation of a video level sampling window used for camera gain control.

Shading Parabola Generation

The shading function makes use of 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 is generated by U3 and reset by U2. After reset, a positive-going ramp is generated by U3. This ramp is applied through C6 to U7, a unity gain inverting amplifier. Both the input and the output of U7 are applied across R10, the VERT SAWTOOTH adjustment potentiometer. The signal from the output of R10 is summed at the summing junction of U5. At the same time the output of U7A is applied the the input of U7B. The resulting parabolic waveform is applied to R15, the VERTICAL PARABOLA potentiometer. The wiper of R15 provides another waveform to be summed by U5. The combination of this signal and that from the wiper of R10 form the vertical shading waveform. The horizontal shading circuit operates similarly. 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.

Because of the cameras ability to reverse sweep direction, the horizontal sawtooth must be set for both directions (R40 and R41).

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. 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 cascade input stage Q2 and Q3. The signal current through Q1 and through the drain connections of Q2 and Q3 is direct coupled to Q4.

White clipping occurs when the emitter of Q1 goes more positive than -0.7 volts. The unclipped 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 mid-range gain of the preamplifier is fixed; the output of Q5 is 250 millivolts when the target current is 300 nanoamperes. The peaking control C# compensates for high-frequency rolloff and provides a uniform frequency response from the preamplifier.

3.11.7 Video PCB

Refer to Figure 3-23 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 each minute, 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 settings between these two extremes the dark-current compensation is interpolated.

Black Level

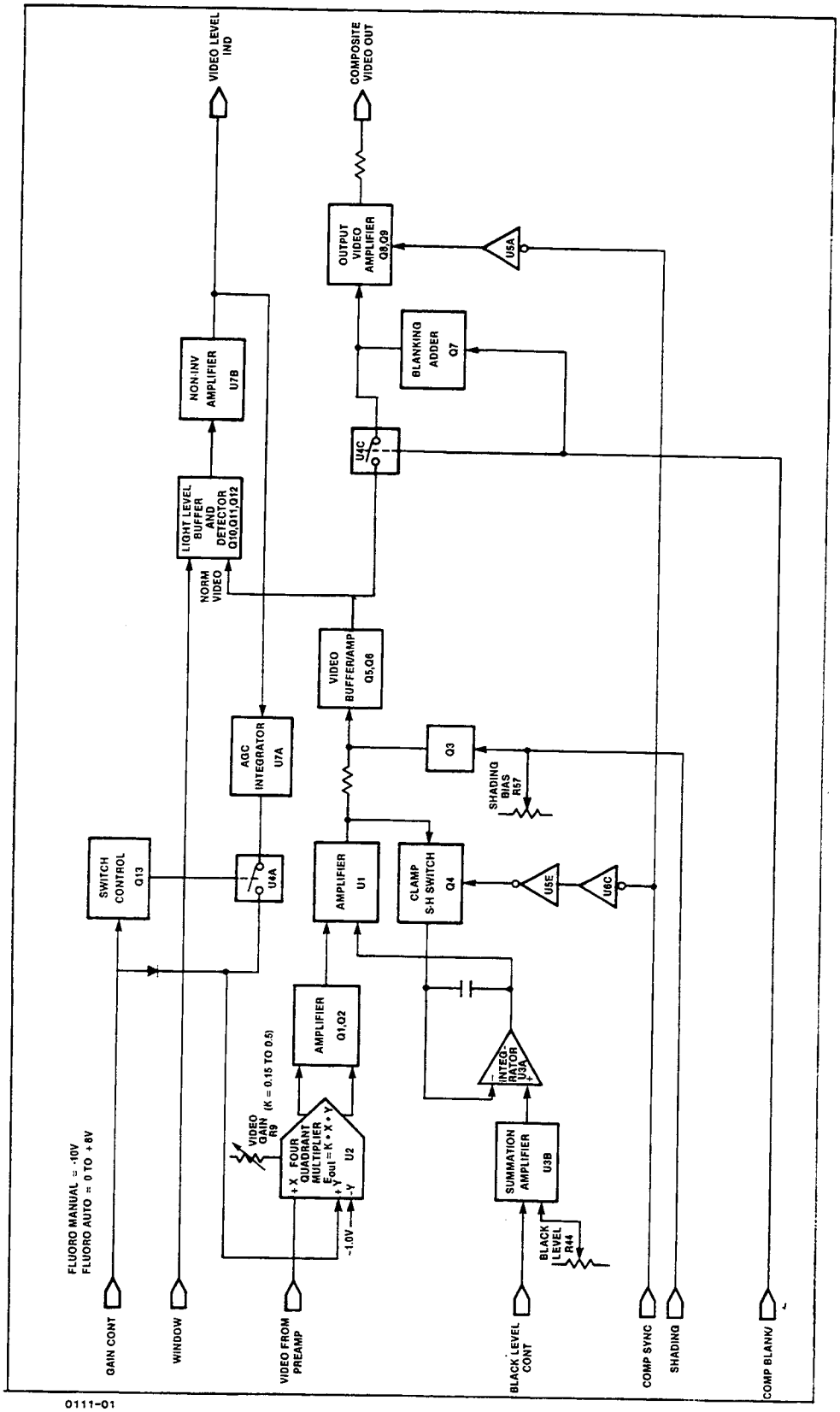
A black level adjustment is provided by R44. The output of U3 combines both black level adjustment and dark-current compensation. If the shading jumper is in place, a bias adjustment, set by R57, enables gain control through Q3. The input to Q3 is received from the Shading PCB.

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 3-23 - *Block diagram of the Video PCB.*



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 frequency current that is applied to the primary of a high voltage transformer. The transformer steps up the primary voltage from about 400 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 currents 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

Refer to Schematic 00-870779 and Figure 3-24.

Overview

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 14 character alphanumeric display, 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.

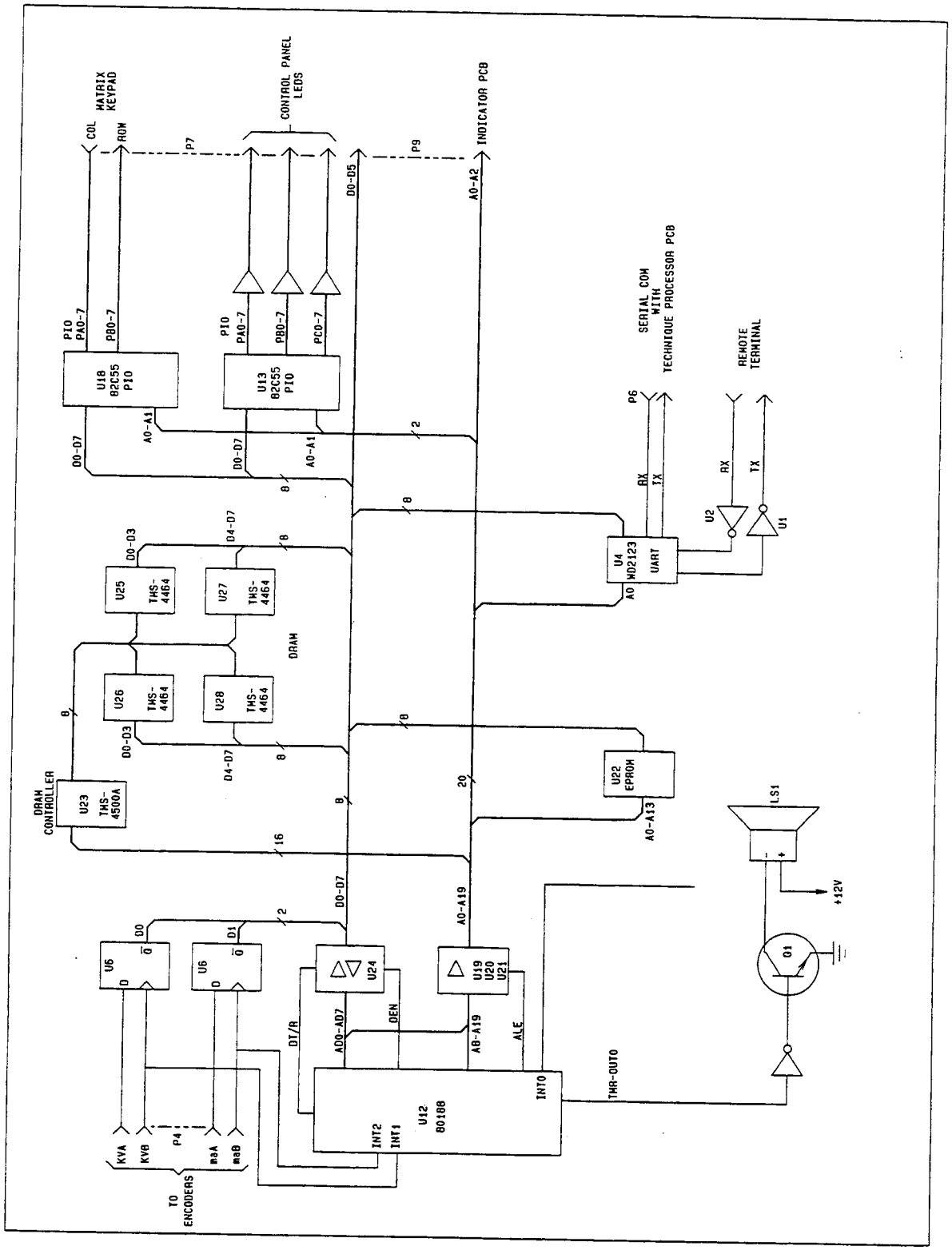
Switch Matrix Interface

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 Indicator PCB

Refer to Schematic 00-870916.

The Indicator PCB contains fourteen 16-segment LED modules with multiplexed text and decimal points. These operate in two different modes:

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.

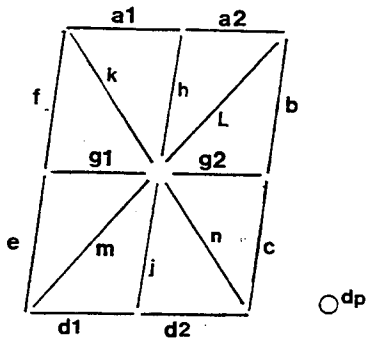


Figure 3-25 - *The LED character segments.*

The 14 character alphanumeric display located on the Indicator PCB is controlled by the 80188 on the Control Panel Processor PCB. Character multiplexing is handled by the PAL output on pin U6-14, which clocks the latches of U7 and the demux chip U11. Character segments are multiplexed in three groups, A1-D2, E-H, and L-DP by the PAL outputs on pins U6-13, 12, 11. DATA 0 through DATA 5 is latched into U1, U3 and U5 according to these PAL outputs.

The common cathode LED module segments are driven by UDN-2981 current drivers U2 and U4. Input P1-8 is a powerup reset which clears the latches. The decimal points are driven by Q1.

3.12.3 Technique Processor PCB

Refer to Schematic 00-870591 and Figure 3-26.

Overview

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

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 3-26 - *Technique Processor PCB block diagram.*

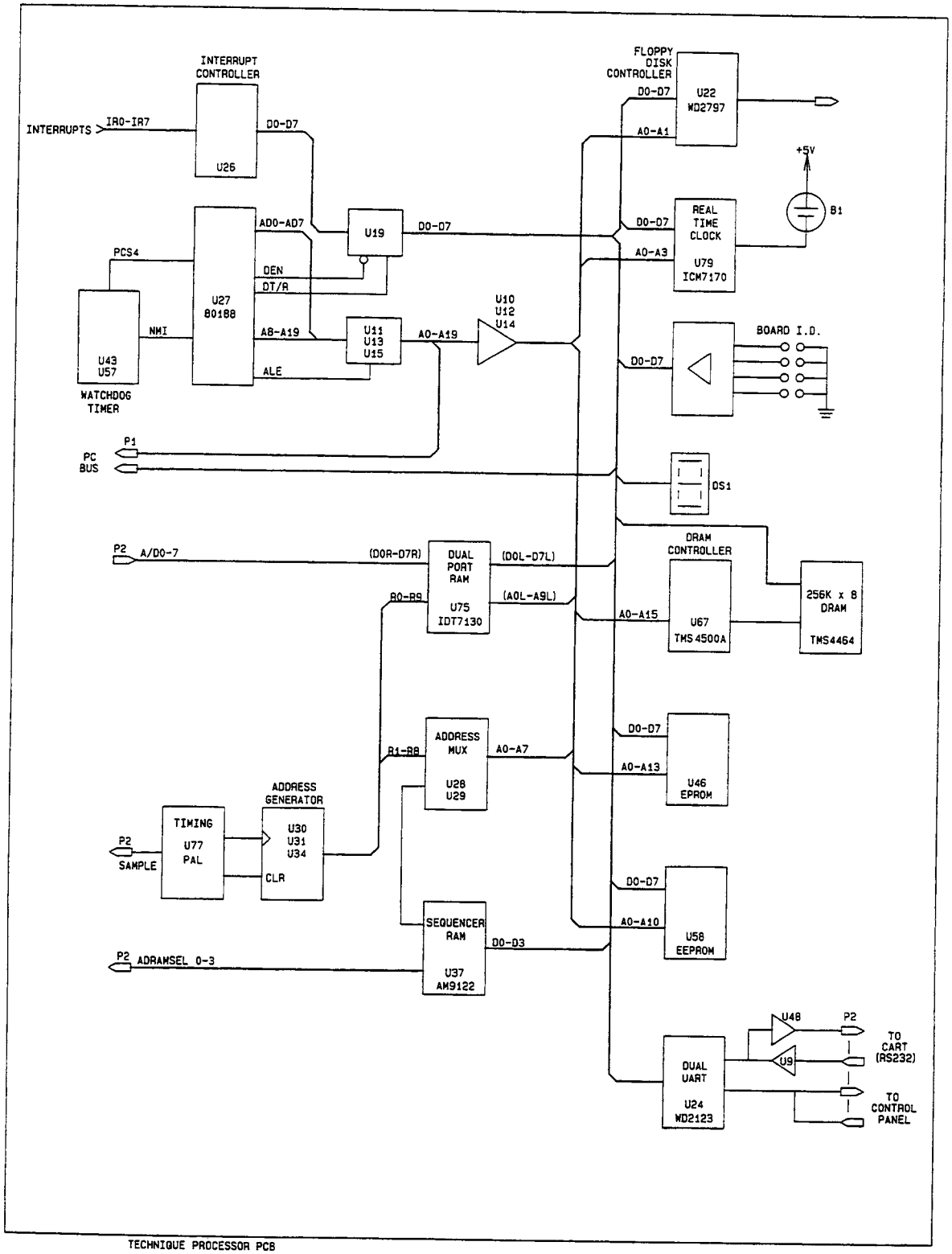


Table 2 Technique Processor Memory and Peripheral Chip Decoding

Memory

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

Peripherals

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 2 (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

DMA Channels

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

Figure 3-27 - *Block diagram of the Analog Support PCB.*

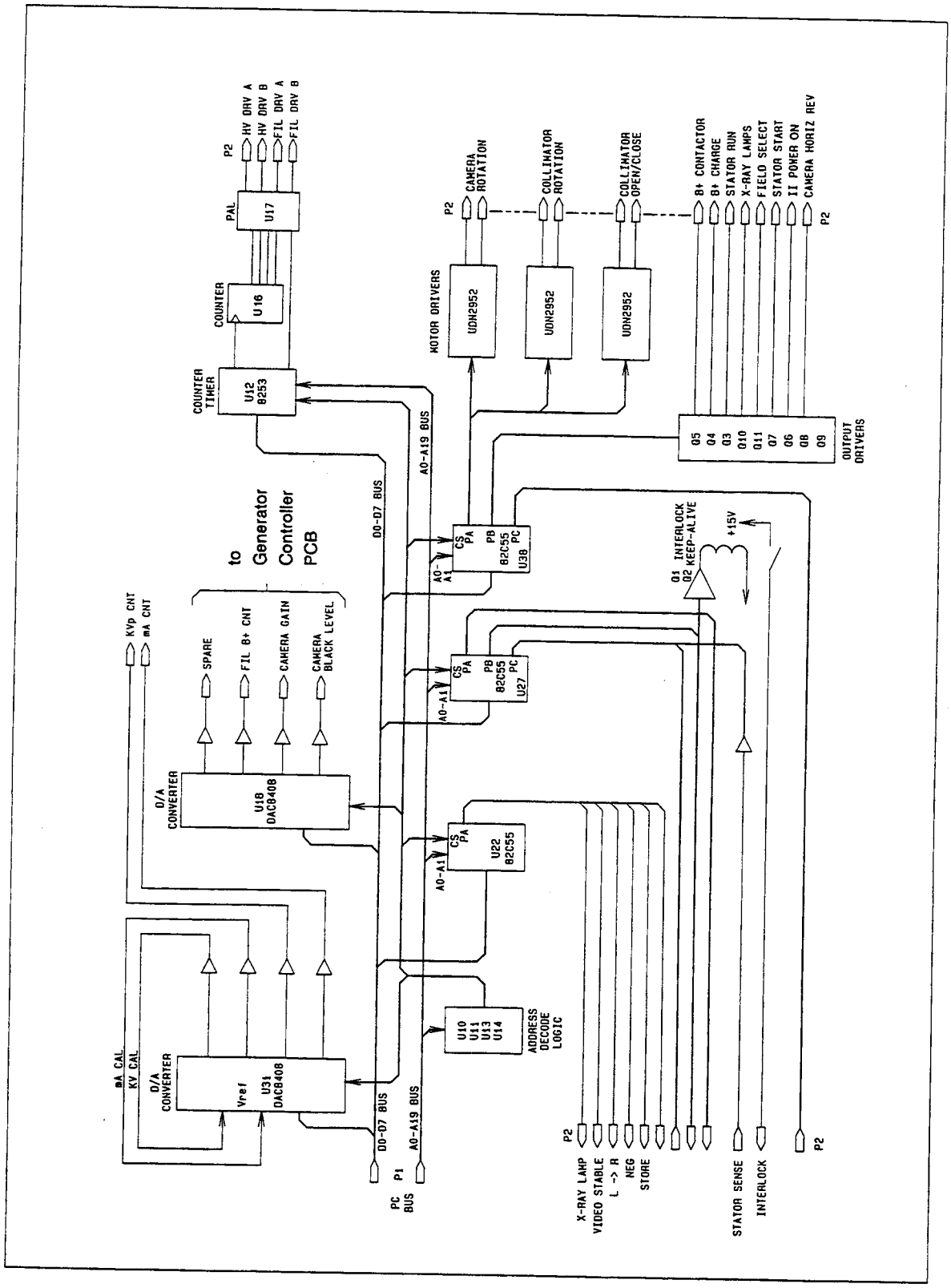
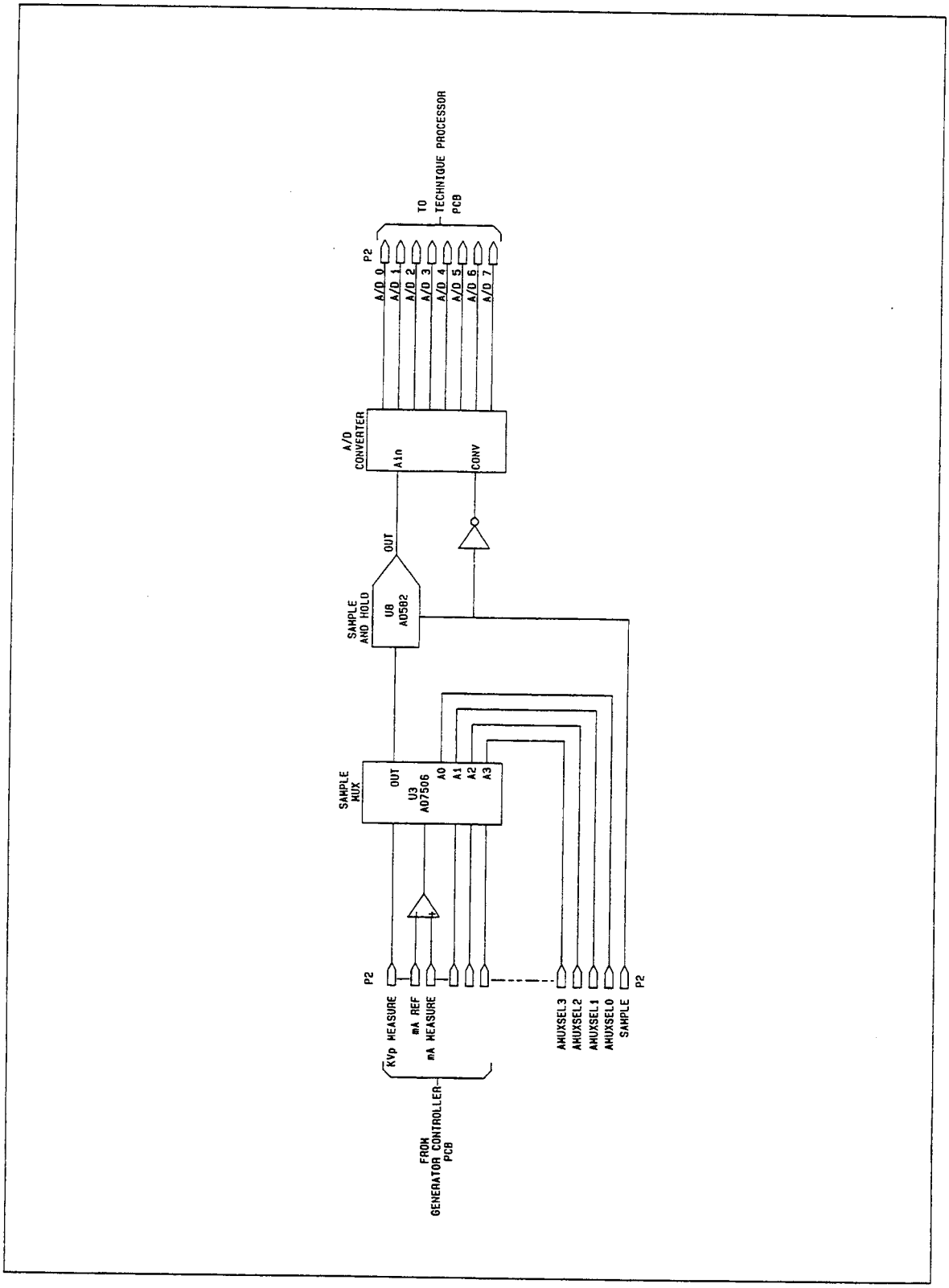


Figure 3-28 - *Block diagram of the A/D portion of the Analog Support PCB.*



3.12.4 Analog Support PCB

Overview

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

Refer to Schematic 00-870771 and Figures 3-28 and 3-29.

The Analog Support PCB performs the following functions:

1. Sample and digitize signals from the Generator Controller PCB to be read by the Technique Processor PCB.
2. Convert data bytes from the Technique Processor into analog signals for such functions as camera gain control, kVp control, and filament control.
3. Generate the high voltage drive and filament drive signals.
4. Provide a digital interface between the Technique Processor and discrete digital signals such as *STORE* and *B+ CONTACTOR*.
5. Control the camera and collimator motors.
6. 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
U26	Motor Controller	UDN 2952
U37	Motor Controller	UDN 2952
U39	Motor Controller	UDN 2952

Transistors Q3 - Q11 drive individual control lines.

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, 9, 10, and 11 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.

UDN-2952 Full-Bridge Motor Drivers

These integrated circuits combine low-level logic circuitry compatible with TTL and CMOS levels. They allow bidirectional control of DC motors with continuous load currents of up to 2 A. Internal protection includes thermal shutdown and transient suppression.

Sample Mux

Refer to Figure 3-28.

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.

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 3 A/D Sense Lines

A/D CHANNEL	*FUNCTION*
U3-S1	kVp measured
U3-S2	mA measured
U3-S3	filament B+ sense
U3-S4	video level
U3-S5	housing temperature
U3-S6	dosimeter
U3-S7	spare
U3-S8	spare
U3-S9	secondary tap voltage
U3-S10	line voltage
U3-S11	charger current
U3-S12	battery voltage
U3-S13	filament current
U3-S14	spare
U3-S15	spare
U3-S16	spare

Table 4

PIO 1, U38 Summary

BIT	*PIN*	*FUNCTION*	*COMMENT*
PA0	4	camera rotate CW	see state table
PA1	3	camera rotate enable	
PA2	2	collimator rotate CW	
PA3	1	collimator rotate enable	
PA4	40	collimator open	
PA5	39	collimator enable	
PA6	38	iris open	
PA7	37	iris enable	
PB0	18	B+ contactor	active hi
PB1	19	B+ charge	
PB2	20	stator run	
PB3	21	X-ray on lamps	not used
PB4	22	field select	
PB5	23	stator start	hi for 2 sec
PB6	24	II power	used in fluoro
PB7	25	camera horizontal reverse	
PC0	14	spare	sense
PC1	15	spare	sense
PC2	16	cassette detect	sense
PC3	17	field detect	sense
PC4	13	not used	
PC5	12	fluoro only	left footswitch sense
PC6	11	boost	boost sense
PC7	10	X-ray switch	switch or footswitch sense

Table 5

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	camera vertical reverse	
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	overvoltage 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 6

PIO 3, U22 Summary

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

Signal Descriptions

Charger Control

Charger Disable.....U27-PB0
when high: causes the charger to stop charging the batteries. On the Generator Controller PCB this line is connected to the shutdown pin on U22, a current mode PWM controller.

X-ray Tube Control

Stator Start.....U38-PB5
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-PB2
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.

Start/Run Logic Table

	PB5	PB2
OFF	0	0
RUN	0	1
ILLEGAL	1	0
START	1	1

Stator Sense.....U27-PC7
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.

Generator Control

B+ Charge.....U38-PB1
When active, a high is applied to the base of Q4. Q4 collector (B+ Charge) is looped through the Generator Controller PCB and routed to the charging relay K1 mounted below the Generator Controller PCB. 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-PB0
When active, a high is applied to the base of Q5. Q5 collector (B+ Contactor) is looped thru the Generator Controller PCB and routed to the relay K2 located under the Generator Controller PCB. 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-PA7
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 Controller PCB and applied to the fault protection logic PAL U32.

KVP Control.....U31-CH3
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 Controller PCB.*

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

mA Control.....U31-CH4
Delivers a control voltage to the filament regulator circuit. Measure this voltage at TP18. *Refer to the filament control circuit on the Generator Controller PCB.*

mA Reference (mA Cal) U31-CH2
Sets the reference voltage for the DAC used to generate mA CONTROL. Measure this voltage at TP16.

Filament B+ Control.....U18-CH2
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 Controller PCB.*

Focal Spot.....U27-PA1
The state of this line selects the focal spot size.

1 = 0.3 mm spot
0 = 1.0 mm spot

On the Generator Controller PCB - 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. Refer to be Generator Controller PCB.

Generator Shutdown (Shutdown Command).....U27-PA3
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 Controller PCB 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 Controller PCB.*

mA Scale Factor.....U27-PA0
Selects the mA scale factor for film or fluoro - 1 = Fluoro, 0 = Film.

HV Drive.....U12
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 Controller PCB, 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 Controller PCB.*

HV Generator On.....U27-PC4
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 Controller PCB at PAL U21, which monitors the states of the HV Drives, X-ray On, X-ray Enable, and other lines.

Generator Fault.....U27-PC3
Indicates that one of the fault conditions has been detected and the generator has been shut down. Originates on the Generator Controller PCB at PAL U32.

Overload Fault.....U27-PC0
Indicates that the generator has detected an overload and shutdown. Originates on the Generator Controller PCB at PAL U32.

Saturation Fault.....U27-PC1
Indicates that the generator has detected a saturation fault and shut down. Originates on the Generator Controller PCB at PAL U32.

Filament Fault.....U27-PC2
Indicates that a filament fault has been detected and the generator has been shutdown. Originates on the Generator Controller PCB at PAL U32.

mA Test.....U27-PA4
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 Controller PCB.

Generator Mode (High Power Mode).....U27-PA2
When high, this line causes the generator to use the full bridge configuration to drive the output transistors. When low, causes the generator to use the half bridge configuration to drive the output transistors. The signal is applied to Q10 on the Generator Controller PCB. The collector of Q10 controls relay K3.

Camera/Image Intensifier Control

Camera Horizontal Sweep Control..... U38-PB7
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.

Camera Rotate Direction U38-PA0
The camera will rotate CW or CCW according to the table below.

Camera Rotation Enable.....U38-PA1
Enables camera rotation, see the table below.

PA1	*PA0*	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

PA0 AND PA1 are applied to the phase and enable inputs of the motor control IC U26. The direction of current flow from out1 and out2 on this IC determines the direction of motor rotation.

Disregarding slippage, camera rotation speed is about 8 degrees per second. Coast is about 3 degrees (maximum). The camera motor has limit switches that activate at either end of the rotational limits.

The direction of camera rotation depends on both the control command and the direction of camera horizontal sweep.

Camera Rotate	CW	CCW	CW	CCW
Reverse Sweep	No	Yes	Yes	No
Actual Direction	CW	CW	CCW	CCW

Camera Mode..... U27-PB1
Not currently used, should be set low.

Camera Gain.....U18-CH3
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-CH4
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-PB6
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.

Iris Aperture.....U38-PA6,PA7
Not installed.

Camera/Image Intensifier Sensing

Film Cassette U38-PC2
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.

Collimator Rotation Direction U38-PA2
Determines the direction of collimator rotation according to the table below.

Collimator Rotation Enable U38-PA3
Enables collimator rotation according to the table below.

PA3	PA2	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

PA2 and PA3 are applied to the phase and enable inputs of the motor controller IC U37. The direction of current flow from OUT1 to sT2 determines the direction of motor rotation.

Disregarding slip, the collimator rotation speed is about 8 degrees per second. Coast is approximately 3 degrees. The collimator rotation motor has no limit switches. Rotation is continuous obtaining power from slip rings.

Collimator Aperture Direction U38-PA4
Causes the aperture to open or close according to the table below.

Collimator Aperture Enable U38-PA5
Enables motorized collimation according to the table below.

PA5	PA4	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

Note: The collimator leaf motor speed is about 0.25 inches per second when viewed in the 6" field. The leaf motor has no limit switches.

Field Select U38-PB4
When low, the flipper is placed in the beam, restricting the field diameter. When high, the flipper is put out of the beam. This line is applied to the base of Q11. The collector of Q11 drives the field select solenoid at the collimator.

Note: When the large field is selected, the solenoid draws about 1 amp of current.

Field Detect U38-PC3
PIO input reads the status of the field size through a microswitch at the flipper. This line reads low when the flipper is out of the beam.

Cart Control and Sensing

Store U22-PA4
When low, informs the image processor that an exposure is being made.

Video Stable U22-PA1
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-PC5
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-PB7
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-PC6
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-PC7
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-PC6
PIO Input. Signals that the boost position of the footswitch has been pressed.

Fluoro Only U38-PC5
PIO Input. Signals that the left side of the footswitch, FLUORO ONLY, has been pressed.

3.12.5 Generator Controller PCB

Overview

Refer to Schematic 00-871044.

The major functions of the Generator Controller are:

1. Regulate Filament Current
2. Regulate X-ray tube high voltage
3. Charge the batteries
4. 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.

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 VR1. The rectified voltage is regulated by VR5 and VR6 to provide +/- 12 VDC. These are identified as +/- 12SEP and they power the battery charger circuits separately from the other voltages on the board.

The other supply voltages, +/- 12 VDC and +/- 6 VDC, are regulated by VR3 and VR4.

Grounding

The Generator Controller PCB 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:

Ground A: Battery minus (B-) and 115 VAC Neutral
Ground B: ground for the driver stage Q14-Q17
DC Common: ground for most low voltages, and forms the PCB ground plane

Be sure that voltage measurements are referenced to the correct ground.

Fault Detection Logic

Refer to *Section 3.4 - Fault Conditions and Error Checks* for a full description of the fault detection logic.

Battery Charger Circuit

Refer to Figure 3-29.

The battery charger is a boost regulator which provides a controlled current and voltage to the battery 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 U15, Q4 is turned on, placing R70 in parallel in the voltage feedback loop with R98 and R108. 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, Q4 turns off and regulates the charging voltage back to the 211 VDC level. Hysteresis is biased into the op-amp circuit of U26 causing this transition to occur gradually.

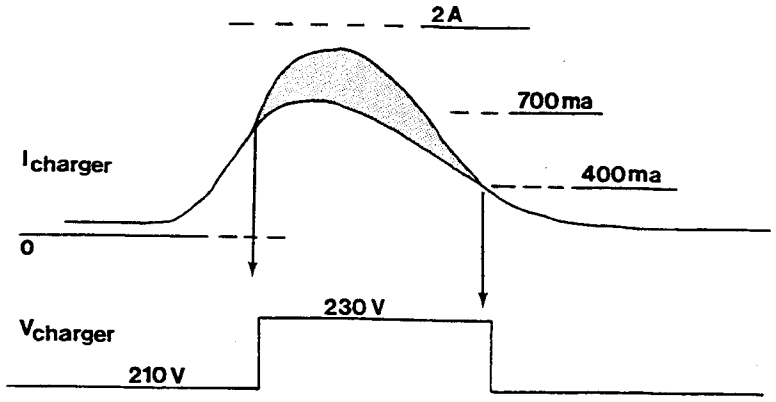
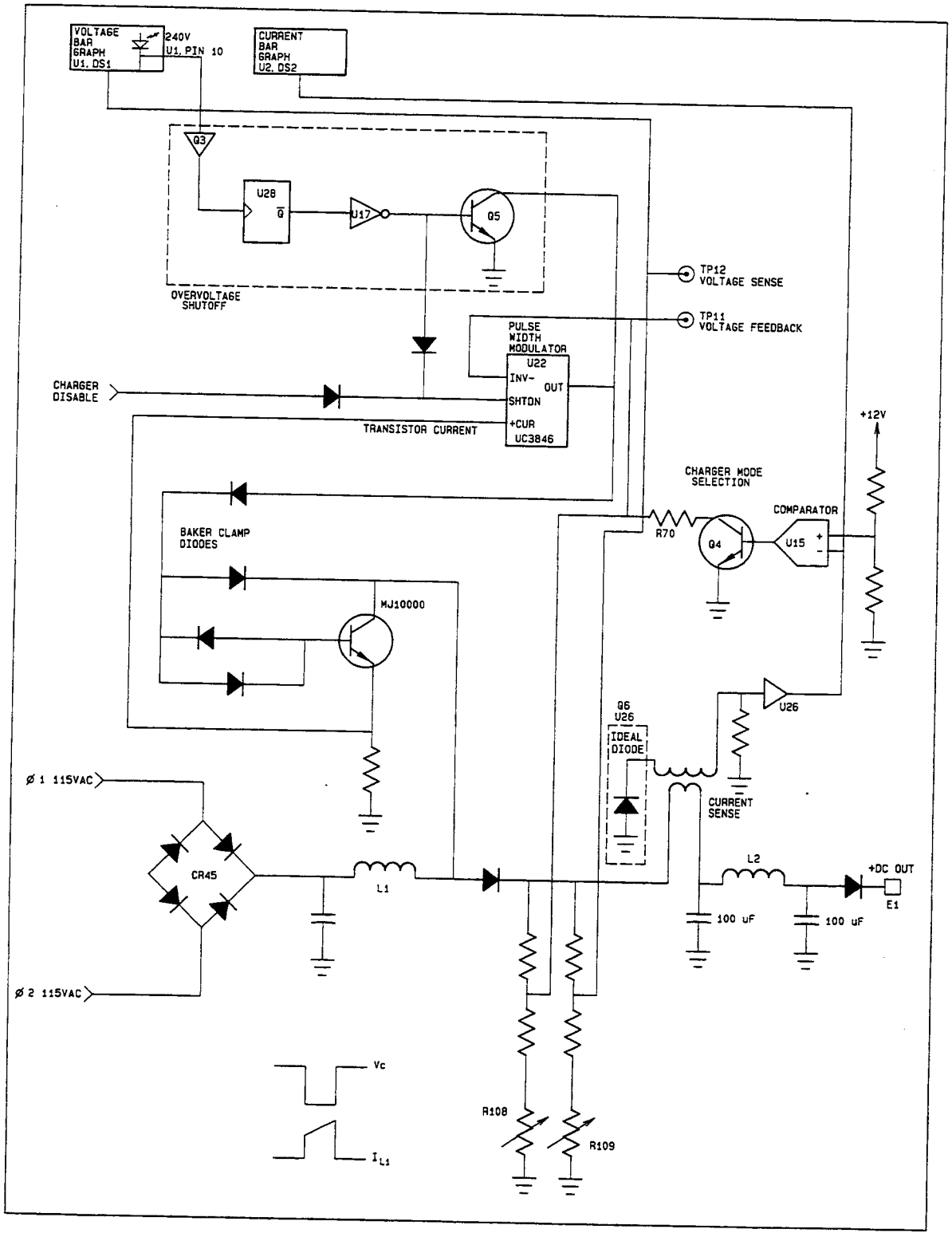


Figure 3-29 - *The current and voltage output during low and high charge.*

Pulse Width Modulator Circuit

U22 (UC3846) is a current mode, pulse width modulator with a built in 5.1 volt reference. The reference is accessible on pin 2 (Vr). U22 controls the duty cycle applied to the base of the MJ10000 transistor Q18 mounted above the board on a heat sink. When this transistor turns on, the current into L1 increases. The Baker clamp on the base of Q18 prevents saturation and speeds up the switching response.

Figure 3-30 - *Block diagram of the battery charger portion of the Generator Controller PCB.*



Boost Regulator Cycle

Line current is rectified by bridge rectifier CR45 and applied to the inductor L2. When The regulator transistor Q18 receives no drive voltage the rectified line voltage is lower than the battery voltage and diode CR67 is backbiased. There is no current flow.

When the transistor Q18 turns on, one side of the inductor is grounded thru resistor R122. There is a gradually increasing current flow through the inductor. When the transistor turns off, the inductor supplies current by flyback action which results in a voltage forward biasing CR67. Cycle variations are filtered by C59, L2 and C63. Note on the schematic that E1 is connected to the + side of the batteries and ground "A" is connected to the - side.

Transistor current feedback is obtained from the emitter resistor R122 and fed back to one side of the differential current sense input of U22-pin4. The other differential side is connected to ground A.

When Q18 turns off, the flyback action of inductor L1 boosts the voltage by an amount determined by the on-time. CR67 prevents backward current flow when Q18 is turned on and allows current flow to the batteries during the flyback phase.

Resistor network R111/R98/R108 provides feedback to the inverting voltage sense input of U22. *R108 is adjusted to produce 211 VDC output at E1 or 5.1 VDC at TP11, Voltage Feedback.*

Voltage is sensed for the charging voltage bar graph display by resistor network R94/R95/R109/R112. *R109 is adjusted for the correct display of the charging voltage on the bargraph.*

Charging Current Sense

T1 and the ideal (0 drop) diode formed by U26/CR19/Q6 develop a voltage across the resistor R86 proportional to the charging current in the T1 primary. U26 is a 2X voltage amplifier providing the CHARGER CURRENT SENSE signal. This signal is fed to comparator U15, which switches when current demand is increased, current indicator display U2, and is also available off board where it is digitized on the Analog Support PCB and read by the processor.

Protection

The overcurrent protection circuit consists of Q3, flip flop U28, inverter U17 and transistor Q5.

Flip flop U28 is reset by the powerup reset circuit C15/R30 and also when the processor toggles the reset line via Q18 and Q19. Resetting U28 enables the U22 output and turns off Q5.

The CHARGER DISABLE line from the processor (via the Analog Support PCB) is attached to the U22 pin-SHTDN. When held high by the processor, this disables the pulse width modulator.

If excessive charging current is sensed, overcurrent protection is provided in two steps: apply a high to the SHTDN pin of the PWM U22, and ground the U22 drive output through transistor Q5.

Excessive charging current is sensed when the highest segment on the voltage bar graph lights, causing Q3 to clock the flip flop U28.

Indicators

Charging current is indicated on the LED bar graph display U2. U2 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, U1, is driven by the VOLTAGE SENSE line. The indicator reads in 10 linear steps from 150 VDC to 240 VDC.

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.

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.

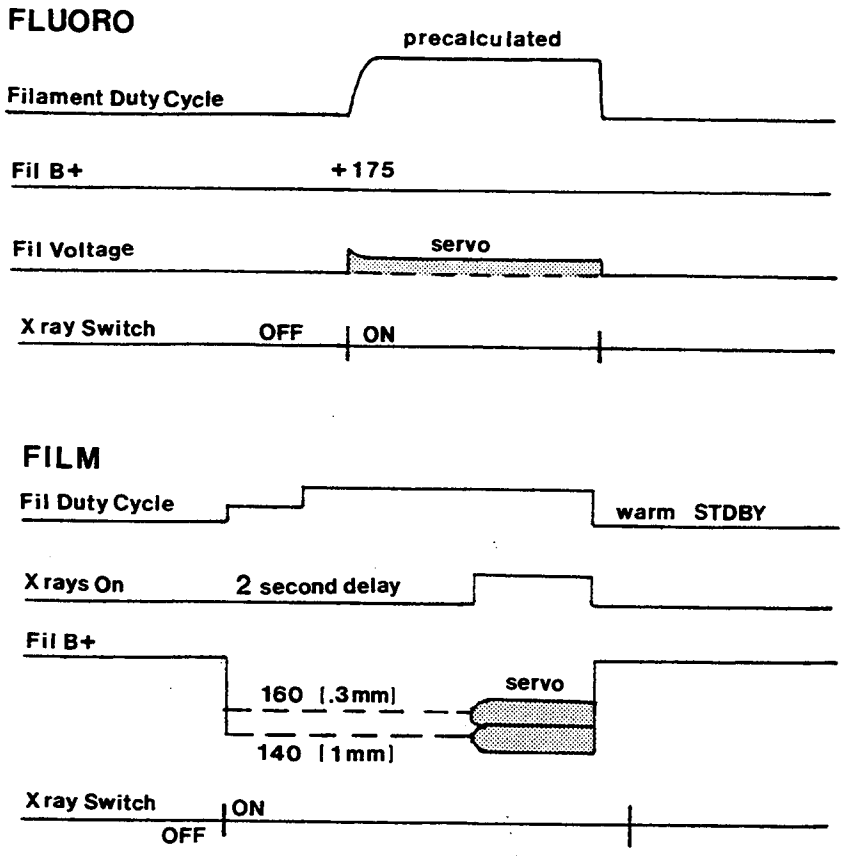


Figure 3-31 - *Filament duty cycle and filament B+ regulation before and during a shot.*

The filament B+ voltage is initially set to a low value by the processor: 140 volts for film mode and 175 volts for fluoro mode. As the shot begins the B+ is increased and 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.

In Other Words

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

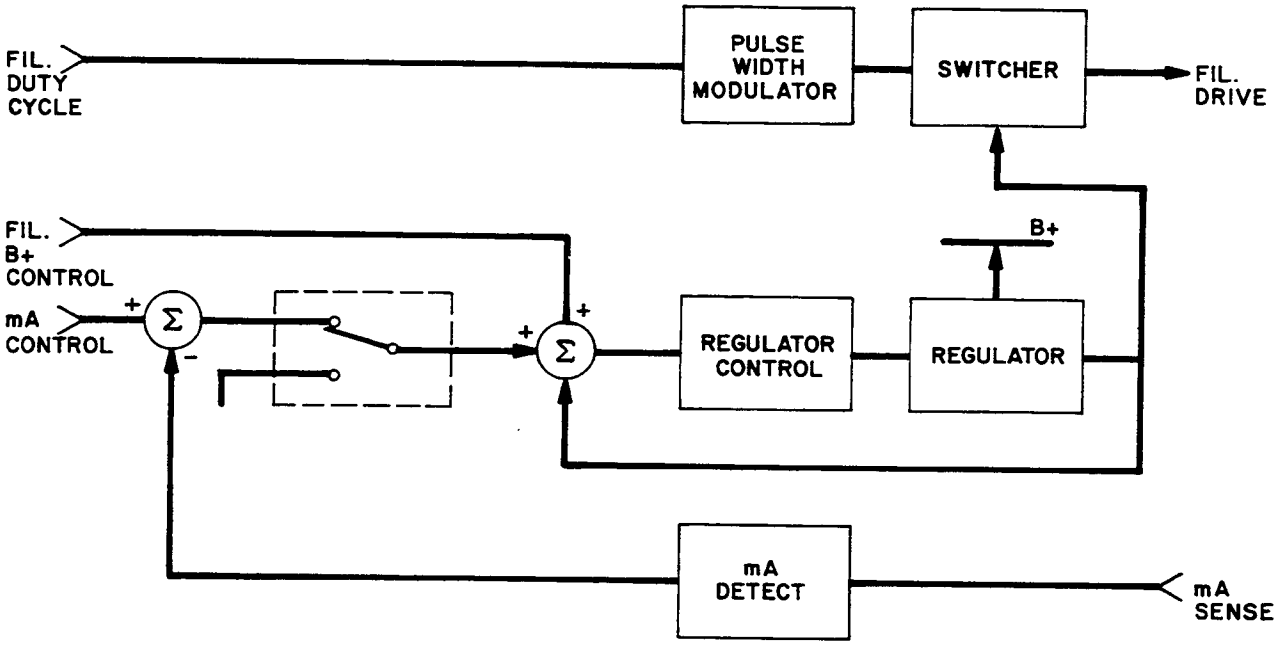
1. Vary the duty cycle of the output switcher stage comprised of transistors Q12 and Q13. This is the means the processor uses to preadjust the filament temperature, prior to a film shot and at the beginning of a fluoro shot, to an approximate value for the technique selected.

   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).

Figure 3-32 - *The filament dynamic regulation loop, compares the measured filament current (mA-sense) against the filament control signal (mA-control) obtained from the processor.*



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 U11, resulting in d.c. restoration. U11 acts as a current to voltage converter.

The two stages of U20 form a 4-pole low pass filter. The output of U20 is applied to film/fluoro scaling amplifier U10. U23 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.

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, opening analog switch U39. As the shot begins, switch U39 opens, enabling error amplifier U30. U30 compares the MA CONTROL voltage with the mA sense voltage obtained from op amp U10.

The difference, or error voltage, is applied to error amplifier U38 whose output controls the voltage on the base of transistor Q11.

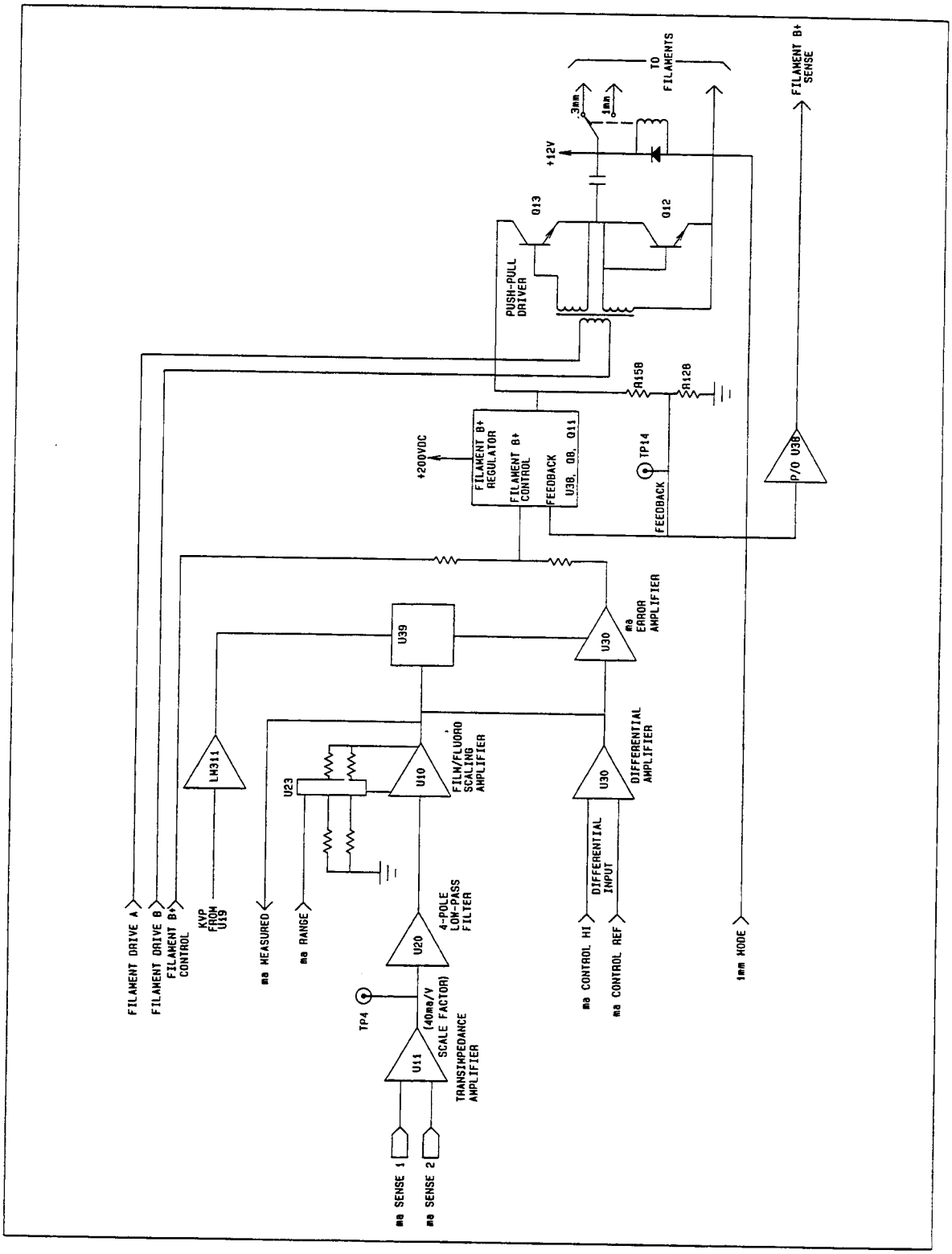
The signal applied to the base of Q11 regulates the B+ voltage applied to the filament driver stage Q12 and Q13.

The linear regulator circuit, Q8 and Q11, controls the battery B+ voltage applied to the push-pull filament driver circuit Q12, Q13.

The final output is applied through L4 and C77 to relay K1. According to the state of the 1mm 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.

Figure 3-33 - *Block diagram of mA regulation circuit.*



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 U23 and applies the MA TEST CONTROL VOLTAGE to op amp U7.

U7 and Q2 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 3-34 - *The mA test circuit.*

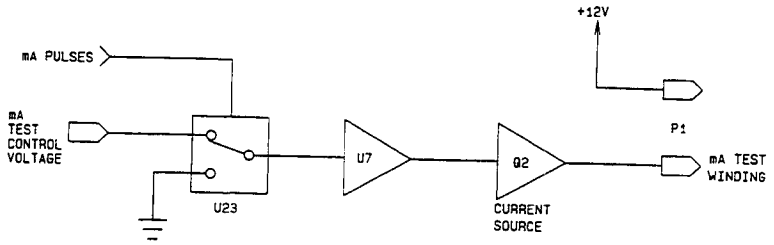
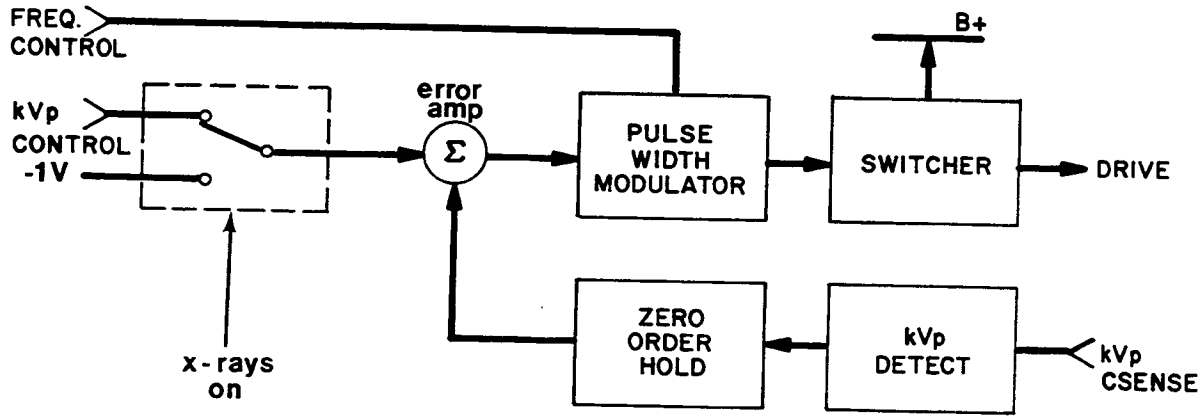


Figure 3-35 - *KVp regulation Loop.*



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 Controller PCB KV SENSE is applied across R42. The positive peaks of the KV SENSE waveform are buffered by U27 and peak detected by U24/U16. The negative peaks of the waveform are inverted by U27, and detected by U12/U27.

Both peaks are sampled and held by U29/U39, then combined and integrated by C49 and U19. The result is KVP MEASURED. This signal is then sampled and digitized on the Analog Support PCB.

Analog switch U45 is controlled by MA RANGE. With its associated RC network, its action is to reduce overshoot in fluoro modes.

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 U9, U18, and Q1. The PWM output PWM COMPARATOR forms a logic input to PAL U21, along with the signals HV DRIVE A and B, an X-RAY ON and X-RAY ENABLE. PAL U21 produces the signals HV DRV A and HV DRV B which determine the duty cycle of the switcher drives.

Error amplifier U19 compares the KVP MEASURED with the HV CONTROL signal. HV CONTROL is applied to the error amplifier by switch U23 controlled by the signal HV INV ON. When HV CONTROL is not applied to U19, a voltage set by resistive divider network R91/R105 is switched into the error amplifier input by U23 to prevent the regulation feedback loop from overcompensating for zero voltage sensed.

Comparator U9, transistor Q1, and flip-flop U18 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) U21. HV DRV A and HV DRV B are output by U21, buffered and inverted by U31. U40 provides current gain before applying the drive signals to Q14/Q15 and Q16/Q17.

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, since 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. U5 is a peak detector whose output, SECONDARY TAP VOLTAGE, is proportional to the kVp voltage from the tank. This signal is digitized on the Analog Support PCB and read by the processor.

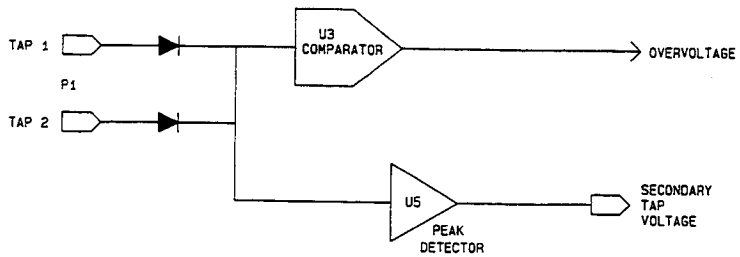
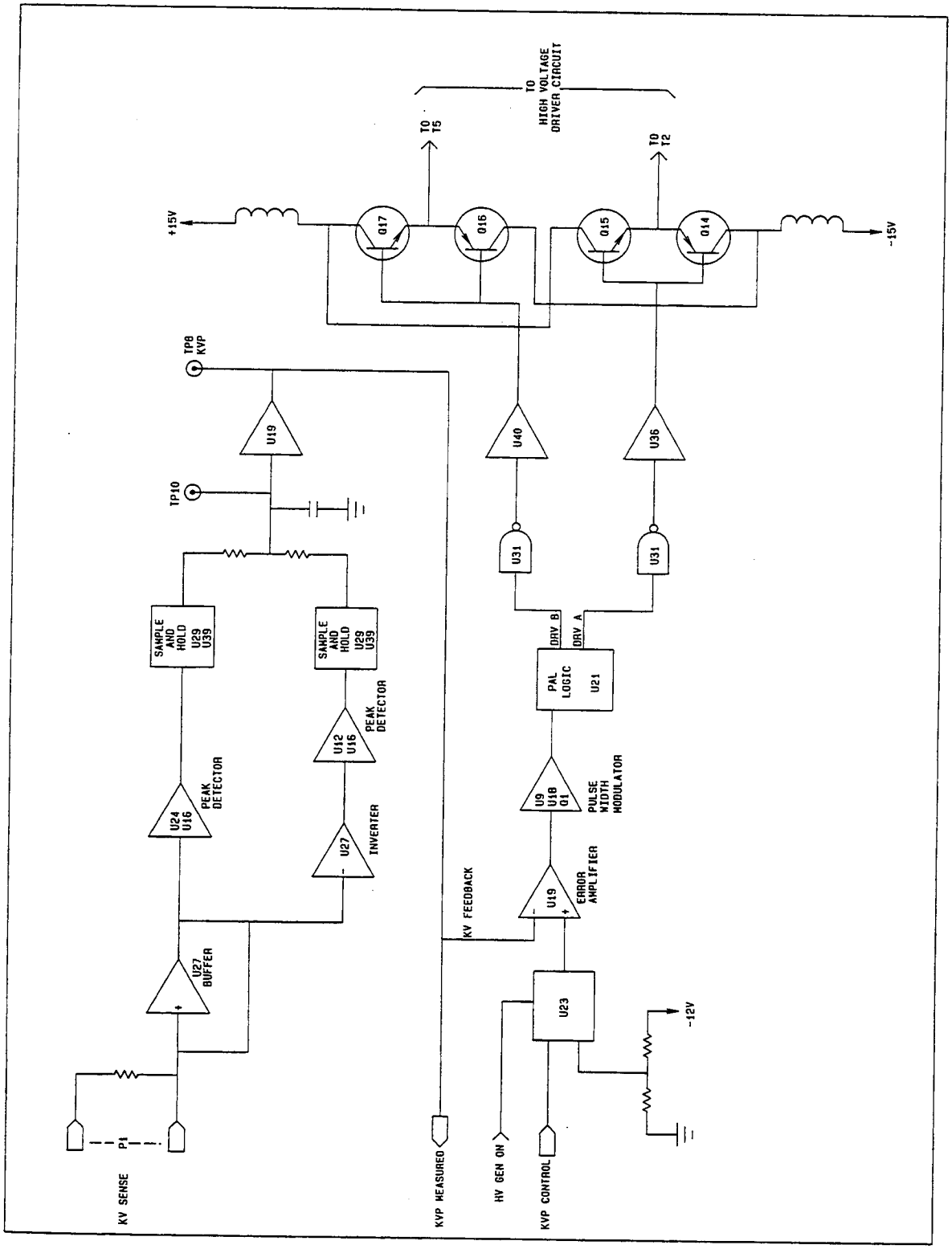


Figure 3-36 - *Secondary Tap Voltage Sense.*

Figure 3-37 - *Block diagram of the KVp regulation circuit.*



Overvoltage Protection Circuit

The SEC TAP V measurement is also used to test for an overvoltage fault, which if it occurs, disables the drives from PAL U32.

Comparator U3 senses an overvoltage fault condition which it signals on the OVERVOLTAGE line.

This line will then trip a latch in the fault detection PAL U32, resulting in loss of drive pulses at PAL U21 and hence loss of drive to the output stage. This can occur in as little as one drive cycle (400 microsecond) This latch must be reset by the processor in order to resume operation.

Calibration Issues

Refer to the section in this manual on *Calibration* for a discussion of the theory of 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.

Intermediate Driver Circuit

HV DRV A and HV DRV B are buffered by the inverting driver pair U31. More drive current amplification is provided by op amps U36 and U40.

After the driving op amps U36 and U40, a circuit has been added to protect the bridge circuit formed by transistors Q14, Q15, Q16, and Q17 on power-down. This transistor protection circuit is comprised of two 2N3906 transistors and associated 1N914 diodes.

Predrive Stage

Transistors Q14/Q15 and Q16/Q17 form a bridge circuit. Their emitters are coupled via C99 and C89 to transformers T5 and T2. 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.

High Voltage Drive Circuit

Refer to Figure 3-38.

T5 and T2 each have two secondary windings, individually fused, which drive the high power transistors Q1 and Q2

The main power transistors, Q1 and Q2, each containing two darlington pairs, 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, F3, F4, and F5 are located on the Generator Controller PCB in the secondary circuits of T2 and T5.

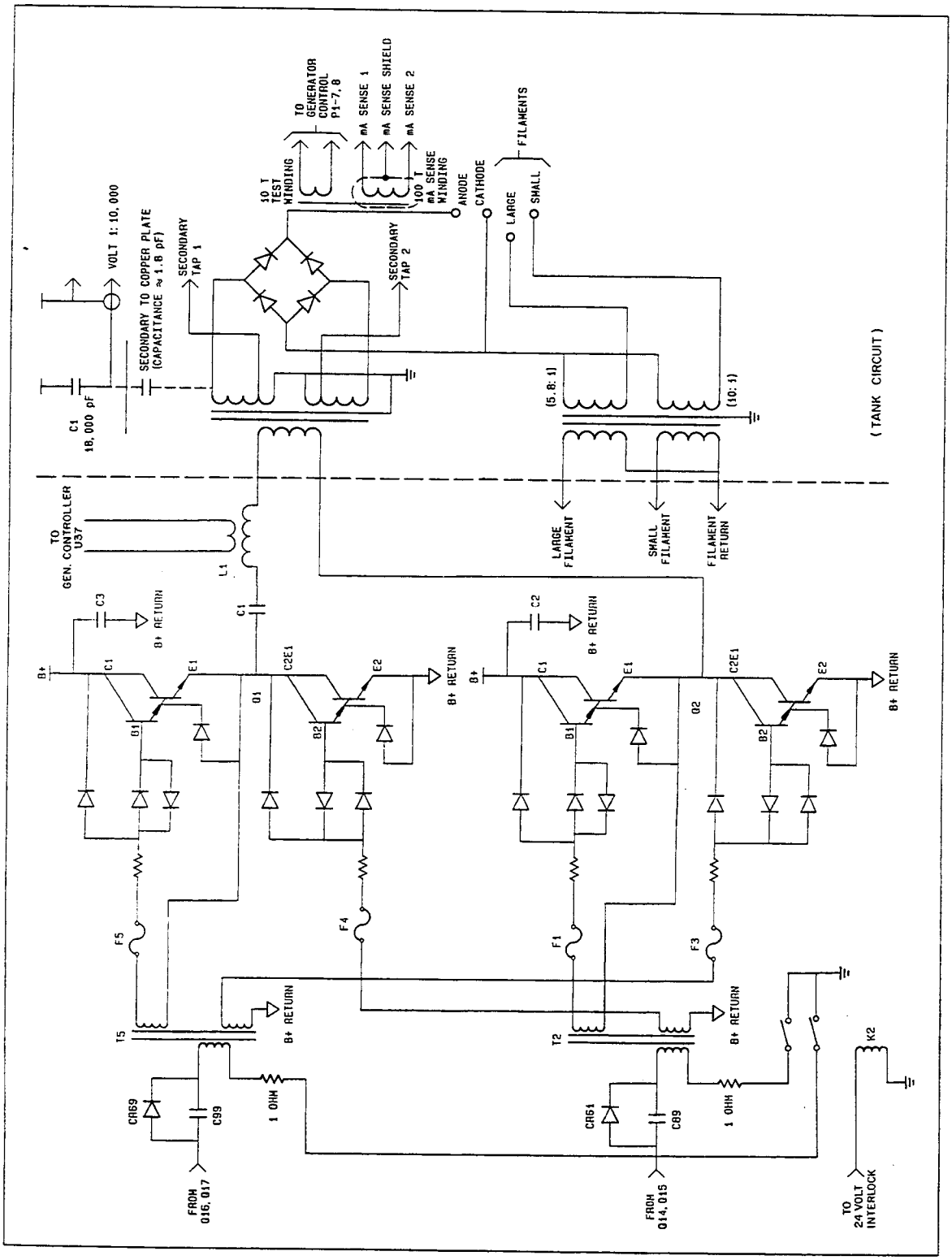
With the exception of the fuses and the baker clamping diodes, the high voltage driver circuit is constructed on the assembly below the Generator Controller PCB.

The large switching transistors Q1 and Q2 each contain two internally wired Darlington pairs. These form an H-bridge switching regulator. Baker clamp diodes are added externally to bias the darlington pairs for fast switching response.

The output legs of the H-bridge individually display ringing in the current waveforms. However when these are combined on the primary winding of the tank transformer, the ringing cancels out. C1 and L1 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 sinewave across the tank transformer primary.

Figure 3-38 - *Block diagram of the high voltage drive and tank circuits.*



3.12.6 High Voltage Circuit (Tank)

Refer to Figure 3-38. 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:

* Filament transformer with secondary windings for both filaments.
* High voltage transformer
* High voltage rectifier
* Capacitive voltage divider for voltage sensing with a divider ratio of 1:10,000 volts.
* 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.
* Secondary winding taps for voltage sensing.

Note: The Cathode connection is also the common filament return.

3.12.7 Battery Circuit

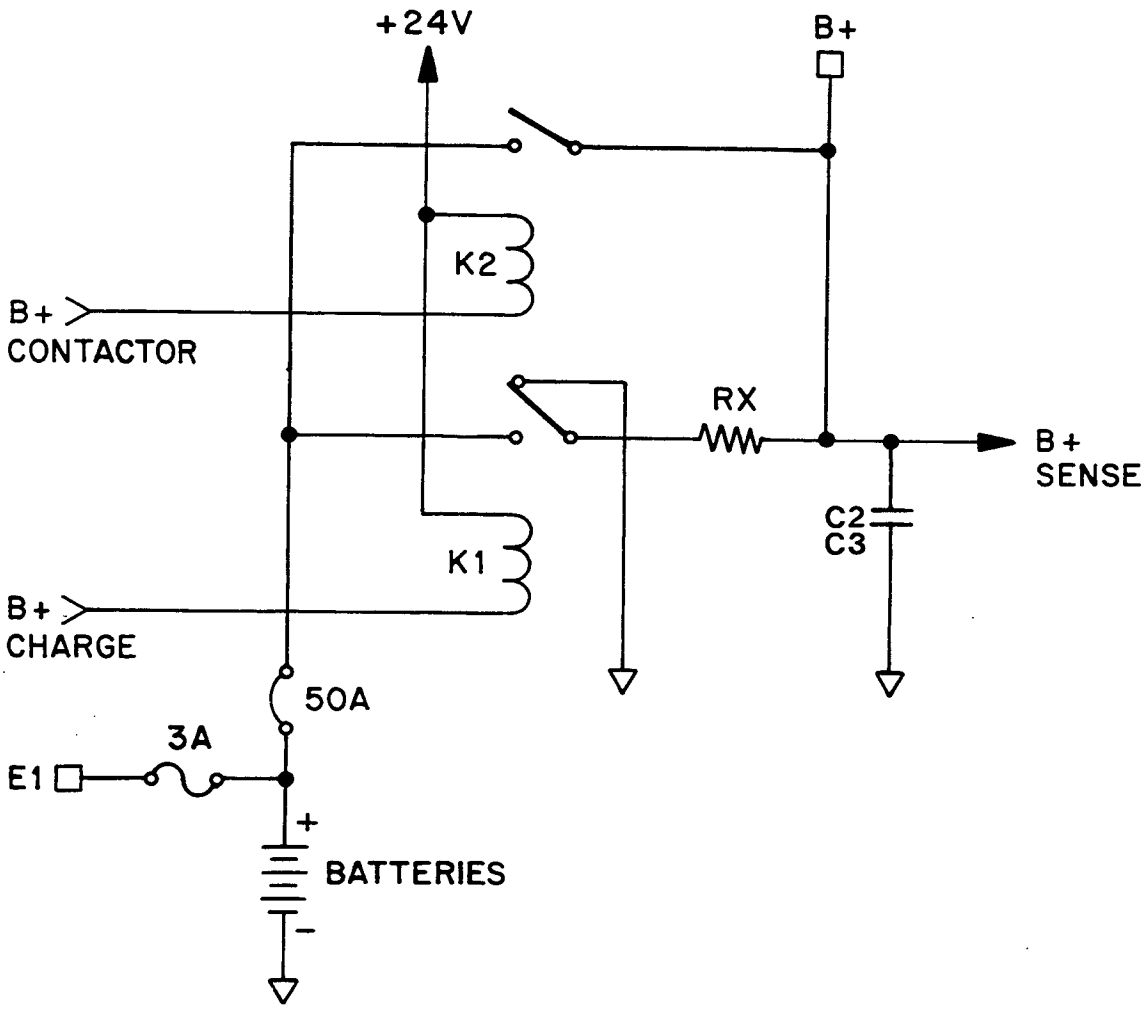
Refer to Figure 3-39. The battery circuit is comprised of:

* Six 30 volt battery packs
* Capacitor C4
* Charging resistor Rx
* 50 Amp contact closure fuse
* 3 Amp charger fuse
* B+ charge relay
* 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 200 VDC stack. This provides nearly 3.6 million watt-seconds of capacity, well beyond the tube rating. Each exposure draws from this energy source. The batteries are continuously recharged from the line at a 400 watt-second rate. 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, the batteries and the capacitor C4 provide energy for the X-ray shot.

Figure 3-39 - *Block diagram of the battery circuit.*



The charger circuit (E1) is connected through a 3 Amp fuse to the positive side of the battery pack. When K1, the B+ charge relay, is closed, the B+ voltage is applied through the 1 kOhm resistor Rx to charge the capacitor C4. C4 buffers the B+ line under rapidly varying current loads. After C4 has been precharged, the B+ CONTACTOR relay K2 is closed, finally connecting the battery, battery charger, and C4 all up to the B+ line, ready to supply 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

The 24 volt interlock line, the START switch, and the EMERGENCY OFF 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.

SECTION 6
MONITOR CART PARTS, DISASSEMBLY AND REPLACEMENT

The information in this section will help you identify, disassemble and replace parts on the monitor cart. Section 6.2 contains assembly and disassembly instructions. Section 6.3 provides an illustrated parts list.

6.1 Safety

It is very important that you read and understand the emergency and safety procedures described in the Safety Section of the service manual.

WARNING: **Circuits inside the equipment use voltages which are capable of causing serious injury or death from electrical shock. To avoid this hazard always unplug the AC power cable before opening, removing, or replacing equipment covers or doors.**

There are no procedures in this section of the manual which should be attempted by anyone other than a properly trained service technician.

6.2 Monitor Cart Assembly/Disassembly

6.2.1 Removing the Access Panels

Refer to Figures 6-1 through 6-3.

The electronics of the monitor cart are accessed by removing sectional panels and covers.

Generally, all these panels attach in the same manner: interlocking tabs are attached to the frame along one edge, and the panel is secured with screws along the opposite edge.

6.2.1.1. Front Panel Removal for Access to Card Rack

Refer to Figure 6-1.

1. Remove two screws from the bottom of the panel and tilt the bottom edge of the panel out slightly.
2. Lift up on the panel to clear the tabs along the top edge and remove the panel.

6.2.1.2 Right Front Panel Removal for Access to Monitor Power Supply

Refer to Figure 6-1.

1. Remove two screws from the bottom of the panel.
2. Lift the panel up slightly, and then off.

6.2.1.3 Rear Panel Removal

Refer to Figure 6-2.

Removing the rear panel allows access to the Isolation Transformer T1 and the rear of the card cage.

1. Remove the seven screws along the bottom and sides of the rear panel.
2. There are no locking tabs, the panel can be simply lifted off.

6.2.1.4 Left Side Panel Removal for Access to Disk Interface and Video Switching PCB'S

Refer to Figure 6-3.

1. Remove the front panel.
2. Remove the two screws inside the left front cart frame.
3. Slide the panel toward the rear of the cart about 1 inch to clear the tabs.
4. Lift off the side panel.

6.2.2 Replacing the Air Filter

1. Face the front of the monitor cart and locate the air filter underneath the cart cooling fans.
2. Pull the air filter straight out.
3. Replace the air filter when it has become dirty enough to impair the flow of air through the fans.

Figure 6-1 - *Monitor cart covers, front view.*

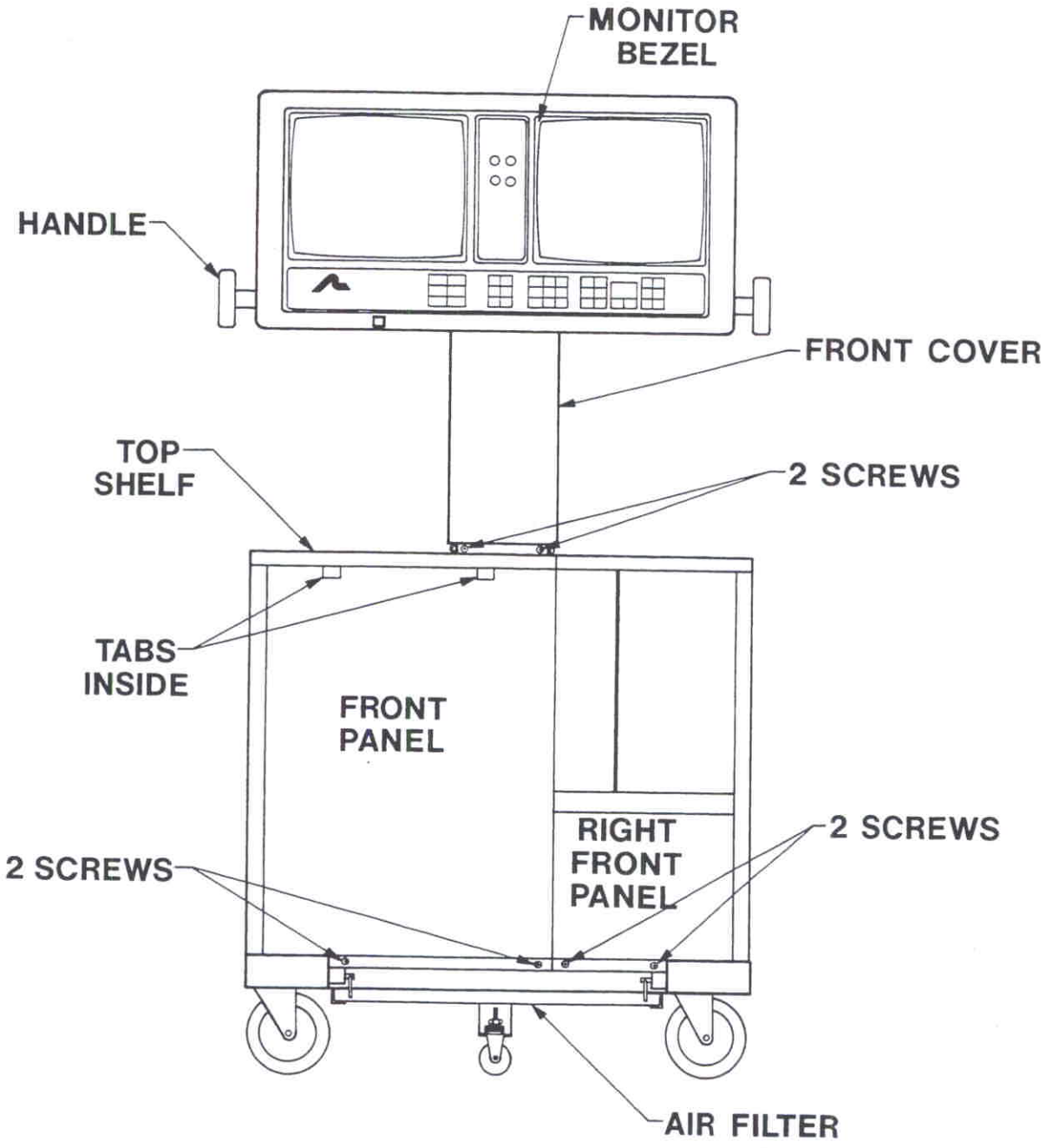


Figure 6-2 - *Monitor cart covers, rear view.*

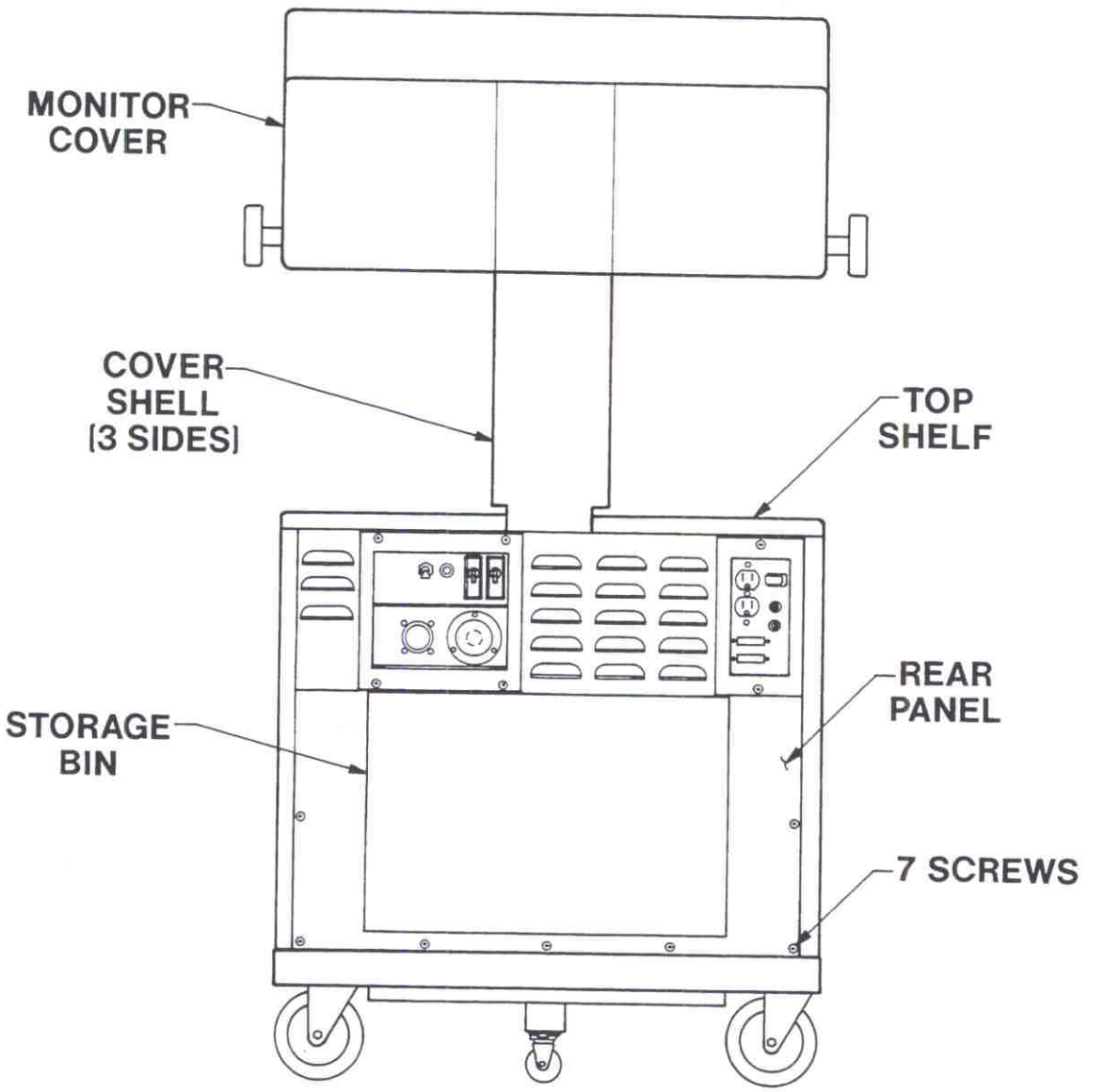
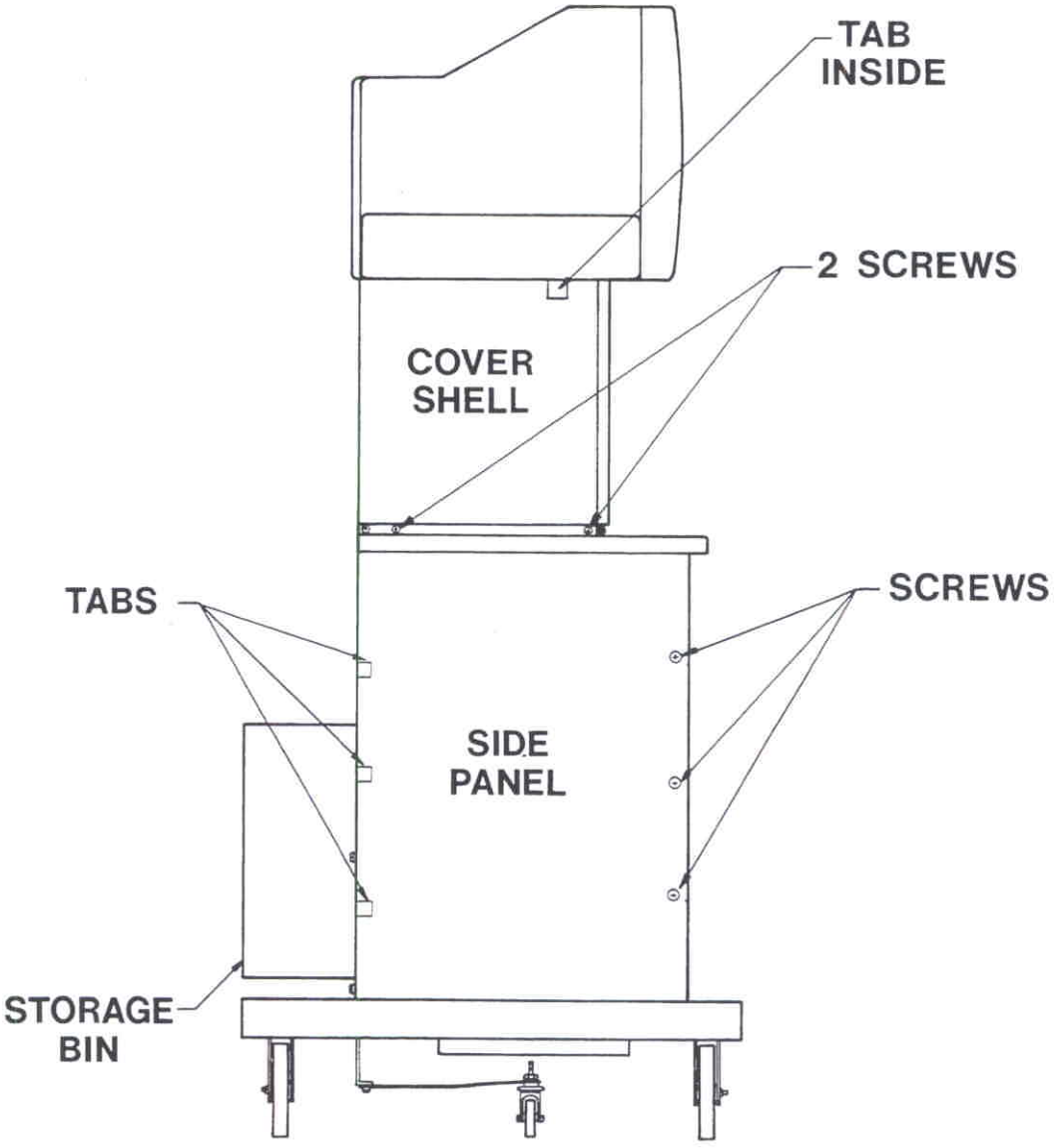


Figure 6-3 - *Monitor cart covers, side view.*



6.2.3 Removing the Monitor Covers

Refer to Figure 6-4.

1. Remove the four screws and grillwork from the bottom of each monitor.
2. Remove the two screws from the rear inside corners of the monitor cover.
3. Remove the two screws from the front inside corners of the monitor cover.
4. Lift the front edge of the cover up about 1/16 inch, to avoid trapping the cover tab on the monitor base.
5. Slide the cover back from the monitors and lift it away.

6.2.4 Removing the Monitors

Refer to Figures 6-5 and 6-6.

1. Remove the monitor cover as described in procedure 6.2.2 above.

WARNING: Observe the high voltage and implosion hazard warnings for handling CRTs.

2. Disconnect the brightness and contrast control connectors and the 2-pin Molex video connector going to the circuit board mounted on the monitor.
3. Disconnect the 3-pin Molex power connector.
4. Remove the nylon tie wraps as needed to free the disconnected wiring from the monitor frame.
5. Remove 3 screws on each side of the monitor base (6 screws total).
6. Carefully remove the monitor.
7. When replacing a monitor make sure that the front of the tube is firmly seated forward against the bezel. The monitor can be positioned with the screws on the monitor base brackets.

Figure 6-4 - *The attachment points for the monitor cover and grillwork are shown in this photo. With the grillwork removed, the Front Panel Processor PCB and the Remote Contrast/Brightness PCB are visible on their mounting plates.*

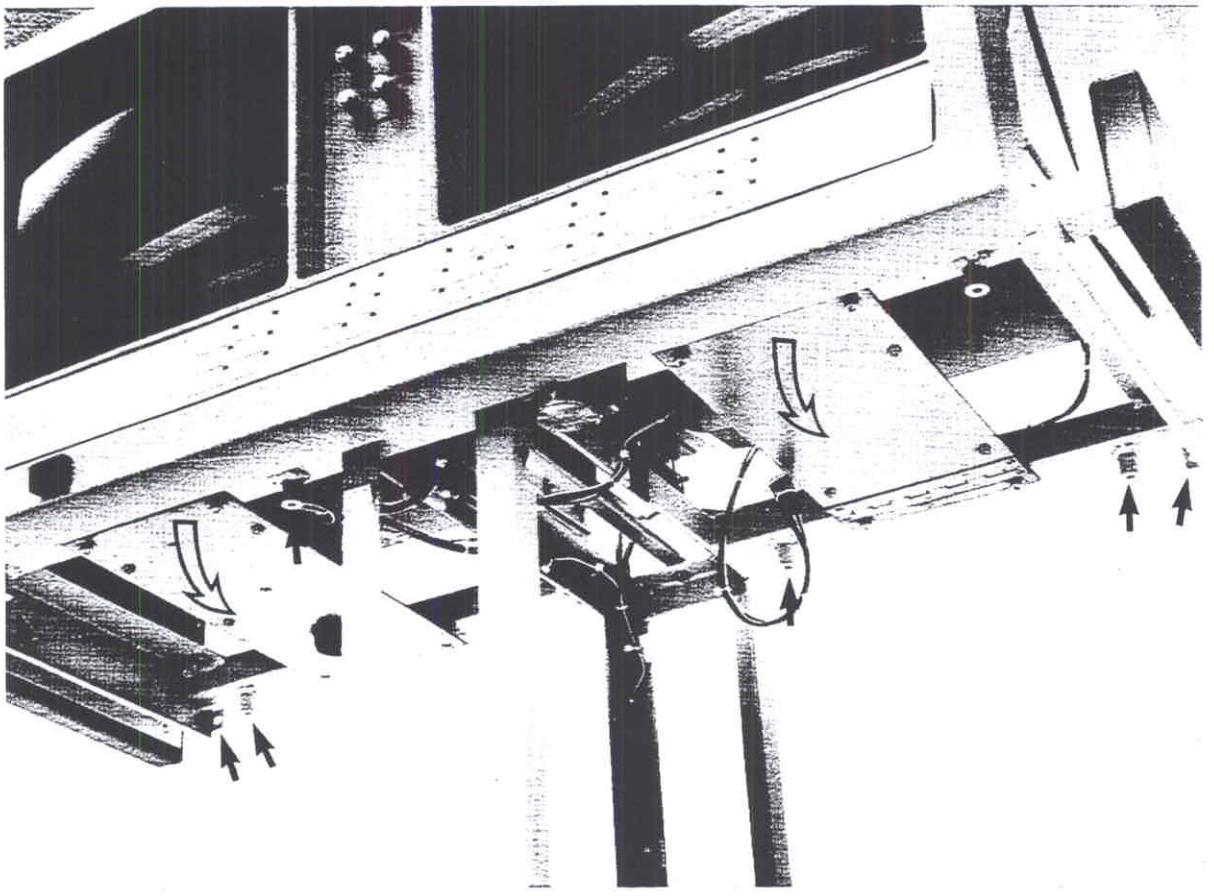


Figure 6-5 - *Remove the six screws holding each monitor as indicated in these photos.*

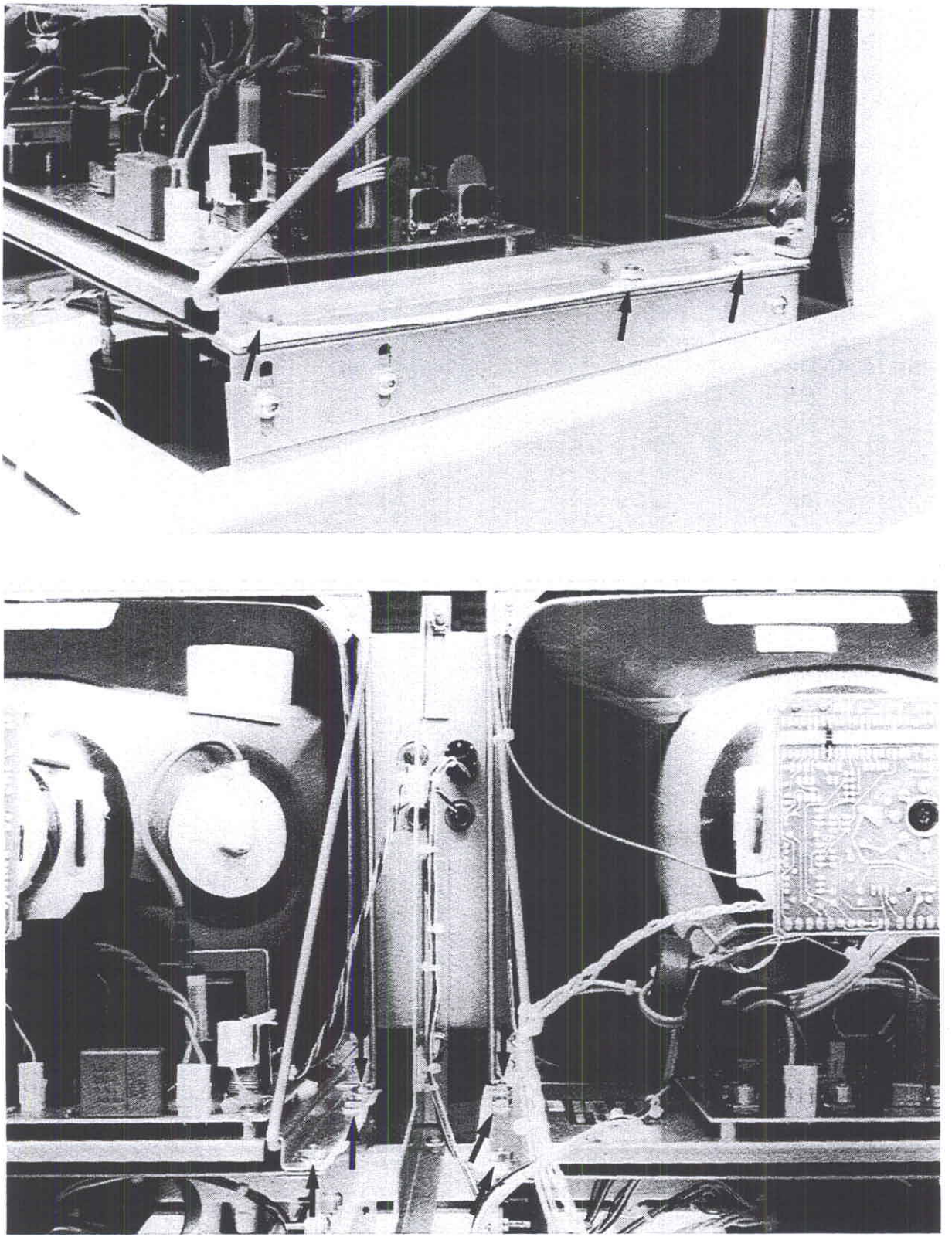
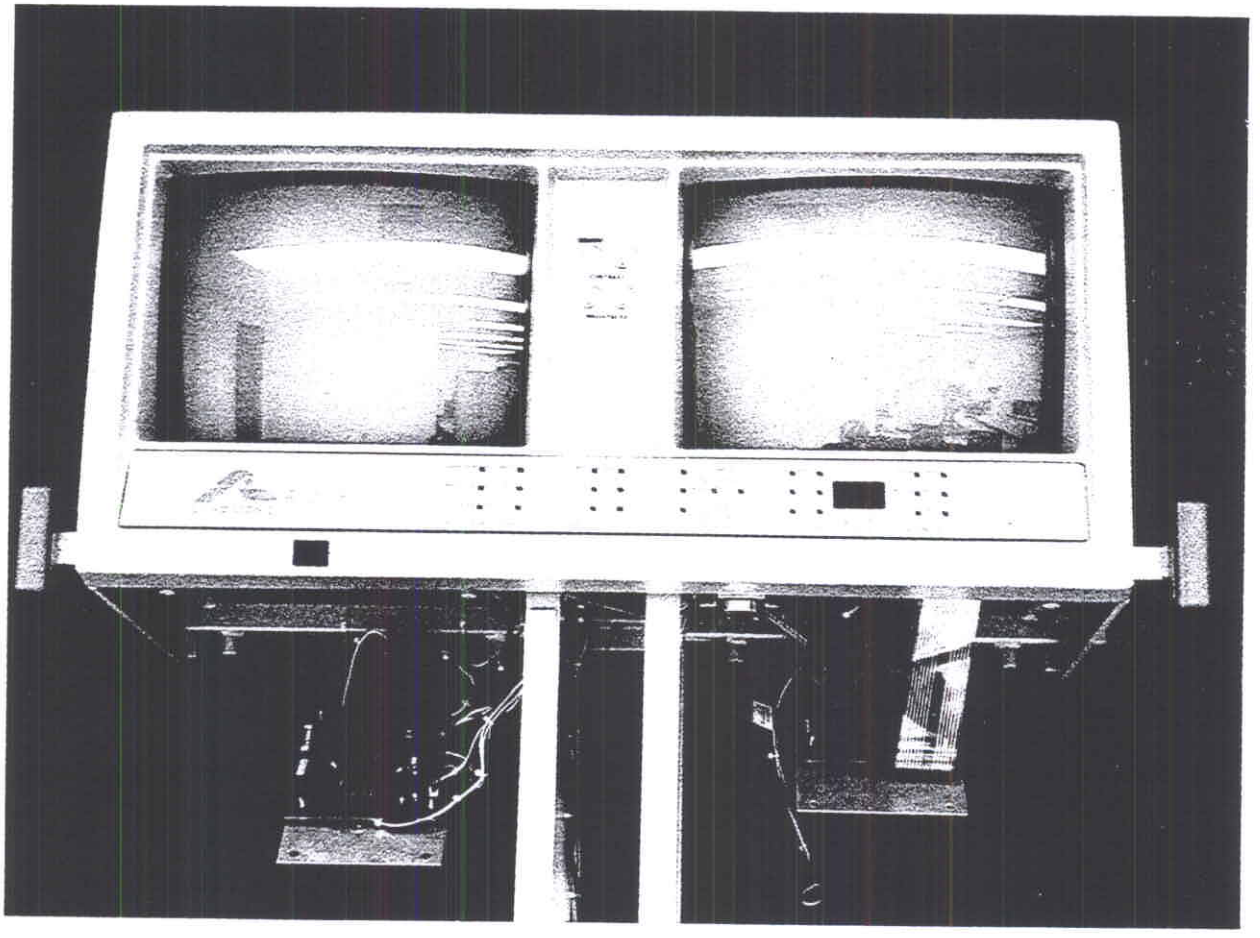


Figure 6-6 - *The panels below each monitor drop down to expose the Front Panel Processor PCB and the Remote Contrast/Brightness Control PCB.*

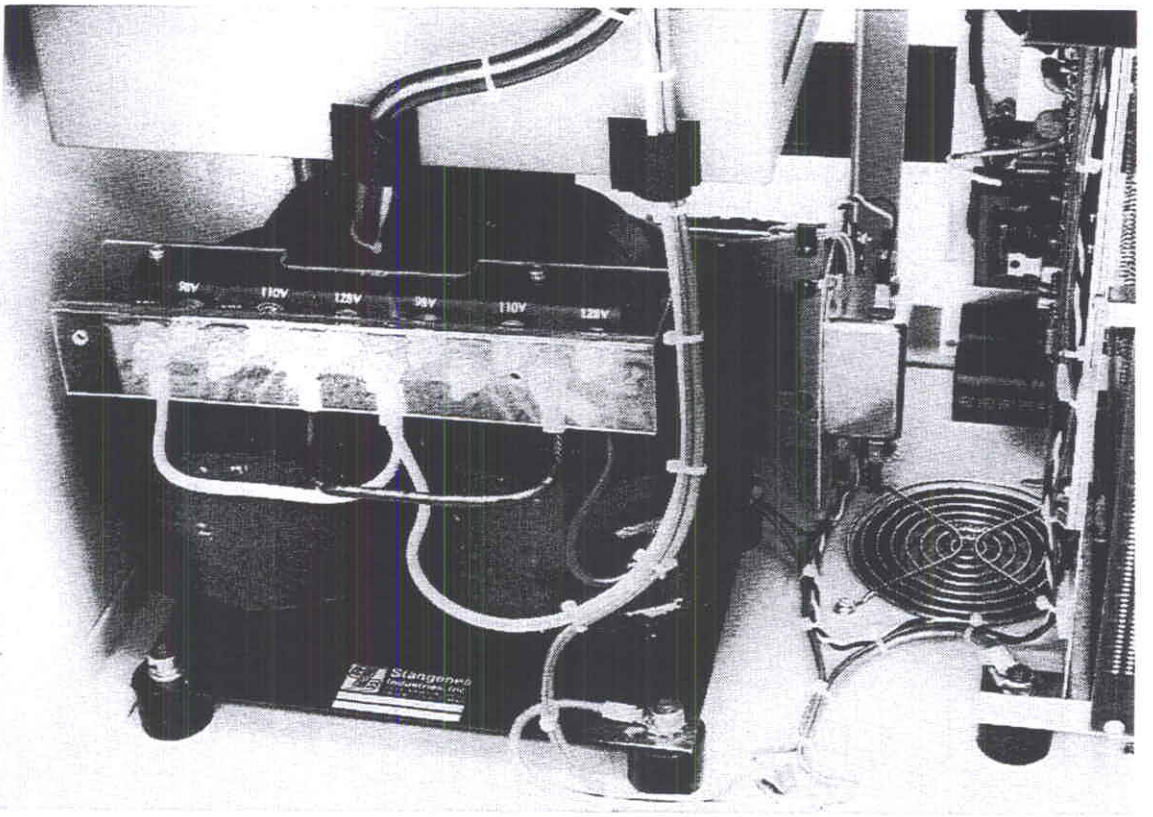


6.2.5 Removing the Isolation Transformer

Refer to Figure 6-7.

1. Unplug the main power cable from the wall outlet.
2. Remove the rear access panel.
3. Label all wires before removing them from the transformer. Disconnect the wires from the isolation transformer terminals.
4. Remove the four nuts securing the transformer to the shock mounts in the base of the cart.
5. Lift the transformer off the shock mounts and out of the cart. The transformer is heavy - lift it carefully.

Figure 6-7 - *Removing the isolation transformer.*



6.2.6 Access to the Front Panel Processor PCB

Refer to Figure 6-6.

1. Remove the grillwork below the right monitor.
2. Locate the Front Panel Processor PCB on the hinged panel under the monitor. Remove the 2 screws and swing the panel and PCB assembly down on its hinge.
3. Use care not to strain the cables and their connectors which are plugged into the PCB.

6.2.7 Access to the Remote Contrast/Brightness PCB

Refer to Figure 6-6.

1. Remove the grillwork below the left monitor.
2. Locate the PCB on the hinged panel below the monitor. Remove the two screws and swing the panel down on its hinge.
3. Use care not to strain the cables and their connectors which are plugged into the PCB.

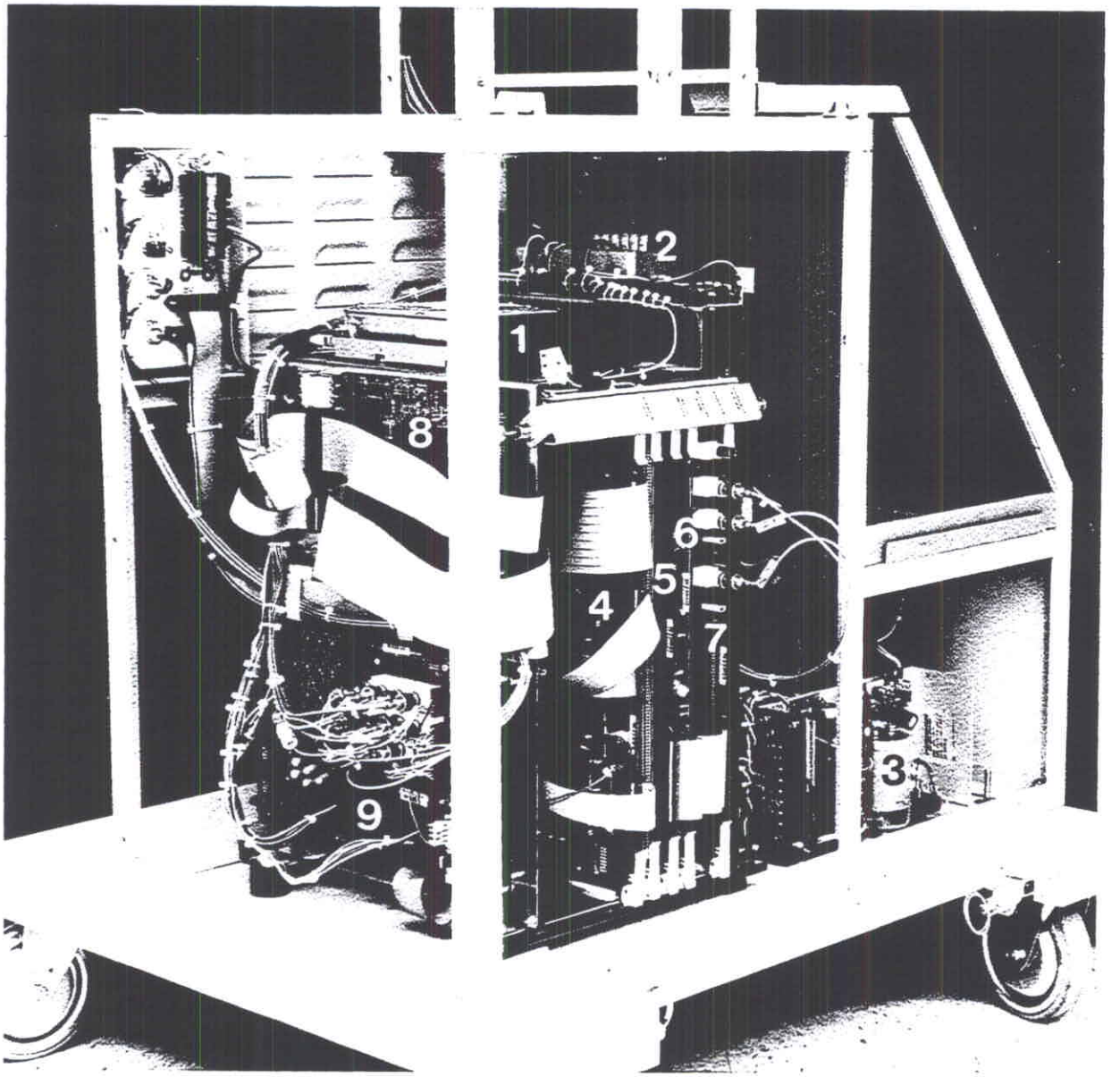
6.2.8 Removing the Card Rack Power Supply

Refer to Figure 6-8.

1. Remove all wiring from their push on connections at the terminal strip on the bottom of the power supply.
2. Remove the circuit boards from the card rack.
3. Reach inside the card rack and remove the 2 screws securing the lower end of the power supply.
4. Remove the screws securing the hard disk drive on the top of the card rack and shift it to the side to access the two screws holding the top of the power supply. It is not necessary to disconnect the cables to the disk drive.

Figure 6-8 - *The components in the base of the monitor cart are identified in this photo.*

1- Hard disk, 2- card rack power supply, 3- monitor power supply, 4- Disk Interface PCB, 5- Pipeline Filter PCB, 6-Image Processor PCB, 7- AD/DA PCB, 8- Disk Controller PCB, 9- IO Distribution/ Video Switch PCB



6.2.9 Removing the Hard Disk Drive

Refer to Figure 6-8.

1. Disconnect the two ribbon cables and the power cable connection to the hard disk drive.

   (Note that different drives may be mounted with the connectors to the front or the rear). *If the connectors are inaccessible, then perform the following removal steps 2 and 3 and then turn the drive to access the connectors.*

2. Remove the circuit boards from the card rack.

3. Reach up from inside the card rack and remove the four screws securing the Hard Disk Drive to the top of the rack.

4. Remove the drive.

6.2.10 Removing PCBs From the Card Rack

Refer to Figure 6-8.

1. Remove the front access panel.

2. Loosen the knurled screws at each end of the retaining bar, and swing it up on its hinge.

3. Remove the ribbon cables from their their front edge connections. Be sure they are adequately labeled for later reconnection.

4. Pull out on the card ejectors to disengage the PCBs from their rear edge connectors on the motherboard.

6.2.11 Installing PCBs in the Card Rack

Refer to Figure 6-8.

The PCBs which slide into the card rack slots are from left to right:

Disk Controller PCB
Extender Board
Pipeline Filter PCB
Image Processor PCB
AD/DA PCB

1. Make sure that the rear edge connectors are clean and bright. Clean with a soft eraser and a cloth with solvent.

2. Line up each PCB with the top and bottom card edge guides and slide the cards into the rack until the rear edge connectors engage the motherboard.

3. Press firmly on the card ejectors until the PCB is fully seated in both rear edge connectors on the motherboard.

4. Reconnect all ribbon cables. Be sure that pin 1 of each ribbon cable connector matches up with pin 1 of each PCB connector.

   Connect the short, multiconnector daisy-chain cable to the P-3 connectors of the Image Processor, Pipeline Filter, and AD/DA PCBs.

   Attach the ribbon cables to P-9, P-10, P-11 and P-12 on the Disk Interface PCB.

   Attach the coaxial cables to J-5, J-6 and J-8 on the AD/DA PCB.

5. Swing down the PCB retaining bar and lock it in place by tightening the knurled screws.

6.2.12 Removal of the I/O Distribution-Video Switching PCB

Refer to Figure 6-8 and Figure 6-9.

The I/O Distribution-Video Switching PCB is mounted on standoffs attached to the left side of the card rack.

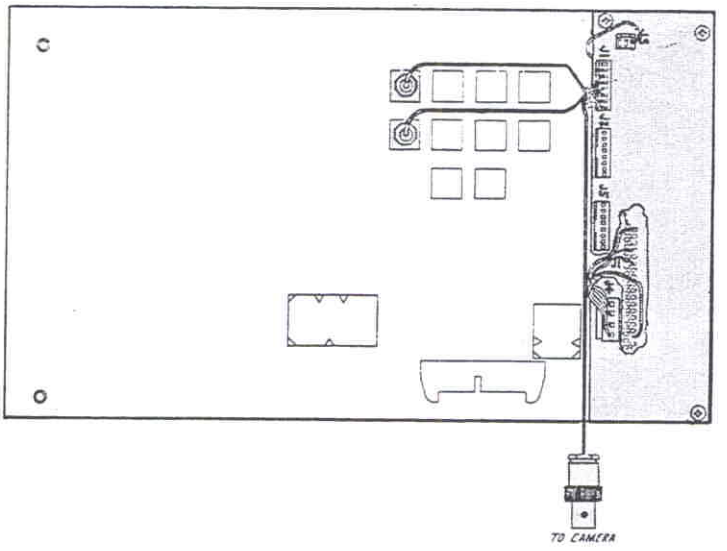
1. Remove the front and the left side access panels.

2. Remove the PCBs from the card rack as required to reach the screws which secure the I/O Distribution-Video Switching PCB standoffs.

3. Disconnect all BNC, ribbon, and power cables from the PCB. *Refer to Figure 6-9 for connector replacement.*

4. Remove the screws securing the PCB standoffs to the card rack and remove the PCB.

Figure 6-9 - *I/O Distribution Video Switch PCB connections are shown below; detail on right shows connections to the Sync Separator PCB*



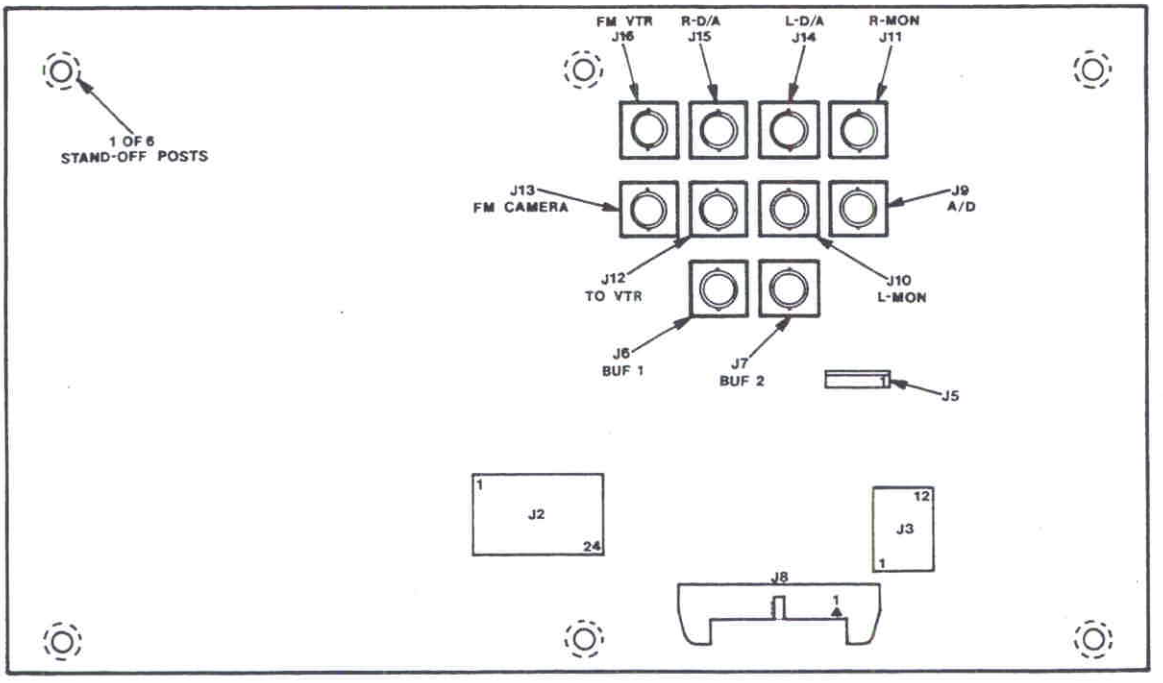
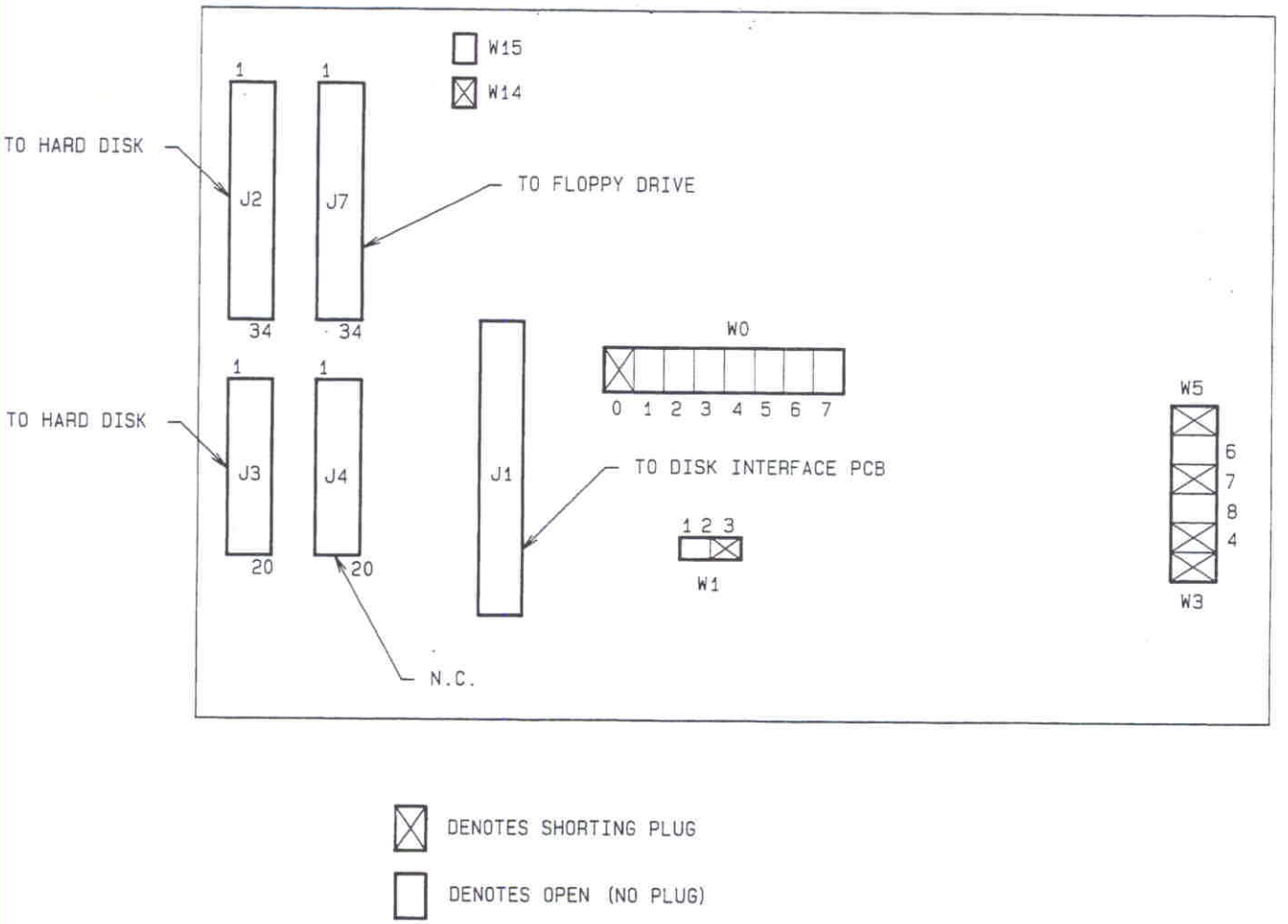


Figure 6-10 - *The connector placement on the Disk Controller PCB is shown in this drawing.*



6.2.13 Sync Separator (AngioStor Interface) PCB

Refer to Schematic 00-870543, and Figures 6-8 and 6-9.

On systems equiped with the AngioStor Disk Recorder, an interface PCB is mounted piggyback on the I/O Distribution PCB. The connections between the Interface PCB and the I/O Video Switch PCB are as follows:

I/O Dist Video Switch PCB	AngioStor Interface PCB
J1-19	J3-1
J1-21	J4-1
J1-34	J4-2
J1-32	J4-3
J1-37	J4-4
J16	J1-3, J1-4
J-13	J1-5, J1-6

6.2.14 Removal of the Disk Controller PCB

Refer to Figure 6-10.

1. Remove the left side panel to access the PCB.
2. Disconnect all connections to the PCB. *Refer to Figure 6-10 for connector placement.*
3. Remove the 4 sets of screws and insulating washers. Each screw is insulated from the PCB with nylon washers on both sides of the board. *When the board is reinstalled be sure that these insulating washers are in place.*

6.3 Illustrated Parts List

The major replacable assemblies are illustrated on the following pages.

Part numbers are subject to change. Contact Technical Support for assistance with part interchangeability.

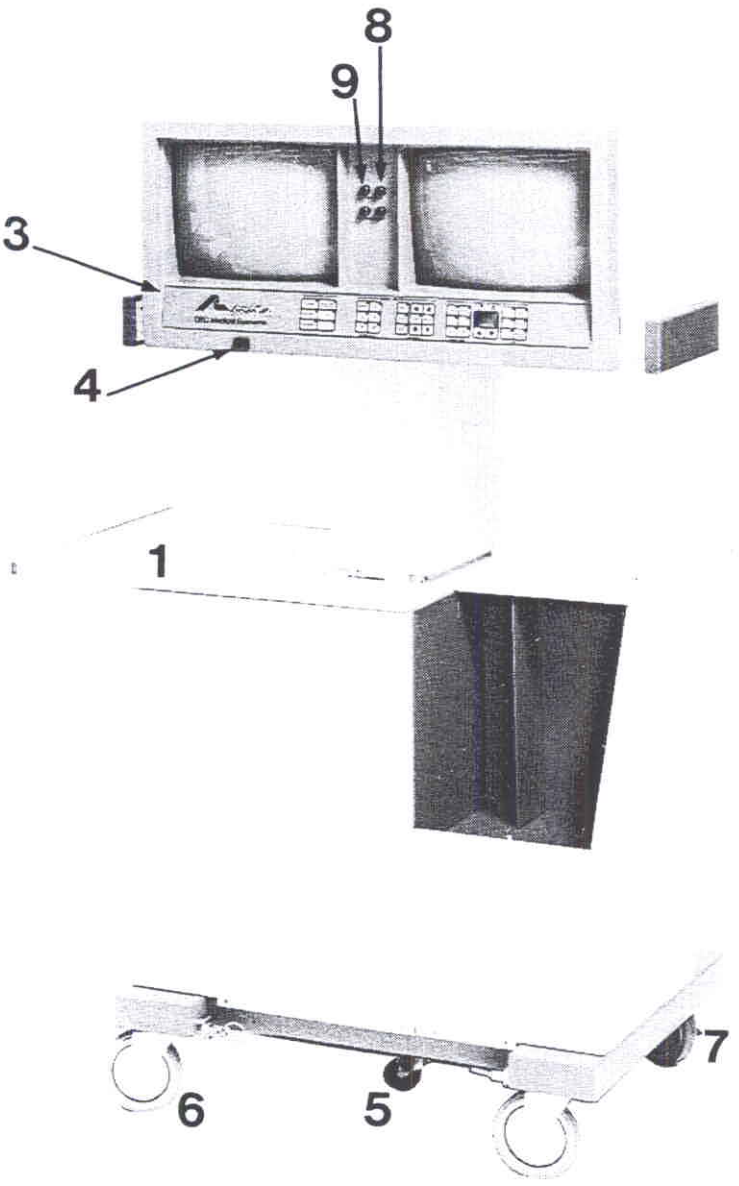
Fig. 1 Monitor Cart

1.	shelf, accessory, monitor cart	00-870523
2. *	shelf, accessory, RH, monitor cart	00-870541
3.	front panel assembly	00-870398
	membrane switch panel sub-asm	00-870397
	LED PCB display	00-870394
	display, 7-segment LED	67-480626
	lamp, red LED, MV5753	67-499845
4.	indicator, rectangular	71-229509
	cap, lens, red	00-870739
	lamp, 6.3VDC	71-229506
5.	conductive caster asm	00-860092
6.	casters, front	10-08-390
7.	casters, rear w/ brakes	10-08-391
8.	knobs 1/8-inch shaft	23-519934
9.	knobs 1/4-inch shaft (remote)	23-519931

Overall View

* Item 2 is not shown in this photo.

Monitor Cart



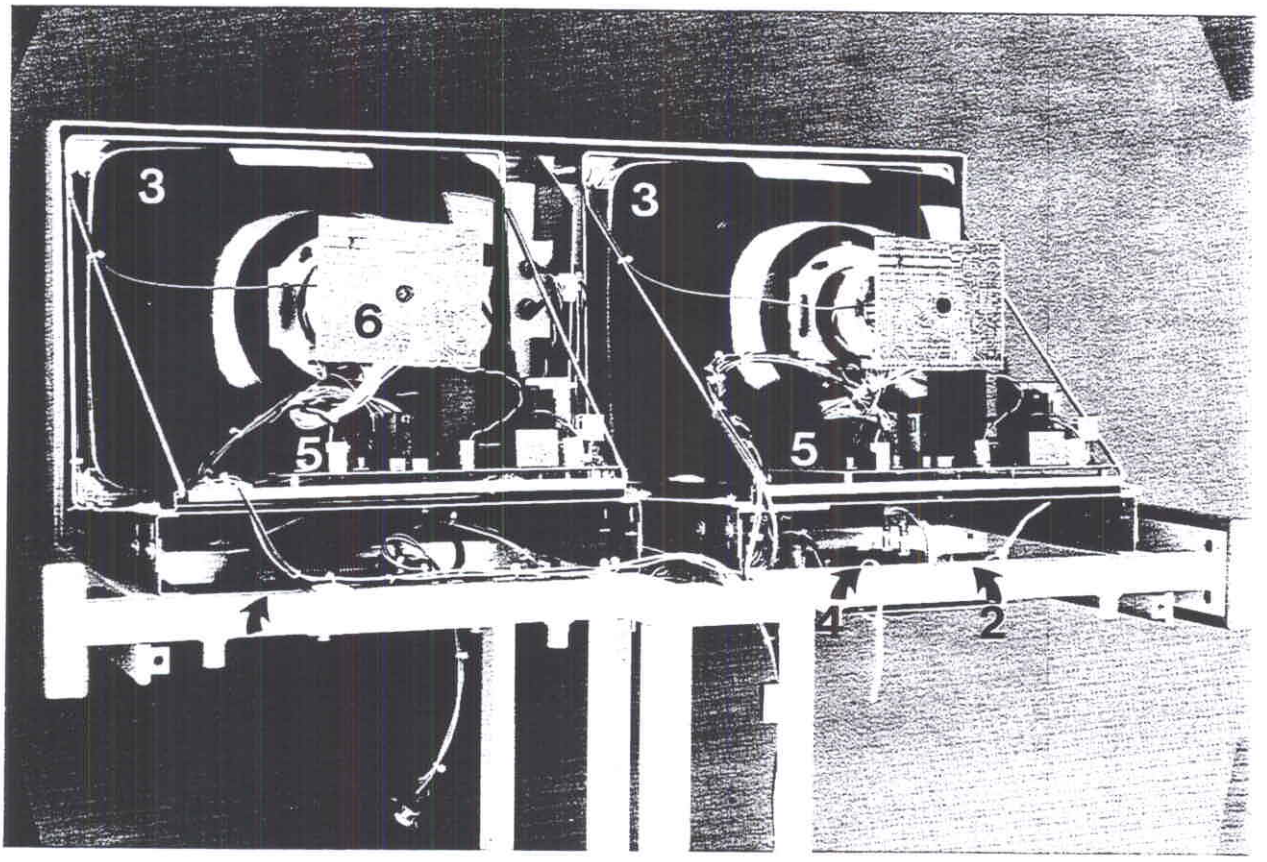
Overall View **Fig. 1**

Fig. 2 Monitor Cart

1.	Front Panel Processor PCB	00-870509
2.	Remote Contrast Brightness Control PCB	00-870930
3.	TV monitor	00-860364
4.	audio alarm	76-829967
5.	Dataray Video Procesor PCB	00-900036
6.	Dataray Deflection PCB	00-900035

Rear Exposed Monitor View

Monitor Cart



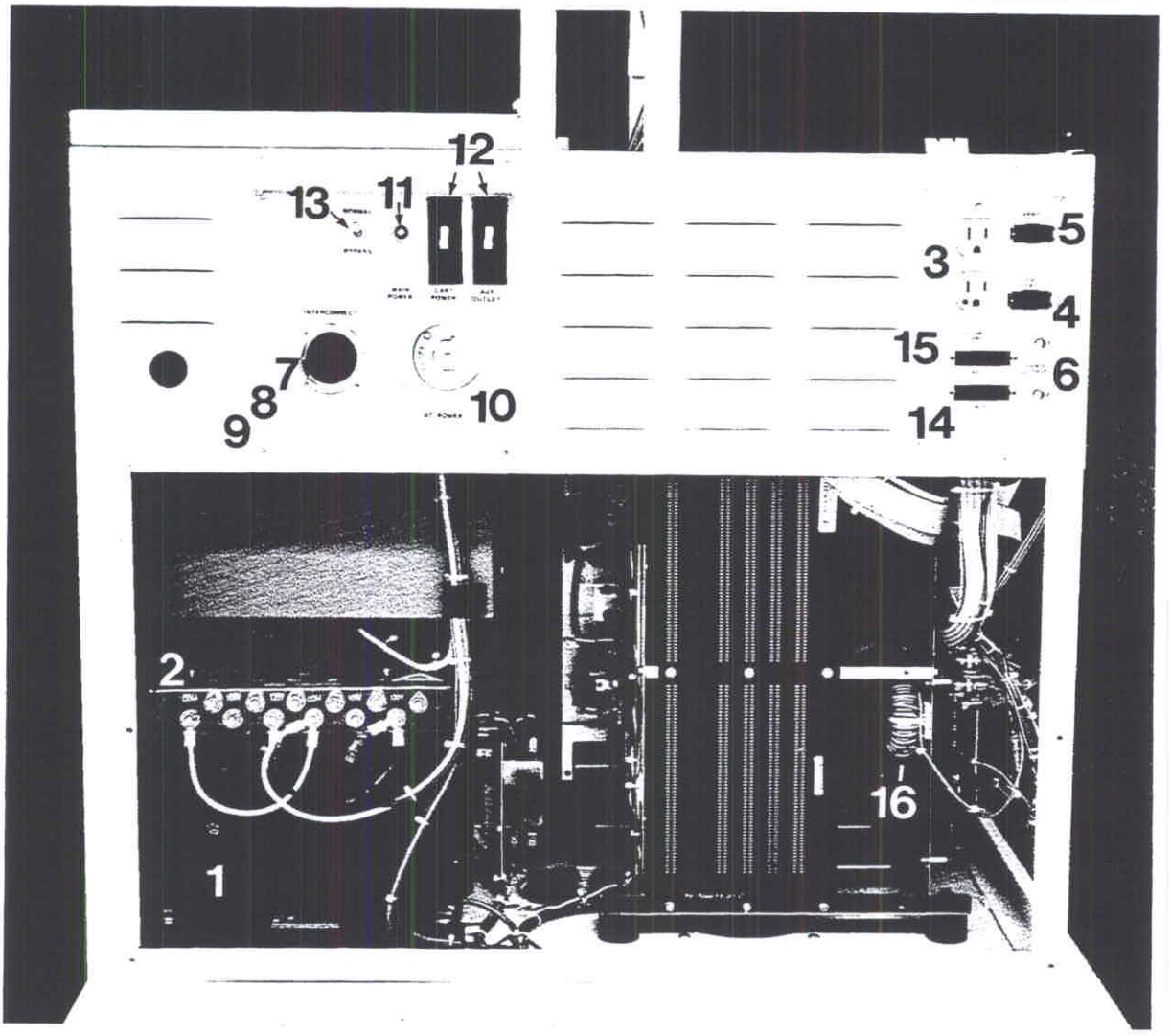
Rear Exposed Monitor View **Fig. 2**

Fig. 3 Monitor Cart

1.	isolation transformer	00-860736
2.	transformer terminal cover	00-870136
3.	duplex outlet, 3-wire	51-433989
4.	connector jack, 8-pin VTR	00-900047
5.	connector jack, 8-pin AngioStor	00-900047
6.	connector jack, BNC	58-018941
7.	connector, receptacle, circ	52-998346
8.	contact pin	52-998300
9.	bracket, retainer, interconnect cable	00-871331
10.	connector, inlet, 3-pin M	51-332981
11.	ckt breaker, 10 A	55-700448
12.	ckt breaker, 5A	55-700032
13.	toggle switch, DPDT	71-149970
14.	cable asm, AUX	00-870117
15.	cable asm, RS232	00-870118
16.	video balun	00-870370

Rear Lower View

Monitor Cart



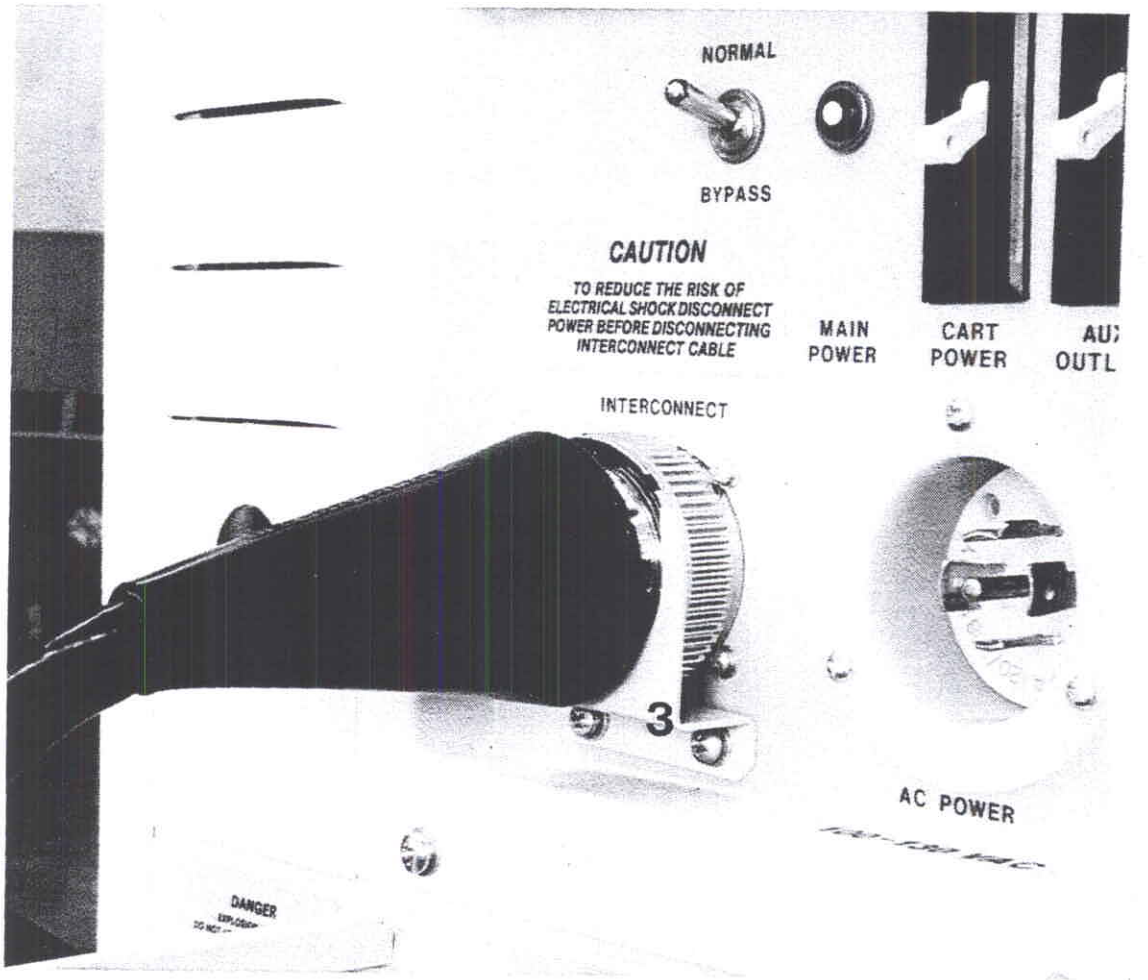
Rear Lower View

Fig. 3

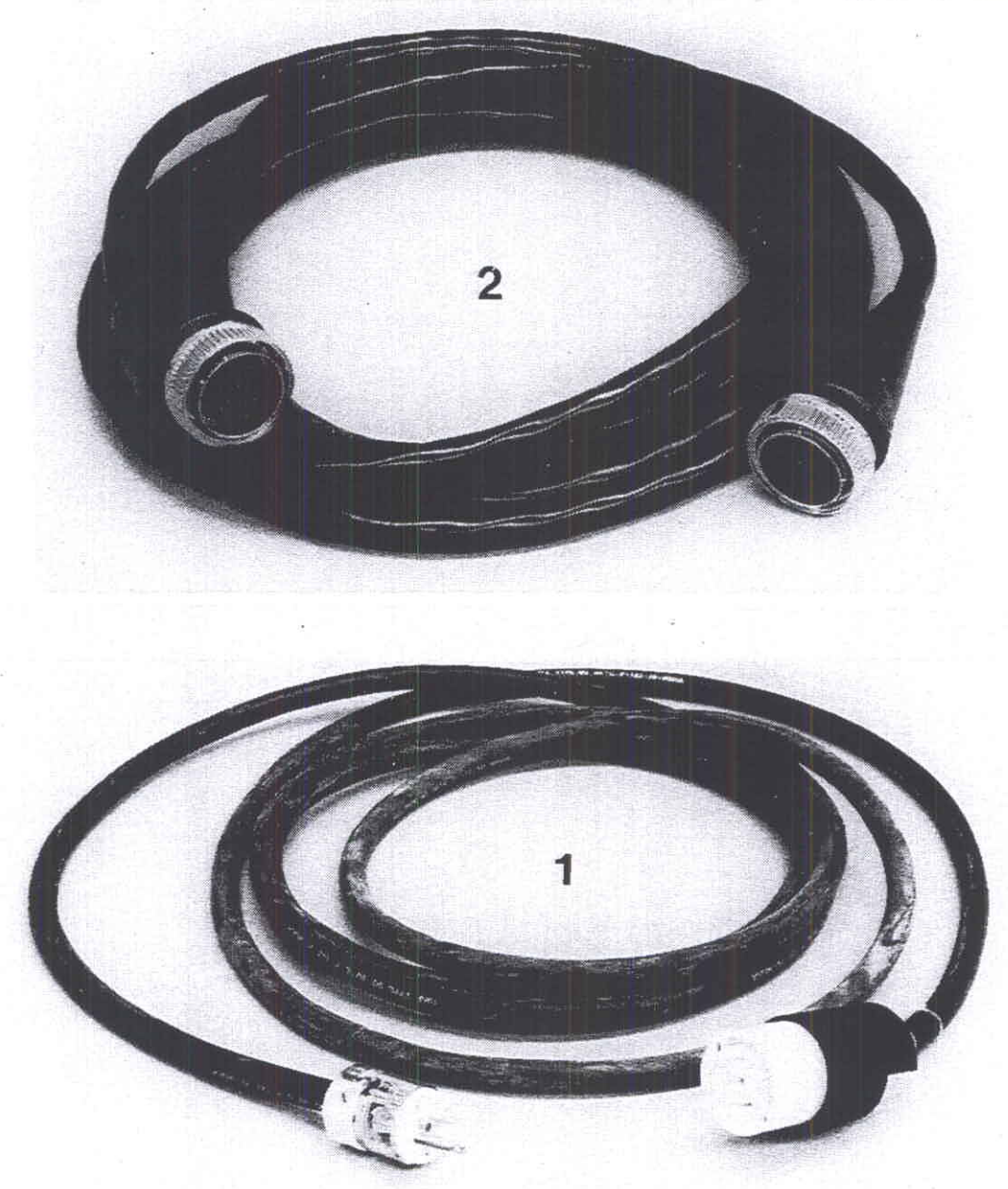
Fig. 4 a, b, c Power and Interconnect Cables

1.	asm, power cable	00-871369
2.	asm, interconnect cable	00-900101
3.	bracket, retainer, interconnect cable	00-871331

Fig. 4a



Monitor Cart



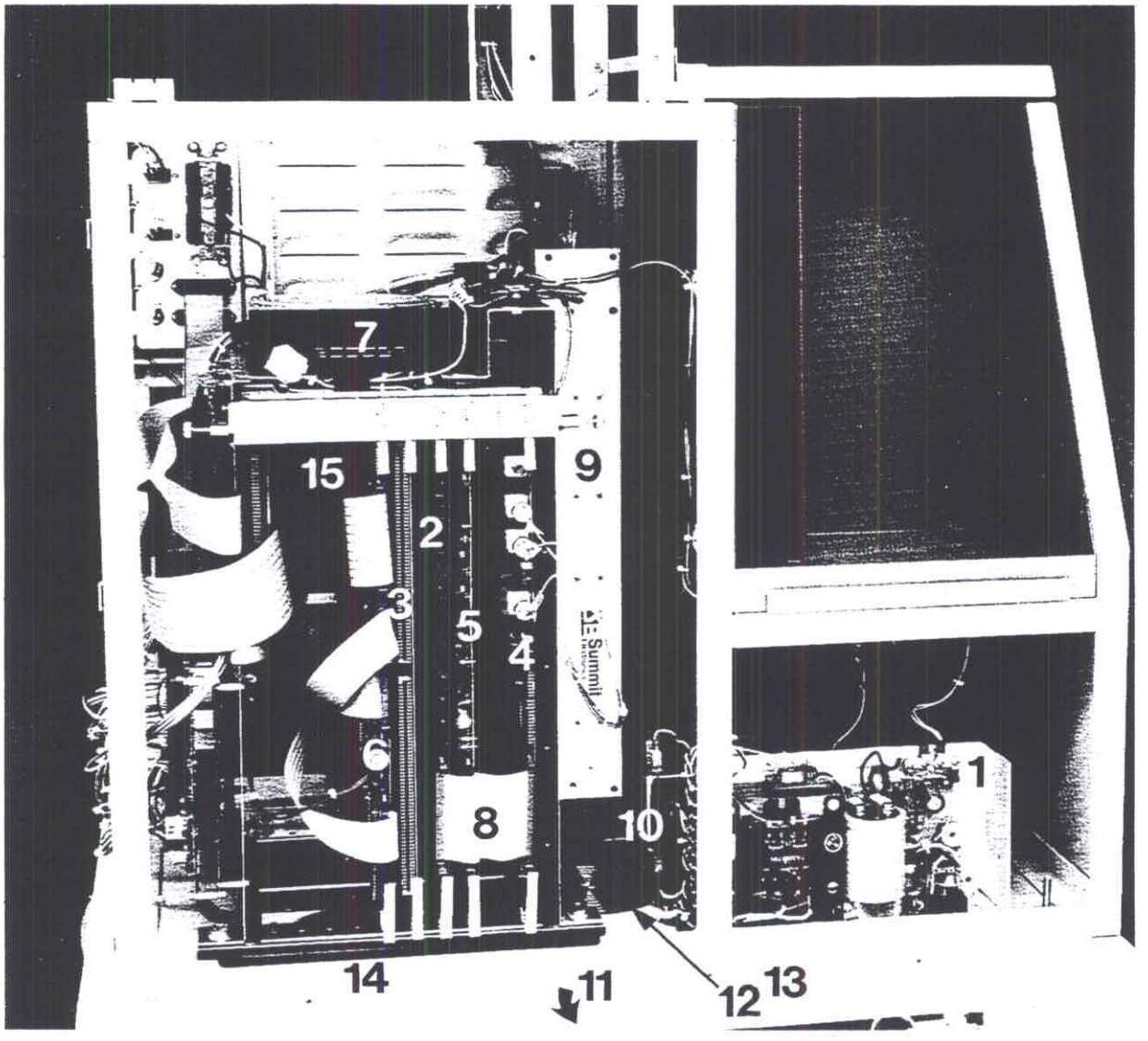
Power and Interconnect Cables **Fig. 4b, c**

Fig. 5 Monitor Cart

1.	24 Volt power supply	00-870285
2.	pipeline filter PCB	00-870503
3.	extender pcb	00-860893
4.	AD/DA converter pcb	00-860898
5.	image processor PCB	00-870390
6.	disk interface PCB	00-870015
7.	disk drive, winchester, 1/2 height	00-900077
8.	daisy chain cable	00-870556
9.	power supply, 5 VDC	00-870065
10.	filter, pwr line, 10 A	43-399887
11.	air filter asm	00-870386
12.	finger guard	20-839926
13.	fan, 4" axial	20-839955
14.	card guides	22-319805
15.	disk controller adapter PCA	00-900075

Lower Electronics, Front View

Monitor Cart



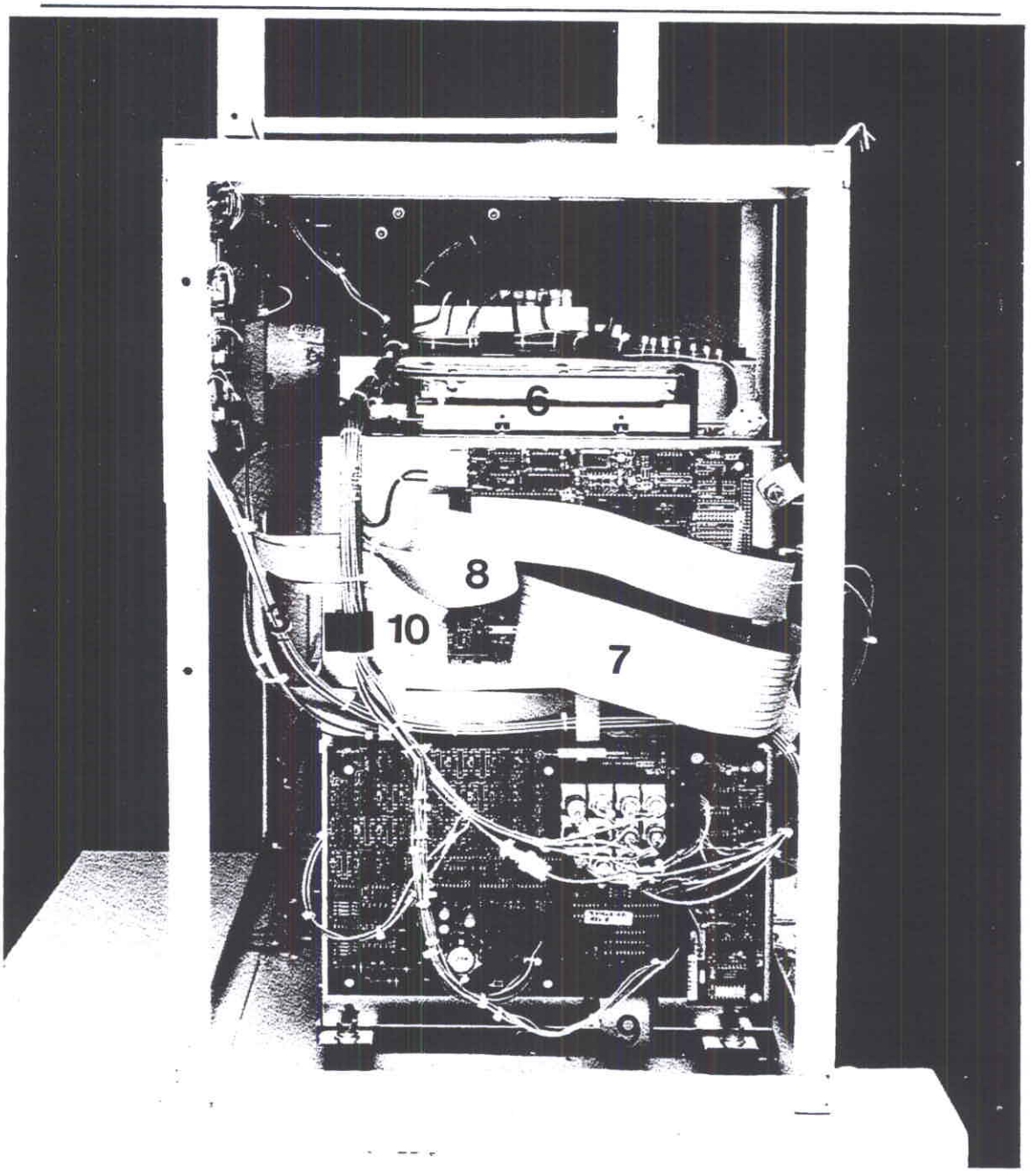
Lower Electronics, Front View **Fig. 5**

Fig. 6 Monitor Cart

1.	OMTI disk controller PCA	00-900079
2.	cable asm, AUX	00-870117
3.	cable asm, RS232	00-870118
4.	asm, PCB, I/O DIST/VIDEO SW	00-870187
5.	sync-separator PBC	00-870545
6.	disk drive, winchester, 1/2 height	00-900077
7.	cable asm, 50 pin ribbon	00-870024
8.	cable asm, disk control	00-870121
9.	cable asm, image processor interface	00-870119
10.	cable asm, disk data	00-870120

Lower Electronics, Side View

Monitor Cart



Lower Electronics, Side View **Fig. 6**

SECTION 8
MONITOR CART
SERVICE AND DIAGNOSTICS

8.1 Safety Precautions During Service

Read the Safety section of this manual before attempting any service procedures which require removal of the electronics covers.

WARNING **Use extreme care if you must perform adjustments or tests on the electronics when power is applied.**

8.2 Monitor Cart Progress and Error Codes

The alphanumeric display on the monitor cart front panel will display error codes when faults occur with the monitor cart electronics. These are listed and described below.

8.2.1 Boot Progress Codes

During the software loading or boot process, the alphanumeric LEDs on the front panel will display "b" codes, indicating where in the boot sequence, code is being executed. Since these codes do not normally indicate an error, they are referred to as *progress codes*. Typically, these codes will be erased once normal program operation has begun. If the program does not complete the boot process, a "b" code will remain on the LED display, indicating the point where an error occurred. The meaning of each "b" code is described below.

b0 - Initial start from address 0000H.
b1 - Attempting to load from floppy disc drive
(may be connected during service or software installation).
b2 - Attempting load from hard drive.
b3 - Boot load failed.
b4 - Cold boot program loaded, attempting to load DOS.
b5 - DOS loaded.
b6 - SEARCH.COM has been loaded and is searching for the number of the last image saved to the hard disk.
b7 - SEARCH.COM has successfully completed the search.

8.2.2 Initialization Progress Codes

Once the main program has been loaded, a series of "A" progress codes will be displayed. When initialization is completed, the "A" code will be erased and the next available image location will be displayed. Each "A" code which occurs during the initialization process is defined below.

A1 - Overlay manager is loaded.
A2 - Memory is being initialized.
A3 - Video relays are being initialized.
A4 - Image Processor PCB is being initialized.
A5 - Initializing X-Ray system communications.
A6 - Initializing internal software error handler.
A7 - Initialize gray scales and log RAMS.
A8 - Initialize VTR.
A9 - Initialize HELP function.

8.2.3 Hard Disk Drive Error Codes

During initialization or program execution, unrecoverable hard disk errors may occur. An error will be reported on the monitor cart front panel LED display. "d" codes that might appear during initialization or operation of the system are described below.

d0 - No image was found at the location specified during a hard disk image recall. This is a user error which does not indicate a malfunction.
d2 - Cannot find the requested data block.
d3 - A bad data block was encountered.
d4 - A formatting error occurred.
d5 - The drive cannot find its alternate track.
d6 - A Disk Controller PCB time out error occurred.
d7 - An internal software error was detected.
d9 - The hard disk is not ready.
dA - A drive error occurred.
dB - A Disk Controller PCB error occurred.
dC - Attempting to recall an invalid image.
dD-dF - Reserved for future use.

8.2.4 Program Errors

Operator and program errors are displayed on the front panel. The following error codes all occur during execution of the main program:

ERROR: **E1**
CAUSE: The front panel has not responded to the host processor over the serial communication link.
CHECKS: Observe the serial data lines between the host and the front panel. Verify that the front panel software is correct and that the processor is running.

ERROR: **E2**
CAUSE: Repeated NAK response from the front panel to the host processor.
CHECKS: Same as error E1.

ERROR: **E3**
CAUSE: Repeated invalid response from the front panel to the host processor.
CHECKS: Same as error E1.

ERROR: **E4**
CAUSE: Image processor has not responded to the host processor over the serial communication link.
CHECKS: Check the serial data lines between the host and IP. Verify that the IP software is correct and processor is running.

ERROR: **E5**
CAUSE: Repeated NAK response from IP to the host processor.
CHECKS: Same as error E4.

ERROR: **E6**
CAUSE: Repeated invalid response from the IP .
CHECKS: Same as error E4.

ERROR: **E7**
CAUSE: X-ray System communications error.

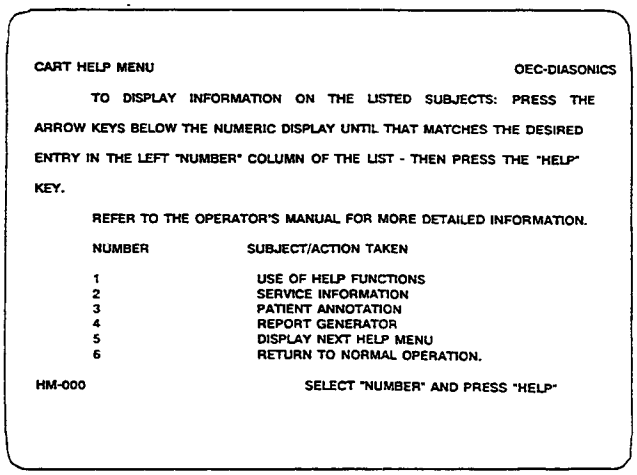
8.3 Monitor Cart Diagnostics Menus

The Diagnostics Menus provide access to:

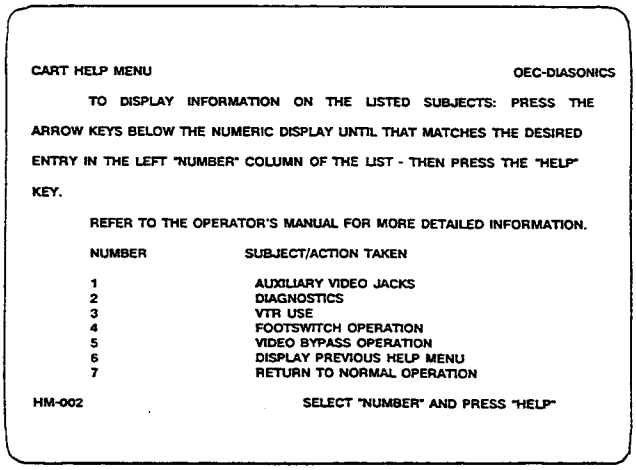
Front Panel Controlled Diagnostics
Terminal controlled Diagnostics

These are discussed in the following pages. The steps below describe how to select and use the Diagnostics Menus:

1. Press HELP HELP (HELP twice) to view the first menu, shown here. From this menu select entry NUMBER 5.

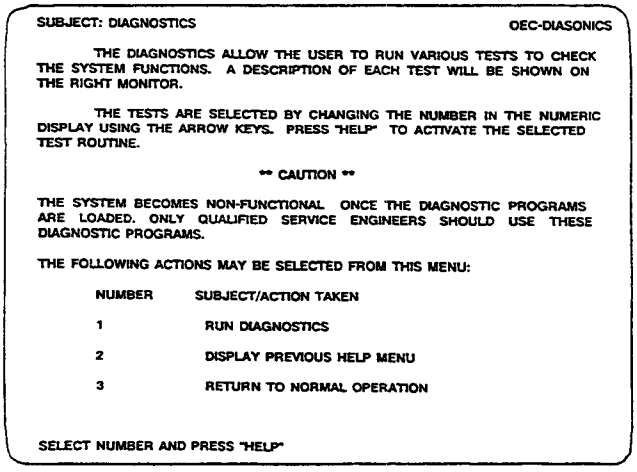


2. Select NUMBER 2 - DIAGNOSTICS and press HELP.



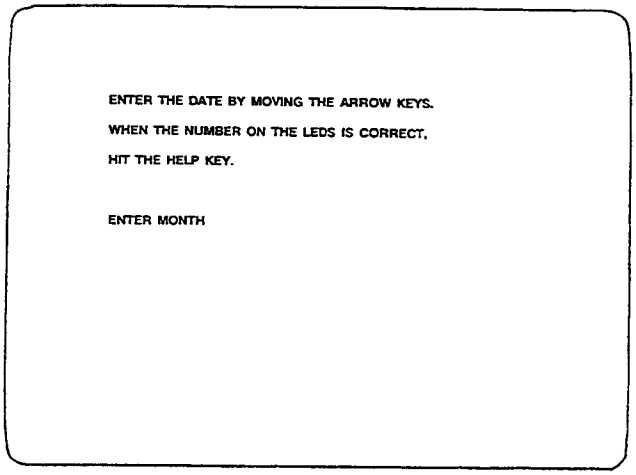
3. Select NUMBER 1 - RUN DIAGNOSTICS.

   The system cannot be operated for normal use when the diagnostic software is loaded. Only qualified service engineers should use these programs.

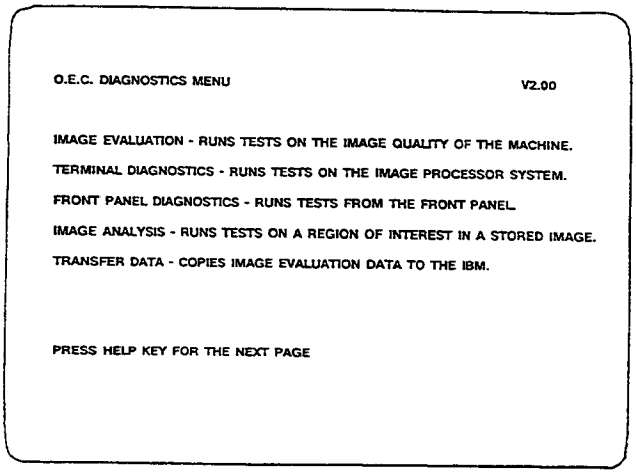


4. You are first asked to enter the date. Press the arrow keys, up or down, until the correct number is displayed on the LED readout. Then press HELP to complete the entry.

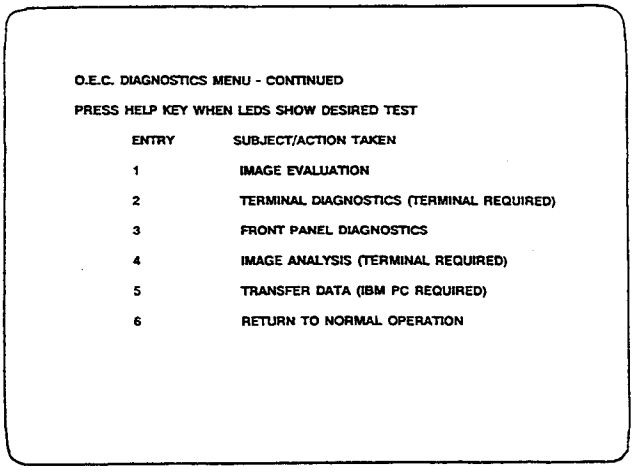
Enter the month.
Enter the day
Enter the year.



5. This help screen will appear with a brief description of the functions available in the next menu. Press HELP for the next screen.



6. Select the desired diagnostics from this menu. Each of the diagnostics is described in the following sections. Enter the number and press HELP. Entry NUMBER 6 will return you to normal operation.

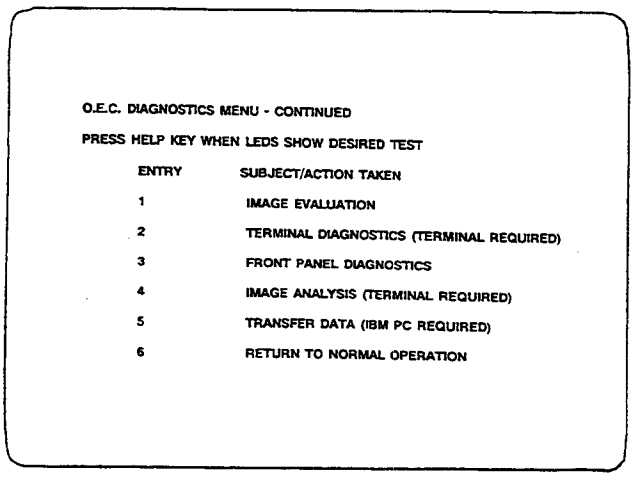


8.4 Front Panel Diagnostics

The Front Panel Diagnostics test the monitor cart electronics and are selected from the Front Panel Diagnostic Menu.

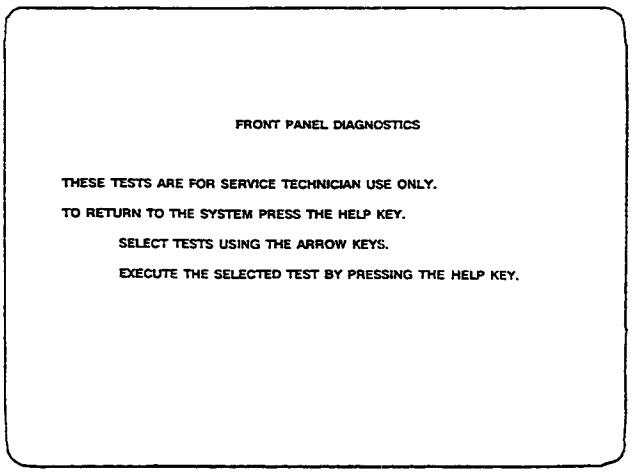
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1. Select ENTRY 3 - FRONT PANEL DIAGNOSTICS from the Diagnostics Menu. (See above: *Entering the Diagnostics Menus*).



2. Refer to the list of Terminal Diagnostics given in the next section. These tests are identical, except where noted. (The cycle memory test #11, for example, is not available from the front panel).

3. Select the desired test number on the LED readout by using the arrow keys. Begin the test by pressing HELP.



8.5 Terminal Controlled Diagnostics

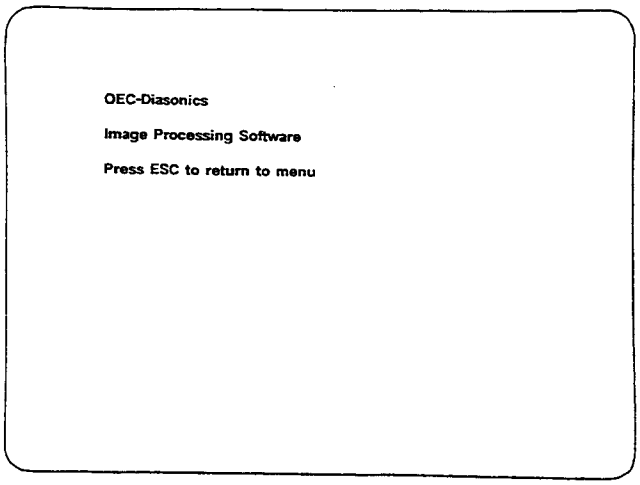
The Terminal Controlled Diagnostics test the monitor cart electronics. These same tests may be accessed from the front panel.

8.5.1 Using the Terminal Controlled Diagnostics

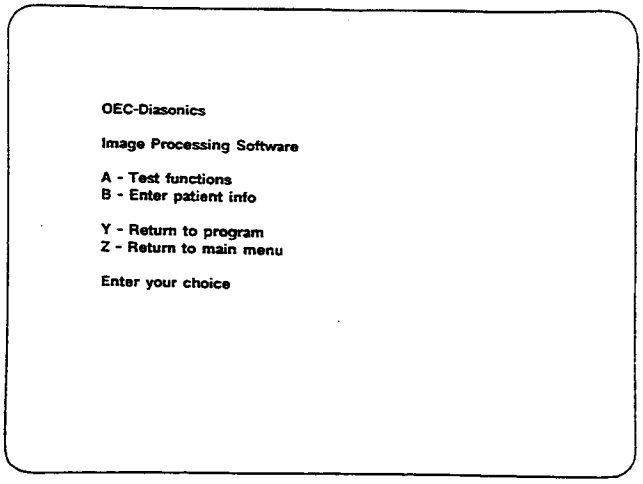
The Terminal Diagnostics require the use of an externally connected computer terminal. (Refer to the Appendix: *Terminal Installation and Use*).

---

1. Connect a terminal (such as the DXR keyboard terminal described in the Appendix), to the RS-232 connector on the rear of the monitor cart. The screen shown here will appear when the cart is booted. Press [ESC].

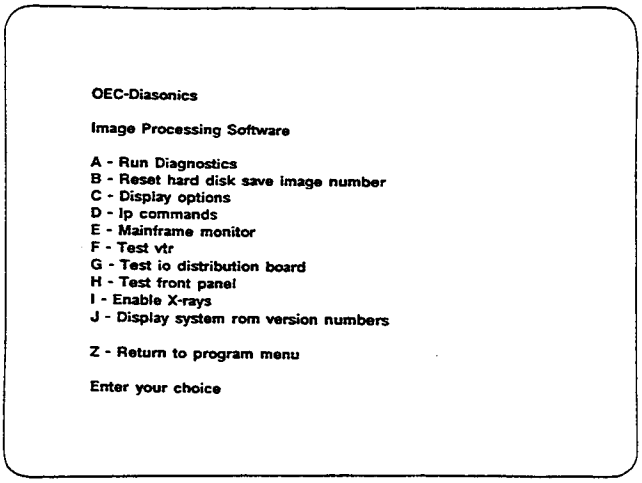


2. Select ENTRY A - TEST FUNCTIONS from the program access menu.



3. A list of choices will appear on the terminal screen (or the monitor screen if it is being used as the terminal).

Enter: A - RUN DIAGNOSTICS.



4. The following tests may be selected from the terminal screen. Type in the number and press [RETURN].

1 - Segment Ram Test	15 - Exchange M1 Data
2 - Memory Segment Read Test	16 - Exchange M2 Data
3 - Memory Segment Write Test	17 - Swap M1/m2 Data
4 - M1 Clear Test	18 - Left Monitor Live
5 - M1 Memory Test	19 - Left Monitor Digital
6 - M1 Exchange Test	20 - Select Gray Scale Val.
7 - M1/M2 Swap Test	21 - CRT Character Test
8 - M2 Clear Test	22 - Front Panel Test
9 - M2 Memory Test	23 - Video Test Pattern
10 - M2 Exchange Test	24 - Front Panel LED Test
11 - Cycle Memory Tests	
12 - Write Vertical Gray Scale	99 - return to system
13 - Write Horiz. Gray Scale	
14 - Invert M1 Data	

8.5.2 Explanations of the Terminal Diagnostics

This section briefly describes each diagnostic test. Note that options 1 thru 10 are memory tests that can be repeatedly cycled by selecting option 11. However, the cycle capability exists only when the external terminal is used. The front panel diagnostics will automatically jump over option number 11 (and option 20 which is also limited) while scrolling through the options.

Most tests listed below may be performed in any order required. The Video Test Pattern is one of the tests included in this group.

The order in which the memory tests are listed is the order in which they should be run. Their order must be followed since an error in a prior test will make the next test useless.

Error Messages - The errors that are detected during these tests are displayed in different ways depending on how the tests were originated. When using the terminal oriented diagnostics it is possible to relay more information about the error condition to the terminal than it is using the front panel diagnostics. The front panel diagnostics assume that there is not a terminal interfaced to the system, so all error messages are displayed on the front panel LED display. The first character of the display will be an "E" and the second digit will be a hex value between 0 and F that corresponds to the error found. If the error condition is a number greater than 15 (or F hex) then an F will be displayed. The cycle test mode also restricts the amount of error information displayed.

1- SEGMENT RAM TEST

This test first writes AA hex to every address in the segment ram. Each line is then read into a 512 byte buffer that was previously cleared to 0's. If each byte of the buffer now contains AA hex, then the same test is performed using 55 hex.

Error messages- In the terminal diagnostic mode text messages indicate the number of errors encountered for each bit mask. The cycle test returns 1 error for each bit mask test that failed, for a possible total of 2 errors per pass. The front panel diagnostics will return an error code of "E1" if any error occurred, or an error code of "E0" if no errors were detected.

2- MEMORY SEGMENT READ TEST

The function of this test is to verify that a segment can be read from the memory M1. This is accomplished by filling a 16k byte block of dram with the value FF hex (this sets all bits to 1), then clearing the memory, reading segment #0 of M1 into the DRAM block that previously contained all 1's, and then checking to see that all memory bits were cleared to 0.

Error messages- The error value returned by this test indicates the number of bytes in the segment that remained uncleared. In the front panel diagnostic mode, an error value greater than 15 will be displayed as

an "F". In the cycle mode, any number of errors found will be counted as a single error per pass.

3- MEMORY SEGMENT WRITE TEST

This test is to verify that a segment of data can be written to the memory M1. First M1 is cleared, then a 16k byte section of DRAM is filled with the alternating bit pattern of 55 hex. The entire segment is written to memory M1 segment #0, then read back into dram and checked to see if every byte was properly written. The test is then repeated using the bit pattern AA hex.

Error messages - The error value returned by this test indicates the number of bytes in the segment that was found to contain a value other than that which was written to it.In the front panel diagnostic mode an error value greater than 15 will be displayed as an "F". In the cycle mode, any errors found will be counted as a single error per pass.

4- M1 CLEAR TEST

This test checks to see that a "clear frame" operation can be performed on memory M1. The hex value FF is written to an address in segment #0 of memory M1, and then a clear frame operation clears the entire 128k block. The address previously written to is then checked for a value of 0.

Error messages - This test returns an error of 1 if it failed, and 0 if it passed.

5- M1 MEMORY TEST (takes approximately 3.5 min)

This test alternates every bit of the frame and checks the result. First the value 55 hex is written to each byte of the frame, and then read back and verified. The same is done using the hex value AA.

Error messages- Using the terminal diagnostics, an error message statement is returned for each segment declaring that either an error was found in that segment, or that the segment memory checked out OK. In the front panel test mode an error code of "E1" indicates that the failure occurred during the first pass when the hex value 55 was written, and an error code of "E2" means that the error was discovered when expecting to read back AA hex. In cycle mode the error value accumulated during a single pass indicates how many segment errors were found for both bit masks. For example, if the error total was incrementing by 32 for each cycle, that would indicate that all 16 segments had at least 1 error during both the AA and 55 bit tests.

6- M1 EXCHANGE TEST

This test verifies that the "exchange frame" function is working properly. When an exchange frame is performed on either M1, or M2, the address lines are changed so that the background frame becomes the foreground frame, and vice versa. First the hex value AA is stored in a single memory address in segment #0of M1. The foreground frame is then exchanged to the background, and the hex value 55 is stored in the new foreground frame. Another exchange frame is called which, if everything happened according to plan, should leave the AA back in the foreground memory.

After checking the AA, an exchange frame is called one more time, and the new foreground is checked for the 55 value that was stored there earlier. The same test is then repeated for the other 15 segments.

Error messages - In the terminal diagnostic mode, a message is displayed after checking each of the sixteen segments.The error message will either indicate that the segment checked out OK, or it will say that when it was expecting to read a hex value of ??, it in fact found a hex value of ??. In front panel mode, the error value represents the number of segments in which an error was encountered. In cycle mode, any errors are counted as 1 error per pass.

7- M1/M2 SWAP TEST

Because the only memory that can be read from, and written to directly is the foreground frame of M1, the M2 memories can only be accessed by swapping the information in M2 to M1. The result of a swap leaves the foreground of M2 in M1, and vice versa. The swap test first clears both M1 and M2 foreground memories, and then the value 55 hex is stored to a single address of segment #0, and written to M1. The entire frame is then swapped to M2, and a hex AA is stored in the same address of the cleared frame that is now in M1. A swap is performed again and a check is made to verify that the 55 was swapped back to M1. Once more a swap is performed and this time an AA is expected in M1.

Error messages- During the terminal diagnostic test an error message will be displayed indicating the result of the test. In front panel mode an error code "E1" means that an error was detected while trying to read the 55 hex, an "E2" means that the failure occurred when the AA was expected, and an "E3" indicates that both failed. Cycle mode returns a single error per pass if any errors occurred.

8- M2 CLEAR TEST

This test checks to see that a "clear frame" operation can be performed on memory M2. The hex value FF is written to an address in segment #0 of memory M1, then swapped to M2. M2 is then cleared using a clear frame operation, and swapped back to M1 to be checked for any bits that were not cleared.

Error messages- This test returns an error of 1 if it failed, and 0 if it passed.

9- M2 MEMORY TEST (takes approximately 3.5 min)

This test alternates every bit of the frame and checks the result. First the value 55 hex is written to each byte of the M1 frame, swapped to M2, swapped back to M1, read back and verified. The same is done using the hex value AA.

Error messages-Using the terminal diagnostics, an error message statement is returned for each segment declaring that either an error was found in that segment, or that the segment memory checked out OK. In the front panel test mode the an error code of "E1" indicates that the failure occurred during the first pass when the hex value 55 was written, and an error code of "E2" means that the error was discovered while expecting to read back AA hex. In cycle mode, the error value

accumulated during a single pass indicates in how many segments errors were found, for both bit masks. For example, if the error total was incrementing by 32 for each cycle, that would indicate that all 16 segments had at least 1 error during both the AA and 55 bit tests.

10- M2 EXCHANGE TEST

This test verifies that the "exchange frame" function is working for the M2 frames. First the hex value AA is stored in a single memory address in segment #0 of M1, and then M1 is swapped to M2. The foreground frame of M2 is then exchanged to the background. The hex value 55 is then stored in M1 and then swapped to M2. Another exchange frame is called, which should leave the AA back in the foreground memory of M2, with 55 in the background frame. After checking the AA, an exchange frame is called for M2, and the new foreground is checked for the 55 value that was stored there earlier. The test is repeated for the other 15 segments.

Error messages - In the terminal diagnostic mode, a message is displayed after checking each of the sixteen segments. The error message will either indicate that the segment checked out OK, or it will say that when it expected to read a hex value of xx, it instead read a hex value of yy. In front panel mode, the error value represents the number of segments in which an error was encountered. In cycle mode, errors are counted as 1 error per pass.

11- CYCLE MEMORY TESTS

The cycle mode repeats the memory tests, keeps track of the number of cycles performed, and accumulates the number of errors. This type of test is especially useful in tracking down system failures that are intermittent, or of a thermal nature. One useful feature of this mode is the ability to select the tests to be included in the cycle, while ignoring the others.

NOTE: Most of the following tests write data to the foreground of memory M1. Although it is not possible to write data directly to M2, a "SWAP M1/M2" (option 16) allows any data in M1 to be swapped into M2.

12- WRITE VERTICAL GRAY SCALE

A vertical gray scale is written to M1.

13- WRITE HORIZONTAL GRAY SCALE

A horizontal gray scale is written to M2.

14- INVERT M1 DATA

Inverts the data in the foreground of M1 byte by byte.

15- EXCHANGE M1 DATA

Exchanges the foreground memory of M1 for the background memory by switching address lines.

16- EXCHANGE M2 DATA

Exchanges the foreground memory of M2 for the background by switching address lines.

17- SWAP M1/M2 DATA
A processing function of the Image Processor swaps the data in the foreground memory of M1 with the data currently in the foreground memory of M2.

18- DISPLAY LEFT MONITOR LIVE
The left monitor displays a live non-digitized picture, and the system allows X-rays. X-rays are disabled upon exiting this option.

19- DISPLAY LEFT MONITOR DIGITAL
The left monitor displays a digitized picture, and the system allow X-rays. X-rays are disabled upon exiting this option.

20- SELECT GRAY SCALE VALUE
This option allows the technician to choose what gray scale value to write write to M1. The system allows a value between 0 (black) and 200 (white).

21- CRT CHARACTER TEST
A block of text characters is written to M1 which can be used to verify that the monitors have been set up properly, allowing all text lines to be clearly visible.

22- FRONT PANEL TEST
Using the terminal diagnostics, the scan codes for each front panel key is displayed on the terminal when each key is pressed. With the front panel diagnostics the scan codes are displayed as hex values on the LED display.

23- VIDEO TEST PATTERN
This test draws a special video test pattern to M1, and uses that pattern on M1 as a mask to do a digitized subtraction on M2. X-rays are allowed during this option so that the camera can be properly centered. The instructions to the technician for aligning both the monitors and the camera are written to the monitors along with the pattern. X-rays are disabled upon exiting this mode.

24- FRONT PANEL LED TEST
The front panel LED test turns on all of the front panel LED's. The LED`s are all turned off again when the test is exited. When this test is initiated using the front panel diagnostics, the "HELP" key LED will flash to remind the technician how to exit this mode.

99- RETURN TO SYSTEM
Places the system at the diagnostics menu, where Return to System can be selected, returning normal operation with the same defaults and parameters used to begin with at power-up.

8.6 Monitor Cart Terminal Mode

The Terminal Mode requires the use of an externally connected computer terminal. (Refer to this in the Appendix under *Terminal Installation and Use*).

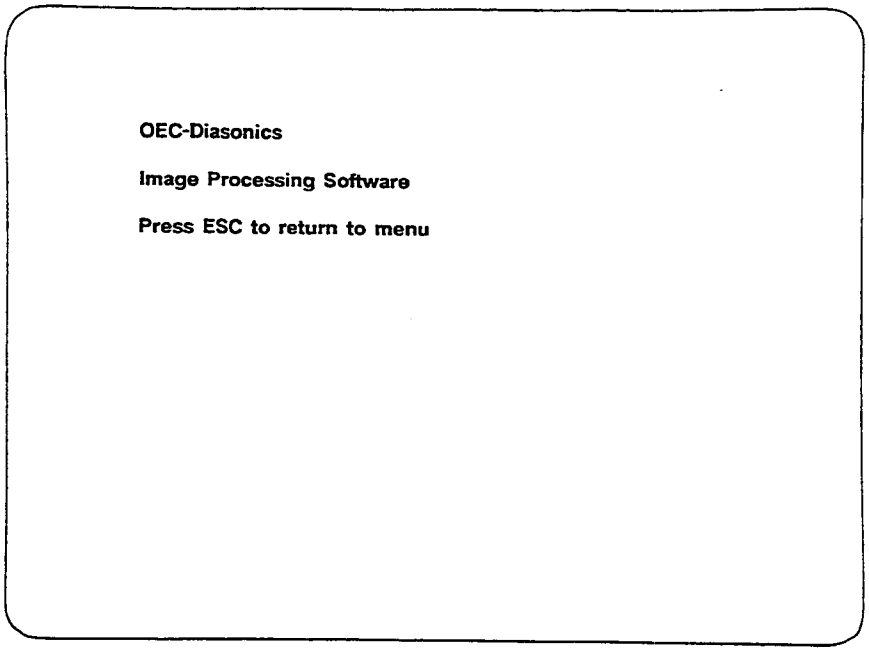
Some menu entries are passcode protected. Each attempt to select one of these protected entries generates an access code. A passcode is then required to unlock each access code. A new access code is generated with each access.

The major screen menus which can be accessed with a terminal are shown below.

8.6.1 Initial Menus

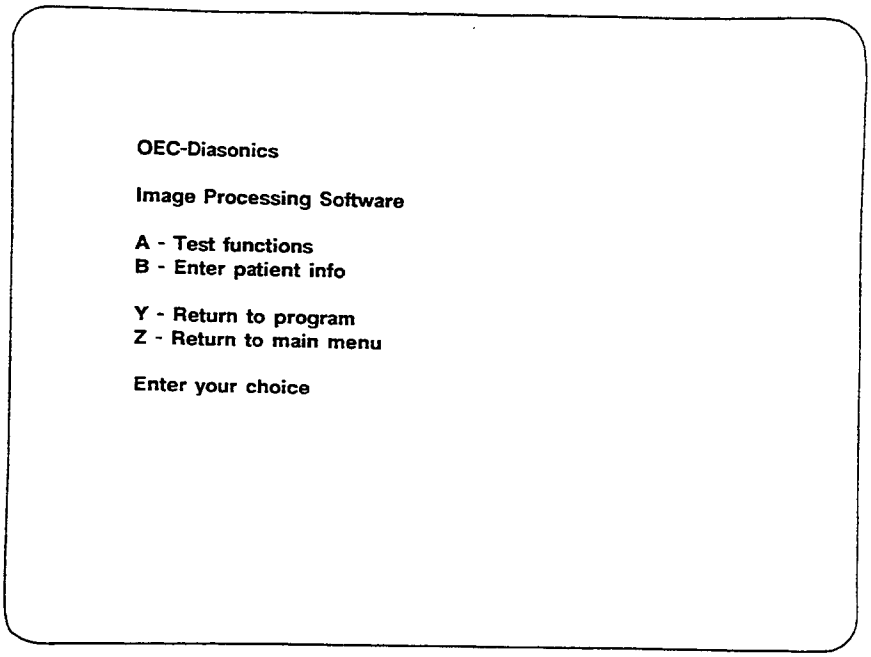
8.6.1.1 Powerup Screen Message

The powerup screen first appears when the terminal is turned on.



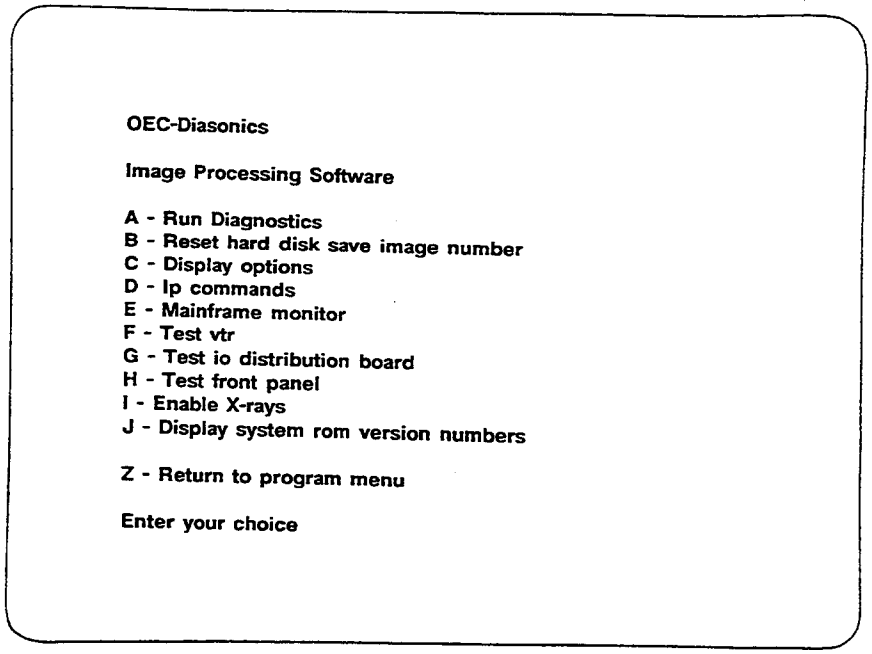
8.6.1.2 Program Access Menu

Press [ESC] for the Program Access Menu.

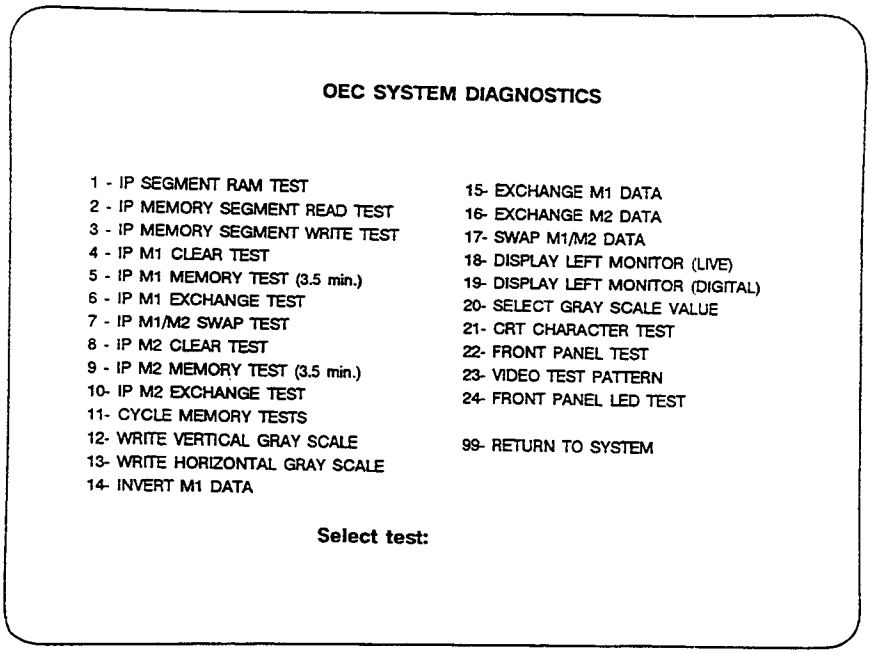


8.6.2 Test Function Menu

This menu lists test functions.

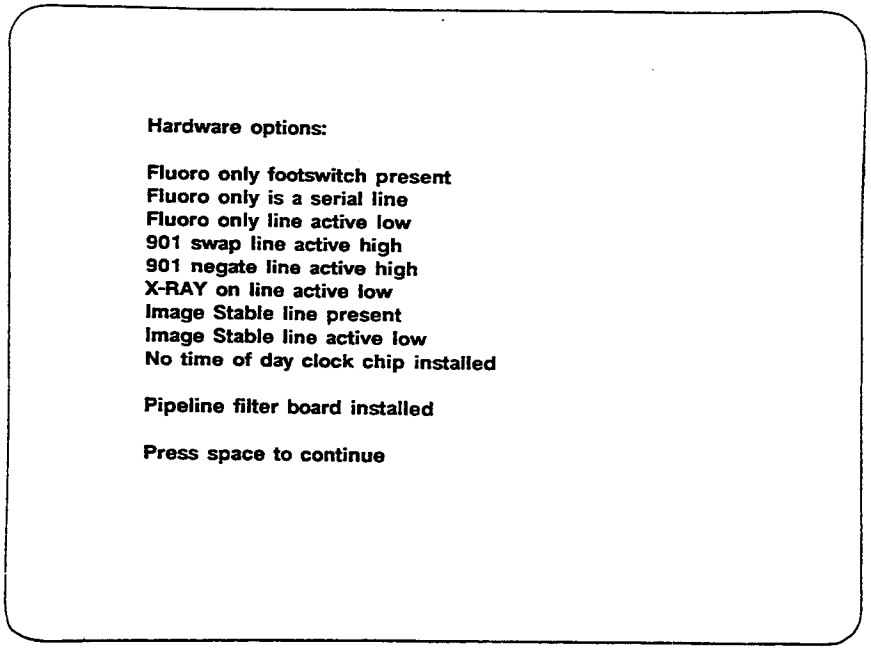


8.6.2.1 Run Diagnostics

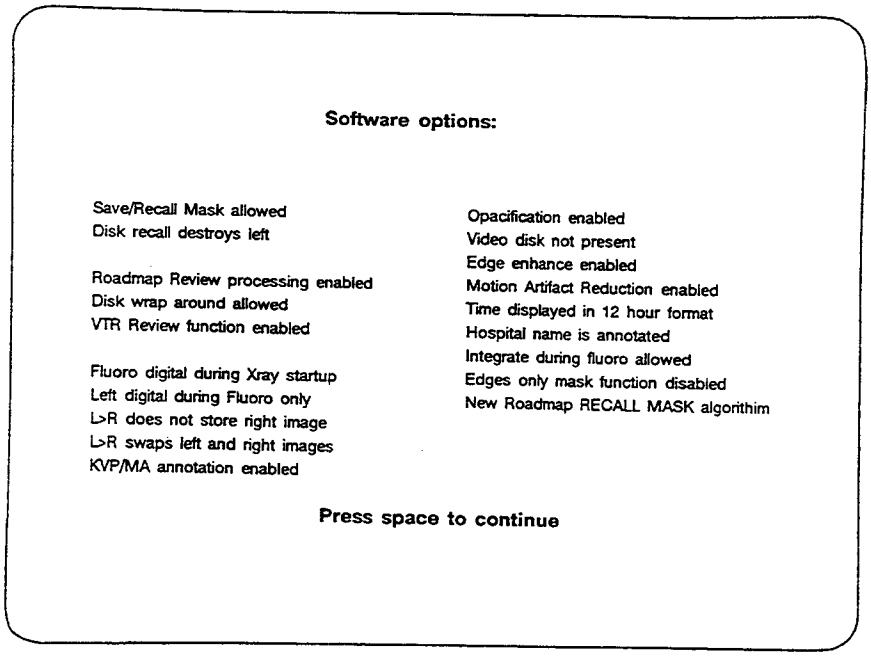


8.6.2.2 Display Options

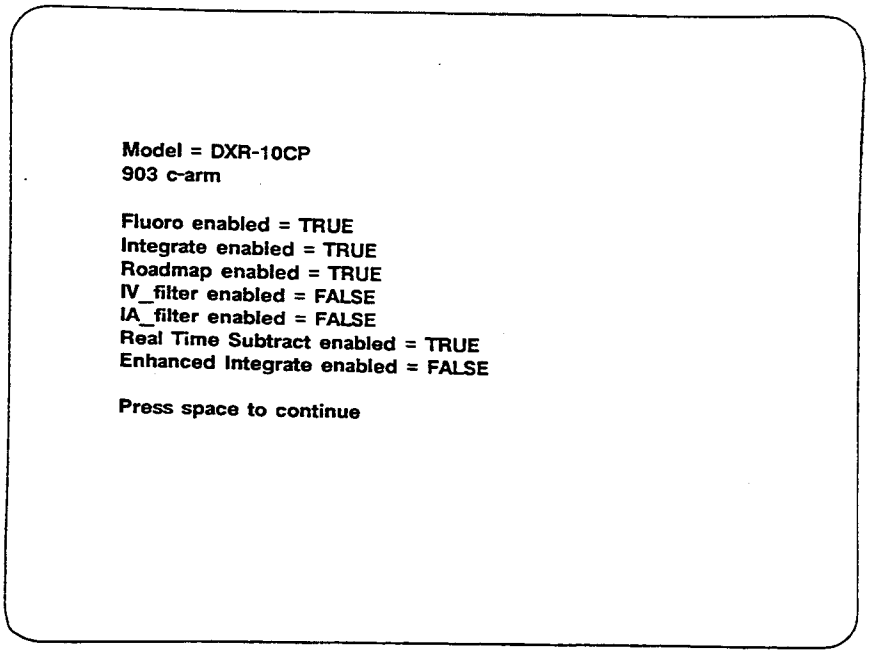
Hardware Options



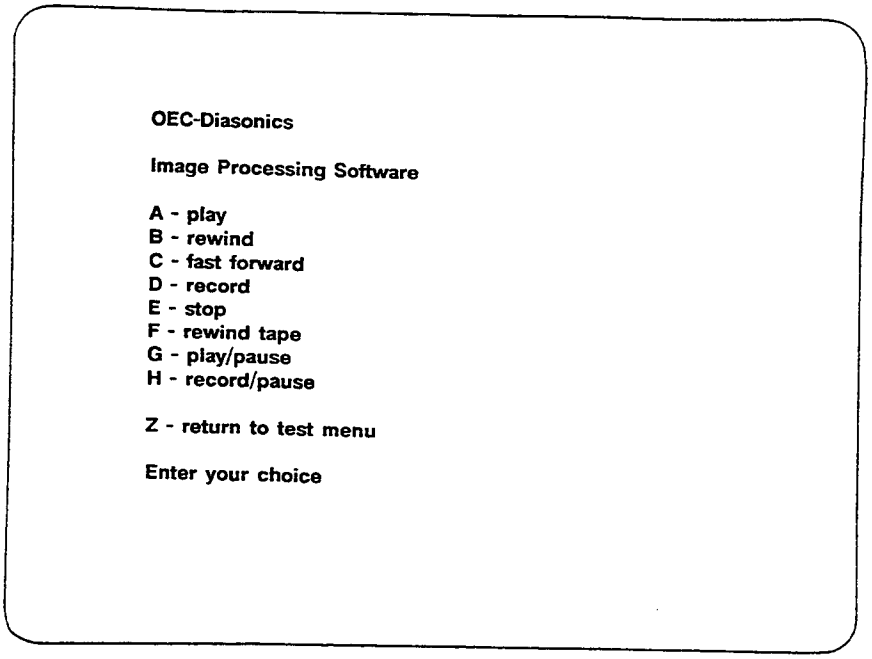
Software Options



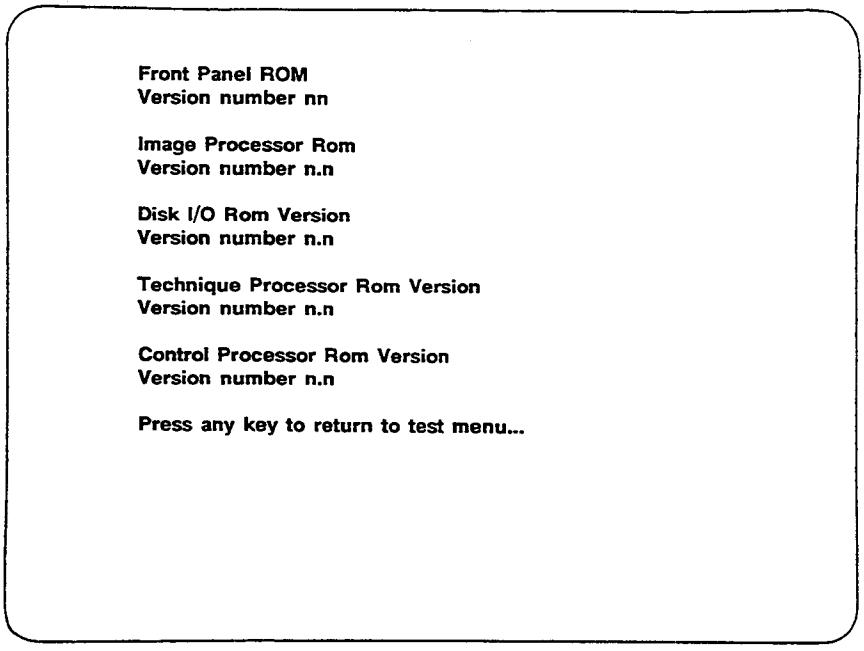
More Software Options



8.6.2.3 Test VTR



8.6.2.4 Display ROM Version Numbers



8.6.3 Main Menu

This menu can be accessed directly from the Program Access Menu.

```
OEC-Diasonics
System Software Manager
System ID Code:

A - Run Applications
B - Change system options
C - Run Diagnostics
D - Reboot to floppy disk
E - Load system software
F - Modify Terminal installation
G - Run Image Analysis
H - Examine shot log file
I - Erase shot log file
J - Transfer image files

Y - Access mainframe menu (903 only)
Z - Exit to DOS

Please make a selection:
```

8.6.3.1 Change System Options

```
OEC-Diasonics
Option change and display program
System Part No:

A - Hardware options
B - Software options
C - Mode options
D - Set power up default mode
E - Screen storage definitions
F - System relay definitions
G - Other byte options
H - Model number
I - Serial number

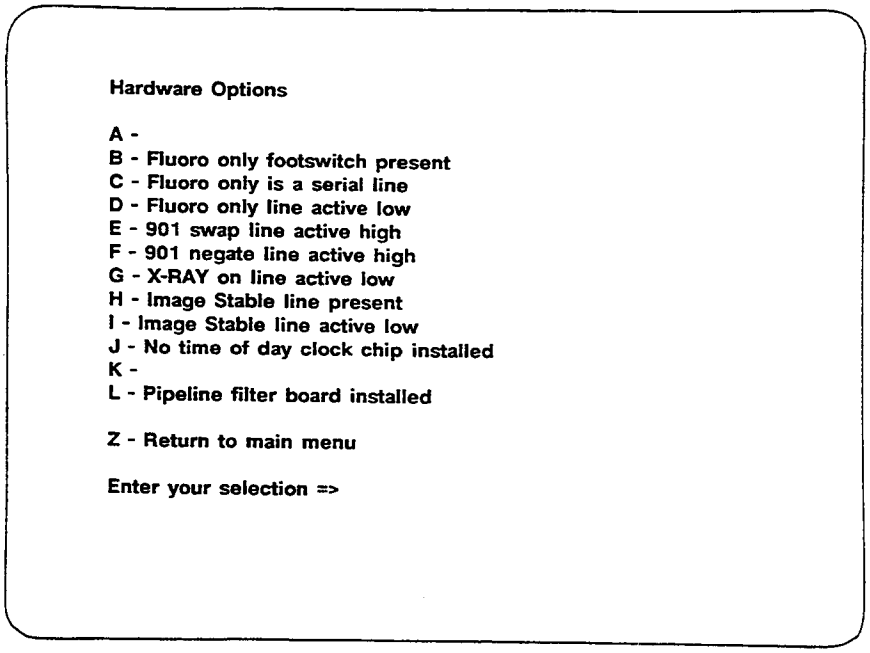
J - Hospital name

L - C-arm model number

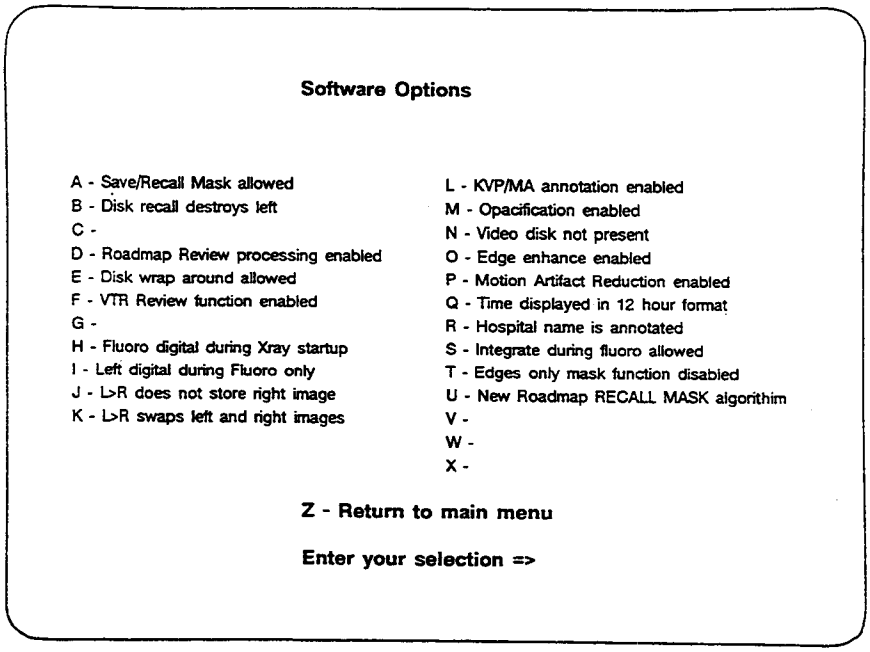
Y - Abort program, make no changes
Z - Exit program and update changes

Enter your selection =>
```

Hardware Options



Software Options



Mode Options (example)

```
Fluoro ENABLED

A - Enable Fluoro
B - Disable Fluoro
C - Change Fluoro default parameters

Z - Next processing mode

Enter your selection =>
```

Mode Options (example)

```
Integrate ENABLED

A - Enable Integrate
B - Disable Integrate
C - Change Integrate default parameters

Z - Next processing mode

Enter your selection =>
```

Set Powerup Default Mode

```
Current Power Up Mode = Fluoro

A - Fluoro
B - Integrate
C - Roadmap
D -
E -
F - Real Time Subtract
G -
H -

Z - No change

Enter your selection =>
```

Screen Storage Definitions

```
A - Pixels per scan line = 512
B - Scan lines per field = 240
C - Save and Recall start even field line number = 2
D - Save and Recall start odd field line number = 2
E - Display is    Interlaced

Z - Return to main menu

Enter your selection =>
```

System Relay Definitions

```
A - Normal closed relay setting
  = [K24,K22,K15,K7]
B - Normal video relay setting
  = [OUT,K30,K25,K22,K15,K8,K1,]
C - Xrays on relay setting
  = [OUT,K30,K24,K22,K15,K8,K1,]
D - Process video tape relay setting
  = [OUT,K30,K25,K15,K8,K4]
E - Review video tape relay setting
  = [OUT,K30,K25,K15,K10]
F - Process video disk relay setting
  = [K30,K25,K15,K8,K4]
G - Review video disk relay setting
  = [K30,K25,K15,K10]
Z - Exit

Enter your selection =>
```

Other Byte Options

This list is several screens in length and scrolls up as you progress down the list.

```
Log scale factor = 128
Change it? (Y or N) N

Fluoro window scale factor = 255
Change it? (Y or N) N

Fluoro level scale factor = 255
Change it (Y or N) N

Subtract window scale factor = 255
Change it? (Y or N) N

Subtract level scale factor = 160
Change it? (Y or N) N

Max hard disk value = 60
Change it? (Y or N) N

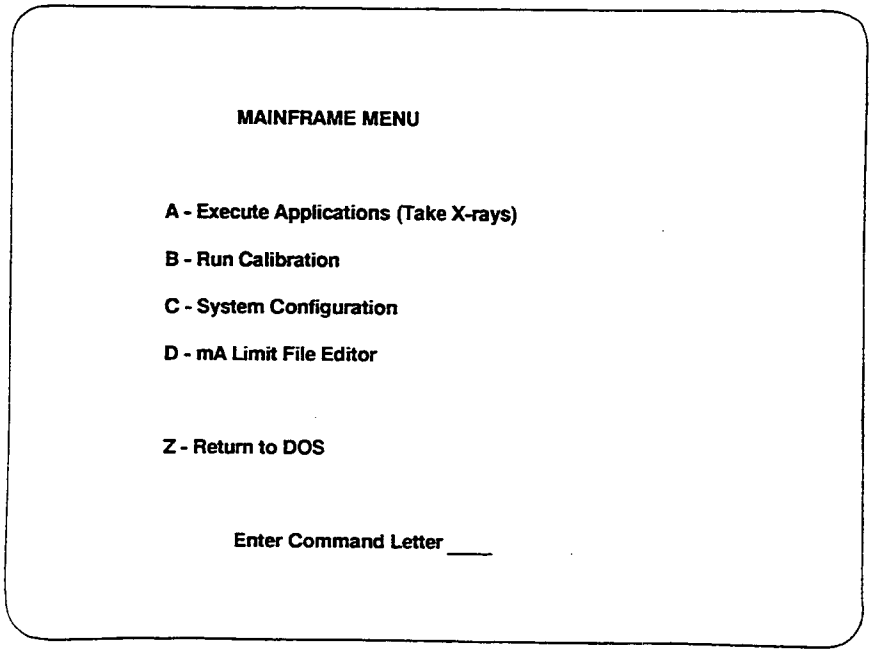
Subtract stable delay = 240
Change it? (Y or N)
```

8.6.3.2 Mainframe Access Menu

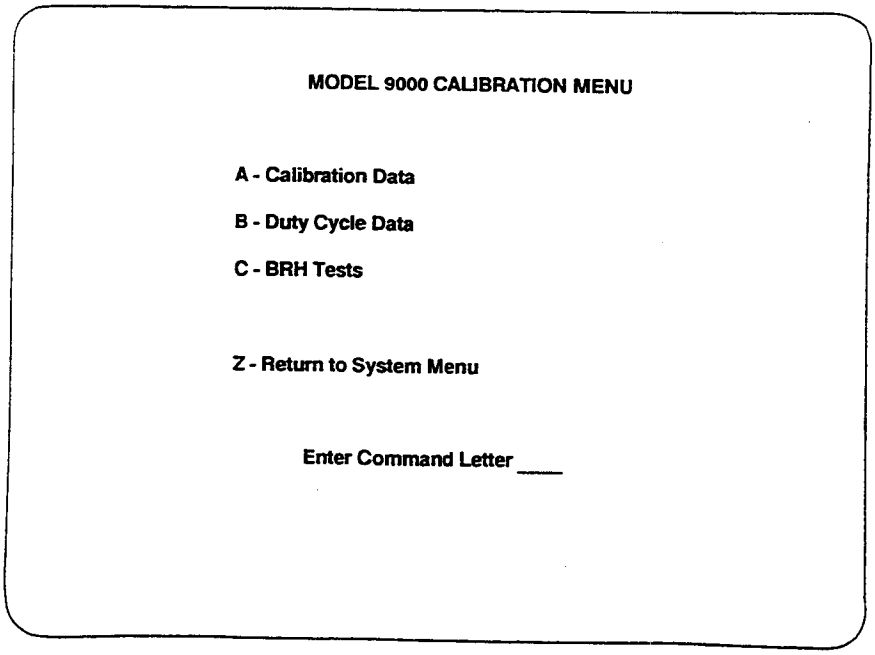
Select this menu from the monitor cart MAIN MENU.

When this menu is selected, the mainframe interlocks open to prevent X-rays.

To resume normal mainframe operation select "Execute Applications" from this menu.

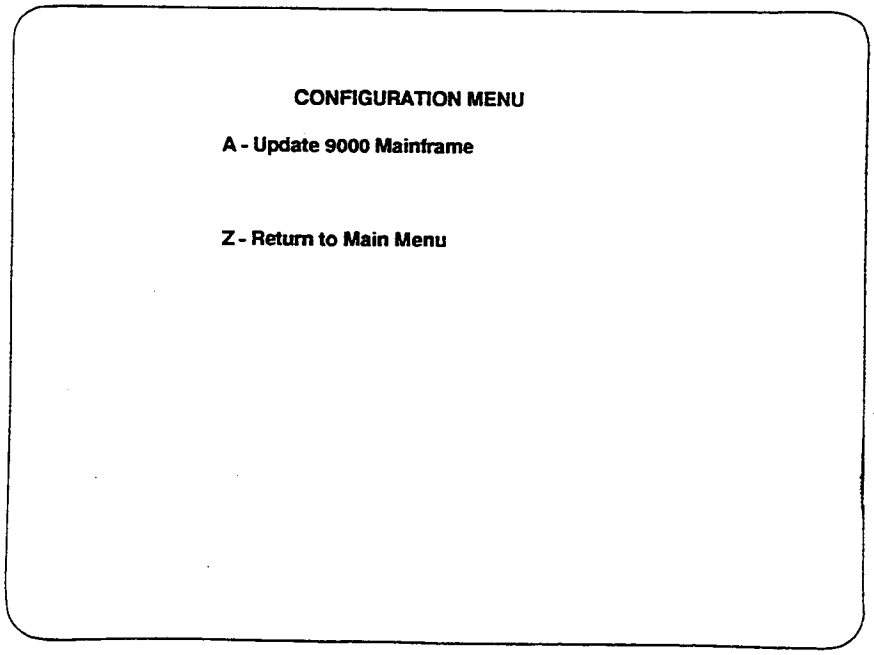


Model 9000 Calibration Menu



Configuration Menu

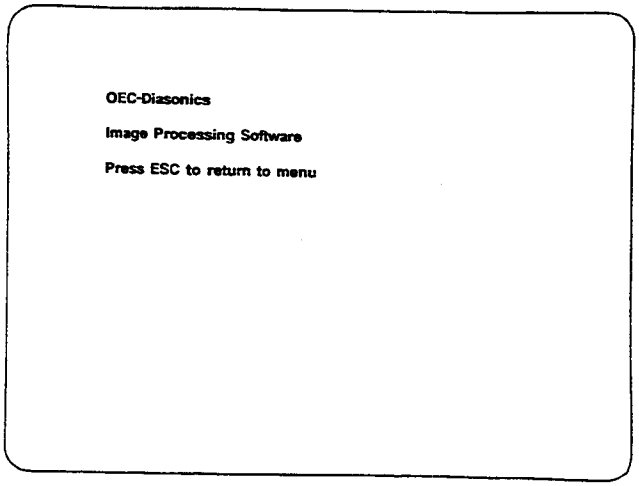
The Configuration Menu allows changes of boost operation and image tube size.



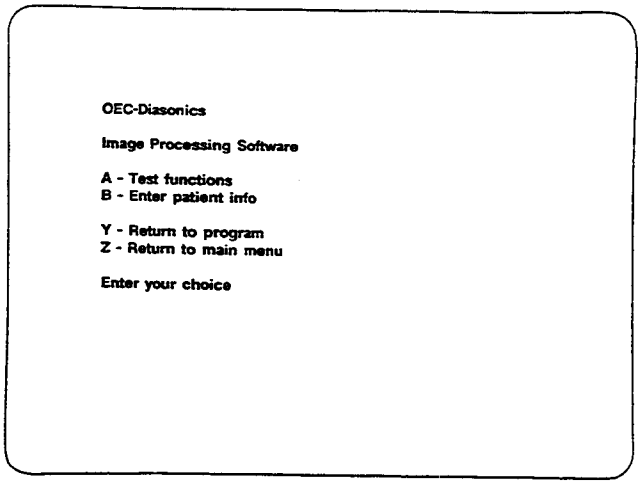
8.7 Examine Shot Log File

Shot Logging provides the field engineer with a record of the last 500 X-ray shots. This can be of value in evaluating X-ray tube history and performance.

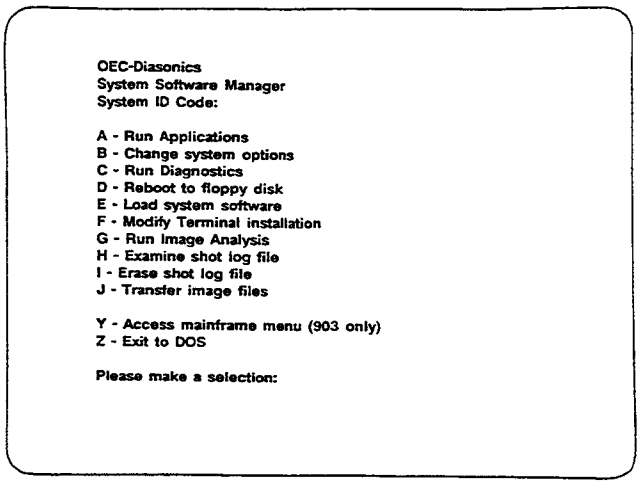
1. An external terminal must be connected to examine the shot log file. Press [ESC].



2. Enter [Z] and press [RETURN].

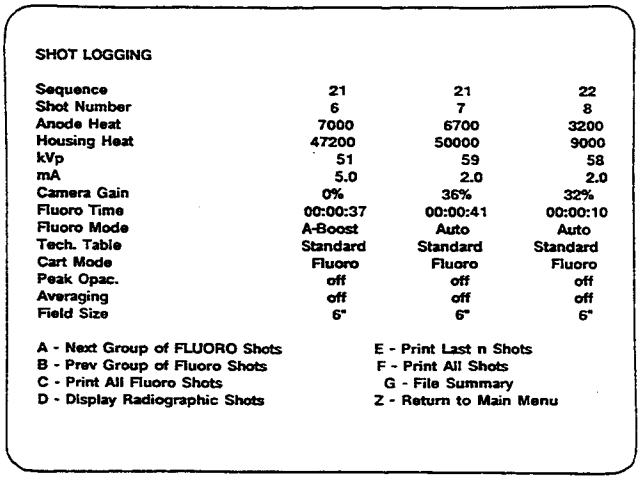


3. From the MAIN MENU, select entry [H] - EXAMINE THE SHOT LOG FILE.



4. A portion of the shot log file will appear on the screen with a command menu below.

From this menu enter:
C - Print all fluoro shots
E - Print last n shots
F - Print all shots
G - View overall shot summary
G, then P - Print shot summary



5. If a printout is desired, connect a printer using a printer cable such as P/N 870596 to the monitor cart AUX connector. Follow the instructions given in the Appendix for printer installation.

Figure 8-1 - *Here is a sample of a printout obtained by entering C - Print all Fluoro shots:*

10CPXXXX Cottonwood Hospital Page 1

Fluoro SEQ	Mode NUM	ANODE	HOUSING	KVP	MA	GAIN	ON-TIME	MD	CART-MODE	OPAC	AVG	FD
1	1	800	6500	61	2.2	36%	0:00:09	A	Fluoro	Off	Off	6"
2	1	400	19300	63	2.4	36%	0:00:05	A	Fluoro	Off	Off	6"
2	2	1400	21600	63	2.4	36%	0:00:13	A	Fluoro	Off	Off	6"
2	3	1300	27500	40	0.5	0%	0:00:13	A	Fluoro	Off	Off	6"
2	4	2000	29600	63	2.4	36%	0:00:19	A	Fluoro	Off	Off	6"
2	5	1400	45800	61	2.2	36%	0:00:22	A	Fluoro	Off	Off	6"
2	6	3000	50900	120	3.2	100%	0:00:29	A	Fluoro	Off	Off	6"
2	7	800	57800	40	0.5	0%	0:00:29	A	Fluoro	Off	Off	6"
2	8	3000	61300	40	15.0	0%	0:00:34	AB	Fluoro	Off	Off	6"
2	9	2900	61000	40	0.5	0%	0:00:47	A	Fluoro	Off	Off	6"
2	10	5500	66300	47	20.0	73%	0:00:51	AB	Fluoro	Off	Off	6"
2	11	13500	75800	47	20.0	44%	0:00:59	AB	Fluoro	Off	Off	6"
2	12	12900	79900	40	20.0	49%	0:01:01	AB	Fluoro	Off	Off	6"
2	13	23400	92500	40	20.0	73%	0:01:16	AB	Fluoro	Off	Off	6"
2	14	22300	95200	61	2.2	36%	0:01:24	A	Fluoro	Off	Off	6"
2	15	24100	98700	61	20.0	97%	0:01:26	AB	Fluoro	Off	Off	6"
2	16	32300	109300	61	20.0	88%	0:01:38	AB	Fluoro	Off	Off	6"
2	17	36000	119700	50	5.6	0%	0:01:49	AB	Fluoro	Off	Off	6"
2	18	37500	123600	42	20.0	58%	0:01:54	AB	Fluoro	Off	Off	6"
2	19	33700	130700	45	20.0	74%	0:02:00	AB	Fluoro	Off	Off	6"
2	20	29900	137300	120	3.2	100%	0:02:10	A	Fluoro	Off	Off	6"
2	21	29700	139100	62	2.3	36%	0:02:23	A	Fluoro	Off	Off	6"
2	22	28900	142600	64	2.5	36%	0:02:41	A	Fluoro	Off	Off	6"
2	23	17600	146600	62	2.3	36%	0:03:08	A	Fluoro	Off	Off	6"
3	1	0	11700	50	2.0	10%	0:00:00	P	Fluoro	Off	Off	6"
3	2	0	11700	50	2.0	43%	0:00:00	P	Fluoro	Off	Off	6"
3	3	0	11700	50	2.0	99%	0:00:01	P	Fluoro	Off	Off	6"
3	4	0	11600	50	2.0	99%	0:00:01	P	Fluoro	Off	Off	6"
3	5	0	11600	50	2.0	99%	0:00:02	P	Fluoro	Off	Off	6"
3	6	0	11600	50	2.0	99%	0:00:02	P	Fluoro	Off	Off	6"
3	7	0	11600	50	2.0	99%	0:00:03	P	Fluoro	Off	Off	6"
3	8	0	11600	50	2.0	99%	0:00:03	P	Fluoro	Off	Off	6"
3	9	0	11600	50	2.0	99%	0:00:04	P	Fluoro	Off	Off	6"
3	10	0	11600	50	2.0	99%	0:00:04	P	Fluoro	Off	Off	6"
3	11	0	11600	50	2.0	99%	0:00:05	P	Fluoro	Off	Off	6"
3	12	0	11600	50	2.0	99%	0:00:05	P	Fluoro	Off	Off	6"
3	13	0	11500	50	2.0	99%	0:00:06	P	Fluoro	Off	Off	6"
3	14	0	11500	50	2.0	99%	0:00:06	P	Fluoro	Off	Off	6"
3	15	0	11500	50	2.0	99%	0:00:07	P	Fluoro	Off	Off	6"
3	16	0	11500	50	2.0	99%	0:00:07	P	Fluoro	Off	Off	6"
3	17	0	13000	50	2.0	99%	0:00:08	P	Fluoro	Off	Off	6"
3	18	0	13000	50	2.0	99%	0:00:08	P	Fluoro	Off	Off	6"
3	19	0	13000	50	2.0	99%	0:00:09	P	Fluoro	Off	Off	6"
3	20	0	13000	50	1.5	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	0	13000	50	1.1	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	13000	50	0.7	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	36%	0:00:08	A	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0:00:10	A	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6"

Figure 8-2 - *Here is a sample printout obtained by entering G - File Summary, then P - Print Summary.*

10CPXXXX Cottonwood Hospital Summary

Total shots..... 190
Total sequences..... 25

Highest Anode Heat.... 37500
Sequence.... 2
Number.... 18
Average Anode Heat.... 4301

Highest Housing Heat.. 146600
Sequence.... 2
Number.... 23
Average Housing Heat.. 34455

Total Radiographic Shots....9
Neo-Natal Shots....0

	0.3mm	1.0mm
Number of shots	9	0
Average KVP used	57	0
Average MAS used	43	0

Total Fluoro Shots.....181

	Auto	Manual	A-Boost	M-Boost	Pulsed	One-Shot
Number of shots	128	12	19	0	0	22
Average KVP used	66	80	52	0	0	50
Average MA used	2	4	15	0	0	2
Average GAIN used	39%	74%	29%	0%	0%	92%

Technique Table	Standard	Modified	Custom
Number of shots...	181	0	0

	Fluoro	Integrate	Roadmap	IV-filter	IA-Filter	Subtract
Number of shots	134	8	17	0	0	22
Opacified shots	0	0	1	0	0	0
Averaging Off	126	0	12	0	0	21
Averaging of 2	0	0	0	0	0	0
Averaging of 4	1	2	4	0	0	1
Averaging of 8	2	0	1	0	0	0
Averaging of 16	0	0	0	0	0	0
Averaging of 32	5	6	0	0	0	0
Averaging of 64	0	0	0	0	0	0
Averaging of 128	0	0	0	0	0	0

8.8 Monitor Cart Adjustments, Switches and Jumpers

8.8.1 I/O Distribution/Video Switch PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	OUT	Bit PA7
E4-E5-E6	OUT	Bit PA6
E7-E8-E9	E8-E9	Bit PA5 X-ray On
E10-E11-E12	E11-E12	Bit PA4 Video Stable
E13-E14-E15	E14-E15	Bit PA3 Store

Adjustment **Floppy Disk Voltage Adjustment**

Adjust R24 on this PCB for +12 VDC between TP19 and TP20.

8.8.2 AD/DA Converter PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Video buffer and sync separator
E4-E5-E6	E5-E6	Buffered Video select
E7-E8-E9	E8-E9	Video Sync Select

Adjustment **Circular blanking**

Vertical	R47, R45
Horizontal	R48, R50

Adjustment **Offset Adjustment**

(Adjust blanking level to 0 VDC)

Left video (P5) offset	R2
Right video (P6) offset	R1

8.8.3 Sync Separator PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Video Source Select

8.8.4 Image Processor PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2	IN	U8 Vertical Reset
E3-E4	IN	Timing Clock Output
E5-E6	IN	U8 Horizontal Reset
E7-E8	IN	A12
E9-E10	IN	A13
E11-E12	IN	A14
E13	OPEN	Ground
E14-E15-E16	E15-E16	No CPU Wait States

Adjustment **Gen-lock Adjustment**

1. Place scope probe on TP27 and TP5 (ground) and adjust C-6 for + 2.5 VDC.

2. Verify that the video is stable and displayed in the center of the circular blanking window.

8.8.5 Disk Interface PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E58-E59	IN	Reset Circuit
E53-E54	OUT	Reset Circuit
E21-E29		
E28-E36	E25-E33	1200 Baud, Front Panel and Mainframe
E37-E45		
E44-E52	E41-E49	1200 Baud, External Ports
E17-E18-E19	E17-E18	DTR handshaking
E55-E56-E57	E56-E57	X-ray disable pullup
E62-E63-E64	E62-E63	DRAM Controller Reset

Disk Interface U8 DIP Switch Settings

(1=on 0=off)
8 7 6 5 4 3 2 1

1	autoboot
0	use DMA
1	50 Hz operation
0	60 Hz operation
0	1024 bytes/sector
x	reserved
0 0 0	Miniscribe HD
0 0 1	Fujitsu
0 1 0	Tandon, IMI, Seagate

8.8.6 Pipeline Filter PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Memory Out Disable

8.8.7 Remote Contrast/Brightness PCB

Set the following jumpers according to the type of monitor installed.

DATA-RAY MONITOR	*ELSTON MONITOR*
E2	E1
E7	E8
E5	E6
E3	E4

8.9 Formatting the Hard Disk

If the Hard Disk requires formatting (after replacement or because of a format problem) follow this procedure:

CAUTION **Formatting the hard disk will erase all data and programs. The monitor cart is then unusable until the software has been recopied from a source floppy disk.**

1. Connect an external computer terminal to the serial communications connector on the rear of the cart. Follow the instructions for using the external keyboard and monitor found in the Appendix.

2. Follow the instructions in the Appendix for installing the external floppy disk drive.

3. Insert the system floppy disk into the floppy drive.

4. Format the hard disk using the following menu sequence:

   (ESC) Select Program Menu
   (Z) Return to Main Menu
   (D) Create Hard Disk System

5. Enter the correct hard disk model, the correct line frequency, and hit the RETURN key. The hard disk will be formatted and system information will be copied to it. This takes about 20 minutes to complete.

6. After the format and copy sequence is complete, turn the video circuit breaker off. Disconnect and remove the floppy drive.

7. Turn the video circuit breaker on again and verify that the system will boot from the hard disk.

8. Enter the model number at the terminal using the following menu sequence:

   (ESC) Select Program menu
   (Z) Return to Main Menu
   (B) Change System Options
   (G) Model Number

9. After entering the correct access code, enter the model number. Access Codes are available by telephoning 800-453-8412.

10. Select (H) Serial Number. After entering the correct access code, enter the serial number of the machine.

11. Exit the main menu (Z) and update the changes made in the last two steps.

SECTION 4
MONITOR CART
THEORY OF OPERATION

This section provides technical descriptions of the hardware and software used in the OEC-Diasonics Mobile C-arm Imaging System. The purpose is to assist the service technician or field engineer in understanding the maintenance and calibration procedures in this manual.

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

The software plays a central role in the operation of the system. Therefore discussion of software is combined with the theory of operation of the hardware in this section.

4.1 Major Components and Options

4.1.1 Major Components

Figure 4-1 is a block diagram showing the major components and some options available on the monitor cart. The major control, data, and address busses within the system are illustrated. The bit width of these busses is indicated in parentheses. The serial links employ subsets of standard RS-232 serial interfaces.

The monitor cart contains the following major components:

Disk Interface PCB - coordinates image and data transfers between the system hard disk and memory; also programs image processing operations.

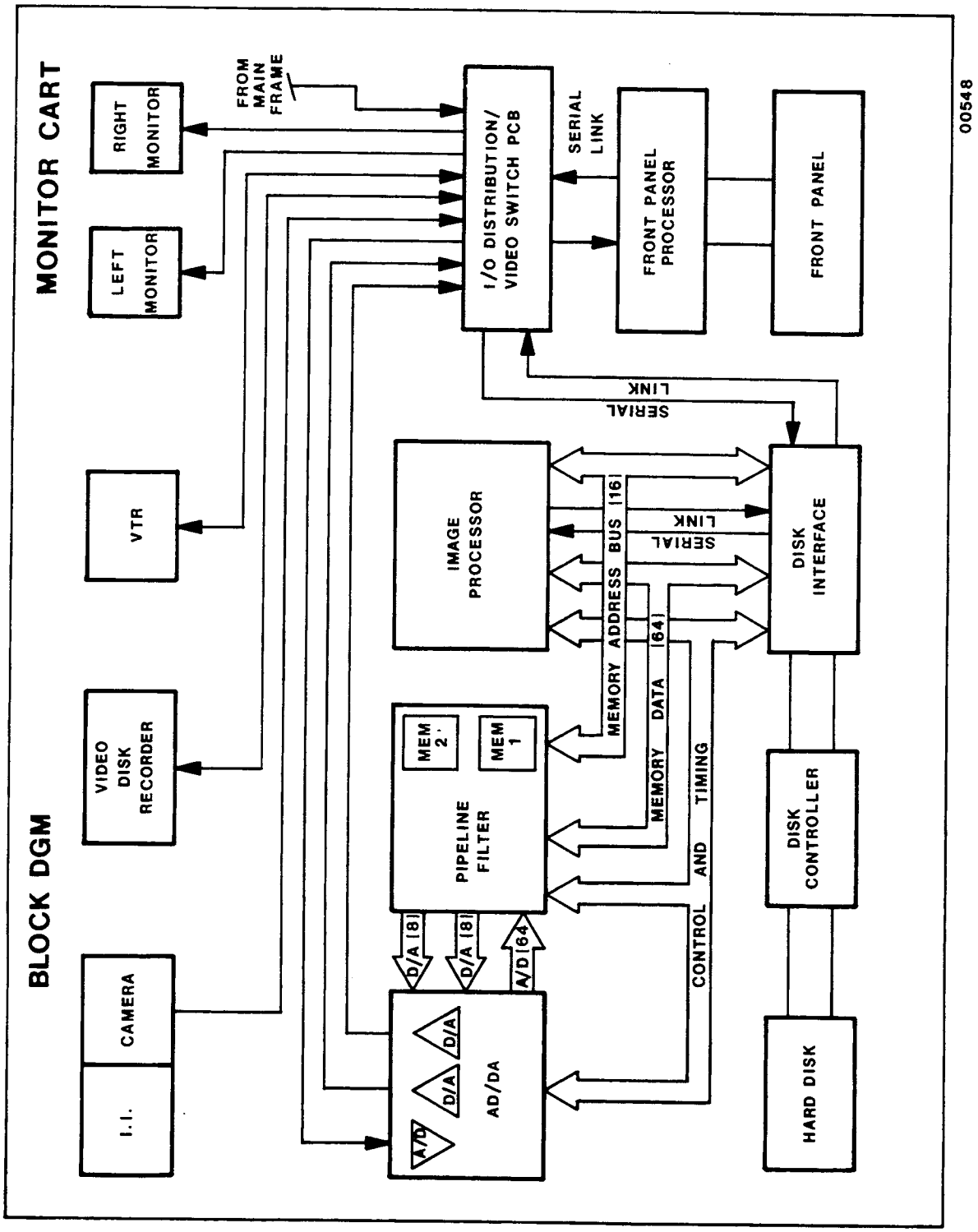
Front Panel Processor Assembly - consists of the control panel switches, LEDs, and the Front Panel Processor PCB.

Image Processor PCB - a board level microcomputer that controls the special functions of the digital processing circuits.

I\O Distribution\Video Switch PCB - controls the distribution of the video inputs and outputs of the image processing circuits.

AD\DA Converter PCB - digitizes the incoming composite video signal for processing and converts the digital image data into a composite video signal for display on the TV monitors.

Figure 4-1 - *Block diagram of the major components of the monitor cart.*



Pipeline Filter PCB - performs algorithms on the digital image data and also contains the image memories.

Disk Controller PCB - an OEM circuit board that controls the hard disk and also controls a floppy disk when connected.

OEM components - which include DC power supplies, the isolation transformer and the two TV monitors.

4.1.2 Image Storage Options

Various options may be installed depending on the system configuration:

Hard disk image storage for up to 60 digitized images.

Video tape recorder for real time storage of the composite video signal.

AngioStor video disk recorder for high resolution storage of video frames.

Multi-format camera to make hard copies of fluoro images.

Patient annotation for identifying and commenting stored images.

4.1.3 Image Processing Options

The major image processing and image storage options can be identified by referring to the front panels shown in Figure 4-2. Model upgrades can be performed by replacing these panels and their associated electronics and software.

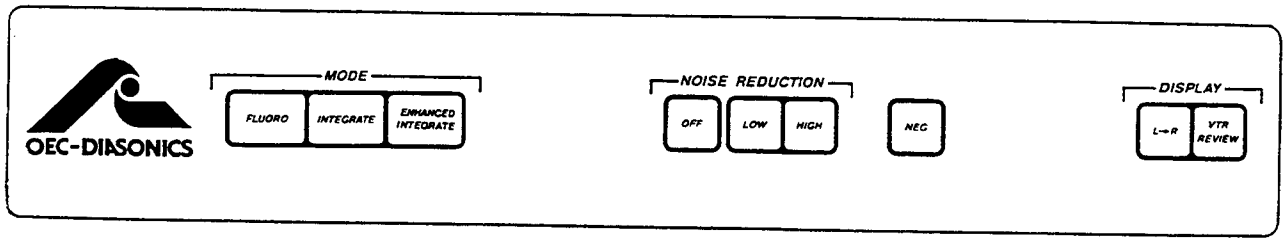
In Figure 4-2 the following panels are identified:

1 - Basic 9000 system

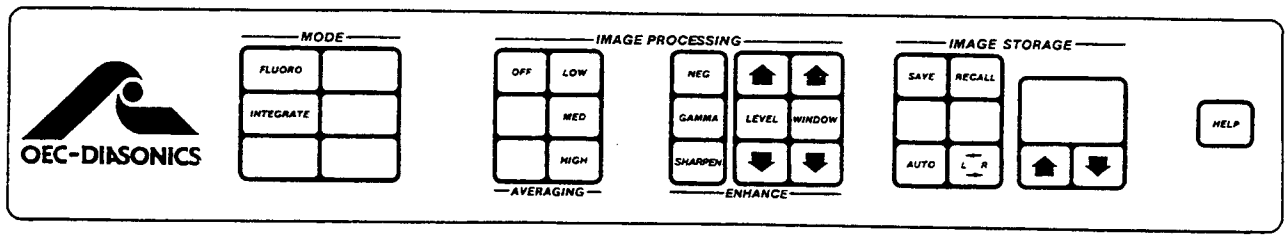
2 - Expanded Surgical Package

3 - Expanded Surgical Package with Vascular or Neurovascular Options

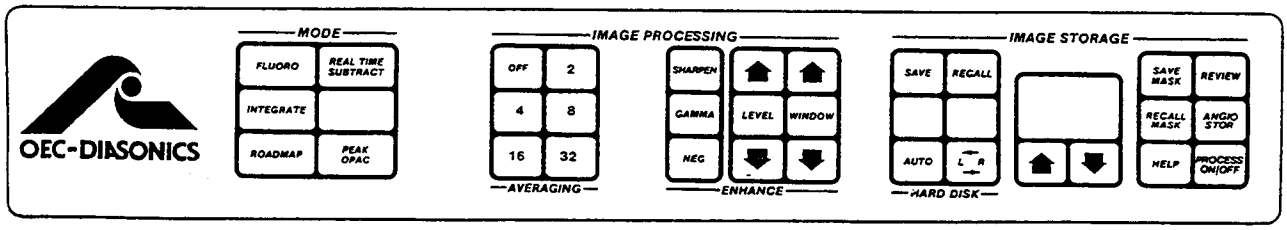
Figure 4-2 - *The major image processing options can be identified by their different front panels.*



1



2



3

4.1.4 Major Connections

Interconnect Cable

Refer to Drawing 00-870735.

The interconnect cable provides AC power to the mainframe, control communications between the mainframe and monitor cart and the video signal to the monitor cart. This is described further in the *Mainframe Theory of Operation.*

Other Connections

The following tables describe the connectors located on the interface panel on the rear of the monitor cart.

Table 1 RS232 Connector

PIN	*SIGNAL*
3	RXD
5	TXD
7	RTS
9	CTS
11	DSR
13	COM
14	DTR
15	DCD

Table 2 AUX Connector

PIN	*SIGNAL*
3	spare
5	stop
7	record
9	search
10	VTR clock
11	pause
12	ground
13	play
14	ground
15	f. forward
16	ground
17	reverse
18	ground
20	ground
22	ground
24	ground

Table 3 **VTR - J34**

PIN	*SIGNAL*
3	shield
4	video to VTR
2	video from VTR
6	shield

Table 4 **Video Out**

PIN	*SIGNAL*
J36	video out 1
J35	video out 2

Table 5 **Video Disk J37**

PIN	*SIGNAL*
1	record enable
5	ground
4	video to AngioStor
3	shield
2	video from AngioStor
6	shield
8	composite sync
7	shield

4.2 Power Distribution

AC Power Input power is supplied via the isolation transformer T1 located in the base of the monitor cart assembly. Taps on the primary and secondary windings of T1 allow system connection to various line source voltages.

DC Power DC voltages for circuit board operation (+5, -5, +/- 15 VDC) are obtained from the switching power supply located on the side of the card rack.

A 24 VDC supply in the base of the monitor cart supplies power to the tv monitors.

4.3 Monitor cart operation

4.3.1 Image Processing Functions

The image processing functions, selected from the front panel, may include the following, depending on system options and model:

Averaging Real-time video frame averaging is used to improve signal to noise ratio and reduce motion artifacts. A running average is calculated for each pixel to be displayed. The average can be obtained over a variable number of frames: 2, 4, 8, 16, 32. Noise and motions which are not correlated with structures in the image are averaged out. Since it is a real-time average, the pixel values used in the calculation are constantly changing and the average is recalculated each time a new frame is added.

Integration Frame integration is similar to frame averaging. The main difference is that integration stops after a specific number of frames have been averaged. The last image displayed when integrating results from averaging the previous frames.

Real-time Subtraction Real-time subtraction allows successive images to be subtracted from a mask image. Perfect subtraction results in a gray-scale value which is off-set to 80 Hex, a mid-range gray.

Roadmapping Roadmapping is similar to real time subtraction, but the mask image is negated and reused for successive subtractions until another mode of processing is selected.

Peak Opacification Peak Opacification can be performed on successive frames. The darkest value for each pixel in the image is saved and displayed.

Gamma The gamma function maps the gray scale range as an exponential function. This results in a compression of the dynamic range when dealing with an image where the brightness range is large. Linear gray scale mapping is used when gamma is not enabled.

Sharpen Image sharpening is achieved by an algorithm which emphasizes image edges. This process involves translations of horizontal and vertical pixel locations. The circuitry to perform these translational movements is divided between the Image Processor PCB and the Recursive Filter PCB. This requires executing an algorithm which shifts the image a certain number of pixels in the X axis and a number of lines in the Y axis. The Y shift is set by changing the beginning pixel address generated by the address counters on the Image Processor PCB.

Window and Level Window and Level controls are used to remap the gray scale to upper and lower portions of the gray range and to alter the slope of the video transfer function. These are analogous to contrast and brightness controls.

Subtraction With Averaging and Peak Opacification Averaging and peak opacification can be selected from the front panel for use during real time subtraction and roadmapping. These are applied selectively during the mask and subtraction phases as shown below:

	REAL TIME SUB		ROADMAPPING	
PHASE	*MASK*	*SUB*	*MASK*	*SUB*
AVG		X		X
		or		
PK OPAC		X	X	

4.3.2 Image Memories

The fluoro image is transferred between several memories during processing. These memories are described below:

Segment Ram Sixteen kbytes of static ram located on the Disk Interface PCB are used to read and write segments of data to the Pipeline Filter memory from the hard disk. The 16 kbytes translates to the monitor as an image segment 32 lines down x 512 pixels across. Only Pipeline Filter memory M1 can be written to or read from via the segment ram.

Pipeline Filter Memory 512 kbytes of ram is mapped into two pairs of memory (M1 and M2) for a total of four 128 kbytes image frames.

Image Frame Each 128 kbyte memory frame is large enough to store a 512 x 512 byte image. Whichever frame is currently mapped to the monitor is considered the foreground frame, while the other 128k block is the background frame. The Image Processor can switch the address lines so that these memory blocks exchange roles.

DRAM 64 kbytes of dynamic ram located on the Disk Interface PCB is not used for image storage but is where the system software resides after boot-up.

4.3.3 Serial Links Between Boards

Monitor Cart-Mainframe The serial communications port between the monitor cart and the mainframe uses hardware handshaking and operates at 9600 baud.

I.P. - Disk Interface Serial communications between the Disk Interface PCB and the Image Processor PCB operates at 1200 baud and supports XON/XOFF handshaking. The Image Processor also has a 128 byte buffer for this port.

Front Panel - Disk Interface PCB Serial communications between the Front Panel Processor and the Disk Interface PCB operates at 1200 baud and supports XON/XOFF handshaking.

4.4 Monitor Cart Software

The monitor cart software can be divided into three major functional areas:

1. Main program software
2. Image processing software
3. Front Panel software

4.4.1 Main Program Software

The main program consists of system operating software and application programs which are stored on the hard disk and loaded into the Disk Interface board DRAM for execution. The transfer occurs during the monitor cart booting process and is directed by a smaller program in EPROM on the Disk Interface PCB. When executed by the processor on the Disk Interface PCB, the application program issues commands to the other processors on the Image Processor and Front Panel Processor PCB's. The operation of the I/O Distribution - Video Switching PCB is also controlled by the main program.

4.4.2 Image Processing Software

This software resides in EPROM on the Image Processor PCB and controls the operation of the Pipeline Filter and Image Processor PCB's. For some processing applications it receives function calls from the application program running on the Disk Interface PCB.

4.4.3 Front Panel Software

The Front Panel Processor PCB executes a program which resides in EPROM. It scans the front panel keys and sends the scan codes to the application program for interpretation. The application program, in turn, issues commands to the Front Panel Processor PCB to update the LEDs and the alphanumeric display on the front panel. The Front Panel Processor PCB also sends commands to the Disk Interface PCB for image processing selection.

4.4.4 System Initialization

When power is first applied, each microprocessor starts an initialization or "boot" sequence by executing software code which resides in EPROM.

Disk Interface Initialization: Commands are issued to the Disk Controller PCB, via a parallel port on the Disk Interface PCB, to read the first sector from the hard disk into memory. If a floppy disk drive is installed during service procedures, the first sector of the floppy disk will be read instead.

If the disk read operation is unsuccessful, an error message is issued to the AUX port, which may be read on an external terminal during service procedures. The system then enters the monitor program, contained in EPROM on the Disk Interface PCB.

The code read from the first sector directs the transfer of the rest of the operating system into memory and transfers control to the Disk Operating System. The function of the Disk Operating System is to load various utilities, diagnostic, and application programs into RAM for execution. In normal operation, the Disk Operating System then executes the application program.

Image Processor Initialization: The monitors are cleared, gray scale and log table RAM's are loaded on the AD/DA and Pipeline Filter PCB's, and communication ports are initialized. The Image Processor PCB then waits for function calls from the Disk Interface PCB, and Front Panel commands.

Front Panel Processor Initialization: The Front Panel Processor initialization consists of clearing all I/O ports to turn off all LEDs. It then begins scanning the keyboard and multiplexing the LEDs. Commands are exchanged with the Disk Interface PCB through a serial data interface.

4.5 Monitor Cart Electronics

4.5.1 Disk Interface PCB

Refer to Figure 4-3 and Schematic 00-870013.

The Disk Interface PCB is a Z80-based board level computer. Its main tasks are to load and execute the disk operating system and applications software from the hard disk and to control image transfers between the hard disk and memory. Data transfers between the hard disk and memory are accomplished via the Disk Controller PCB. Handshaking occurs between the Disk Interface and Disk Controller PCBs to control the data transfer with the hard disk.

The Disk Interface PCB communicates with the Front Panel Processor PCB, with the Image Processor PCB, and with the main frame X-ray Processor PCB via RS 232 serial data links. The Front Panel Processor PCB reads the switch panel and passes the data to the Disk Interface PCB. The Disk Interface PCB then selects the appropriate image processing program segment and sends it to the Image Processor PCB.

CPU

The CPU, U60 is a Z80A. It uses an 8-bit data bus and 16-bit address bus.

The CPU is reset in either of three ways:

1. At power-up, by the charge time of C137 through R20.

2. On manual reset, during tests and adjustment of the system. Closing S1 discharges C137, and allows it to recharge through R20.

3. By the watchdog timer, U75, when its Q7 output goes active (high).

Watchdog Timer

In order to prevent the watchdog timer from resetting the CPU during normal operations, the CPU periodically resets counter U75 via I/O 4 (U77E).

DMA Controller

The direct memory access (DMA) controller, U59, emulates the Z-80 CPU during fast data transfers. Wait requests from the DRAM controller are applied to U80-10 when the controller forces an internal refresh. The DMA can perform memory to memory, and memory to I/O transfers at a rate of up to one megabyte per second.

Multiplexer U67 selects either the wait state or I/O 70 as the chip enable input to the DMA based upon the state of the BUSAK control signal. When the BUSAK output from the Z-80 is low, the output of the wait-state generator (U78C-8) is applied to the DMA controller U59. During DMA accesses, the interrupt line is pulsed periodically by the DMA controller (U59). These are gated through U79C to provide a reset to the watchdog timer, preventing it from timing out. Since the CPU is held in the wait state by the output from U78C, it does not sense the interrupt pulses from the DMA.

Programmable Counter and Baud Rate Generator

Counter timer circuit (CTC) U61 contains three independently programmable counters. The output of counter "0" provides a non-maskable interrupt to the CPU.

Counter "1" provides a software controllable baud rate clock to the auxiliary serial communications port U30. Counter "2" provides a standard baud rate clock (307.2 kHz) to counter U52.

Counter U52 is operated as an 8-bit binary counter. It provides output clock signals for baud rates of 9600, 4800, 2400, 1200, 600, 300, 150, and 75. (The actual clock signal is 16-times the Baud rate.) The outputs of U52 are configured with jumpers so that two separate baud rates can be selected, EE to serial communications port U31, and FF to serial communications port U30.

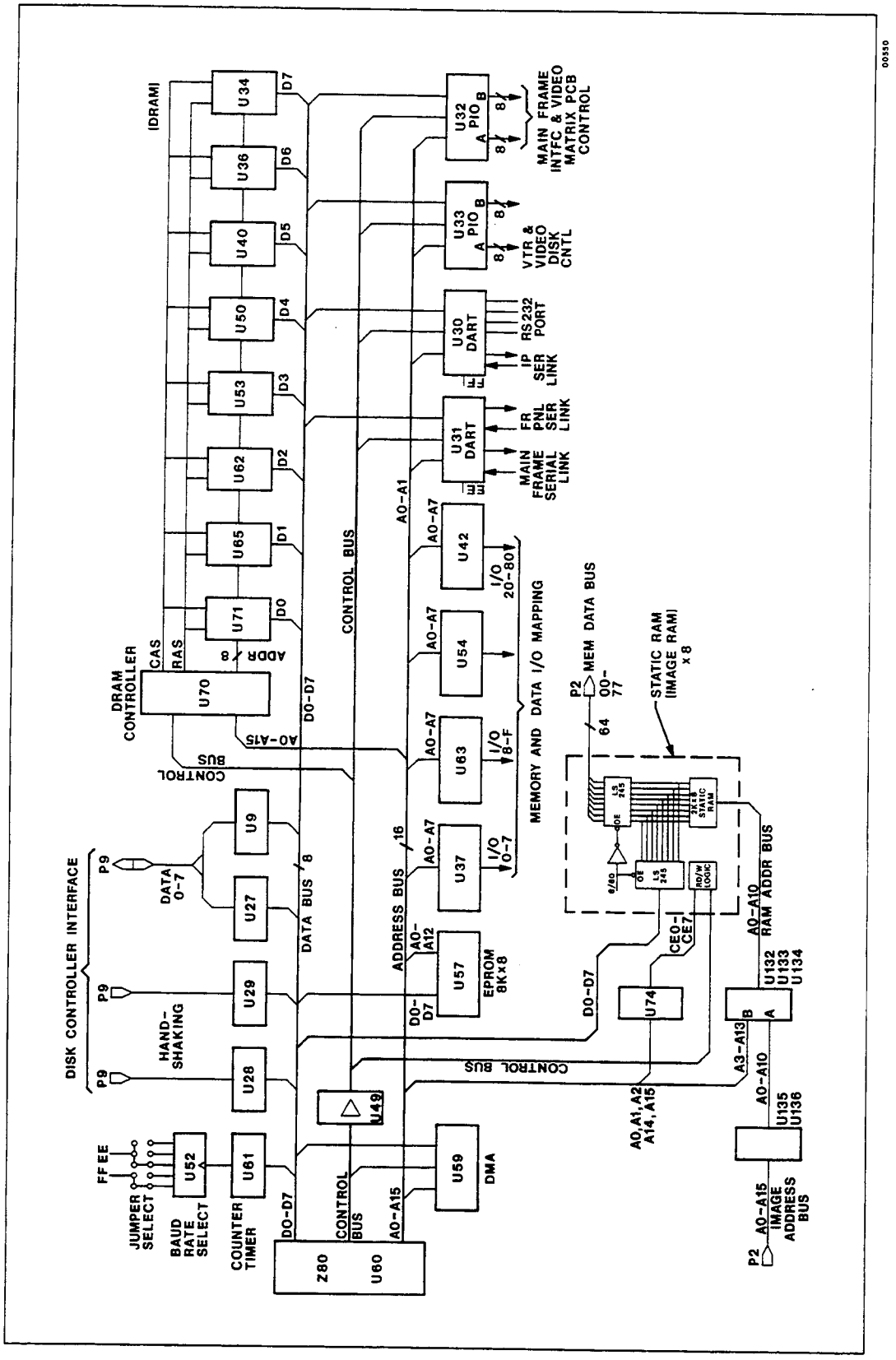
Disk Controller Interface

Communications between the Disk Interface PCB and the Disk Controller PCB is via bi-directional open-collector TTL lines. The open-collector lines are balanced with 220 ohm pull-up resistors to +5V, and 330 ohm pull-down resistors to ground. All control signals between the two devices are active low.

For DMA writes to the Disk Controller PCB, the D0-7 bits on the internal data bus are clocked into U27 by the negative true I/O 2. For DMA reads of data from the Disk Controller PCB, the input DATA 0-7 bits are enabled through buffer U9 by the negative true I/O 3.

The handshake function is provided by flip-flop U1A and gates U12A and U23C. This circuit provides an automatic acknowledge every time the DMA writes a data byte to, or reads a data byte from the Disk Controller PCB.

Figure 4-3 - *Block diagram of the Disk Interface PCB.*



Boot PROM

The boot PROM (U57) occupies memory space from "0" to "1FFF" (HEX), and is controlled by the memory map I/O circuit. The boot PROM contains the program necessary to load the disk operating system from the hard disk into RAM. Execution then jumps to the newly located code in the disk operating system program. The boot PROM is disabled until the next time the system is reset.

Parallel Interface

Parallel interface is provided by two Z80 PIO's, U32 and U33. U32 port A is assigned as the interface for data to and from the mainframe, U32 port B interfaces various functions such as X-RAY ON AND DISABLE/, SWITCH DATA, SWITCH CLOCK, SWITCH LATCH, IM- REQ/, TIMER and VERT INT. Bit 7, VERT INT, is dedicated to the vertical reset which provides a 60 Hz clock to allow the system to synchronize any necessary software functions to the vertical field rate of the imaging system. U33 port A is assigned as a VTR remote control interface. U33 port B is assigned to an auxiliary device output connector and serves as a printer port.

Memory Map

The memory map circuit consists of memory chip enable PROM U39, the flip-flops of U38 and gate U43C. There are three memory spaces on the Disk I/O Interface PCB. The three memory spaces are occupied by:

* 8k x 8 boot PROM
* 16k x 8 image memory, static RAM
* 64k x 8 DRAM

When I/O 6 is asserted true, U38B is set and U39 selects the DRAM for the entire 64k memory space. When I/O 7 is asserted, U38A is set, the 80/8 signal is high and U39 enables the lower 16K memory space as image memory in the 8-bit wide mode, and the remaining memory space is dedicated to the DRAM. In all configurations of the memory map, the DRAM occupies the block of memory address space above that used by either the boot PROM or the image memory.

When the image RAM is not selected, and thus not mapped into the addressable memory, the DRAM is configured in the 64-bit wide mode and is available for data transactions with the image memory data bus.

I/O Decoders

The data and memory mapping I/O signals for the Disk Controller PCB are decoded by PROMs U37, U42, U54, and U63. The I/O decoder PROMs are enabled when the IORQ/ signal is true and the inverted M1/ output of U45D is low; and they are addressed by the A0-7 address bus bits.

Image Memory

Depending on the state of the 80/8 signal, the image memory RAMs are either connected in parallel with the 64-bit wide image memory bus, or connected sequentially with the Z80 data bus.

Memory Control Logic

When the system is in the 80-wide mode, it is reading 64 bits at a time. When in the 8-bit wide mode, 8-bit pixels are read in sequential order. PROM U74 provides chip enable signals based on this system status. In the 80-wide mode CE0-7 are issued simultaneously. In the 8-bit mode, CE0-7 are issued sequentially when memory is being accessed by the Z-80 DMA. Addresses are selected by multiplexers U132/133/134 from the internal address bits A3-A13 and the system image address bits A0-A10.

Image transfer from buffer to system image memory is implemented in hardware. The Z80 determines and preloads a segment number of the image (there are 16 segments in an image). The segment number is held in latch U81 and compared with the image address bus A11-A14. When the two are equal, a high level is asserted at U97-6 (OUT). The OUT signal triggers the circuits for reading or writing an entire segment to the main image-memory.

The Image Processor PCB controls the main image-memory data by providing RAS, CAS, READ ENABLE, WRITE ENABLE, and address control.

DRAM

The 64k x 8 dynamic RAM section consists of the eight 64k x 1 RAMs U34-/36/40/50/53/62/65/71. U70 is a TMS4500A dynamic RAM controller. U70 generates all of the RAS and CAS signals, and multiplexes the A0-15 address bits. It also provides refresh and arbitration logic to the DRAM's.

U70 is enabled or disabled by the memory mapping circuit via U77D and U68B. U70 is clocked by the 8 MHz clock signal so it can generate RAS and CAS pulses with adequate system timing for the DRAMs to be accessed without wait states.

Serial Communications

Serial communications occur via two dual asynchronous receiver /transmitters (DARTs) U30 and U31.

Channel A of U31 is a buffered serial RS-232 port dedicated to two-way communications with the mainframe X-ray Processor PCB. Channel B of U31 is TTL open-collector buffered, serial RS-232 port, dedicated to two-way communications with the Front Panel Processor PCB.

Channel A of U30 is a buffered TTL serial RS-232 port, dedicated to two-way communications with the Image Processor PCB. Channel B of U30 is a buffered serial RS-232 port with selectable baud rate, for two-way communications with an external terminal.

4.5.2 Front Panel Processor Assembly

Refer to Schematic No. 870507 and Figure 4-4.

The Front Panel Processor Assembly consists of the following:

* Front Panel Processor PCB, No 00-870507
* Overlay, Front Panel, SCD No. 00-870481
* LED Display PCB, Schematic No 00-870392

The Front Panel Processor Assembly provides the interface between the touch-sensitive membrane switches of the monitor cart front panel and the Disk Interface PCB. It senses front panel switch closures and reports the results to the Disk Interface PCB, which in turn provides commands to the Front Panel Processor to drive the LED indicators, the two digit numeric display, and the beeper.

Front Panel Processor PCB

Refer to Figure 4-5.

The Front Panel Processor PCB is based on the Z8 microcomputer, U20, a Z8682. The Z8682 data bus is multiplexed with the lower A0-A7 address bits. Demultiplexing of the AD bus is achieved by latch U3.

Processor I/O Ports

Communications between the Front Panel Processor PCB and the Disk Interface PCB takes place over a serial RS-232 link. U20 can be programmed to function as a universal asynchronous receiver/transmitter (UART) for serial RS-232 data by using its built-in I/O ports P3-0 and P3-7. The internal UART baud rate clock is software controlled and is generated by one of two timers that are part of U20.

Clock Generator

The clock signal for U20 is derived from 8 MHz crystal Y1.

Program Storage

Program storage is provided by the 4K x 8 EPROM U13. U12 is an 8 2K RAM.

LEDs and Alphanumeric Display

The LED indicators and the two numeric displays are driven by a time-multiplexed refresh technique. Each LED is associated with a position in an 8 x 8 matrix. The position within the matrix is determined by a row number (R0 - R7) and a column number (C0 - C7). To light a particular LED, both of its associated row and column drivers must be on.

The row driver U10, consists if eight common emitter current sources. The contents of the row register U9 control the row drivers of U10. A high output from U9 turns its associated row driver on; a low output turns its driver off, placing the outputs of U9 in the high Z state. A high applied to U9-1 (OE) also disables the row drivers of U10.

The column drivers of U7 and U5 are open-collector inverting drivers. They are controlled by the outputs of column register U14. A high output from U14 turns its associated column driver on (low impedance to ground); a low outputs turns its driver off.

The outputs from the LED drivers are connected with the LED Display PCB via connectors P27 (column bits C0-C7) and P28 (row bits R0-R7).

If the LED refresh fails, the LEDs are protected by the watchdog timer U4A, which will turn off all of the row drivers, setting the outputs of U9 to the high Z state.

Figure 4-4 - *Block diagram of the Front Panel Assembly.*

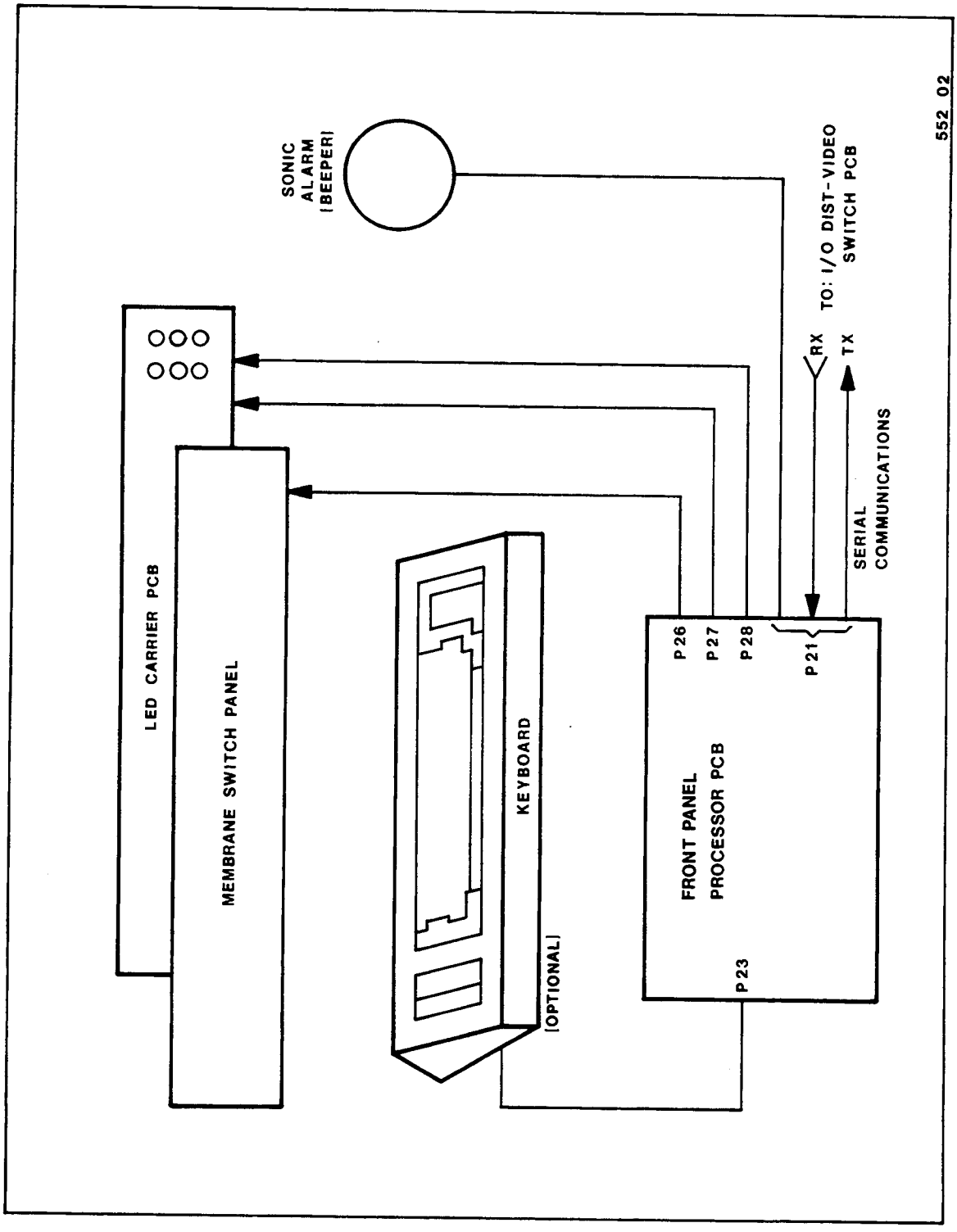
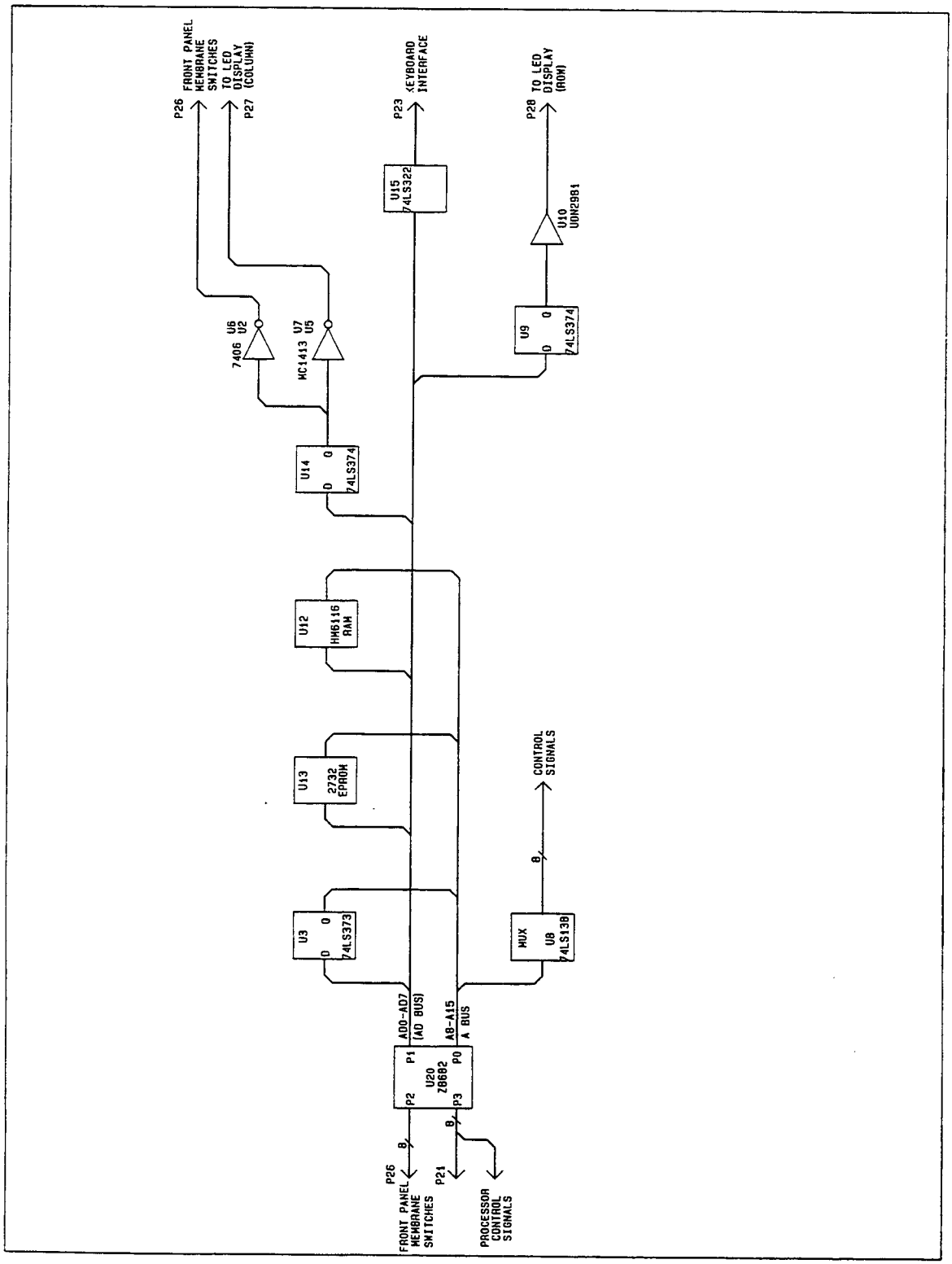


Figure 4-5 - *Block diagram of the Front Panel Processor PCB.*



Beeper (Sonic Alarm) Driver

The beeper is driven by the P3-5 output of U20-10. A high level output at U20-10 turns the driver U5G on, providing a return path to ground for the device.

Front Panel Switch Matrix

The switches on the front panel are arranged in a matrix similar to the LED matrix. Each switch is identified by a row and column number. The switch matrix is scanned using a time-multiplexed technique.

Optional Keyboard Interface

P23 provides a connection for the optional keyboard used for patient annotation. Three signals are required for keyboard operation: KBDATA, KBCLK, and RESET.

4.5.3 Image Processor PCB

Refer to Figures 4-6 and Schematic 00-870388.

The Image Processor PCB is a Z80 based board level computer which controls the operation of the I/O Distribution/Video Switch PCB, AD/DA Converter PCB and Pipeline Filter PCB, and executes data transfers with the 64-bit system memory bus. It communicates with the Disk Interface PCB via an RS-232 serial data link and the system control bus. The image processing program-segment is received from the Disk Interface PCB via the serial link.

Reset

The CPU can be reset by the EXT RESET/ signal. A low level is applied to the RESET input of the CPU, U80.

Data Bus

The Image Processor PCB has two internal data buses: a bidirectional data bus (to/from the CPU) identified by D0-D7 and a uni-directional bus (from the CPU) identified by DB0-DB7.

The D0-D7 internal bus interfaces data with the PROM, the Serial Timer and Interrupt Controller, and the RAMs. The 8-bit internal data bus is interfaced with the 64 bit memory data bus by latches U100 - U107 and U110 - U117.

The unidirectional internal data bus (BD0-BD7) is interfaced with the bidirectional data bus through 8-bit buffer U109. The data on the BD0-BD7 internal bus is applied directly to the system control bus through pins 1-8 of connector P3, the daisy-chained ribbon cable. The system control data bus is used to write log-RAM and processing control data to registers on the Pipeline Filter PCB. Grayscale-RAM data is also written to the AD/DA PCB from the Image Processor PCB.

Memory Data Bus

The 64-bit wide image-memory bus is read and written to by latches U110-U117 and U100-U107. The read and write data transfers between the latches and the memory data bus are controlled by the RMD (read memory data) and EMD (enable memory data) signals. The sequential transfer of data in 8-bit bytes between the latches and the internal data buses D0-D7 and DB0-DB7 is determined by the sequence of the OUT 00-07 and IN 00-07 signals from the I/O port decoders.

Memory Addressing

Latches U95 and U96 multiplex the 8-bit BD data bus onto the 16-bit memory address bus. U95 and U96 are also used to initialize the address counters U84, U85, U88, and U89.

Edge Enhancement Pixel Shift

Address counters may be initialized with an offset count which produces a line shift in the vertical image axis. This is used by the edge enhancement algorithm when combined with the horizontal axis shifting performed on the Pipeline Filter PCB.

PROMS

Programming on the Image Processor PCB resides in the PROM U50 (2764). This PROM based software directs much of the image processing on the Pipeline Filter PCB.

RAM

The Image Processor PCB has three 2K X 8 static RAMs, U31, U32, U51. These RAMs serve as a scratch pad memory for the CPU.

Serial Timer and Interrupt Controller

U73 provides a serial RS-232 data link with the Disk Interface PCB and the Front Panel Processor PCB. Data received over this link includes function calls from the Disk Interface PCB and scan codes from the Front Panel.

Memory Control Logic

The memory control logic is synchronized to the video rates by composite blanking (C BLANK, H-rate) and vertical drive (VR DRV, V-rate).

Video Sync Generator

Refer to Figure 4-7 and Schematic 00-870388.

The 82 MHz clock signal produced by VCO U5 is applied to a binary divider which provides three outputs: 10.25 MHz (PC1), 5.125 MHz (PC2), and 2.58 MHz. The 2.58 MHz signal is applied as the clock input to TV sync generator U8 which in turn provides five TV signal outputs: C SYNC, C BLANK, HR DRV, VR DRV, and an even field signal E FLD. These signals are synchronized with the incoming video signal through the phase comparator circuit U3, Q2 and U4. Adjustment of C6 changes the frequency of the VCO until the incoming video rate and the U8 video rate are in phase.

Figure 4-6 - *Block diagram of the Image Processor PCB.*

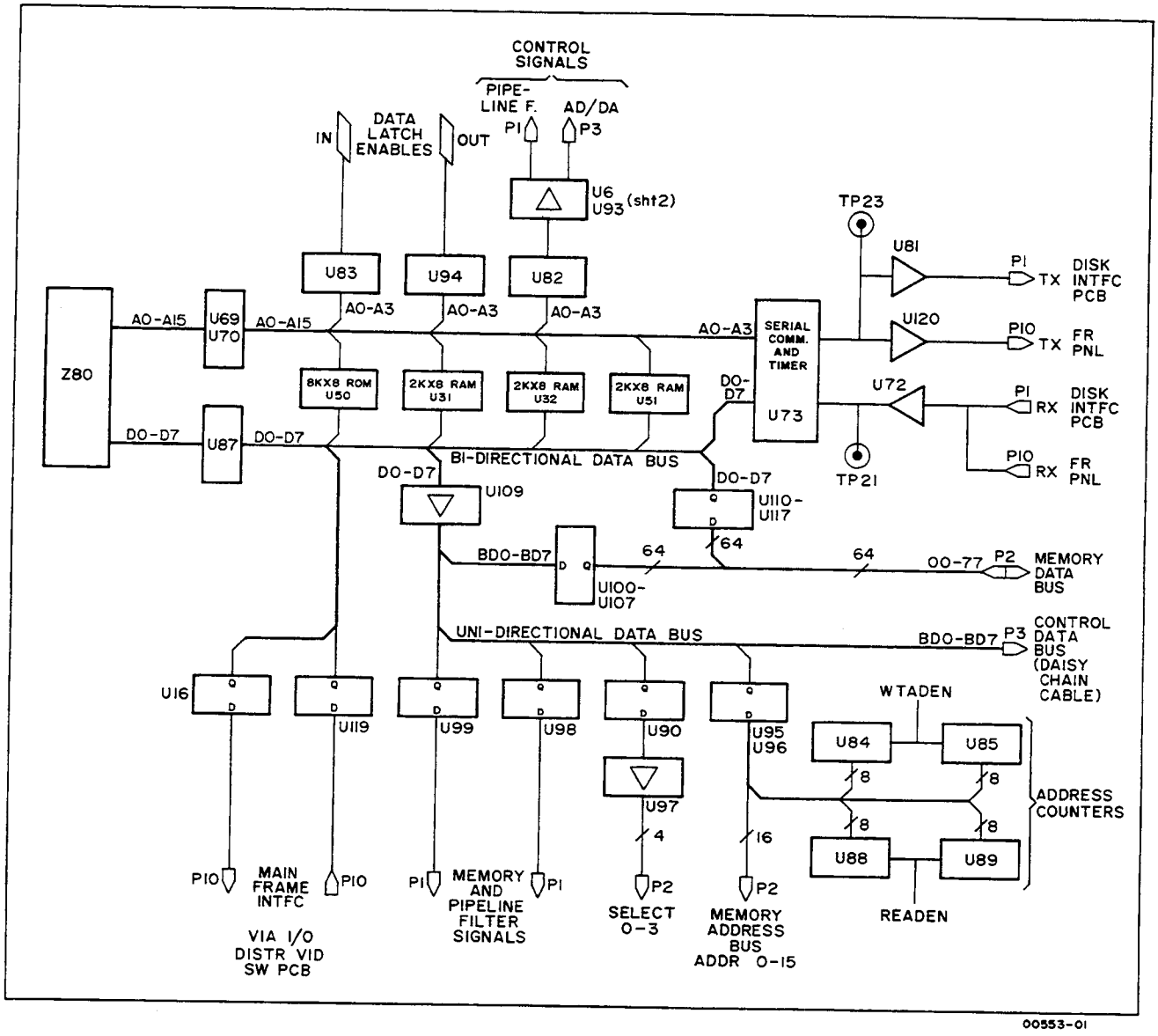
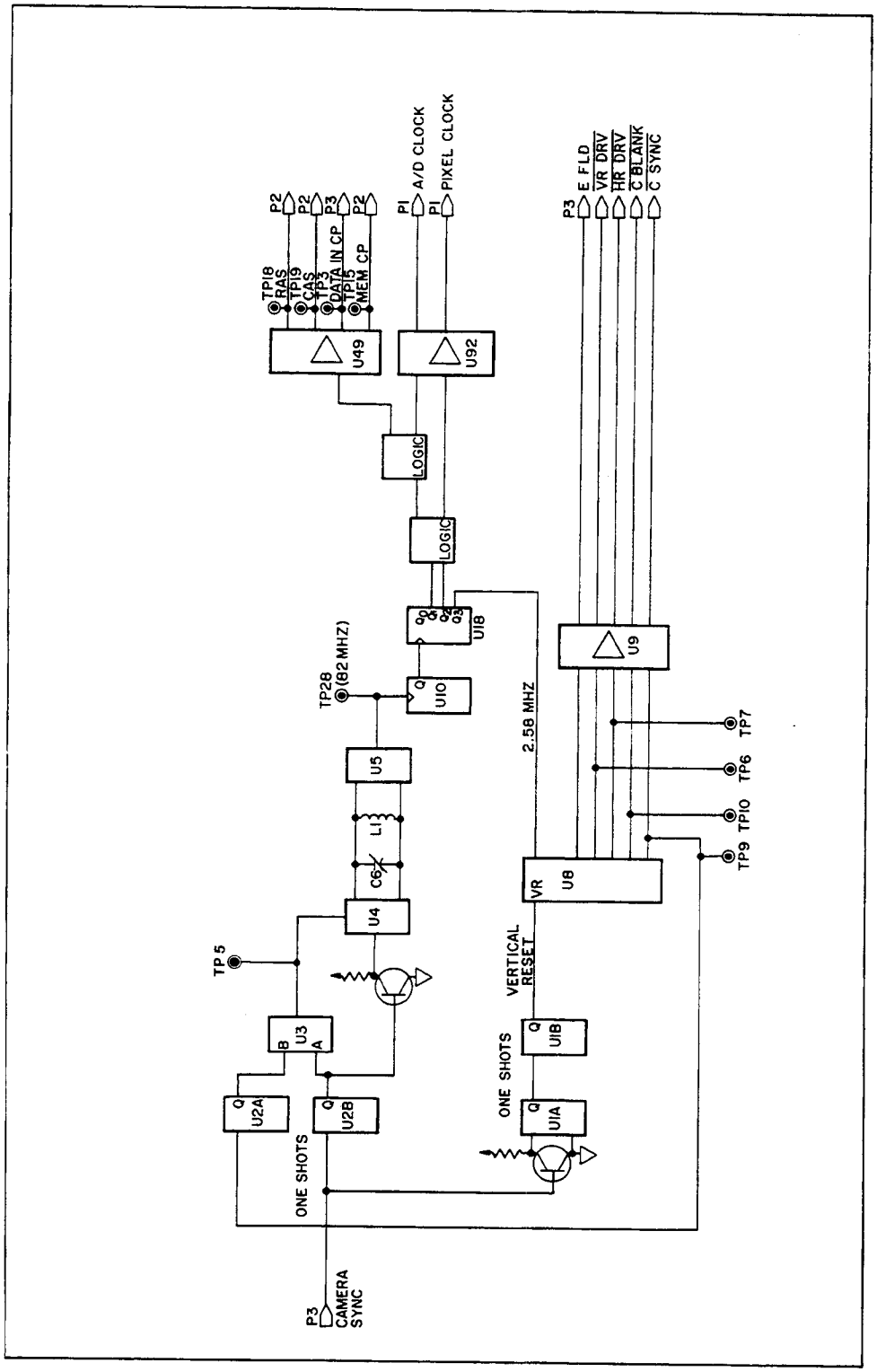


Figure 4-7 - *Block diagram of the Image Processor PCB, Video Sync Circuit.*



4.5.4 I/O Distribution/Video Switch PCB

Refer to Figure 4-8 and Schematic 00-870185.

The I/O Distribution/Video Switch PCB contains five primary circuits:

* Voltage Regulator Circuit
* Connector Interface Circuit
* Control Word Serial-to-Parallel Shift Register
* Video Switching Relay Matrix Circuit
* Video Buffer/Driver Circuit.

Voltage Regulator

Potentiometer R24 is adjusted so that the output of VR1 (TP19) provides +12 VDC at the input connector to the hard disk drive assembly.

Other DC inputs on the PCB are: +5 VDC, -5 VDC, -15 VDC, and the switched +5 VDC which is applied to the switching relays.

Connector Interface

The connector interface allows routing a number of mainframe control signals to the Disk Interface PCB where they are used to coordinate image processing with X-ray exposures.

Control Word Shift Register

U7 through U10 comprise a 16-bit serial-to-parallel shift register for the switching relay matrix control word. The word is latched at the outputs of U7 and U8 as a 16-bit wide parallel word and is applied to inverting buffers U1-U4. Each inverter output drives an associated video switching relay. Note that some of the relays are normally open and some are normally closed.

Switching Relay Matrix

Note: Only the following relays are installed:

K1, K4, K7, K8, K10, K15, K16, K18, K19, K20, K24, K25, K28, K30, K31.

There are five possible video sources in the imaging system:

* Camera (live video)
* Left D/A channel
* Right D/A channel
* VTR option
* AngioStor option

There are six possible video destinations:

* A/D converter (for digital processing)
* left monitor
* right monitor
* VTR
* AngioStor
* VIDEO OUT 1 and 2, BNC connectors on the monitor cart rear panel.

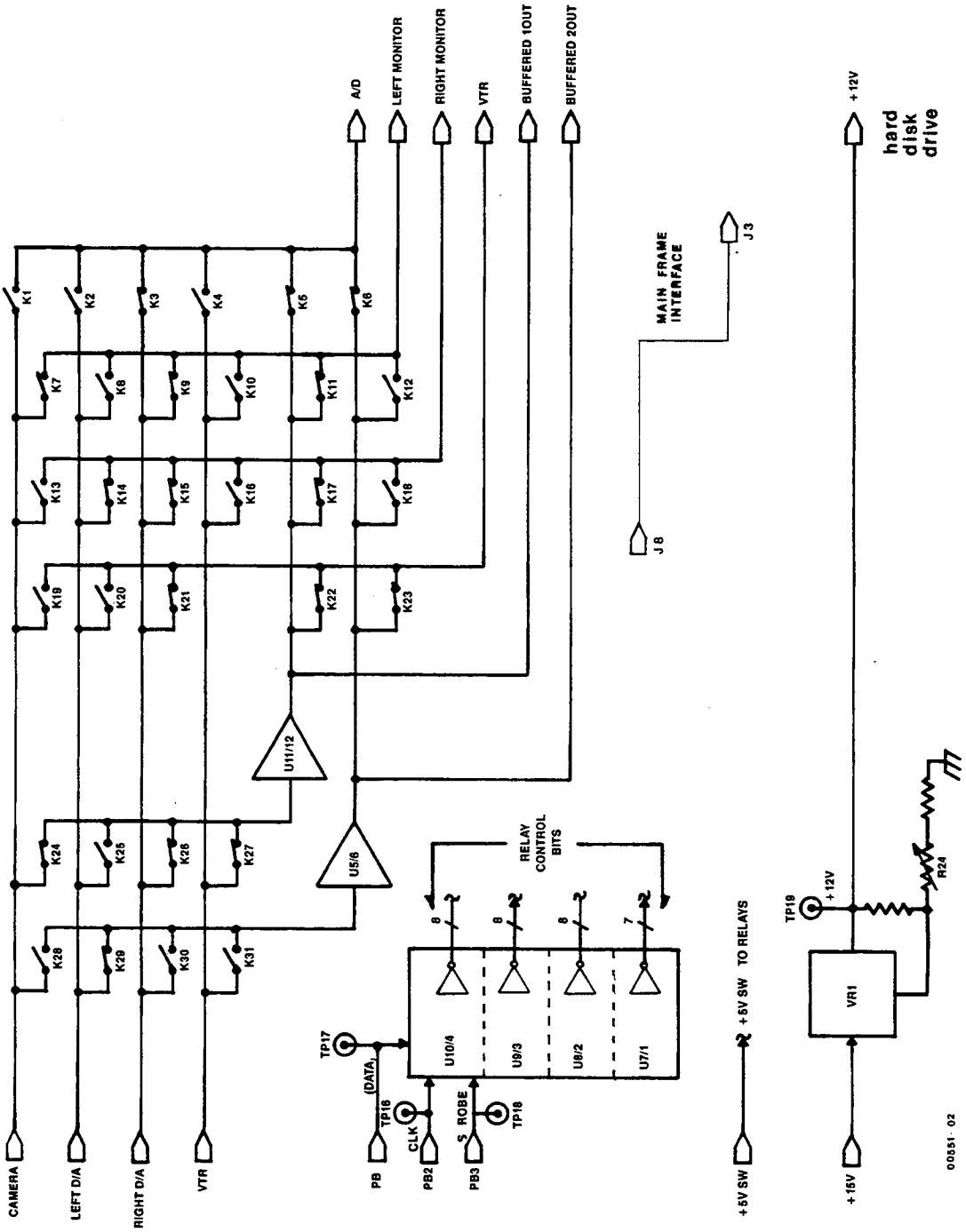
Note that the camera (live) video output is applied directly to the input of the AD/DA Converter PCB, but to the VTR through a buffer. This circuit configuration prevents double termination of the camera video output. The software control of the relays prevents undesirable double termination of any of the video sources. The video output of the VTR can be selected through K4 and applied to the analog input of the AD/DA Converter PCB and processed in the same manner as the camera video.

AngioStor Interface

Refer to Schematic 00-870543.

Additional video buffering and sync circuitry for the AngioStor disk recorder is provided by the piggy-back PCB installed on the right side of the I/O Distribution-Video Switching PCB. Refer to the *Options* section of this manual.

Figure 4-8 - *Block diagram of the I/O Distribution Video Switch PCB.*



4.5.5 AD/DA Converter PCB

Refer to Figures 4-9, 4-10 and Schematic 00-860896.

The AD/DA Converter PCB contains circuits that perform the following functions:

1. Conversion of the incoming composite video from the I/O Distribution/Video Switch PCB to digital data which is then available to the Pipeline Filter PCB on the 64 bit wide A/D bus.
2. Generation of a circular blanking window.
3. Subtraction of two separate images (D/A OUT 1 and D/A OUT 2, from the Pipeline Filter PCB) from each other.
4. Detection and removal of the sync pulses from incoming video signal.
5. Gray scale correction of the digital data output from the Pipeline Filter PCB.
6. Conversion of the digital image-data from the Pipeline Filter PCB into a composite analog video signal which is routed through the I/O Distribution/Video Switch PCB for display on the TV monitors.

A/D Conversion

The incoming video signal is AC coupled to buffer Q2. The Q2 output is applied to comparator U19 which is biased to strip the inverted sync signal. The video signal is amplified by U18, and a porch is added by clamping the output to ground before the C-SYNC pulse. The clamped video signal is buffered through U33 and applied to the analog input of A/D converter U32 and also to analog mux U24 for raw display.

The analog input to U32 is converted into 8 bit data words at the 10 mHz clock rate of the A/D CLOCK signal and is applied to 8-bit tri-state buffer U54. The outputs of U54 are enabled only during the video window of the circular blanking signal (CIRC BLANK/).

Circular Blanking

U28a and U29a produce a ramping voltage, reset at the CSYNC rate, which is applied through U73a to the input of multiplier U34. Similarly, U29b and U28b produce a ramp, reset at the vertical rate, which is applied through U73b to the input of multiplier U35.

The outputs of U34 and U35 are parabolas which are then applied to the summing node of U36. The result, at the output of U36, is the circular blanking signal (CIRC BLANK/) used to control the size of the video window.

A/D Clock and Data Latches

The AD PIXEL MR signal clears 8-bit flip flop U52. When U52 is enabled, it generates eight separate A/D clock signals. The sequential outputs from U52 convert the digital video data from U32, and the digital blanking data from U72, into the eight 8-bit parallel channels for transfer to the 64-bit video data bus.

Data Bus Interface

Data on the system data bus is buffered through U16 and applied to the internal data bus. Control and clock signals are buffered through U7. The gray scale data is clocked into latch U15 by the GRAY DATA LCH signal. The gray scale address data is clocked into latch U17 by the ADDA CONT LCH. The blanking level data (for the area outside of circular blanking) is clocked into latch U72 by the BLNK LEVEL SET clock signal.

Digital Image Subtraction

D/A DATA 1 processed digital image data is clocked into latches U50, U56 and U70 by the D/A clock signal. D/A DATA 2 is clocked into latches U49, U50, and U68. The two data channels may be subtracted by the ALU U51, U57. The output of the ALU is applied to the left monitor processing channel.

Gray Scale RAMS

Each monitor channel has a dedicated 256 x 8 gray scale RAM: U26, U30 for the left monitor, and U39, U46 for the right. The gray scale RAMs contain a 256-value gray scale table which performs the WINDOW, LEVEL, and NEGATE mapping functions on the digitized video. Gray scale data is addressed by the image data.

Left D/A Channel

The digital output from U26, U30 (gray scale data addressed by image data) is applied to the digital input of D/A converter U25 and clocked by the D/A CLK signal. Delayed composite blanking (DLY C BLNK) is applied to the disable input of U25 which sets the level of the analog output during blanking. The resultant video signal is buffered through U10 which provides a source terminated composite video output.

Right D/A Channel

The digital output from U39, U46 (gray scale data addressed by image data) is applied to the digital input of D/A converter U38 and clocked by the D/A CLK signal. Delayed composite blanking (DLY C BLNK) is applied to the disable input of U38 which sets the level of the analog output during blanking. The resultant video signal is buffered through U8 which provides a source terminated composite video output.

Figure 4-9 - *Block diagram of the AD/DA Converter PCB, A/D circuits.*

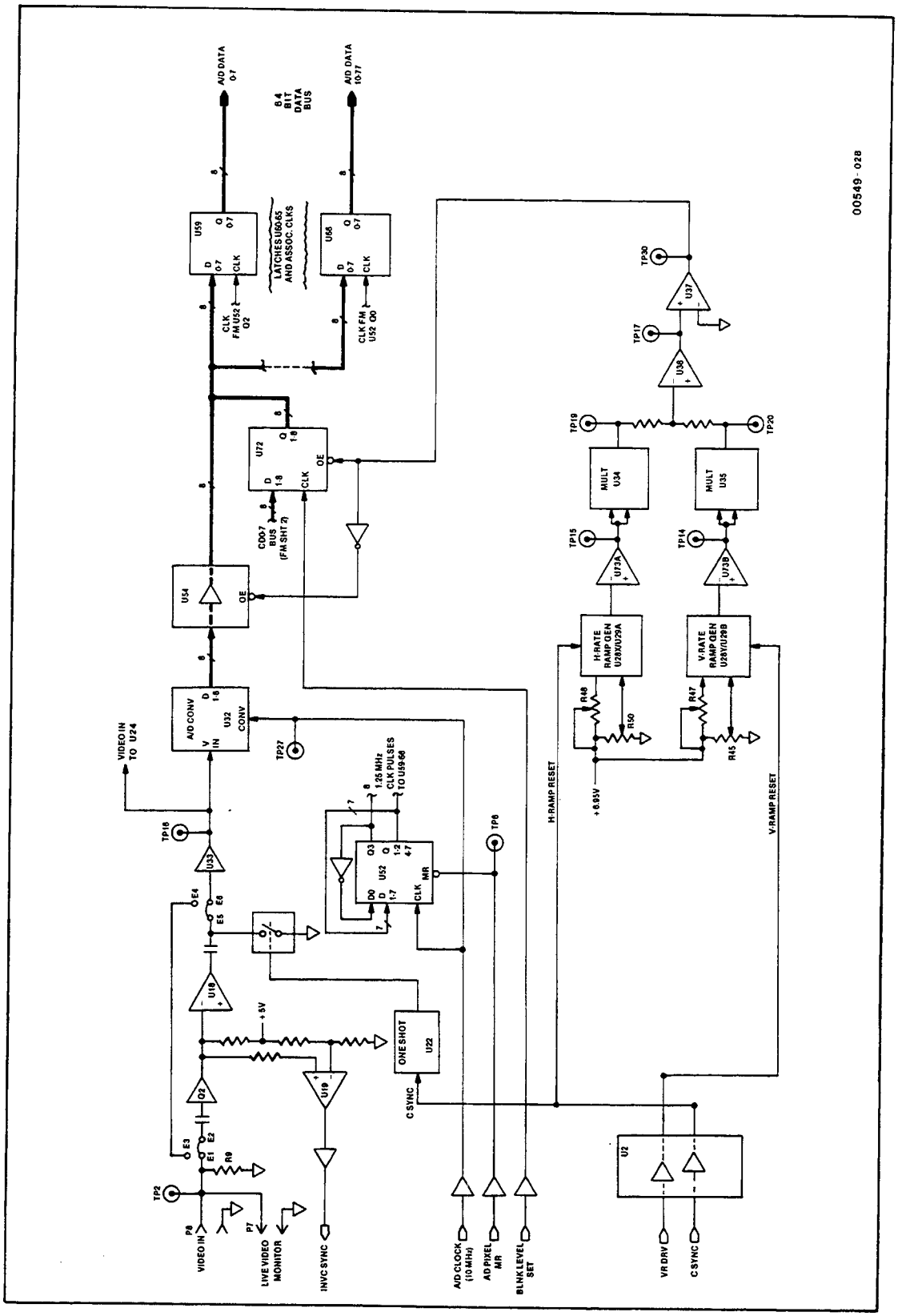
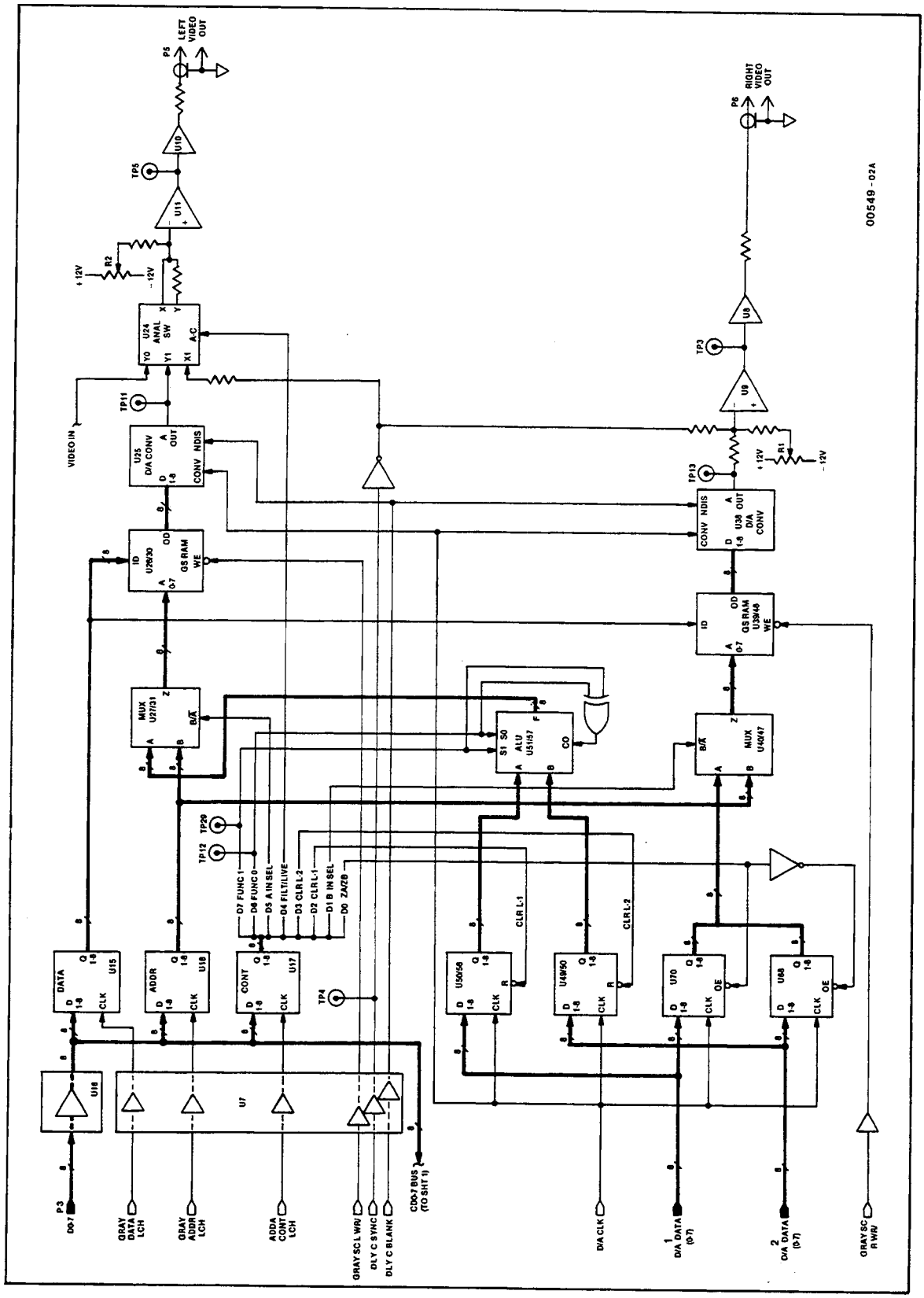


Figure 4-10 - *Block diagram of the AD/DA Converter PCB, D/A circuits.*



4.5.6 Pipeline Filter PCB

Circuit Functions

Refer to Figure 4-11 and Schematic 00-870501.

Referring to the block diagram, the hardware on the Pipeline Filter PCB may be divided into five functional areas:

The Filter Circuit - consists of the adder/subtractors, shifters, and assorted registers and selectors that control the data flow in the top half of the block diagram. The filter is used for averaging, opacification, edge sharpening, motion artifact reduction, and integration. The output of the filter is channeled through a log-table RAM, into either of the frame memories, and out to the AD/DA PCB to be displayed as an image. The log-RAMs are updated during the vertical interval.

The Buffer - consists of the selectors, adder/subtractors, shifters and latches that control the data flow on the lower half of the block diagram. Normally the Buffer simply passes a saved image to the AD/DA PCB to be displayed. However the Buffer can be used for live-digitizing, integration, and single frame subtraction processing.

Memory 1 - holds two frames of data. Incoming data can come from either the filter or the buffer. The memory bus connects with the Disk Interface and Image Processor PCB's. The memory output bus is also connected to the buffer inputs.

Memory 2 - Holds two frames of data. Incoming data can come from either the filter or the buffer. The memory 2 output bus is connected back to the filter circuit inputs.

Control Signals - Control timing and functions of the filter, buffer, and memories.

Pipeline Filter Buses

The following data busses can be identified in the block diagram.

R0 - R7: Filtered, integrated, shifted, or live data that is input to the log-RAMs.

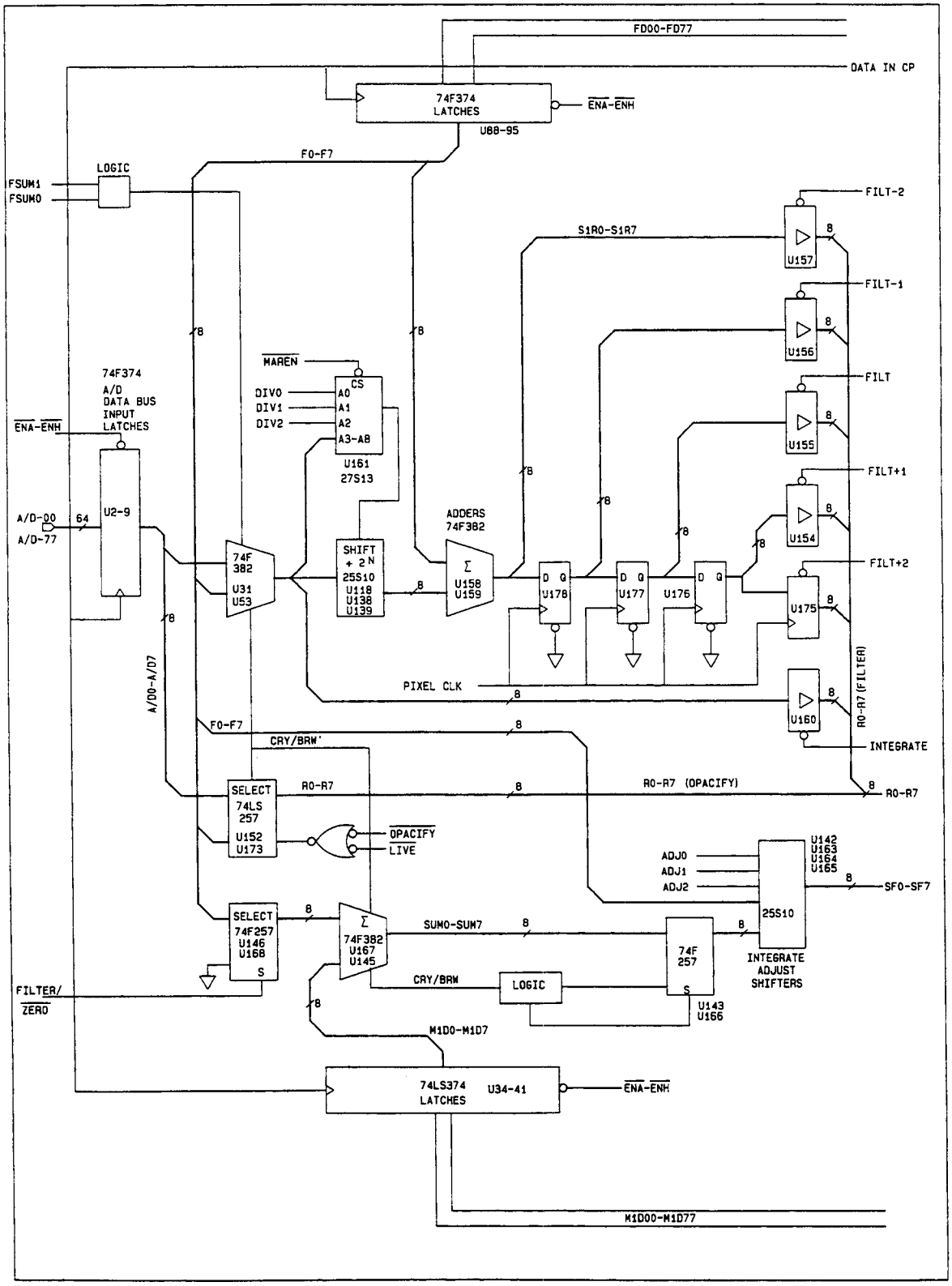
S1R0 - S1R7: The sum of M2 data (F0-F7) and shifted or subtracted A/D data. Used to implement normal averaging.

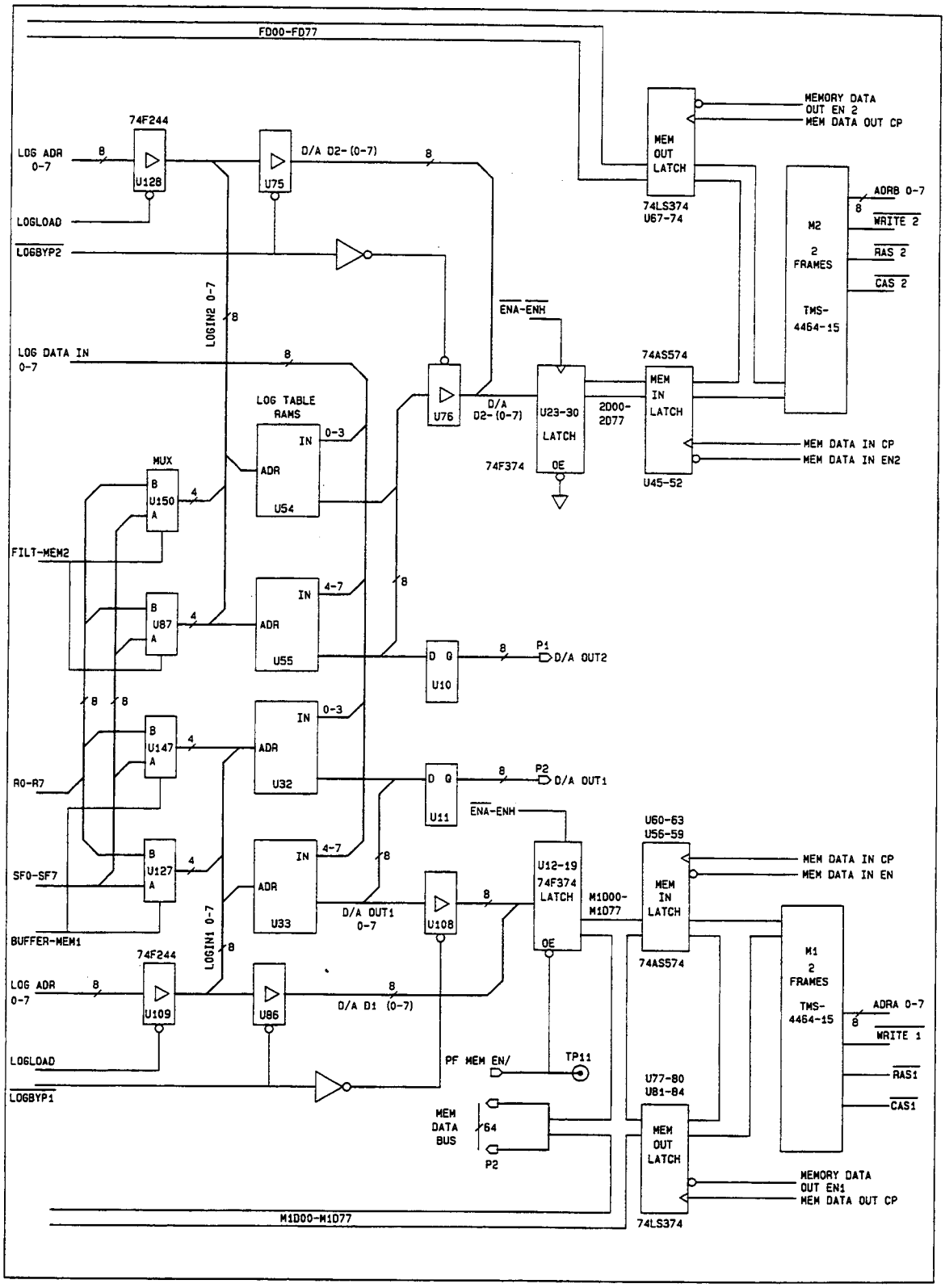
F0 - F7: Data bus from M2, demultiplexed to sequentially transmit the 64-bit bus as eight 8-bit bytes.

SF0 - SF7: Output from integration adjust shifters.

A/D0 - A/D7: Demultiplexed A/D data from AD/DA PCB.

Figure 4-11 - *Block diagram of the Pipeline Filter PCB (two pages).*




FD00-FD77
74F244
LOG ADR 0-7
8
U128
LOGLOAD
LOGBYP2
U75
D/A D2-(0-7)
8
MEM OUT LATCH
74LS374 U67-74
MEMORY DATA OUT EN 2
MEM DATA OUT CP
M2 2 FRAMES TMS-4464-15
ADRB 0-7
8
WRITE 2
RAS 2
CAS 2
LOGIN2 0-7
8
ENA-ENH
LOG DATA IN 0-7
8
LOG TABLE RAMS
U76
D/A D2-(0-7)
U23-30 LATCH
74F374
OE
2D00-2D77
74AS574
MEM IN LATCH
U45-52
MEM DATA IN CP
MEM DATA IN EN2
MUX
B
U150
A
4
IN
ADR
U54
0-3
FILT-MEM2
B
U87
A
4
IN
ADR
U55
4-7
8
D Q
U10
8
P1
D/A OUT2
8
8
B
U147
A
4
IN
ADR
U32
0-3
D Q
U11
8
P2
D/A OUT1
R0-R7
ENA-ENH
B
U127
A
4
IN
ADR
U33
4-7
8
D/A OUT1 0-7
U108
8
U12-19 74F374 LATCH
OE
M1D00-M1D77
U60-63
U56-59
MEM IN LATCH
74AS574
MEM DATA IN CP
MEM DATA IN EN
SF0-SF7
BUFFER-MEM1
LOGIN1 0-7
8
74F244
LOG ADR 0-7
8
U109
U86
8
D/A D1 (0-7)
M1 2 FRAMES TMS-4464-15
ADRA 0-7
8
WRITE 1
RAS1
CAS1
LOGLOAD
LOGBYP1
PF MEM EN/
TP11
U77-80
U81-84
MEM OUT LATCH
74LS374
MEM DATA BUS
64
P2
MEMORY DATA OUT EN1
MEM DATA OUT CP
M1D00-M1D77

M1D0 - M1D7: Data bus from M1. demultiplexed to sequentially transmit the 64-bit bus as eight 8-bit bytes.

D/A D1-0 - D/A D1-7: Output from log-RAMs or output obtained bypassing log-RAMS. Will be multiplexed onto 64-bit M1 data bus.

D/A D2-0 - D/A D2-7: Output from log-RAMs or output obtained bypassing log-RAMS. Will be multiplexed onto 64-bit M1 data bus.

Overall Operation

The Pipeline Filter latches a 64-bit wide data path (A/D00-A/D77) originating from the AD/DA PCB. This is read from the latches in 8-bit wide pixel bytes to be processed sequentially, as if on a pipeline. The 64-bit words are clocked into latches U2 through U9 by DATA IN CP. 8-bit pixel bytes are enabled onto the internal A/D0-A/D7 bus by ENA - ENH.

Data transfers between the 8-bit and 64- bit buses are controlled throughout the board by the DATA IN CP and the eight enable signals: ENA-ENH. ENA-ENH are derived from the pixel clock and the DATA IN CP by counter U153 and mux U1.

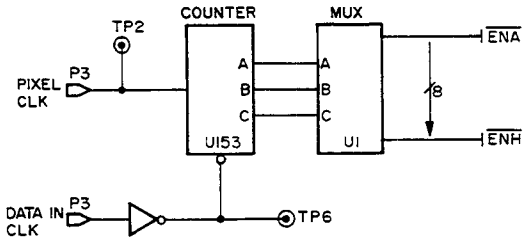
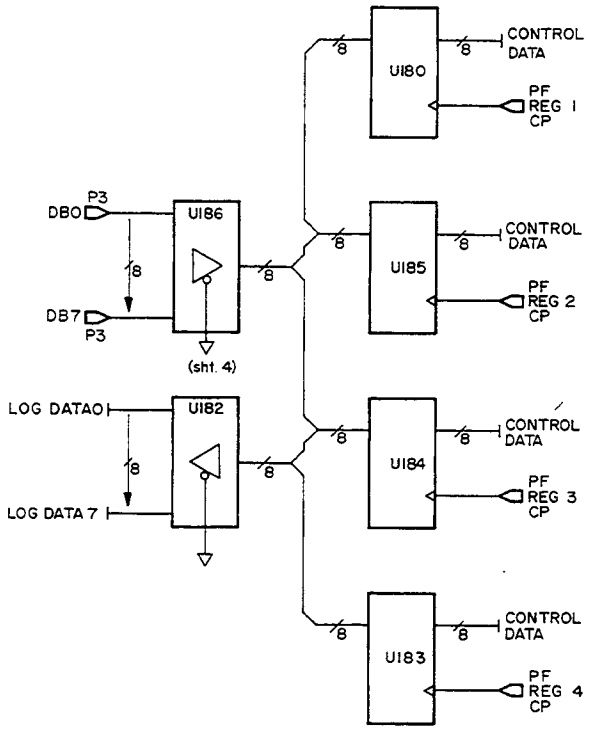


Figure 4-12 - *Decoding the eight enable signals, ENA-ENH.*

Processing command words are received from the Image Processor PCB via the daisy chained ribbon cable at P3. These are addressed to four control data registers PF REG 1-4. Log Data LOG DATA 0-7 (for the Gamma function) is also received from the Image Processor PCB and loaded into the log-RAMS.

Figure 4-13 - *The four control data registers, PF REG 1- PF REG 4.*



Memory control signals, the pixel clock, and DATA IN CP are generated on the Image Processor PCB. They are transmitted to the Filter PCB via P3, the daisy-chain ribbon cable connector.

After processing, the data is again clocked onto a 64 bit wide bus before being stored in memory or placed on the system image-data bus.

But the pixel data is passed in 8-bit bytes to the AD/DA via P1 (D/A OUT2) and P2 (D/A OUT1).

Memory consists of dynamic RAM TMS-4464 (4-bit x 64 k), in two separate banks of 16 each. ADRA0-ADRA7 is multiplexed with the RAS and CAS signals to address memory 1. ADRB0-ADRB7 is multiplexed with RAS and CAS to address memory 2.

Figure 4-14 - *Addressing memories 1 and 2.*

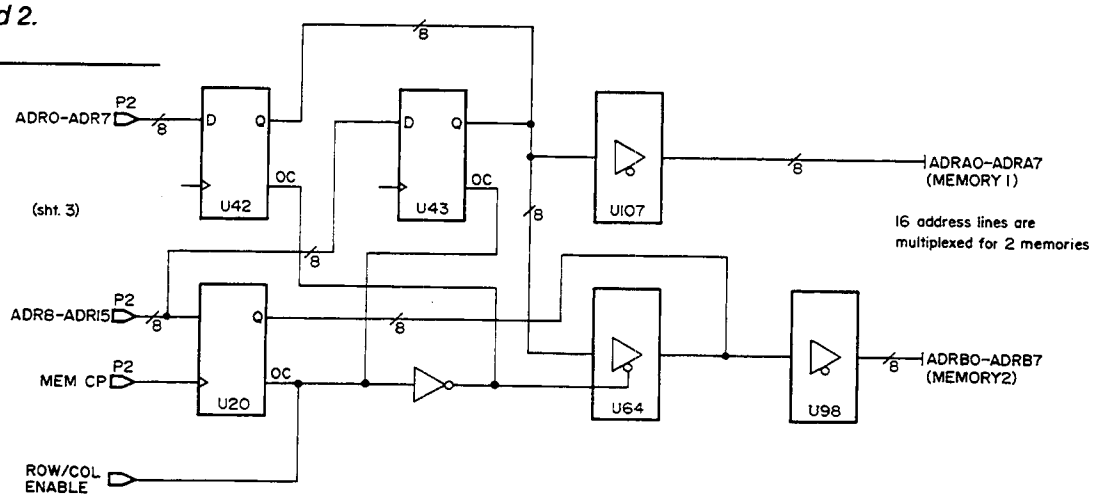


Image Processing Functions

Under software control the image data is routed through the circuits described above to provide the following:

Live Digitized Output — A/D0-A/D7 is selected by U152/U173. The pixel data is passed to the log RAMs for application of any selected gamma function, and then is output at P1, D/A OUT 2.

Stored Image Output from M1 and M2 — Memory contents are routed via the internal buses through the log RAMs. Memory 1 appears on D/A OUT1, Memory 2 appears on D/A OUT1.

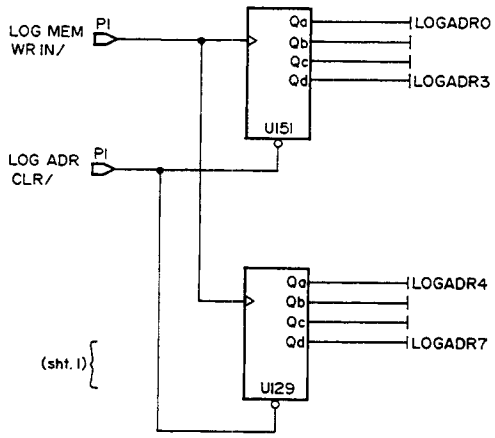
Frame Averaging — An algorithm is performed in which incoming pixel data is combined with the running average for that pixel. The subtraction algorithm D-M(t)/N + M(t) is performed as follows, where D= D/A data, M(t) = old memory value, M(t+1) is the new memory value, and N is the number of frames averaged.

Memory Swap — Image transfer between memories, M1 to M2 or M2 to M1, bypasses the log RAMs. The bypass control lines LOGBYP2 and LOGBYP1 are active. LOGBYP2 enables U75 to buffer the data onto the D/A D2 bus where it is latched onto the 64-bit bus 2D00-2D77 and into M2. LOGBYP1 enables U86 to buffer the data onto D/A D1 where it is latched onto the 64-bit bus M1D00-M1D77.

Gamma — The log RAMS on the Pipeline Filter PCB are loaded with a table from the Image Processor PCB according to which the image pixel values are mapped to an exponential gray scale.

LOG ADR 0-7 are generated by address counters U151 and U129.

Figure 4-15 - *Log RAM address counters.*



Motion Artifact Reduction

When the difference between the incoming and previous images is large, there is an adjustment of the averaging algorithm divisor. MARS is enabled by setting MAREN/ low.

Opacification

The incoming pixel value is compared against the previous value for that pixel in the image. The darker value of the two is kept. When (AD0-AD7) is greater than (F0-F7), summer U31,U53 generates a carry/borrow signal. This selects the source of the pixel placed on the R0-R7 bus by selector U152, U173.

Integration

Allows an average to be computed over a predetermined number of image frames. Result of addition step is a 16-bit word, overflow occurs into the upper eight bits. Last step is a division performed by right justifying into the upper byte.

Single Frame Subtraction

This subtraction is performed on the Pipeline Filter PCB alone. M2-M1 or M1-M2. Subtraction from both memories occurs a byte at a time by Adders U145 and U167. The result is placed on the SUM0-SUM7 bus and routed back into memory.

Edge Enhancement

This requires executing an algorithm which shifts the image a certain number of pixels in the X axis and a number of lines in the Y axis, and adds the original pixels with those at the shifted position. The Y shift is determined by changing the beginning storage address generated by the address counters on the Image Processor PCB. The X shift is produced with delay flip flops (U175-U178). which are selected by the FILT/ controls. FILT select lines are generated by 3 to 8 line decoder U179 which multiplexes control data latched from the Image Processor DB 0-7 control bus.

4.5.7 TV Monitors

The two TV monitors are designed especially for medical diagnostic applications. These provide:

* 75 ohm terminated input impedance
* RS170 standard negative sync
* Composite input video range of 0.3 to 2.5 volts p-p;
* Bandwidth in excess of 15 MHz at -3 dB
* Full genlock synchronization (vertical and horizontal).

4.5.8 Remote Contrast/Brightness Control PCB

Refer to Schematic 00-870928.

This PCB is located below the left monitor and allows the left monitor to be adjusted from either the mainframe or the monitor cart.

4.6 Image Storage

4.6.1 Hard Disk (Winchester Drive)

The hard disk unit contains space for storage of up to 60 images in digital format which can be recalled and displayed at a later time for further review. In addition, interfaces are provided for non-digital storage of images on video tape recorder or video disk.

The hard disk has a storage capacity of 20 megabytes, 15 megabytes of which are dedicated to image storage. The remaining 5 megabytes serve as program storage.

4.6.2 Video Tape Recorder (VTR)

The VTR may be used to store real time images on magnetic tape. The storage format is not digital. Successive video frames at a rate of 30 per second can be continuously recorded for up to one hour on a single cassette. Single frames cannot be randomly accessed. The tape counter offers an approximation of frame location and must be referenced against an external log of image contents.

4.6.3 AngioStor Video Disk Recorder

The AngioStor Video Disk Recorder may be used to store real-time images in a non-digital format. Up to 600 frames may be stored and later played back at rates of 30, 15, 6 and 4.5 frames per second.

4.6.4 Multi-Format Camera

The multi-format camera is provided with the same video signals which are displayed on the monitors. These signals are displayed on an internal monitor screen which is photographed. The format and number of images which are placed on the photographic film vary depending upon the camera model.

SECTION 11
OPTIONS

Various options which may be installed on the imaging system are covered in this section:

* Video tape recorder
* AngioStor video disk recorder
* Multiformat camera
* Patient annotation

Table 1 summarizes the signals provided for external image storage at the rear monitor cart connectors.

Table 1 Interfacing Signals

CONNECTOR & PIN	*SIGNAL*
MULTIFORMAT CAMERA INTERFACE	
J35	VIDEO OUT 2
J36	VIDEO OUT 1
VIDEO DISK INTERFACE	
J37-1	RECORD ENABLE
J37-5	GND
J37-4	TO VIDEO DISK
J37-3	SHIELD
J37-2	FROM VIDEO DISK
J37-6	SHIELD
J37-8	COMPOSITE SYNC
J37-7	SHIELD
VTR INTERFACE	
J38-4	TO VTR INPUT (LIVE VIDEO)
J38-3	SHIELD
J38-2	TO VTR OUTPUT
J38-6	SHIELD

11.1 Video Tape Recorder

11.1.1 VTR Installation

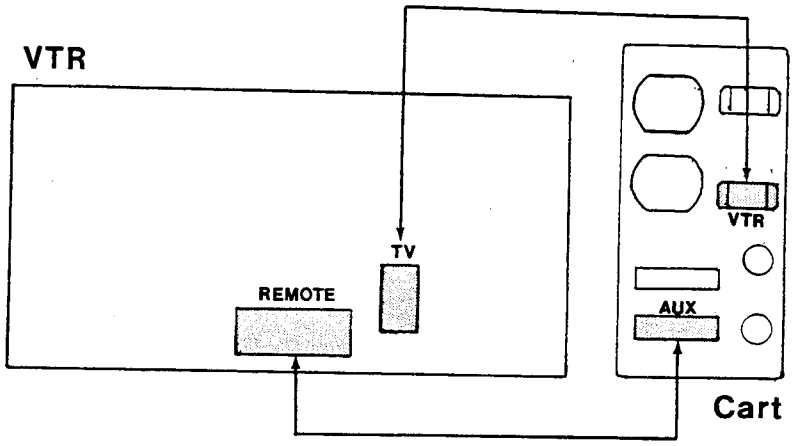


Figure 11-1 - *Connections are made between the VTR and the rear of the monitor cart.*

1. Connect the VTR VIDEO CABLE between the TV connector on the VTR and the VTR VIDEO connector on the rear of the monitor cart.
2. Connect the VTR CONTROL CABLE between the REMOTE connector on the rear of the VTR and and the AUX connector on the monitor cart rear panel.
3. Connect the VTR power cord to the service outlet.
4. Set up the VTR Controls as shown in Table 2.
5. Turn on the Service breaker and the VTR. Insert a blank video tape into the VTR.

   Note: a red button is provided with each video cassette. It must be installed in order to record. When it is removed, the tape can be played back, but not recorded.
6. Place the VTR in the RECORD mode by simultaneously depressing the PLAY, RECORD, and PAUSE buttons.

Figure 11-2 - *Power, Remote and TV input connections are made on the rear of the VTR.*

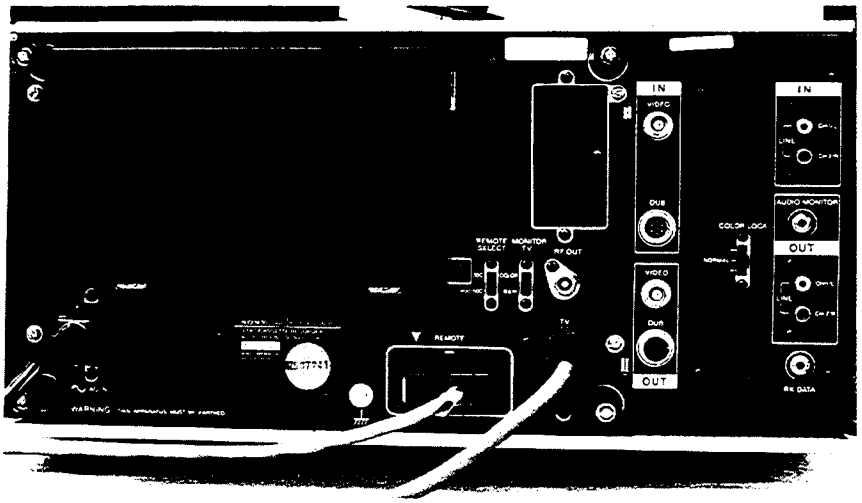


Table 2 **VTR Settings**

SWITCH/CONTROL	*SETTING*
AUDIO LEV	0
AUDIO LIMIT	OFF
AUDIO MON	MIX
DUB/CH 1	N.A.
EJECT	OFF
F-FWD	OFF
HEADPHONE	1
INPUT SEL	T.V.
PAUSE	OFF
PLAY	OFF
POWER	ON
PROGRAMED OPERATION	OFF
REC	OFF
REW	OFF
SEARCH	OFF
STOP	OFF
TIMER	OFF
TRACKING	FIXED

11.1.2 VTR Adjustment

Refer to Figure 11-3.

With an oscilloscope, verify the amplitude of the VTR video output as 1 volt composite video. Use the following procedure to adjust the VTR video output level.

1. Place the 60 kV shading tool on the image intensifier. Set the X-ray technique for MANUAL FLUORO at 60 kVp and 1.0 mA.
2. Connect an oscilloscope to J12 (To VTR) on the I/O Distribution Video Switch PCB using a coaxial "T" adaptor.
3. Tape several minutes of continuous fluoro imaging of the shading tool.
4. Verify that the video at J12, from baseline to white peaks, does not exceed 850 mVp and the sync portion of the signal is approximately 400 mVp.
5. Remove the top cover of the VTR and locate the 3 full depth PCBs. Locate the adjustment pot **RV6** on the inner-most board on the side facing the head assembly.
6. Connect the oscilloscope to J16 (From VTR) on the I/O Distribution Video Switch PCB using a coaxial "T" adaptor.
7. Rewind and review the recording you have made of the shading tool. Adjust **RV6** so the video signal meets the requirements of step 4.
8. Reinstall the VTR cover.



Figure 11-3 - *Adjust RV6 as shown in this photo.*

11.2 Angiostor Video Disk Recorder

The AngioStor is used primarily for recording raw video for post-processing. The video disk system is capable of storing 20 seconds of video at the rate of 30 frames per second.

The AngioStor must be supplied with a continuous source of composite video sync pulses, and the video being recorded must be composite video. Both the sync pulses and the composite video are provided by the Sync Separator PCB (P/N 00-870545, see schematic 00-870543).

The Sync Separator PCB supplies the AngioStor with a composite sync signal that is generated on the PCB when the AngioStor is not recording and with the sync that is stripped from the source video while the AngioStor is recording.

In addition, this PCB routes the source video from either the camera or from the VCR, and also routes the output video to either the VCR or the image processing system.

For more information refer to Service Technical Bulletin 86-011, 5 December 1986.

Additional maintenance and operating instructions are found in the OEM manual supplied with the AngioStor.

11.2.1 Installing the AngioStor Video Disk Recorder

1. Unpack the AngioStor. The Angiostor is shipped as the following components:

   * Mobile rack cabinet with installed electronics.
   * Remote control panel (optional)
   * Oktel operation and maintenance manual.
   * Storage disk (platter).

2. The Angiostor is shipped fully tested, but with the storage platter removed. Refer to the Oktel manual for instructions on installing the platter.

3. Place the AngioStor rack cabinet in a convenient location.

Note: The control panel may be located remotely on some installations.

4. Connect the cabinet electronics to a hospital grade receptacle capable of providing 117 VAC +/- 10% 60Hz. 950 VA (approx. 5 Amps). *Do not plug the AngioStor into the service outlet on the rear of the monitor cart.*

5. Connect the multiconductor-cable snap-on plug to the mating connector on the monitor cart rear panel. This is labeled: DISK VIDEO OUTPUT.

6. (OPTIONAL) If the control panel is not mounted in the rack cabinet - connect the coaxial cable to the rear of the remote control panel.

7. When installation is complete, proceed with the power up procedure.

11.2.2 Angiostor Power Up

NOTE: Do not plug the AngioStor into the cart service breaker.

1. Power up the monitor cart.

2. Turn on the **main power switch (1)** on the front of the AngioStor cabinet.

   Refer to Figure 11-5.

3. Turn on the **power switch (2)** located on the AngioStor control panel.

4. When the **servo lock LED (3)** on the AngioStor control panel turns on, the system is ready for use.

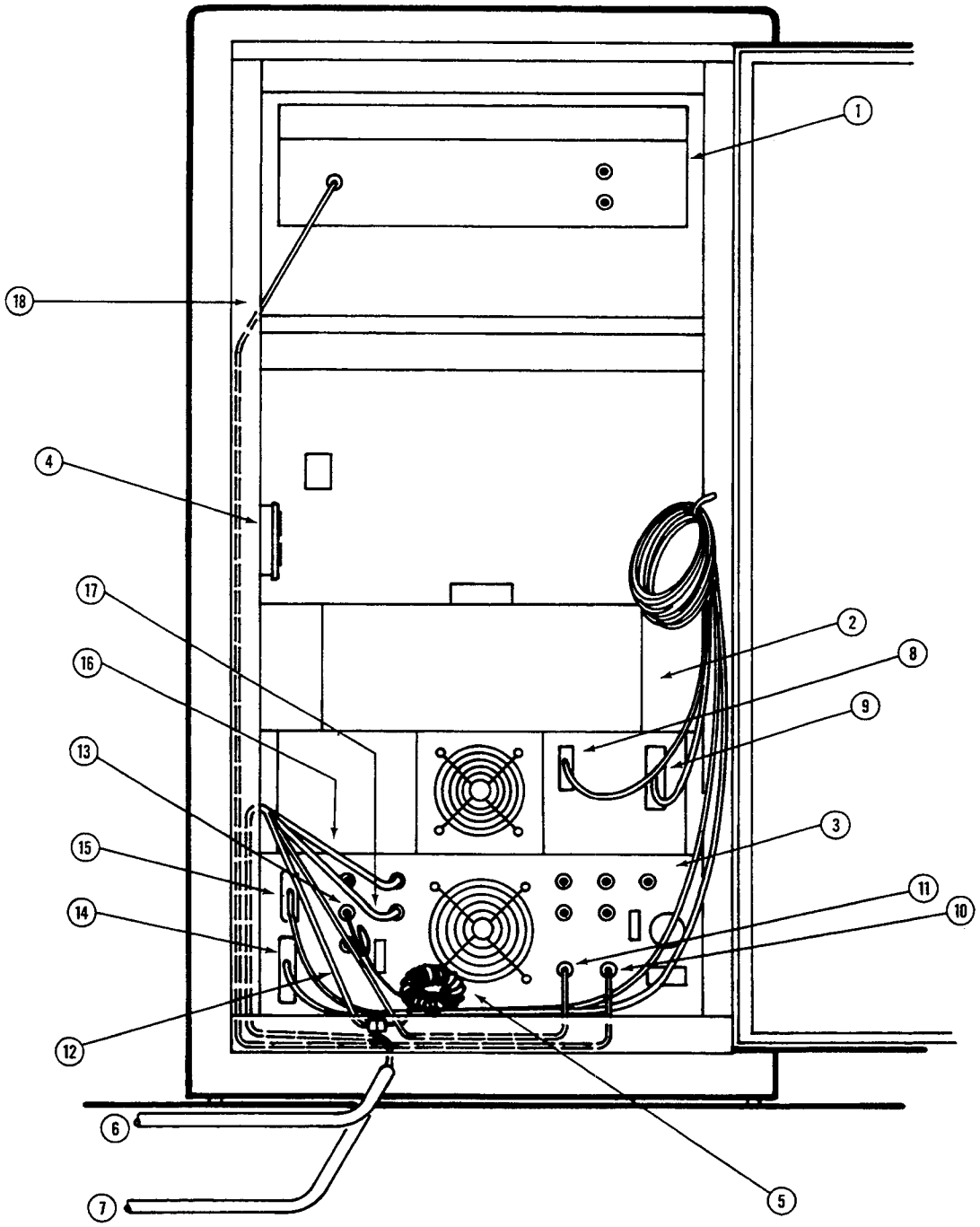
   Refer to the Operator's Manual for operating instructions.

11.2.3 AngioStor Connections

The following major components, cables and connections are found inside the rear of the AngioStor cabinet. Refer to Figure 11-4 for their locations.

1 - Control panel unit
2 - Video disk drive
3 - Signal processor/ servo drive
4 - Power outlet box
5 - Video filter balun
6 - Cable to monitor cart
7 - Power cord
8 - Connector: READ/WRITE 2
9 - Connector: SERVO
10 - Connector: REMOTE PANEL (to control panel unit)
11 - Connector: REMOTE RECORD
12 - Coax: Video-In (black)
13 - Connector: VIDEO-IN
14 - Connector: SERVO
15 - Connector: READ/WRITE
16 - Coax: Video-Out (white)
17 - Coax: Sync (gray)
18 - Coax cable to signal processor/servo drive.

Figure 11-4 - *Connections are made to the rear of the AngioStor components as shown in this drawing.*



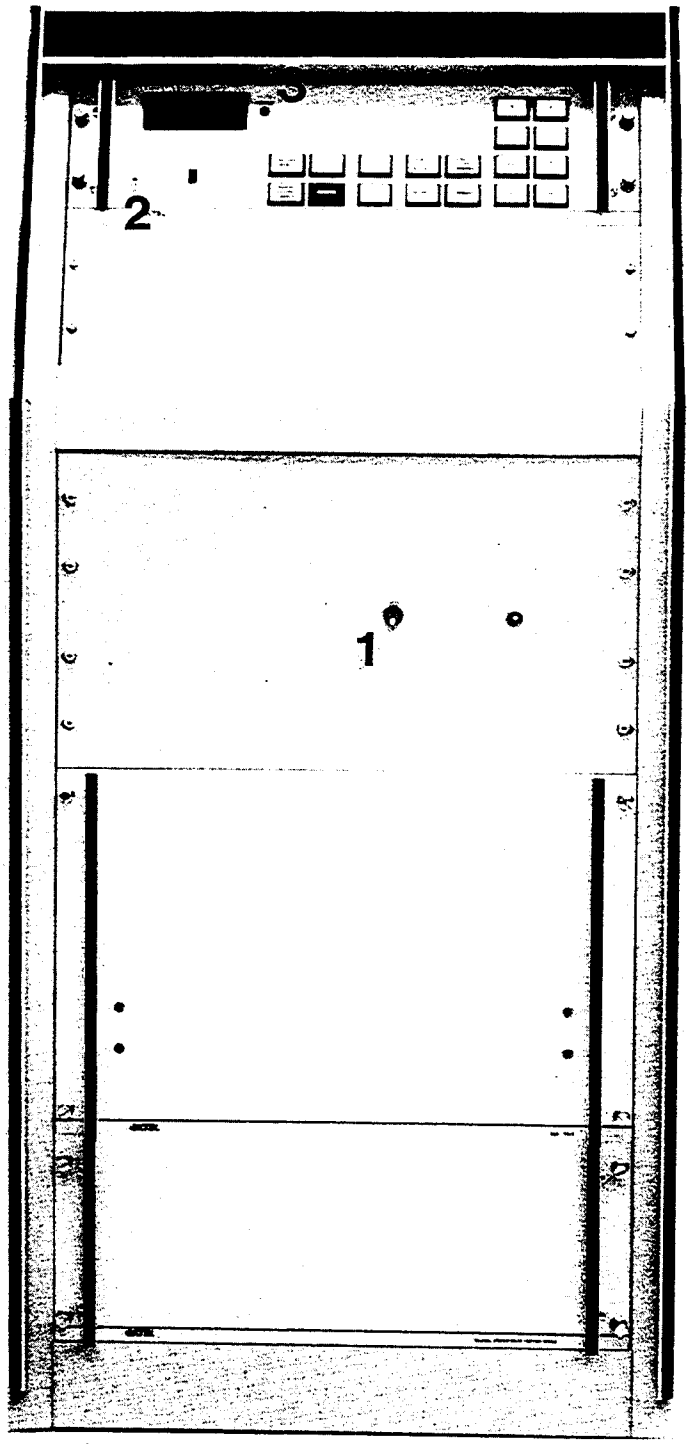


Figure 11-5 - *The AngioStor main switches are shown in this photo.*

11.2.4 AngioStor Troubleshooting Notes

Refer to the AngioStor Service Manual for detailed fault determination procedures. Before you do, however, check the following items:

1. Are all cables and connections in place? Are all BNC connectors solidly mated to their cables?
2. Have all switches been turned on in the correct order?
3. Are the disk and the disk heads clean?
4. Is the disk side with a light colored stripe under the hub lock positioned on top, so that the N-track is being read?
5. Are the motor SYNC LED on the control panel and the SERVO LOCK LED on the remote control unit on?
6. Does the numeric display on the AngioStor remote control unit contain the number 1 on powerup?
7. Do the lighted switches on the remote control unit respond by turning on and off when the switches are pressed?
8. Is the composite video sync signal from the monitor cart reaching the AngioStor?
9. Are all AngioStor printed circuit boards well seated in their connectors?

11.2.5 AngioStor Maintenance Notes

1. In normal operation the video disk rotates clockwise as viewed from the top. Always turn the disk in this direction, never counterclockwise.
2. Exercise extreme care when handling the video disk. Never touch it with bare hands, as this will leave oils and acids from the skin which will damage the media surface. Avoid contaminating the surface of the disk with dust or liquid spills.
3. The disk surface and the recording heads are delicate. To avoid damaging them during any major relocation of the AngioStor, remove the video disk and package it carefully. The best packaging is the original shipping container in which the disk was supplied. The head actuator arm locking screws should also be tightened before relocation to prevent damage to the heads. The dust cover should be secured over the head actuator assemblies during shipment to prevent contamination and damage.

4. The disk should be cleaned before it is installed. Clean the bottom side of the disk while it rests in the shipping container and then after mounting the disk onto the hub and tightening the diskhub retainer, clean the top of the disk. Only clean, dry, lint free wiping materials should be used for disk cleaning. Use only "zero residue" solvents to clean the disk surface. Some solvents which fit this description are: Tech Spray "Zero Residue Cleaner", T-P35 (available as OEC-Diasonics P/N 88-299318), and 95% isopropanol (reagent grade).

5. When bringing the heads into contact with the disk, always use a smooth-finished piece of plain white paper to ease the heads onto the disk. The paper should then be removed from between the disk and the head with a gentle pull tangent to the radius of the head and in a counter-clockwise direction.

6. The heads themselves need to be cleaned only infrequently, as determined by visual inspection of the heads with a magnifying lens. When head cleaning is required, it can be done without removing the heads from their actuator assemblies:

   a. Swing the actuator arm for the head to be cleaned off of the disk.

   b. Clean the head by dragging a piece of smooth-finished white paper, saturated with cleaning solvent, across the disk contact surface of the head.

   c. When the head has been cleaned, swing the arm back over the disk using the procedure described above to protect the head from damage.

   Use extreme care when working with the heads, and especially with the very fragile thick-film ribbon cables.

7. After installing the disk, the phase error signal should always be checked with an oscilloscope. The maximum allowed value of the phase error signal is 50 mV peak-to-peak. A new "N-track" signal should only be recorded on the disk if the phase error signal has an amplitude greater than this value.

11.3. Multiformat Camera

The video connections for the multiformat camera are located on the rear of the monitor cart.

Instructions for the camera are provided separately.

11.4 Patient Annotation

Patient annotation consists of a PC-compatible keyboard, a connector to the Front Panel Processor PCB, and special software.

The keyboard connector provides the following signals:

Table 3 Keyboard Interface

PIN	*SIGNAL*
PIN	*SIGNAL*
1	KBCLK
2	KBDATA
3	RESET
4	GROUND
5	+5 VDC

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 all safety requirements applicable to medical electronic equipment of this type.

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

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 who has been trained to troubleshoot and repair the Series 9000 System.

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

WARNING: **The procedures in this manual should not be attempted by anyone who is not specifically trained by OEC-Diasonics to work on the Series 9000 System.**

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; nor can it be responsible 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.
P.O.Box 25296
Salt Lake City, Utah
84125-0296
801-973-6800

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 who work with or are exposed to X-ray tubes must take precautions to protect themselves against serious injury. Do not be careless.

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.

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.

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: **This equipment contains very high power electrical components and should be serviced only by personnel intimately 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.**
- Video monitors (monitor cart) - **25,000 volts.**
- Transformers (especially the isolation transformer in the monitor cart) - **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.**

WARNING: **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.**

WARNING: **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.**

WARNING: **Do not remove the interconnect cable from its connector on the monitor cart. Hazardous voltage (120 VAC) is present on the pins of this connector when the monitor cart is plugged into a power outlet. These pins are exposed when the interconnect cable is not in place.**

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.

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

Federal DHHS guide lines specify that the minimum source-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-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 Emergency Power Off

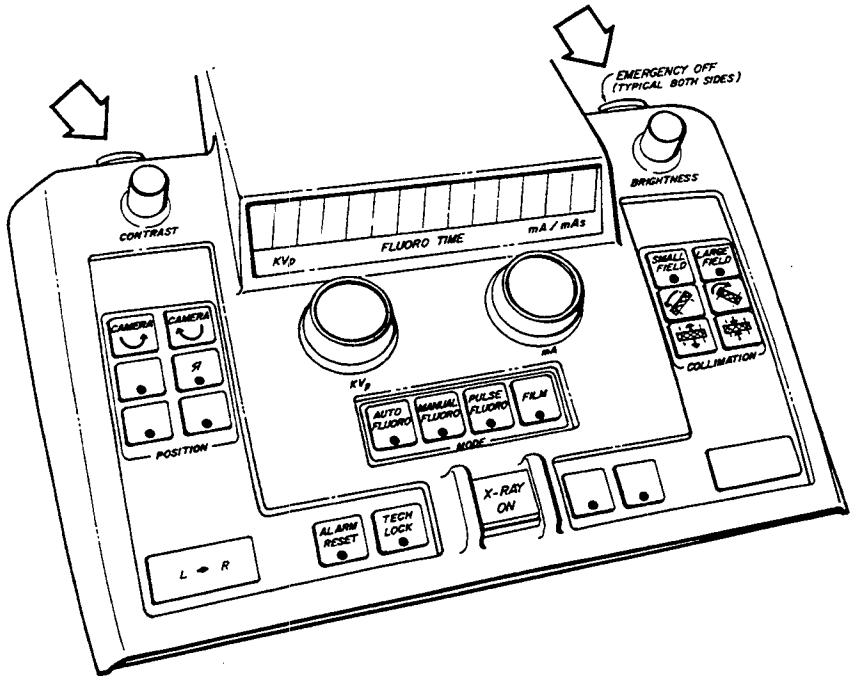
Refer to Figure 1.

The system has two EMERGENCY OFF buttons located on the C-arm control panel. When either button is pressed, operation of the system 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.

In the unlikely event that a malfunction in the motor control circuitry causes a motor to drive without an operator command, it is important to train all operators to respond by pressing the EMERGENCY OFF switch.

The monitor cart electronics are separately controlled by the cart power breaker on the cart power panel. To remove power only from the monitor cart electronics turn this breaker off.

Fig. 1 - The locations of the two emergency off buttons are shown here.



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 by a qualified service technician.

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 System Failure During Fluoroscopic Use

If the system image processing electronics fail during a critical operative procedure, set the toggle switch on the rear of the monitor cart to BYPASS. This will direct undigitized live fluoro images to the left monitor, bypassing the image processing electronics.

NOTE: Last-image-hold will not operate in BYPASS.

2.5.4 System Malfunction

If a fuse is blown repeatedly or a circuit breaker trips after being reset, it may indicate an equipment malfunction. Do not attempt to operate the system until it has been checked out by a qualified service technician.

If any of the system controls fail to respond as indicated in the Operator's Manual, the operator should, if the immediate circumstances allow:

1. Turn the power off.
2. Unplug the system from the wall outlet.
3. Notify a qualified service technician immediately.
4. Do not attempt to operate the system until the service technician has advised that it is operating properly.

The system should not used beyond the immediate situation if any system control failure occurs.

2.5.5 Electrical Fire

The owner should develop an emergency procedure for the area in which the system is installed that includes the following safety measures:

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 *The use of 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.*

2.5.6 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.

2.6 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:

- The potential for death or the type of serious injury that may result is specified in the labeling for the system.

- The malfunction and the routine service, repair, or maintenance instructions to correct the malfunction are described in the labeling for the system.

- The malfunction has occurred at or below its expected rate of frequency and severity.

- 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.

2.7 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.

9000 SERVICE MANUAL

UPDATE
00-876628-01
REV. A

INSTRUCTIONS:

1. Insert this -01 Update tab and text at the back of the manual, after the last page.

Date of Issue: November 1993

OEC MEDICAL SYSTEMS, INC.

384 Wright Brothers Drive
Salt Lake City
Utah
84116

(801) 328-9300

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Revision History

Update PN & Rev.	Manual PN	Manual Revision
00-876628-01, Rev. A	00-870820-01	C

UPDATE

1. BATTERY REPLACEMENT, TECHNIQUE PROCESSOR BOARD

The real time clock battery, B1, on the technique processor board should be replaced every two years. The age of the battery can be derived from either the delivery date, for a recently purchased unit, or from the dated label that is applied during battery service. Under normal operating conditions, the expected life of the battery is well in excess of two years. However, replacement every two years insures that the battery will not deplete during usage.

9000/URO1000 BATTERY REPLACEMENT KIT, 00-876434-03:

Quantity	Part Number	Description
1	74-122902-00	3V Lithium Battery
1	32-301420-00	2KΩ, 1/4W Resistor
1	88-359989-00	Self Adhesive Label
2	00-876488-01	Operator's Mnl. Replacement Pages
2	00-876801-01	Operator's Mnl. Replacement Pages

BATTERY REPLACEMENT KIT, 00-876434-02*:

Quantity	Part Number	Description
1	74-122902-00	3V Lithium Battery
1	88-359989-00	Self Adhesive Label

*See NOTE on the following page which explains when the -02 Kit is needed.

PARTS/TOOLS REQUIRED:

Indelible Marker

Soldering Iron

Solder

1.1 PROCEDURE

NOTE:

The following procedure is for first-time installation of a new battery on the PCB. It assumes that the 2KW resistor has *not* yet been installed near IC U79 and that you are using Battery Replacement Kit PN 00-876434-03. If this resistor has already been installed and you are only replacing the battery, you need to use Battery Replacement Kit PN 00-876434-02 which includes the new battery and label. Be sure to write the date of installation on the new label and place the label on U79 after replacing the battery.

1) Turn off all power to the system.

2) Remove the Technique Processor PCB from the generator card rack (see Figure 1, page 7).

3) Carefully remove U79 from the socket on the Technique Processor PCB and set aside (see Figure 2, page 8).

4) Locate the battery (B1) on the Technique Processor PCB (see Figure 2, page 8) and carefully remove the battery from the Technique Processor PCB by cutting the battery leads. After you remove the battery, carefully remove the leads of the battery from the Technique Processor PCB with your soldering iron and clean the solder holes so that the new battery can be installed.

5) While looking at the component side of the Technique Processor PCB locate the socket for U79. Near pin 12 of the socket for U79 is a short solder trace with a solder pad at both ends of the trace. Electrically this trace goes from U79 pin 14 to the battery B1. Refer to Figure 3, page 9, for the location of this trace.

6) Carefully cut the middle of the solder trace from step 5. Refer to Figure 3, page 9. Use your soldering iron to carefully remove the solder from the solder pads at the ends of the trace you cut.

7) Install the 2KΩ resistor (32-301420-00) provided with the Battery Replacement Kit on the component side of the Technique Processor PCB by inserting the leads of the resistor through the holes of the solder pads of the trace you cut in step 6. Carefully solder the resistor into place. Electrically this resistor is now in series between U79 pin 14 and the battery B1.

8) Install the new 3V battery (74-122902-00) provided with the Battery Replacement Kit on the Technique Processor PCB into the same location as the old battery. Carefully solder the battery onto the Technique Processor PCB.

9) Install U79 back into the socket on the Technique Processor PCB.

10) Using an indelible marker write the current date on the self adhesive label (88-359989-00) provided with the Battery Replacement Kit. Affix the self adhesive label to the top of U79 on the Technique Processor PCB.

11) Carefully install the Technique Processor PCB back into the system.

12) Turn the system on and allow it to boot completely. You may get a message on the control panel that says the system needs 24 hours to recharge. You may ignore this message and get past it by pressing any key on the control panel.

13) Enter the STATUS mode of the system through the control panel and set the time and date. Instructions on entering the STATUS mode for your particular system may be found in the Maintenance section of the Operator's Manual.

14) Reboot the system and make sure it boots up completely. Make sure the system operates correctly by verifying fluoro operation, film operation, image storage, etc.

15) After upgrading the 9000, leave the Operator's Manual Replacement Pages (00-876488-01) and (00-876801-01) that were sent as part of the upgrade kit with the customer.

Figure 1 - Technique Processor PCB location in 9000 Electronics Cabinet

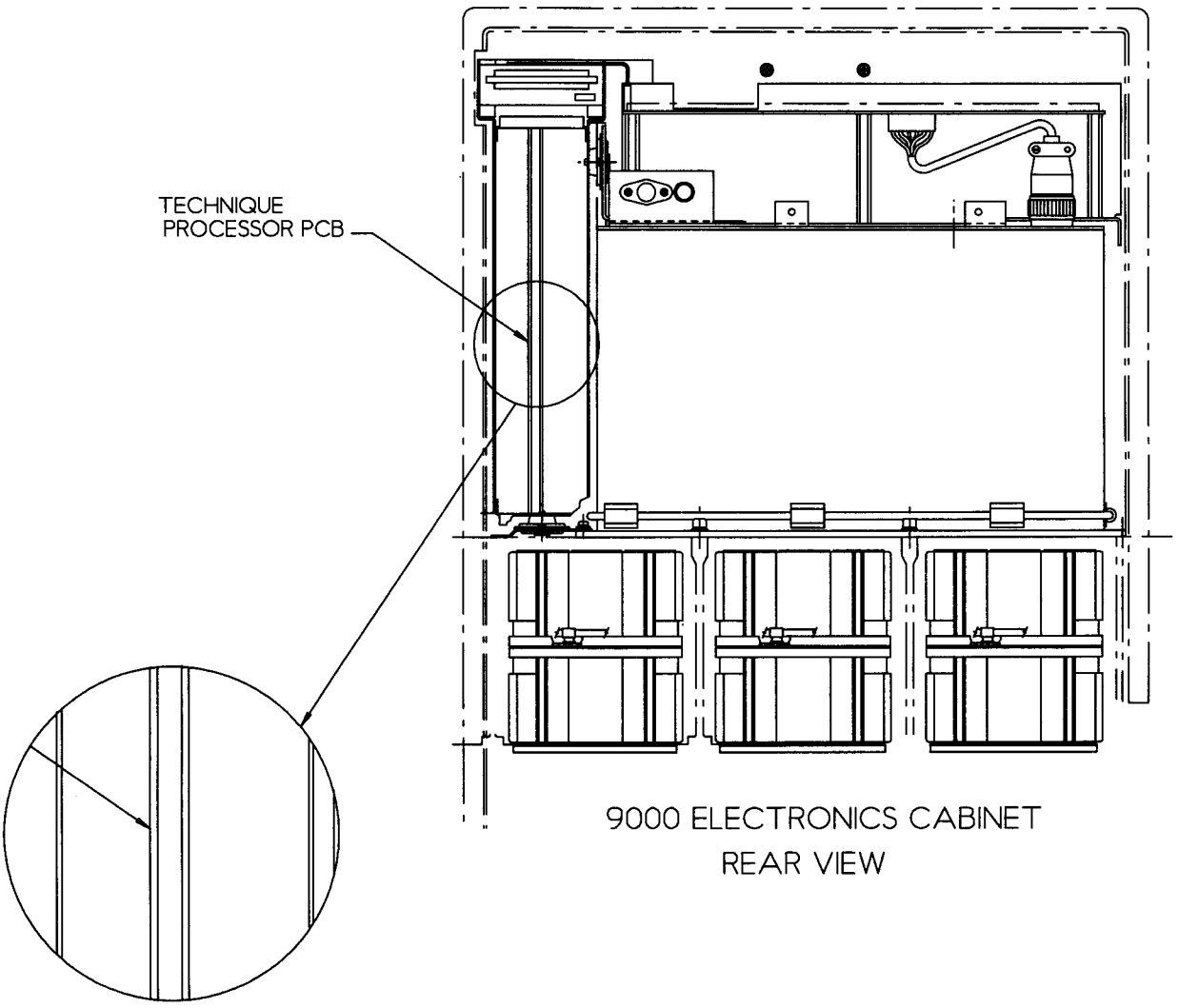


Figure 2 - Battery and Real Time Clock IC locations on Technique Processor Board

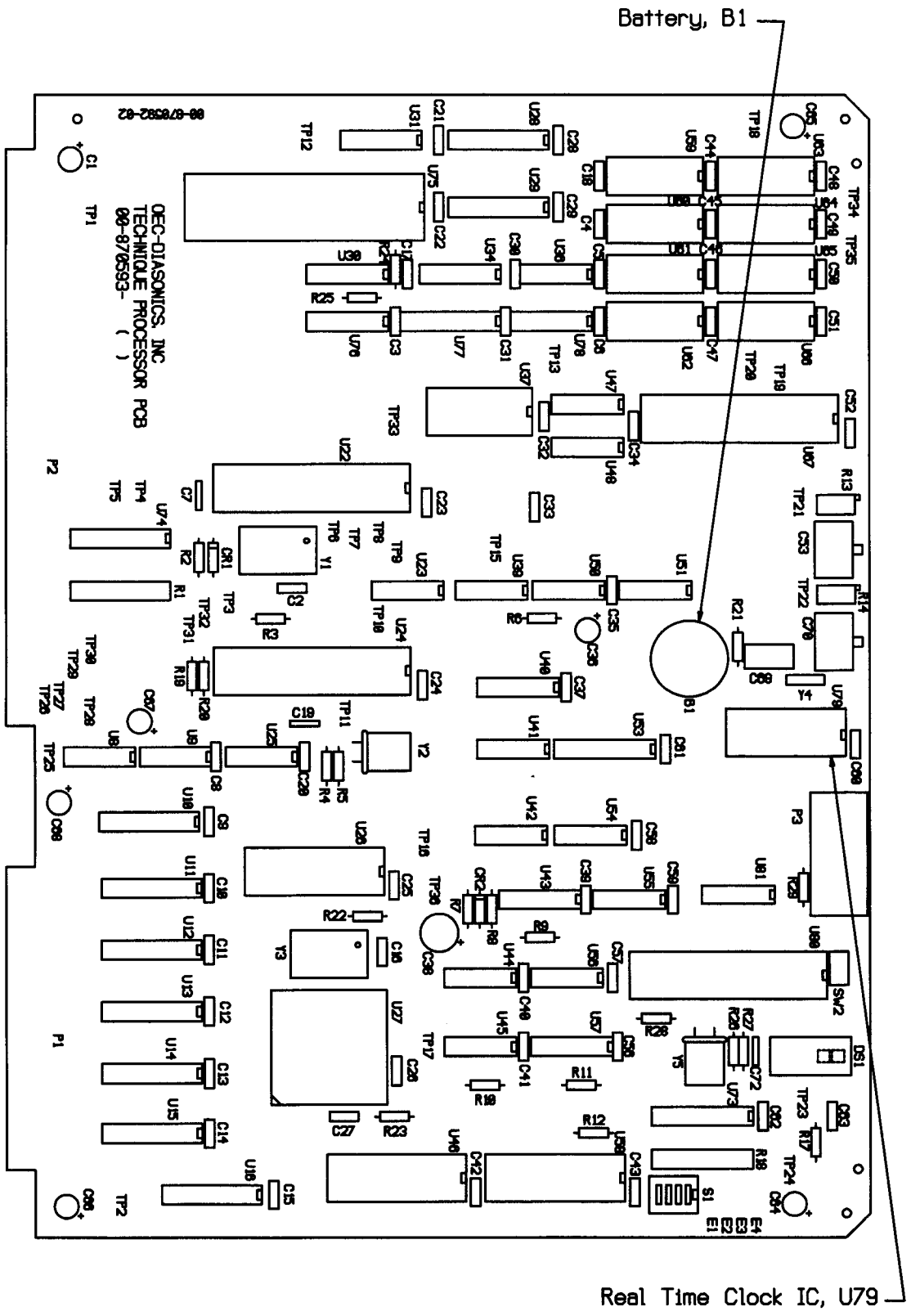
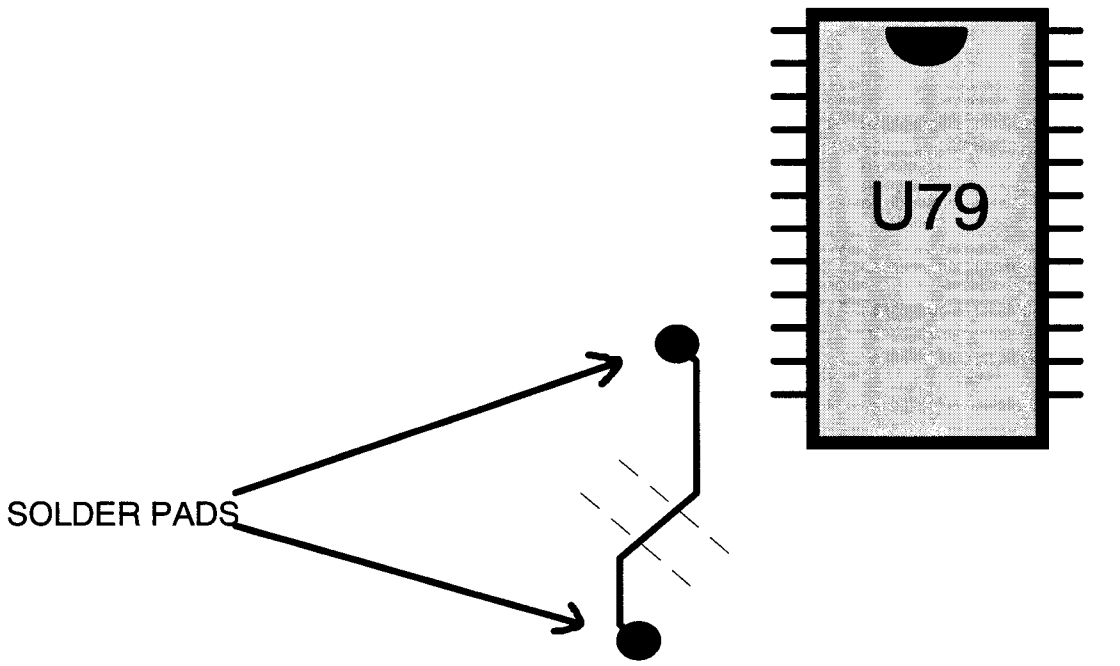


Figure 3 - Location of 2KΩ Resistor installation on the Technique Processor PCB



CUT TRACE BETWEEN DASHED LINES

INSTALL RESISTOR BETWEEN SOLDER PADS

SERVICE MANUAL

00-870820-01

SERIES 9000

X-RAY IMAGING SYSTEM

Effectivity:

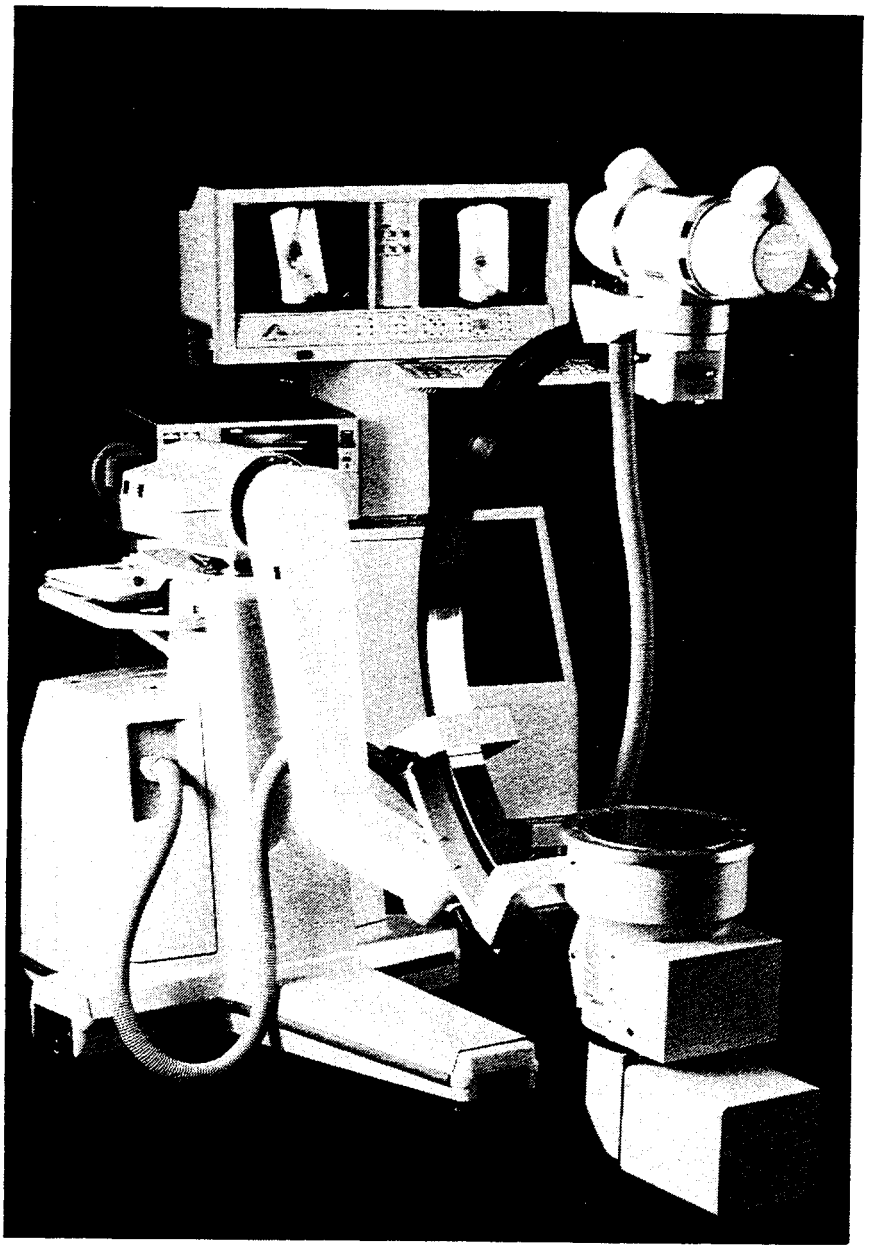
This manual contains descriptions, instructions and procedures which apply only to Series 9000 systems with serial numbers in the 96-000 and 99-000 series.

Date of Issue: September 1987

OEC-DIASONICS

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Salt Lake City
Utah
84116

(801) 328-9300



SERIES 9000 X-RAY IMAGING SYSTEM (Details of this photograph may vary depending on options).

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 the properly trained service engineer who 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 Series 9000 system.

This manual is intended to compliment the training offered by OEC-Diasonics. You should not attempt any of the procedures in this manual unless you have received this training on the Series 9000 System. Reading this manual does not alone 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.

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APPENDIX A

Recommended Tools and Test Equipment

Installation and Use of Special Equipment

Dosimeter

Printer Installation

Terminal Installation and Use

Service Log

This appendix describes recommended test equipment and the installation and use of special equipment needed to calibrate the system:

DOSIMETER
DYNALYZER
FLOPPY DISK DRIVE (INCLUDED IN DXR KIT)

This appendix also contains special instructions for connecting a terminal and printer to the system, and using the terminal menus to access special software.

NOTE: *Calibration must be current on the Dynalyzer, Dynalyzer Digital Display and the Dosimeter.*

A.1 Recommended Tools and Test Equipment

In addition to common hand tools normally in any service technicians tool kit, Table A-1 lists additional tools and equipment necessary for calibration and maintenance.

TABLE A-1

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 General 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 +/- .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.

    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 30 cm (12 inches) 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 30 cm (12 inches) 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 hence open to the atmosphere, the mass of air inside will depend upon the temperature and absolute pressure of the ambient air.

Table A-2 Temperature and Pressure Correction Factors for a vented ion chamber such as the Keithley Model 96030A.

Pressure in mm Hg	Temperature (in degrees Celcius)																					
mm	20	21	22	23	23.5	24	24.5	25	25.5	26	26.5	27	27.5	28	28.5	29	29.5	30
630	1.202	1.206	1.211	1.215	1.217	1.219	1.222	1.224	1.226	1.228	1.230	1.232	1.234	1.237	1.239	1.241	1.243	1.245
631	1.200	1.205	1.209	1.213	1.215	1.217	1.220	1.222	1.224	1.226	1.228	1.230	1.232	1.235	1.237	1.239	1.241	1.243
632	1.198	1.203	1.207	1.211	1.213	1.216	1.218	1.220	1.222	1.224	1.226	1.228	1.231	1.233	1.235	1.237	1.239	1.241
633	1.196	1.201	1.205	1.209	1.211	1.214	1.216	1.218	1.220	1.222	1.224	1.226	1.229	1.231	1.233	1.235	1.237	1.239
634	1.195	1.199	1.203	1.207	1.210	1.212	1.214	1.216	1.218	1.220	1.222	1.224	1.227	1.229	1.231	1.233	1.235	1.237
635	1.193	1.197	1.201	1.205	1.208	1.210	1.212	1.214	1.216	1.218	1.220	1.223	1.225	1.227	1.229	1.231	1.233	1.235
636	1.191	1.195	1.199	1.204	1.206	1.208	1.210	1.212	1.214	1.216	1.219	1.221	1.223	1.225	1.227	1.229	1.231	1.233
637	1.189	1.193	1.197	1.202	1.204	1.206	1.208	1.210	1.212	1.214	1.217	1.219	1.221	1.223	1.225	1.227	1.229	1.232
638	1.187	1.191	1.196	1.200	1.202	1.204	1.206	1.208	1.210	1.213	1.215	1.217	1.219	1.221	1.223	1.225	1.227	1.230
639	1.185	1.189	1.194	1.198	1.200	1.202	1.204	1.206	1.209	1.211	1.213	1.215	1.217	1.219	1.221	1.223	1.226	1.228
640	1.183	1.188	1.192	1.196	1.198	1.200	1.202	1.205	1.207	1.209	1.211	1.213	1.215	1.217	1.219	1.221	1.224	1.226
641	1.182	1.186	1.190	1.194	1.196	1.198	1.201	1.203	1.205	1.207	1.209	1.211	1.213	1.215	1.217	1.220	1.222	1.224
642	1.180	1.184	1.188	1.192	1.194	1.197	1.199	1.201	1.203	1.205	1.207	1.209	1.211	1.213	1.216	1.218	1.220	1.222
643	1.178	1.182	1.186	1.190	1.193	1.195	1.197	1.199	1.201	1.203	1.205	1.207	1.209	1.212	1.214	1.216	1.218	1.220
644	1.176	1.180	1.184	1.189	1.191	1.193	1.195	1.197	1.199	1.201	1.203	1.205	1.208	1.210	1.212	1.214	1.216	1.218
645	1.174	1.178	1.183	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.202	1.204	1.206	1.208	1.210	1.212	1.214	1.216
646	1.172	1.177	1.181	1.185	1.187	1.189	1.191	1.193	1.195	1.198	1.200	1.202	1.204	1.206	1.208	1.210	1.212	1.214
647	1.171	1.175	1.179	1.183	1.185	1.187	1.189	1.192	1.194	1.196	1.198	1.200	1.202	1.204	1.206	1.208	1.210	1.212
648	1.169	1.173	1.177	1.181	1.183	1.185	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.202	1.204	1.206	1.209	1.211
649	1.167	1.171	1.175	1.179	1.182	1.184	1.186	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.202	1.205	1.207	1.209
650	1.165	1.169	1.174	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.201	1.205	1.207
651	1.163	1.168	1.172	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.193	1.195	1.197	1.199	1.201	1.203	1.205
652	1.162	1.166	1.170	1.174	1.176	1.178	1.180	1.182	1.184	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.201	1.203
653	1.160	1.164	1.168	1.172	1.174	1.176	1.178	1.181	1.183	1.185	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.201
654	1.158	1.162	1.166	1.170	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.187	1.189	1.191	1.193	1.195	1.197	1.199
655	1.156	1.160	1.165	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.187	1.189	1.191	1.194	1.196	1.198
656	1.155	1.159	1.163	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.188	1.190	1.192	1.194	1.196
657	1.153	1.157	1.161	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.180	1.182	1.184	1.186	1.188	1.190	1.192	1.194
658	1.151	1.155	1.159	1.163	1.165	1.167	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.192
659	1.149	1.153	1.157	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190
660	1.148	1.152	1.156	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.187	1.189
661	1.146	1.150	1.154	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.177	1.179	1.181	1.183	1.185	1.187
662	1.144	1.148	1.152	1.156	1.158	1.160	1.162	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185
663	1.142	1.146	1.150	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183
664	1.141	1.145	1.149	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181
665	1.139	1.143	1.147	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179
666	1.137	1.141	1.145	1.149	1.151	1.153	1.155	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178
667	1.135	1.140	1.144	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176
668	1.134	1.138	1.142	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174
669	1.132	1.136	1.140	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172
670	1.130	1.134	1.138	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171
671	1.129	1.133	1.137	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169
672	1.127	1.131	1.135	1.139	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167
673	1.125	1.129	1.133	1.137	1.139	1.141	1.143	1.145	1.147	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166
674	1.124	1.128	1.132	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164
675	1.122	1.126	1.130	1.134	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162
676	1.120	1.124	1.128	1.132	1.134	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160
677	1.119	1.123	1.127	1.131	1.133	1.135	1.137	1.139	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159

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 degrees 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 A-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 that gravity and altitude are minor corrections compared with temperature and pressure.*

A.4 Connecting A Printer to the Monitor Cart

The Report Generator Software, and also Shot Logging, can produce printed reports using any of a number of compatible printers. Contact your field service representative for more information on specific printers which can be used. The printer interface cable (OEC-Diasonics P/N 870596) will work with some of them.

The printer should have a standard parallel interface. The corresponding cable connector on the monitor cart is a 25 pin D-type which is labeled AUX.

The AUX connector on the rear of the monitor cart does not provide a standard interface. The signals provided at the pins on this connector are listed below in table A-3.

Aux Connector Printer Interface **Table A-3**

SIGNAL	CONNECTOR PIN
Strobe/	1
D0	2
D1	3
D2	4
D3	5
D4	6
D5	7
D6	8
D7	9
Ack	14
Fault/	15
Init	16
Busy	17
Ground	19,20,21,22,23,24,25
Not used	10-13 and 18

A.5 Floppy Disk Drive Installation

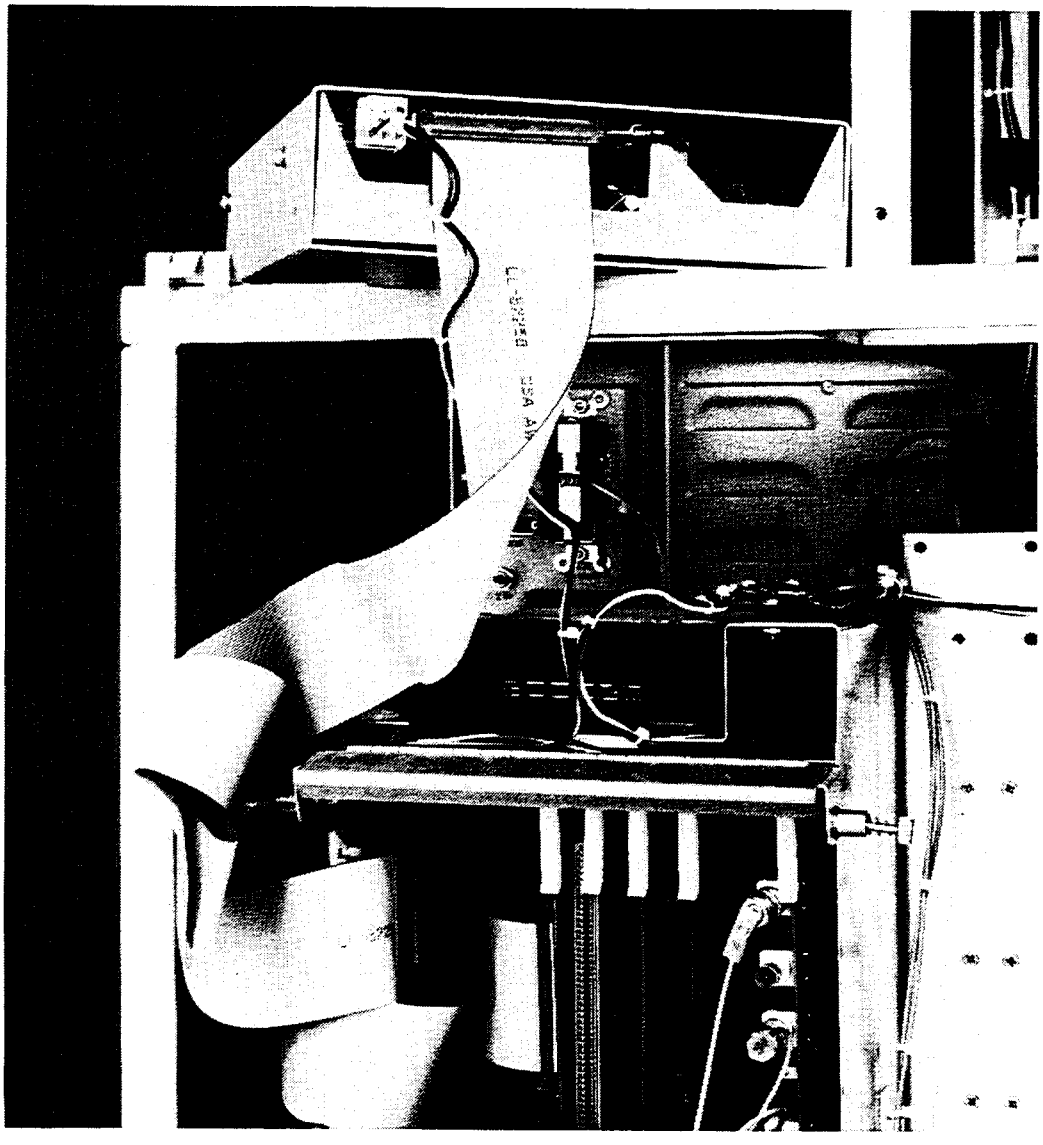
Refer to Figure 1. An 8-inch portable floppy disk drive is included in the DXR Field Kit.

The floppy drive must be installed to use diagnostic software not resident in the system, to install new versions of disk software or to add additional programs to the hard disk. The floppy drive requires an interface to the system through the Disk Controller PCB and is supplied with operating power by a molex connector.

Follow this installation procedure:

1. Unplug the monitor cart from the wall outlet.
2. Remove the left side and front panels.
3. Place the floppy drive conveniently on the left shelf top.
4. Locate the square molex connector with three wires: red, yellow, and black. This will be tied down just in front of the hard disk drive. Connect this to the mating connector on the floppy drive.
5. Connect the 50 pin ribbon cable between the floppy drive and the 50 pin connection on the OMT Adapter Board. This is a 1.5" x 3" board attached just inside the card cage on the upper left.
6. The floppy disk should be inserted into the drive with the label side facing the drive closing lever (facing up).
7. If the drive lever is closed with a floppy disk in place, the monitor cart will attempt to boot from the floppy disk when the cart power circuit breaker is turned on.

Figure 1 - *The floppy disk drive is shown connected to the monitor cart in this photo.*



A.6 External Terminal Installation and Use

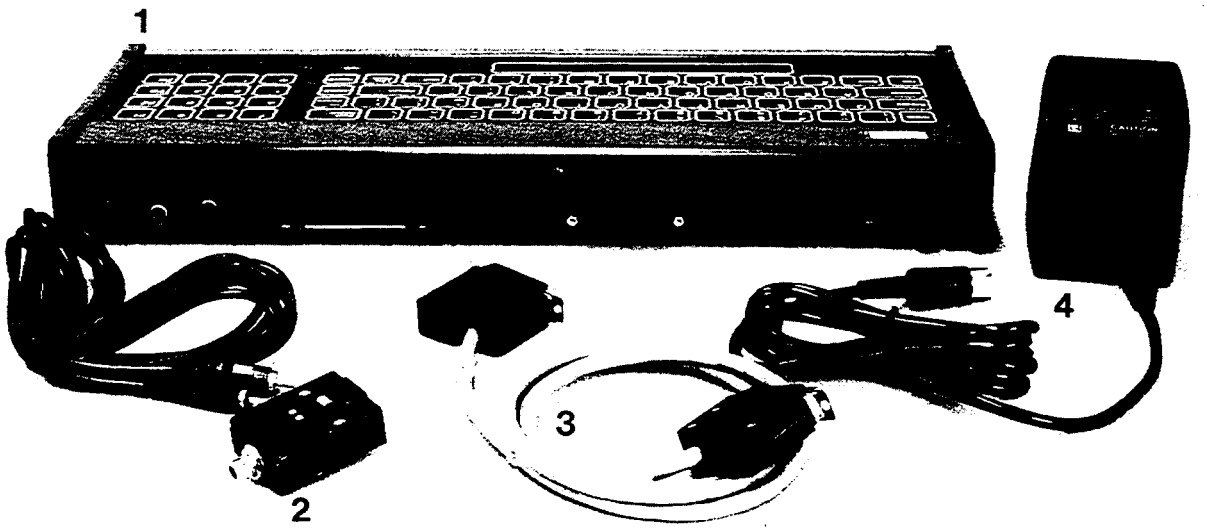
Several of the diagnostic software procedures and some of the specialized application software requires the use of an external computer terminal. If one is available on site it may be used with the proper communications protocol. This is discussed later in this section under "Installing Other Terminals".

Because of the variations in available terminals, for most field service applications it is strongly recommended that the DXR Field Service Kit is used.

The DXR Kit contains a keyboard terminal, power supply, modified RS-232 cable, and a video cable. The video jack adapter (P/N 870964), available separately, is also required. These parts are connected to the monitor cart to provide a computer terminal which uses the left monitor cart screen for the terminal monitor.

Figure 2 - *Components of the keyboard terminal are shown in this photo.*

1) Terminal/keyboard unit; 2) Video Out to VTR plug adaptor; 3) Interface cable to RS232 connector; 4) Power module.



A.6.1 Interfacing the Keyboard Terminal

1. Connect the keyboard or "RCA" labeled end of the interface cable (P/N 870257) to the keyboard terminal and the DXR labeled end to the monitor cart connector labeled "RS-232 Interface".

2. Clip the video jack adapter (P/N 870964) into the VTR connector on the rear of the monitor cart. Connect the video coax cable between the RCA-type connector on the adapter and the video out jack on the keyboard terminal.

3. Plug the power module into a 110 VAC power source and connect it to the keyboard unit.

4. Turn on the cart power and service breakers.

5. Press VTR Review to display keyboard terminal video on the left monitor.

A.6.2 Configuring the Keyboard Terminal

The keyboard will remember the communications setup for several weeks before it must be reinstalled. *Note: if the keyboard has been used within the last two weeks, skip ahead to "Activating Communications".* In the following instructions, type the keys indicated in the [ ] brackets.

1. Turn on the keyboard switch.

2. Type [2].

3. Type [3].

4. Follow the on-screen instructions to produce the following display on the monitor screen:

0 - Previous Menu	
1 - Screen Format	80
2 - TV Channel	3
3 - Cursor	Blink
4 - Line Wrap	On
5 - Auto Line End	Off
6 - Auto Screen Blank	On
7 - Status Line	On
A - Key Beep	On
B - Alpha Lock	On
C - User 1 Key	Select
D - User 2 Key	Menu

5. Once these options are correct as indicated above, type [0].

6. Type [3].

7. Another display will appear. Set it up as shown:

0 - Previous Menu	
1 - Communications Type	Direct
2 - Baud Rate	9600
3 - Data Bits	8
4 - Parity	None
5 - Stop Bits	2
6 - Duplex	Full
7 - Handshaking	Off

8. Once these options are correct type [0].

9. Type [0] again.

A.6.3 Activating communications

1. Type [3], then type [H].

2. The line at the bottom of the monitor should now read:

LINE SELECT MENU

3. After booting the system with the keyboard terminal installed, the monitor will display the line:

Press ESC to return to menu.

A.7 Service Log

The service log is found on the next pages. Enter the appropriate information when service or maintenance is performed.

OEC-DIASONICS, INC.

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

OEC-DIASONICS, INC.

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

SERVICE MANUAL

00-870820-01

SERIES 9000

X-RAY IMAGING SYSTEM

Effectivity:

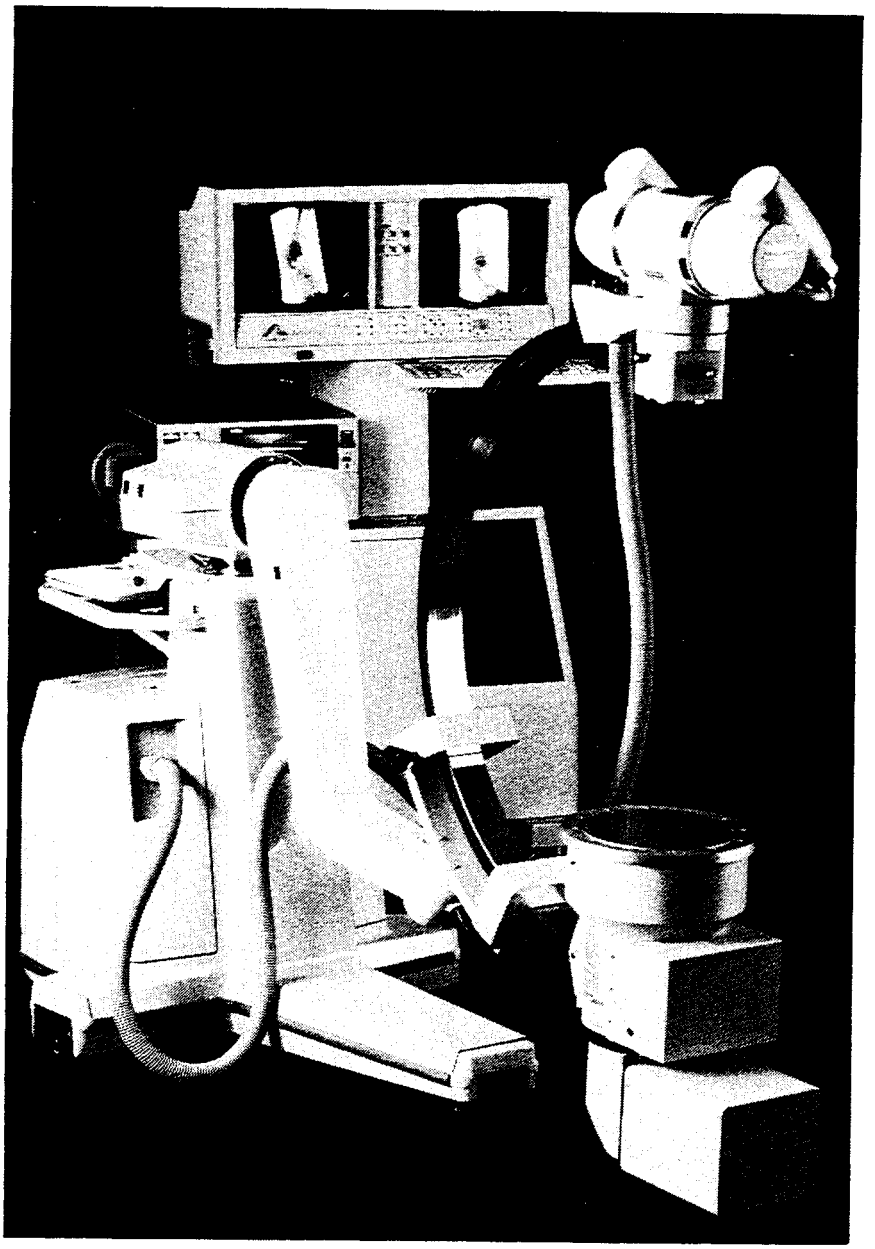
This manual contains descriptions, instructions and procedures which apply only to Series 9000 systems with serial numbers in the 96-000 and 99-000 series.

Date of Issue: September 1987

OEC-DIASONICS

384 Wright Bros Drive
Salt Lake City
Utah
84116

(801) 328-9300



SERIES 9000 X-RAY IMAGING SYSTEM (Details of this photograph may vary depending on options).

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 the properly trained service engineer who 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 Series 9000 system.

This manual is intended to compliment the training offered by OEC-Diasonics. You should not attempt any of the procedures in this manual unless you have received this training on the Series 9000 System. Reading this manual does not alone 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.

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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 the properly trained service engineer who 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 Series 9000 System.

This manual is intended to compliment the training offered by OEC-Diasonics. Reading this manual does not alone 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.

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 certain hazards, emergency procedures and instructions for accident reporting.

Section 3
Mainframe 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.

Section 4
Monitor Cart Theory of Operation
A description of the hardware and software is provided to facilitate an understanding of the maintenance, calibration and repair of the monitor cart. Optional patient annotation and hard disk image storage are covered.

Section 5
Mainframe Parts, Disassembly and Replacement
Step by step instructions for removing and replacing field serviceable parts.

The major field replaceable parts are pictured and identified with their OEC-Diasonics part numbers.

Section 6
Monitor Cart Parts, Disassembly and Replacement
Step by step instructions for removing and replacing field serviceable parts.

The major field replaceable parts are pictured and identified with their OEC-Diasonics part numbers.

Section 7
Mainframe Service and Diagnostics
Mainframe boot and error codes, event codes and warning messages. Using the control panel Status Mode. Tables of adjustments, switches and jumpers.

Section 8
Monitor Cart Service and Diagnostics
How to change the monitor cart option configuration. Front Panel error messages. Built-in test and diagnostic software. Shot logging.

Section 9
Mainframe Calibration
Calibration procedures for the system are provided. A calibration worksheet is included.

Section 10
Installation
Unpacking, repacking, installation and on-site checkout instructions are provided.

Section 11
Options
Installation of options, interfaces, special troubleshooting and maintenance notes. Options include: VTR, AngioStor, multiformat camera.

Appendix
Recommended tools and test equipment. Installation and Use of Special Equipment. Printer Installation. Terminal installation and use. Test Log.

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 00-870820-01). Operating instructions for the system are contained in the Operator's Manuals for each member of the Series 9000 family:

9000 basic model - 00-871352
9000 with E.S.P. Option - 00-871353
9000 with E.S.P. and Vascular or Neuro-Vascular Option - 00-871354

Schematic diagrams for the system are contained in the schematic package, part number 00-870822.

The system contains some equipment and assemblies manufactured by original equipment manufacturers (OEM's) and not OEC-Diasonics. 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 maintenance 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 (21CFR 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, Generator Controller 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

Figures 1, 2, and 3 illustrate the major assemblies of the OEC-Diasonics Mobile C-arm X-ray System. The two major assemblies, the mainframe and the monitor cart, are connected by an 18 foot interconnect cable which carries power, video and communications signals.

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 to provide static grounding in an operating room environment.

1.5 Standard Equipment

Table 2 Standard Equipment

ITEM	*PART NUMBER*
C-arm Assembly	00-870724
Monitor Cart Assembly	00-870727
Collimator and Plate Assembly	
(6-inch)	00-870472
(6/9-inch)	00-870472
Image Intensifier Asm w/ Vidicon	
(6-inch)	00-870725
(6/9-inch)	00-870817
Cassette Holder	
(6-inch standard)	00-861095
(6-inch metric)	00-871096
(9-inch standard)	00-871138
(9-inch metric)	00-871139
Accessory Parts Kit	00-870729
Conductive Caster Asm	00-860092
Foot Switch Assembly (Dual Stage)	00-900012
30 cm Extension Spacer	00-837201

Figure 1 - *The mainframe is shown in this drawing.*

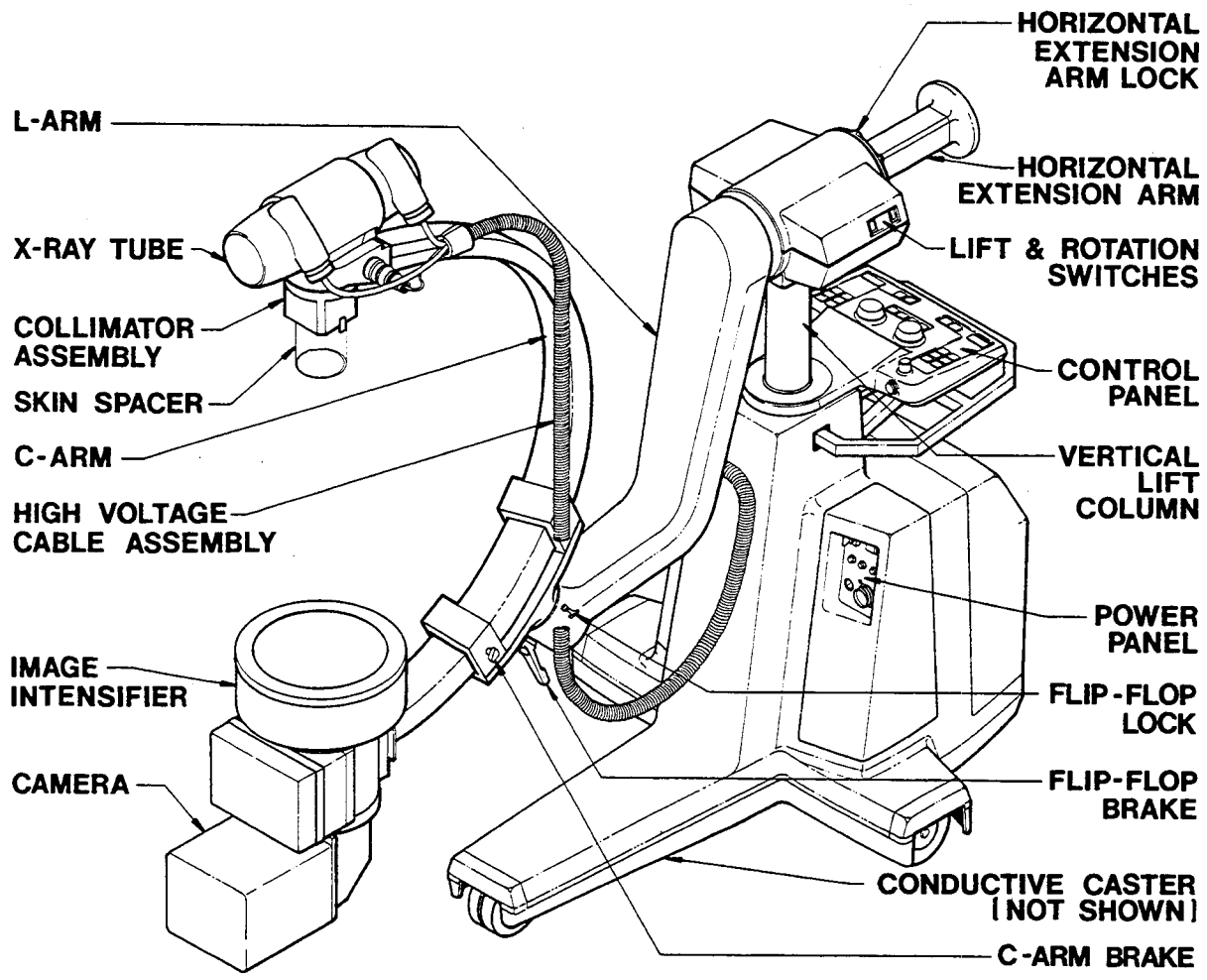


Figure 2 - *Front view of the monitor cart.*

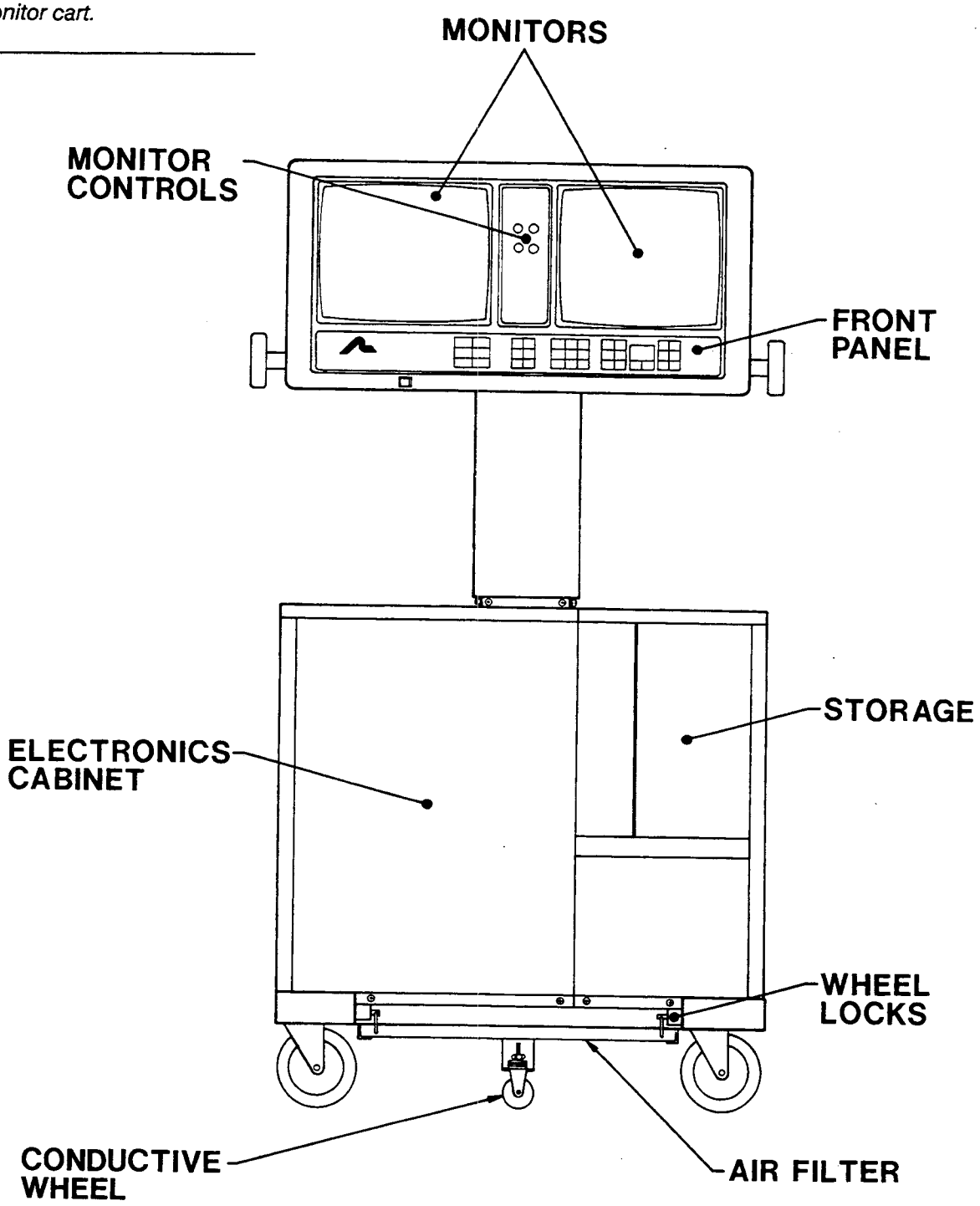
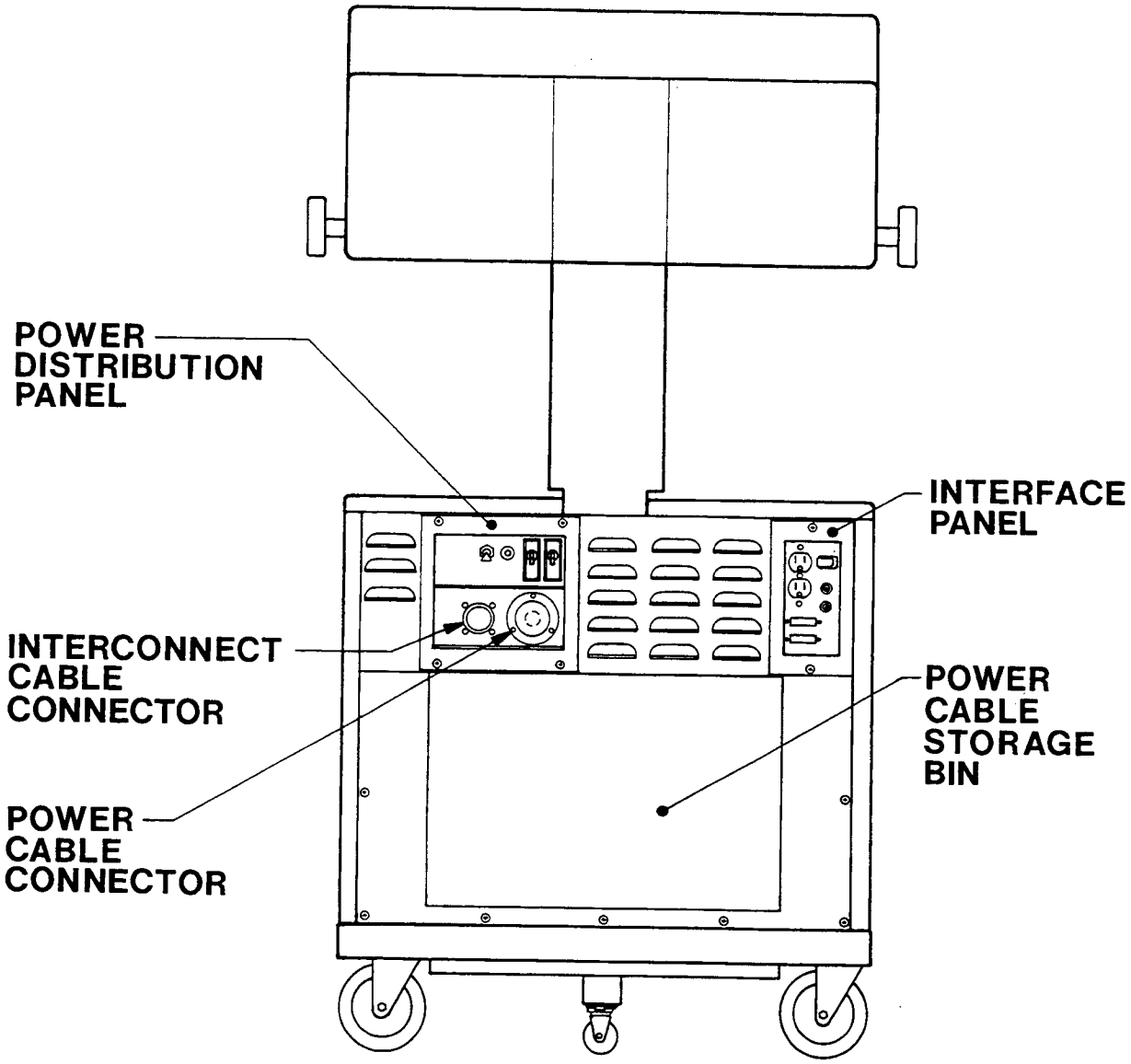


Figure 3 - *Rear view of the monitor cart.*



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 connecting an external terminal. The option files are described in the sections of this manual: "Mainframe Service" and "Monitor Cart Service."

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 dual mode 6/9-inch image intensifier. Serial numbers in the 63-000 range identify systems equipped with 6-inch image tubes. Serial numbers in the 93-000 range identify those equipped with 6/9-inch image tubes.

1.9 Monitor Cart Options

Image Storage

Images may be stored by several means, in analog or digital format, depending upon the system configuration.

Internal Hard Disk Image Storage - a hard disk memory system capable of storing sixty 512 x 512 x 8 bit matrix images. The digitized image can be saved on the hard disk and later recalled.

Video Tape Recorder - The undigitized image is available for storage on a video tape recorder or AngioStor.

AngioStor - Up to 20 seconds of high resolution video can be stored and reviewed. Playback can be continuous or stepped a single frame at a time.

Multi-format Camera - Several models are available to make hard copy films of fluoro images.

Patient Annotation - Images can be annotated with identifying information on the screen or on hard disc. A swing out keyboard is used with special software.

Image Processing

The circuits and software in the monitor cart perform image processing on the video signal. The specific operations, which may include frame integration, frame averaging, image subtractions, and "window" and "level" control of the gray scale, are selected from the monitor cart front panel.

Most image processing options can be identified by examining the monitor cart front panel.

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 all safety requirements applicable to medical electronic equipment of this type.

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

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 who has been trained to troubleshoot and repair the Series 9000 System.

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

WARNING: **The procedures in this manual should not be attempted by anyone who is not specifically trained by OEC-Diasonics to work on the Series 9000 System.**

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; nor can it be responsible 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.
P.O.Box 25296
Salt Lake City, Utah
84125-0296
801-973-6800

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 who work with or are exposed to X-ray tubes must take precautions to protect themselves against serious injury. Do not be careless.

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.

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.

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: **This equipment contains very high power electrical components and should be serviced only by personnel intimately 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.**
- Video monitors (monitor cart) - **25,000 volts.**
- Transformers (especially the isolation transformer in the monitor cart) - **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.**

WARNING: **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.**

WARNING: **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.**

WARNING: **Do not remove the interconnect cable from its connector on the monitor cart. Hazardous voltage (120 VAC) is present on the pins of this connector when the monitor cart is plugged into a power outlet. These pins are exposed when the interconnect cable is not in place.**

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.

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

Federal DHHS guide lines specify that the minimum source-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-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 Emergency Power Off

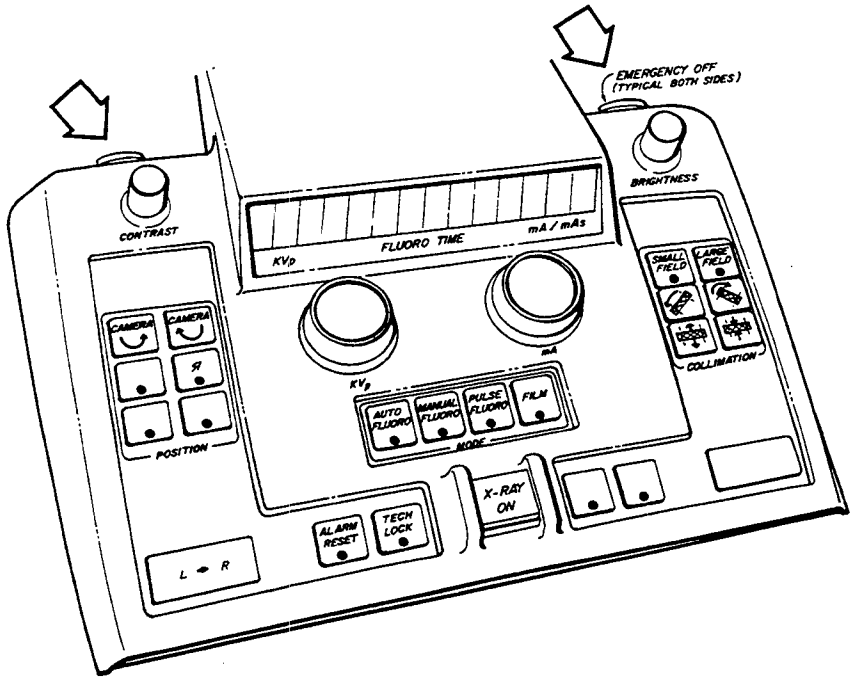
Refer to Figure 1.

The system has two EMERGENCY OFF buttons located on the C-arm control panel. When either button is pressed, operation of the system 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.

In the unlikely event that a malfunction in the motor control circuitry causes a motor to drive without an operator command, it is important to train all operators to respond by pressing the EMERGENCY OFF switch.

The monitor cart electronics are separately controlled by the cart power breaker on the cart power panel. To remove power only from the monitor cart electronics turn this breaker off.

Fig. 1 - The locations of the two emergency off buttons are shown here.



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 by a qualified service technician.

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 System Failure During Fluoroscopic Use

If the system image processing electronics fail during a critical operative procedure, set the toggle switch on the rear of the monitor cart to BYPASS. This will direct undigitized live fluoro images to the left monitor, bypassing the image processing electronics.

NOTE: Last-image-hold will not operate in BYPASS.

2.5.4 System Malfunction

If a fuse is blown repeatedly or a circuit breaker trips after being reset, it may indicate an equipment malfunction. Do not attempt to operate the system until it has been checked out by a qualified service technician.

If any of the system controls fail to respond as indicated in the Operator's Manual, the operator should, if the immediate circumstances allow:

1. Turn the power off.
2. Unplug the system from the wall outlet.
3. Notify a qualified service technician immediately.
4. Do not attempt to operate the system until the service technician has advised that it is operating properly.

The system should not used beyond the immediate situation if any system control failure occurs.

2.5.5 Electrical Fire

The owner should develop an emergency procedure for the area in which the system is installed that includes the following safety measures:

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 *The use of 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.*

2.5.6 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.

2.6 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:

- The potential for death or the type of serious injury that may result is specified in the labeling for the system.

- The malfunction and the routine service, repair, or maintenance instructions to correct the malfunction are described in the labeling for the system.

- The malfunction has occurred at or below its expected rate of frequency and severity.

- 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.

2.7 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
MAINFRAME
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 in understanding the maintenance and calibration procedures in this manual.

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

The software plays a central role in the operation of the system. Therefore discussion of software is combined with the hardware theory of operation.

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 (00-870735) and the Image System Interconnect Diagram (00-871059).

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. The connectors J1, J2, J3 and J4 provide the internal computer bus.

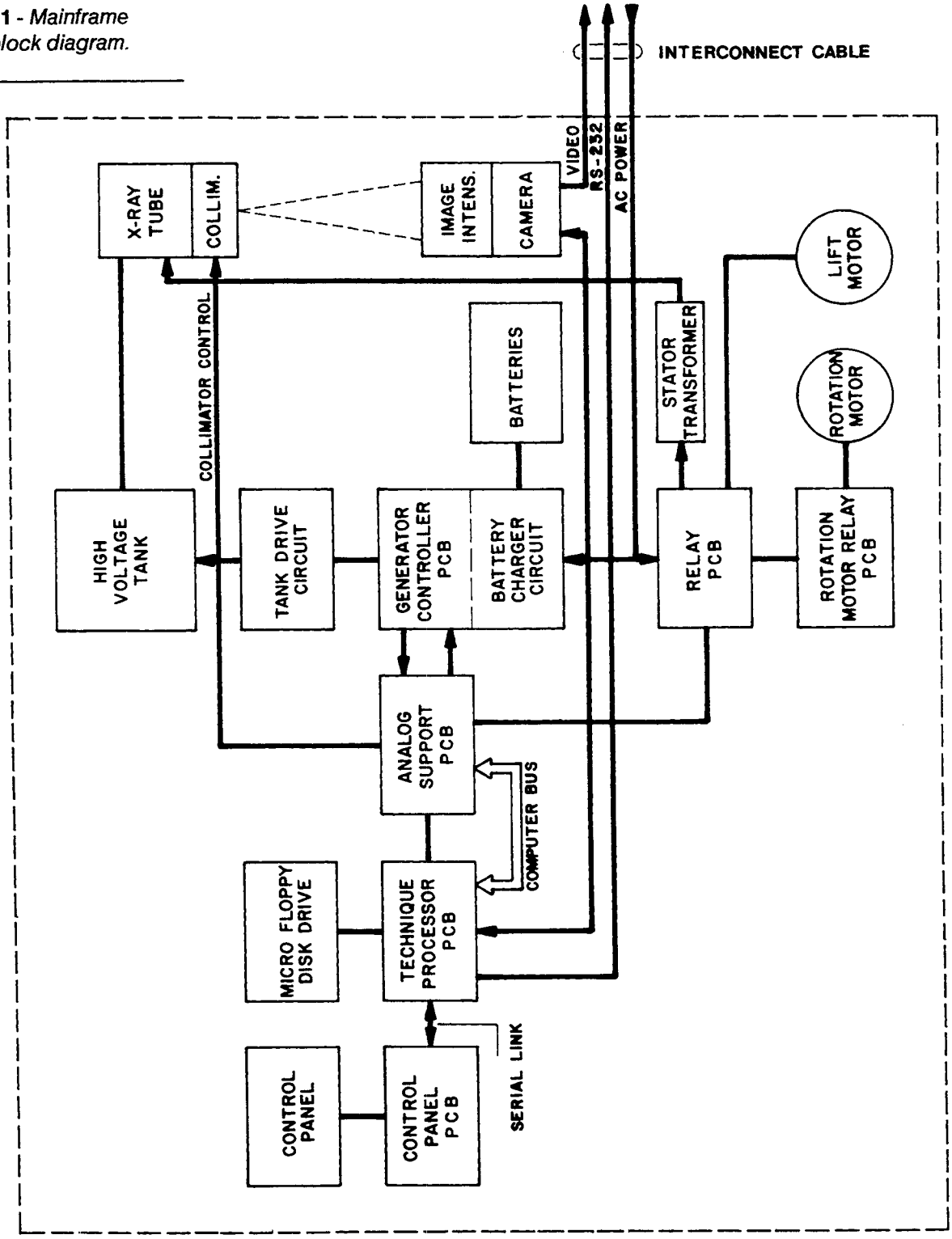
Floppy Disk Drive - Mainframe operating and application software is contained on a 3 1/2-inch microfloppy disk. Each time the system is started, the software is loaded from the disk drive.

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 Controller PCB - the filament control, high voltage control, mA and kVp sensing and battery charger are combined on this board.

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.

The mainframe and monitor cart are interconnected by an 18-foot cable which carries power, video and communications signals. Both ends are interchangeable. The monitor cart end is normally locked in place to prevent the electrical shock hazard that could result from accidentally contacting the line voltage pins on the connector. A stand-alone adapter is not required to operate the monitor cart for post-processing without the mainframe attached.

3.2 Power Distribution

3.2.1 AC Power

Refer to the Mainframe Interconnect Diagram 00-870735.

Power is obtained from the AC line by the isolation transformer in the monitor cart and applied to the mainframe through an 18-foot interconnect cable. In the mainframe, 115 VAC (optimal) is distributed to the battery charger circuit on the Generator Controller PCB, 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.

Table 1 Interconnect Cable Wiring List

PIN	*FUNCTION*
1	X-ray disable
2	video stable
3	L>R
4	spare
5	store
6	spare
7	RTS cart
8	TXD cart
9	CTS cart
10	RXD cart
11	brightness
12	contrast
13	X-ray lamp 3
14	n.a.
15	n.a.
16	n.a.
17	n.a.
18	n.a.
19	n.a.
20	n.a.
21	n.a.
22	n.a.
23	n.a.
24	n.a.

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. EMERGENCY OFF 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 portion of the Generator Controller 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 00-870735.

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 to the six 30-volt battery packs.

3.2.3 Battery Packs

Six 30 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 on the Generator Controller PCB 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 these batteries. Remember that they are a source of high voltage (180 VDC) and high current which can be hazardous even when the system is not plugged in.

NOTE: The condition of the six 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. Many of these circuits provide redundant protection.

3.3.1 24 Volt Interlock

Refer to Figure 3-2.

The 24 volt interlock circuit passes through the Relay PCB, Technique Processor PCB, Analog Control PCB, and the motherboard. This provides the means to halt system operation when the EMERGENCY OFF 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 signal to the Relay PCB.

The 15 volt 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 15 volt interlock passes through both EMERGENCY OFF switches and the START switch.

When the START switch is pressed, relay K2 latches, supplying +24 volts to relays K1, K3, K4 and K5. If the interlock loop is broken, 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 same 24 volts is also supplied to the *Generator Controller PCB* where it latches relay K2. If this relay opens, it disables the high voltage generator by disconnecting the 15 volt return path from transistors Q14-Q17.

The B+ charge and B+ contactor relays, mounted below the Generator Controller PCB, also obtain 24 VDC from this 24 volt interlock circuit.

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 imbeded 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.*

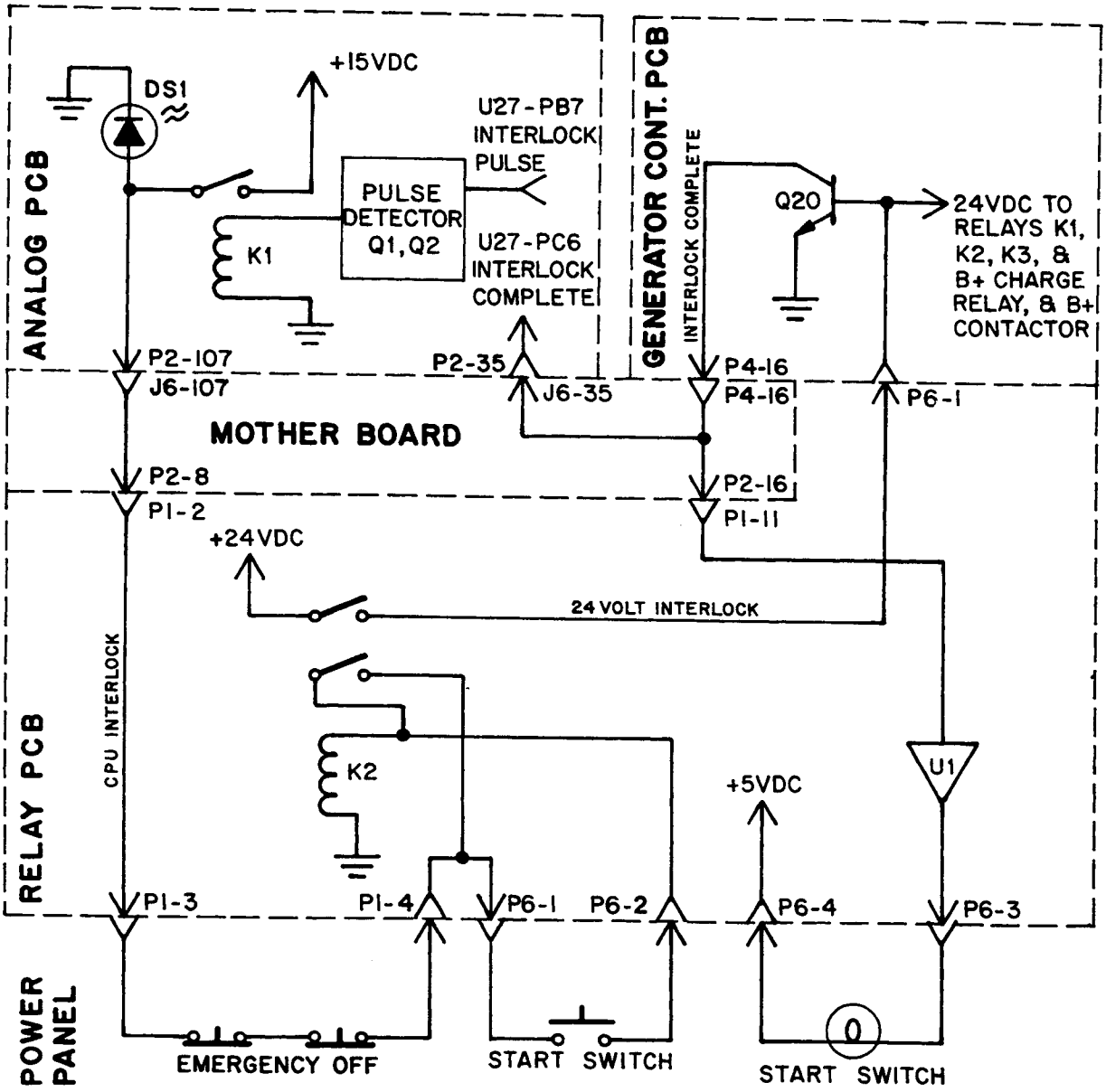
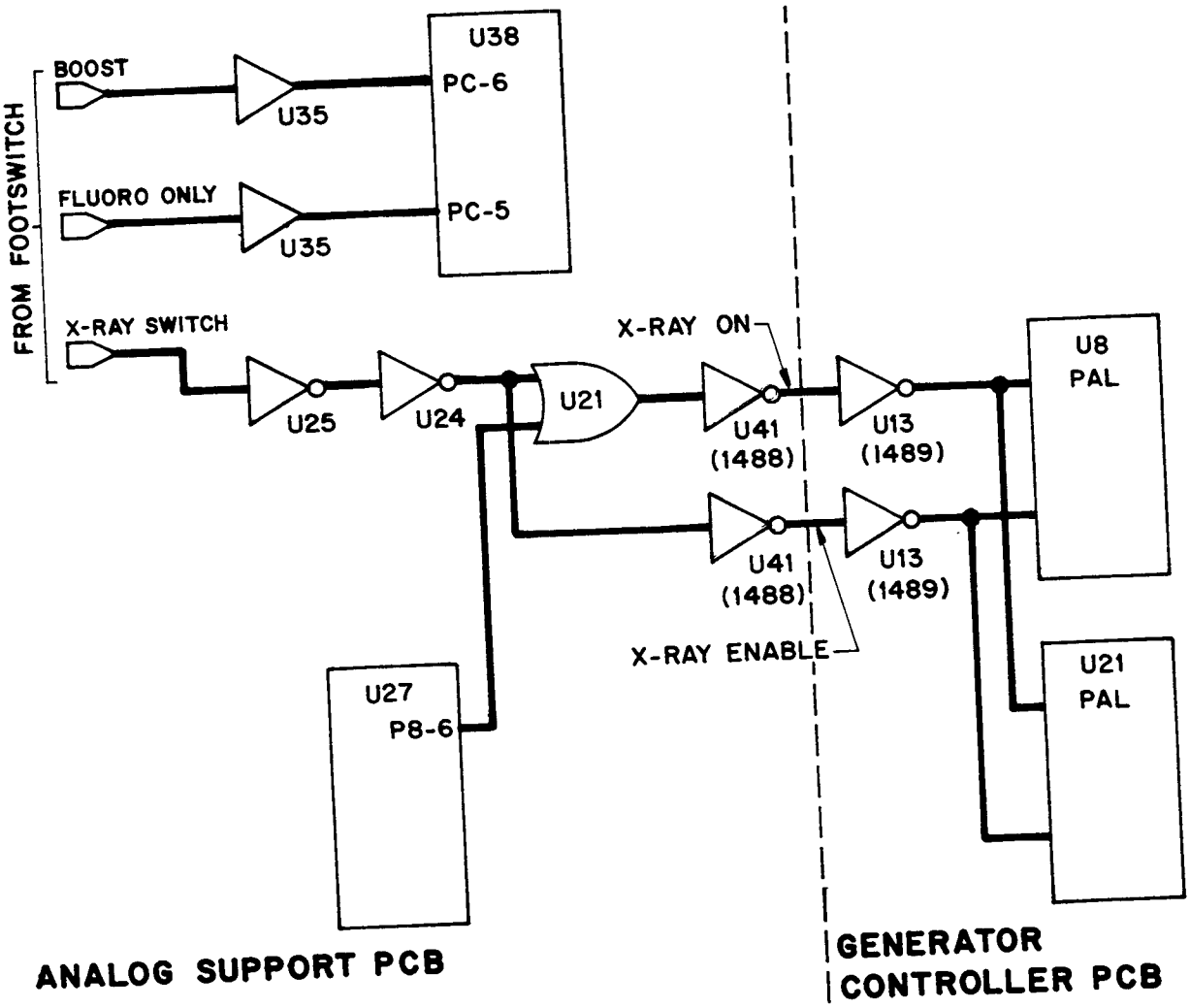


Figure 3-3 - *Block diagram of the footswitch logic.*



3.3.3 Footswitch Logic

Refer to Figure 3-3.

Protection logic on the Generator Controller PCB 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 Generator Controller PCB where they are inverted and input to the PAL logic at U21 and U8. The outputs from these PALs form the filament and high voltage drives.

6. Faults on the Generator Controller PCB are sensed by fault PAL U32.

7. If X-RAY ON and X-RAY ENABLE are true and there are no faults reported to PAL U21 pin-9 from the FAULT output of U32, then U21 output HV GEN ON will be true.

8. HV INV ON is sensed by the processor at Analog Support PCB, PIO U27-PC4.

3.3.4 Fuse Protection

In the unlikely event of multiple catastrophic failures, the 50 Amp circuit breaker in the connection to the battery pack provides fire protection.

Fuses F1, F3, F4 and F5 on the Generator Controller 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 Controller PCB 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 bring the system to a de-energized stand still. Warning messages are displayed on the control panel. These are listed and described in the section Mainframe Service and Repair.

Conditions which are monitored include:

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

When a fault is detected severe enough to cause the system to shut down, a complete restart of the system is required.

3.4.1 KVp Overvoltage

If the voltage sensed on the SECONDARY TAPS 1 and 2 of the high voltage tank exceeds about 135 kVp, comparator U3 on the Generator Controller PCB will trip the OVERVOLTAGE input to PAL U32. The FAULT output from U32 disables the high voltage drives from the output of PAL U21.

NOTE: If the secondary tap 1 and 2 signals carried through P1 on the Generator Controller PCB are disconnected, pullup resistors R1 and R3 will cause comparator U3 to trip the the OVERVOLTAGE line. This is an important safety factor; all signals on connector P1 must be connected for the generator to operate without damage.

3.4.2 Short Circuit Protection

A winding on the series tuning inductor L1, in the tank circuit input, senses the differential voltage across the inductor. This CURRENT LOOP signal is integrated on the Generator Controller 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 Output Transistor On-State C-E Voltage Fault

This circuit, also known as the saturation fault detector, is found on the Generator Controller PCB. The main power transistors, Q1 and Q2, each contain two darlington pairs, and drive the primary of the high voltage transformer (tank). Bridge rectifier VR2 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 R147 to the ground referenced R149. The open collector buffer U6 enables the input of comparator U42 only during the output stage drive period. At this time, rectifiers CR50 and CR53 can cause comparator U42 to trip the FAULT 1 line, feeding PAL U32.

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 10 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 high voltage, filament current and anode rotation are turned off and the collimator is returned to the small field position. 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 are dependent upon which technique has been selected. In all cases, 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 Manual Continuous except that the exposure is generated only for the duration of a pulse. The pulse is repeated each second with the ON button or footswitch depressed.

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 is repeated each second with the ON button or footswitch depressed.

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.

Film Mode

The presence of a film cassette is required in this mode. The 6-inch, but not the 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 prearm 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 prearmed, however, exposures are immediate, 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 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 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 for the first several seconds, then gradually increasing the duty cycle, and consequently the temperature, to the required value over 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. Hardware is again initialized as a precaution.
2. The 40 kHz clock on the Analog Support PCB is started.
3. Interlocks are made.
4. The stator line is pulsed.
5. Small filament is preheated
6. B+ capacitor is charged.
7. Generator and X-ray tube control signals are initialized. After a pre-charge cycle the B+ Contactor is closed.
8. EEPROM is checked.
9. Footswitch is checked (for footswitch stuck fault).
10. Heat units are computed for the anode.
11. Tests are run to determine if the system is capable of functioning. In detail the tests are:
    a. Scroll sign on message
    b. Verify that the kVp and mA sense are near zero.
    c. Check for inadvertent presence of X-ray Activate Jumper which will appear as "Stuck Footswitch".
    d. Verify HV Generator Line OFF
    e. Start interlock pulses and scroll message "PRESS START." Operator presses START SWITCH.
    f. Turn on B+ Precharge. Check batteries during precharge.
    g. Close Main Contactor. Check B+ voltage
    h. Check flipper circuits.
    i. Check EEPROM integrity.
    j. Check EEPROM disk image.
    k. 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:

1. Small field flipper
2. X-ray tube heating
3. Camera dark current compensation - dark current compensation tables are built every 120 seconds after the last fluoro exposure.
4. Monitor battery voltage and current.
5. 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:

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

15. System serial number

16. 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

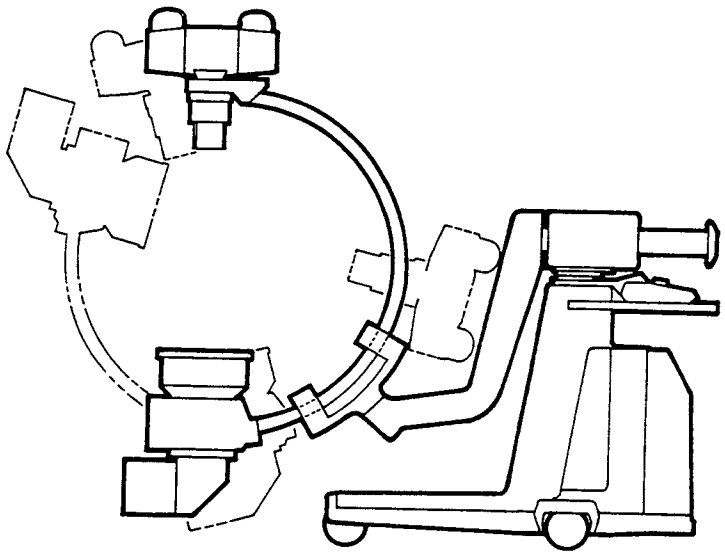
Refer to Schematic 00-870735.

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.

C-arm Radial Movement

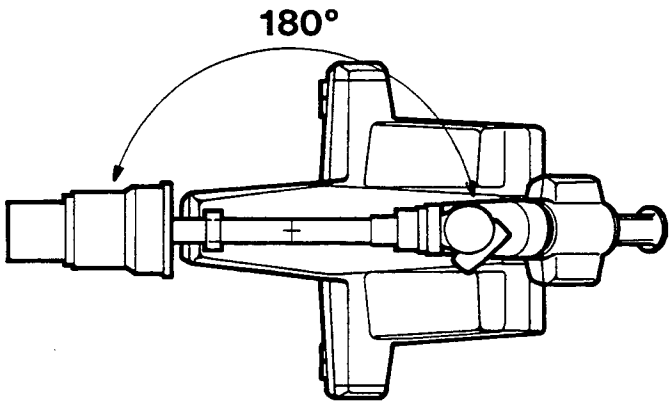
Figure 3-4 - *The C-arm can rotate in its cradle 111 degrees.*



C-arm Flip-Flop Positioning

Figure 3-5 - *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.*



L-arm Rotation

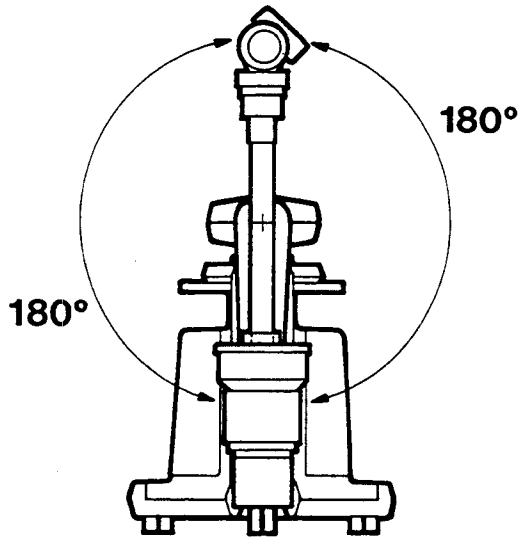


Figure 3-6 - *The L-arm can be rotated 180 degrees in either direction (for a total of 360 degrees).*

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

Vertical Lift Travel

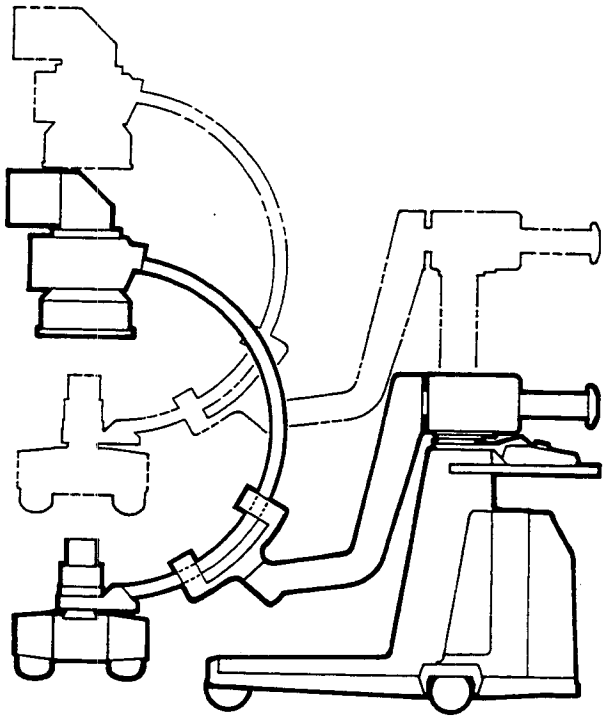


Figure 3-7 - *The entire C-arm and L-arm assembly can be raised up to 18 inches on the central column.*

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

Horizontal Travel (Extension)

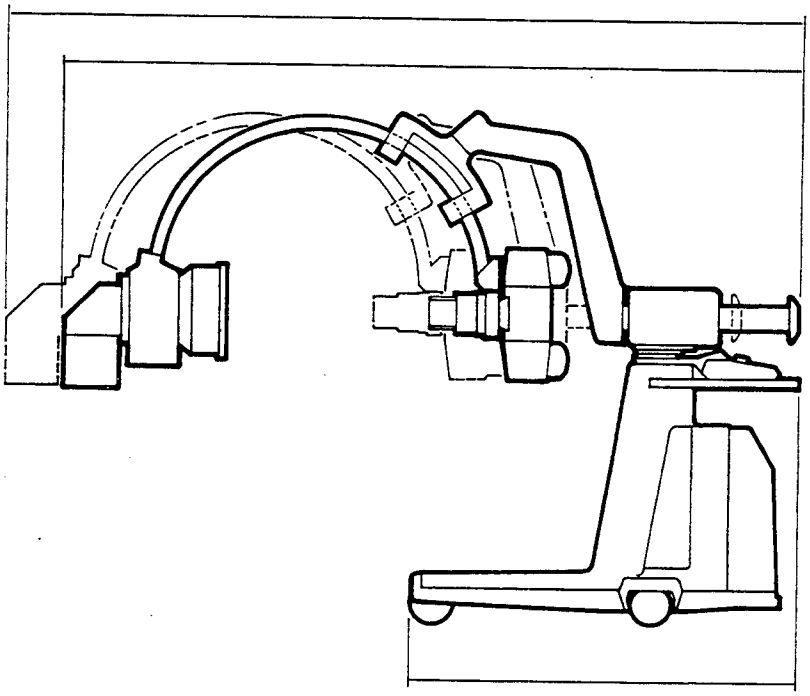


Figure 3-8 - *The L-arm and C-arm assemblies can be extended horizontally up to 8 inches.*

Release the locking ring by turning it counter-clockwise about 15 degrees.

Push or pull on the extension arm to the desired position,

then retighten the locking ring by turning it clockwise until it is fingertight.

Wig-Wag (side-to-side swing)

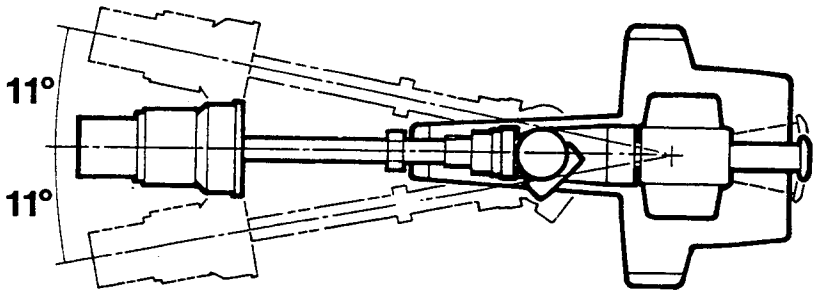


Figure 3-9 - *The entire extension, L-arm, C-arm assembly can swing, or wig-wag, from side to side 11 degrees in either direction for a total of 22 degrees of motion.*

Pull out the locking pin and turn its handle 1/4 turn to latch it open. Loosen the wig-wag brake on the column.

Retighten the brake handle when the desired position is reached.

Control Panel Positioning

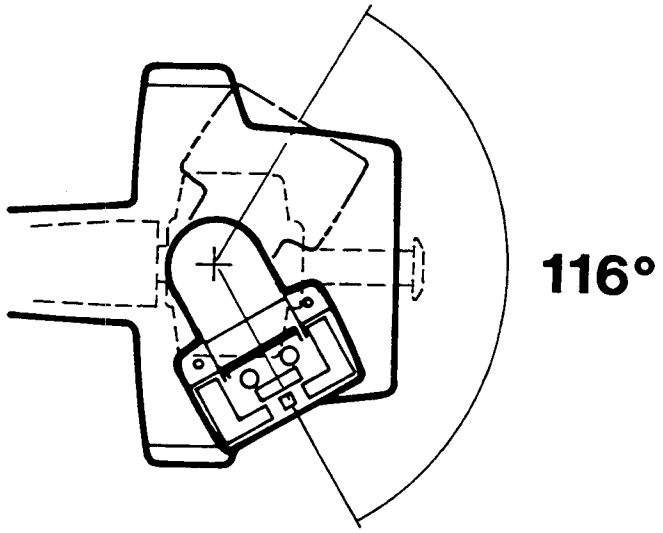


Figure 3-10 - *The control panel can be swung 58 degrees to either side, for a total of 116 degrees of movement. This provides the operator with easy access to the controls.*

The control panel is not locked in position, move it freely as needed.

Steering Control

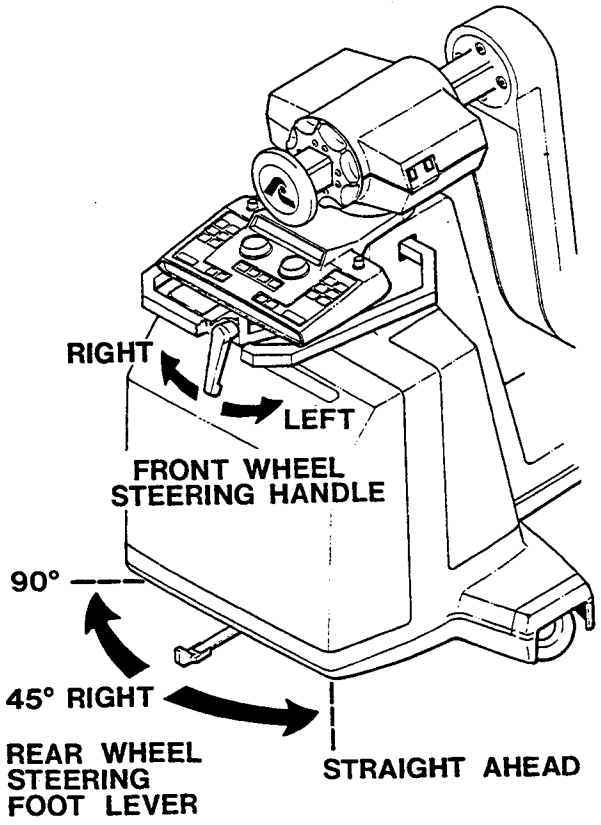
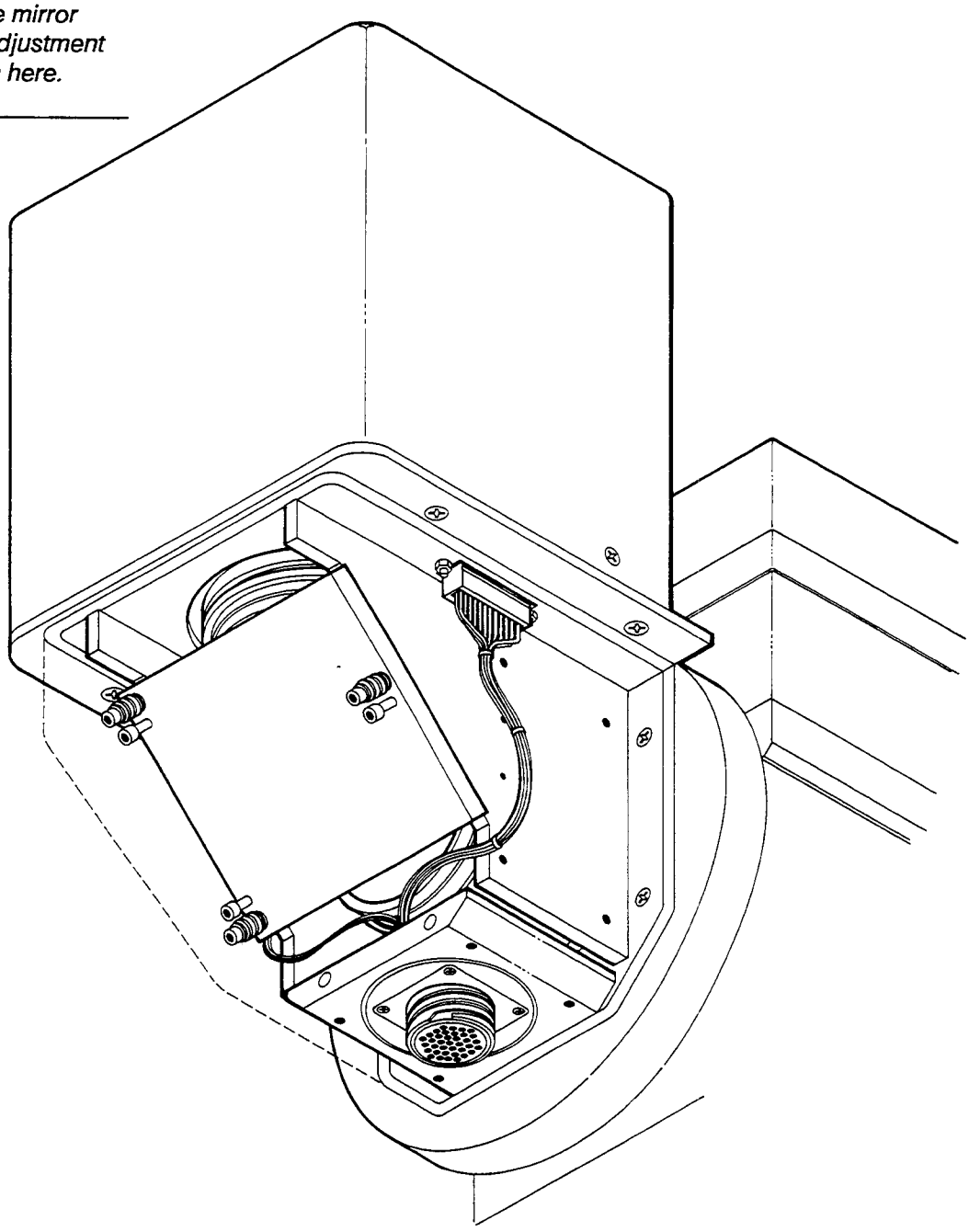


Figure 3-11 - *A steering handle and foot lever are used to control the orientation of the front and rear wheels.*

3.7.2 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 3-12 - *The mirror mounting plate adjustment points are shown here.*



3.8 X-ray Tube

Refer to Figures 3-13 and 3-14.

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 40VAC 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 3-13 - *Cutaway view of the X-ray tube.*

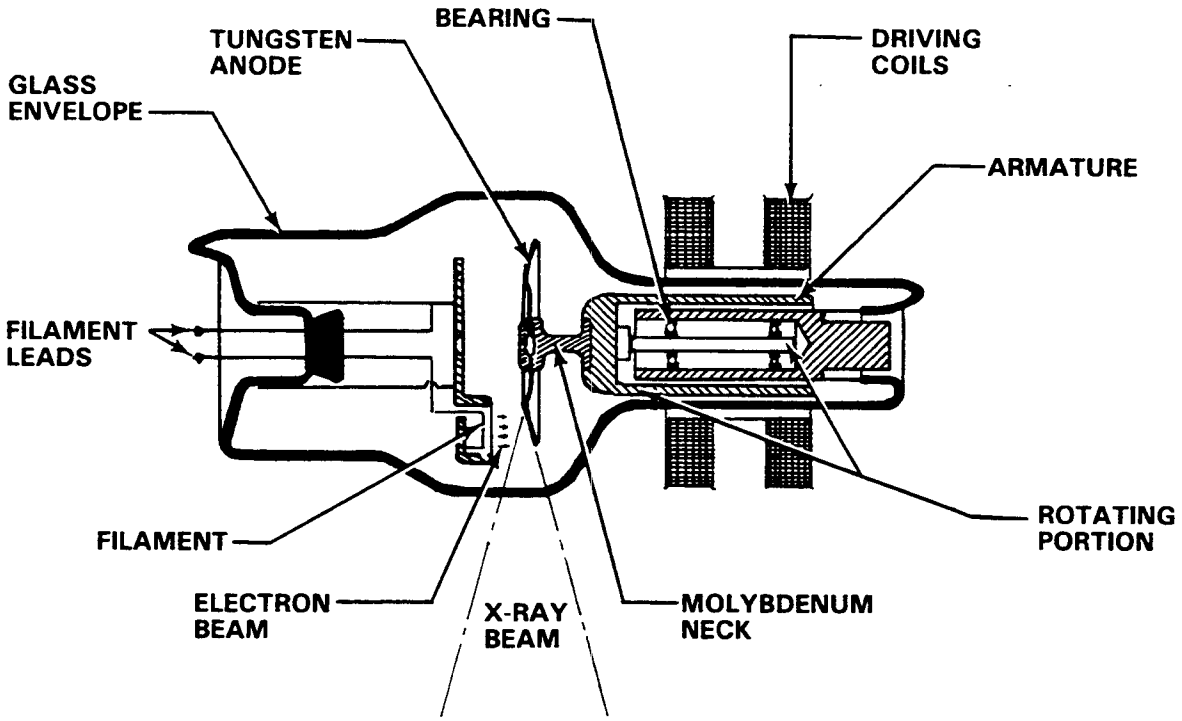
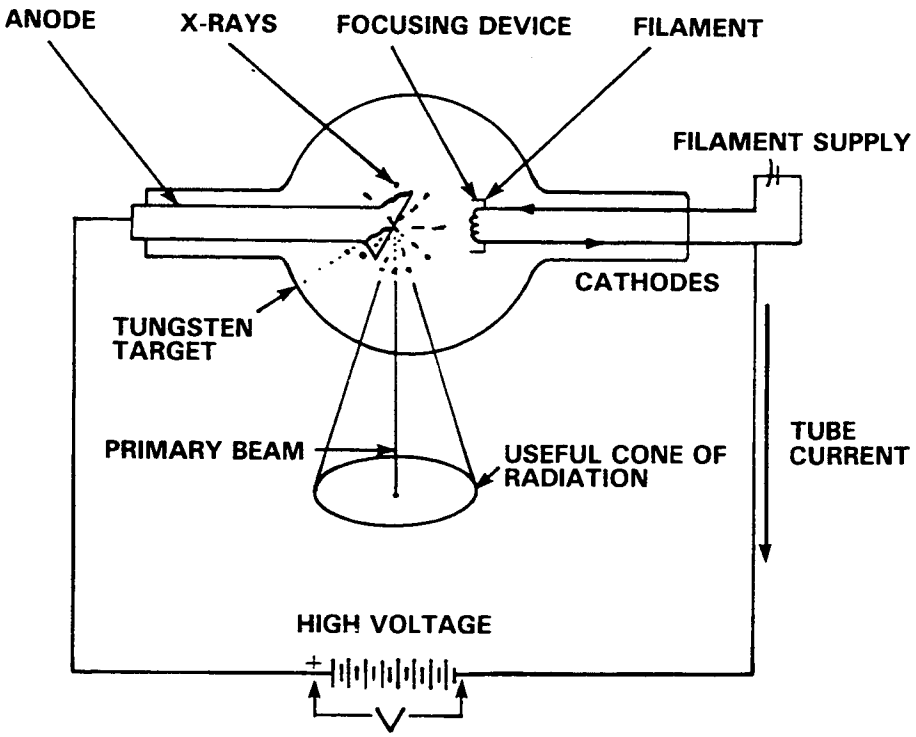


Figure 3-14 - *Schematic of the X-ray tube.*



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 3-15.

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.

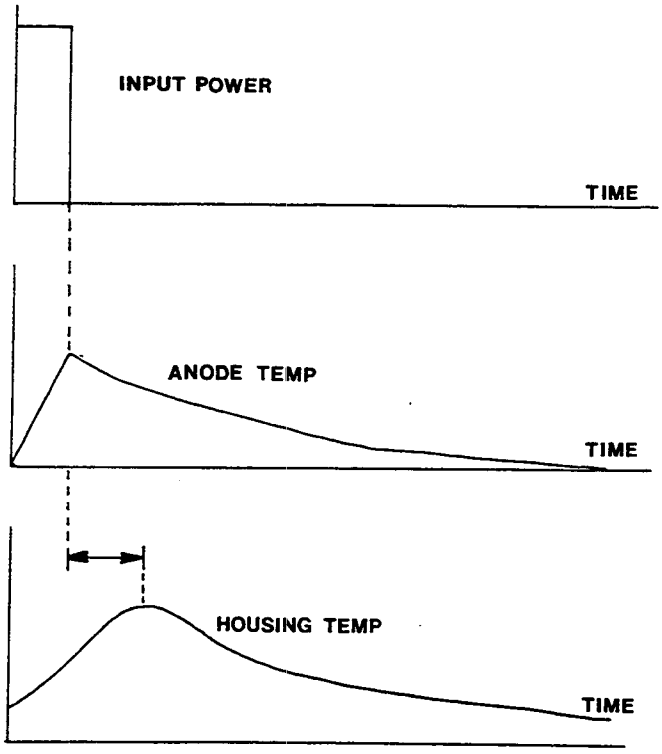


Figure 3-15 - *The relationship of input power, anode and housing temperatures is shown in these graphs.*

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 75 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 3-16 to trace this 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 collimator (3), located within the X-ray tube mounting head, is moved in or out of the beam path to switch between large and small beam diameters. 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 X-ray tube housing.

The minimum beam size of less than 5 X 5 cm square is measured at the source to image receptor distance (SID). The face of the fluoro image intensifier lies slightly outside the film SID and this factor is accounted for at calibration.

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

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

Beam Collimation
Refer to Figure 3-17.

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

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 a five x five centimeter square.

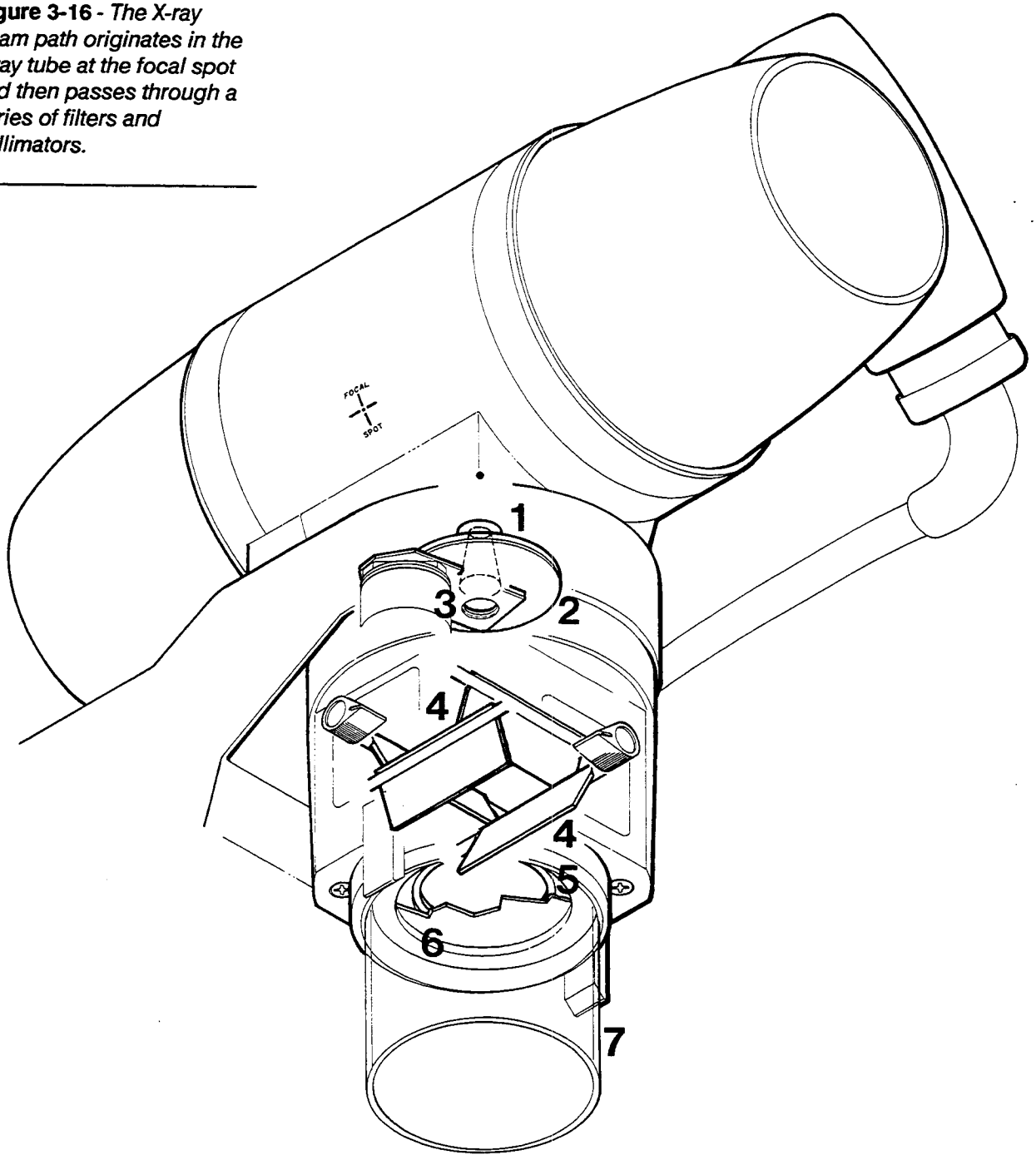
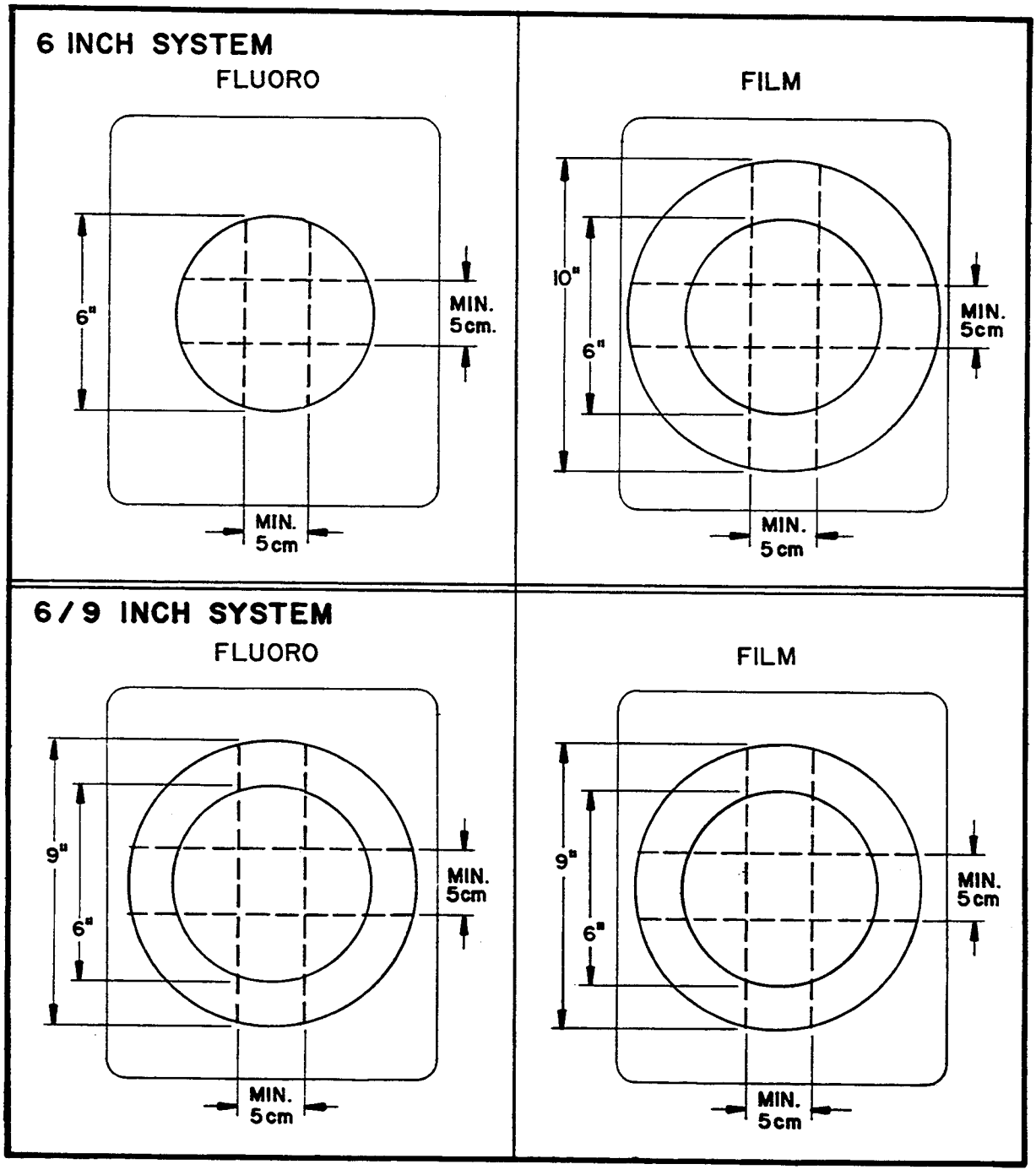


Figure 3-16 - *The X-ray beam path originates in the X-ray tube at the focal spot and then passes through a series of filters and collimators.*

Figure 3-17 - *The X-ray fields produced by varying degrees of collimation are different for 6-inch and 6/9-inch systems.*



The X-ray fields produced by varying degrees of collimation are different for 6-inch and 6/9-inch 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-inch field can be used in the FLUORO mode. The LARGE field on these models is approximately 10 inches in diameter.

6/9-inch Image Intensifier Models - the uncollimated beam is 9 inches in diameter when the small field collimator is retracted. When the small field collimator is in place, the beam is reduced to 6 inches.

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-inch 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-inch image intensifier, the final collimator limits the X-ray beam size and shape to a 9-inch 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 can also be done manually.

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 U26, U36, U37. These devices are integrated motor controllers.

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 low light level lenses and a right angle mirror. The first lens is focused at infinity and the camera 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 3-18 - *The right angle optics consist of a mirror and the camera and image tube lenses.*

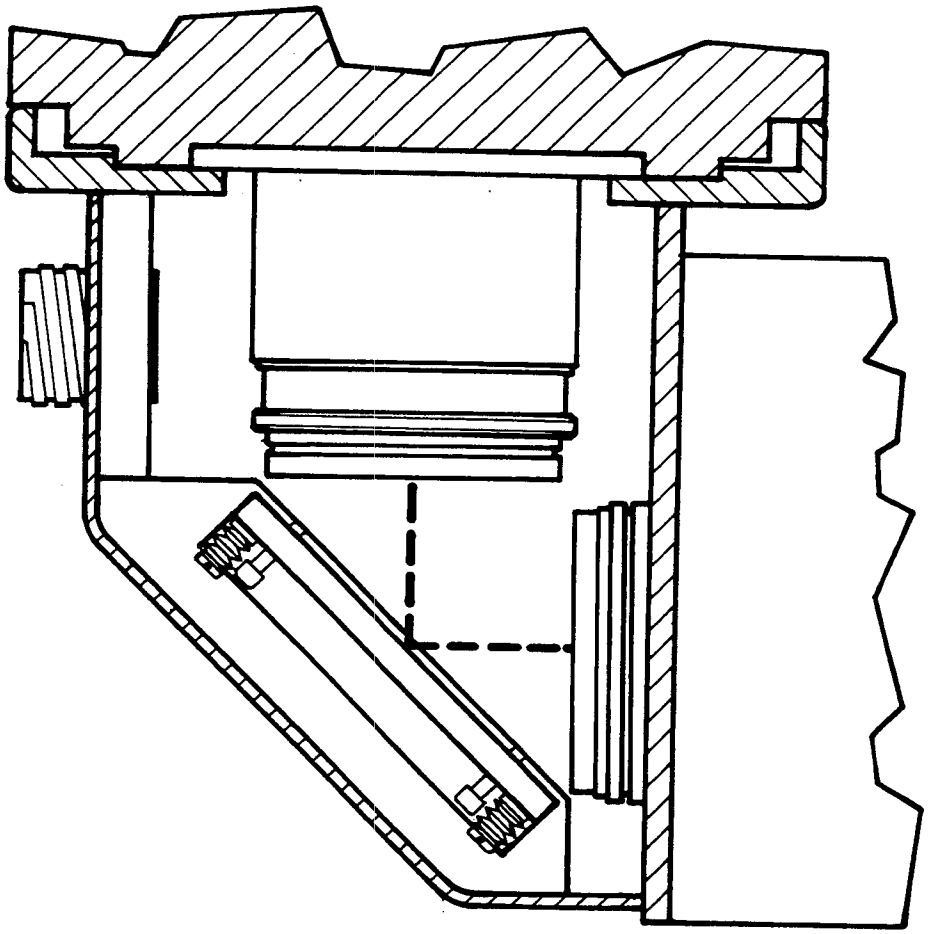
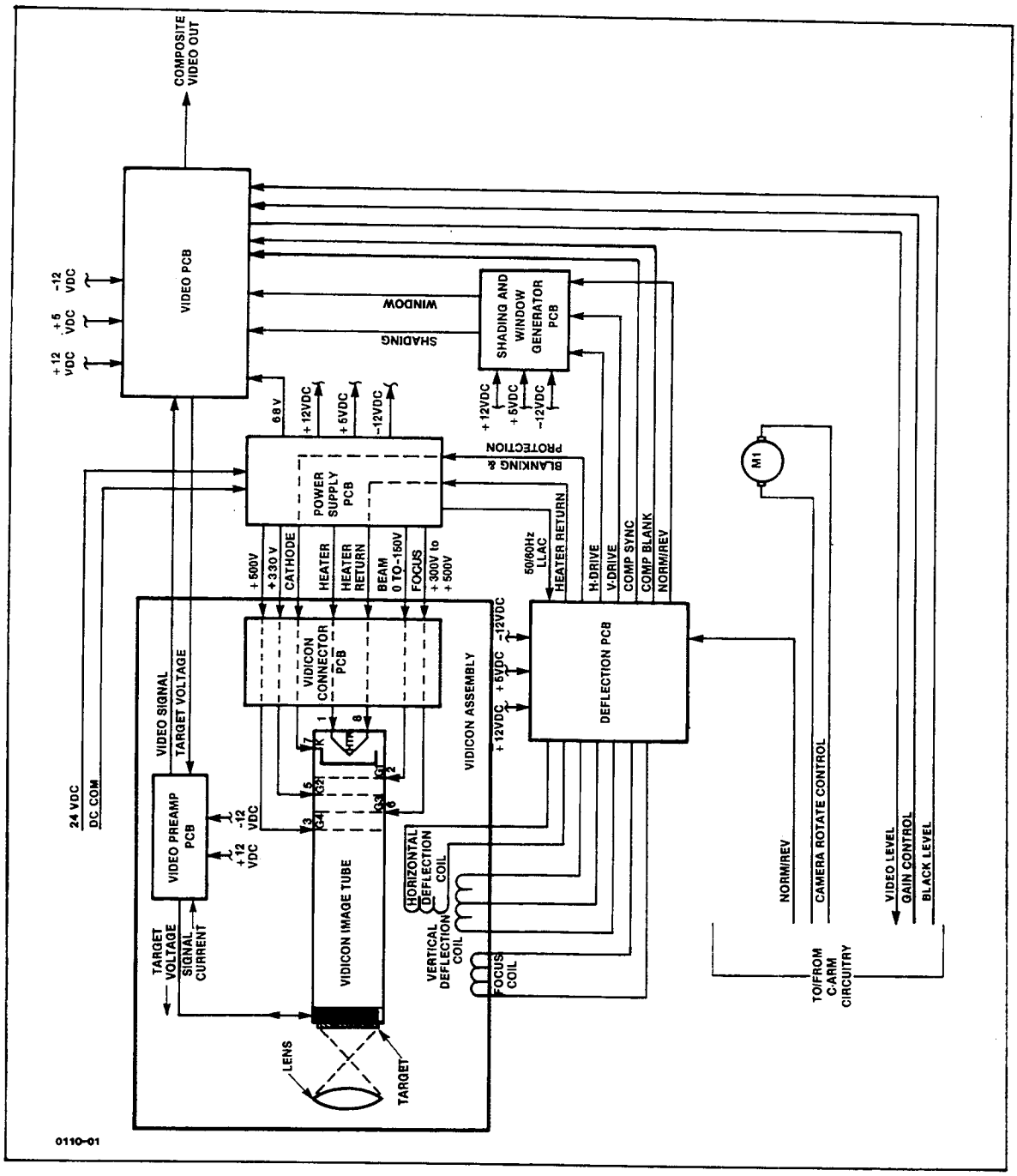


Figure 3-19 - *Camera Block Diagram.*



3.11 Video Camera

Refer to Schematic 00-871059 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 3-19.

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 I\O Distribution\Video Switch PCB in the monitor cart.

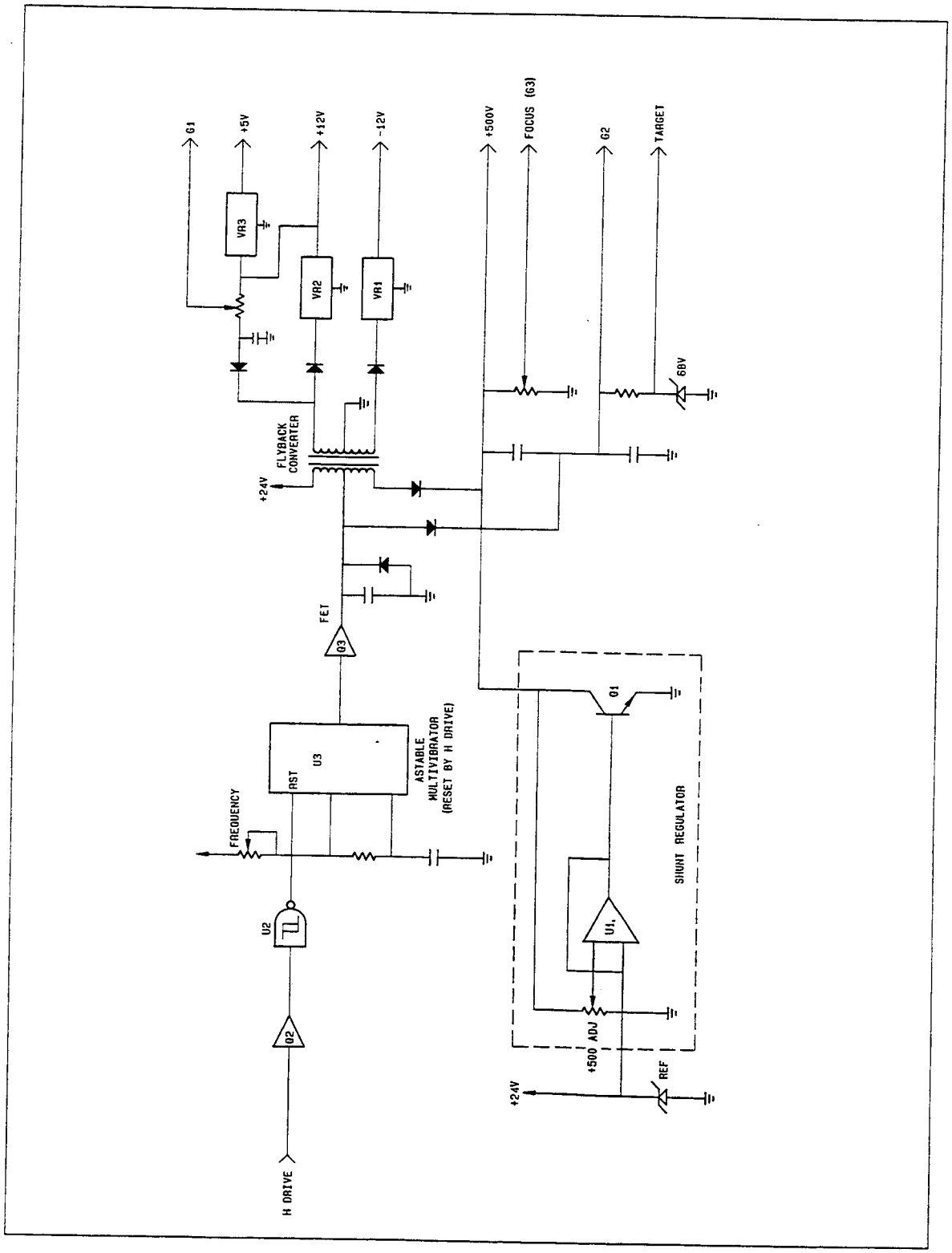
Another video signal, called video level, is produced which is proportional to the brightness within a sampled window area of the image. This is routed to the Analog Support PCB where it is digitized and read by the processor. Under software control, a camera gain control signal is fed back to the camera. 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 which would otherwise detract from the image.

The video sweep direction can be reversed 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.

Figure 3-20 - *Block diagram of the camera Power Supply PCB.*



3.11.2 Camera Power Supply PCB

Refer to Schematic 00-870813 and Figure 3-20.

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

Flyback Regulator

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 H drive rate. Both halves of the T1 primary are flyback inductors which develop high voltage AC waveforms when the centertap switches to 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. 00-860387 and Figure 3-21.

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

1. Sync generator
2. Horizontal deflection coil driver
3. Vertical deflection coil driver
4. Vidicon blanking and protection
5. Focus coil voltage regulator

Sync Generator Section

The video sync generator U2 is clocked by crystal Y1 for 60 Hz operation and Y2 for operation in 50 Hz systems.

Horizontal Deflection

The horizontal deflection driver consists of Q5, Q6, and U1. When the camera beam is scanning horizontally, Q5 is turned off and Q6 is turned on - a linearly increasing current flows in the horizontal deflection coil. When HOR DRV/ occurs, at the start of horizontal retrace, Q5 is turned on and Q6 is turned off. The width of the horizontal scan is proportional to the current supplied to the deflection coil by Q6. This current depends on the Q6 collector voltage set by L5 and the H SIZE potentiometer R40. The horizontal position of the scan is set by the level of the sawtooth current waveform in the deflection coil. The DC current is supplied by L3 and is determined by the setting of the H CENT potentiometers R38 and R39.

Sweep Reversal

Horizontal sweep reversal is accomplished by reversing the direction of the current through the deflection coils. The HORIZ REV control line selects the reverse direction of sweep.

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.

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.

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 3-21 - *Block diagram of the Deflection PCB.*

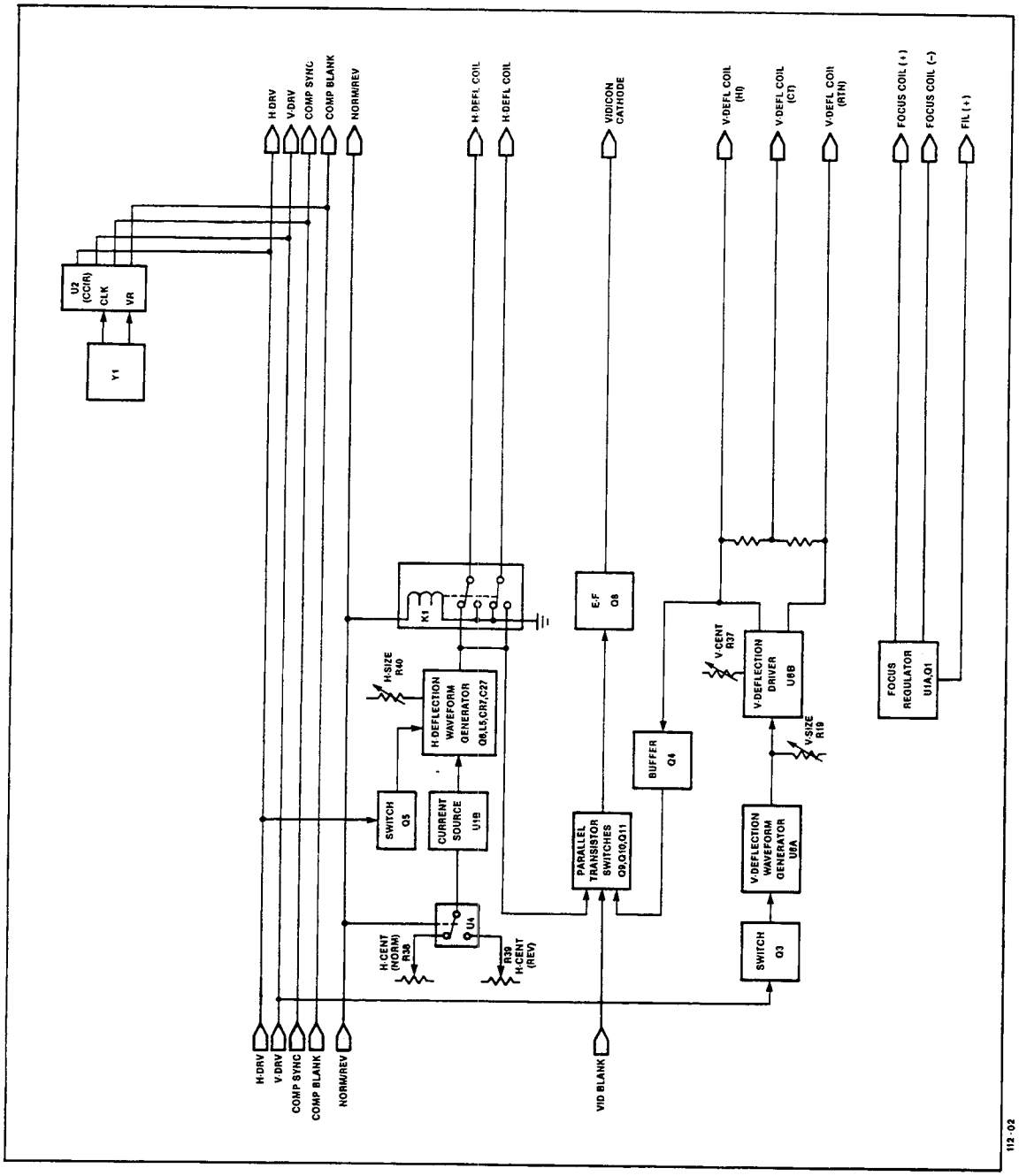
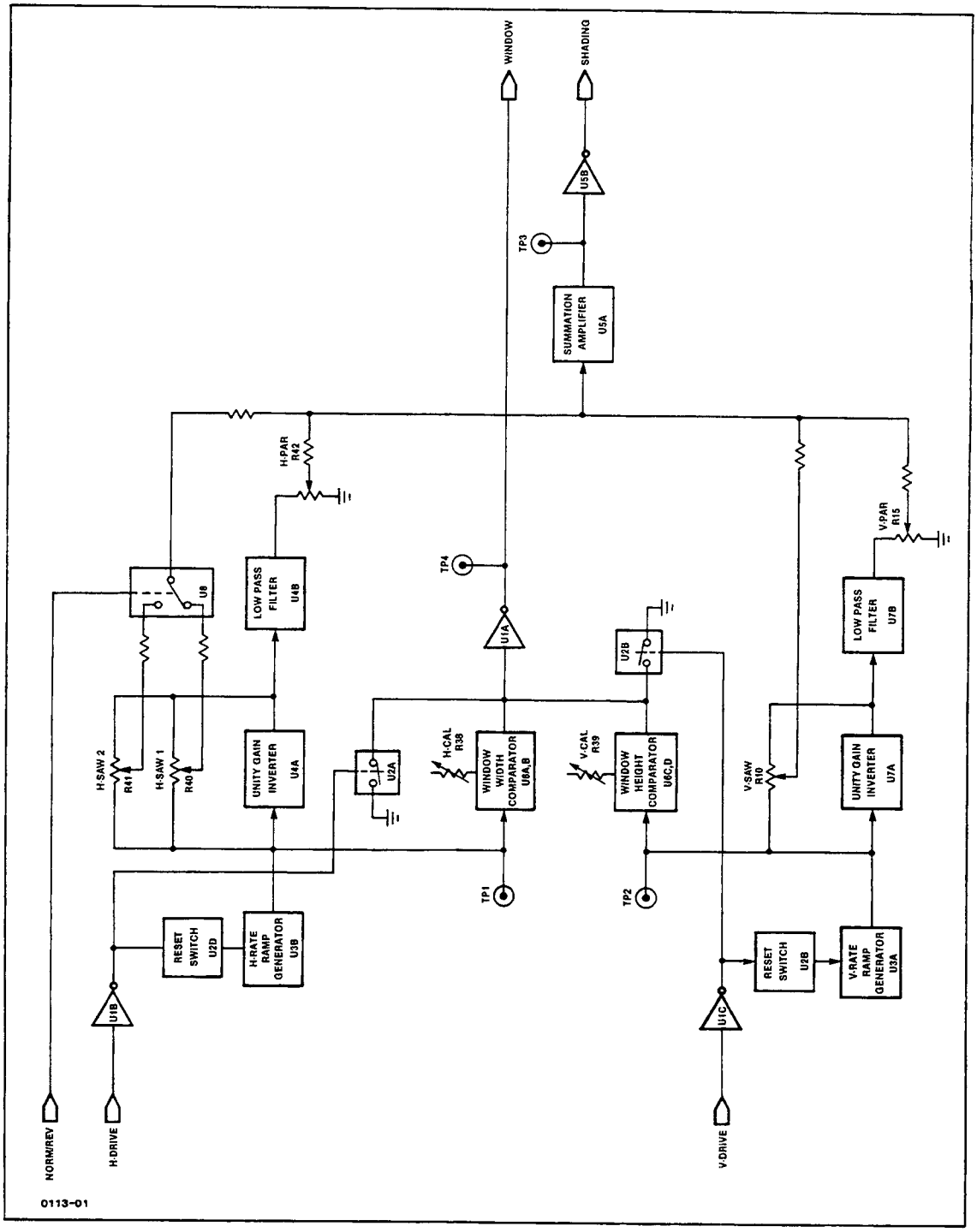


Figure 3-22 - *Block diagram of the Window Shading PCB.*



3.11.4 Shading/Window Generator PCB

Refer to Schematic No. 00-860384 and Figure 3-22.

The Shading/Window Generator PCB provides two functions required for fluoroscopy:

Correction for aberational brightness variations across the image plane (shading).

Generation of a video level sampling window used for camera gain control.

Shading Parabola Generation

The shading function makes use of 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 is generated by U3 and reset by U2. After reset, a positive-going ramp is generated by U3. This ramp is applied through C6 to U7, a unity gain inverting amplifier. Both the input and the output of U7 are applied across R10, the VERT SAWTOOTH adjustment potentiometer. The signal from the output of R10 is summed at the summing junction of U5. At the same time the output of U7A is applied the the input of U7B. The resulting parabolic waveform is applied to R15, the VERTICAL PARABOLA potentiometer. The wiper of R15 provides another waveform to be summed by U5. The combination of this signal and that from the wiper of R10 form the vertical shading waveform. The horizontal shading circuit operates similarly. 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.

Because of the cameras ability to reverse sweep direction, the horizontal sawtooth must be set for both directions (R40 and R41).

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. 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 cascade input stage Q2 and Q3. The signal current through Q1 and through the drain connections of Q2 and Q3 is direct coupled to Q4.

White clipping occurs when the emitter of Q1 goes more positive than -0.7 volts. The unclipped 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 mid-range gain of the preamplifier is fixed; the output of Q5 is 250 millivolts when the target current is 300 nanoamperes. The peaking control C# compensates for high-frequency rolloff and provides a uniform frequency response from the preamplifier.

3.11.7 Video PCB

Refer to Figure 3-23 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 each minute, 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 settings between these two extremes the dark-current compensation is interpolated.

Black Level

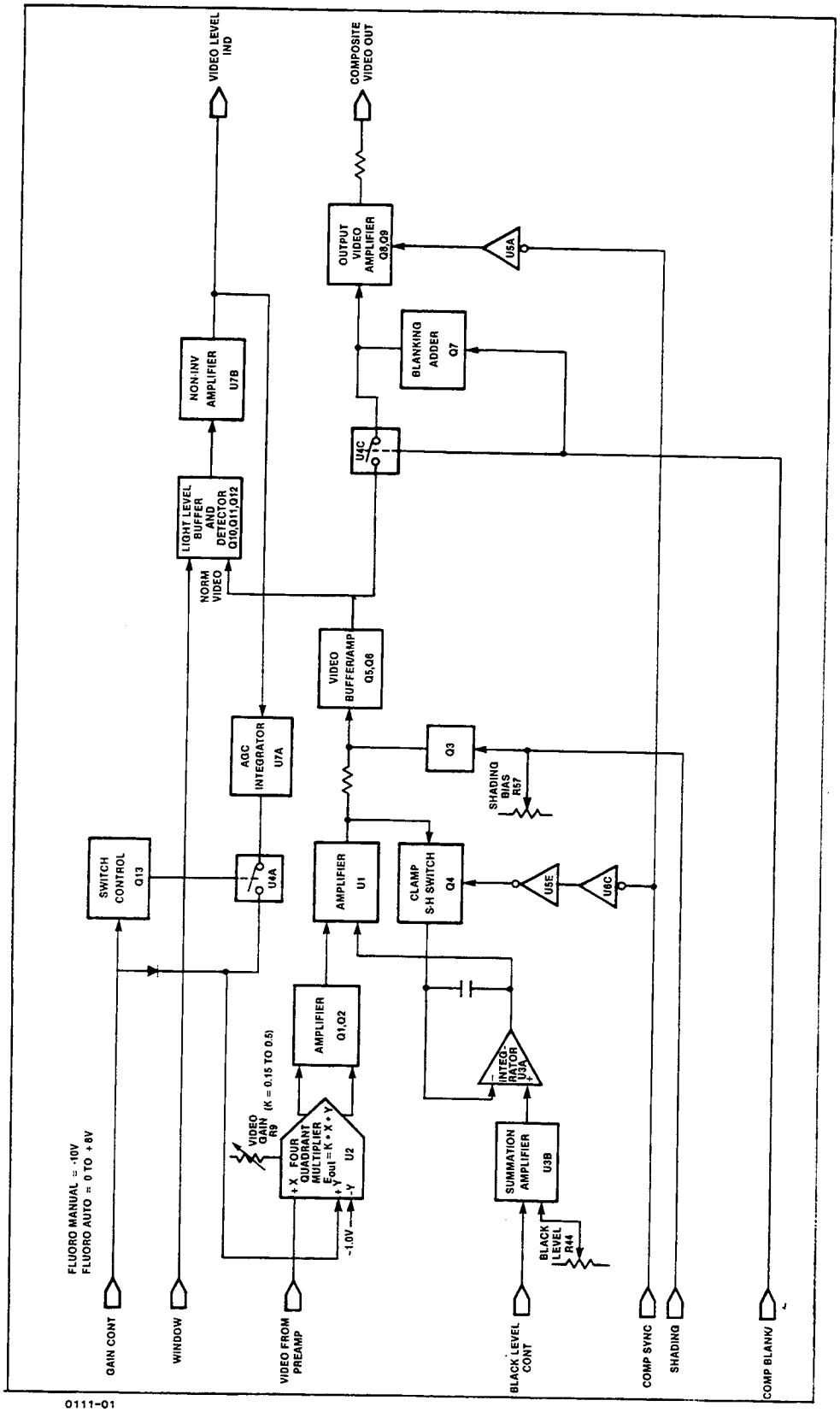
A black level adjustment is provided by R44. The output of U3 combines both black level adjustment and dark-current compensation. If the shading jumper is in place, a bias adjustment, set by R57, enables gain control through Q3. The input to Q3 is received from the Shading PCB.

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 3-23 - *Block diagram of the Video PCB.*



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 frequency current that is applied to the primary of a high voltage transformer. The transformer steps up the primary voltage from about 400 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 currents 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

Refer to Schematic 00-870779 and Figure 3-24.

Overview

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 14 character alphanumeric display, 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.

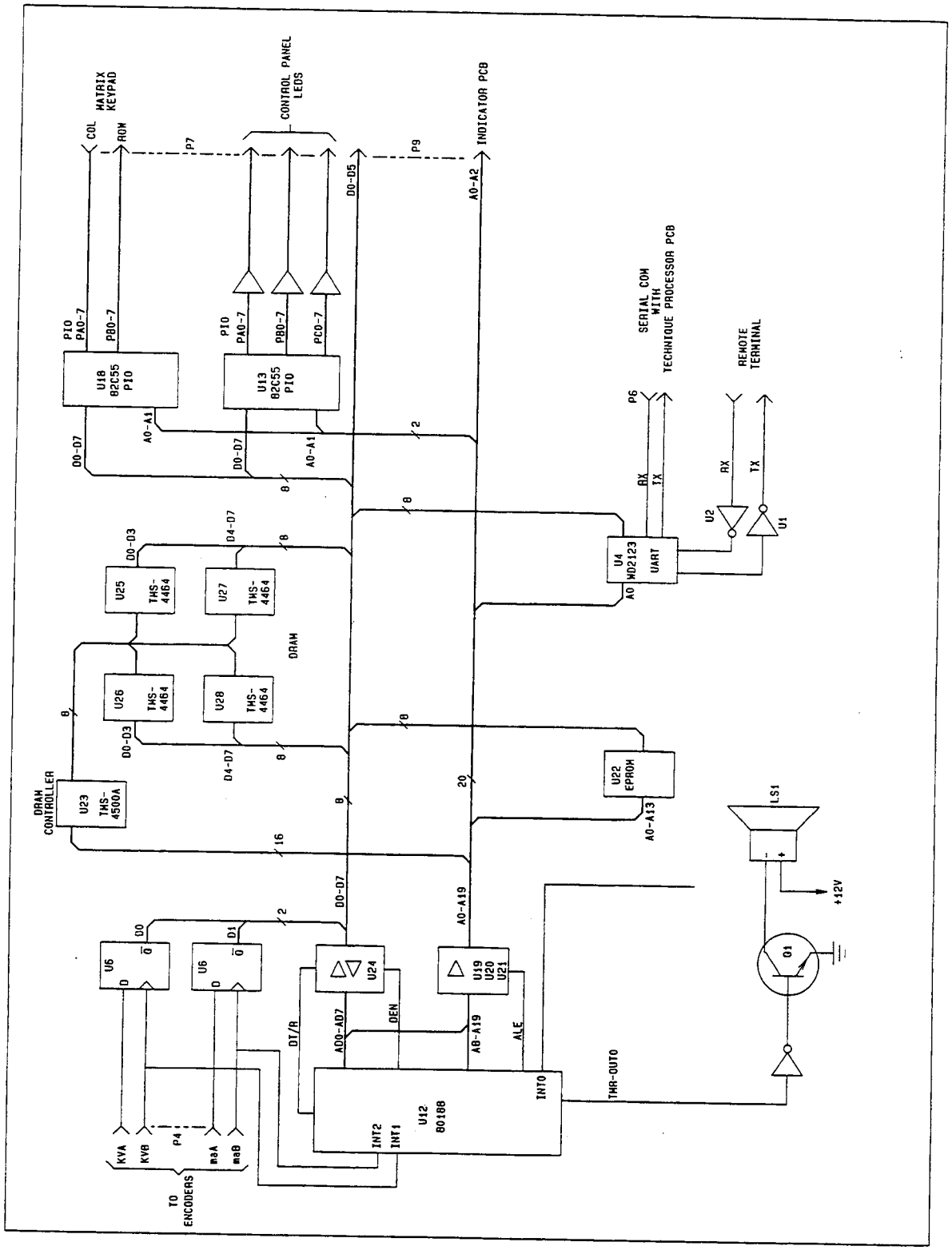
Switch Matrix Interface

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 Indicator PCB

Refer to Schematic 00-870916.

The Indicator PCB contains fourteen 16-segment LED modules with multiplexed text and decimal points. These operate in two different modes:

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.

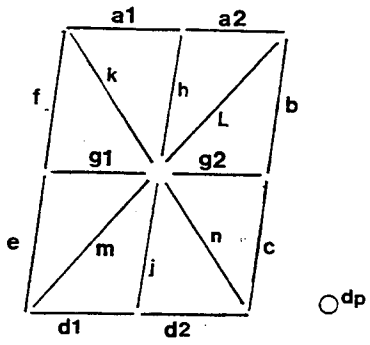


Figure 3-25 - *The LED character segments.*

The 14 character alphanumeric display located on the Indicator PCB is controlled by the 80188 on the Control Panel Processor PCB. Character multiplexing is handled by the PAL output on pin U6-14, which clocks the latches of U7 and the demux chip U11. Character segments are multiplexed in three groups, A1-D2, E-H, and L-DP by the PAL outputs on pins U6-13, 12, 11. DATA 0 through DATA 5 is latched into U1, U3 and U5 according to these PAL outputs.

The common cathode LED module segments are driven by UDN-2981 current drivers U2 and U4. Input P1-8 is a powerup reset which clears the latches. The decimal points are driven by Q1.

3.12.3 Technique Processor PCB

Refer to Schematic 00-870591 and Figure 3-26.

Overview

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

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 3-26 - *Technique Processor PCB block diagram.*

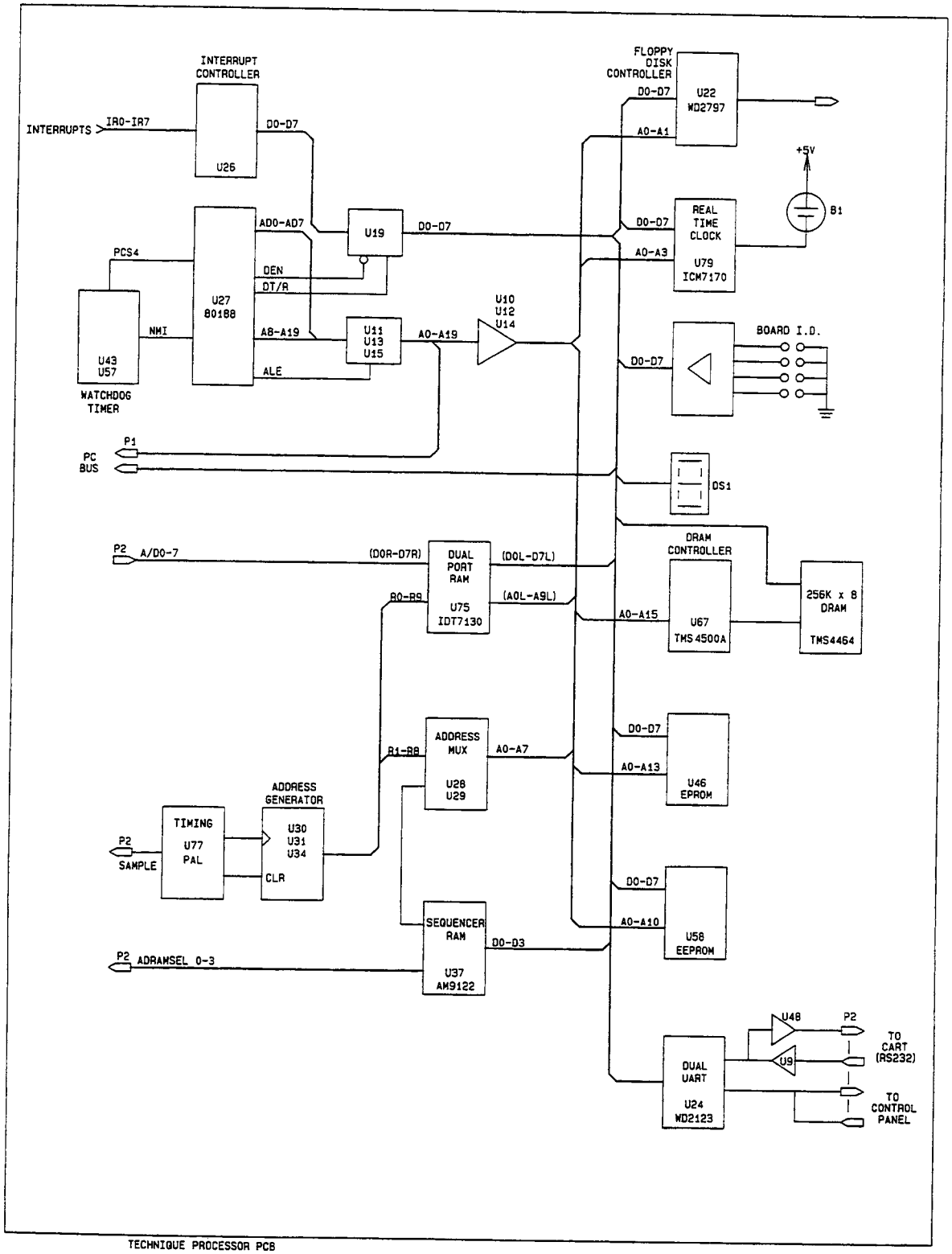


Table 2 Technique Processor Memory and Peripheral Chip Decoding

Memory

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

Peripherals

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 2 (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

DMA Channels

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

Figure 3-27 - *Block diagram of the Analog Support PCB.*

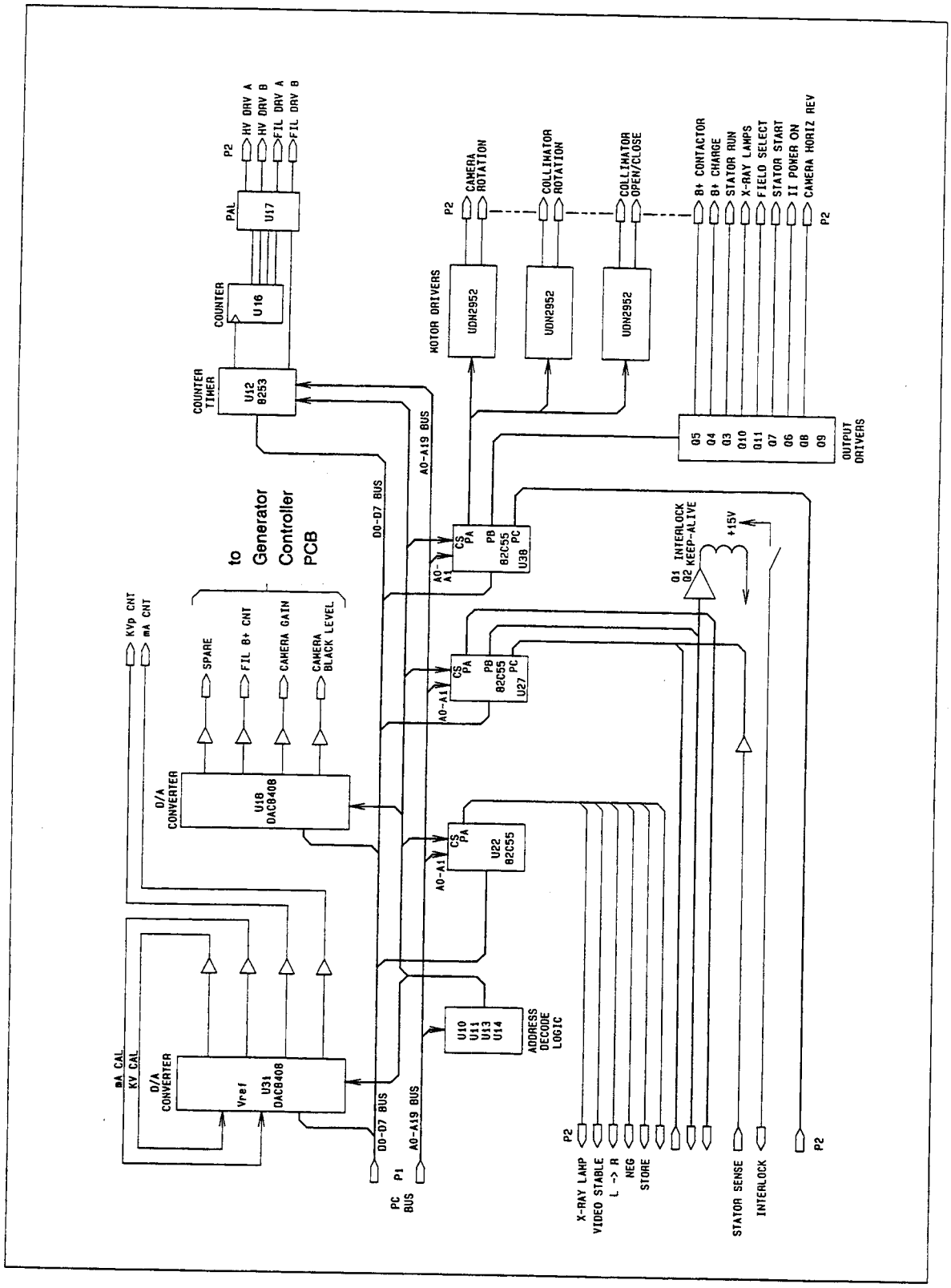
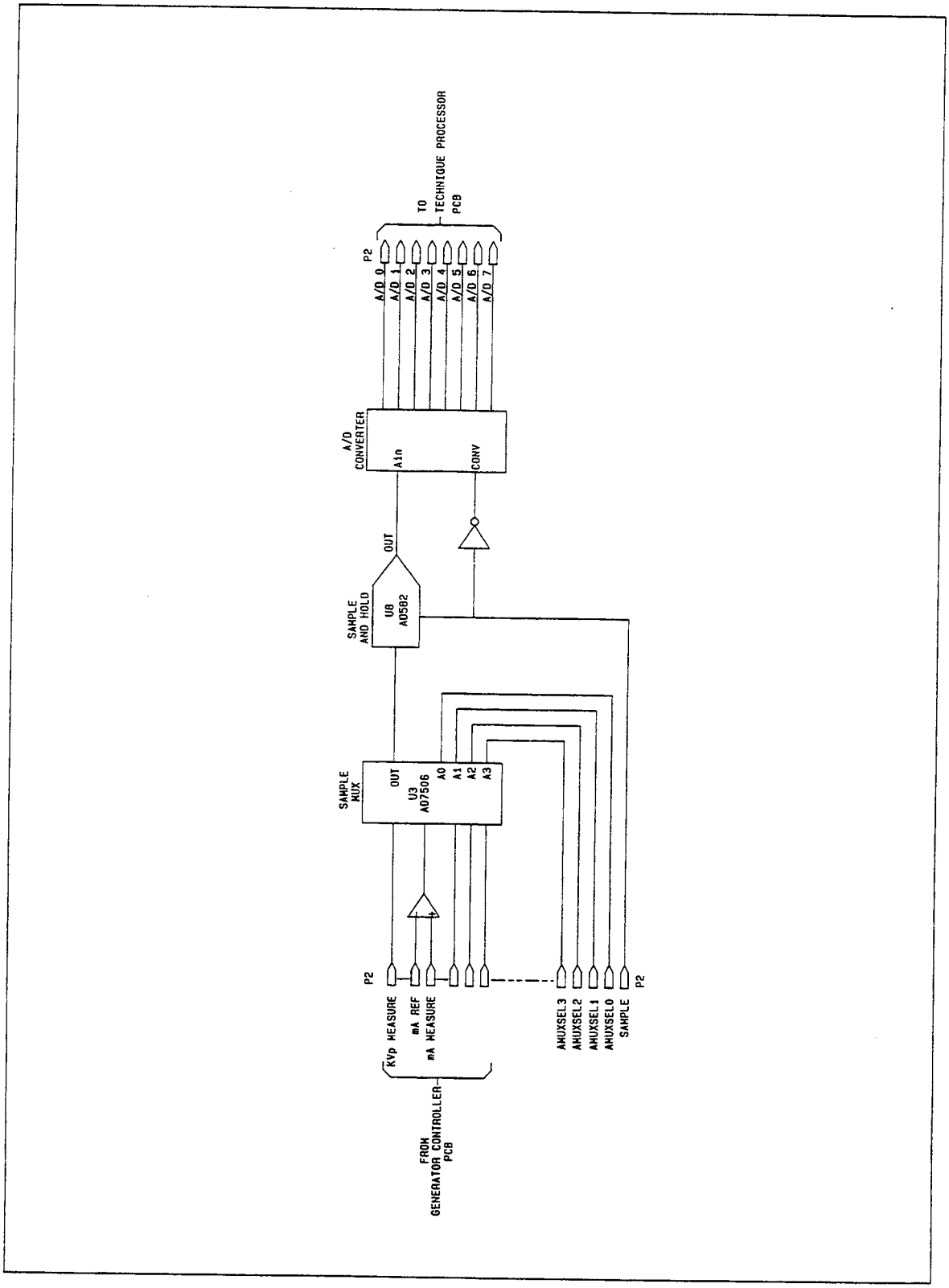


Figure 3-28 - *Block diagram of the A/D portion of the Analog Support PCB.*



3.12.4 Analog Support PCB

Overview

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

Refer to Schematic 00-870771 and Figures 3-28 and 3-29.

The Analog Support PCB performs the following functions:

1. Sample and digitize signals from the Generator Controller PCB to be read by the Technique Processor PCB.
2. Convert data bytes from the Technique Processor into analog signals for such functions as camera gain control, kVp control, and filament control.
3. Generate the high voltage drive and filament drive signals.
4. Provide a digital interface between the Technique Processor and discrete digital signals such as *STORE* and *B+ CONTACTOR*.
5. Control the camera and collimator motors.
6. 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
U26	Motor Controller	UDN 2952
U37	Motor Controller	UDN 2952
U39	Motor Controller	UDN 2952

Transistors Q3 - Q11 drive individual control lines.

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, 9, 10, and 11 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.

UDN-2952 Full-Bridge Motor Drivers

These integrated circuits combine low-level logic circuitry compatible with TTL and CMOS levels. They allow bidirectional control of DC motors with continuous load currents of up to 2 A. Internal protection includes thermal shutdown and transient suppression.

Sample Mux

Refer to Figure 3-28.

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.

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 3 A/D Sense Lines

A/D CHANNEL	*FUNCTION*
U3-S1	kVp measured
U3-S2	mA measured
U3-S3	filament B+ sense
U3-S4	video level
U3-S5	housing temperature
U3-S6	dosimeter
U3-S7	spare
U3-S8	spare
U3-S9	secondary tap voltage
U3-S10	line voltage
U3-S11	charger current
U3-S12	battery voltage
U3-S13	filament current
U3-S14	spare
U3-S15	spare
U3-S16	spare

Table 4

PIO 1, U38 Summary

BIT	*PIN*	*FUNCTION*	*COMMENT*
PA0	4	camera rotate CW	see state table
PA1	3	camera rotate enable	
PA2	2	collimator rotate CW	
PA3	1	collimator rotate enable	
PA4	40	collimator open	
PA5	39	collimator enable	
PA6	38	iris open	
PA7	37	iris enable	
PB0	18	B+ contactor	active hi
PB1	19	B+ charge	
PB2	20	stator run	
PB3	21	X-ray on lamps	not used
PB4	22	field select	
PB5	23	stator start	hi for 2 sec
PB6	24	II power	used in fluoro
PB7	25	camera horizontal reverse	
PC0	14	spare	sense
PC1	15	spare	sense
PC2	16	cassette detect	sense
PC3	17	field detect	sense
PC4	13	not used	
PC5	12	fluoro only	left footswitch sense
PC6	11	boost	boost sense
PC7	10	X-ray switch	switch or footswitch sense

Table 5

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	camera vertical reverse	
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	overvoltage 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 6

PIO 3, U22 Summary

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

Signal Descriptions

Charger Control

Charger Disable.....U27-PB0
when high: causes the charger to stop charging the batteries. On the Generator Controller PCB this line is connected to the shutdown pin on U22, a current mode PWM controller.

X-ray Tube Control

Stator Start.....U38-PB5
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-PB2
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.

Start/Run Logic Table

	PB5	PB2
OFF	0	0
RUN	0	1
ILLEGAL	1	0
START	1	1

Stator Sense.....U27-PC7
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.

Generator Control

B+ Charge.....U38-PB1
When active, a high is applied to the base of Q4. Q4 collector (B+ Charge) is looped through the Generator Controller PCB and routed to the charging relay K1 mounted below the Generator Controller PCB. 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-PB0
When active, a high is applied to the base of Q5. Q5 collector (B+ Contactor) is looped thru the Generator Controller PCB and routed to the relay K2 located under the Generator Controller PCB. 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-PA7
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 Controller PCB and applied to the fault protection logic PAL U32.

KVP Control.....U31-CH3
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 Controller PCB.*

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

mA Control.....U31-CH4
Delivers a control voltage to the filament regulator circuit. Measure this voltage at TP18. *Refer to the filament control circuit on the Generator Controller PCB.*

mA Reference (mA Cal) U31-CH2
Sets the reference voltage for the DAC used to generate mA CONTROL. Measure this voltage at TP16.

Filament B+ Control.....U18-CH2
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 Controller PCB.*

Focal Spot.....U27-PA1
The state of this line selects the focal spot size.

1 = 0.3 mm spot
0 = 1.0 mm spot

On the Generator Controller PCB - 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. Refer to be Generator Controller PCB.

Generator Shutdown (Shutdown Command).....U27-PA3
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 Controller PCB 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 Controller PCB.*

mA Scale Factor.....U27-PA0
Selects the mA scale factor for film or fluoro - 1 = Fluoro, 0 = Film.

HV Drive.....U12
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 Controller PCB, 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 Controller PCB.*

HV Generator On.....U27-PC4
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 Controller PCB at PAL U21, which monitors the states of the HV Drives, X-ray On, X-ray Enable, and other lines.

Generator Fault.....U27-PC3
Indicates that one of the fault conditions has been detected and the generator has been shut down. Originates on the Generator Controller PCB at PAL U32.

Overload Fault.....U27-PC0
Indicates that the generator has detected an overload and shutdown. Originates on the Generator Controller PCB at PAL U32.

Saturation Fault.....U27-PC1
Indicates that the generator has detected a saturation fault and shut down. Originates on the Generator Controller PCB at PAL U32.

Filament Fault.....U27-PC2
Indicates that a filament fault has been detected and the generator has been shutdown. Originates on the Generator Controller PCB at PAL U32.

mA Test.....U27-PA4
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 Controller PCB.

Generator Mode (High Power Mode).....U27-PA2
When high, this line causes the generator to use the full bridge configuration to drive the output transistors. When low, causes the generator to use the half bridge configuration to drive the output transistors. The signal is applied to Q10 on the Generator Controller PCB. The collector of Q10 controls relay K3.

Camera/Image Intensifier Control

Camera Horizontal Sweep Control..... U38-PB7
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.

Camera Rotate Direction U38-PA0
The camera will rotate CW or CCW according to the table below.

Camera Rotation Enable.....U38-PA1
Enables camera rotation, see the table below.

PA1	*PA0*	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

PA0 AND PA1 are applied to the phase and enable inputs of the motor control IC U26. The direction of current flow from out1 and out2 on this IC determines the direction of motor rotation.

Disregarding slippage, camera rotation speed is about 8 degrees per second. Coast is about 3 degrees (maximum). The camera motor has limit switches that activate at either end of the rotational limits.

The direction of camera rotation depends on both the control command and the direction of camera horizontal sweep.

Camera Rotate	CW	CCW	CW	CCW
Reverse Sweep	No	Yes	Yes	No
Actual Direction	CW	CW	CCW	CCW

Camera Mode..... U27-PB1
Not currently used, should be set low.

Camera Gain.....U18-CH3
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-CH4
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-PB6
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.

Iris Aperture.....U38-PA6,PA7
Not installed.

Camera/Image Intensifier Sensing

Film Cassette U38-PC2
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.

Collimator Rotation Direction U38-PA2
Determines the direction of collimator rotation according to the table below.

Collimator Rotation Enable U38-PA3
Enables collimator rotation according to the table below.

PA3	PA2	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

PA2 and PA3 are applied to the phase and enable inputs of the motor controller IC U37. The direction of current flow from OUT1 to sT2 determines the direction of motor rotation.

Disregarding slip, the collimator rotation speed is about 8 degrees per second. Coast is approximately 3 degrees. The collimator rotation motor has no limit switches. Rotation is continuous obtaining power from slip rings.

Collimator Aperture Direction U38-PA4
Causes the aperture to open or close according to the table below.

Collimator Aperture Enable U38-PA5
Enables motorized collimation according to the table below.

PA5	PA4	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

Note: The collimator leaf motor speed is about 0.25 inches per second when viewed in the 6" field. The leaf motor has no limit switches.

Field Select U38-PB4
When low, the flipper is placed in the beam, restricting the field diameter. When high, the flipper is put out of the beam. This line is applied to the base of Q11. The collector of Q11 drives the field select solenoid at the collimator.

Note: When the large field is selected, the solenoid draws about 1 amp of current.

Field Detect U38-PC3
PIO input reads the status of the field size through a microswitch at the flipper. This line reads low when the flipper is out of the beam.

Cart Control and Sensing

Store U22-PA4
When low, informs the image processor that an exposure is being made.

Video Stable U22-PA1
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-PC5
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-PB7
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-PC6
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-PC7
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-PC6
PIO Input. Signals that the boost position of the footswitch has been pressed.

Fluoro Only U38-PC5
PIO Input. Signals that the left side of the footswitch, FLUORO ONLY, has been pressed.

3.12.5 Generator Controller PCB

Overview

Refer to Schematic 00-871044.

The major functions of the Generator Controller are:

1. Regulate Filament Current
2. Regulate X-ray tube high voltage
3. Charge the batteries
4. 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.

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 VR1. The rectified voltage is regulated by VR5 and VR6 to provide +/- 12 VDC. These are identified as +/- 12SEP and they power the battery charger circuits separately from the other voltages on the board.

The other supply voltages, +/- 12 VDC and +/- 6 VDC, are regulated by VR3 and VR4.

Grounding

The Generator Controller PCB 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:

Ground A: Battery minus (B-) and 115 VAC Neutral
Ground B: ground for the driver stage Q14-Q17
DC Common: ground for most low voltages, and forms the PCB ground plane

Be sure that voltage measurements are referenced to the correct ground.

Fault Detection Logic

Refer to *Section 3.4 - Fault Conditions and Error Checks* for a full description of the fault detection logic.

Battery Charger Circuit

Refer to Figure 3-29.

The battery charger is a boost regulator which provides a controlled current and voltage to the battery 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 U15, Q4 is turned on, placing R70 in parallel in the voltage feedback loop with R98 and R108. 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, Q4 turns off and regulates the charging voltage back to the 211 VDC level. Hysteresis is biased into the op-amp circuit of U26 causing this transition to occur gradually.

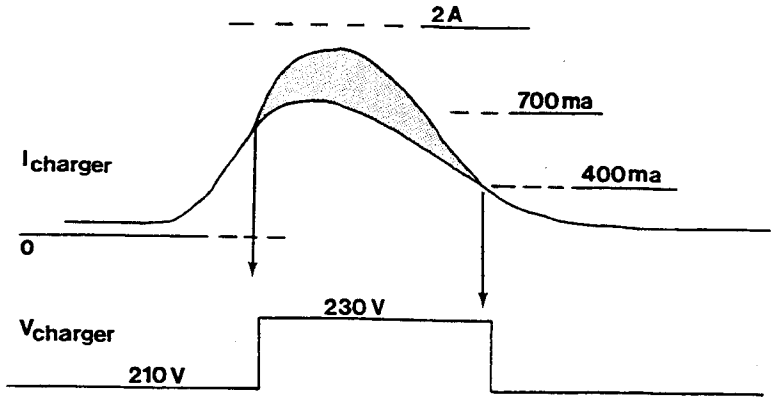
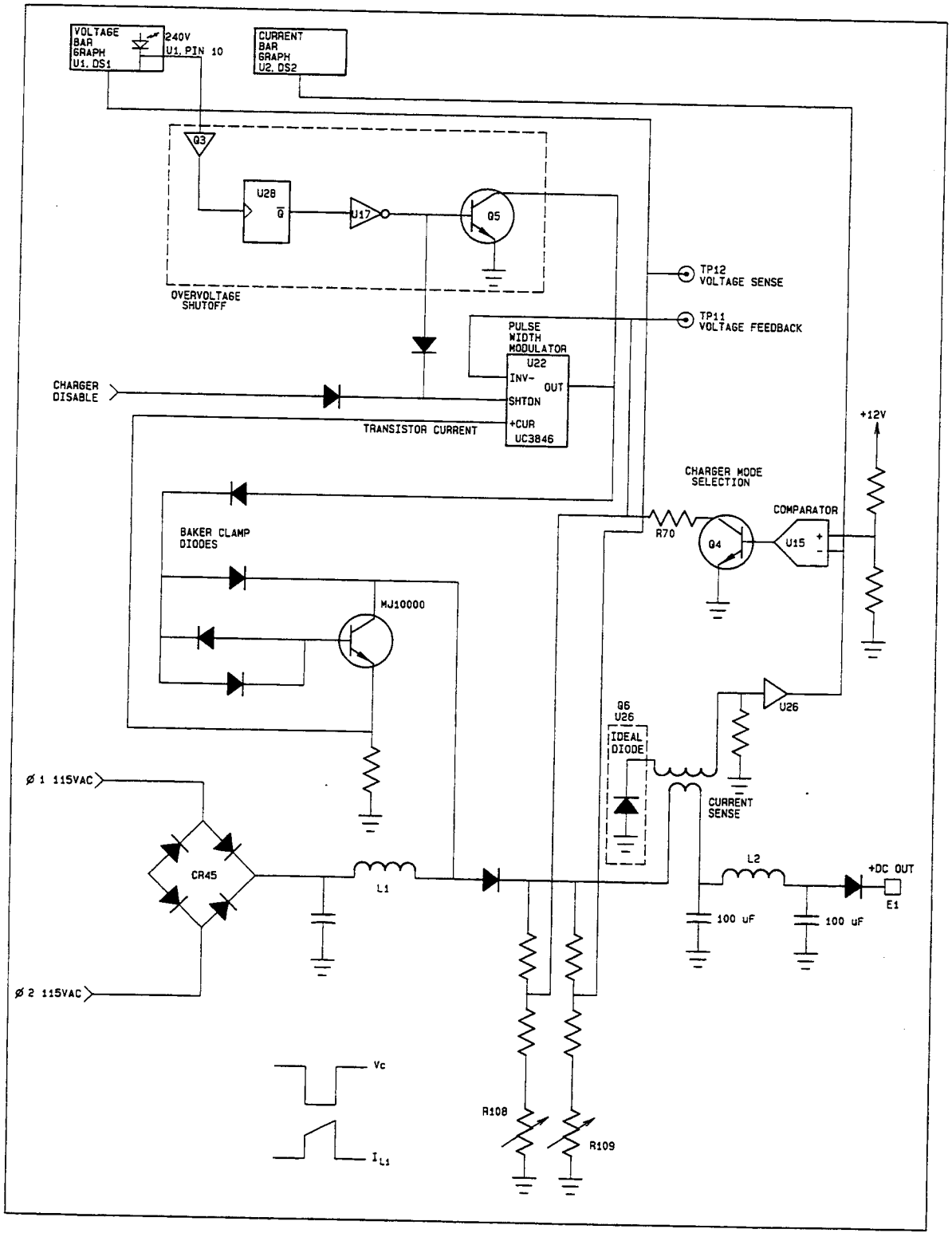


Figure 3-29 - *The current and voltage output during low and high charge.*

Pulse Width Modulator Circuit

U22 (UC3846) is a current mode, pulse width modulator with a built in 5.1 volt reference. The reference is accessible on pin 2 (Vr). U22 controls the duty cycle applied to the base of the MJ10000 transistor Q18 mounted above the board on a heat sink. When this transistor turns on, the current into L1 increases. The Baker clamp on the base of Q18 prevents saturation and speeds up the switching response.

Figure 3-30 - *Block diagram of the battery charger portion of the Generator Controller PCB.*



Boost Regulator Cycle

Line current is rectified by bridge rectifier CR45 and applied to the inductor L2. When The regulator transistor Q18 receives no drive voltage the rectified line voltage is lower than the battery voltage and diode CR67 is backbiased. There is no current flow.

When the transistor Q18 turns on, one side of the inductor is grounded thru resistor R122. There is a gradually increasing current flow through the inductor. When the transistor turns off, the inductor supplies current by flyback action which results in a voltage forward biasing CR67. Cycle variations are filtered by C59, L2 and C63. Note on the schematic that E1 is connected to the + side of the batteries and ground "A" is connected to the - side.

Transistor current feedback is obtained from the emitter resistor R122 and fed back to one side of the differential current sense input of U22-pin4. The other differential side is connected to ground A.

When Q18 turns off, the flyback action of inductor L1 boosts the voltage by an amount determined by the on-time. CR67 prevents backward current flow when Q18 is turned on and allows current flow to the batteries during the flyback phase.

Resistor network R111/R98/R108 provides feedback to the inverting voltage sense input of U22. *R108 is adjusted to produce 211 VDC output at E1 or 5.1 VDC at TP11, Voltage Feedback.*

Voltage is sensed for the charging voltage bar graph display by resistor network R94/R95/R109/R112. *R109 is adjusted for the correct display of the charging voltage on the bargraph.*

Charging Current Sense

T1 and the ideal (0 drop) diode formed by U26/CR19/Q6 develop a voltage across the resistor R86 proportional to the charging current in the T1 primary. U26 is a 2X voltage amplifier providing the CHARGER CURRENT SENSE signal. This signal is fed to comparator U15, which switches when current demand is increased, current indicator display U2, and is also available off board where it is digitized on the Analog Support PCB and read by the processor.

Protection

The overcurrent protection circuit consists of Q3, flip flop U28, inverter U17 and transistor Q5.

Flip flop U28 is reset by the powerup reset circuit C15/R30 and also when the processor toggles the reset line via Q18 and Q19. Resetting U28 enables the U22 output and turns off Q5.

The CHARGER DISABLE line from the processor (via the Analog Support PCB) is attached to the U22 pin-SHTDN. When held high by the processor, this disables the pulse width modulator.

If excessive charging current is sensed, overcurrent protection is provided in two steps: apply a high to the SHTDN pin of the PWM U22, and ground the U22 drive output through transistor Q5.

Excessive charging current is sensed when the highest segment on the voltage bar graph lights, causing Q3 to clock the flip flop U28.

Indicators

Charging current is indicated on the LED bar graph display U2. U2 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, U1, is driven by the VOLTAGE SENSE line. The indicator reads in 10 linear steps from 150 VDC to 240 VDC.

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.

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.

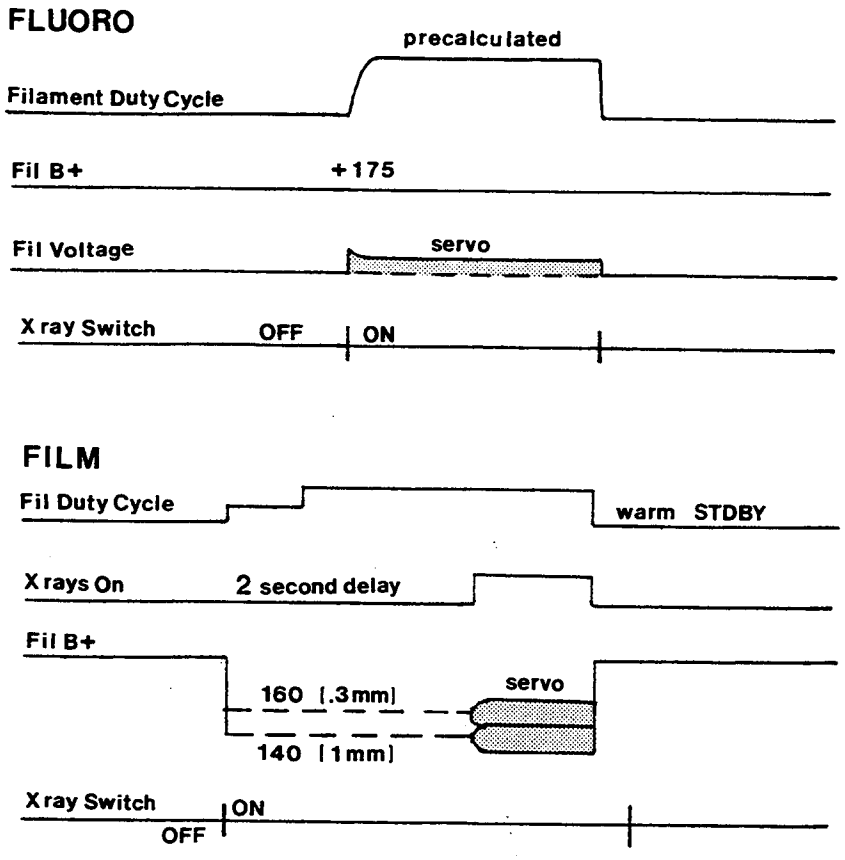


Figure 3-31 - *Filament duty cycle and filament B+ regulation before and during a shot.*

The filament B+ voltage is initially set to a low value by the processor: 140 volts for film mode and 175 volts for fluoro mode. As the shot begins the B+ is increased and 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.

In Other Words

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

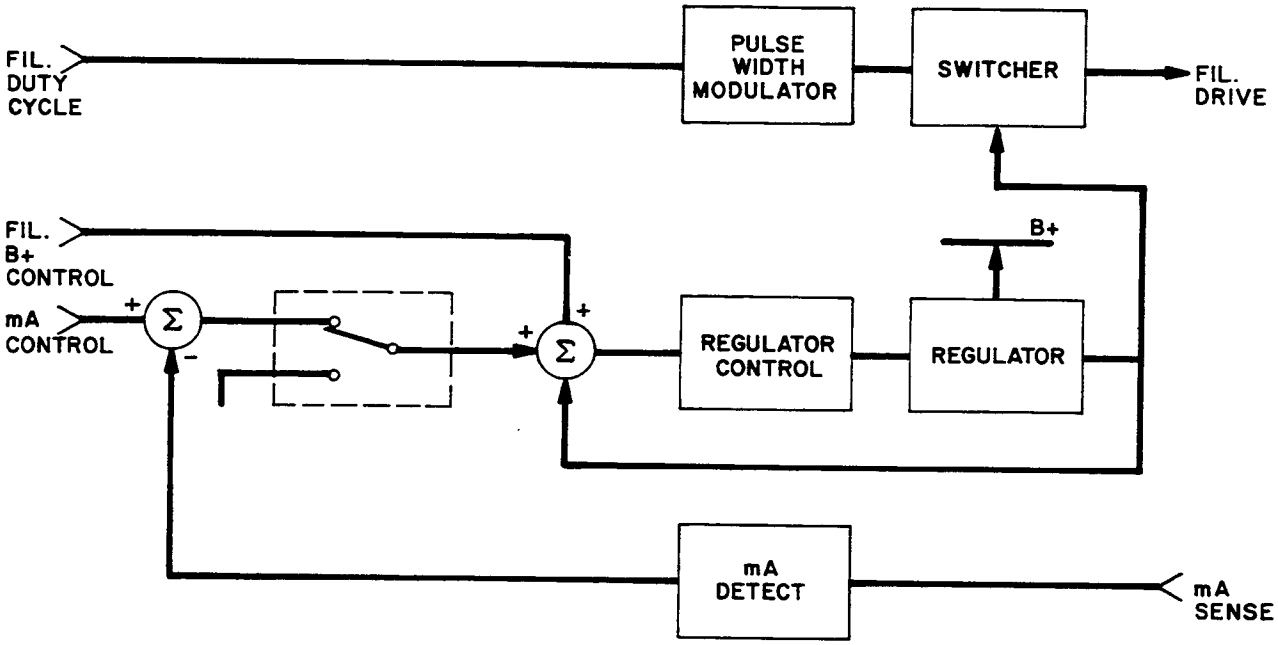
1. Vary the duty cycle of the output switcher stage comprised of transistors Q12 and Q13. This is the means the processor uses to preadjust the filament temperature, prior to a film shot and at the beginning of a fluoro shot, to an approximate value for the technique selected.

   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).

Figure 3-32 - *The filament dynamic regulation loop, compares the measured filament current (mA-sense) against the filament control signal (mA-control) obtained from the processor.*



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 U11, resulting in d.c. restoration. U11 acts as a current to voltage converter.

The two stages of U20 form a 4-pole low pass filter. The output of U20 is applied to film/fluoro scaling amplifier U10. U23 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.

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, opening analog switch U39. As the shot begins, switch U39 opens, enabling error amplifier U30. U30 compares the MA CONTROL voltage with the mA sense voltage obtained from op amp U10.

The difference, or error voltage, is applied to error amplifier U38 whose output controls the voltage on the base of transistor Q11.

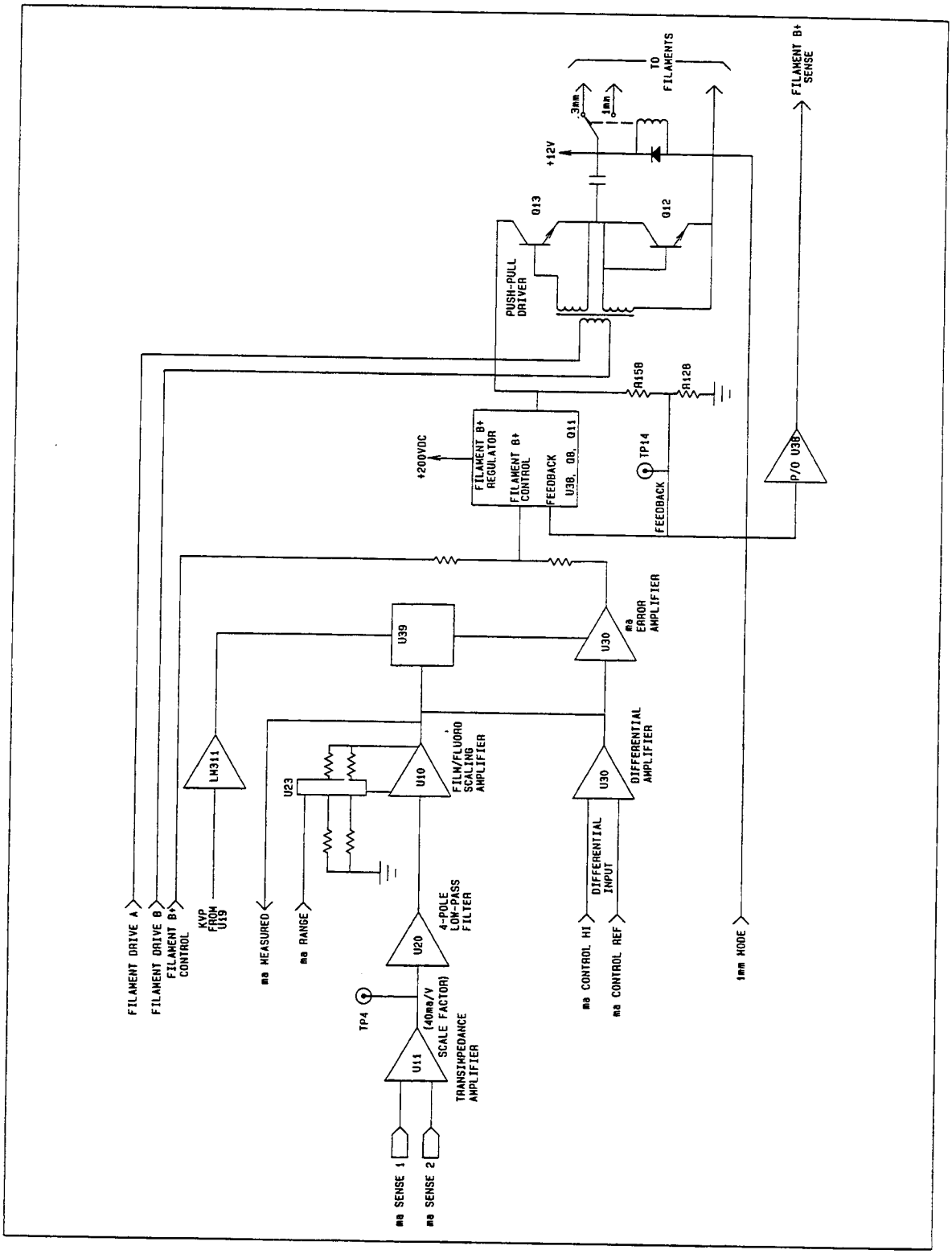
The signal applied to the base of Q11 regulates the B+ voltage applied to the filament driver stage Q12 and Q13.

The linear regulator circuit, Q8 and Q11, controls the battery B+ voltage applied to the push-pull filament driver circuit Q12, Q13.

The final output is applied through L4 and C77 to relay K1. According to the state of the 1mm 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.

Figure 3-33 - *Block diagram of mA regulation circuit.*



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 U23 and applies the MA TEST CONTROL VOLTAGE to op amp U7.

U7 and Q2 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 3-34 - *The mA test circuit.*

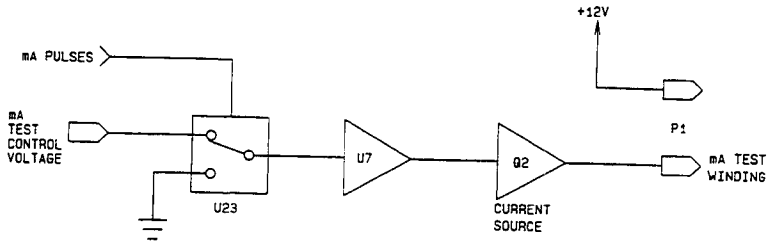
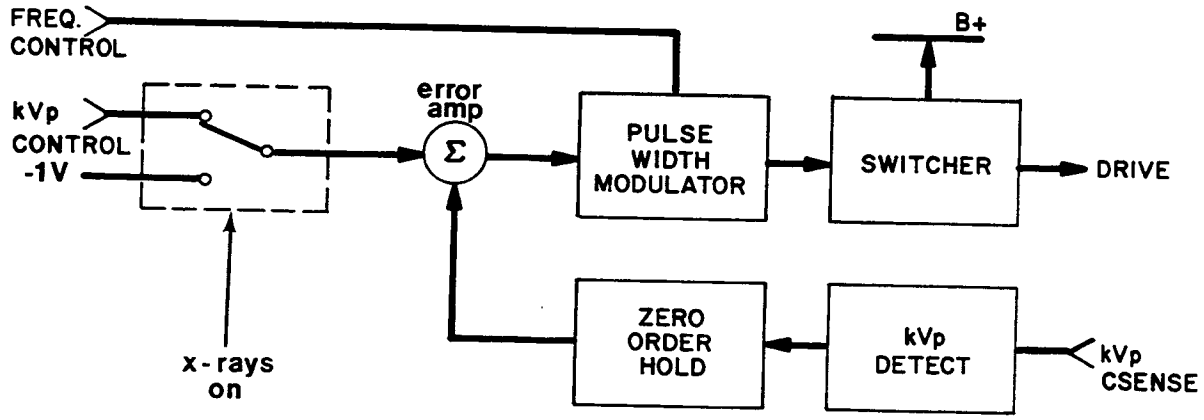


Figure 3-35 - *KVp regulation Loop.*



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 Controller PCB KV SENSE is applied across R42. The positive peaks of the KV SENSE waveform are buffered by U27 and peak detected by U24/U16. The negative peaks of the waveform are inverted by U27, and detected by U12/U27.

Both peaks are sampled and held by U29/U39, then combined and integrated by C49 and U19. The result is KVP MEASURED. This signal is then sampled and digitized on the Analog Support PCB.

Analog switch U45 is controlled by MA RANGE. With its associated RC network, its action is to reduce overshoot in fluoro modes.

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 U9, U18, and Q1. The PWM output PWM COMPARATOR forms a logic input to PAL U21, along with the signals HV DRIVE A and B, an X-RAY ON and X-RAY ENABLE. PAL U21 produces the signals HV DRV A and HV DRV B which determine the duty cycle of the switcher drives.

Error amplifier U19 compares the KVP MEASURED with the HV CONTROL signal. HV CONTROL is applied to the error amplifier by switch U23 controlled by the signal HV INV ON. When HV CONTROL is not applied to U19, a voltage set by resistive divider network R91/R105 is switched into the error amplifier input by U23 to prevent the regulation feedback loop from overcompensating for zero voltage sensed.

Comparator U9, transistor Q1, and flip-flop U18 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) U21. HV DRV A and HV DRV B are output by U21, buffered and inverted by U31. U40 provides current gain before applying the drive signals to Q14/Q15 and Q16/Q17.

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, since 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. U5 is a peak detector whose output, SECONDARY TAP VOLTAGE, is proportional to the kVp voltage from the tank. This signal is digitized on the Analog Support PCB and read by the processor.

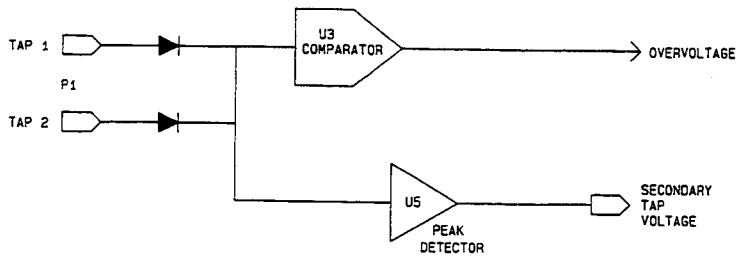
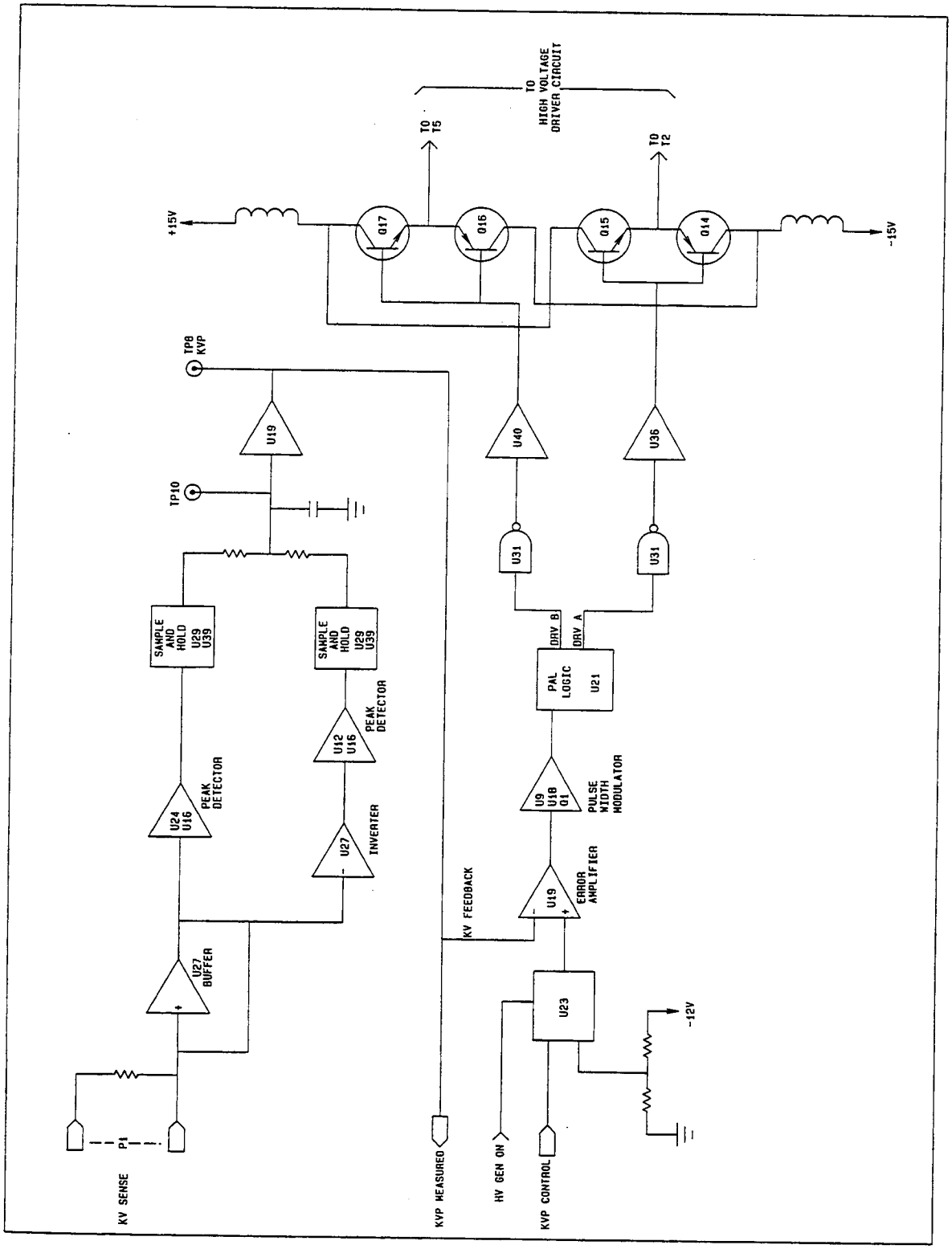


Figure 3-36 - *Secondary Tap Voltage Sense.*

Figure 3-37 - *Block diagram of the KVp regulation circuit.*



Overvoltage Protection Circuit

The SEC TAP V measurement is also used to test for an overvoltage fault, which if it occurs, disables the drives from PAL U32.

Comparator U3 senses an overvoltage fault condition which it signals on the OVERVOLTAGE line.

This line will then trip a latch in the fault detection PAL U32, resulting in loss of drive pulses at PAL U21 and hence loss of drive to the output stage. This can occur in as little as one drive cycle (400 microsecond) This latch must be reset by the processor in order to resume operation.

Calibration Issues

Refer to the section in this manual on *Calibration* for a discussion of the theory of 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.

Intermediate Driver Circuit

HV DRV A and HV DRV B are buffered by the inverting driver pair U31. More drive current amplification is provided by op amps U36 and U40.

After the driving op amps U36 and U40, a circuit has been added to protect the bridge circuit formed by transistors Q14, Q15, Q16, and Q17 on power-down. This transistor protection circuit is comprised of two 2N3906 transistors and associated 1N914 diodes.

Predrive Stage

Transistors Q14/Q15 and Q16/Q17 form a bridge circuit. Their emitters are coupled via C99 and C89 to transformers T5 and T2. 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.

High Voltage Drive Circuit

Refer to Figure 3-38.

T5 and T2 each have two secondary windings, individually fused, which drive the high power transistors Q1 and Q2

The main power transistors, Q1 and Q2, each containing two darlington pairs, 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, F3, F4, and F5 are located on the Generator Controller PCB in the secondary circuits of T2 and T5.

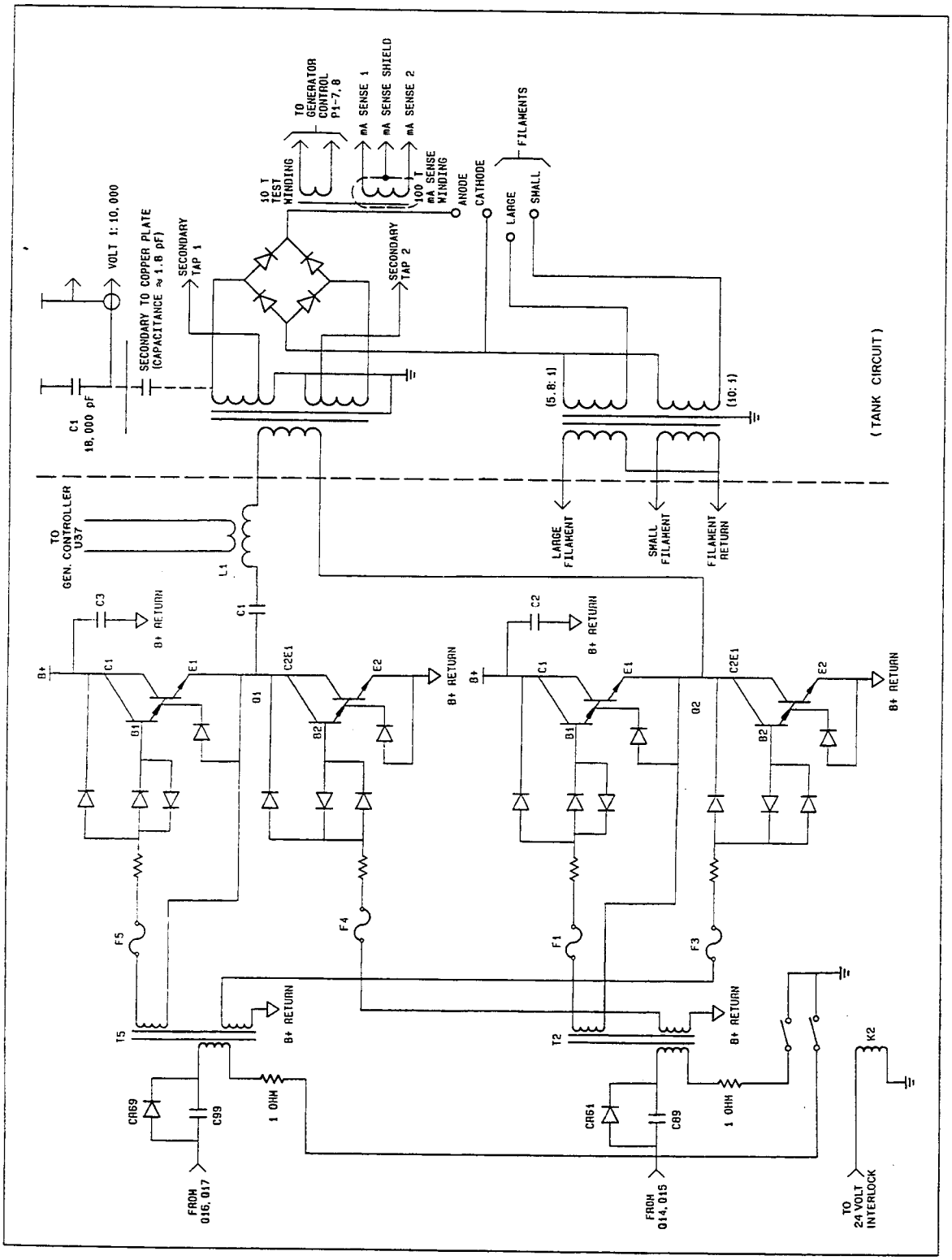
With the exception of the fuses and the baker clamping diodes, the high voltage driver circuit is constructed on the assembly below the Generator Controller PCB.

The large switching transistors Q1 and Q2 each contain two internally wired Darlington pairs. These form an H-bridge switching regulator. Baker clamp diodes are added externally to bias the darlington pairs for fast switching response.

The output legs of the H-bridge individually display ringing in the current waveforms. However when these are combined on the primary winding of the tank transformer, the ringing cancels out. C1 and L1 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 sinewave across the tank transformer primary.

Figure 3-38 - *Block diagram of the high voltage drive and tank circuits.*



3.12.6 High Voltage Circuit (Tank)

Refer to Figure 3-38. 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:

* Filament transformer with secondary windings for both filaments.
* High voltage transformer
* High voltage rectifier
* Capacitive voltage divider for voltage sensing with a divider ratio of 1:10,000 volts.
* 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.
* Secondary winding taps for voltage sensing.

Note: The Cathode connection is also the common filament return.

3.12.7 Battery Circuit

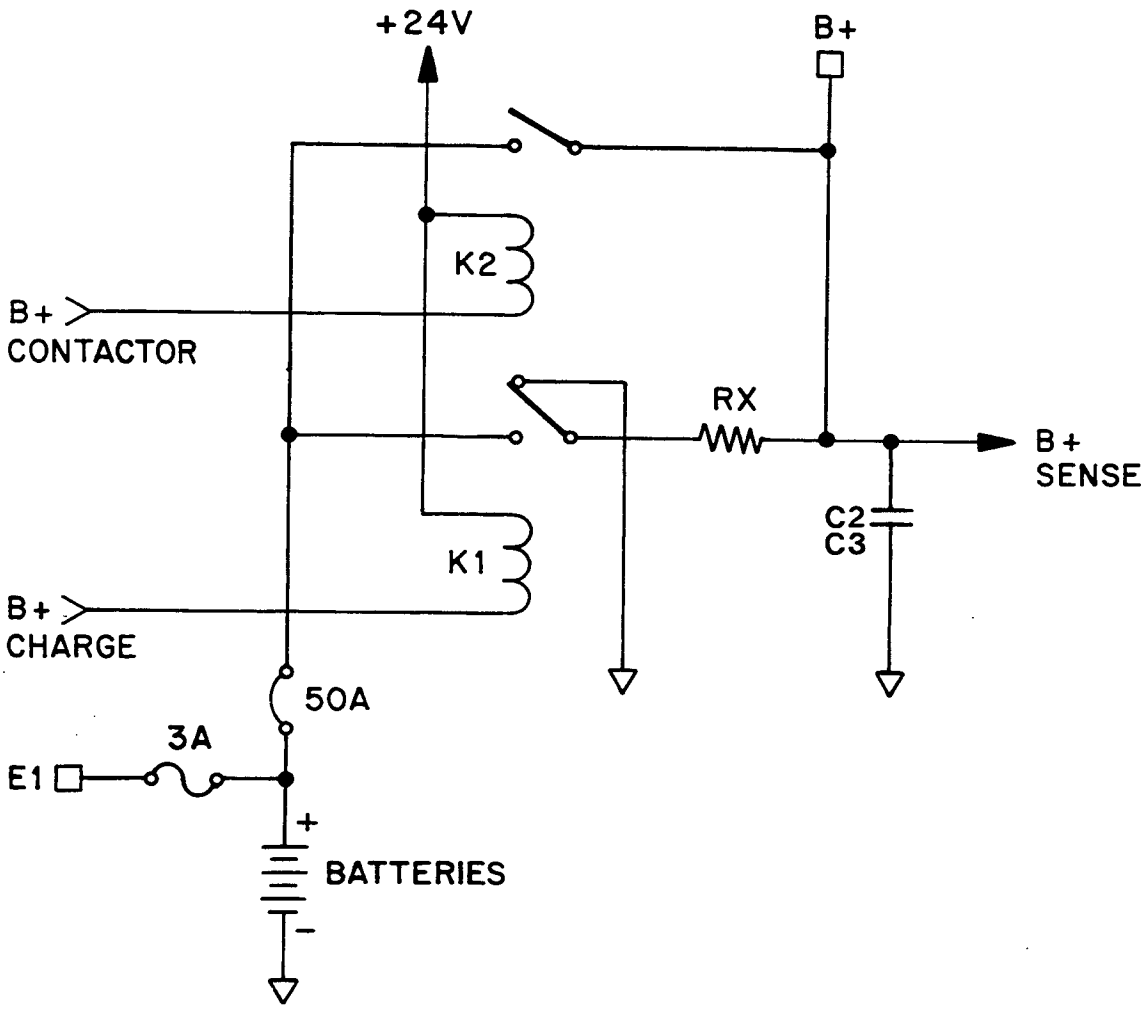
Refer to Figure 3-39. The battery circuit is comprised of:

* Six 30 volt battery packs
* Capacitor C4
* Charging resistor Rx
* 50 Amp contact closure fuse
* 3 Amp charger fuse
* B+ charge relay
* 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 200 VDC stack. This provides nearly 3.6 million watt-seconds of capacity, well beyond the tube rating. Each exposure draws from this energy source. The batteries are continuously recharged from the line at a 400 watt-second rate. 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, the batteries and the capacitor C4 provide energy for the X-ray shot.

Figure 3-39 - *Block diagram of the battery circuit.*



The charger circuit (E1) is connected through a 3 Amp fuse to the positive side of the battery pack. When K1, the B+ charge relay, is closed, the B+ voltage is applied through the 1 kOhm resistor Rx to charge the capacitor C4. C4 buffers the B+ line under rapidly varying current loads. After C4 has been precharged, the B+ CONTACTOR relay K2 is closed, finally connecting the battery, battery charger, and C4 all up to the B+ line, ready to supply 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

The 24 volt interlock line, the START switch, and the EMERGENCY OFF 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.

SECTION 4
MONITOR CART
THEORY OF OPERATION

This section provides technical descriptions of the hardware and software used in the OEC-Diasonics Mobile C-arm Imaging System. The purpose is to assist the service technician or field engineer in understanding the maintenance and calibration procedures in this manual.

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

The software plays a central role in the operation of the system. Therefore discussion of software is combined with the theory of operation of the hardware in this section.

4.1 Major Components and Options

4.1.1 Major Components

Figure 4-1 is a block diagram showing the major components and some options available on the monitor cart. The major control, data, and address busses within the system are illustrated. The bit width of these busses is indicated in parentheses. The serial links employ subsets of standard RS-232 serial interfaces.

The monitor cart contains the following major components:

Disk Interface PCB - coordinates image and data transfers between the system hard disk and memory; also programs image processing operations.

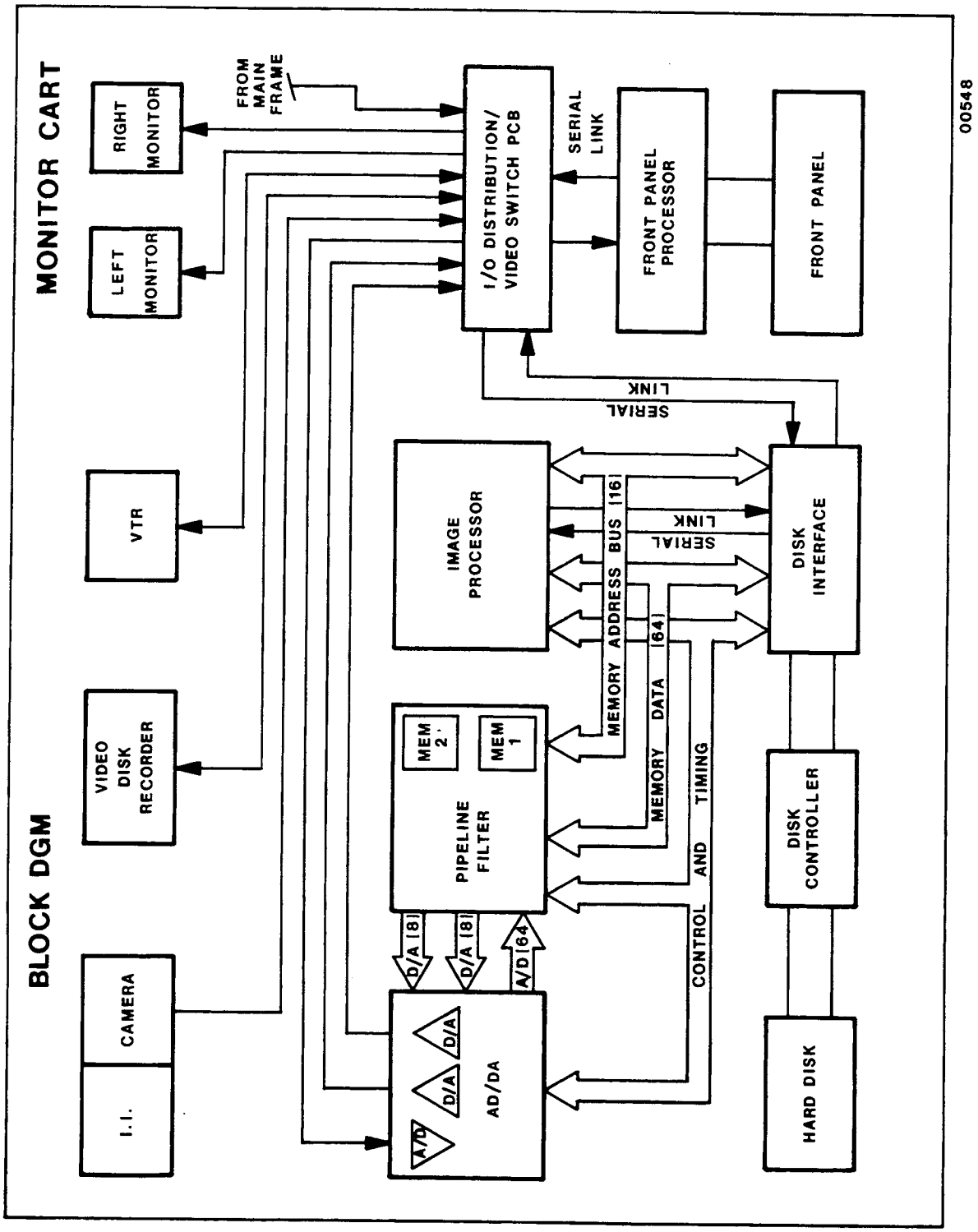
Front Panel Processor Assembly - consists of the control panel switches, LEDs, and the Front Panel Processor PCB.

Image Processor PCB - a board level microcomputer that controls the special functions of the digital processing circuits.

I\O Distribution\Video Switch PCB - controls the distribution of the video inputs and outputs of the image processing circuits.

AD\DA Converter PCB - digitizes the incoming composite video signal for processing and converts the digital image data into a composite video signal for display on the TV monitors.

Figure 4-1 - *Block diagram of the major components of the monitor cart.*



Pipeline Filter PCB - performs algorithms on the digital image data and also contains the image memories.

Disk Controller PCB - an OEM circuit board that controls the hard disk and also controls a floppy disk when connected.

OEM components - which include DC power supplies, the isolation transformer and the two TV monitors.

4.1.2 Image Storage Options

Various options may be installed depending on the system configuration:

Hard disk image storage for up to 60 digitized images.

Video tape recorder for real time storage of the composite video signal.

AngioStor video disk recorder for high resolution storage of video frames.

Multi-format camera to make hard copies of fluoro images.

Patient annotation for identifying and commenting stored images.

4.1.3 Image Processing Options

The major image processing and image storage options can be identified by referring to the front panels shown in Figure 4-2. Model upgrades can be performed by replacing these panels and their associated electronics and software.

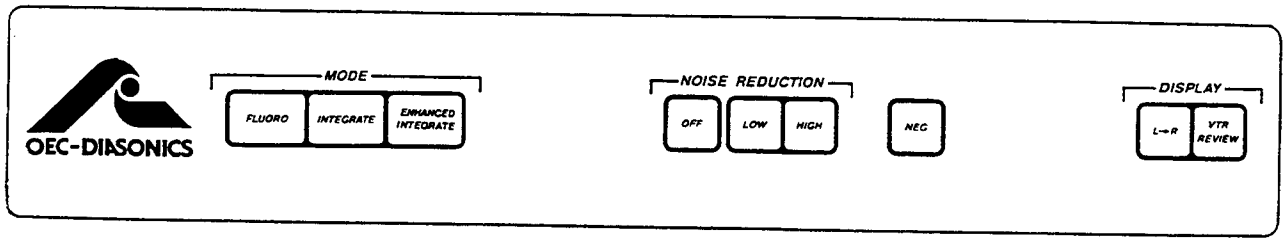
In Figure 4-2 the following panels are identified:

1 - Basic 9000 system

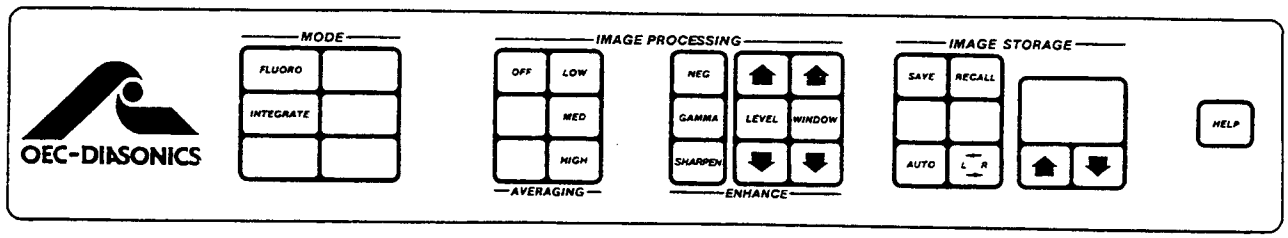
2 - Expanded Surgical Package

3 - Expanded Surgical Package with Vascular or Neurovascular Options

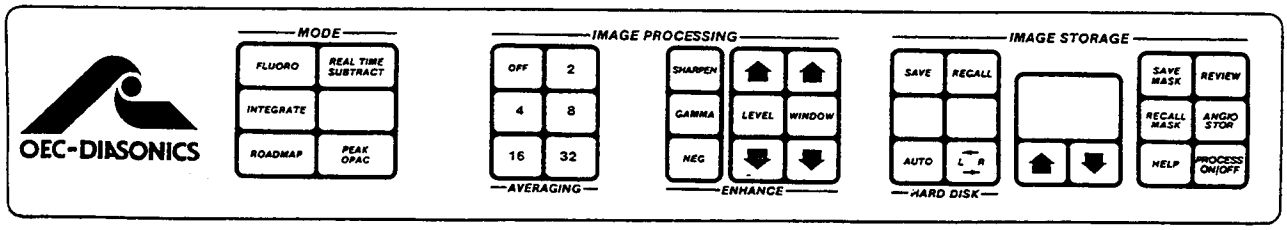
Figure 4-2 - *The major image processing options can be identified by their different front panels.*



1



2



3

4.1.4 Major Connections

Interconnect Cable

Refer to Drawing 00-870735.

The interconnect cable provides AC power to the mainframe, control communications between the mainframe and monitor cart and the video signal to the monitor cart. This is described further in the *Mainframe Theory of Operation.*

Other Connections

The following tables describe the connectors located on the interface panel on the rear of the monitor cart.

Table 1 RS232 Connector

PIN	*SIGNAL*
3	RXD
5	TXD
7	RTS
9	CTS
11	DSR
13	COM
14	DTR
15	DCD

Table 2 AUX Connector

PIN	*SIGNAL*
3	spare
5	stop
7	record
9	search
10	VTR clock
11	pause
12	ground
13	play
14	ground
15	f. forward
16	ground
17	reverse
18	ground
20	ground
22	ground
24	ground

Table 3 **VTR - J34**

PIN	*SIGNAL*
3	shield
4	video to VTR
2	video from VTR
6	shield

Table 4 **Video Out**

PIN	*SIGNAL*
J36	video out 1
J35	video out 2

Table 5 **Video Disk J37**

PIN	*SIGNAL*
1	record enable
5	ground
4	video to AngioStor
3	shield
2	video from AngioStor
6	shield
8	composite sync
7	shield

4.2 Power Distribution

AC Power Input power is supplied via the isolation transformer T1 located in the base of the monitor cart assembly. Taps on the primary and secondary windings of T1 allow system connection to various line source voltages.

DC Power DC voltages for circuit board operation (+5, -5, +/- 15 VDC) are obtained from the switching power supply located on the side of the card rack.

A 24 VDC supply in the base of the monitor cart supplies power to the tv monitors.

4.3 Monitor cart operation

4.3.1 Image Processing Functions

The image processing functions, selected from the front panel, may include the following, depending on system options and model:

Averaging Real-time video frame averaging is used to improve signal to noise ratio and reduce motion artifacts. A running average is calculated for each pixel to be displayed. The average can be obtained over a variable number of frames: 2, 4, 8, 16, 32. Noise and motions which are not correlated with structures in the image are averaged out. Since it is a real-time average, the pixel values used in the calculation are constantly changing and the average is recalculated each time a new frame is added.

Integration Frame integration is similar to frame averaging. The main difference is that integration stops after a specific number of frames have been averaged. The last image displayed when integrating results from averaging the previous frames.

Real-time Subtraction Real-time subtraction allows successive images to be subtracted from a mask image. Perfect subtraction results in a gray-scale value which is off-set to 80 Hex, a mid-range gray.

Roadmapping Roadmapping is similar to real time subtraction, but the mask image is negated and reused for successive subtractions until another mode of processing is selected.

Peak Opacification Peak Opacification can be performed on successive frames. The darkest value for each pixel in the image is saved and displayed.

Gamma The gamma function maps the gray scale range as an exponential function. This results in a compression of the dynamic range when dealing with an image where the brightness range is large. Linear gray scale mapping is used when gamma is not enabled.

Sharpen Image sharpening is achieved by an algorithm which emphasizes image edges. This process involves translations of horizontal and vertical pixel locations. The circuitry to perform these translational movements is divided between the Image Processor PCB and the Recursive Filter PCB. This requires executing an algorithm which shifts the image a certain number of pixels in the X axis and a number of lines in the Y axis. The Y shift is set by changing the beginning pixel address generated by the address counters on the Image Processor PCB.

Window and Level Window and Level controls are used to remap the gray scale to upper and lower portions of the gray range and to alter the slope of the video transfer function. These are analogous to contrast and brightness controls.

Subtraction With Averaging and Peak Opacification Averaging and peak opacification can be selected from the front panel for use during real time subtraction and roadmapping. These are applied selectively during the mask and subtraction phases as shown below:

	REAL TIME SUB		ROADMAPPING	
PHASE	*MASK*	*SUB*	*MASK*	*SUB*
AVG		X		X
		or		
PK OPAC		X	X	

4.3.2 Image Memories

The fluoro image is transferred between several memories during processing. These memories are described below:

Segment Ram Sixteen kbytes of static ram located on the Disk Interface PCB are used to read and write segments of data to the Pipeline Filter memory from the hard disk. The 16 kbytes translates to the monitor as an image segment 32 lines down x 512 pixels across. Only Pipeline Filter memory M1 can be written to or read from via the segment ram.

Pipeline Filter Memory 512 kbytes of ram is mapped into two pairs of memory (M1 and M2) for a total of four 128 kbytes image frames.

Image Frame Each 128 kbyte memory frame is large enough to store a 512 x 512 byte image. Whichever frame is currently mapped to the monitor is considered the foreground frame, while the other 128k block is the background frame. The Image Processor can switch the address lines so that these memory blocks exchange roles.

DRAM 64 kbytes of dynamic ram located on the Disk Interface PCB is not used for image storage but is where the system software resides after boot-up.

4.3.3 Serial Links Between Boards

Monitor Cart-Mainframe The serial communications port between the monitor cart and the mainframe uses hardware handshaking and operates at 9600 baud.

I.P. - Disk Interface Serial communications between the Disk Interface PCB and the Image Processor PCB operates at 1200 baud and supports XON/XOFF handshaking. The Image Processor also has a 128 byte buffer for this port.

Front Panel - Disk Interface PCB Serial communications between the Front Panel Processor and the Disk Interface PCB operates at 1200 baud and supports XON/XOFF handshaking.

4.4 Monitor Cart Software

The monitor cart software can be divided into three major functional areas:

1. Main program software
2. Image processing software
3. Front Panel software

4.4.1 Main Program Software

The main program consists of system operating software and application programs which are stored on the hard disk and loaded into the Disk Interface board DRAM for execution. The transfer occurs during the monitor cart booting process and is directed by a smaller program in EPROM on the Disk Interface PCB. When executed by the processor on the Disk Interface PCB, the application program issues commands to the other processors on the Image Processor and Front Panel Processor PCB's. The operation of the I/O Distribution - Video Switching PCB is also controlled by the main program.

4.4.2 Image Processing Software

This software resides in EPROM on the Image Processor PCB and controls the operation of the Pipeline Filter and Image Processor PCB's. For some processing applications it receives function calls from the application program running on the Disk Interface PCB.

4.4.3 Front Panel Software

The Front Panel Processor PCB executes a program which resides in EPROM. It scans the front panel keys and sends the scan codes to the application program for interpretation. The application program, in turn, issues commands to the Front Panel Processor PCB to update the LEDs and the alphanumeric display on the front panel. The Front Panel Processor PCB also sends commands to the Disk Interface PCB for image processing selection.

4.4.4 System Initialization

When power is first applied, each microprocessor starts an initialization or "boot" sequence by executing software code which resides in EPROM.

Disk Interface Initialization: Commands are issued to the Disk Controller PCB, via a parallel port on the Disk Interface PCB, to read the first sector from the hard disk into memory. If a floppy disk drive is installed during service procedures, the first sector of the floppy disk will be read instead.

If the disk read operation is unsuccessful, an error message is issued to the AUX port, which may be read on an external terminal during service procedures. The system then enters the monitor program, contained in EPROM on the Disk Interface PCB.

The code read from the first sector directs the transfer of the rest of the operating system into memory and transfers control to the Disk Operating System. The function of the Disk Operating System is to load various utilities, diagnostic, and application programs into RAM for execution. In normal operation, the Disk Operating System then executes the application program.

Image Processor Initialization: The monitors are cleared, gray scale and log table RAM's are loaded on the AD/DA and Pipeline Filter PCB's, and communication ports are initialized. The Image Processor PCB then waits for function calls from the Disk Interface PCB, and Front Panel commands.

Front Panel Processor Initialization: The Front Panel Processor initialization consists of clearing all I/O ports to turn off all LEDs. It then begins scanning the keyboard and multiplexing the LEDs. Commands are exchanged with the Disk Interface PCB through a serial data interface.

4.5 Monitor Cart Electronics

4.5.1 Disk Interface PCB

Refer to Figure 4-3 and Schematic 00-870013.

The Disk Interface PCB is a Z80-based board level computer. Its main tasks are to load and execute the disk operating system and applications software from the hard disk and to control image transfers between the hard disk and memory. Data transfers between the hard disk and memory are accomplished via the Disk Controller PCB. Handshaking occurs between the Disk Interface and Disk Controller PCBs to control the data transfer with the hard disk.

The Disk Interface PCB communicates with the Front Panel Processor PCB, with the Image Processor PCB, and with the main frame X-ray Processor PCB via RS 232 serial data links. The Front Panel Processor PCB reads the switch panel and passes the data to the Disk Interface PCB. The Disk Interface PCB then selects the appropriate image processing program segment and sends it to the Image Processor PCB.

CPU

The CPU, U60 is a Z80A. It uses an 8-bit data bus and 16-bit address bus.

The CPU is reset in either of three ways:

1. At power-up, by the charge time of C137 through R20.

2. On manual reset, during tests and adjustment of the system. Closing S1 discharges C137, and allows it to recharge through R20.

3. By the watchdog timer, U75, when its Q7 output goes active (high).

Watchdog Timer

In order to prevent the watchdog timer from resetting the CPU during normal operations, the CPU periodically resets counter U75 via I/O 4 (U77E).

DMA Controller

The direct memory access (DMA) controller, U59, emulates the Z-80 CPU during fast data transfers. Wait requests from the DRAM controller are applied to U80-10 when the controller forces an internal refresh. The DMA can perform memory to memory, and memory to I/O transfers at a rate of up to one megabyte per second.

Multiplexer U67 selects either the wait state or I/O 70 as the chip enable input to the DMA based upon the state of the BUSAK control signal. When the BUSAK output from the Z-80 is low, the output of the wait-state generator (U78C-8) is applied to the DMA controller U59. During DMA accesses, the interrupt line is pulsed periodically by the DMA controller (U59). These are gated through U79C to provide a reset to the watchdog timer, preventing it from timing out. Since the CPU is held in the wait state by the output from U78C, it does not sense the interrupt pulses from the DMA.

Programmable Counter and Baud Rate Generator

Counter timer circuit (CTC) U61 contains three independently programmable counters. The output of counter "0" provides a non-maskable interrupt to the CPU.

Counter "1" provides a software controllable baud rate clock to the auxiliary serial communications port U30. Counter "2" provides a standard baud rate clock (307.2 kHz) to counter U52.

Counter U52 is operated as an 8-bit binary counter. It provides output clock signals for baud rates of 9600, 4800, 2400, 1200, 600, 300, 150, and 75. (The actual clock signal is 16-times the Baud rate.) The outputs of U52 are configured with jumpers so that two separate baud rates can be selected, EE to serial communications port U31, and FF to serial communications port U30.

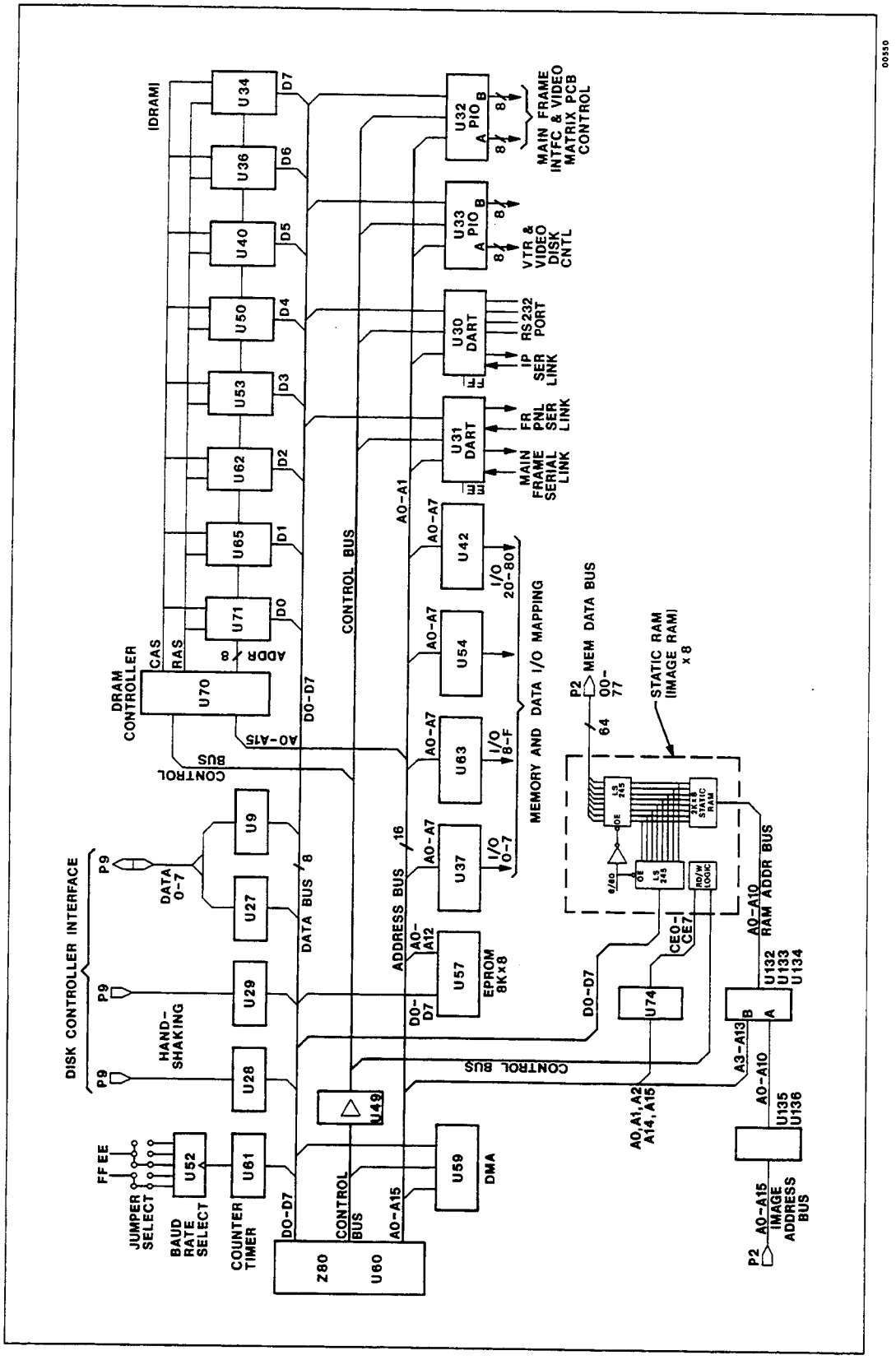
Disk Controller Interface

Communications between the Disk Interface PCB and the Disk Controller PCB is via bi-directional open-collector TTL lines. The open-collector lines are balanced with 220 ohm pull-up resistors to +5V, and 330 ohm pull-down resistors to ground. All control signals between the two devices are active low.

For DMA writes to the Disk Controller PCB, the D0-7 bits on the internal data bus are clocked into U27 by the negative true I/O 2. For DMA reads of data from the Disk Controller PCB, the input DATA 0-7 bits are enabled through buffer U9 by the negative true I/O 3.

The handshake function is provided by flip-flop U1A and gates U12A and U23C. This circuit provides an automatic acknowledge every time the DMA writes a data byte to, or reads a data byte from the Disk Controller PCB.

Figure 4-3 - *Block diagram of the Disk Interface PCB.*



Boot PROM

The boot PROM (U57) occupies memory space from "0" to "1FFF" (HEX), and is controlled by the memory map I/O circuit. The boot PROM contains the program necessary to load the disk operating system from the hard disk into RAM. Execution then jumps to the newly located code in the disk operating system program. The boot PROM is disabled until the next time the system is reset.

Parallel Interface

Parallel interface is provided by two Z80 PIO's, U32 and U33. U32 port A is assigned as the interface for data to and from the mainframe, U32 port B interfaces various functions such as X-RAY ON AND DISABLE/, SWITCH DATA, SWITCH CLOCK, SWITCH LATCH, IM- REQ/, TIMER and VERT INT. Bit 7, VERT INT, is dedicated to the vertical reset which provides a 60 Hz clock to allow the system to synchronize any necessary software functions to the vertical field rate of the imaging system. U33 port A is assigned as a VTR remote control interface. U33 port B is assigned to an auxiliary device output connector and serves as a printer port.

Memory Map

The memory map circuit consists of memory chip enable PROM U39, the flip-flops of U38 and gate U43C. There are three memory spaces on the Disk I/O Interface PCB. The three memory spaces are occupied by:

* 8k x 8 boot PROM
* 16k x 8 image memory, static RAM
* 64k x 8 DRAM

When I/O 6 is asserted true, U38B is set and U39 selects the DRAM for the entire 64k memory space. When I/O 7 is asserted, U38A is set, the 80/8 signal is high and U39 enables the lower 16K memory space as image memory in the 8-bit wide mode, and the remaining memory space is dedicated to the DRAM. In all configurations of the memory map, the DRAM occupies the block of memory address space above that used by either the boot PROM or the image memory.

When the image RAM is not selected, and thus not mapped into the addressable memory, the DRAM is configured in the 64-bit wide mode and is available for data transactions with the image memory data bus.

I/O Decoders

The data and memory mapping I/O signals for the Disk Controller PCB are decoded by PROMs U37, U42, U54, and U63. The I/O decoder PROMs are enabled when the IORQ/ signal is true and the inverted M1/ output of U45D is low; and they are addressed by the A0-7 address bus bits.

Image Memory

Depending on the state of the 80/8 signal, the image memory RAMs are either connected in parallel with the 64-bit wide image memory bus, or connected sequentially with the Z80 data bus.

Memory Control Logic

When the system is in the 80-wide mode, it is reading 64 bits at a time. When in the 8-bit wide mode, 8-bit pixels are read in sequential order. PROM U74 provides chip enable signals based on this system status. In the 80-wide mode CE0-7 are issued simultaneously. In the 8-bit mode, CE0-7 are issued sequentially when memory is being accessed by the Z-80 DMA. Addresses are selected by multiplexers U132/133/134 from the internal address bits A3-A13 and the system image address bits A0-A10.

Image transfer from buffer to system image memory is implemented in hardware. The Z80 determines and preloads a segment number of the image (there are 16 segments in an image). The segment number is held in latch U81 and compared with the image address bus A11-A14. When the two are equal, a high level is asserted at U97-6 (OUT). The OUT signal triggers the circuits for reading or writing an entire segment to the main image-memory.

The Image Processor PCB controls the main image-memory data by providing RAS, CAS, READ ENABLE, WRITE ENABLE, and address control.

DRAM

The 64k x 8 dynamic RAM section consists of the eight 64k x 1 RAMs U34-/36/40/50/53/62/65/71. U70 is a TMS4500A dynamic RAM controller. U70 generates all of the RAS and CAS signals, and multiplexes the A0-15 address bits. It also provides refresh and arbitration logic to the DRAM's.

U70 is enabled or disabled by the memory mapping circuit via U77D and U68B. U70 is clocked by the 8 MHz clock signal so it can generate RAS and CAS pulses with adequate system timing for the DRAMs to be accessed without wait states.

Serial Communications

Serial communications occur via two dual asynchronous receiver /transmitters (DARTs) U30 and U31.

Channel A of U31 is a buffered serial RS-232 port dedicated to two-way communications with the mainframe X-ray Processor PCB. Channel B of U31 is TTL open-collector buffered, serial RS-232 port, dedicated to two-way communications with the Front Panel Processor PCB.

Channel A of U30 is a buffered TTL serial RS-232 port, dedicated to two-way communications with the Image Processor PCB. Channel B of U30 is a buffered serial RS-232 port with selectable baud rate, for two-way communications with an external terminal.

4.5.2 Front Panel Processor Assembly

Refer to Schematic No. 870507 and Figure 4-4.

The Front Panel Processor Assembly consists of the following:

* Front Panel Processor PCB, No 00-870507
* Overlay, Front Panel, SCD No. 00-870481
* LED Display PCB, Schematic No 00-870392

The Front Panel Processor Assembly provides the interface between the touch-sensitive membrane switches of the monitor cart front panel and the Disk Interface PCB. It senses front panel switch closures and reports the results to the Disk Interface PCB, which in turn provides commands to the Front Panel Processor to drive the LED indicators, the two digit numeric display, and the beeper.

Front Panel Processor PCB

Refer to Figure 4-5.

The Front Panel Processor PCB is based on the Z8 microcomputer, U20, a Z8682. The Z8682 data bus is multiplexed with the lower A0-A7 address bits. Demultiplexing of the AD bus is achieved by latch U3.

Processor I/O Ports

Communications between the Front Panel Processor PCB and the Disk Interface PCB takes place over a serial RS-232 link. U20 can be programmed to function as a universal asynchronous receiver/transmitter (UART) for serial RS-232 data by using its built-in I/O ports P3-0 and P3-7. The internal UART baud rate clock is software controlled and is generated by one of two timers that are part of U20.

Clock Generator

The clock signal for U20 is derived from 8 MHz crystal Y1.

Program Storage

Program storage is provided by the 4K x 8 EPROM U13. U12 is an 8 2K RAM.

LEDs and Alphanumeric Display

The LED indicators and the two numeric displays are driven by a time-multiplexed refresh technique. Each LED is associated with a position in an 8 x 8 matrix. The position within the matrix is determined by a row number (R0 - R7) and a column number (C0 - C7). To light a particular LED, both of its associated row and column drivers must be on.

The row driver U10, consists if eight common emitter current sources. The contents of the row register U9 control the row drivers of U10. A high output from U9 turns its associated row driver on; a low output turns its driver off, placing the outputs of U9 in the high Z state. A high applied to U9-1 (OE) also disables the row drivers of U10.

The column drivers of U7 and U5 are open-collector inverting drivers. They are controlled by the outputs of column register U14. A high output from U14 turns its associated column driver on (low impedance to ground); a low outputs turns its driver off.

The outputs from the LED drivers are connected with the LED Display PCB via connectors P27 (column bits C0-C7) and P28 (row bits R0-R7).

If the LED refresh fails, the LEDs are protected by the watchdog timer U4A, which will turn off all of the row drivers, setting the outputs of U9 to the high Z state.

Figure 4-4 - *Block diagram of the Front Panel Assembly.*

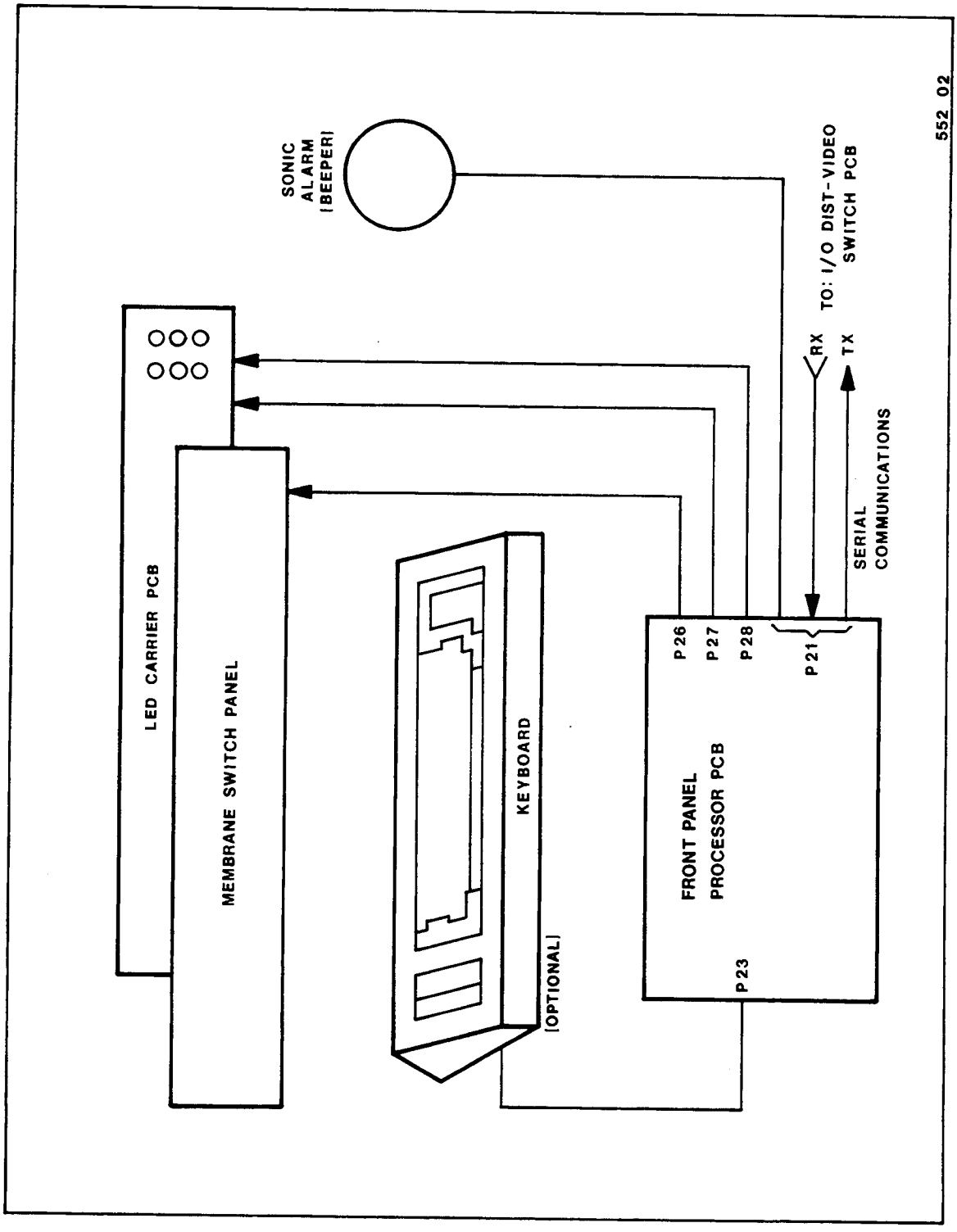
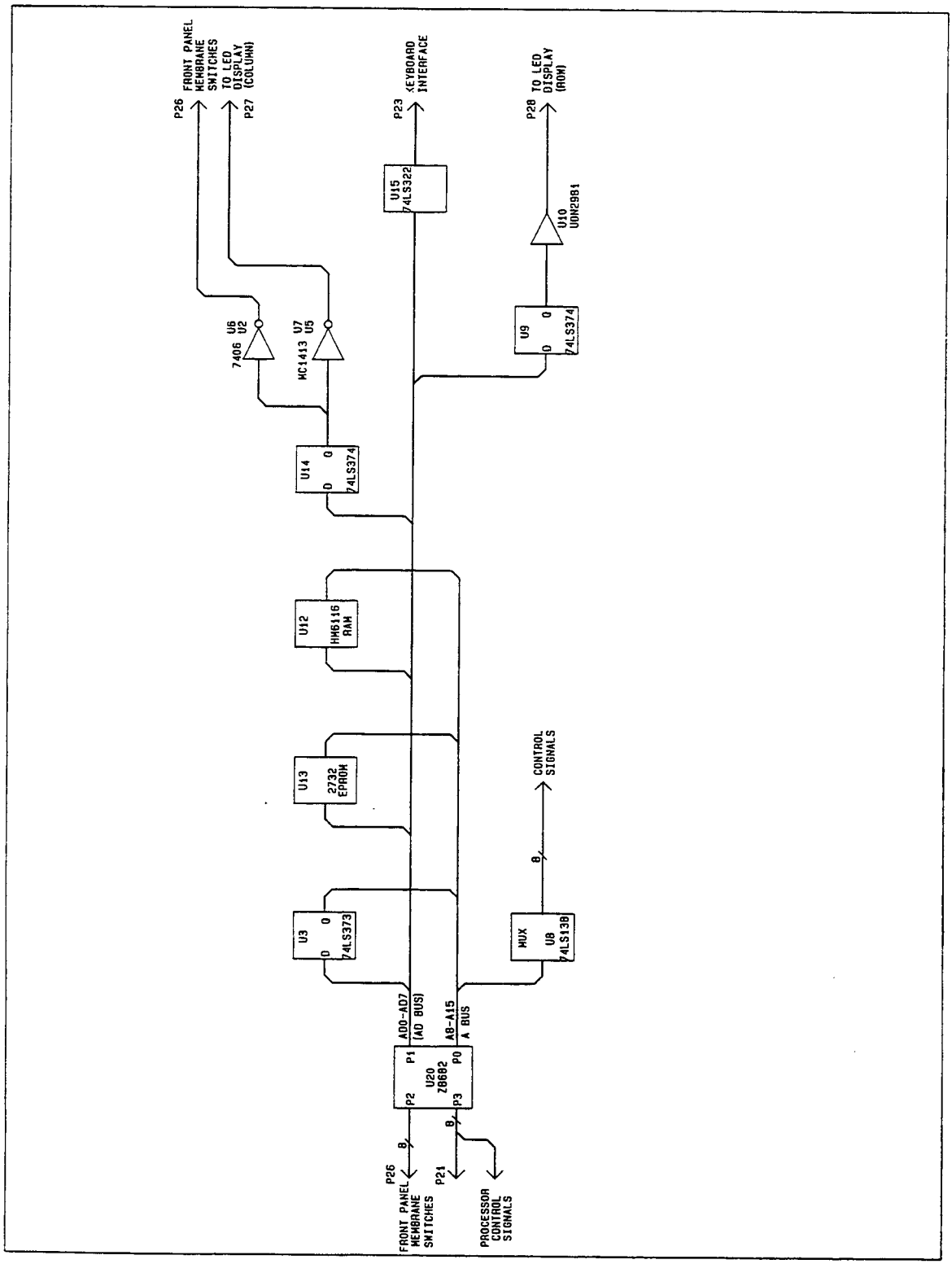


Figure 4-5 - *Block diagram of the Front Panel Processor PCB.*



Beeper (Sonic Alarm) Driver

The beeper is driven by the P3-5 output of U20-10. A high level output at U20-10 turns the driver U5G on, providing a return path to ground for the device.

Front Panel Switch Matrix

The switches on the front panel are arranged in a matrix similar to the LED matrix. Each switch is identified by a row and column number. The switch matrix is scanned using a time-multiplexed technique.

Optional Keyboard Interface

P23 provides a connection for the optional keyboard used for patient annotation. Three signals are required for keyboard operation: KBDATA, KBCLK, and RESET.

4.5.3 Image Processor PCB

Refer to Figures 4-6 and Schematic 00-870388.

The Image Processor PCB is a Z80 based board level computer which controls the operation of the I/O Distribution/Video Switch PCB, AD/DA Converter PCB and Pipeline Filter PCB, and executes data transfers with the 64-bit system memory bus. It communicates with the Disk Interface PCB via an RS-232 serial data link and the system control bus. The image processing program-segment is received from the Disk Interface PCB via the serial link.

Reset

The CPU can be reset by the EXT RESET/ signal. A low level is applied to the RESET input of the CPU, U80.

Data Bus

The Image Processor PCB has two internal data buses: a bidirectional data bus (to/from the CPU) identified by D0-D7 and a uni-directional bus (from the CPU) identified by DB0-DB7.

The D0-D7 internal bus interfaces data with the PROM, the Serial Timer and Interrupt Controller, and the RAMs. The 8-bit internal data bus is interfaced with the 64 bit memory data bus by latches U100 - U107 and U110 - U117.

The unidirectional internal data bus (BD0-BD7) is interfaced with the bidirectional data bus through 8-bit buffer U109. The data on the BD0-BD7 internal bus is applied directly to the system control bus through pins 1-8 of connector P3, the daisy-chained ribbon cable. The system control data bus is used to write log-RAM and processing control data to registers on the Pipeline Filter PCB. Grayscale-RAM data is also written to the AD/DA PCB from the Image Processor PCB.

Memory Data Bus

The 64-bit wide image-memory bus is read and written to by latches U110-U117 and U100-U107. The read and write data transfers between the latches and the memory data bus are controlled by the RMD (read memory data) and EMD (enable memory data) signals. The sequential transfer of data in 8-bit bytes between the latches and the internal data buses D0-D7 and DB0-DB7 is determined by the sequence of the OUT 00-07 and IN 00-07 signals from the I/O port decoders.

Memory Addressing

Latches U95 and U96 multiplex the 8-bit BD data bus onto the 16-bit memory address bus. U95 and U96 are also used to initialize the address counters U84, U85, U88, and U89.

Edge Enhancement Pixel Shift

Address counters may be initialized with an offset count which produces a line shift in the vertical image axis. This is used by the edge enhancement algorithm when combined with the horizontal axis shifting performed on the Pipeline Filter PCB.

PROMS

Programming on the Image Processor PCB resides in the PROM U50 (2764). This PROM based software directs much of the image processing on the Pipeline Filter PCB.

RAM

The Image Processor PCB has three 2K X 8 static RAMs, U31, U32, U51. These RAMs serve as a scratch pad memory for the CPU.

Serial Timer and Interrupt Controller

U73 provides a serial RS-232 data link with the Disk Interface PCB and the Front Panel Processor PCB. Data received over this link includes function calls from the Disk Interface PCB and scan codes from the Front Panel.

Memory Control Logic

The memory control logic is synchronized to the video rates by composite blanking (C BLANK, H-rate) and vertical drive (VR DRV, V-rate).

Video Sync Generator

Refer to Figure 4-7 and Schematic 00-870388.

The 82 MHz clock signal produced by VCO U5 is applied to a binary divider which provides three outputs: 10.25 MHz (PC1), 5.125 MHz (PC2), and 2.58 MHz. The 2.58 MHz signal is applied as the clock input to TV sync generator U8 which in turn provides five TV signal outputs: C SYNC, C BLANK, HR DRV, VR DRV, and an even field signal E FLD. These signals are synchronized with the incoming video signal through the phase comparator circuit U3, Q2 and U4. Adjustment of C6 changes the frequency of the VCO until the incoming video rate and the U8 video rate are in phase.

Figure 4-6 - *Block diagram of the Image Processor PCB.*

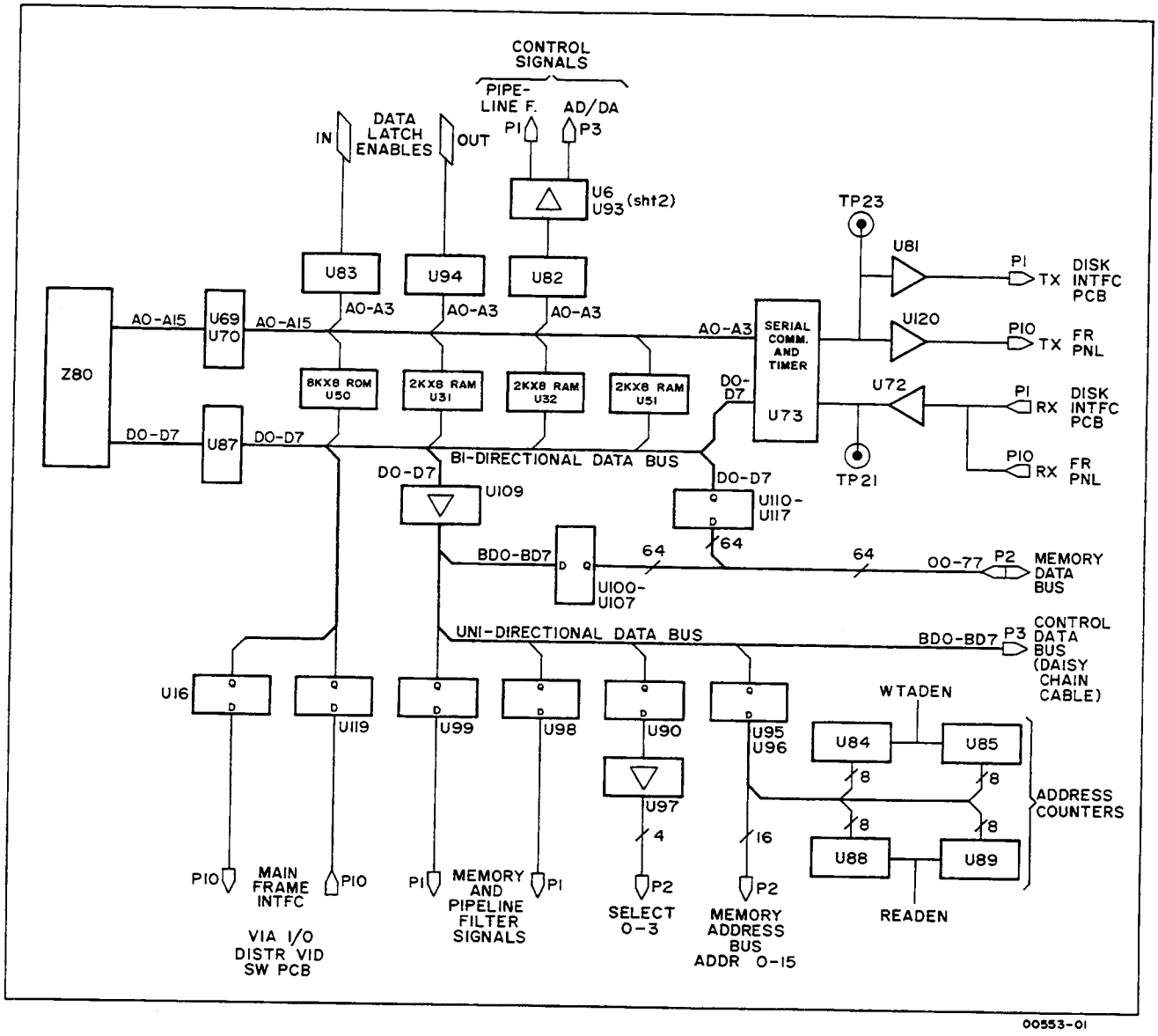
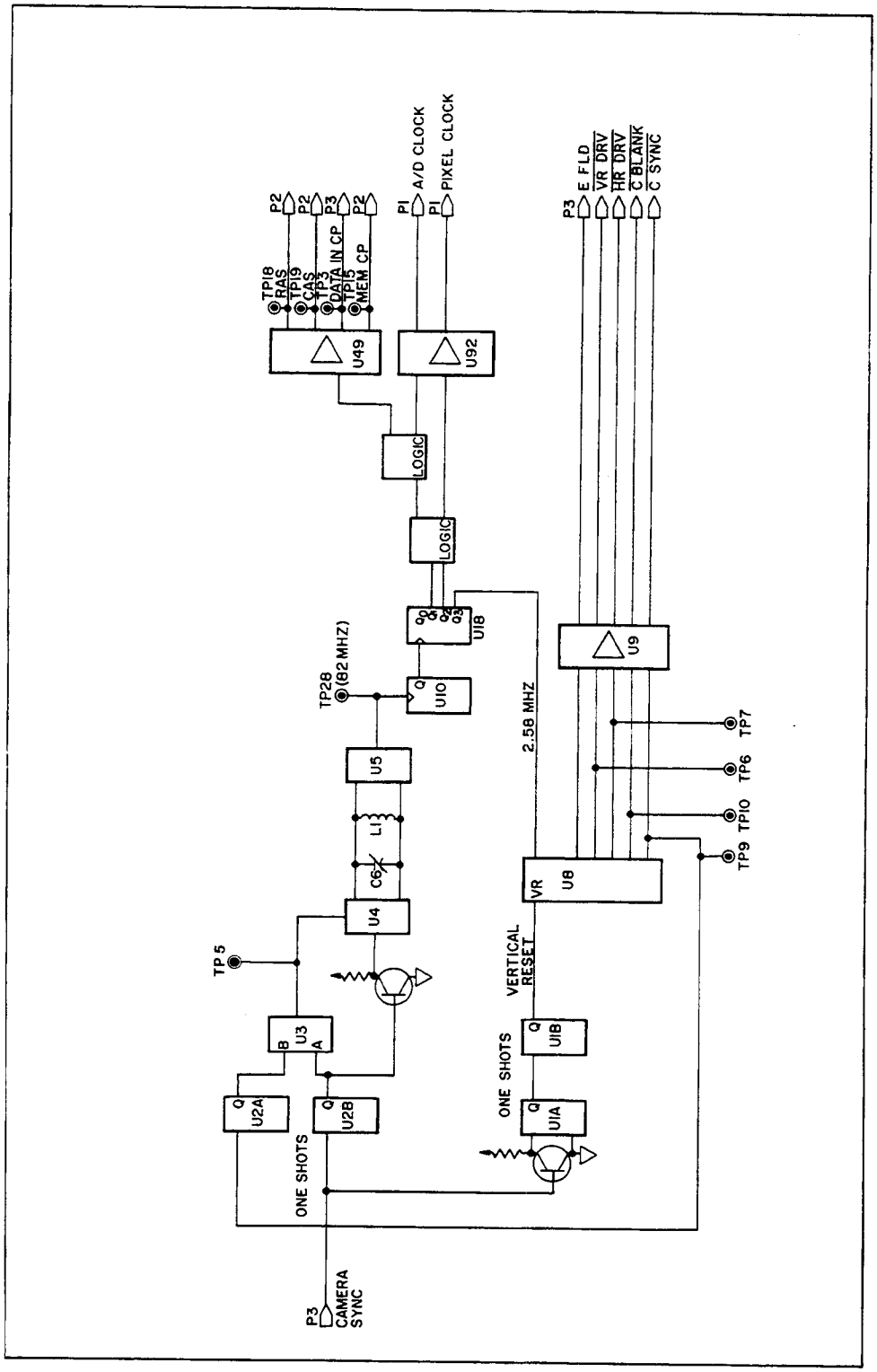


Figure 4-7 - *Block diagram of the Image Processor PCB, Video Sync Circuit.*



4.5.4 I/O Distribution/Video Switch PCB

Refer to Figure 4-8 and Schematic 00-870185.

The I/O Distribution/Video Switch PCB contains five primary circuits:

* Voltage Regulator Circuit
* Connector Interface Circuit
* Control Word Serial-to-Parallel Shift Register
* Video Switching Relay Matrix Circuit
* Video Buffer/Driver Circuit.

Voltage Regulator

Potentiometer R24 is adjusted so that the output of VR1 (TP19) provides +12 VDC at the input connector to the hard disk drive assembly.

Other DC inputs on the PCB are: +5 VDC, -5 VDC, -15 VDC, and the switched +5 VDC which is applied to the switching relays.

Connector Interface

The connector interface allows routing a number of mainframe control signals to the Disk Interface PCB where they are used to coordinate image processing with X-ray exposures.

Control Word Shift Register

U7 through U10 comprise a 16-bit serial-to-parallel shift register for the switching relay matrix control word. The word is latched at the outputs of U7 and U8 as a 16-bit wide parallel word and is applied to inverting buffers U1-U4. Each inverter output drives an associated video switching relay. Note that some of the relays are normally open and some are normally closed.

Switching Relay Matrix

Note: Only the following relays are installed:

K1, K4, K7, K8, K10, K15, K16, K18, K19, K20, K24, K25, K28, K30, K31.

There are five possible video sources in the imaging system:

* Camera (live video)
* Left D/A channel
* Right D/A channel
* VTR option
* AngioStor option

There are six possible video destinations:

* A/D converter (for digital processing)
* left monitor
* right monitor
* VTR
* AngioStor
* VIDEO OUT 1 and 2, BNC connectors on the monitor cart rear panel.

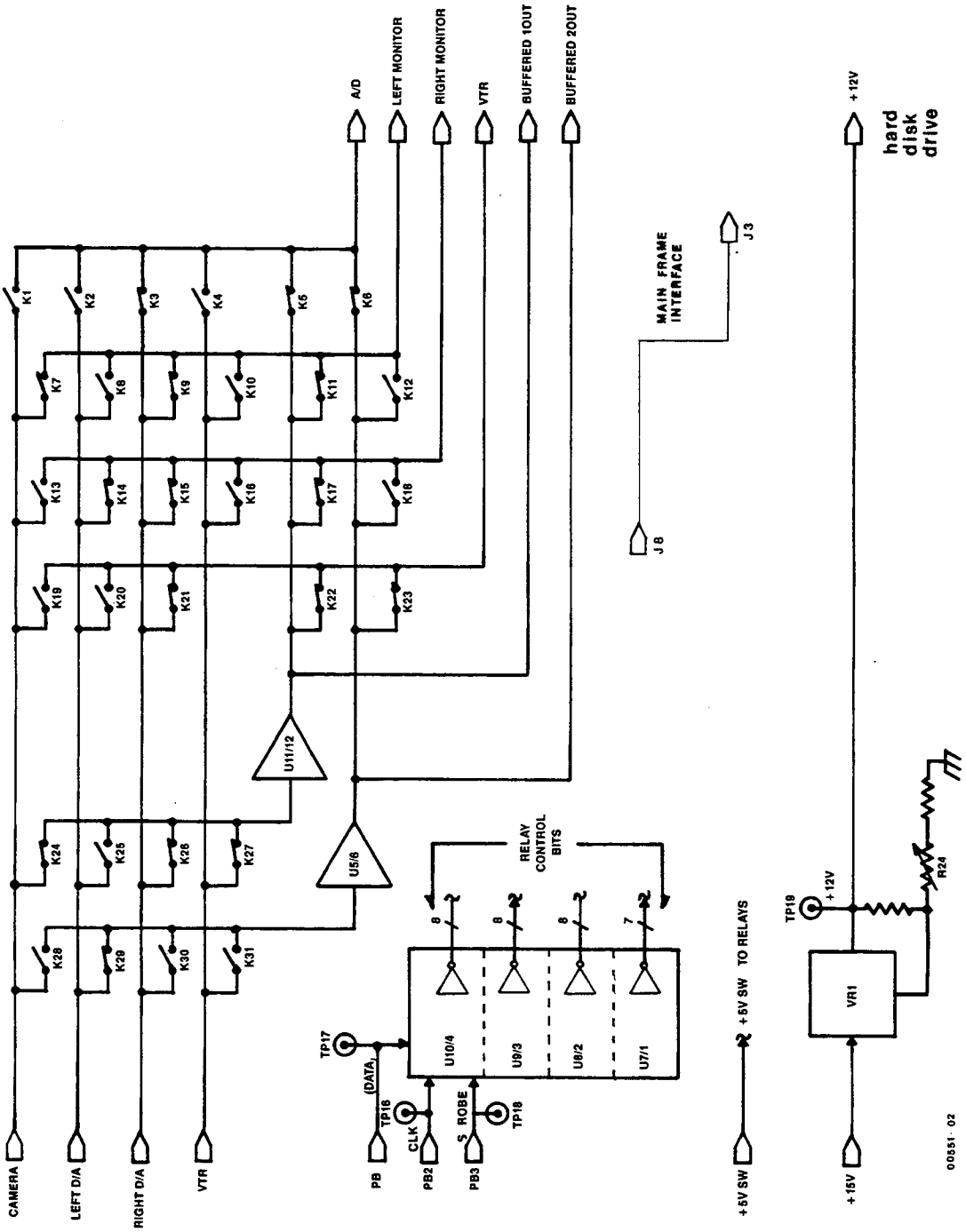
Note that the camera (live) video output is applied directly to the input of the AD/DA Converter PCB, but to the VTR through a buffer. This circuit configuration prevents double termination of the camera video output. The software control of the relays prevents undesirable double termination of any of the video sources. The video output of the VTR can be selected through K4 and applied to the analog input of the AD/DA Converter PCB and processed in the same manner as the camera video.

AngioStor Interface

Refer to Schematic 00-870543.

Additional video buffering and sync circuitry for the AngioStor disk recorder is provided by the piggy-back PCB installed on the right side of the I/O Distribution-Video Switching PCB. Refer to the *Options* section of this manual.

Figure 4-8 - *Block diagram of the I/O Distribution Video Switch PCB.*



4.5.5 AD/DA Converter PCB

Refer to Figures 4-9, 4-10 and Schematic 00-860896.

The AD/DA Converter PCB contains circuits that perform the following functions:

1. Conversion of the incoming composite video from the I/O Distribution/Video Switch PCB to digital data which is then available to the Pipeline Filter PCB on the 64 bit wide A/D bus.
2. Generation of a circular blanking window.
3. Subtraction of two separate images (D/A OUT 1 and D/A OUT 2, from the Pipeline Filter PCB) from each other.
4. Detection and removal of the sync pulses from incoming video signal.
5. Gray scale correction of the digital data output from the Pipeline Filter PCB.
6. Conversion of the digital image-data from the Pipeline Filter PCB into a composite analog video signal which is routed through the I/O Distribution/Video Switch PCB for display on the TV monitors.

A/D Conversion

The incoming video signal is AC coupled to buffer Q2. The Q2 output is applied to comparator U19 which is biased to strip the inverted sync signal. The video signal is amplified by U18, and a porch is added by clamping the output to ground before the C-SYNC pulse. The clamped video signal is buffered through U33 and applied to the analog input of A/D converter U32 and also to analog mux U24 for raw display.

The analog input to U32 is converted into 8 bit data words at the 10 mHz clock rate of the A/D CLOCK signal and is applied to 8-bit tri-state buffer U54. The outputs of U54 are enabled only during the video window of the circular blanking signal (CIRC BLANK/).

Circular Blanking

U28a and U29a produce a ramping voltage, reset at the CSYNC rate, which is applied through U73a to the input of multiplier U34. Similarly, U29b and U28b produce a ramp, reset at the vertical rate, which is applied through U73b to the input of multiplier U35.

The outputs of U34 and U35 are parabolas which are then applied to the summing node of U36. The result, at the output of U36, is the circular blanking signal (CIRC BLANK/) used to control the size of the video window.

A/D Clock and Data Latches

The AD PIXEL MR signal clears 8-bit flip flop U52. When U52 is enabled, it generates eight separate A/D clock signals. The sequential outputs from U52 convert the digital video data from U32, and the digital blanking data from U72, into the eight 8-bit parallel channels for transfer to the 64-bit video data bus.

Data Bus Interface

Data on the system data bus is buffered through U16 and applied to the internal data bus. Control and clock signals are buffered through U7. The gray scale data is clocked into latch U15 by the GRAY DATA LCH signal. The gray scale address data is clocked into latch U17 by the ADDA CONT LCH. The blanking level data (for the area outside of circular blanking) is clocked into latch U72 by the BLNK LEVEL SET clock signal.

Digital Image Subtraction

D/A DATA 1 processed digital image data is clocked into latches U50, U56 and U70 by the D/A clock signal. D/A DATA 2 is clocked into latches U49, U50, and U68. The two data channels may be subtracted by the ALU U51, U57. The output of the ALU is applied to the left monitor processing channel.

Gray Scale RAMS

Each monitor channel has a dedicated 256 x 8 gray scale RAM: U26, U30 for the left monitor, and U39, U46 for the right. The gray scale RAMs contain a 256-value gray scale table which performs the WINDOW, LEVEL, and NEGATE mapping functions on the digitized video. Gray scale data is addressed by the image data.

Left D/A Channel

The digital output from U26, U30 (gray scale data addressed by image data) is applied to the digital input of D/A converter U25 and clocked by the D/A CLK signal. Delayed composite blanking (DLY C BLNK) is applied to the disable input of U25 which sets the level of the analog output during blanking. The resultant video signal is buffered through U10 which provides a source terminated composite video output.

Right D/A Channel

The digital output from U39, U46 (gray scale data addressed by image data) is applied to the digital input of D/A converter U38 and clocked by the D/A CLK signal. Delayed composite blanking (DLY C BLNK) is applied to the disable input of U38 which sets the level of the analog output during blanking. The resultant video signal is buffered through U8 which provides a source terminated composite video output.

Figure 4-9 - *Block diagram of the AD/DA Converter PCB, A/D circuits.*

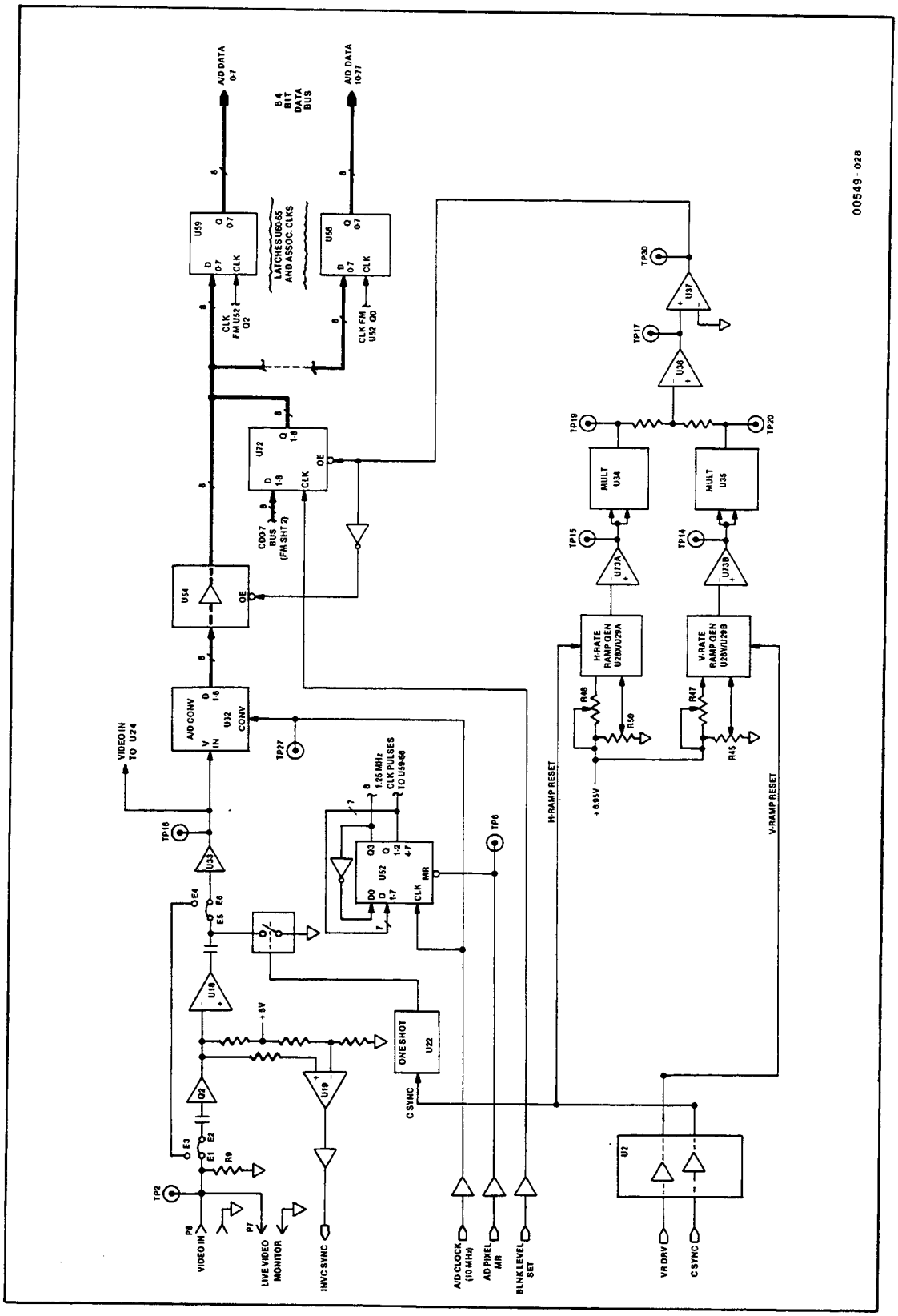
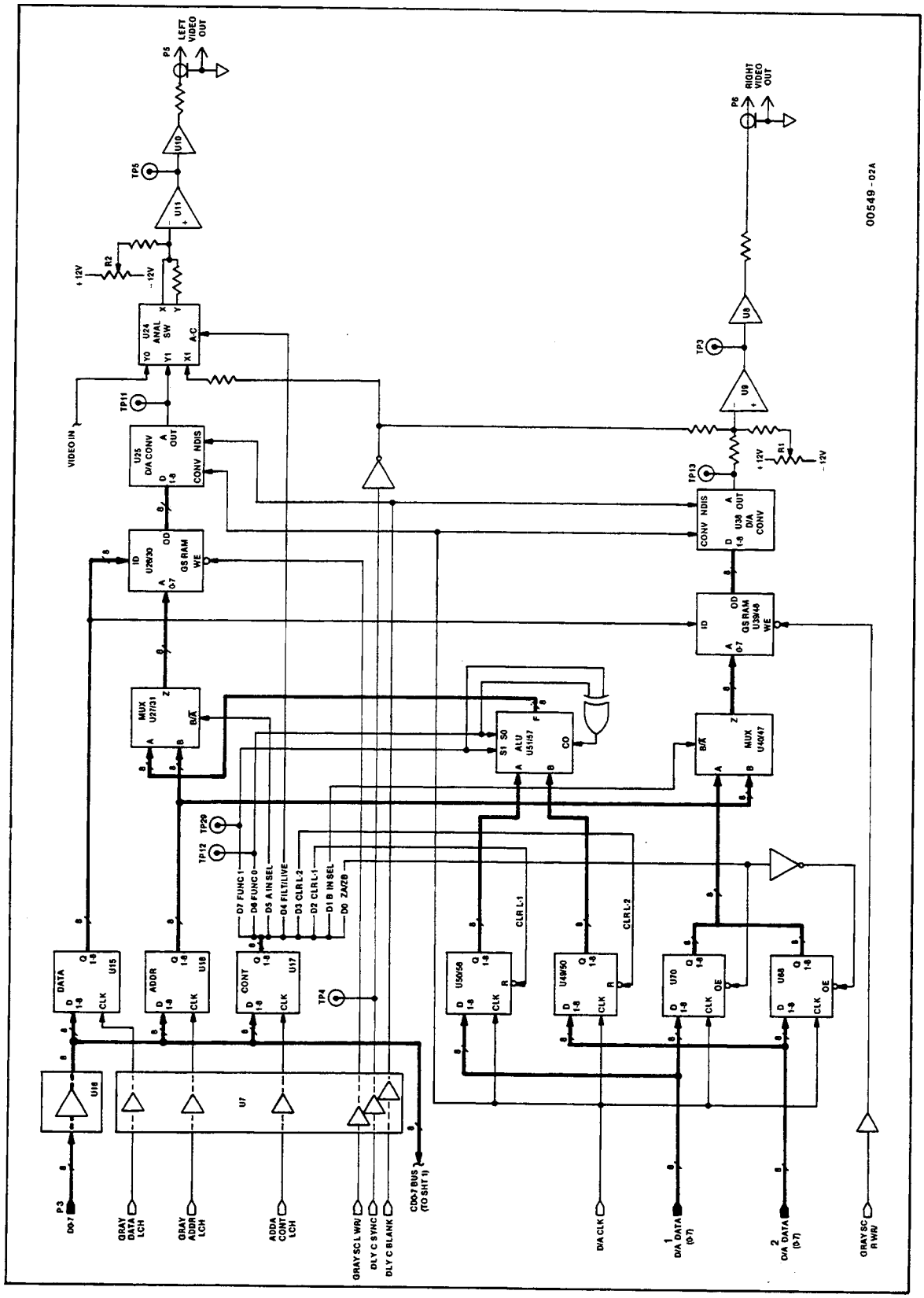


Figure 4-10 - *Block diagram of the AD/DA Converter PCB, D/A circuits.*



4.5.6 Pipeline Filter PCB

Circuit Functions

Refer to Figure 4-11 and Schematic 00-870501.

Referring to the block diagram, the hardware on the Pipeline Filter PCB may be divided into five functional areas:

The Filter Circuit - consists of the adder/subtractors, shifters, and assorted registers and selectors that control the data flow in the top half of the block diagram. The filter is used for averaging, opacification, edge sharpening, motion artifact reduction, and integration. The output of the filter is channeled through a log-table RAM, into either of the frame memories, and out to the AD/DA PCB to be displayed as an image. The log-RAMs are updated during the vertical interval.

The Buffer - consists of the selectors, adder/subtractors, shifters and latches that control the data flow on the lower half of the block diagram. Normally the Buffer simply passes a saved image to the AD/DA PCB to be displayed. However the Buffer can be used for live-digitizing, integration, and single frame subtraction processing.

Memory 1 - holds two frames of data. Incoming data can come from either the filter or the buffer. The memory bus connects with the Disk Interface and Image Processor PCB's. The memory output bus is also connected to the buffer inputs.

Memory 2 - Holds two frames of data. Incoming data can come from either the filter or the buffer. The memory 2 output bus is connected back to the filter circuit inputs.

Control Signals - Control timing and functions of the filter, buffer, and memories.

Pipeline Filter Buses

The following data busses can be identified in the block diagram.

R0 - R7: Filtered, integrated, shifted, or live data that is input to the log-RAMs.

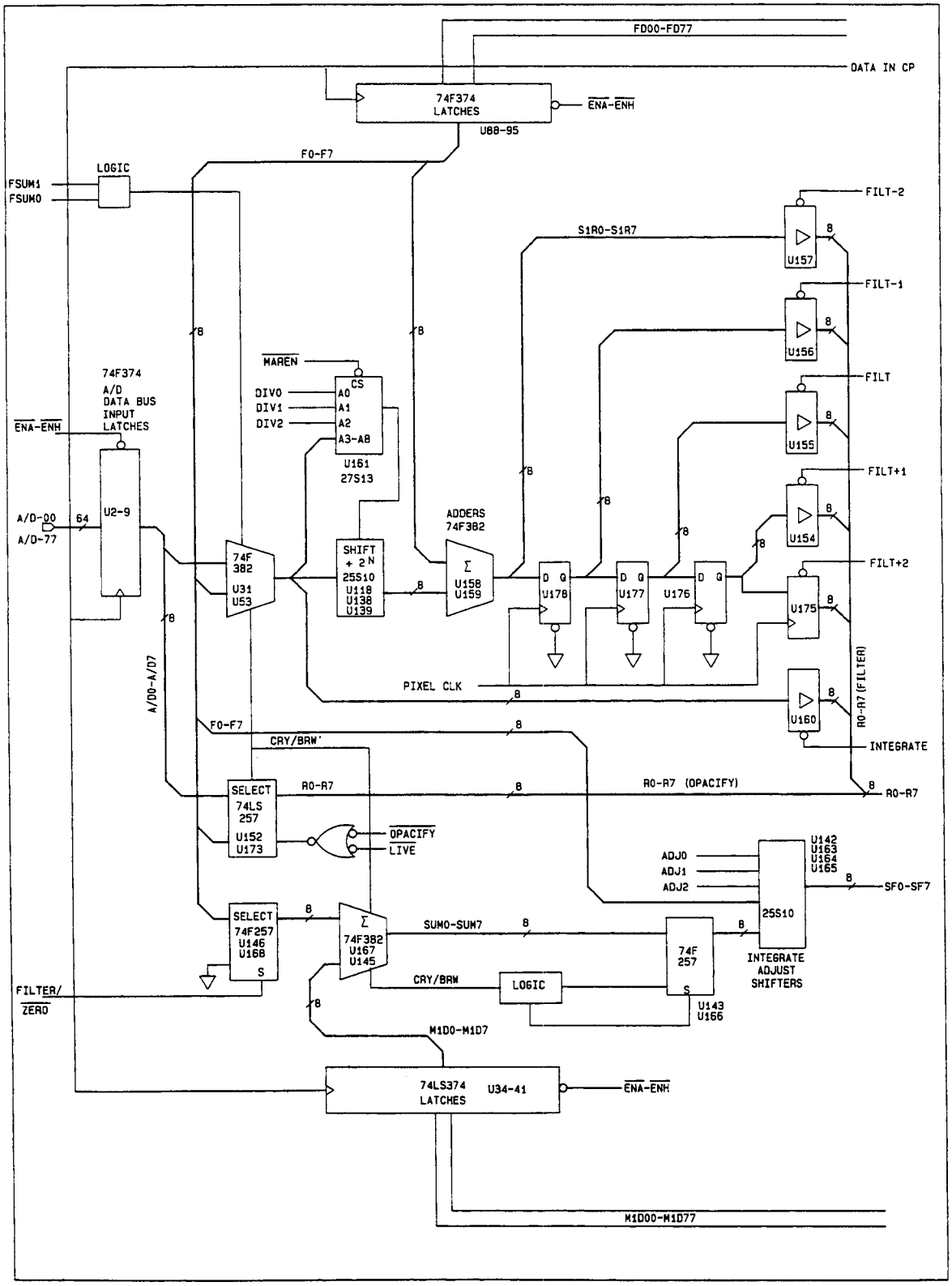
S1R0 - S1R7: The sum of M2 data (F0-F7) and shifted or subtracted A/D data. Used to implement normal averaging.

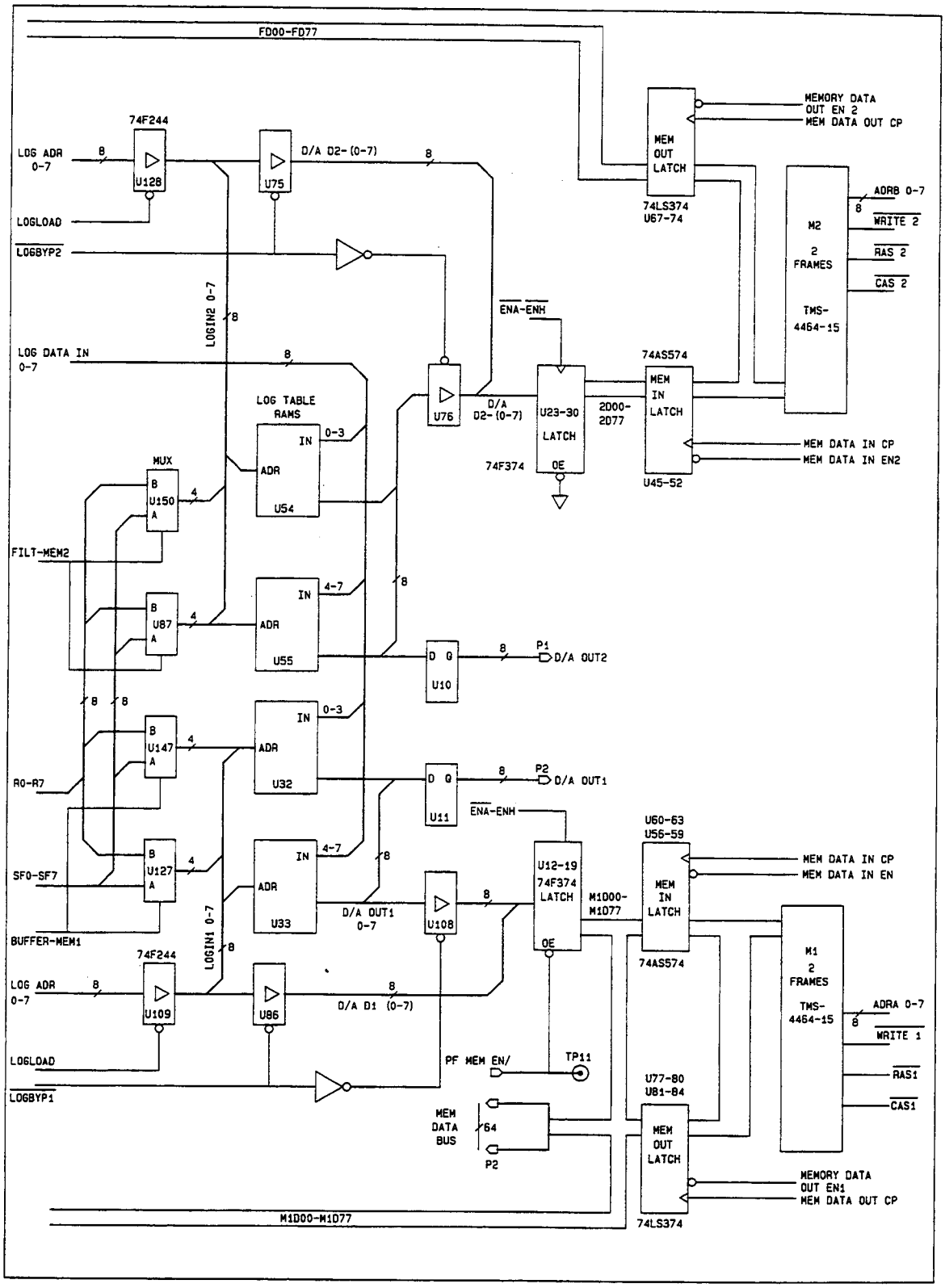
F0 - F7: Data bus from M2, demultiplexed to sequentially transmit the 64-bit bus as eight 8-bit bytes.

SF0 - SF7: Output from integration adjust shifters.

A/D0 - A/D7: Demultiplexed A/D data from AD/DA PCB.

Figure 4-11 - *Block diagram of the Pipeline Filter PCB (two pages).*




FD00-FD77
74F244
LOG ADR 0-7
8
U128
LOGLOAD
LOGBYP2
U75
D/A D2-(0-7)
8
MEM OUT LATCH
74LS374 U67-74
MEMORY DATA OUT EN 2
MEM DATA OUT CP
M2 2 FRAMES TMS-4464-15
ADRB 0-7
8
WRITE 2
RAS 2
CAS 2
LOGIN2 0-7
8
ENA-ENH
LOG DATA IN 0-7
8
LOG TABLE RAMS
U76
D/A D2-(0-7)
U23-30 LATCH
74F374
OE
2D00-2D77
74AS574
MEM IN LATCH
U45-52
MEM DATA IN CP
MEM DATA IN EN2
MUX
B
U150
A
4
IN
ADR
U54
0-3
FILT-MEM2
B
U87
A
4
IN
ADR
U55
4-7
8
D Q
U10
8
P1
D/A OUT2
8
8
B
U147
A
4
IN
ADR
U32
0-3
D Q
U11
8
P2
D/A OUT1
R0-R7
ENA-ENH
B
U127
A
4
IN
ADR
U33
4-7
8
D/A OUT1 0-7
U108
8
U12-19 74F374 LATCH
OE
M1D00-M1D77
U60-63
U56-59
MEM IN LATCH
74AS574
MEM DATA IN CP
MEM DATA IN EN
SF0-SF7
BUFFER-MEM1
LOGIN1 0-7
8
74F244
LOG ADR 0-7
8
U109
U86
8
D/A D1 (0-7)
M1 2 FRAMES TMS-4464-15
ADRA 0-7
8
WRITE 1
RAS1
CAS1
LOGLOAD
LOGBYP1
PF MEM EN/
TP11
U77-80
U81-84
MEM OUT LATCH
74LS374
MEM DATA BUS
64
P2
MEMORY DATA OUT EN1
MEM DATA OUT CP
M1D00-M1D77

M1D0 - M1D7: Data bus from M1. demultiplexed to sequentially transmit the 64-bit bus as eight 8-bit bytes.

D/A D1-0 - D/A D1-7: Output from log-RAMs or output obtained bypassing log-RAMS. Will be multiplexed onto 64-bit M1 data bus.

D/A D2-0 - D/A D2-7: Output from log-RAMs or output obtained bypassing log-RAMS. Will be multiplexed onto 64-bit M1 data bus.

Overall Operation

The Pipeline Filter latches a 64-bit wide data path (A/D00-A/D77) originating from the AD/DA PCB. This is read from the latches in 8-bit wide pixel bytes to be processed sequentially, as if on a pipeline. The 64-bit words are clocked into latches U2 through U9 by DATA IN CP. 8-bit pixel bytes are enabled onto the internal A/D0-A/D7 bus by ENA - ENH.

Data transfers between the 8-bit and 64- bit buses are controlled throughout the board by the DATA IN CP and the eight enable signals: ENA-ENH. ENA-ENH are derived from the pixel clock and the DATA IN CP by counter U153 and mux U1.

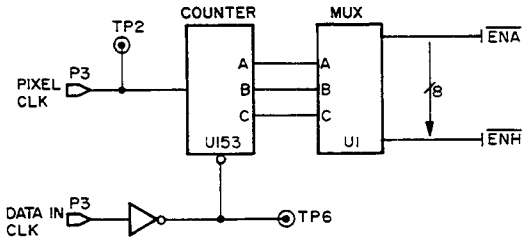
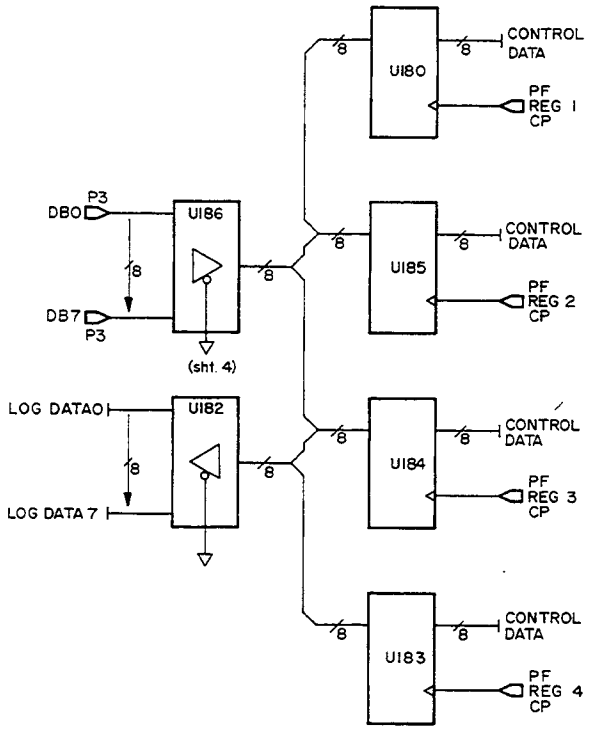


Figure 4-12 - *Decoding the eight enable signals, ENA-ENH.*

Processing command words are received from the Image Processor PCB via the daisy chained ribbon cable at P3. These are addressed to four control data registers PF REG 1-4. Log Data LOG DATA 0-7 (for the Gamma function) is also received from the Image Processor PCB and loaded into the log-RAMS.

Figure 4-13 - *The four control data registers, PF REG 1- PF REG 4.*



Memory control signals, the pixel clock, and DATA IN CP are generated on the Image Processor PCB. They are transmitted to the Filter PCB via P3, the daisy-chain ribbon cable connector.

After processing, the data is again clocked onto a 64 bit wide bus before being stored in memory or placed on the system image-data bus.

But the pixel data is passed in 8-bit bytes to the AD/DA via P1 (D/A OUT2) and P2 (D/A OUT1).

Memory consists of dynamic RAM TMS-4464 (4-bit x 64 k), in two separate banks of 16 each. ADRA0-ADRA7 is multiplexed with the RAS and CAS signals to address memory 1. ADRB0-ADRB7 is multiplexed with RAS and CAS to address memory 2.

Figure 4-14 - *Addressing memories 1 and 2.*

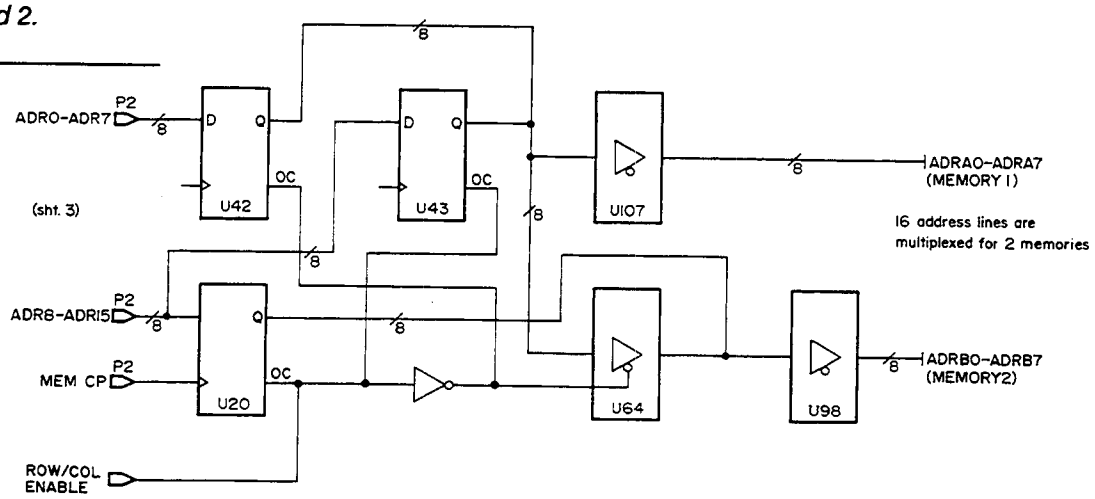


Image Processing Functions

Under software control the image data is routed through the circuits described above to provide the following:

Live Digitized Output — A/D0-A/D7 is selected by U152/U173. The pixel data is passed to the log RAMs for application of any selected gamma function, and then is output at P1, D/A OUT 2.

Stored Image Output from M1 and M2 — Memory contents are routed via the internal buses through the log RAMs. Memory 1 appears on D/A OUT1, Memory 2 appears on D/A OUT1.

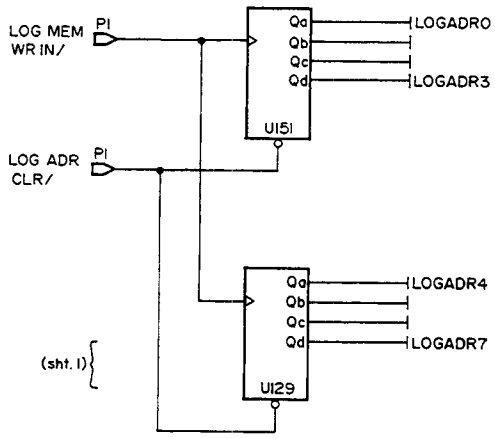
Frame Averaging — An algorithm is performed in which incoming pixel data is combined with the running average for that pixel. The subtraction algorithm D-M(t)/N + M(t) is performed as follows, where D= D/A data, M(t) = old memory value, M(t+1) is the new memory value, and N is the number of frames averaged.

Memory Swap — Image transfer between memories, M1 to M2 or M2 to M1, bypasses the log RAMs. The bypass control lines LOGBYP2 and LOGBYP1 are active. LOGBYP2 enables U75 to buffer the data onto the D/A D2 bus where it is latched onto the 64-bit bus 2D00-2D77 and into M2. LOGBYP1 enables U86 to buffer the data onto D/A D1 where it is latched onto the 64-bit bus M1D00-M1D77.

Gamma — The log RAMS on the Pipeline Filter PCB are loaded with a table from the Image Processor PCB according to which the image pixel values are mapped to an exponential gray scale.

LOG ADR 0-7 are generated by address counters U151 and U129.

Figure 4-15 - *Log RAM address counters.*



Motion Artifact Reduction

When the difference between the incoming and previous images is large, there is an adjustment of the averaging algorithm divisor. MARS is enabled by setting MAREN/ low.

Opacification

The incoming pixel value is compared against the previous value for that pixel in the image. The darker value of the two is kept. When (AD0-AD7) is greater than (F0-F7), summer U31,U53 generates a carry/borrow signal. This selects the source of the pixel placed on the R0-R7 bus by selector U152, U173.

Integration

Allows an average to be computed over a predetermined number of image frames. Result of addition step is a 16-bit word, overflow occurs into the upper eight bits. Last step is a division performed by right justifying into the upper byte.

Single Frame Subtraction

This subtraction is performed on the Pipeline Filter PCB alone. M2-M1 or M1-M2. Subtraction from both memories occurs a byte at a time by Adders U145 and U167. The result is placed on the SUM0-SUM7 bus and routed back into memory.

Edge Enhancement

This requires executing an algorithm which shifts the image a certain number of pixels in the X axis and a number of lines in the Y axis, and adds the original pixels with those at the shifted position. The Y shift is determined by changing the beginning storage address generated by the address counters on the Image Processor PCB. The X shift is produced with delay flip flops (U175-U178). which are selected by the FILT/ controls. FILT select lines are generated by 3 to 8 line decoder U179 which multiplexes control data latched from the Image Processor DB 0-7 control bus.

4.5.7 TV Monitors

The two TV monitors are designed especially for medical diagnostic applications. These provide:

* 75 ohm terminated input impedance
* RS170 standard negative sync
* Composite input video range of 0.3 to 2.5 volts p-p;
* Bandwidth in excess of 15 MHz at -3 dB
* Full genlock synchronization (vertical and horizontal).

4.5.8 Remote Contrast/Brightness Control PCB

Refer to Schematic 00-870928.

This PCB is located below the left monitor and allows the left monitor to be adjusted from either the mainframe or the monitor cart.

4.6 Image Storage

4.6.1 Hard Disk (Winchester Drive)

The hard disk unit contains space for storage of up to 60 images in digital format which can be recalled and displayed at a later time for further review. In addition, interfaces are provided for non-digital storage of images on video tape recorder or video disk.

The hard disk has a storage capacity of 20 megabytes, 15 megabytes of which are dedicated to image storage. The remaining 5 megabytes serve as program storage.

4.6.2 Video Tape Recorder (VTR)

The VTR may be used to store real time images on magnetic tape. The storage format is not digital. Successive video frames at a rate of 30 per second can be continuously recorded for up to one hour on a single cassette. Single frames cannot be randomly accessed. The tape counter offers an approximation of frame location and must be referenced against an external log of image contents.

4.6.3 AngioStor Video Disk Recorder

The AngioStor Video Disk Recorder may be used to store real-time images in a non-digital format. Up to 600 frames may be stored and later played back at rates of 30, 15, 6 and 4.5 frames per second.

4.6.4 Multi-Format Camera

The multi-format camera is provided with the same video signals which are displayed on the monitors. These signals are displayed on an internal monitor screen which is photographed. The format and number of images which are placed on the photographic film vary depending upon the camera model.

SECTION 6
MONITOR CART PARTS, DISASSEMBLY AND REPLACEMENT

The information in this section will help you identify, disassemble and replace parts on the monitor cart. Section 6.2 contains assembly and disassembly instructions. Section 6.3 provides an illustrated parts list.

6.1 Safety

It is very important that you read and understand the emergency and safety procedures described in the Safety Section of the service manual.

WARNING: **Circuits inside the equipment use voltages which are capable of causing serious injury or death from electrical shock. To avoid this hazard always unplug the AC power cable before opening, removing, or replacing equipment covers or doors.**

There are no procedures in this section of the manual which should be attempted by anyone other than a properly trained service technician.

6.2 Monitor Cart Assembly/Disassembly

6.2.1 Removing the Access Panels

Refer to Figures 6-1 through 6-3.

The electronics of the monitor cart are accessed by removing sectional panels and covers.

Generally, all these panels attach in the same manner: interlocking tabs are attached to the frame along one edge, and the panel is secured with screws along the opposite edge.

6.2.1.1. Front Panel Removal for Access to Card Rack

Refer to Figure 6-1.

1. Remove two screws from the bottom of the panel and tilt the bottom edge of the panel out slightly.
2. Lift up on the panel to clear the tabs along the top edge and remove the panel.

6.2.1.2 Right Front Panel Removal for Access to Monitor Power Supply

Refer to Figure 6-1.

1. Remove two screws from the bottom of the panel.
2. Lift the panel up slightly, and then off.

6.2.1.3 Rear Panel Removal

Refer to Figure 6-2.

Removing the rear panel allows access to the Isolation Transformer T1 and the rear of the card cage.

1. Remove the seven screws along the bottom and sides of the rear panel.
2. There are no locking tabs, the panel can be simply lifted off.

6.2.1.4 Left Side Panel Removal for Access to Disk Interface and Video Switching PCB'S

Refer to Figure 6-3.

1. Remove the front panel.
2. Remove the two screws inside the left front cart frame.
3. Slide the panel toward the rear of the cart about 1 inch to clear the tabs.
4. Lift off the side panel.

6.2.2 Replacing the Air Filter

1. Face the front of the monitor cart and locate the air filter underneath the cart cooling fans.
2. Pull the air filter straight out.
3. Replace the air filter when it has become dirty enough to impair the flow of air through the fans.

Figure 6-1 - *Monitor cart covers, front view.*

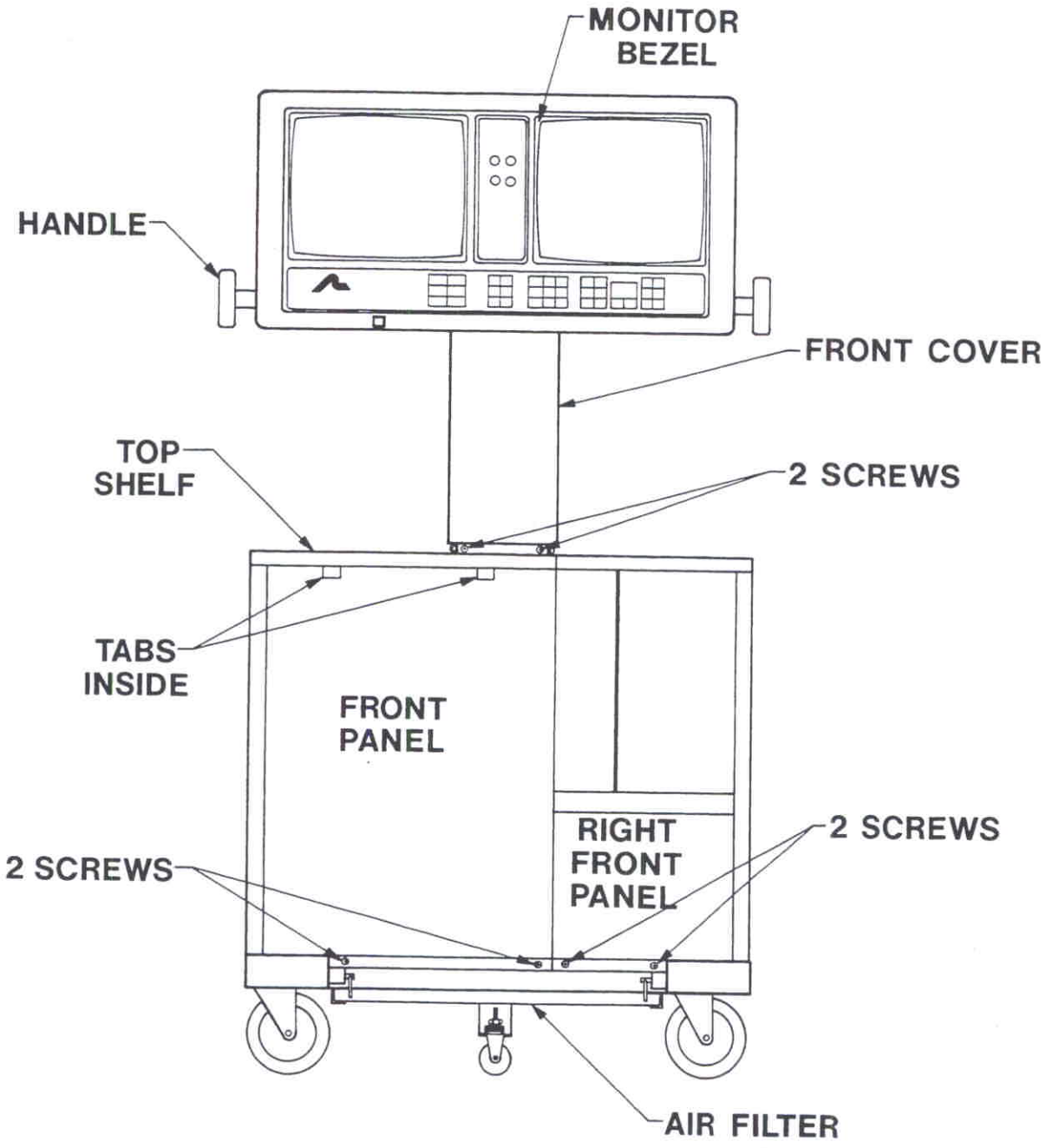


Figure 6-2 - *Monitor cart covers, rear view.*

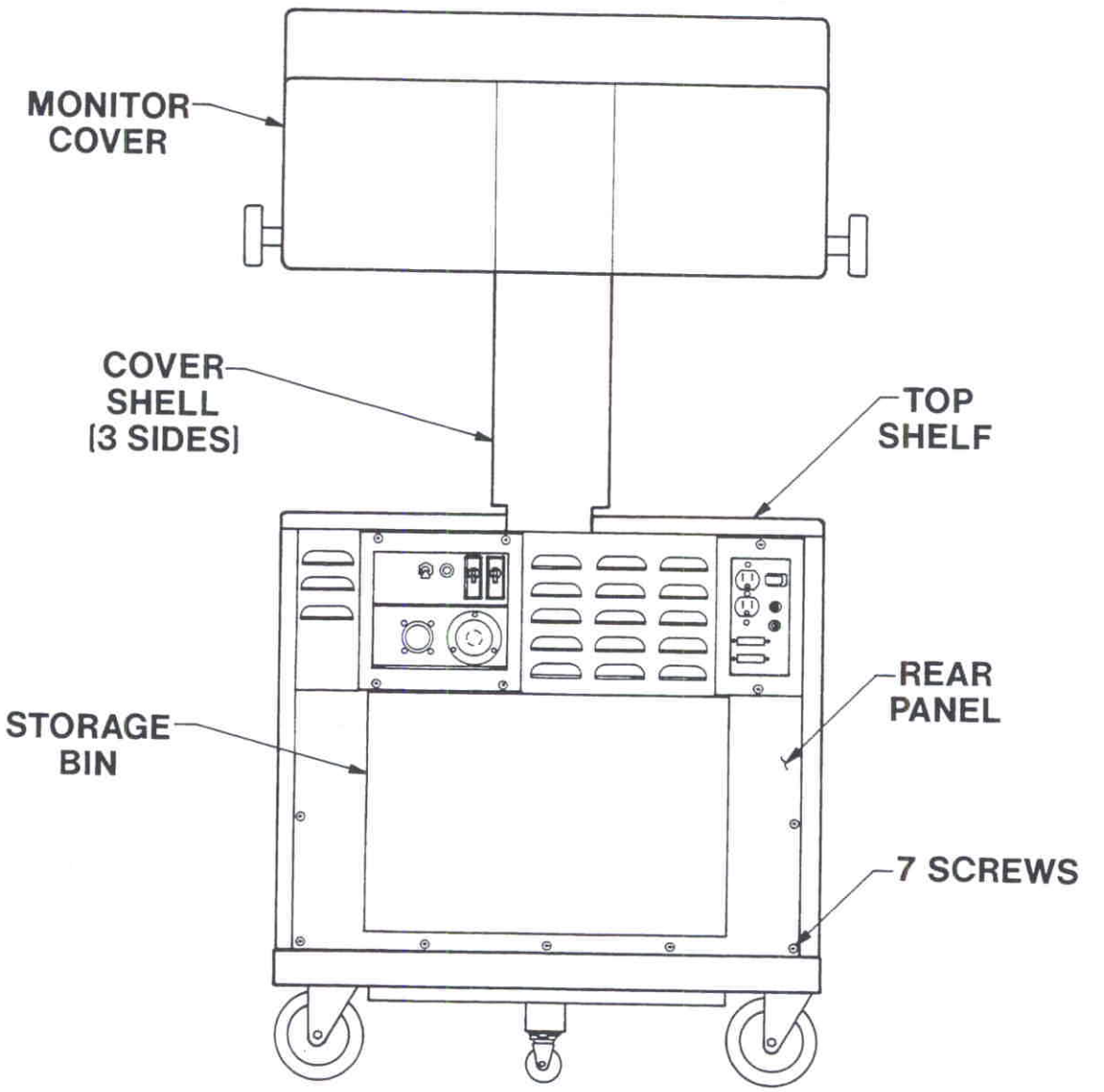
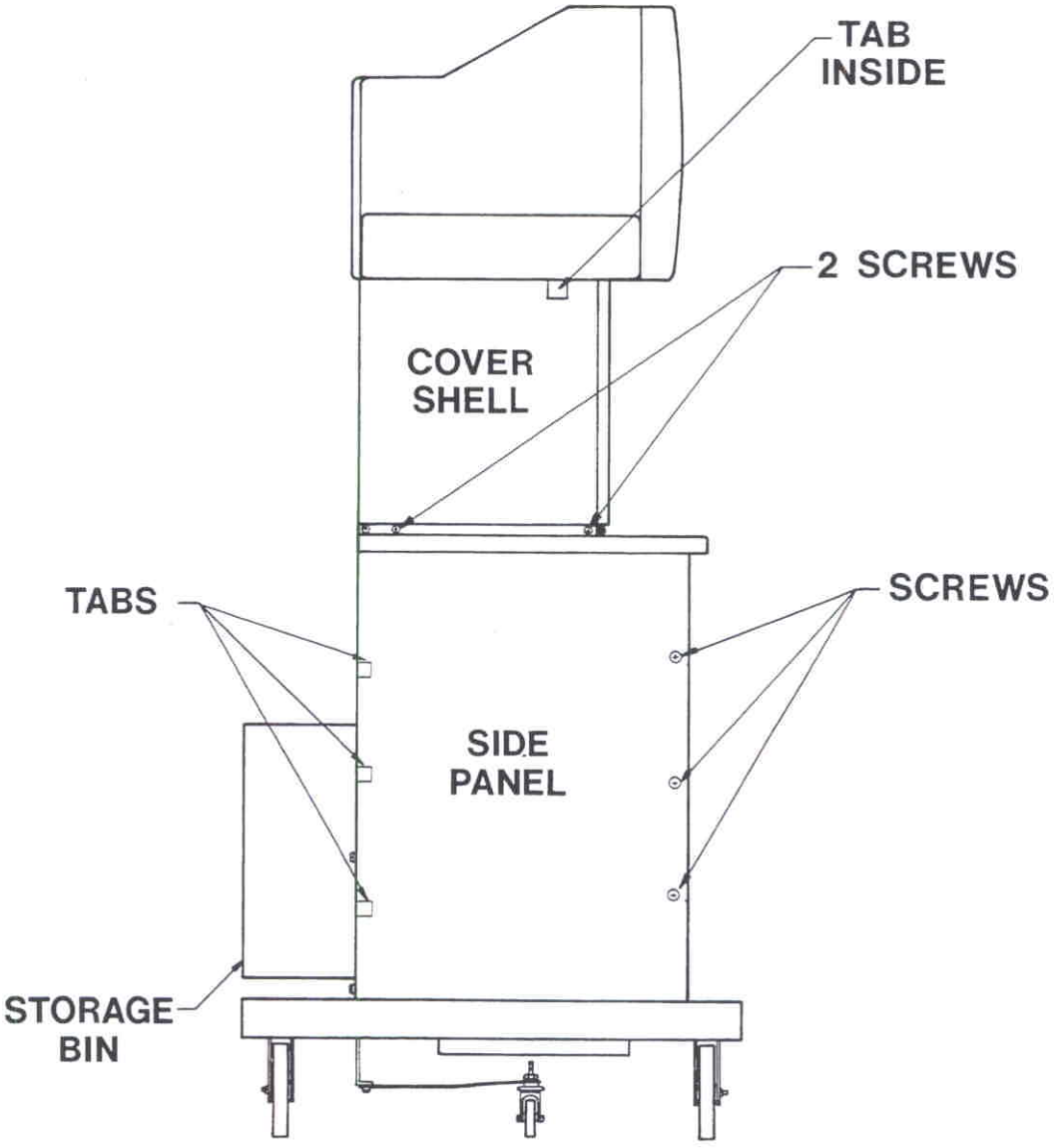


Figure 6-3 - *Monitor cart covers, side view.*



6.2.3 Removing the Monitor Covers

Refer to Figure 6-4.

1. Remove the four screws and grillwork from the bottom of each monitor.
2. Remove the two screws from the rear inside corners of the monitor cover.
3. Remove the two screws from the front inside corners of the monitor cover.
4. Lift the front edge of the cover up about 1/16 inch, to avoid trapping the cover tab on the monitor base.
5. Slide the cover back from the monitors and lift it away.

6.2.4 Removing the Monitors

Refer to Figures 6-5 and 6-6.

1. Remove the monitor cover as described in procedure 6.2.2 above.

WARNING: Observe the high voltage and implosion hazard warnings for handling CRTs.

2. Disconnect the brightness and contrast control connectors and the 2-pin Molex video connector going to the circuit board mounted on the monitor.
3. Disconnect the 3-pin Molex power connector.
4. Remove the nylon tie wraps as needed to free the disconnected wiring from the monitor frame.
5. Remove 3 screws on each side of the monitor base (6 screws total).
6. Carefully remove the monitor.
7. When replacing a monitor make sure that the front of the tube is firmly seated forward against the bezel. The monitor can be positioned with the screws on the monitor base brackets.

Figure 6-4 - *The attachment points for the monitor cover and grillwork are shown in this photo. With the grillwork removed, the Front Panel Processor PCB and the Remote Contrast/Brightness PCB are visible on their mounting plates.*

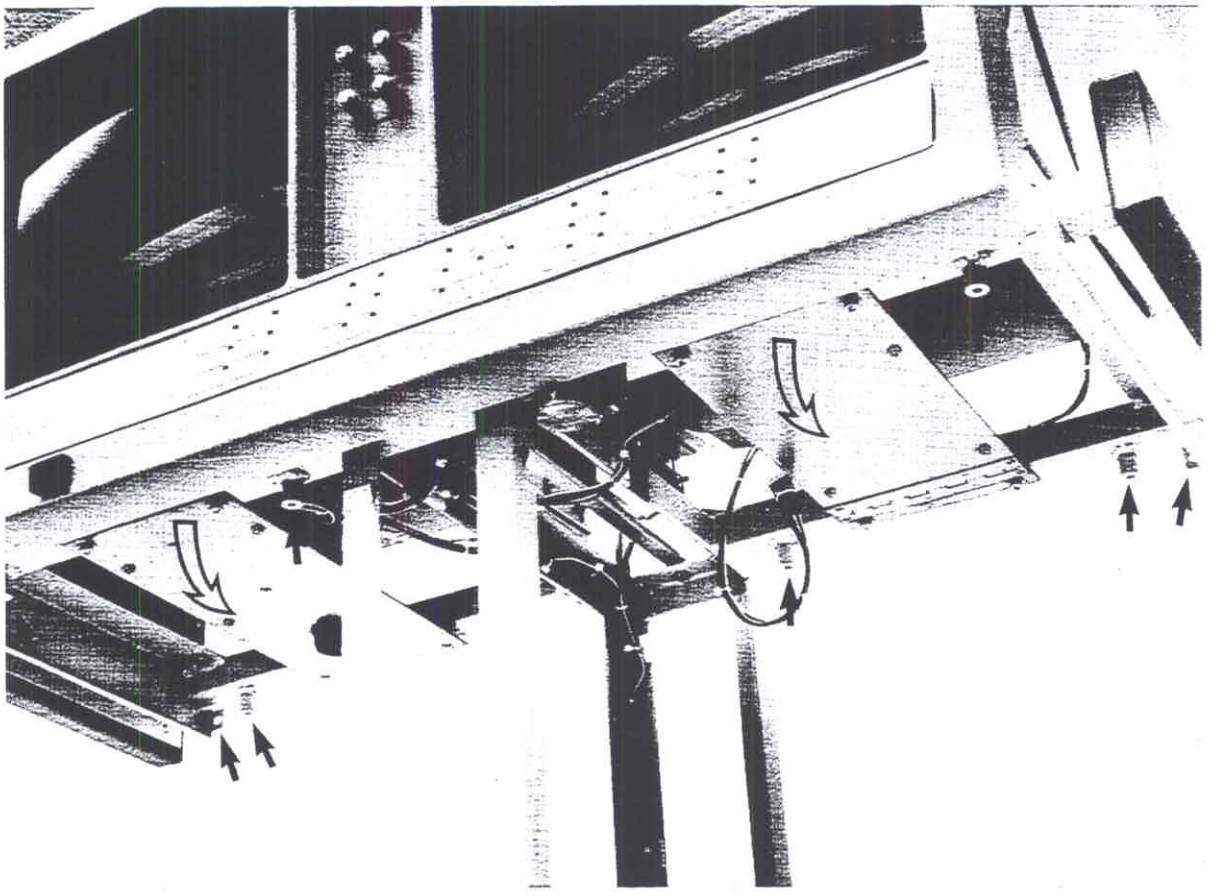


Figure 6-5 - *Remove the six screws holding each monitor as indicated in these photos.*

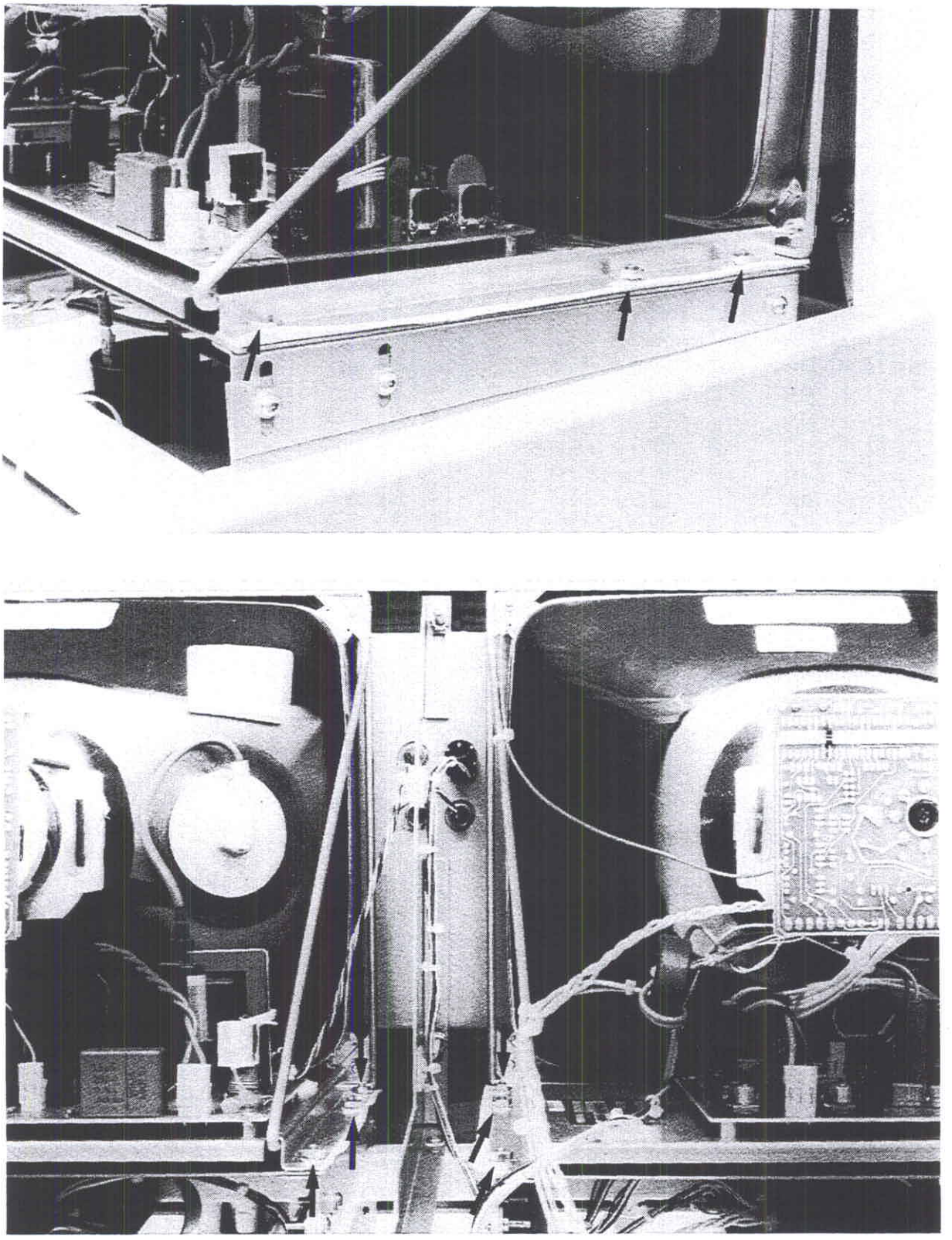
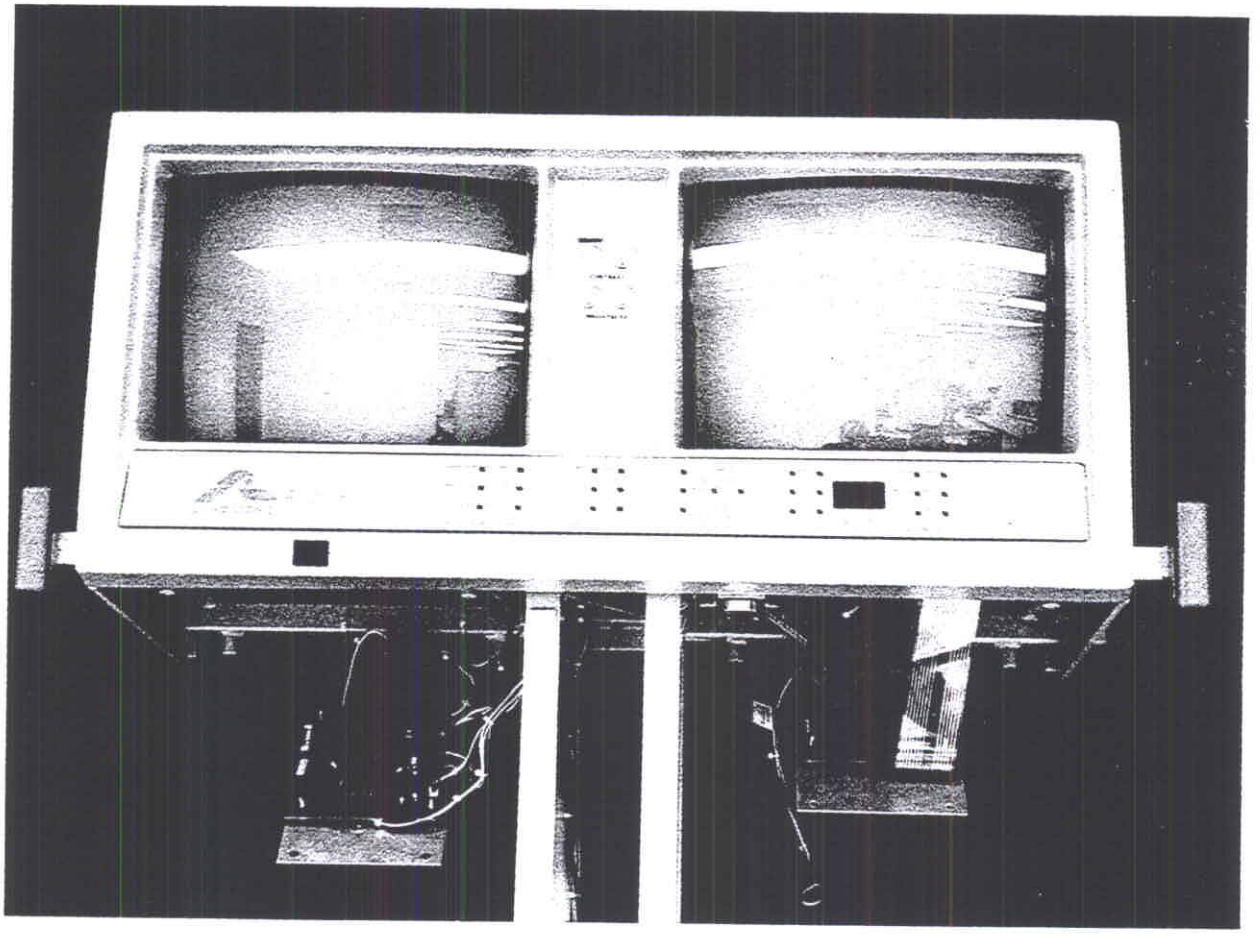


Figure 6-6 - *The panels below each monitor drop down to expose the Front Panel Processor PCB and the Remote Contrast/Brightness Control PCB.*

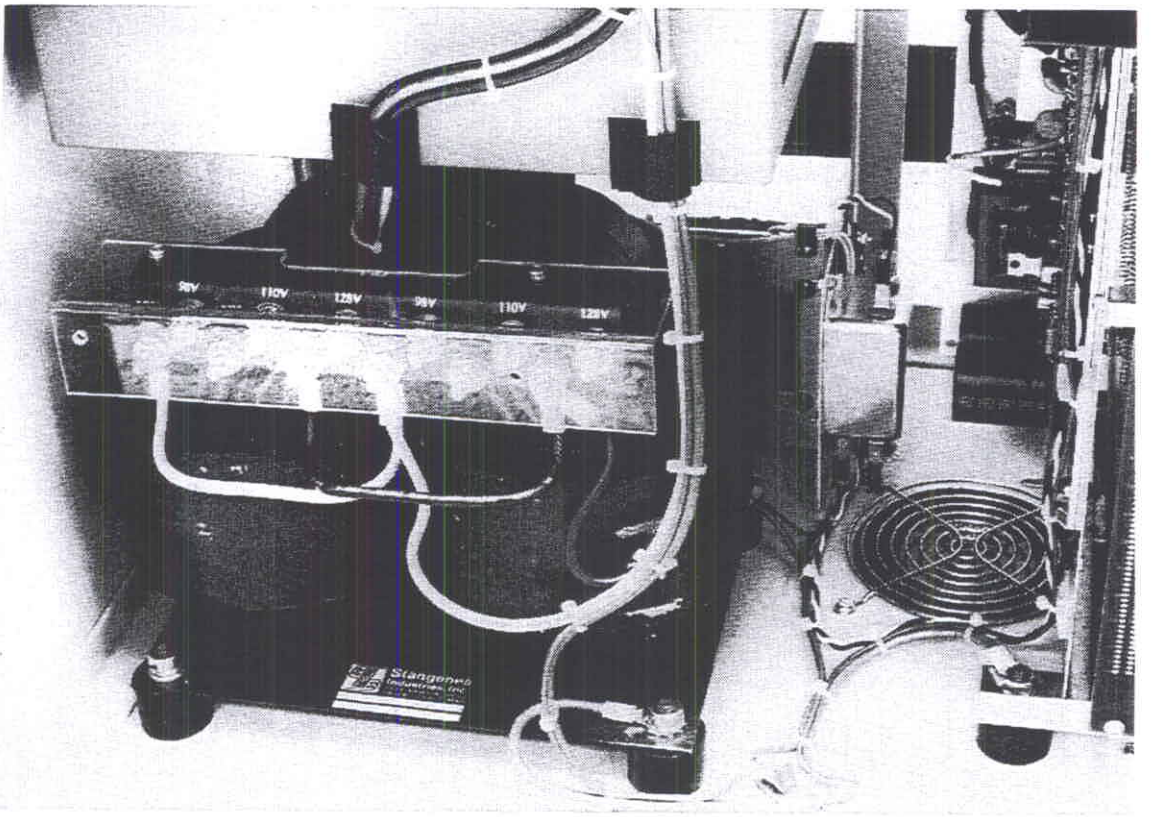


6.2.5 Removing the Isolation Transformer

Refer to Figure 6-7.

1. Unplug the main power cable from the wall outlet.
2. Remove the rear access panel.
3. Label all wires before removing them from the transformer. Disconnect the wires from the isolation transformer terminals.
4. Remove the four nuts securing the transformer to the shock mounts in the base of the cart.
5. Lift the transformer off the shock mounts and out of the cart. The transformer is heavy - lift it carefully.

Figure 6-7 - *Removing the isolation transformer.*



6.2.6 Access to the Front Panel Processor PCB

Refer to Figure 6-6.

1. Remove the grillwork below the right monitor.
2. Locate the Front Panel Processor PCB on the hinged panel under the monitor. Remove the 2 screws and swing the panel and PCB assembly down on its hinge.
3. Use care not to strain the cables and their connectors which are plugged into the PCB.

6.2.7 Access to the Remote Contrast/Brightness PCB

Refer to Figure 6-6.

1. Remove the grillwork below the left monitor.
2. Locate the PCB on the hinged panel below the monitor. Remove the two screws and swing the panel down on its hinge.
3. Use care not to strain the cables and their connectors which are plugged into the PCB.

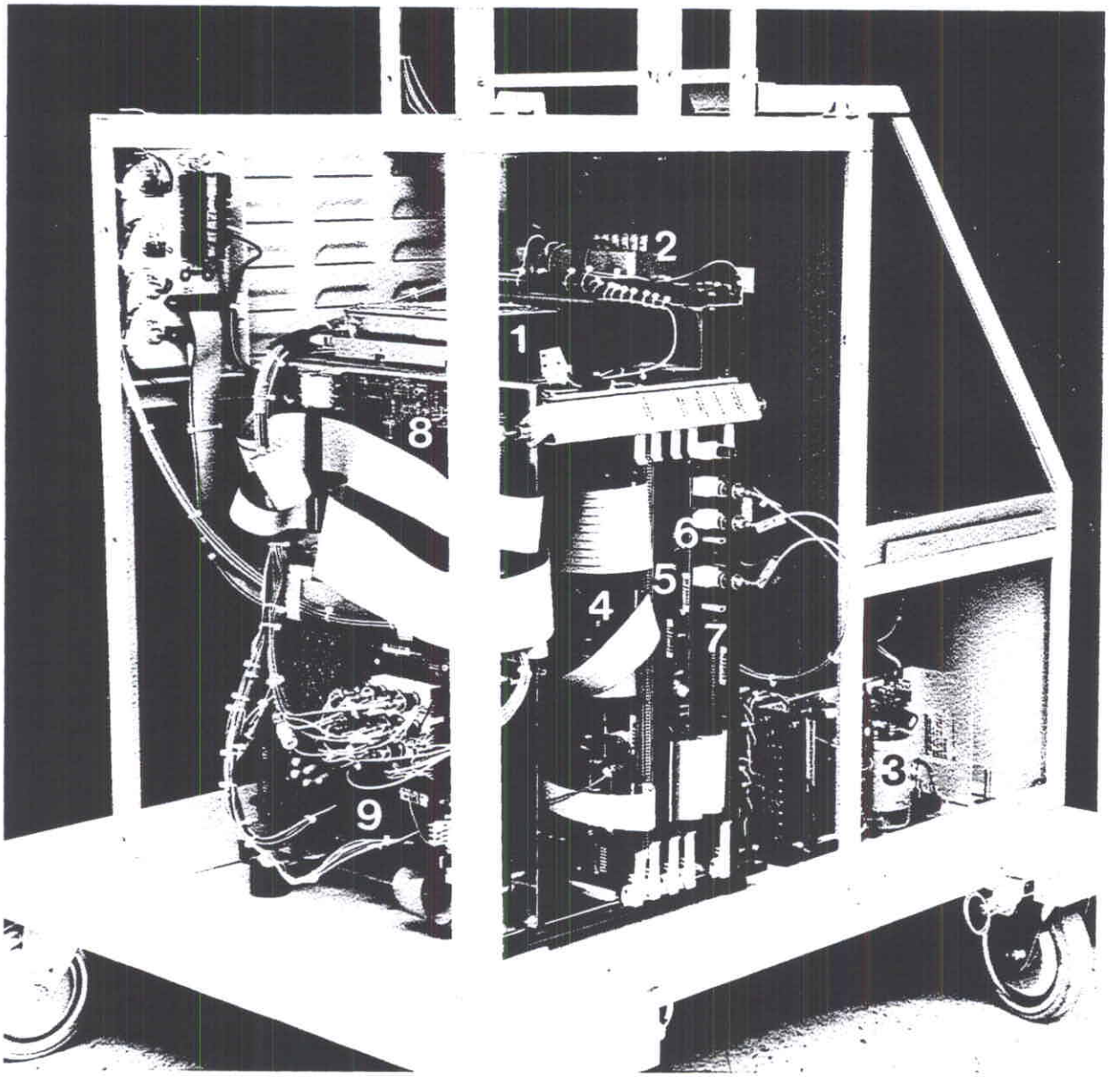
6.2.8 Removing the Card Rack Power Supply

Refer to Figure 6-8.

1. Remove all wiring from their push on connections at the terminal strip on the bottom of the power supply.
2. Remove the circuit boards from the card rack.
3. Reach inside the card rack and remove the 2 screws securing the lower end of the power supply.
4. Remove the screws securing the hard disk drive on the top of the card rack and shift it to the side to access the two screws holding the top of the power supply. It is not necessary to disconnect the cables to the disk drive.

Figure 6-8 - *The components in the base of the monitor cart are identified in this photo.*

1- Hard disk, 2- card rack power supply, 3- monitor power supply, 4- Disk Interface PCB, 5- Pipeline Filter PCB, 6-Image Processor PCB, 7- AD/DA PCB, 8- Disk Controller PCB, 9- IO Distribution/ Video Switch PCB



6.2.9 Removing the Hard Disk Drive

Refer to Figure 6-8.

1. Disconnect the two ribbon cables and the power cable connection to the hard disk drive.

   (Note that different drives may be mounted with the connectors to the front or the rear). *If the connectors are inaccessible, then perform the following removal steps 2 and 3 and then turn the drive to access the connectors.*

2. Remove the circuit boards from the card rack.

3. Reach up from inside the card rack and remove the four screws securing the Hard Disk Drive to the top of the rack.

4. Remove the drive.

6.2.10 Removing PCBs From the Card Rack

Refer to Figure 6-8.

1. Remove the front access panel.

2. Loosen the knurled screws at each end of the retaining bar, and swing it up on its hinge.

3. Remove the ribbon cables from their their front edge connections. Be sure they are adequately labeled for later reconnection.

4. Pull out on the card ejectors to disengage the PCBs from their rear edge connectors on the motherboard.

6.2.11 Installing PCBs in the Card Rack

Refer to Figure 6-8.

The PCBs which slide into the card rack slots are from left to right:

Disk Controller PCB
Extender Board
Pipeline Filter PCB
Image Processor PCB
AD/DA PCB

1. Make sure that the rear edge connectors are clean and bright. Clean with a soft eraser and a cloth with solvent.

2. Line up each PCB with the top and bottom card edge guides and slide the cards into the rack until the rear edge connectors engage the motherboard.

3. Press firmly on the card ejectors until the PCB is fully seated in both rear edge connectors on the motherboard.

4. Reconnect all ribbon cables. Be sure that pin 1 of each ribbon cable connector matches up with pin 1 of each PCB connector.

   Connect the short, multiconnector daisy-chain cable to the P-3 connectors of the Image Processor, Pipeline Filter, and AD/DA PCBs.

   Attach the ribbon cables to P-9, P-10, P-11 and P-12 on the Disk Interface PCB.

   Attach the coaxial cables to J-5, J-6 and J-8 on the AD/DA PCB.

5. Swing down the PCB retaining bar and lock it in place by tightening the knurled screws.

6.2.12 Removal of the I/O Distribution-Video Switching PCB

Refer to Figure 6-8 and Figure 6-9.

The I/O Distribution-Video Switching PCB is mounted on standoffs attached to the left side of the card rack.

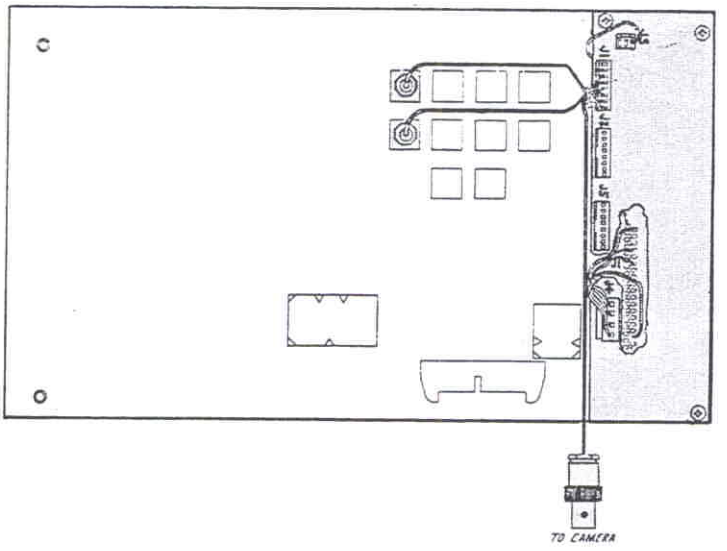
1. Remove the front and the left side access panels.

2. Remove the PCBs from the card rack as required to reach the screws which secure the I/O Distribution-Video Switching PCB standoffs.

3. Disconnect all BNC, ribbon, and power cables from the PCB. *Refer to Figure 6-9 for connector replacement.*

4. Remove the screws securing the PCB standoffs to the card rack and remove the PCB.

Figure 6-9 - *I/O Distribution Video Switch PCB connections are shown below; detail on right shows connections to the Sync Separator PCB*



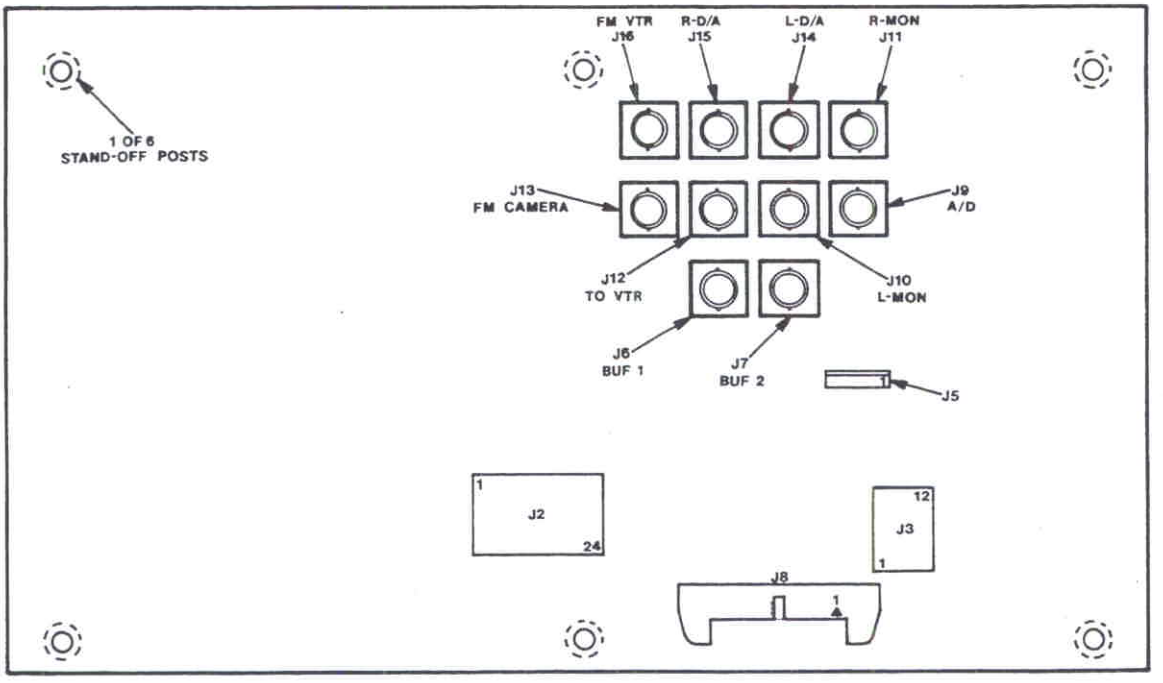
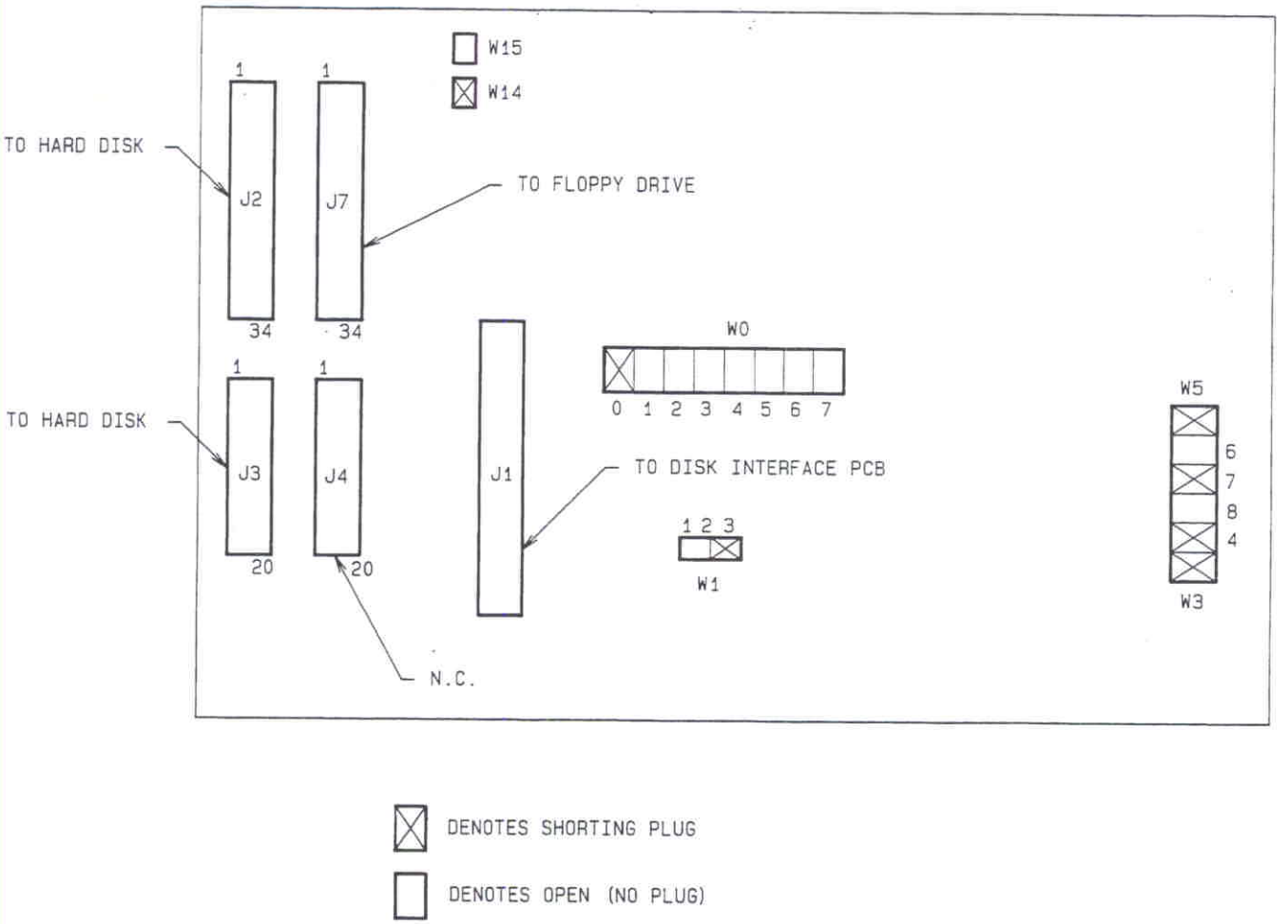


Figure 6-10 - *The connector placement on the Disk Controller PCB is shown in this drawing.*



6.2.13 Sync Separator (AngioStor Interface) PCB

Refer to Schematic 00-870543, and Figures 6-8 and 6-9.

On systems equiped with the AngioStor Disk Recorder, an interface PCB is mounted piggyback on the I/O Distribution PCB. The connections between the Interface PCB and the I/O Video Switch PCB are as follows:

I/O Dist Video Switch PCB	AngioStor Interface PCB
J1-19	J3-1
J1-21	J4-1
J1-34	J4-2
J1-32	J4-3
J1-37	J4-4
J16	J1-3, J1-4
J-13	J1-5, J1-6

6.2.14 Removal of the Disk Controller PCB

Refer to Figure 6-10.

1. Remove the left side panel to access the PCB.
2. Disconnect all connections to the PCB. *Refer to Figure 6-10 for connector placement.*
3. Remove the 4 sets of screws and insulating washers. Each screw is insulated from the PCB with nylon washers on both sides of the board. *When the board is reinstalled be sure that these insulating washers are in place.*

6.3 Illustrated Parts List

The major replacable assemblies are illustrated on the following pages.

Part numbers are subject to change. Contact Technical Support for assistance with part interchangeability.

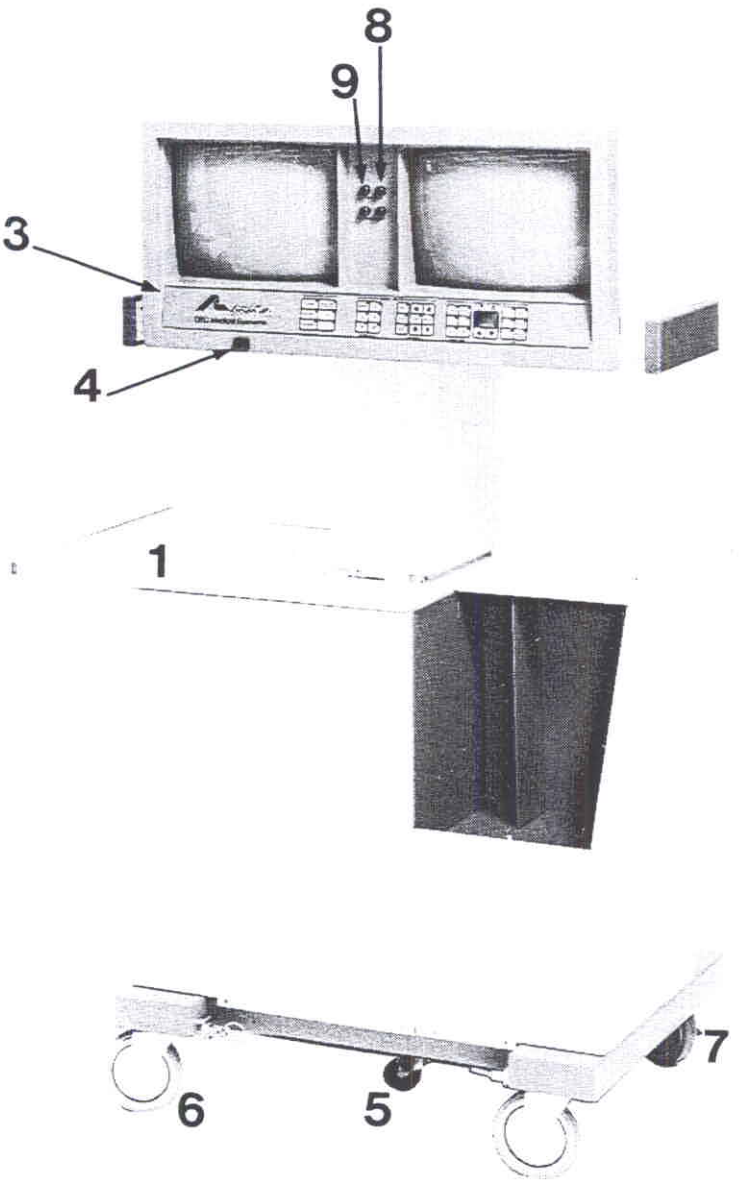
Fig. 1 Monitor Cart

1.	shelf, accessory, monitor cart	00-870523
2. *	shelf, accessory, RH, monitor cart	00-870541
3.	front panel assembly	00-870398
	membrane switch panel sub-asm	00-870397
	LED PCB display	00-870394
	display, 7-segment LED	67-480626
	lamp, red LED, MV5753	67-499845
4.	indicator, rectangular	71-229509
	cap, lens, red	00-870739
	lamp, 6.3VDC	71-229506
5.	conductive caster asm	00-860092
6.	casters, front	10-08-390
7.	casters, rear w/ brakes	10-08-391
8.	knobs 1/8-inch shaft	23-519934
9.	knobs 1/4-inch shaft (remote)	23-519931

Overall View

* Item 2 is not shown in this photo.

Monitor Cart



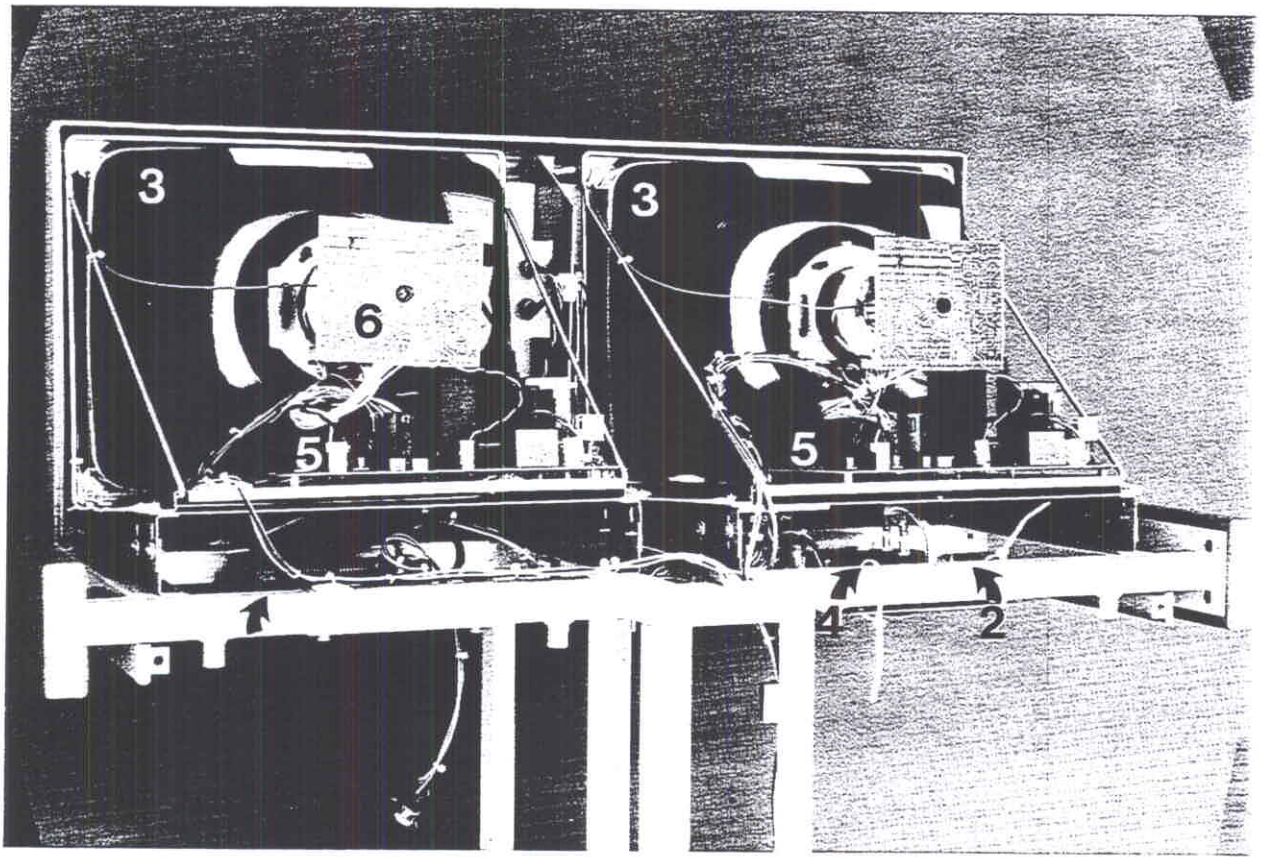
Overall View **Fig. 1**

Fig. 2 Monitor Cart

1.	Front Panel Processor PCB	00-870509
2.	Remote Contrast Brightness Control PCB	00-870930
3.	TV monitor	00-860364
4.	audio alarm	76-829967
5.	Dataray Video Procesor PCB	00-900036
6.	Dataray Deflection PCB	00-900035

Rear Exposed Monitor View

Monitor Cart



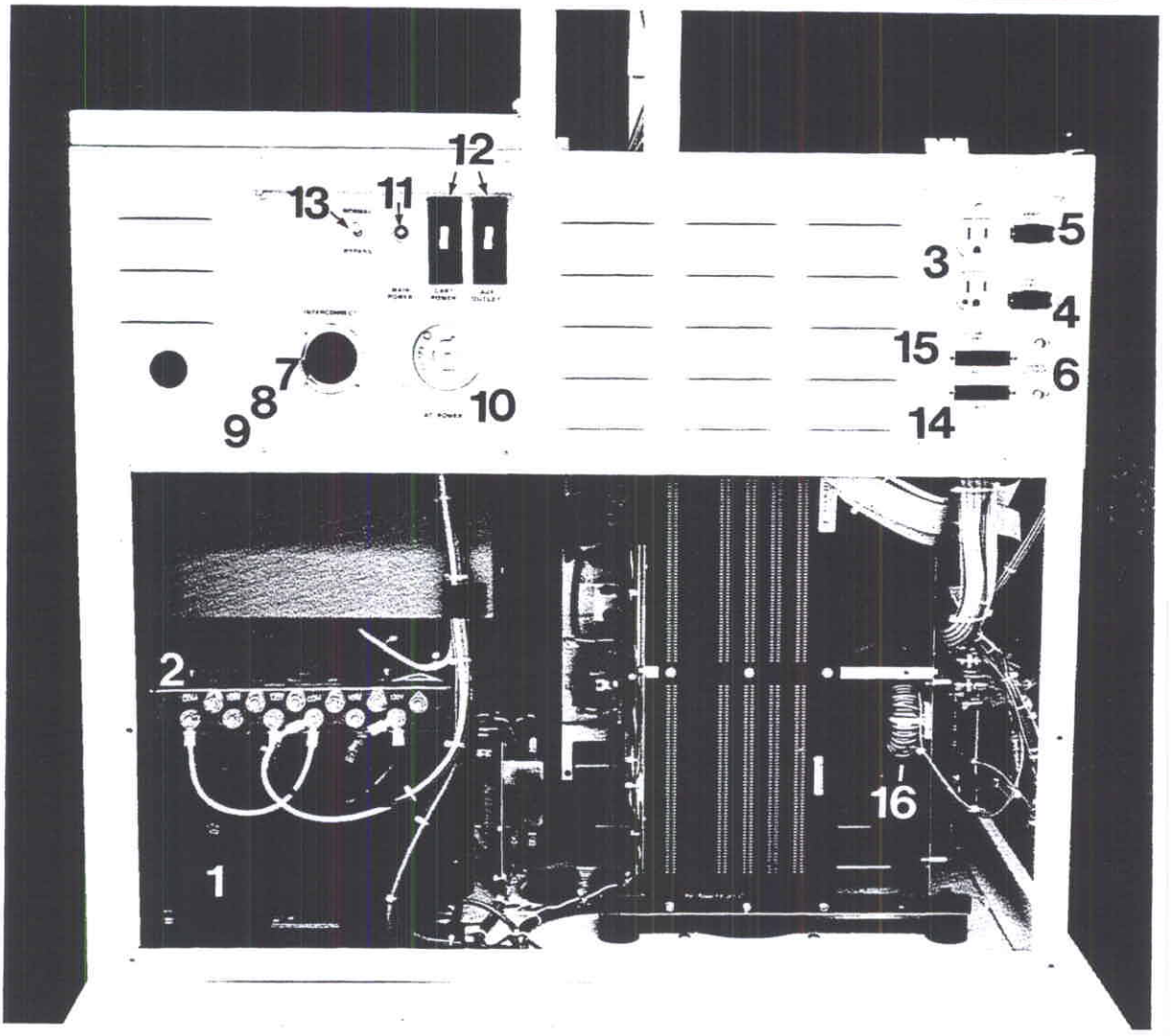
Rear Exposed Monitor View **Fig. 2**

Fig. 3 Monitor Cart

1.	isolation transformer	00-860736
2.	transformer terminal cover	00-870136
3.	duplex outlet, 3-wire	51-433989
4.	connector jack, 8-pin VTR	00-900047
5.	connector jack, 8-pin AngioStor	00-900047
6.	connector jack, BNC	58-018941
7.	connector, receptacle, circ	52-998346
8.	contact pin	52-998300
9.	bracket, retainer, interconnect cable	00-871331
10.	connector, inlet, 3-pin M	51-332981
11.	ckt breaker, 10 A	55-700448
12.	ckt breaker, 5A	55-700032
13.	toggle switch, DPDT	71-149970
14.	cable asm, AUX	00-870117
15.	cable asm, RS232	00-870118
16.	video balun	00-870370

Rear Lower View

Monitor Cart



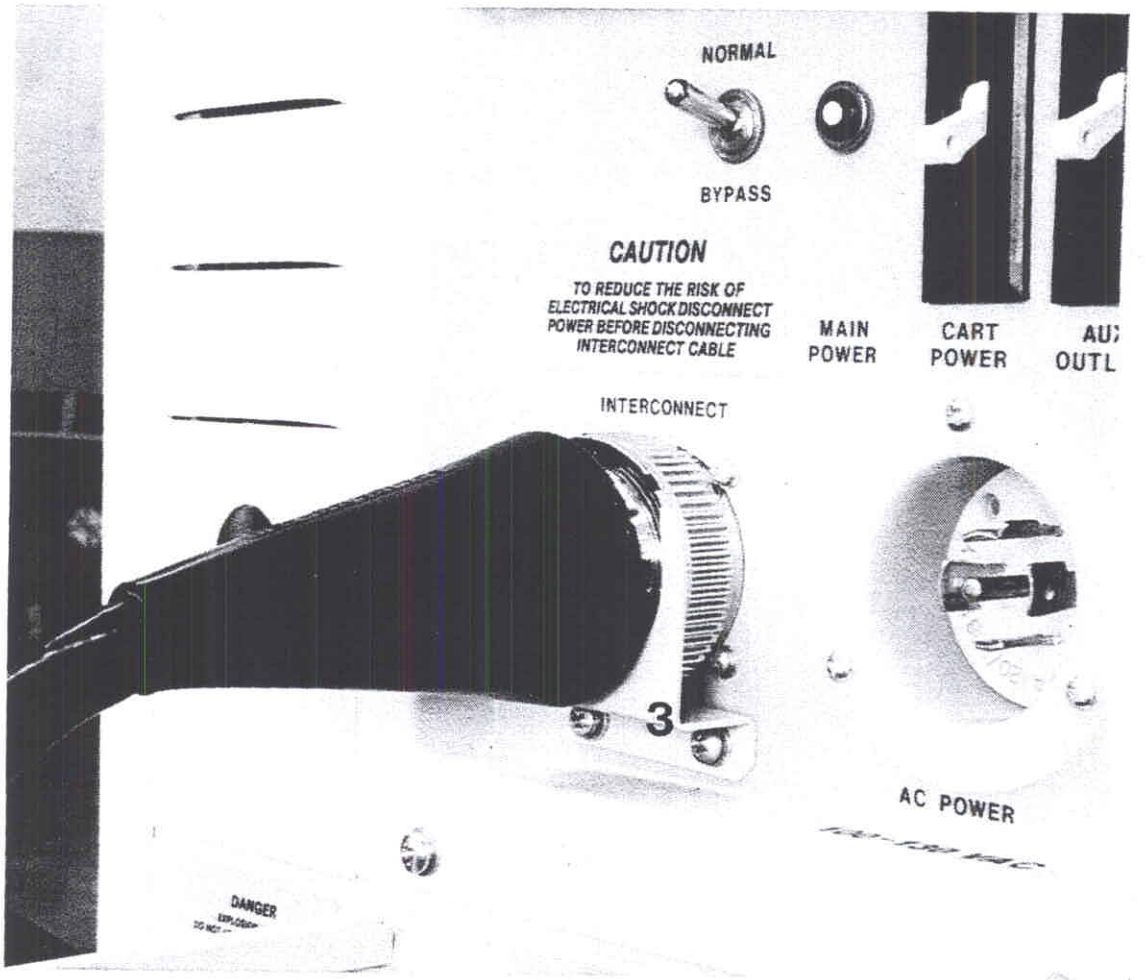
Rear Lower View

Fig. 3

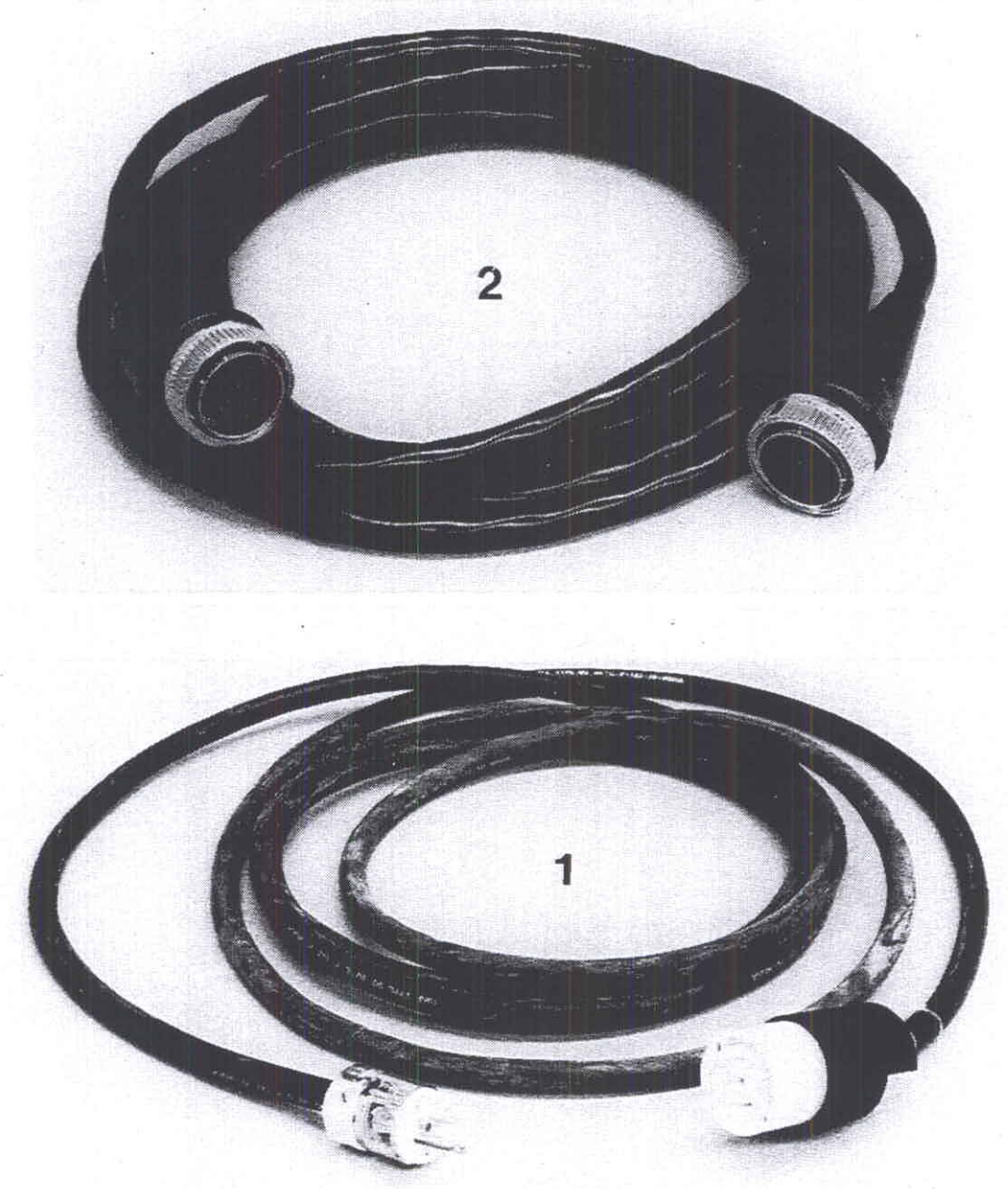
Fig. 4 a, b, c Power and Interconnect Cables

1.	asm, power cable	00-871369
2.	asm, interconnect cable	00-900101
3.	bracket, retainer, interconnect cable	00-871331

Fig. 4a



Monitor Cart



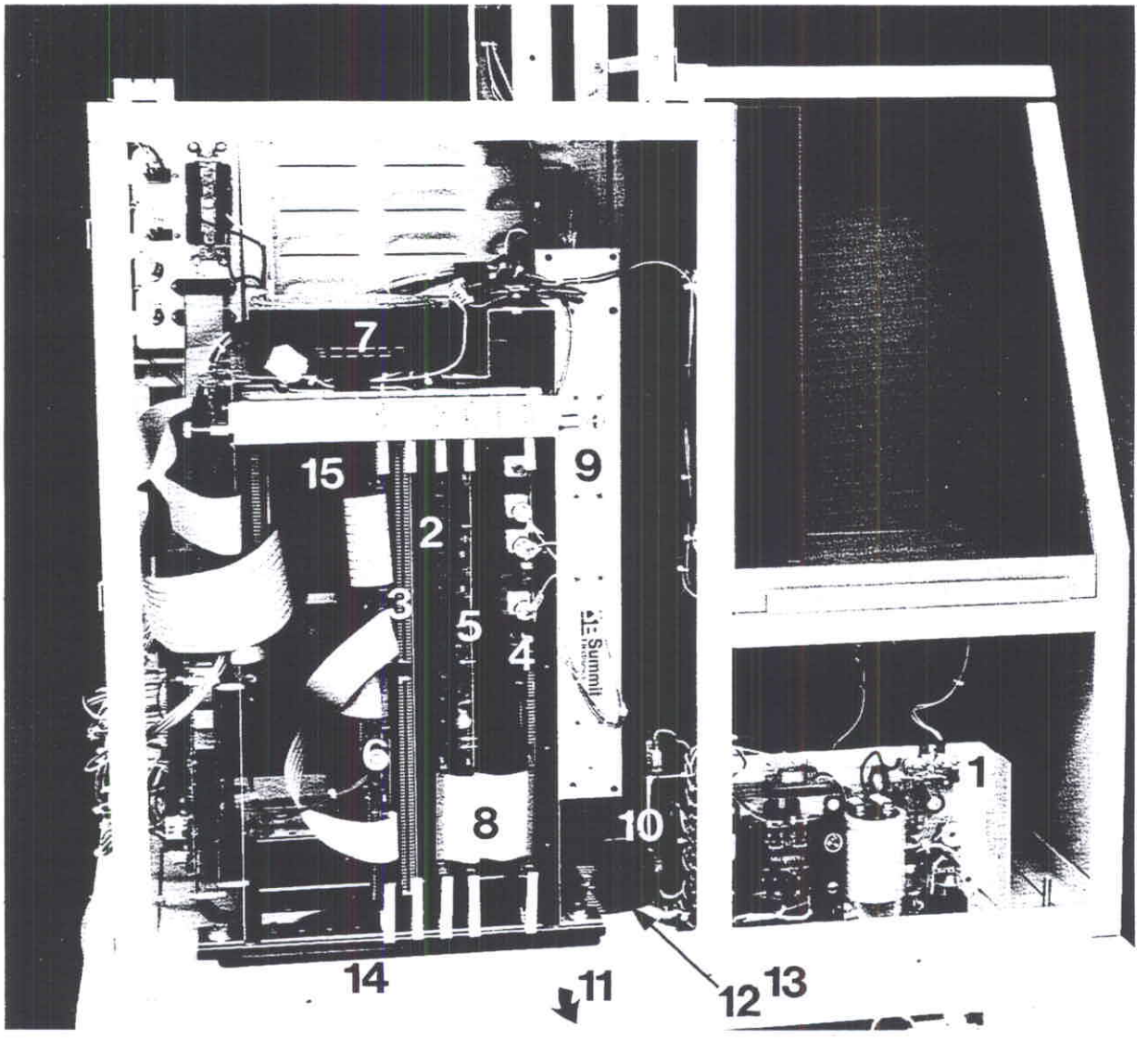
Power and Interconnect Cables **Fig. 4b, c**

Fig. 5 Monitor Cart

1.	24 Volt power supply	00-870285
2.	pipeline filter PCB	00-870503
3.	extender pcb	00-860893
4.	AD/DA converter pcb	00-860898
5.	image processor PCB	00-870390
6.	disk interface PCB	00-870015
7.	disk drive, winchester, 1/2 height	00-900077
8.	daisy chain cable	00-870556
9.	power supply, 5 VDC	00-870065
10.	filter, pwr line, 10 A	43-399887
11.	air filter asm	00-870386
12.	finger guard	20-839926
13.	fan, 4" axial	20-839955
14.	card guides	22-319805
15.	disk controller adapter PCA	00-900075

Lower Electronics, Front View

Monitor Cart



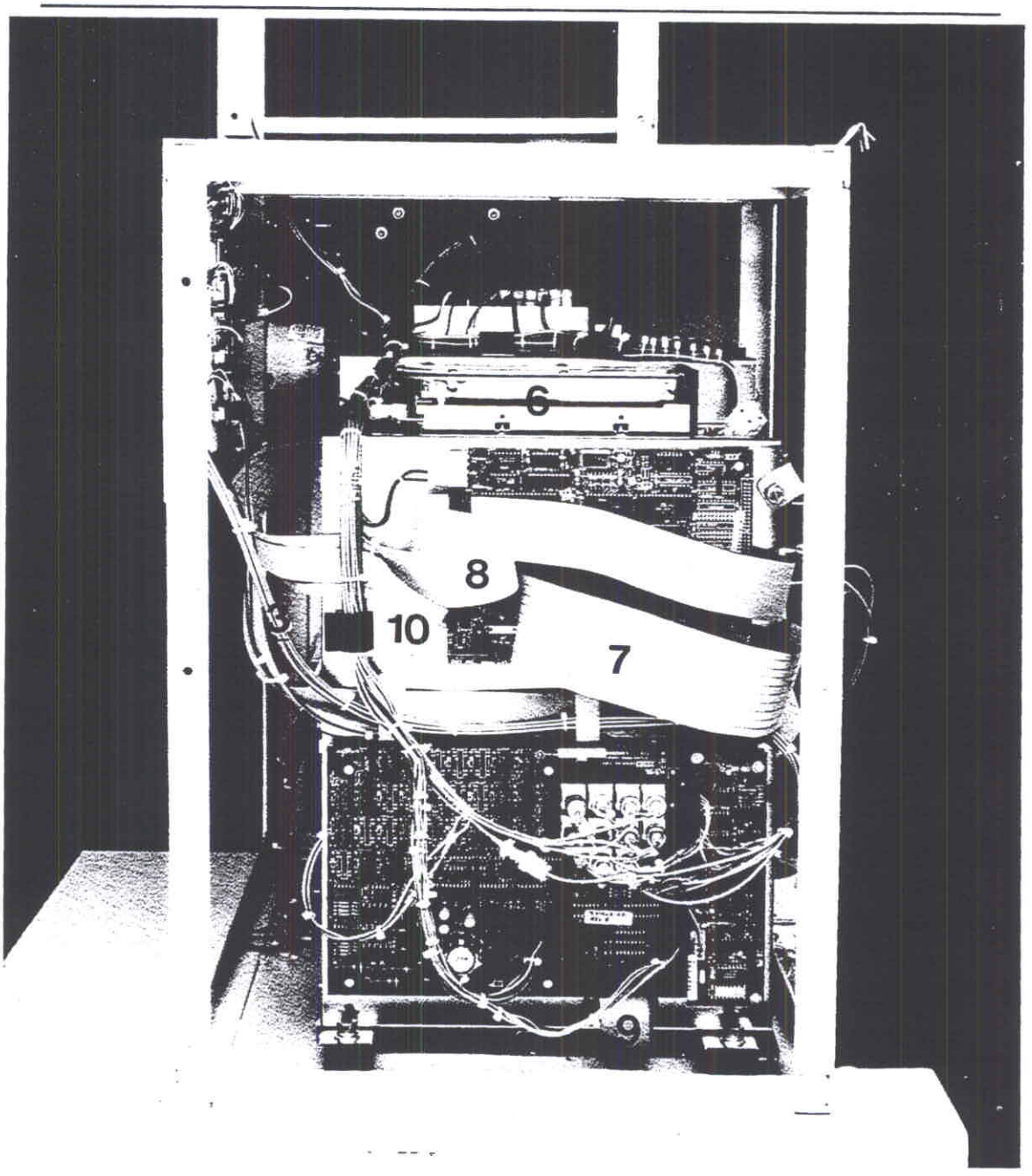
Lower Electronics, Front View **Fig. 5**

Fig. 6 Monitor Cart

1.	OMTI disk controller PCA	00-900079
2.	cable asm, AUX	00-870117
3.	cable asm, RS232	00-870118
4.	asm, PCB, I/O DIST/VIDEO SW	00-870187
5.	sync-separator PBC	00-870545
6.	disk drive, winchester, 1/2 height	00-900077
7.	cable asm, 50 pin ribbon	00-870024
8.	cable asm, disk control	00-870121
9.	cable asm, image processor interface	00-870119
10.	cable asm, disk data	00-870120

Lower Electronics, Side View

Monitor Cart



Lower Electronics, Side View **Fig. 6**

SECTION 7
MAINFRAME
SERVICE AND DIAGNOSTICS

7.1 Safety Procedures During Service

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 adjustments 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 can result if such metal articles are placed across the battery terminals.

7.2 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 however, 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.

7.2.1 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

7.2.2 Technique Processor Boot Codes

These codes are 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

7.2.3 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

7.2.4 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

7.2.5 Misc 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.

7.3 Event Codes and Warning Messages

7.3.1 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 7.4.

Event Code Table

Refer to Table 1; 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 a * in the table.

Table 1 Event Code Listing

01	not used	
02	not used	
03	not used	
04*	X-RAY JUMPER ON	jumper left in after calibration
05	SWITCH STUCK	x-ray switch is sensed as on improperly
06*	PRECHARGE FAIL	precharge cycle has failed
07*	HV INVERTER ON	high voltage generator is on
08	not used	
09	MAIN PGM LOAD	main program is loaded to RAM
0A	INIT COMPLETE	hardware initialization is complete
0B	not used	
0C	D CURRENT FAIL	dark current cannot be calculated
0D	not used	
0E	FLUORO-PREP	indicates software state
0F	FLUORO-INIT	indicates software state
10	FLUORO-READY	indicates software state
11	FLUORO-XRAY	indicates software state
12	not used	
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	not used	
18	not used	
19	FLUOROS FILM	indicates transition: standby to film
1A	not used	
1B	not used	
1C	not used	
1D	BOOST FOOT UP	boost switch released
1E	BOOST OVERTIME	boost terminated at 30 seconds
1F	HOUSING 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 OVERHEAT	heat integrator warning
24	HOUSE OVERHEAT	heat integrator warning
25	WILL OVERHEAT	film mode warning
26	CP DEAD	control panel dead
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 was terminated from front panel
2A	not used	
2B	X-RAY ARMED	instant on is prearmed
2C	FILM - PREP	indicates software state
2D	FILM - INIT	indicates software state
2E	FILMX - FLUORO	indicates software state

Table 1 (continued) Event Code Listing

2F	FILM - READY	indicates software state
30	not used	
31	FILM - WARMUP	indicates software state
32	FILMS - FLUORO	indicates software state
33	FILM - XRAY	indicates software state
34	FILM - INST ON	indicates software state
35	FILM XOFF	indicates software state
36	XRAY COMPLETE	exposure has ended
37	FOOT RELEASED	x-ray switch released early in film mode
38	XRAY OVERTIME	film mAs integration error has occurred
39	not used	
3A	not used	
3B	not used	
3C	not used	
3D	EXCESS FILM KVP	a calibration error has occurred
3E	LOW FILM KVP	a calibration error has occurred
3F	EXCESS FILM MA	a calibration error has occurred
40	LOW FILM MA	a calibration error has occurred
41	not used	
42*	FLIPPER STUCK	the flipper collimator is stuck
43	MA ON IN ERROR	improper generator operation
44	not used	
45	KV ON IN ERROR	improper generator operation
46*	STATOR NOT ON	rotating target stator is not running
47*	OVERLOAD FAULT	generator fault detected
48*	SATURATION FLT	generator saturation fault detected
49*	FILAMENT FAULT	generator fault detected
4A*	INTRLKS BROKEN	interlock circuit was interrupted
4B*	HV INVERTER OFF	high voltage generator is on
4C	not used	
4D*	OVERVOLTGE FLT	generator overvoltage fault
4E*	NO SERVO TABLE	disk software failure
4F*	NO MUXRAM DATA	disk software failure
50	NO OPTIONS FILE	no default parameters
51	USER END	normal operation has been interrupted
52	EXIT PROGRAM	exit program from terminal
53	NO CASSETTE	
54	LOADING STATUS	control panel is entering the status mode
55	NO SYSTEM FILE	disk software failure
56	NO MA LIMITS	disk software failure

* Fatal Errors

7.3.2 Warning Messages During Operation

Follow the recommendations below for remedying 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.

7.3.3 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. These conditions can be remedied by allowing time for the X-ray tube to cool. These messages alternate with the normal information displayed on the LED panel.

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.

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.

7.3.4 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 provide additional recharging time, leave the system plugged in with the interconnect cable in place overnight.

7.3.5 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 Generator Controller PCB has been left in place, disabling regulation. Results in automatic shutdown.

SWITCH 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.

BPLUS FAULT
The battery voltage is low; the batteries may be weak. Results in automatic shutdown.

SHOT TOO LONG
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.

LG FIELD STUCK
The collimator is stuck in the large field position. 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 FLT
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.

INTRLKS 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.

7.4 Control Panel Status Mode

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.

If the mainframe fails at the "Press Start" prompt during startup, the Status Mode can still be entered in the manner described below.

7.4.1 To Enter the Status Mode:

1. PRESS and HOLD the unlabeled button below the image reversal button for five seconds.
2. The message *STATUS V n.n* indicates that you have entered the status mode. Once in this mode, turn either the right or left knob 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 knob.
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, scroll the menu item *EXIT THIS MENU* onto the display 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*.

7.4.2 Status Menus

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

7.4.2.1 Battery Status

When this menu is entered, you are instructed to press START. This completes the interlock circuit and allows battery measurement. If no action is taken within ten seconds, the message PRESS START is replaced by INTERLOCK TIMEOUT, and you are returned to the the status menu level.

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

7.4.2.2 Camera Status

VIDEO LEVEL
DARK CURRENT
CAMERA GAIN
EXIT THIS MENU

7.4.2.3 Heat Status

HOUSING HEAT
ANODE HEAT
THERMISTOR
EXIT THIS MENU

7.4.2.4 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 NUMBER	
0	*MEASURED KVP*
1	*MEASURED MA*
2	*FILAMENT B+*
3	*VIDEO LEVEL*
4	*HOUSING TEMPERATURE*
5	*DOSIMETER*
6	*SPARE*
7	*SPARE*
8	*TAP VOLTAGE*
9	*LINE VOLTS*
10	*CHARGE CURRENT*
11	*CHARGE VOLT*
12	*FIL CURRENT*
13	*SPARE*
14	*SPARE*
15	*SPARE*

EXIT THIS MENU

7.4.2.5 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 and 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

7.4.2.6 Control Panel Diagnostics

PANEL LED TEST
PANEL KEY TEST
PANEL KNOB TEST
PANEL CLOCK TEST
SPEAKER TEST
CLOCK TEST
REMOTE BAUD CHECK
EXIT THIS MENU

7.4.2.7 Date/Time Set

SET TIME
SET DATE
EXIT THIS MENU

7.4.2.8 System Options

(XXXX below indicates the current option setting).

ABS TABLE XXXX
ABS BOOT XXXX
CAM GAIN XXXX
LENGTH OF PULSED MODE PULSE
EXIT THIS MENU

7.4.2.9 Examine Calibration Parameters

TABLE A	*TABLE B*
TABLE C	*TABLE D*
TABLE E	*TABLE F*
TABLE G	*TABLE H*
TABLE I	*TABLE J*
TABLE K	*TABLE L*

LAST CAL DATE and TECHNICIAN
NUMBER OF CALIBRATIONS

7.4.2.10 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 - (last 128, beginning with most recent stored in EEPROM. This table is only updated when a fatal system error occurs.)

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

NUMBER OF FATAL EVENTS (accumulated number of fatal event occurances).

DATE AND TIME OF LAST FATAL ERROR

7.4.2.11 Miscellaneous

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

MODEL NUMBER
SERIAL NUMBER
TOTAL RAM
FREE RAM SPACE
TOTAL DISK SPACE
FREE DISK SPACE
INSTALLATION DATE AND TECH
NUMBER OF FILM EXPOSURES
EXIT THIS MENU

7.5 Internal LED indicators

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

The Technique Processor LED digit - This LED echos 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 interlock circuit is complete. 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 Generator Controller PCB.

7.6 Video Camera - Jumpers and Adjustments

7.6.1 Video PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1	IN	Shading
E2	IN	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

7.6.2 Preamp and Yoke ASM

FUNCTION	*ADJUSTMENT*
Peaking	C3

7.6.3 Power Supply PCB

FUNCTION	*ADJUSTMENT*
Beam Discharge	R14
+500 VDC	R13
Focus	R11
H-drive Sync	R25

Adjustment **H-Drive Sync Frequency**

1. Disconnect the H-drive.
2. Adjust R25 to obtain 14.5 kHz at TP14.

7.6.4 Shading/Window PCB

FUNCTION	*ADJUSTMENT*
H- Sawtooth #1	R40
H- Sawtooth #2	R41
H- Parabola	R42
H- Window Cal.	R38
V- Sawtooth	R10
V- Parabola	R16
V- Window Cal.	R39

7.6.5 Deflection PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1	AFC	line Lock/Auto Freq Cntl
E2	525 (60 Hz)	line rate select
	625 (50 Hz)	line rate select
E3		unused
E4		unused
E5-E6	OUT	U2 clock source
E7-E8-E9	E7-E8	50 HZ
	E8-E9	60 HZ
E10-E11-E12	E11-E12	Clock
E16-E17-E18	E16-E17	Horiz reversal

FUNCTION	*ADJUSTMENT*
H- Size	R40
H- Normal Centering	R38
H- Reverse Centering	R39
V- Size	R19
V- Centering	R37
AFC Tuning	L1

7.7 Image Intensifier Adjustments

7.7.1 6-inch Image Intensifier

ELECTROSTATIC FOCUS ADJUSTMENT

Refer to figure 7-1 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.

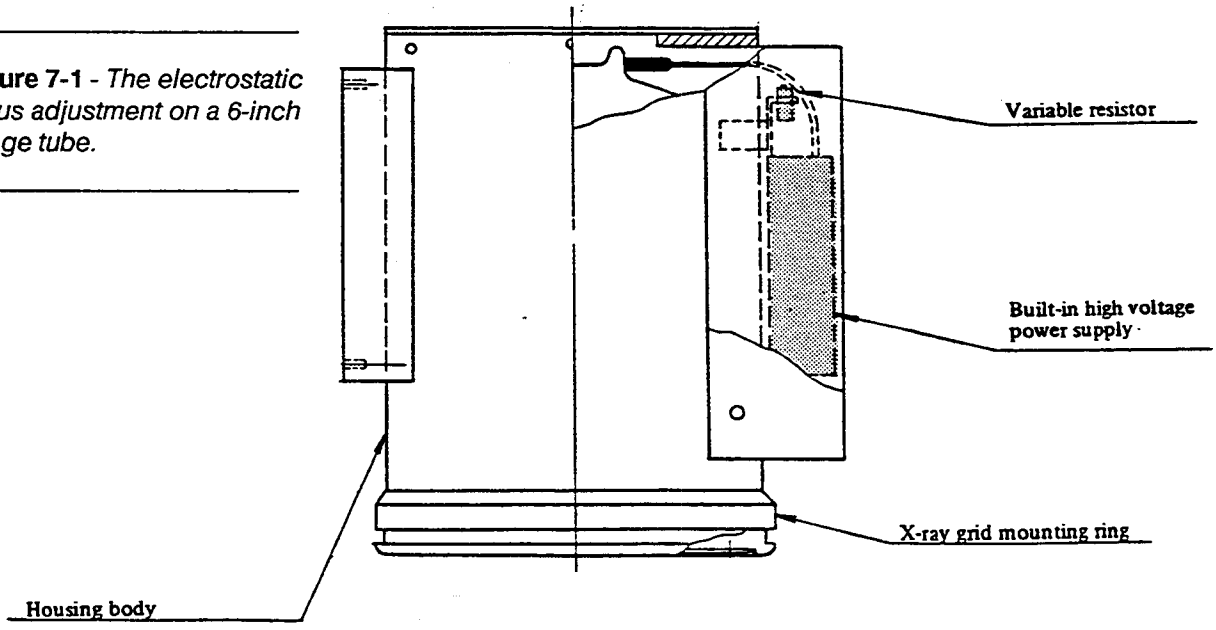


Figure 7-1 - *The electrostatic focus adjustment on a 6-inch image tube.*

7.7.2 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. Refer to Table 2.

Table 2 6/9-inch Image Tube Adjustments

The 6-inch mode adjustments are made to the pots labeled M1; 9-inch mode adjustments are made to the pots labeled N. The M2 adjustments are not applicable.

MODE	*OVERALL SIZE*	*OVERALL FOCUS*	*EDGE FOCUS*
6-INCH	G3	G2	G1
9-INCH	G3	G2	G1

Note: G3 (overall size) may only need adjustment in the 9-inch mode to make the image slightly smaller.

7.8 High Voltage Generator and Generator Controller PCB

These procedures are recommended if the Generator Controller PCB or any High Voltage Generator major component is replaced. Follow these procedures in order.

WARNING: This equipment contains very high power electrical components and should be serviced only by personnel intimately familiar with the circuitry and its operation. The voltages and power levels attainable are capable of causing serious injury, burns, and electrocution. At certain locations, these voltages are present EVEN WITH POWER CORD DISCONNECTED.

WARNING: Due to the high power delivery capability of the battery, and the hazardous voltages present, the mainframe high voltage circuitry should be approached in a cautious and orderly manner.

When energizing a system for the first time following a major repair of the high power or control circuitry, it is important that power limiting techniques be applied until proper functioning can be determined.

7.8.1 Checkout Preparation:

CAUTION: **These checkout tests are to be conducted with the battery and the battery charger disconnected. Do not reconnect the battery or power the charger until directed to do so in these procedures.**

1. Unplug the system from the wall outlet.
2. Disconnect the red connector to the positive lead of the battery, and remove the fuses F2 and F3 in the A.C. power path of the battery charger circuit (these fuses are located on the front of the power panel).

7.8.2 High Power Driver Stage Tests

1. With the high voltage supplies disconnected (as described above) boot the system by running "MAIN 0 " from the external terminal according to the instructions in Section 7.12. The "0 " argument allows the software to operate with no high voltage present.

2. Press START to engage the interlock circuit when prompted on the control panel.

3. Press the "X-RAY ON" switch; with an oscilloscope, the drive pulses at R139 and R156 (ungrounded end) should measure 2.6 +/- .3 volts peak.

4. Measure the turn-off pulse at the trailing edge of the drive pulses seen at R139 and R156. This should be a negative going spike, greater than -1.0 volt in amplitude, and greater than 5 usec. in duration.

5. Disable kV servo by installing jumper E5 on the Generator Controller PCB.

6. Measure the duration of the on-pulses. The duration should be approximately 20 usec.

7. Check that the on-pulse duration can be varied by turning the kVp Knob on the control panel.

8. Remove the jumper from E5.

7.8.3 Power Limited Functional Test

1. Disable the kVp servo by installing a jumper at E5 on the Generator Controller PCB.

2. Set the fluoro technique to: 50 kVp and 0.5 mA.

3. Connect one battery (60 VDC) into the circuit with a 12 ohm 100 watt resistor wired in series with the positive battery lead. (Bypass the other two battery packs).

4. Boot the system by running "MAIN 40 " from the external terminal according to the instructions in Section 7.12. The "40 " argument allows the software to operate with a lower battery voltage present.

5. Make an exposure while observing the following:

   There should be no fault messages on the control panel display and a sinewave should appear at P1-4 and P1-5 of the Generator Controller PCB.

6. Make a fluoro exposure and observe the waveform at TP-13 on the Generator PCB for the following:

kVp Sensor Functional Test A sinewave equal to 42 to 48 percent of the amplitude seen in step 5 should be present during the exposure.

7. Remove the jumper at E5.

8. Make an exposure and observe the following:

kVp Regulation Test The amplitude of the waveform at TP-13 should be 5.0 +/- .20 Vpp, and its amplitude should be adjustable by varying the "KV" knob on the control panel.

NOTE: *It will not be possible to obtain more than about 6 volts p-p with only one battery connected.*

9. Verify the waveform at P1-12 (small filament output) without making an exposure.

Filament Drivers

There should be no signal at P1-11 (large filament) in this mode.

10. Put the system in "FILM" mode and arm for "instant on". This is done by pressing the X-RAY ON switch and releasing it before the exposure actually occurs.

11. Verify the waveform at P1-11 without making an exposure.

Filament Drivers There should not be a signal at P1-12 (small filament) in this mode.

7.8.4 High Voltage Application

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

1. Open the interlock circuit by pressing EMERGENCY OFF. Wait one minute to discharge the filter capacitance. Reconnect all batteries but leave the 12 ohm 100 watt resistor in series.

2. Jumper E5 should be removed and Jumper E3 installed. Set the technique for FLUORO and 50 kVp, 0.5 mA.

3. Reboot the system by typing MAIN at the terminal. (Refer to the instructions in Section 7.12).

CAUTION: *Do not use the "0 NOCAL" argument this time, as this will close the large contactor prematurely, resulting in very large inrush currents.*

4. Make a fluoro exposure and observe that no fault messages appear on the control panel display.

5. Turn off the keyswitch. Disconnect the power cord from the wall outlet. Wait one minute to discharge the filter capacitance. Remove the series 12 ohm resistor, reconnecting the batteries in their normal configuration.

6. Remove both jumpers E3 and E5 from the Generator Controller PCB.

7.8.5 Adjusting Charger Output Voltage

1. The batteries are connected in their normal configuration prior to this procedure (see step 5 of the previous procedure).
2. Unplug the power cord. Install F-2 and F-3 to provide A.C. power to the charger circuit.
3. Remove the panel mount fuse below the Generator Controller PCB.
4. Plug in the power cord. Leave the interlocks disengaged - DO NOT PRESS START.
5. Adjust R-108 for 211 +/- 3 VDC at C-63(+).

7.8.6 Adjusting Charger Voltage Readout (Bargraph)

1. Adjust R109 clockwise until the bargraph reads below 210 volts.
2. Then turn R109 counter-clockwise until the 210 volt LED just turns on.

7.8.7 Generator Controller PCB Jumpers

JUMPER	*SHOULD BE*	*FUNCTION*
E3	IN only for calibration	disables mA servo
E5	IN only for test	disables kV servo

7.9 Analog Support PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Counter Timer Clock-Input
E4-E11	TBA	Board Rev

7.10 Technique Processor PCB

Switch Settings

SWITCH	*SHOULD BE*	*FUNCTION*
S1		reserved
S2		reserved
S3	OFF	real time clock disable
S4	ON	autoboot switch, if off mainframe will boot in monitor program
E0-E3		Board Rev
E9, E10	IN, IN	Real Time Clock Oscillator

Adjustment

Disk Drive Interface - Read/Write Pulses

Use this procedure to adjust the read/write data pulse widths. Measure frequency and pulse widths at the test points indicated using an oscilloscope. To obtain proper accuracy in this measurement, set the horizontal scale as indicated in [brackets] below.

1. Connect the 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 [set scope on 100 ns/div].

7.11 Control Panel Processor PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E3	IN	Dual UART Oscillator Circuit

Switch Settings

SW8	*SW7*	*BAUD RATE*
off	off	9600 baud (normal)
off	on	4800 baud
on	off	2400 baud
on	on	1200 baud

SW5	SW4	COMMUNICATION DIAGNOSTICS
off	off	disabled (normal)
off	on	echo key request to terminal
on	off	echo T.P. commands to terminal
on	on	undefined

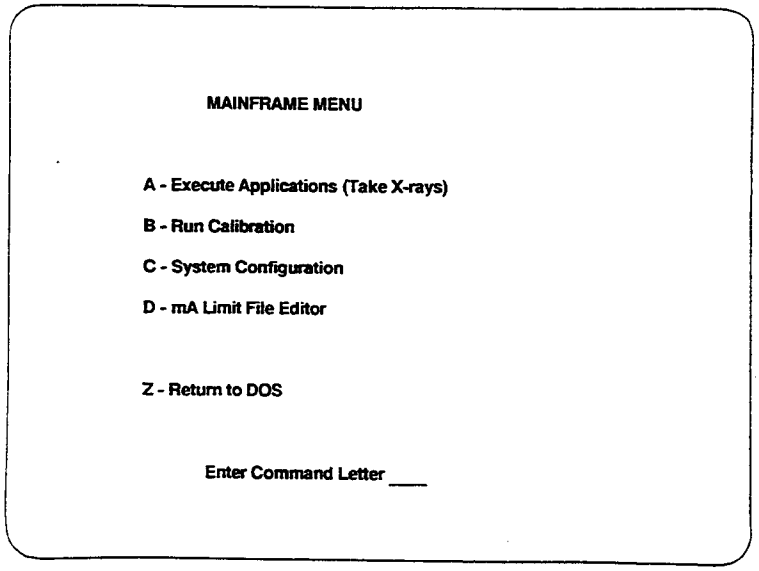
SW3	SW2	SW1	DIAGNOSTIC MODES
off	off	off	normal operation
off	off	on	segment & LED check
off	on	off	keyboard diagnostics
off	on	on	clock & speaker checks
on	off	off	UART loop test
on	off	on	memory test
on	on	off	undefined
on	on	on	undefined

7.12 Accessing the Mainframe with the External Terminal

7.12.1 Mainframe Terminal Menus

Mainframe software menus are accessed from the monitor cart MAIN MENU by selecting "Access Mainframe Menu".

This Mainframe Menu will appear.



Refer also to Section 8.6.3 in *Monitor Cart Service* for a summary of the selections available from the monitor cart Main Menu.

7.12.2 To Access Mainframe DOS (MSDOS$_{TM}$)

1. Connect the external terminal by following the instructions given in the Appendix: *External Terminal Use*.
2. Press [ESC] to view the Program Access Menu.
3. From the Program Access Menu select: *Z-Return to Main Menu.*
4. From the Main Menu select: *Y-Access Mainframe Menu.*
5. From the Mainframe Main Menu select: *Z-Exit to DOS.*

7.12.3 Booting From the External Terminal

1. The system can be booted from the external terminal for certain test procedures. Do this only when specifically told to do so in the test procedure.
2. Enter the command line desired after performing step 5 in Section 7.12.2 above:

   Type *MAIN* to invoke the Main Program.

   Type *MAIN 0* when required by certain test procedures.

7.12.4 Exit Applications Software

If the mainframe fails at the "Press Start" prompt during startup, the Main Menu can be accessed by pressing [ESC] and typing END.

7.13 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 Generator Controller PCB.
3. The bargraph may indicate 160 or 170 volts during the exposure. If the voltage drops to 150 volts, there could be a problem with the batteries.

7.14 Evaluating the Battery Charger

The battery charger circuit on the Generator Controller 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 measured at E1 should be about 210 VDC.
2. Above 625 mA the voltage measured at E1 should rise to approximately 230 VDC.
3. Above about 2 amps charger current, the charger current limits and the charger voltage at E1 will decrease.
4. Overvoltage shutdown should occur above approximately 240 VDC, indicated by a sudden drop in output voltage at E1.
5. During mainframe boot, the charger output is shutdown momentarily; the output voltage should briefly drop to about 150 VDC.

7.15 Resetting the Battery Circuit Breaker

The 50 Amp battery circuit breaker will trip in the event of a major overload in the battery circuit. Determine the cause before resetting. *Refer to Figure 7-2.*

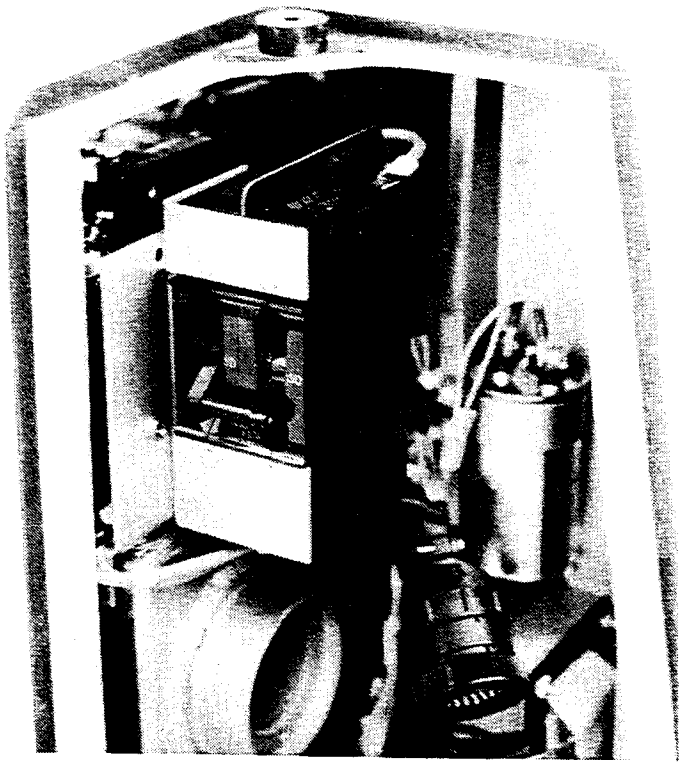


Figure 7-2 - *The battery circuit breaker is shown in this photo.*

7.16 Mainframe Mechanical Adjustments

7.16.1 Loosening a Stuck Lift Shaft

If either of the limit switches on the lift column are badly misadjusted, the column may bind at the top or bottom of its travel.

1. Directly above the top of the shaft, there is an access hole through which to insert a hex wrench.
2. Reach the wrench into the hole and onto the hex head at the top of the shaft. Turn the shaft in the direction opposite to the bind.

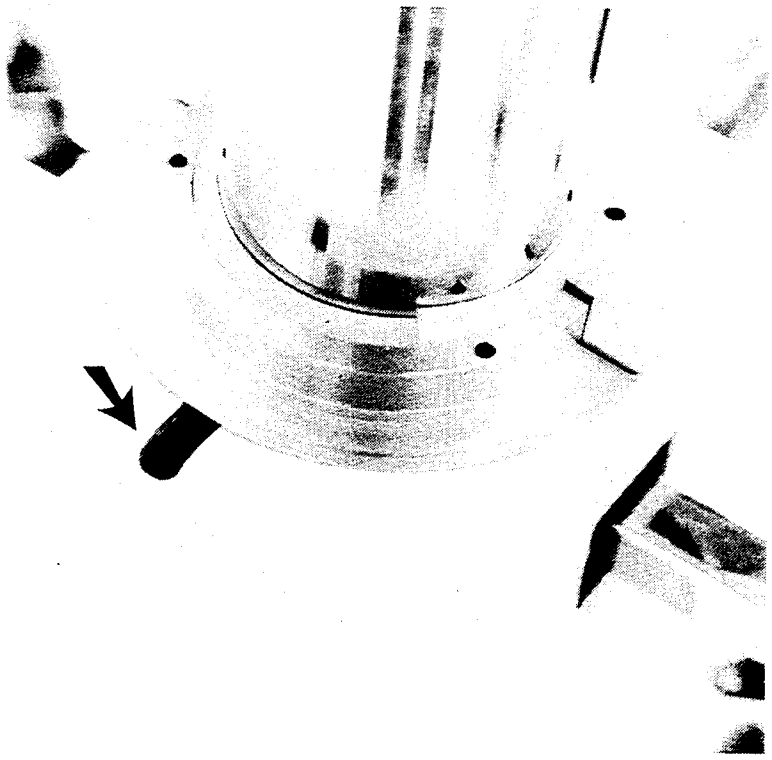


Figure 7-3 - *The lift shaft can be turned with a hex wrench inserted through this hole.*

7.16.2 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 blade screwdriver rotate each bearing to minimize sloppy, loose or irregular movement of the the C-arm within the cradle. Do not adjust these to cause overtight bearing contact.
3. Test the bearing contact through the full range of movement.
4. Tighten the set screws.

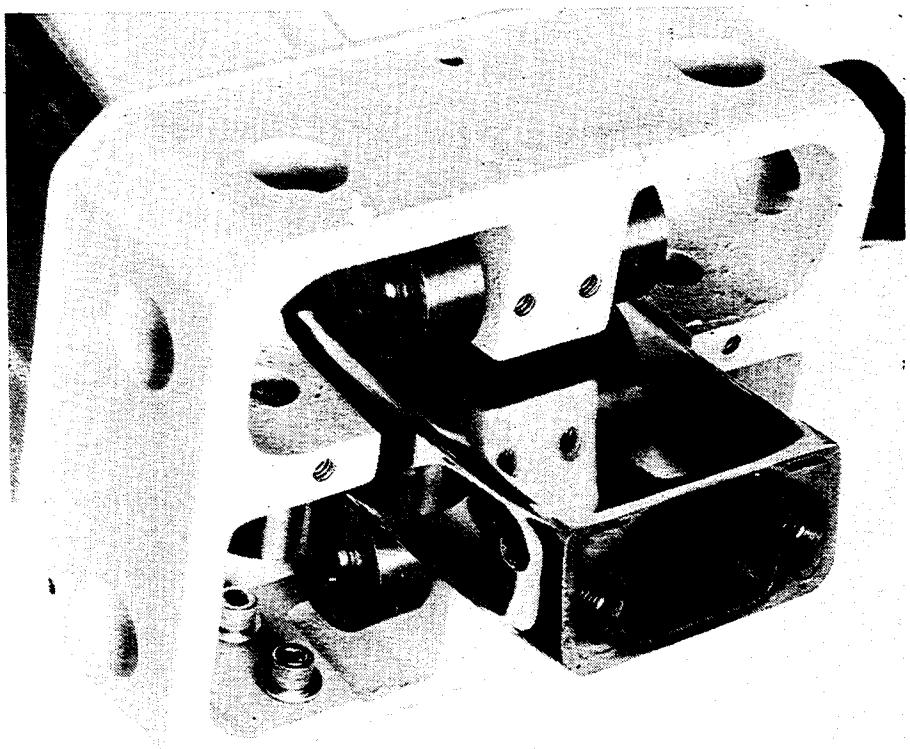


Figure 7-4 - *The cradle bearings can be exposed in the bearing blocks.*

SECTION 8
MONITOR CART
SERVICE AND DIAGNOSTICS

8.1 Safety Precautions During Service

Read the Safety section of this manual before attempting any service procedures which require removal of the electronics covers.

WARNING **Use extreme care if you must perform adjustments or tests on the electronics when power is applied.**

8.2 Monitor Cart Progress and Error Codes

The alphanumeric display on the monitor cart front panel will display error codes when faults occur with the monitor cart electronics. These are listed and described below.

8.2.1 Boot Progress Codes

During the software loading or boot process, the alphanumeric LEDs on the front panel will display "b" codes, indicating where in the boot sequence, code is being executed. Since these codes do not normally indicate an error, they are referred to as *progress codes*. Typically, these codes will be erased once normal program operation has begun. If the program does not complete the boot process, a "b" code will remain on the LED display, indicating the point where an error occurred. The meaning of each "b" code is described below.

b0 - Initial start from address 0000H.
b1 - Attempting to load from floppy disc drive
(may be connected during service or software installation).
b2 - Attempting load from hard drive.
b3 - Boot load failed.
b4 - Cold boot program loaded, attempting to load DOS.
b5 - DOS loaded.
b6 - SEARCH.COM has been loaded and is searching for the number of the last image saved to the hard disk.
b7 - SEARCH.COM has successfully completed the search.

8.2.2 Initialization Progress Codes

Once the main program has been loaded, a series of "A" progress codes will be displayed. When initialization is completed, the "A" code will be erased and the next available image location will be displayed. Each "A" code which occurs during the initialization process is defined below.

A1 - Overlay manager is loaded.
A2 - Memory is being initialized.
A3 - Video relays are being initialized.
A4 - Image Processor PCB is being initialized.
A5 - Initializing X-Ray system communications.
A6 - Initializing internal software error handler.
A7 - Initialize gray scales and log RAMS.
A8 - Initialize VTR.
A9 - Initialize HELP function.

8.2.3 Hard Disk Drive Error Codes

During initialization or program execution, unrecoverable hard disk errors may occur. An error will be reported on the monitor cart front panel LED display. "d" codes that might appear during initialization or operation of the system are described below.

d0 - No image was found at the location specified during a hard disk image recall. This is a user error which does not indicate a malfunction.
d2 - Cannot find the requested data block.
d3 - A bad data block was encountered.
d4 - A formatting error occurred.
d5 - The drive cannot find its alternate track.
d6 - A Disk Controller PCB time out error occurred.
d7 - An internal software error was detected.
d9 - The hard disk is not ready.
dA - A drive error occurred.
dB - A Disk Controller PCB error occurred.
dC - Attempting to recall an invalid image.
dD-dF - Reserved for future use.

8.2.4 Program Errors

Operator and program errors are displayed on the front panel. The following error codes all occur during execution of the main program:

ERROR: **E1**
CAUSE: The front panel has not responded to the host processor over the serial communication link.
CHECKS: Observe the serial data lines between the host and the front panel. Verify that the front panel software is correct and that the processor is running.

ERROR: **E2**
CAUSE: Repeated NAK response from the front panel to the host processor.
CHECKS: Same as error E1.

ERROR: **E3**
CAUSE: Repeated invalid response from the front panel to the host processor.
CHECKS: Same as error E1.

ERROR: **E4**
CAUSE: Image processor has not responded to the host processor over the serial communication link.
CHECKS: Check the serial data lines between the host and IP. Verify that the IP software is correct and processor is running.

ERROR: **E5**
CAUSE: Repeated NAK response from IP to the host processor.
CHECKS: Same as error E4.

ERROR: **E6**
CAUSE: Repeated invalid response from the IP .
CHECKS: Same as error E4.

ERROR: **E7**
CAUSE: X-ray System communications error.

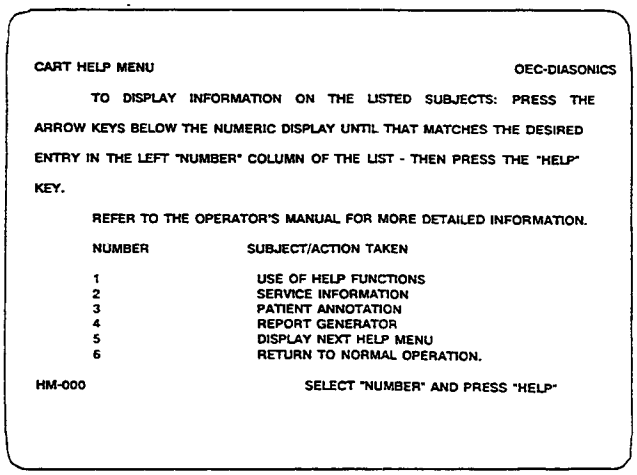
8.3 Monitor Cart Diagnostics Menus

The Diagnostics Menus provide access to:

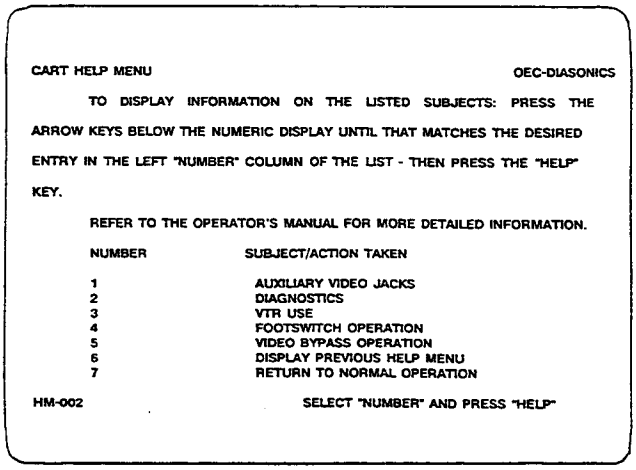
Front Panel Controlled Diagnostics
Terminal controlled Diagnostics

These are discussed in the following pages. The steps below describe how to select and use the Diagnostics Menus:

1. Press HELP HELP (HELP twice) to view the first menu, shown here. From this menu select entry NUMBER 5.

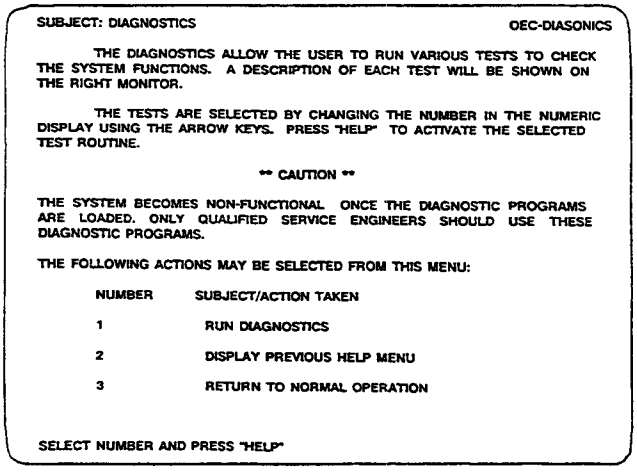


2. Select NUMBER 2 - DIAGNOSTICS and press HELP.



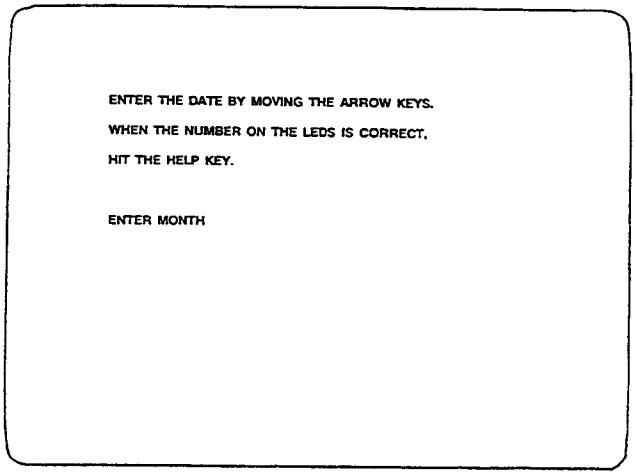
3. Select NUMBER 1 - RUN DIAGNOSTICS.

   The system cannot be operated for normal use when the diagnostic software is loaded. Only qualified service engineers should use these programs.

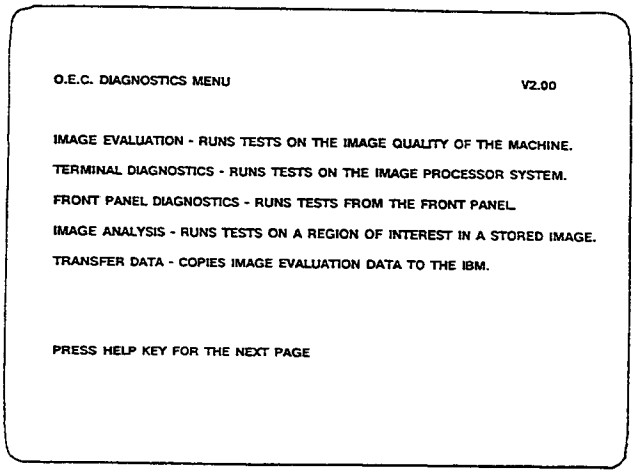


4. You are first asked to enter the date. Press the arrow keys, up or down, until the correct number is displayed on the LED readout. Then press HELP to complete the entry.

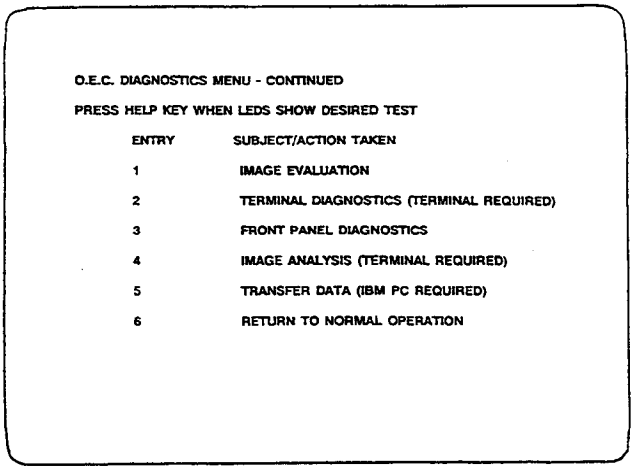
Enter the month.
Enter the day
Enter the year.



5. This help screen will appear with a brief description of the functions available in the next menu. Press HELP for the next screen.



6. Select the desired diagnostics from this menu. Each of the diagnostics is described in the following sections. Enter the number and press HELP. Entry NUMBER 6 will return you to normal operation.

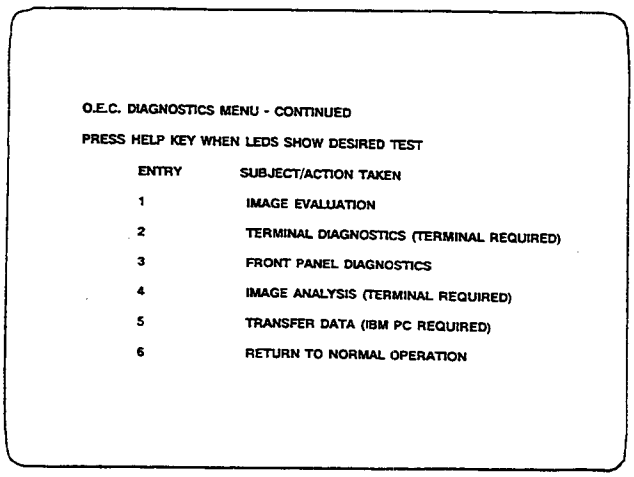


8.4 Front Panel Diagnostics

The Front Panel Diagnostics test the monitor cart electronics and are selected from the Front Panel Diagnostic Menu.

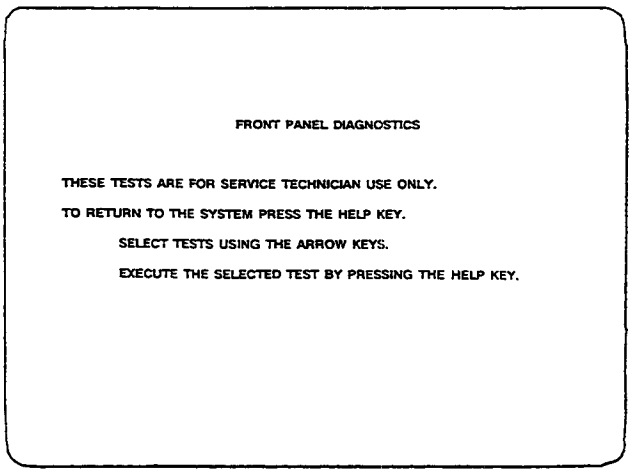
---

1. Select ENTRY 3 - FRONT PANEL DIAGNOSTICS from the Diagnostics Menu. (See above: *Entering the Diagnostics Menus*).



2. Refer to the list of Terminal Diagnostics given in the next section. These tests are identical, except where noted. (The cycle memory test #11, for example, is not available from the front panel).

3. Select the desired test number on the LED readout by using the arrow keys. Begin the test by pressing HELP.



8.5 Terminal Controlled Diagnostics

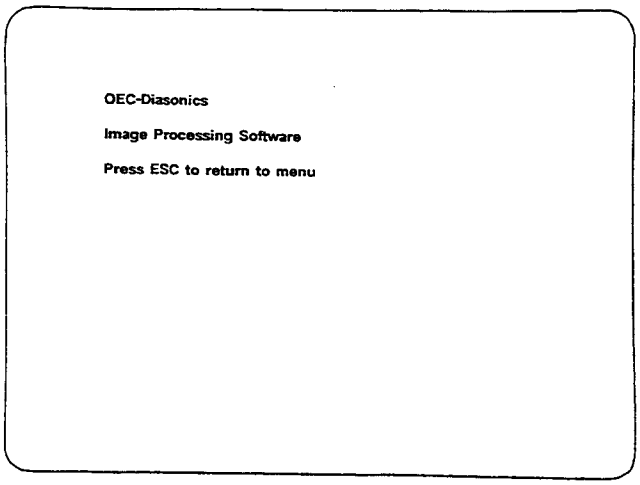
The Terminal Controlled Diagnostics test the monitor cart electronics. These same tests may be accessed from the front panel.

8.5.1 Using the Terminal Controlled Diagnostics

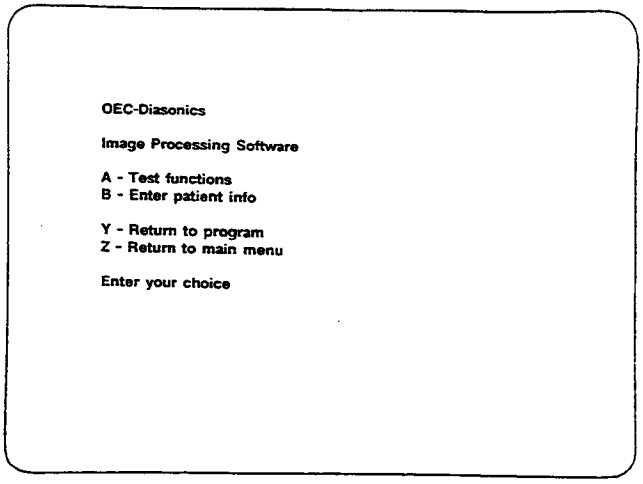
The Terminal Diagnostics require the use of an externally connected computer terminal. (Refer to the Appendix: *Terminal Installation and Use*).

---

1. Connect a terminal (such as the DXR keyboard terminal described in the Appendix), to the RS-232 connector on the rear of the monitor cart. The screen shown here will appear when the cart is booted. Press [ESC].

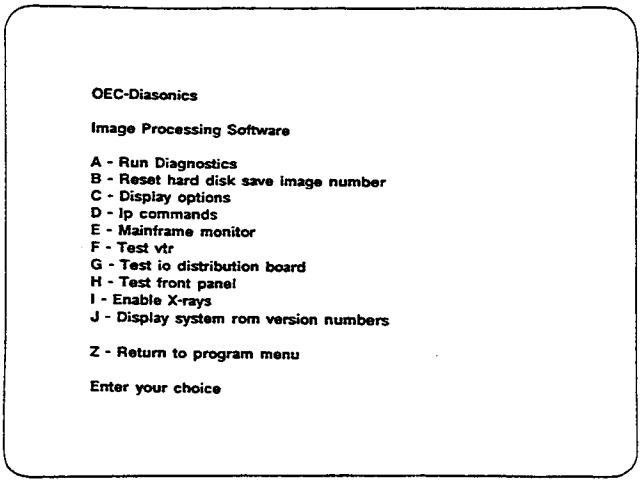


2. Select ENTRY A - TEST FUNCTIONS from the program access menu.



3. A list of choices will appear on the terminal screen (or the monitor screen if it is being used as the terminal).

Enter: A - RUN DIAGNOSTICS.



4. The following tests may be selected from the terminal screen. Type in the number and press [RETURN].

1 - Segment Ram Test	15 - Exchange M1 Data
2 - Memory Segment Read Test	16 - Exchange M2 Data
3 - Memory Segment Write Test	17 - Swap M1/m2 Data
4 - M1 Clear Test	18 - Left Monitor Live
5 - M1 Memory Test	19 - Left Monitor Digital
6 - M1 Exchange Test	20 - Select Gray Scale Val.
7 - M1/M2 Swap Test	21 - CRT Character Test
8 - M2 Clear Test	22 - Front Panel Test
9 - M2 Memory Test	23 - Video Test Pattern
10 - M2 Exchange Test	24 - Front Panel LED Test
11 - Cycle Memory Tests	
12 - Write Vertical Gray Scale	99 - return to system
13 - Write Horiz. Gray Scale	
14 - Invert M1 Data	

8.5.2 Explanations of the Terminal Diagnostics

This section briefly describes each diagnostic test. Note that options 1 thru 10 are memory tests that can be repeatedly cycled by selecting option 11. However, the cycle capability exists only when the external terminal is used. The front panel diagnostics will automatically jump over option number 11 (and option 20 which is also limited) while scrolling through the options.

Most tests listed below may be performed in any order required. The Video Test Pattern is one of the tests included in this group.

The order in which the memory tests are listed is the order in which they should be run. Their order must be followed since an error in a prior test will make the next test useless.

Error Messages - The errors that are detected during these tests are displayed in different ways depending on how the tests were originated. When using the terminal oriented diagnostics it is possible to relay more information about the error condition to the terminal than it is using the front panel diagnostics. The front panel diagnostics assume that there is not a terminal interfaced to the system, so all error messages are displayed on the front panel LED display. The first character of the display will be an "E" and the second digit will be a hex value between 0 and F that corresponds to the error found. If the error condition is a number greater than 15 (or F hex) then an F will be displayed. The cycle test mode also restricts the amount of error information displayed.

1- SEGMENT RAM TEST

This test first writes AA hex to every address in the segment ram. Each line is then read into a 512 byte buffer that was previously cleared to 0's. If each byte of the buffer now contains AA hex, then the same test is performed using 55 hex.

Error messages- In the terminal diagnostic mode text messages indicate the number of errors encountered for each bit mask. The cycle test returns 1 error for each bit mask test that failed, for a possible total of 2 errors per pass. The front panel diagnostics will return an error code of "E1" if any error occurred, or an error code of "E0" if no errors were detected.

2- MEMORY SEGMENT READ TEST

The function of this test is to verify that a segment can be read from the memory M1. This is accomplished by filling a 16k byte block of dram with the value FF hex (this sets all bits to 1), then clearing the memory, reading segment #0 of M1 into the DRAM block that previously contained all 1's, and then checking to see that all memory bits were cleared to 0.

Error messages- The error value returned by this test indicates the number of bytes in the segment that remained uncleared. In the front panel diagnostic mode, an error value greater than 15 will be displayed as

an "F". In the cycle mode, any number of errors found will be counted as a single error per pass.

3- MEMORY SEGMENT WRITE TEST

This test is to verify that a segment of data can be written to the memory M1. First M1 is cleared, then a 16k byte section of DRAM is filled with the alternating bit pattern of 55 hex. The entire segment is written to memory M1 segment #0, then read back into dram and checked to see if every byte was properly written. The test is then repeated using the bit pattern AA hex.

Error messages - The error value returned by this test indicates the number of bytes in the segment that was found to contain a value other than that which was written to it.In the front panel diagnostic mode an error value greater than 15 will be displayed as an "F". In the cycle mode, any errors found will be counted as a single error per pass.

4- M1 CLEAR TEST

This test checks to see that a "clear frame" operation can be performed on memory M1. The hex value FF is written to an address in segment #0 of memory M1, and then a clear frame operation clears the entire 128k block. The address previously written to is then checked for a value of 0.

Error messages - This test returns an error of 1 if it failed, and 0 if it passed.

5- M1 MEMORY TEST (takes approximately 3.5 min)

This test alternates every bit of the frame and checks the result. First the value 55 hex is written to each byte of the frame, and then read back and verified. The same is done using the hex value AA.

Error messages- Using the terminal diagnostics, an error message statement is returned for each segment declaring that either an error was found in that segment, or that the segment memory checked out OK. In the front panel test mode an error code of "E1" indicates that the failure occurred during the first pass when the hex value 55 was written, and an error code of "E2" means that the error was discovered when expecting to read back AA hex. In cycle mode the error value accumulated during a single pass indicates how many segment errors were found for both bit masks. For example, if the error total was incrementing by 32 for each cycle, that would indicate that all 16 segments had at least 1 error during both the AA and 55 bit tests.

6- M1 EXCHANGE TEST

This test verifies that the "exchange frame" function is working properly. When an exchange frame is performed on either M1, or M2, the address lines are changed so that the background frame becomes the foreground frame, and vice versa. First the hex value AA is stored in a single memory address in segment #0of M1. The foreground frame is then exchanged to the background, and the hex value 55 is stored in the new foreground frame. Another exchange frame is called which, if everything happened according to plan, should leave the AA back in the foreground memory.

After checking the AA, an exchange frame is called one more time, and the new foreground is checked for the 55 value that was stored there earlier. The same test is then repeated for the other 15 segments.

Error messages - In the terminal diagnostic mode, a message is displayed after checking each of the sixteen segments.The error message will either indicate that the segment checked out OK, or it will say that when it was expecting to read a hex value of ??, it in fact found a hex value of ??. In front panel mode, the error value represents the number of segments in which an error was encountered. In cycle mode, any errors are counted as 1 error per pass.

7- M1/M2 SWAP TEST

Because the only memory that can be read from, and written to directly is the foreground frame of M1, the M2 memories can only be accessed by swapping the information in M2 to M1. The result of a swap leaves the foreground of M2 in M1, and vice versa. The swap test first clears both M1 and M2 foreground memories, and then the value 55 hex is stored to a single address of segment #0, and written to M1. The entire frame is then swapped to M2, and a hex AA is stored in the same address of the cleared frame that is now in M1. A swap is performed again and a check is made to verify that the 55 was swapped back to M1. Once more a swap is performed and this time an AA is expected in M1.

Error messages- During the terminal diagnostic test an error message will be displayed indicating the result of the test. In front panel mode an error code "E1" means that an error was detected while trying to read the 55 hex, an "E2" means that the failure occurred when the AA was expected, and an "E3" indicates that both failed. Cycle mode returns a single error per pass if any errors occurred.

8- M2 CLEAR TEST

This test checks to see that a "clear frame" operation can be performed on memory M2. The hex value FF is written to an address in segment #0 of memory M1, then swapped to M2. M2 is then cleared using a clear frame operation, and swapped back to M1 to be checked for any bits that were not cleared.

Error messages- This test returns an error of 1 if it failed, and 0 if it passed.

9- M2 MEMORY TEST (takes approximately 3.5 min)

This test alternates every bit of the frame and checks the result. First the value 55 hex is written to each byte of the M1 frame, swapped to M2, swapped back to M1, read back and verified. The same is done using the hex value AA.

Error messages-Using the terminal diagnostics, an error message statement is returned for each segment declaring that either an error was found in that segment, or that the segment memory checked out OK. In the front panel test mode the an error code of "E1" indicates that the failure occurred during the first pass when the hex value 55 was written, and an error code of "E2" means that the error was discovered while expecting to read back AA hex. In cycle mode, the error value

accumulated during a single pass indicates in how many segments errors were found, for both bit masks. For example, if the error total was incrementing by 32 for each cycle, that would indicate that all 16 segments had at least 1 error during both the AA and 55 bit tests.

10- M2 EXCHANGE TEST

This test verifies that the "exchange frame" function is working for the M2 frames. First the hex value AA is stored in a single memory address in segment #0 of M1, and then M1 is swapped to M2. The foreground frame of M2 is then exchanged to the background. The hex value 55 is then stored in M1 and then swapped to M2. Another exchange frame is called, which should leave the AA back in the foreground memory of M2, with 55 in the background frame. After checking the AA, an exchange frame is called for M2, and the new foreground is checked for the 55 value that was stored there earlier. The test is repeated for the other 15 segments.

Error messages - In the terminal diagnostic mode, a message is displayed after checking each of the sixteen segments. The error message will either indicate that the segment checked out OK, or it will say that when it expected to read a hex value of xx, it instead read a hex value of yy. In front panel mode, the error value represents the number of segments in which an error was encountered. In cycle mode, errors are counted as 1 error per pass.

11- CYCLE MEMORY TESTS

The cycle mode repeats the memory tests, keeps track of the number of cycles performed, and accumulates the number of errors. This type of test is especially useful in tracking down system failures that are intermittent, or of a thermal nature. One useful feature of this mode is the ability to select the tests to be included in the cycle, while ignoring the others.

NOTE: Most of the following tests write data to the foreground of memory M1. Although it is not possible to write data directly to M2, a "SWAP M1/M2" (option 16) allows any data in M1 to be swapped into M2.

12- WRITE VERTICAL GRAY SCALE

A vertical gray scale is written to M1.

13- WRITE HORIZONTAL GRAY SCALE

A horizontal gray scale is written to M2.

14- INVERT M1 DATA

Inverts the data in the foreground of M1 byte by byte.

15- EXCHANGE M1 DATA

Exchanges the foreground memory of M1 for the background memory by switching address lines.

16- EXCHANGE M2 DATA

Exchanges the foreground memory of M2 for the background by switching address lines.

17- SWAP M1/M2 DATA
A processing function of the Image Processor swaps the data in the foreground memory of M1 with the data currently in the foreground memory of M2.

18- DISPLAY LEFT MONITOR LIVE
The left monitor displays a live non-digitized picture, and the system allows X-rays. X-rays are disabled upon exiting this option.

19- DISPLAY LEFT MONITOR DIGITAL
The left monitor displays a digitized picture, and the system allow X-rays. X-rays are disabled upon exiting this option.

20- SELECT GRAY SCALE VALUE
This option allows the technician to choose what gray scale value to write write to M1. The system allows a value between 0 (black) and 200 (white).

21- CRT CHARACTER TEST
A block of text characters is written to M1 which can be used to verify that the monitors have been set up properly, allowing all text lines to be clearly visible.

22- FRONT PANEL TEST
Using the terminal diagnostics, the scan codes for each front panel key is displayed on the terminal when each key is pressed. With the front panel diagnostics the scan codes are displayed as hex values on the LED display.

23- VIDEO TEST PATTERN
This test draws a special video test pattern to M1, and uses that pattern on M1 as a mask to do a digitized subtraction on M2. X-rays are allowed during this option so that the camera can be properly centered. The instructions to the technician for aligning both the monitors and the camera are written to the monitors along with the pattern. X-rays are disabled upon exiting this mode.

24- FRONT PANEL LED TEST
The front panel LED test turns on all of the front panel LED's. The LED`s are all turned off again when the test is exited. When this test is initiated using the front panel diagnostics, the "HELP" key LED will flash to remind the technician how to exit this mode.

99- RETURN TO SYSTEM
Places the system at the diagnostics menu, where Return to System can be selected, returning normal operation with the same defaults and parameters used to begin with at power-up.

8.6 Monitor Cart Terminal Mode

The Terminal Mode requires the use of an externally connected computer terminal. (Refer to this in the Appendix under *Terminal Installation and Use*).

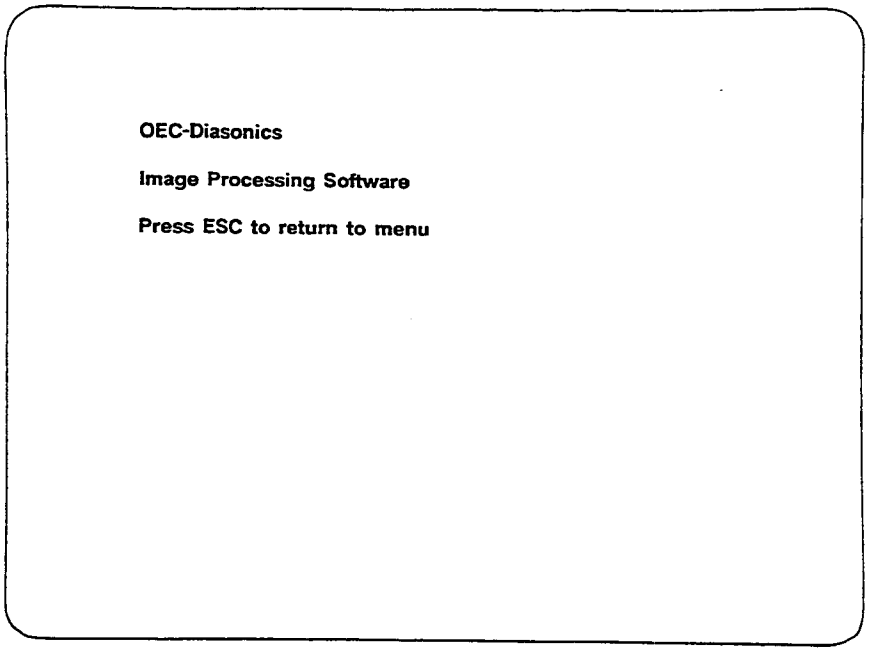
Some menu entries are passcode protected. Each attempt to select one of these protected entries generates an access code. A passcode is then required to unlock each access code. A new access code is generated with each access.

The major screen menus which can be accessed with a terminal are shown below.

8.6.1 Initial Menus

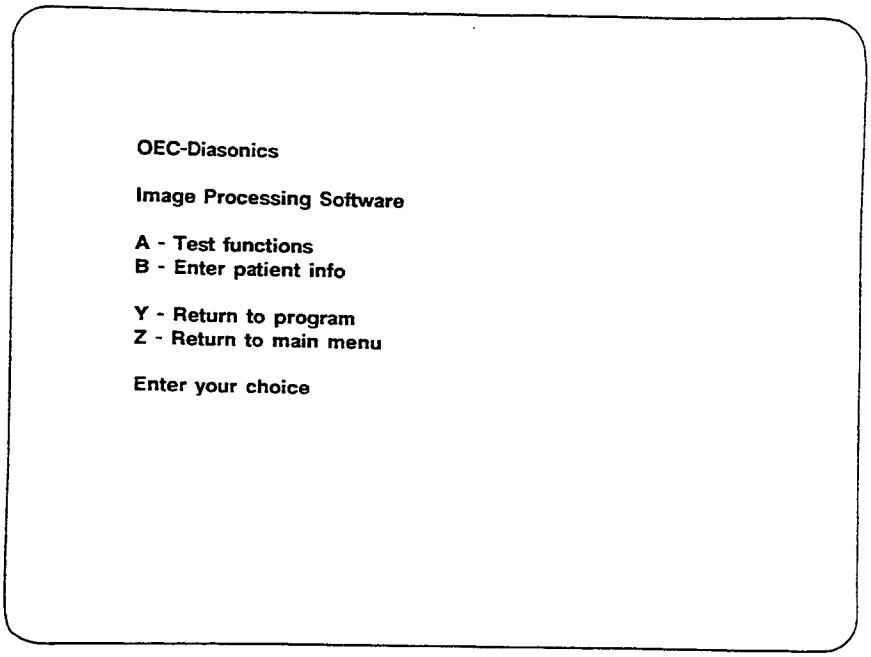
8.6.1.1 Powerup Screen Message

The powerup screen first appears when the terminal is turned on.



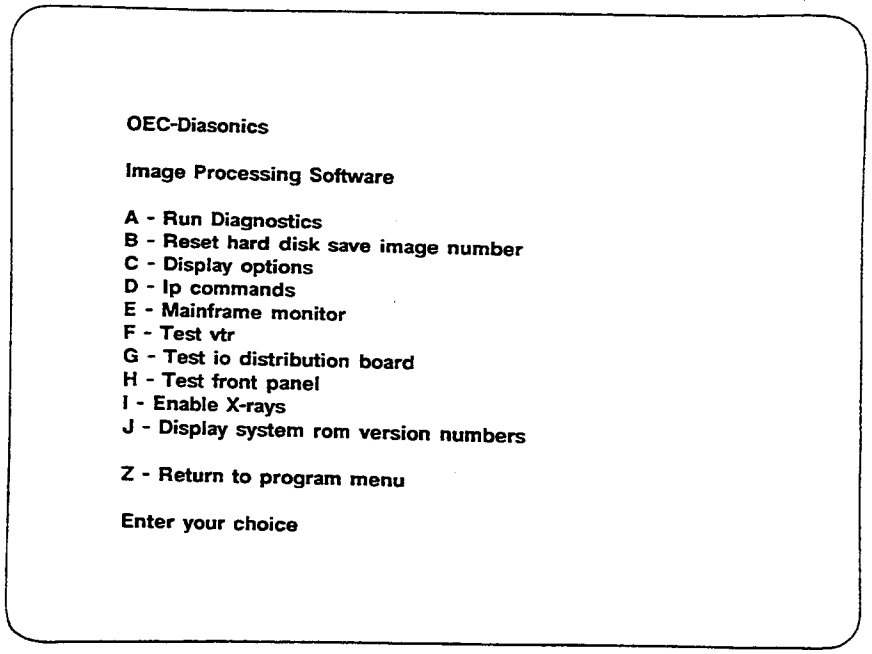
8.6.1.2 Program Access Menu

Press [ESC] for the Program Access Menu.

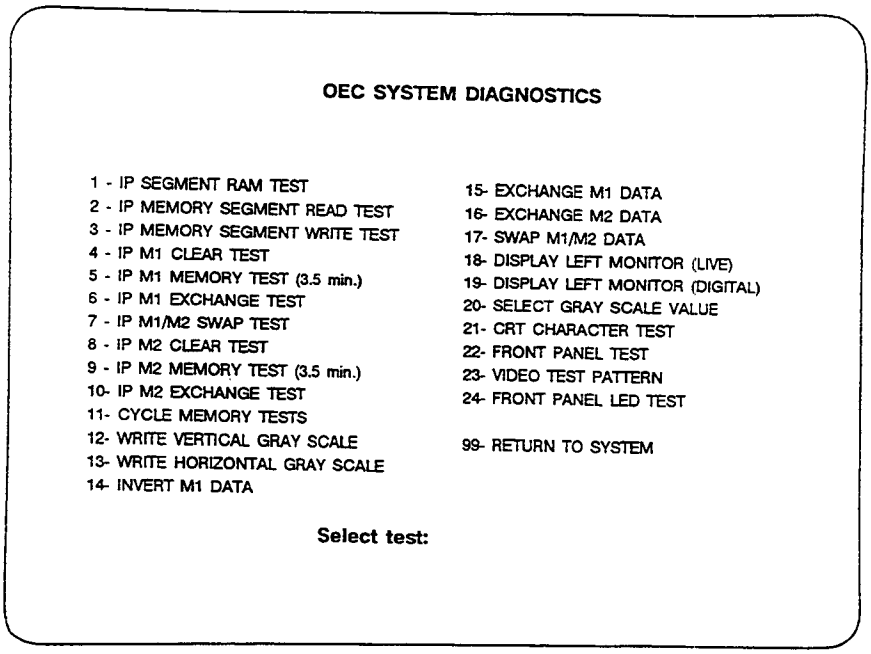


8.6.2 Test Function Menu

This menu lists test functions.

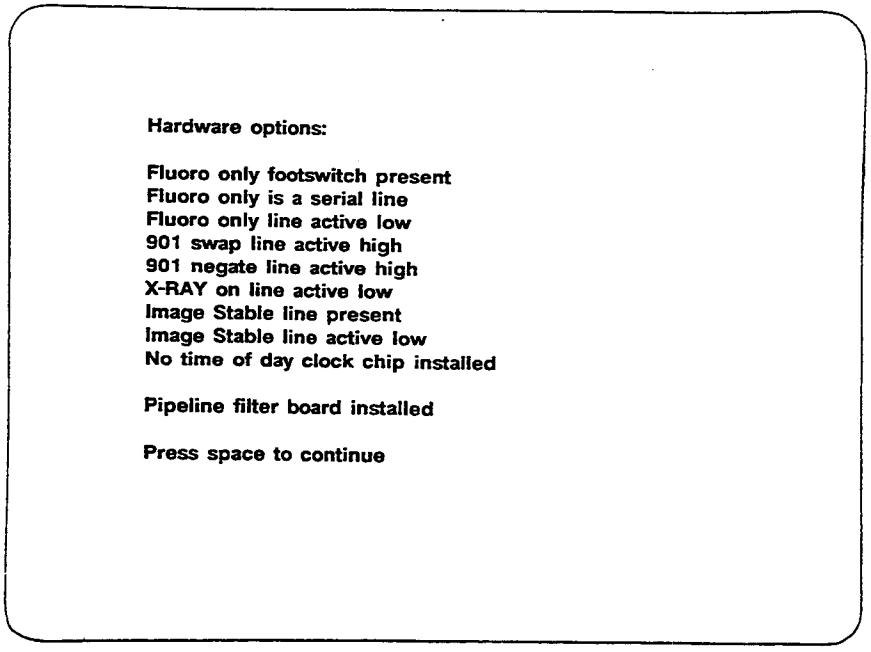


8.6.2.1 Run Diagnostics

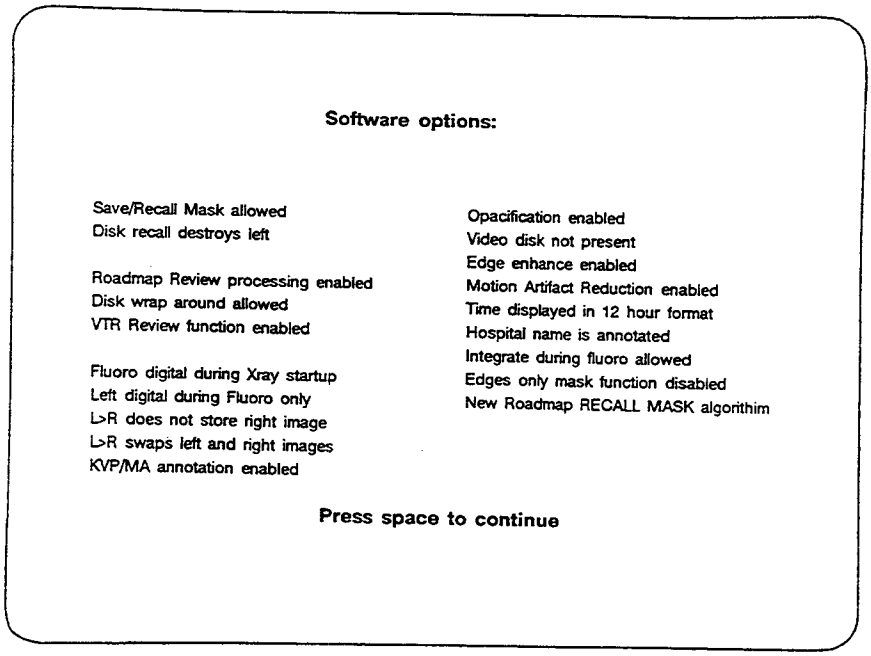


8.6.2.2 Display Options

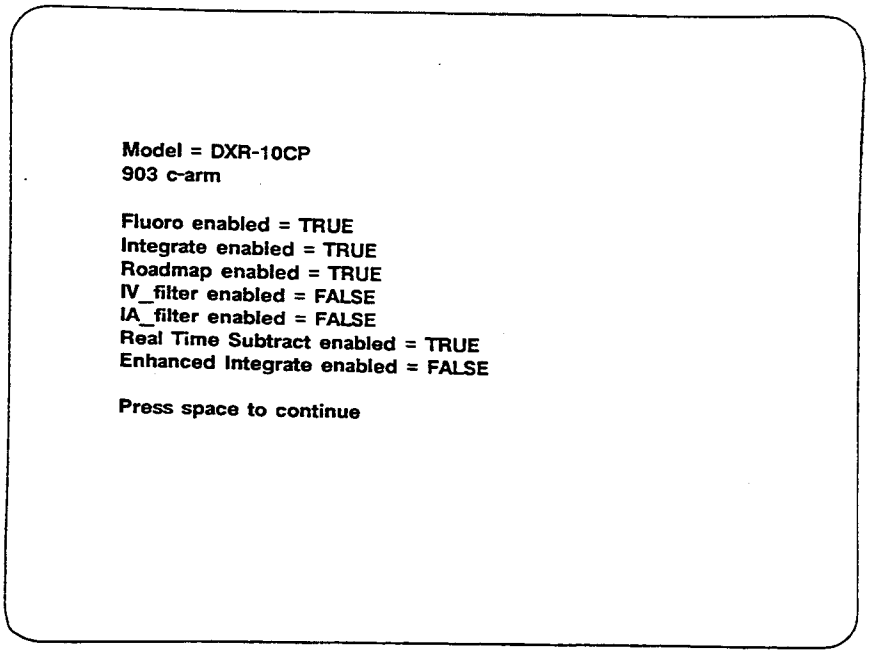
Hardware Options



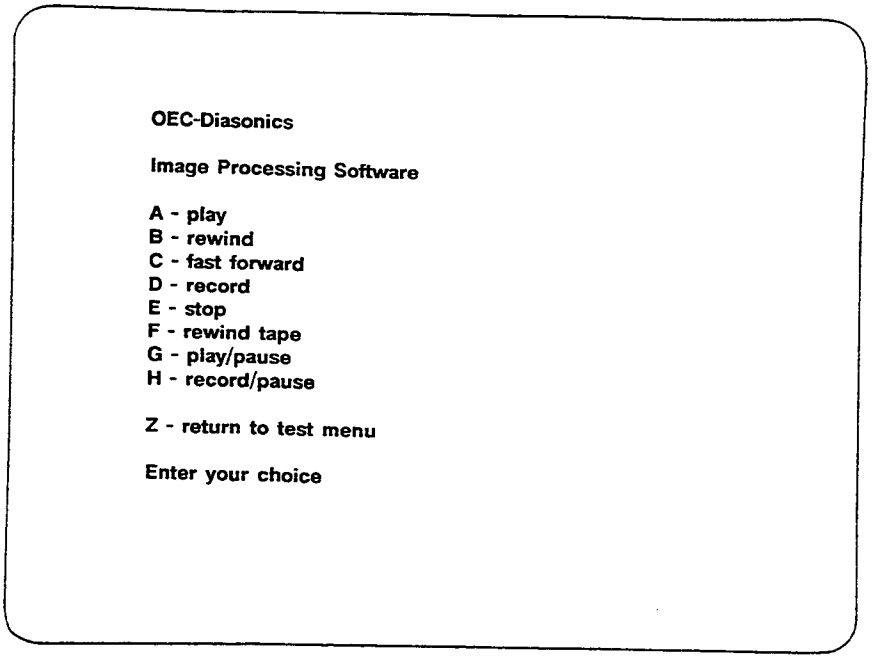
Software Options



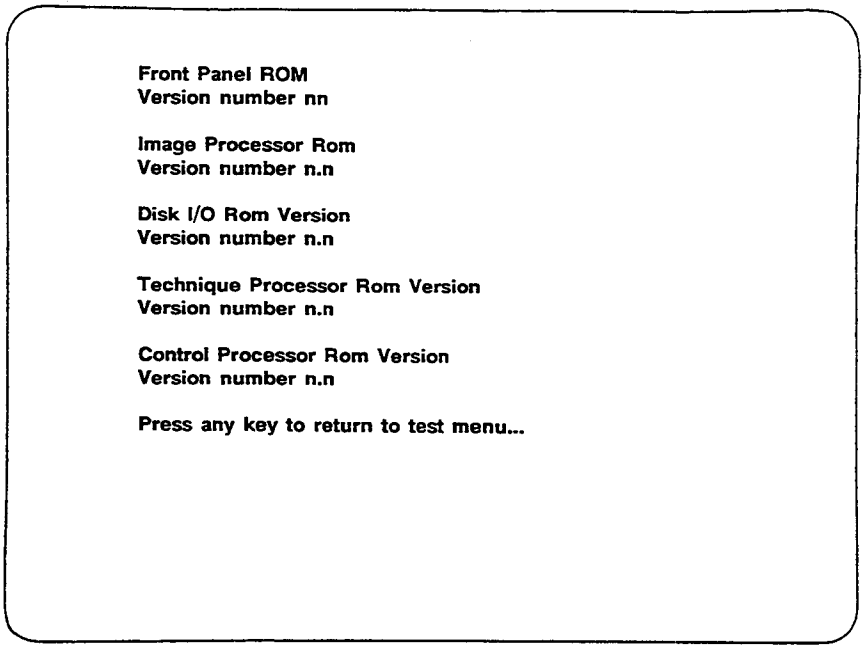
More Software Options



8.6.2.3 Test VTR



8.6.2.4 Display ROM Version Numbers



8.6.3 Main Menu

This menu can be accessed directly from the Program Access Menu.

```
OEC-Diasonics
System Software Manager
System ID Code:

A - Run Applications
B - Change system options
C - Run Diagnostics
D - Reboot to floppy disk
E - Load system software
F - Modify Terminal installation
G - Run Image Analysis
H - Examine shot log file
I - Erase shot log file
J - Transfer image files

Y - Access mainframe menu (903 only)
Z - Exit to DOS

Please make a selection:
```

8.6.3.1 Change System Options

```
OEC-Diasonics
Option change and display program
System Part No:

A - Hardware options
B - Software options
C - Mode options
D - Set power up default mode
E - Screen storage definitions
F - System relay definitions
G - Other byte options
H - Model number
I - Serial number

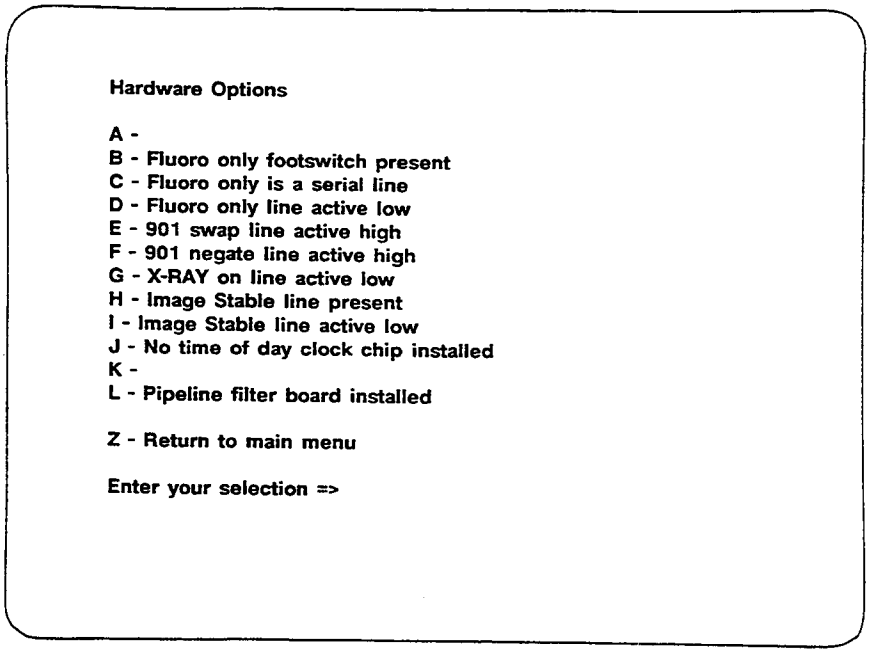
J - Hospital name

L - C-arm model number

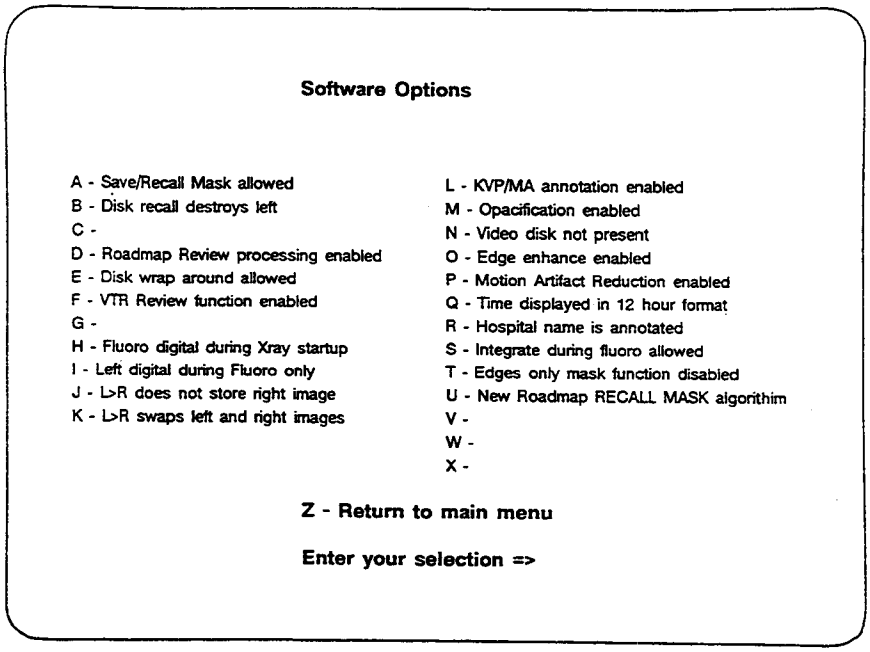
Y - Abort program, make no changes
Z - Exit program and update changes

Enter your selection =>
```

Hardware Options



Software Options



Mode Options (example)

```
Fluoro ENABLED

A - Enable Fluoro
B - Disable Fluoro
C - Change Fluoro default parameters

Z - Next processing mode

Enter your selection =>
```

Mode Options (example)

```
Integrate ENABLED

A - Enable Integrate
B - Disable Integrate
C - Change Integrate default parameters

Z - Next processing mode

Enter your selection =>
```

Set Powerup Default Mode

```
Current Power Up Mode = Fluoro

A - Fluoro
B - Integrate
C - Roadmap
D -
E -
F - Real Time Subtract
G -
H -

Z - No change

Enter your selection =>
```

Screen Storage Definitions

```
A - Pixels per scan line = 512
B - Scan lines per field = 240
C - Save and Recall start even field line number = 2
D - Save and Recall start odd field line number = 2
E - Display is    Interlaced

Z - Return to main menu

Enter your selection =>
```

System Relay Definitions

```
A - Normal closed relay setting
  = [K24,K22,K15,K7]
B - Normal video relay setting
  = [OUT,K30,K25,K22,K15,K8,K1,]
C - Xrays on relay setting
  = [OUT,K30,K24,K22,K15,K8,K1,]
D - Process video tape relay setting
  = [OUT,K30,K25,K15,K8,K4]
E - Review video tape relay setting
  = [OUT,K30,K25,K15,K10]
F - Process video disk relay setting
  = [K30,K25,K15,K8,K4]
G - Review video disk relay setting
  = [K30,K25,K15,K10]
Z - Exit

Enter your selection =>
```

Other Byte Options

This list is several screens in length and scrolls up as you progress down the list.

```
Log scale factor = 128
Change it? (Y or N) N

Fluoro window scale factor = 255
Change it? (Y or N) N

Fluoro level scale factor = 255
Change it (Y or N) N

Subtract window scale factor = 255
Change it? (Y or N) N

Subtract level scale factor = 160
Change it? (Y or N) N

Max hard disk value = 60
Change it? (Y or N) N

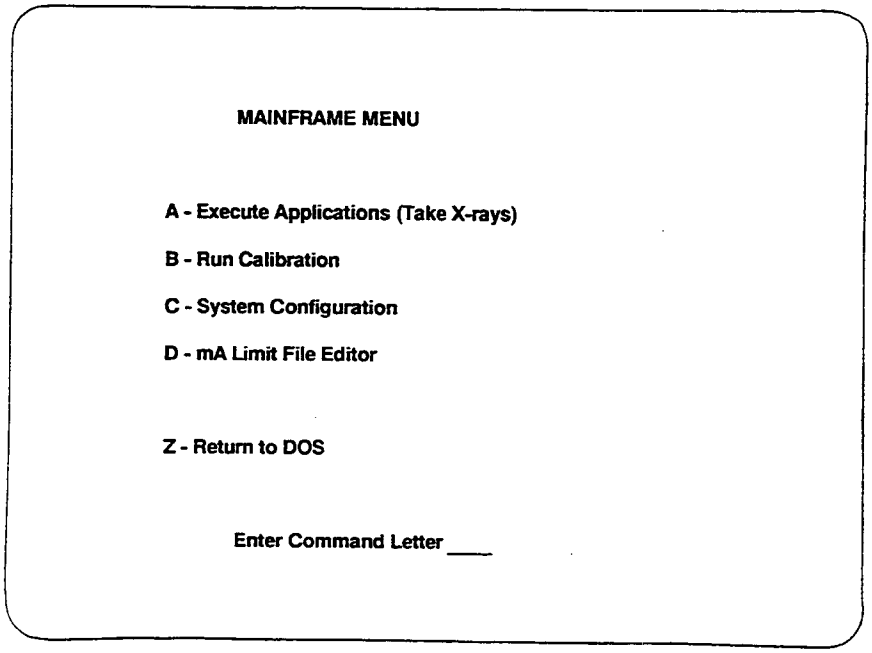
Subtract stable delay = 240
Change it? (Y or N)
```

8.6.3.2 Mainframe Access Menu

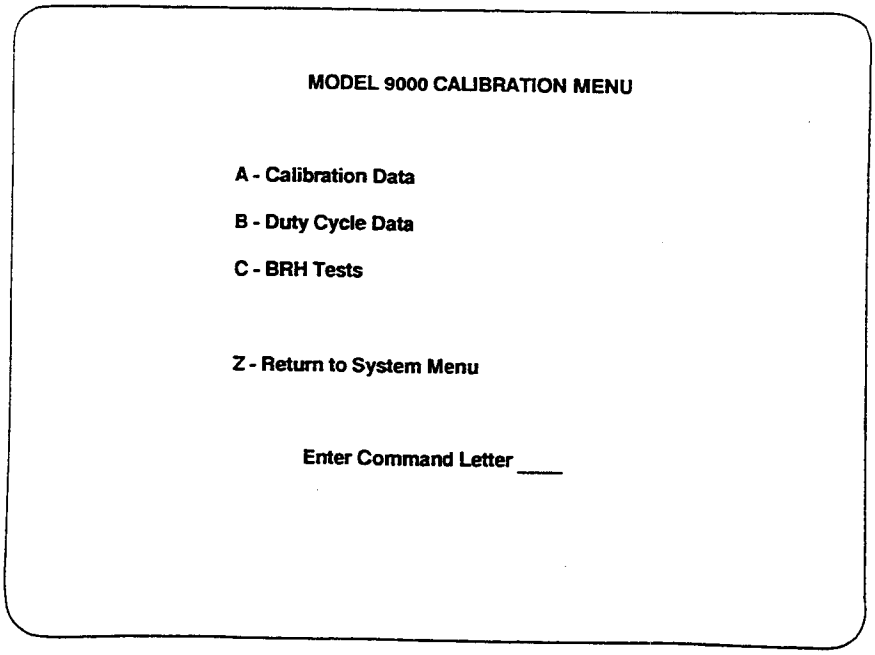
Select this menu from the monitor cart MAIN MENU.

When this menu is selected, the mainframe interlocks open to prevent X-rays.

To resume normal mainframe operation select "Execute Applications" from this menu.

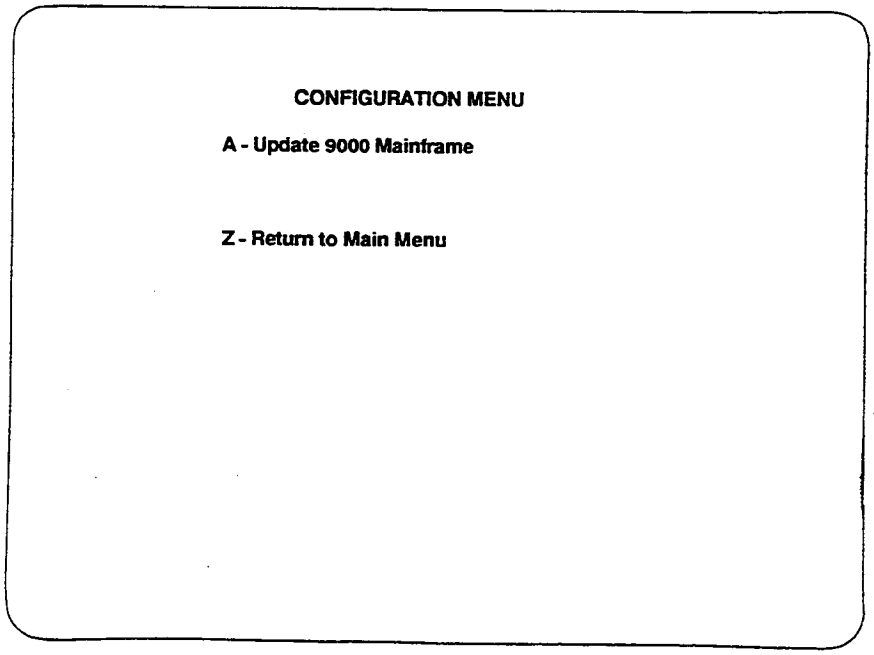


Model 9000 Calibration Menu



Configuration Menu

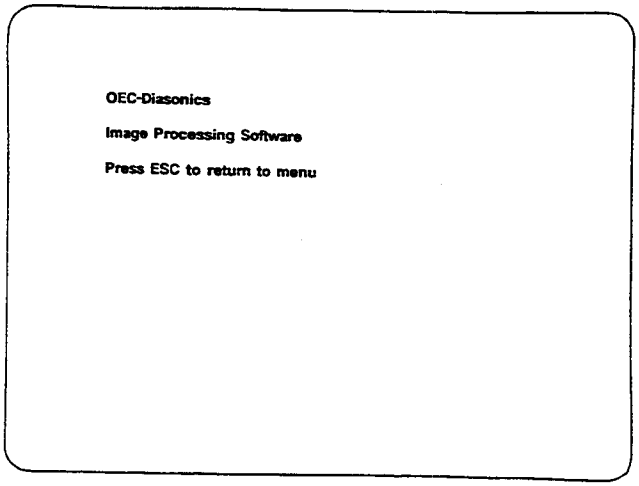
The Configuration Menu allows changes of boost operation and image tube size.



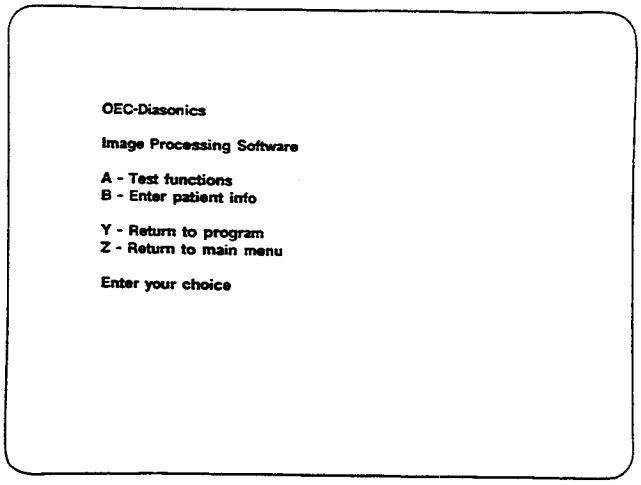
8.7 Examine Shot Log File

Shot Logging provides the field engineer with a record of the last 500 X-ray shots. This can be of value in evaluating X-ray tube history and performance.

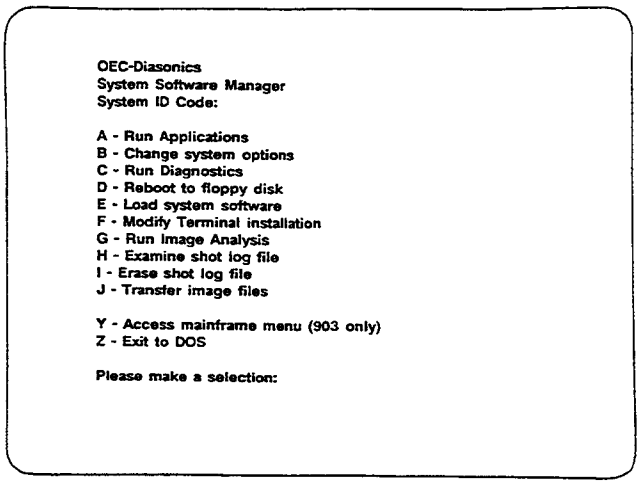
1. An external terminal must be connected to examine the shot log file. Press [ESC].



2. Enter [Z] and press [RETURN].

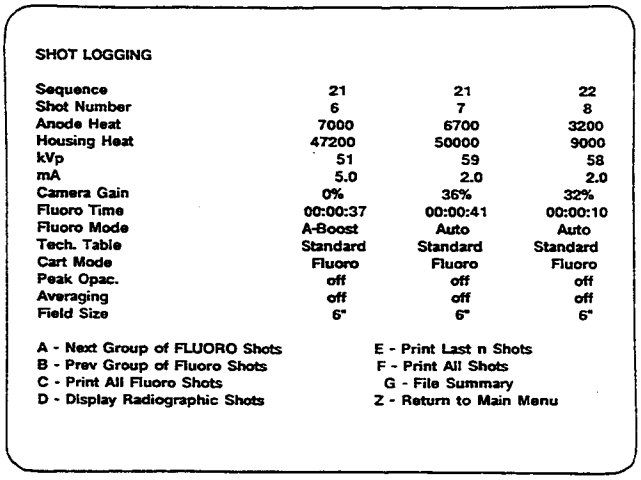


3. From the MAIN MENU, select entry [H] - EXAMINE THE SHOT LOG FILE.



4. A portion of the shot log file will appear on the screen with a command menu below.

From this menu enter:
C - Print all fluoro shots
E - Print last n shots
F - Print all shots
G - View overall shot summary
G, then P - Print shot summary



5. If a printout is desired, connect a printer using a printer cable such as P/N 870596 to the monitor cart AUX connector. Follow the instructions given in the Appendix for printer installation.

Figure 8-1 - *Here is a sample of a printout obtained by entering C - Print all Fluoro shots:*

10CPXXXX Cottonwood Hospital Page 1

Fluoro SEQ	Mode NUM	ANODE	HOUSING	KVP	MA	GAIN	ON-TIME	MD	CART-MODE	OPAC	AVG	FD
1	1	800	6500	61	2.2	36%	0:00:09	A	Fluoro	Off	Off	6"
2	1	400	19300	63	2.4	36%	0:00:05	A	Fluoro	Off	Off	6"
2	2	1400	21600	63	2.4	36%	0:00:13	A	Fluoro	Off	Off	6"
2	3	1300	27500	40	0.5	0%	0:00:13	A	Fluoro	Off	Off	6"
2	4	2000	29600	63	2.4	36%	0:00:19	A	Fluoro	Off	Off	6"
2	5	1400	45800	61	2.2	36%	0:00:22	A	Fluoro	Off	Off	6"
2	6	3000	50900	120	3.2	100%	0:00:29	A	Fluoro	Off	Off	6"
2	7	800	57800	40	0.5	0%	0:00:29	A	Fluoro	Off	Off	6"
2	8	3000	61300	40	15.0	0%	0:00:34	AB	Fluoro	Off	Off	6"
2	9	2900	61000	40	0.5	0%	0:00:47	A	Fluoro	Off	Off	6"
2	10	5500	66300	47	20.0	73%	0:00:51	AB	Fluoro	Off	Off	6"
2	11	13500	75800	47	20.0	44%	0:00:59	AB	Fluoro	Off	Off	6"
2	12	12900	79900	40	20.0	49%	0:01:01	AB	Fluoro	Off	Off	6"
2	13	23400	92500	40	20.0	73%	0:01:16	AB	Fluoro	Off	Off	6"
2	14	22300	95200	61	2.2	36%	0:01:24	A	Fluoro	Off	Off	6"
2	15	24100	98700	61	20.0	97%	0:01:26	AB	Fluoro	Off	Off	6"
2	16	32300	109300	61	20.0	88%	0:01:38	AB	Fluoro	Off	Off	6"
2	17	36000	119700	50	5.6	0%	0:01:49	AB	Fluoro	Off	Off	6"
2	18	37500	123600	42	20.0	58%	0:01:54	AB	Fluoro	Off	Off	6"
2	19	33700	130700	45	20.0	74%	0:02:00	AB	Fluoro	Off	Off	6"
2	20	29900	137300	120	3.2	100%	0:02:10	A	Fluoro	Off	Off	6"
2	21	29700	139100	62	2.3	36%	0:02:23	A	Fluoro	Off	Off	6"
2	22	28900	142600	64	2.5	36%	0:02:41	A	Fluoro	Off	Off	6"
2	23	17600	146600	62	2.3	36%	0:03:08	A	Fluoro	Off	Off	6"
3	1	0	11700	50	2.0	10%	0:00:00	P	Fluoro	Off	Off	6"
3	2	0	11700	50	2.0	43%	0:00:00	P	Fluoro	Off	Off	6"
3	3	0	11700	50	2.0	99%	0:00:01	P	Fluoro	Off	Off	6"
3	4	0	11600	50	2.0	99%	0:00:01	P	Fluoro	Off	Off	6"
3	5	0	11600	50	2.0	99%	0:00:02	P	Fluoro	Off	Off	6"
3	6	0	11600	50	2.0	99%	0:00:02	P	Fluoro	Off	Off	6"
3	7	0	11600	50	2.0	99%	0:00:03	P	Fluoro	Off	Off	6"
3	8	0	11600	50	2.0	99%	0:00:03	P	Fluoro	Off	Off	6"
3	9	0	11600	50	2.0	99%	0:00:04	P	Fluoro	Off	Off	6"
3	10	0	11600	50	2.0	99%	0:00:04	P	Fluoro	Off	Off	6"
3	11	0	11600	50	2.0	99%	0:00:05	P	Fluoro	Off	Off	6"
3	12	0	11600	50	2.0	99%	0:00:05	P	Fluoro	Off	Off	6"
3	13	0	11500	50	2.0	99%	0:00:06	P	Fluoro	Off	Off	6"
3	14	0	11500	50	2.0	99%	0:00:06	P	Fluoro	Off	Off	6"
3	15	0	11500	50	2.0	99%	0:00:07	P	Fluoro	Off	Off	6"
3	16	0	11500	50	2.0	99%	0:00:07	P	Fluoro	Off	Off	6"
3	17	0	13000	50	2.0	99%	0:00:08	P	Fluoro	Off	Off	6"
3	18	0	13000	50	2.0	99%	0:00:08	P	Fluoro	Off	Off	6"
3	19	0	13000	50	2.0	99%	0:00:09	P	Fluoro	Off	Off	6"
3	20	0	13000	50	1.5	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	0	13000	50	1.1	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	13000	50	0.7	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	36%	0:00:08	A	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0:00:10	A	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6"

Figure 8-2 - *Here is a sample printout obtained by entering G - File Summary, then P - Print Summary.*

10CPXXXX Cottonwood Hospital Summary

Total shots..... 190
Total sequences..... 25

Highest Anode Heat.... 37500
Sequence.... 2
Number.... 18
Average Anode Heat.... 4301

Highest Housing Heat.. 146600
Sequence.... 2
Number.... 23
Average Housing Heat.. 34455

Total Radiographic Shots....9
Neo-Natal Shots....0

	0.3mm	1.0mm
Number of shots	9	0
Average KVP used	57	0
Average MAS used	43	0

Total Fluoro Shots.....181

	Auto	Manual	A-Boost	M-Boost	Pulsed	One-Shot
Number of shots	128	12	19	0	0	22
Average KVP used	66	80	52	0	0	50
Average MA used	2	4	15	0	0	2
Average GAIN used	39%	74%	29%	0%	0%	92%

Technique Table	Standard	Modified	Custom
Number of shots...	181	0	0

	Fluoro	Integrate	Roadmap	IV-filter	IA-Filter	Subtract
Number of shots	134	8	17	0	0	22
Opacified shots	0	0	1	0	0	0
Averaging Off	126	0	12	0	0	21
Averaging of 2	0	0	0	0	0	0
Averaging of 4	1	2	4	0	0	1
Averaging of 8	2	0	1	0	0	0
Averaging of 16	0	0	0	0	0	0
Averaging of 32	5	6	0	0	0	0
Averaging of 64	0	0	0	0	0	0
Averaging of 128	0	0	0	0	0	0

8.8 Monitor Cart Adjustments, Switches and Jumpers

8.8.1 I/O Distribution/Video Switch PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	OUT	Bit PA7
E4-E5-E6	OUT	Bit PA6
E7-E8-E9	E8-E9	Bit PA5 X-ray On
E10-E11-E12	E11-E12	Bit PA4 Video Stable
E13-E14-E15	E14-E15	Bit PA3 Store

Adjustment **Floppy Disk Voltage Adjustment**

Adjust R24 on this PCB for +12 VDC between TP19 and TP20.

8.8.2 AD/DA Converter PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Video buffer and sync separator
E4-E5-E6	E5-E6	Buffered Video select
E7-E8-E9	E8-E9	Video Sync Select

Adjustment **Circular blanking**

Vertical	R47, R45
Horizontal	R48, R50

Adjustment **Offset Adjustment**

(Adjust blanking level to 0 VDC)

Left video (P5) offset	R2
Right video (P6) offset	R1

8.8.3 Sync Separator PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Video Source Select

8.8.4 Image Processor PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2	IN	U8 Vertical Reset
E3-E4	IN	Timing Clock Output
E5-E6	IN	U8 Horizontal Reset
E7-E8	IN	A12
E9-E10	IN	A13
E11-E12	IN	A14
E13	OPEN	Ground
E14-E15-E16	E15-E16	No CPU Wait States

Adjustment **Gen-lock Adjustment**

1. Place scope probe on TP27 and TP5 (ground) and adjust C-6 for + 2.5 VDC.

2. Verify that the video is stable and displayed in the center of the circular blanking window.

8.8.5 Disk Interface PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E58-E59	IN	Reset Circuit
E53-E54	OUT	Reset Circuit
E21-E29		
E28-E36	E25-E33	1200 Baud, Front Panel and Mainframe
E37-E45		
E44-E52	E41-E49	1200 Baud, External Ports
E17-E18-E19	E17-E18	DTR handshaking
E55-E56-E57	E56-E57	X-ray disable pullup
E62-E63-E64	E62-E63	DRAM Controller Reset

Disk Interface U8 DIP Switch Settings

(1=on 0=off)
8 7 6 5 4 3 2 1

1	autoboot
0	use DMA
1	50 Hz operation
0	60 Hz operation
0	1024 bytes/sector
x	reserved
0 0 0	Miniscribe HD
0 0 1	Fujitsu
0 1 0	Tandon, IMI, Seagate

8.8.6 Pipeline Filter PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Memory Out Disable

8.8.7 Remote Contrast/Brightness PCB

Set the following jumpers according to the type of monitor installed.

DATA-RAY MONITOR	*ELSTON MONITOR*
E2	E1
E7	E8
E5	E6
E3	E4

8.9 Formatting the Hard Disk

If the Hard Disk requires formatting (after replacement or because of a format problem) follow this procedure:

CAUTION **Formatting the hard disk will erase all data and programs. The monitor cart is then unusable until the software has been recopied from a source floppy disk.**

1. Connect an external computer terminal to the serial communications connector on the rear of the cart. Follow the instructions for using the external keyboard and monitor found in the Appendix.

2. Follow the instructions in the Appendix for installing the external floppy disk drive.

3. Insert the system floppy disk into the floppy drive.

4. Format the hard disk using the following menu sequence:

   (ESC) Select Program Menu
   (Z) Return to Main Menu
   (D) Create Hard Disk System

5. Enter the correct hard disk model, the correct line frequency, and hit the RETURN key. The hard disk will be formatted and system information will be copied to it. This takes about 20 minutes to complete.

6. After the format and copy sequence is complete, turn the video circuit breaker off. Disconnect and remove the floppy drive.

7. Turn the video circuit breaker on again and verify that the system will boot from the hard disk.

8. Enter the model number at the terminal using the following menu sequence:

   (ESC) Select Program menu
   (Z) Return to Main Menu
   (B) Change System Options
   (G) Model Number

9. After entering the correct access code, enter the model number. Access Codes are available by telephoning 800-453-8412.

10. Select (H) Serial Number. After entering the correct access code, enter the serial number of the machine.

11. Exit the main menu (Z) and update the changes made in the last two steps.

SECTION 9
CALIBRATION

9.1 Introduction

This section contains procedures used to test and calibrate the OEC-Diasonics Series 9000 System.

The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9000 System.

9.1.1 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 have been properly installed and correctly wired. It is further assumed that all subassemblies are without defect and 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 for use before beginning the calibration.

9.1.2 Test and Calibration Outline

The calibration procedures are presented in the following order:

i. Preparation
ii. Electrical Checks
iii. Mechanical Checks
iv. Functional Checks
v. Beam alignment
vi. X-ray Calibration
vii. Dose Calibration
viii. Imaging Chain
ix. Accuracy Verification
x. Special Image Processing and Monitor Cart Tests

9.2 Safety Precautions

WARNING: **The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9000 System.**

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.

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.

9.3 Preparation and Setup

9.3.1 Record the Test Equipment Used

Record the information requested on the Worksheet.

9.3.2 Preparation and Inspection

1. To prevent the mainframe from rolling, position the front and rear wheels at right angles to each other . To keep the monitor cart from rolling, engage the monitor cart wheel locks.
2. Turn the keyswitch to OFF.
3. Unplug the power cord on the monitor cart.
4. Inspect the interconnect cable; make sure the interconnect cable is permanently attached by its bracket to the monitor cart.
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 conductive casters on both the mainframe and the monitor cart for proper pressure and freedom of movement.
8. Remove the front, rear, and left side panels from the monitor cart and the left, right and rear covers from the mainframe.
9. Connect the terminal to the mainframe as instructed in the Appendix.

9.4 Electrical Tests

9.4.1 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 100 uA (or other value specified by the user) in any of certain standard test configurations. *Leakage currents in excess of 100 uA may be recognized as unsafe in equipment of this type.*

1. Unplug the line cord.

2. Complete the measurement according to the instructions applicable to the available test device.

3. If leakage currents exceed the user's specifications during any of the preceding tests, the system under test has failed this test section. Document the fault and corrective action taken on the worksheet.

9.4.2 Ground Continuity

1. Disconnect the power cord and connect the interconnect cable between the monitor cart and the mainframe.

2. Check the continuity of the system ground between the mainframe and the monitor cart. Resistance shall be less than 0.5 ohms.

3. Measure the continuity of each power plug ground pin to its corresponding chassis. Resistance shall be less than 0.5 ohms.

9.4.3 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:

$$100\ (Vn - V1)/\ (V1)$$

where: Vn = No load voltage
V1 = 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.

9.4.4 Monitor Cart Power Supplies

1. Unplug the system power cord from the wall outlet.

2. Inspect the following power supply connections to the monitor cart electronics:

Disk Controller PCB supply	P-10
Hard disk power supply	P-3
I/O Dist.-Video Switching PCB	P-2 & P-3
Front Panel Processor PCB	J-21
Black and yellow wires	TV monitors

3. Plug the power cord into the wall. Turn on the CART POWER circuit breaker. Verify that the three cooling fans in the base of the cart are running.

4. Measure the output of the TV monitor power supply. It should measure +24 volts DC.

5. Measure the following voltages relative to DC Common (PS-1 pin 7):

PS-1 pin 12	+5 volts DC	red wire
PS-1 pin 6	+15 volts DC	gray wire
PS-1 pin 5	-15 volts DC	violet wire
PS-1 pin 4	+24 volts DC	yellow wire
PS-1 pin 3	-5 volts DC	blue wire

6. Check for the correct AC line voltage at the rear monitor cart AUX outlets.

9.4.5 Mainframe Power Supplies

1. Turn on the mainframe keyswitch.

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

WARNING: * F2 and F3 carry line voltage whenever the power cord is plugged in.

9.5 Mechanical Checks

In the steps below, check for ease of movement without excessive play.

1. Check the **foot lever and steering handle** for proper movement. Then lock the C-arm in place by setting the wheels at right angles to each other.

2. Check **Wig Wag** - horizontal swing of the C-arm from side to side.

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 proper action of 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. 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. Rotate the **L-arm** 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

9.6 Functional Checks

9.6.1 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 front panel. Refer to what these codes mean in the service sections of this manual.

3. Observe the Boot Codes on the mainframe LED panel and the Progress Codes on the monitor cart LED display as the operating software is loaded and the system is initialized.

4. If any of these codes remains on the LEDs and the system fails to complete its booting and initialization, refer to the listing of boot codes in the Mainframe Service Section or the listing of progress codes in the Monitor Cart Service Section.

9.6.2 Emergency Off and Processor Reset Test

1. With the system powered up, depress the **left** EMERGENCY OFF switch and make sure that the interlock circuit breaks and the LED display reads *INTERLKS BROKEN*.

2. Press any key, and then press the START switch to resume operation.

3. Again, with the system powered up, repeat step one using the **right** EMERGENCY OFF switch.

9.6.3 Status Mode Tests

Refer to the Mainframe 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 *LED 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).

9.6.4 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 make sure that the *NO CASSETTE* message does not appear.
5. Remove the cassette and observe that the *NO CASSETTE* does appear.
6. Rotate the C-arm to return the image intensifier below the X-ray tube.

9.6.5 Verify Operation of Mainframe Controls

WARNING: These tests produces X-rays. Take the 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 an LED 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 LARGE FIELD switch removes the 6-inch collimator by listening for the "thunk" sound produced when you press the switch.

5. Verify that the X-RAY ON lamps on the X-ray tube assembly, control panel and monitor cart light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

6. Verify operation of the footswitch.

7. Verify that early footswitch release will terminate the FILM exposure. The message *FOOT RELEASED* should appear on the control panel display.

9.6.6 Field Solenoid Position Test

This test verifies that the system can sense the position of the SMALL FIELD collimator.

1. Remove the bottom filtration plate on the collimator.

2. Place the system in the FLUORO mode and select the SMALL FIELD. Verify that the flipper returns to the 6-inch position.

3. Reach into the collimator and move the flipper (small field) collimator out of the center.

   Verify that the control panel displays the message *FLIPPER STUCK.*

4. Release the collimator and allow it to return to center.

5. Place the system in the FILM mode and select the LARGE FIELD.

   Verify that the flipper (small field) collimator moves out of the center.

6. Reach into the collimator and hold the flipper in the LARGE FIELD position. While holding the flipper in this position, select the SMALL FIELD from the front panel. The control panel should display the message *FLIPPER STUCK.*

7. Replace the filtration plate on the collimator.

9.6.7 Verify Controls in MANUAL FLUORO

1. Select MANUAL FLUORO mode.

2. Verify that kVp and mA can be controlled using the control panel knobs.

9.6.8 AUTO FLUORO Tests

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

1. Select AUTO FLUORO mode.
2. Switch to live video using the VIDEO BYPASS switch (on the monitor cart rear) and verify that true live video appears on the left monitor and that the TV monitors do not lose video sync.
3. Switch the VIDEO BYPASS switch to NORMAL.
4. Make a fluoro exposure and transfer the image to the right-hand monitor.
5. Make another exposure. The image will appear on the left monitor.
6. 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. 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 one set 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.

9. Verify operation of the left monitor's remote contrast and brightness controls on the mainframe control panel. (Set the left contrast control near the monitor screen to REMOTE).

9.6.9 Fluoro Boost Option

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

1. Enable BOOST on the control panel (if provided). Then to make the exposure, press down into the second position on the right footswitch.
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 image doesn't "burn out" or appear too dark.

9.6.10 Pulsed Operation

1. Enter the PULSE FLUORO mode.
2. Press X-ray On and verify pulsed operation when the button is pressed.

9.6.11 Verify Fluoro Timer and Timer Reset

1. In fluoro mode the accumulated exposure time is displayed in the center of the LED 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 should stop but the accumulated exposure display should not reset.
3. Press and hold the ALARM RESET for three full seconds. The accumulated timer display should reset to 0.

9.7 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

9.7.1 Preparation

1. Position the X-ray tube/image tube axis at a 45-degree angle to the floor. *Refer to Figure 9-1.*

2. Attach the beam alignment fixture and a loaded film cassette to the image intensifier assembly.

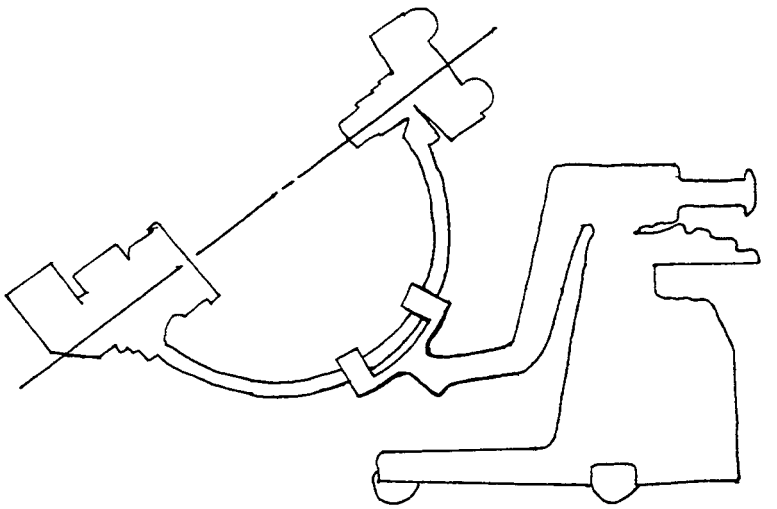


Figure 9-1 - *Position the imaging axis at a 45-degree angle to the floor.*

9.7.2 Radiographic Beam Alignment

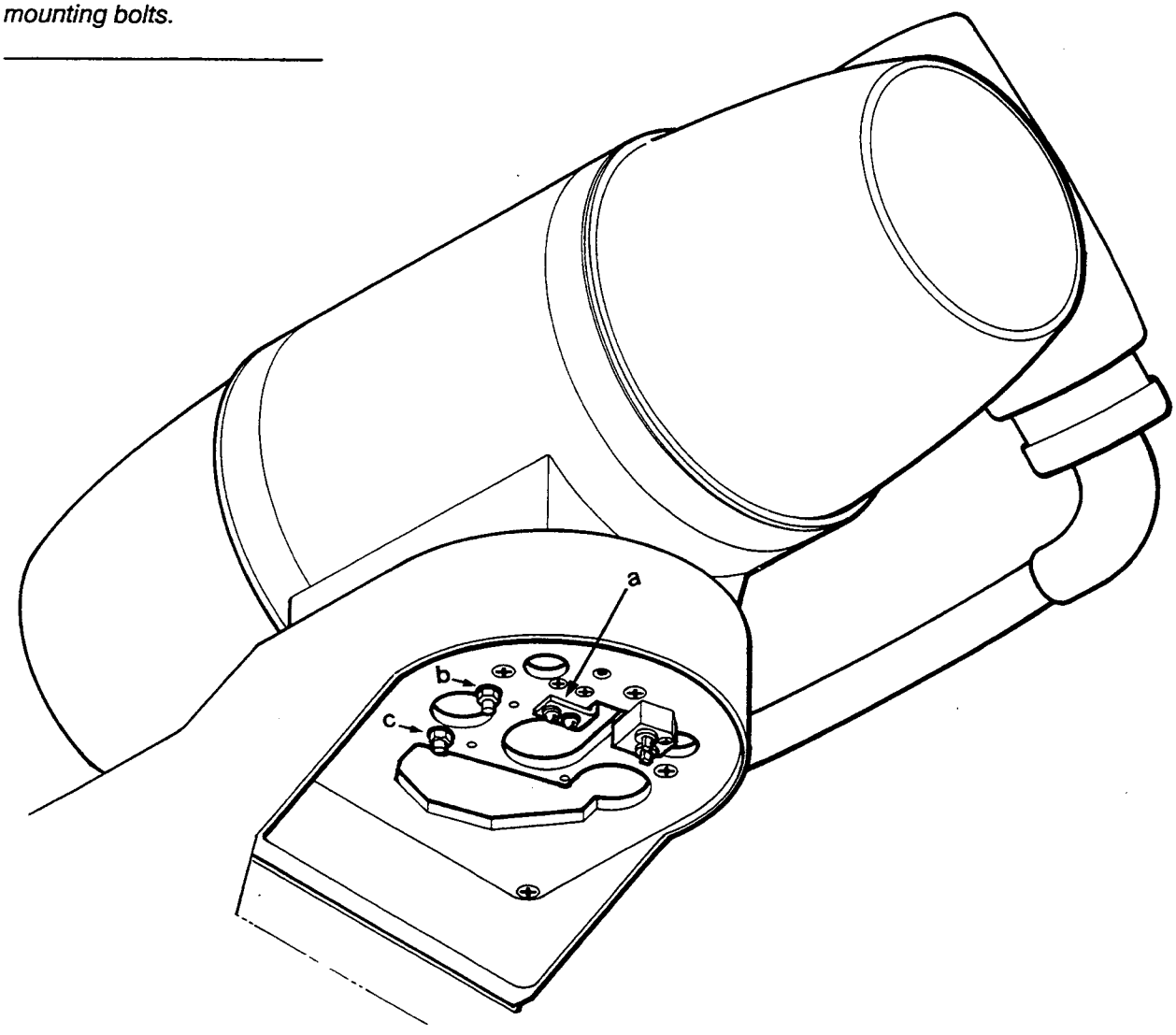
WARNING: This procedure produces X-rays. Take the appropriate precautions.

1. Set a radiographic technique of 50 kV 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 9-2 - *Adjust the shutter stop and the solenoid mounting bolts.*



4. Verify that the exposed area covers the entire large field.

5. If the beam is occluded 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:

   1. Remove the screws and cover plate from the X-ray head mounting assembly.

   2. 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.

   3. Make exposures as needed to verify the beam position.

   4. When the large field is properly centered, carefully retighten the locking screws avoiding any movement of the X-ray head as you tighten. Fine readustments may be needed as the eccentrics are tightened into place.

6. Remove the collimator assembly from the X-ray head, and select the small field.

7. Making exposures as required, adjust the 6-inch flipper stop (a) and the shutter solenoid mounting bolts (b & c) to center the 6-inch beam on the beam alignment fixture. *Refer to Figure 9-2.*

8. Check that the microswitch still functions properly.

9. Reinstall the collimator. Select the 6" field and make a radiographic exposure. Select the Large field and make another exposure on the same film.

   Check that the alignment of both fields is correct.

10. Complete the information on the film label and attach it to the upper right hand corner of the developed film.

11. Select the LARGE FIELD. Adjust the leaf collimator shutters to 6 x 6 inches and make an exposure.

12. Measure the actual size of the exposed area on the film. If necessary, loosen the set screws on the shutter adjustment knobs and adjust the collimator knobs to correspond to that size.

13. Tighten all set screws.

14. Set the radiographic technique to 50 kV and 1 mAs.

15. Make multiple exposures on a film with the shutters set to minimum, 4", 6" and 8". Label one shutter direction X and the other Y.

16. Measure the actual dimensions of the exposed areas. *The measured and actual dimensions should coincide within +/- 0.5 inch.*

    The dimensions of each field shall be as follows:

Minimum field -	less than 1.97", square *
4-inch field -	4" +/- 0.50", square
6-inch field -	6" +/- 0.50", square
8-inch field -	8" +/- 0.50", square

    * 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.

    Note: The corners of the 8" field will be clipped by the 10" collimating ring on 6" image intensifiers.

17. Record the measured values on the supplied label. Attach the label to the film.

18. On the exposed film obtained in step 15, mark each corner of the 6" area with a pen. Using a straight edge, connect the dots diagonally. *The intersection of the diagonal lines should fall within the center circle on the beam alignment fixture.*

19. Install the 0.5 mm aluminum filter on the collimator.

9.7.3 Fluoroscopic Beam Alignment

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

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. Set the video selector switch on the rear of the monitor cart to BYPASS.

5. 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 fluoroscopic test reticle should be visible around the entire input area of the image intensifier tube.

6. Return the video selector switch to NORMAL.

9.8 X-ray Calibration

9.8.1 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 is removed, disabling mA servo.
2. A series of exposures is 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.

Overview: mA/kVp Technique Calibration

1. mA servos are enabled (the mA jumper is replaced).
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.

9.8.2 Connections

Refer to Figures 9-3 and 9-4.

Connect the Dynalyzer III High Voltage Unit, Digital Display (DRO) III, Autocal Interface Box, and DVM to the mainframe electronics as shown in Figure 9-3.

NOTE: Refer to the general instructions for the Dynalyzer in the Appendix.

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.

Dynalyzer II

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.

Autocal Interface

Connect the autocal interface box to connectors J1 and J2 on the Analog Support PCB (cable part number 00-871432).

Figure 9-3 - *Connections between the Analog PCB and the calibration equipment.*

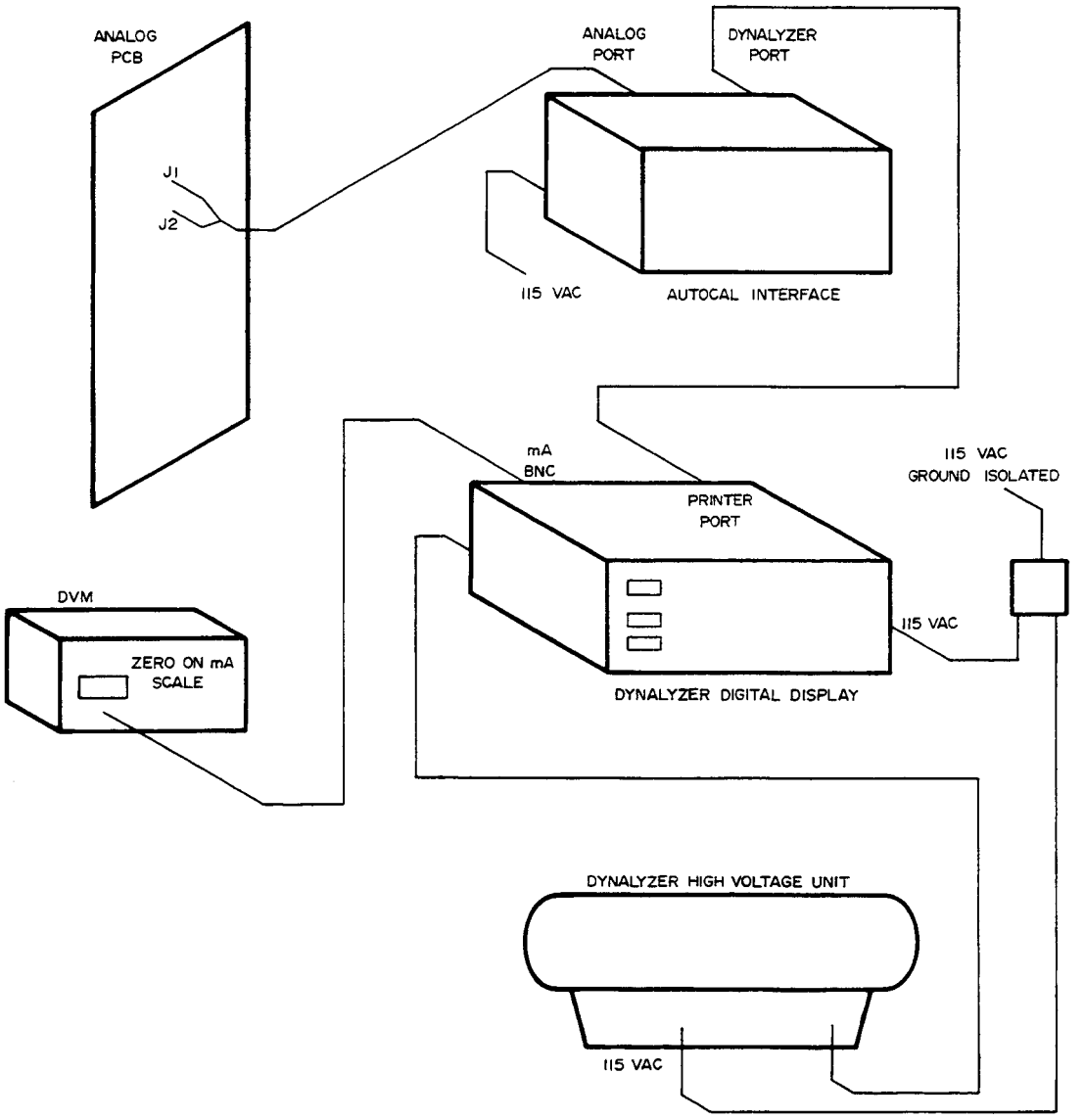


Figure 9-4 - *Connections are made between the back of the Analog PCB and the AutoCal Interface Box.*

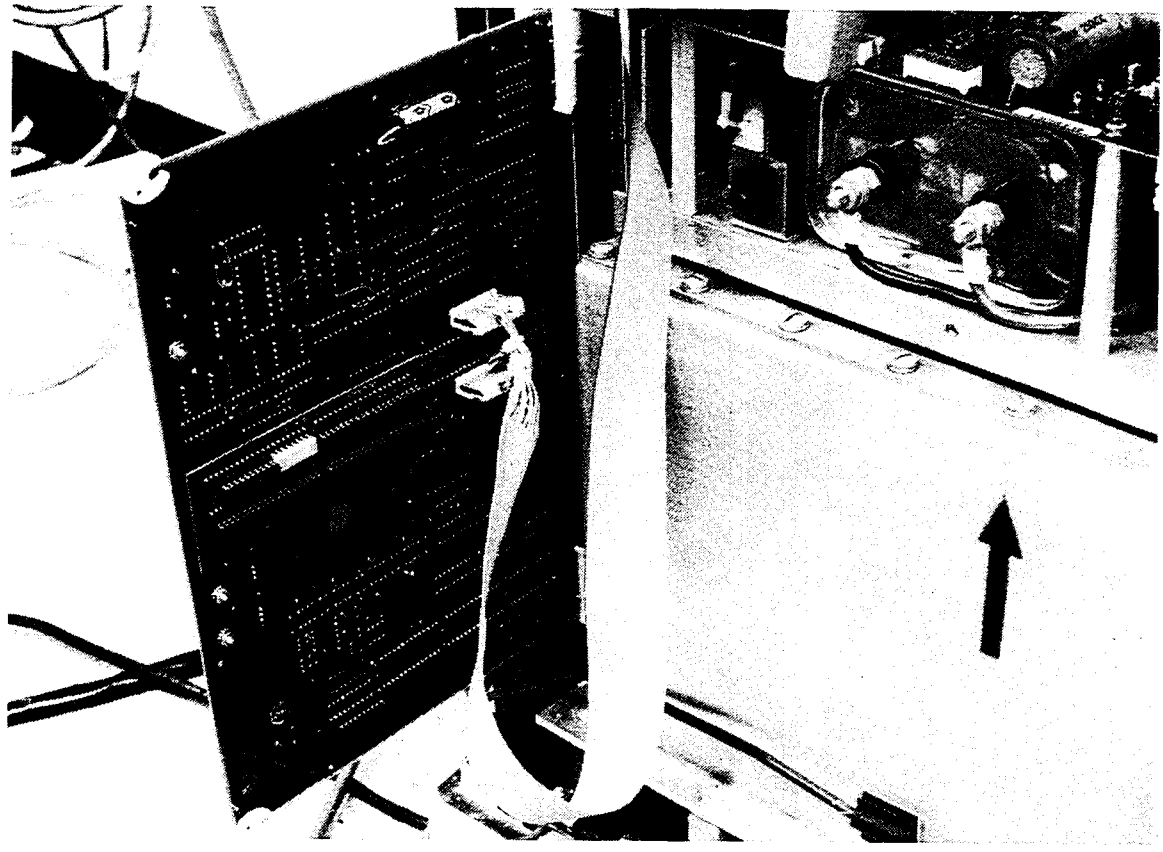
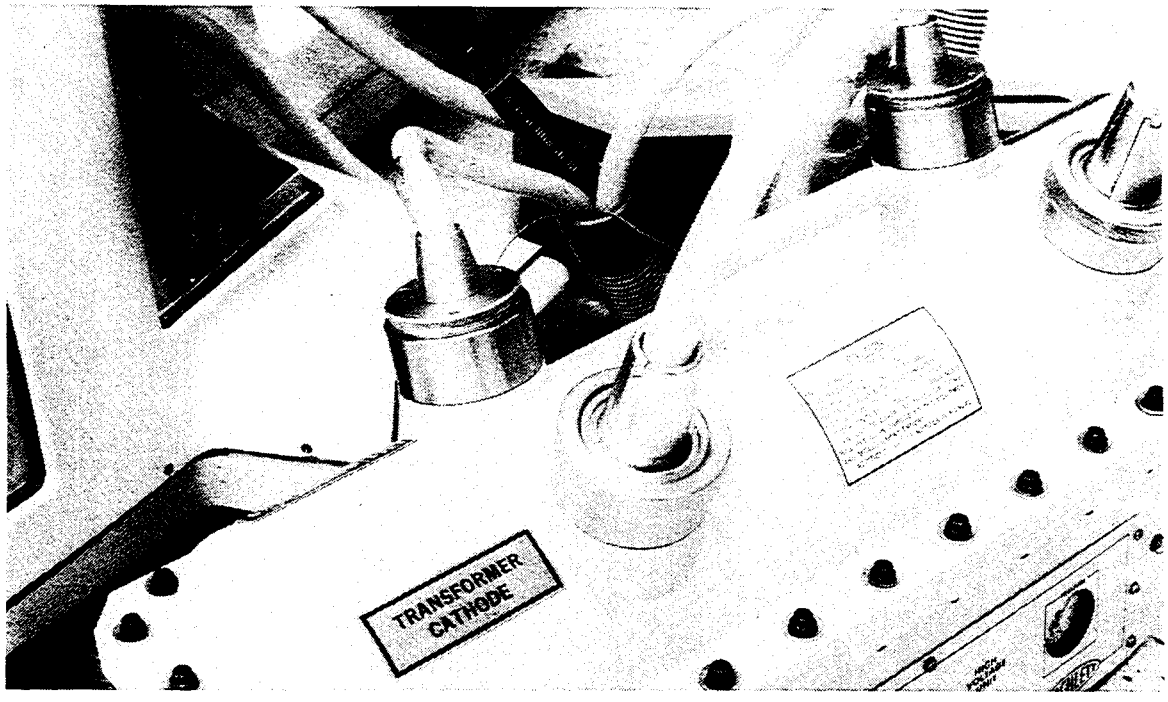


Figure 9-5 - *Refer to the Appendix for instructions on making the high voltage connections to the Dynalyzer High Voltage Unit.*



9.8.3 Setup

NOTE: Refer also to the general instructions for Dynalyzer use in the Appendix.

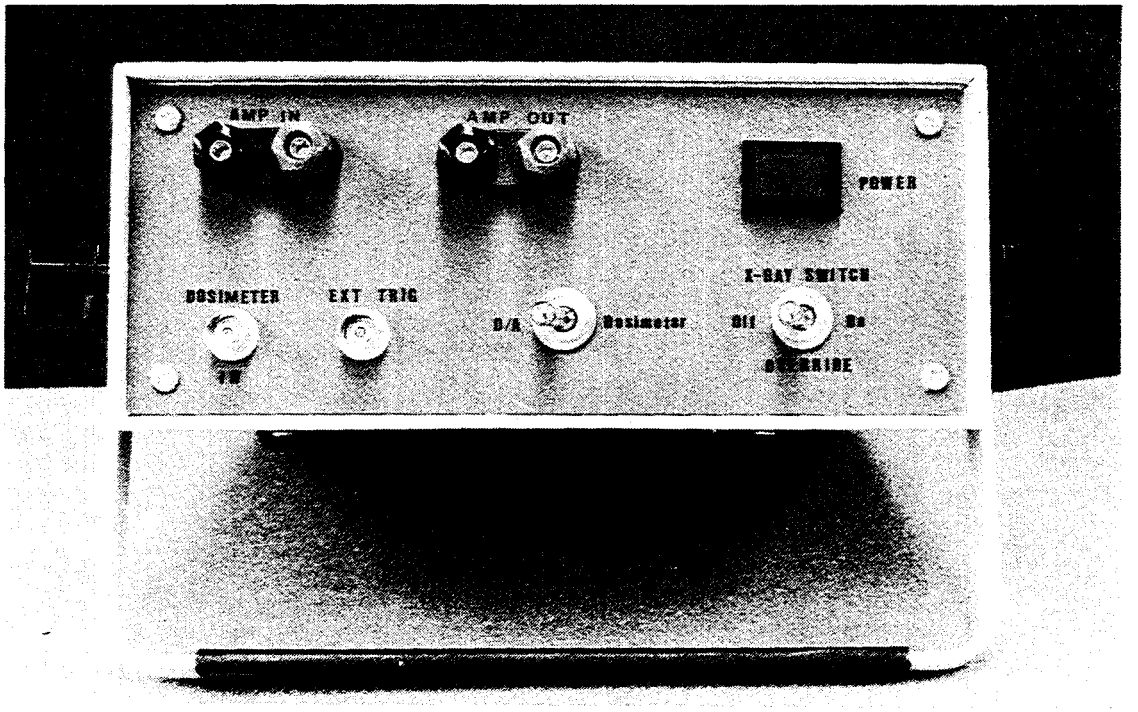
General Setup

1. Jumper across E3 on the Generator Controller PCB with a shorting plug to disable mA servo.
2. Turn on the power to all calibration equipment.

Autocal Interface Box

Refer to Figure 9-6. Turn X-ray Switch Override **ON**.

Figure 9-6 - *The AutoCal Box. Refer to the text for proper switch settings.*



Dynalyzer III High Voltage Unit

Refer to Figure 9-7. 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 9-7 - *The Dynalyzer III High Voltage Unit. Set the FLUORO/RAD switch as described in the text.*

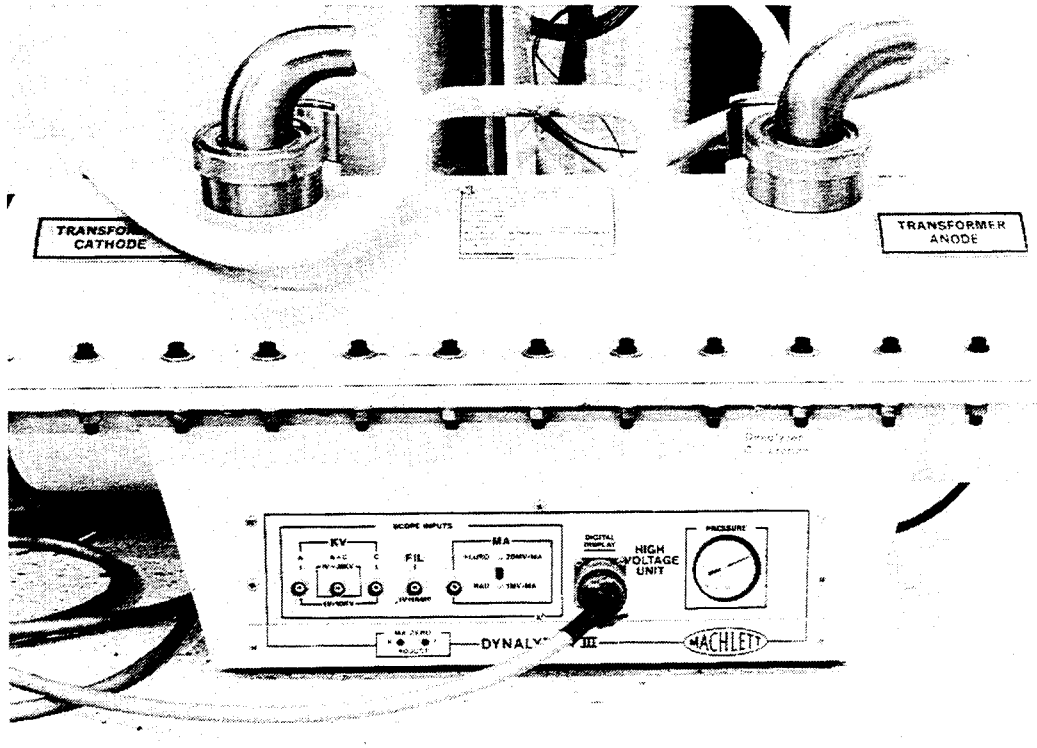
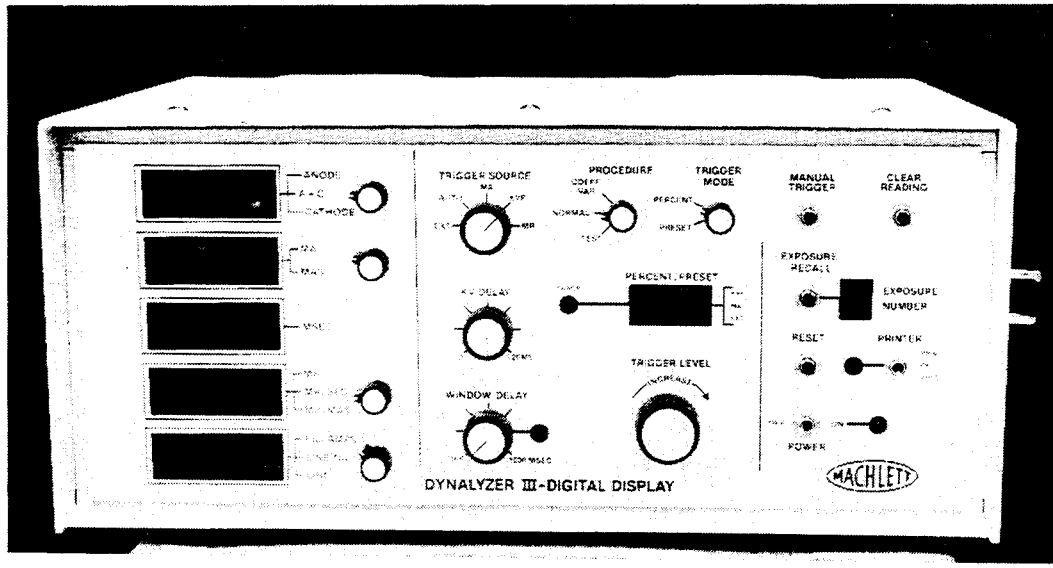


Figure 9-8 - *Dynalyzer III Digital Display*. Set the controls as described in the text.



Dynalyzer III DRO (Digital Display Unit)

Refer to Figure 9-8.

Set the controls as follows:

Displays:	**A+C,**	**mA**
Trigger Source:	**kVp**	
Procedure:	**NORMAL**	
Trigger Mode:	**PERCENT**	
kV Delay:	**20 ms**	
Window Delay:	**OFF**	
Trigger Level:	**50**	
Printer	**AUTO**	

Dynalyzer II High Voltage Unit

No special settings are required.

Dynalyzer II DRO (Digital Display Unit)

Refer to Figure 9-9.

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)		

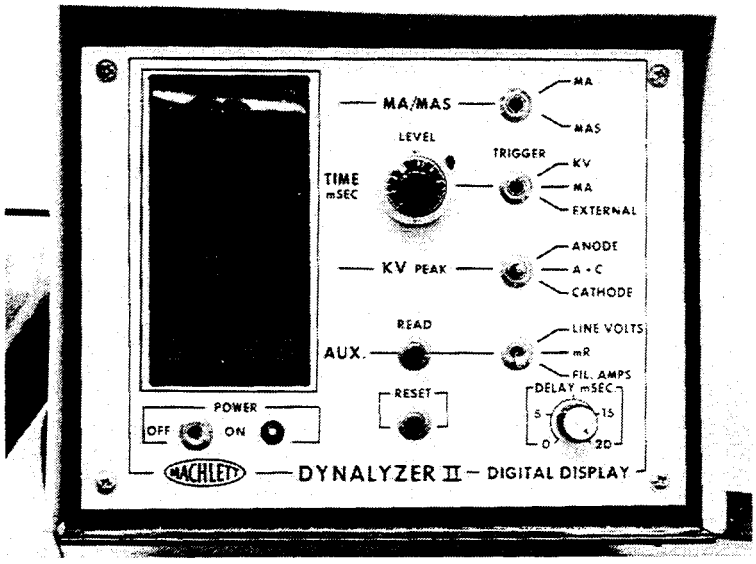
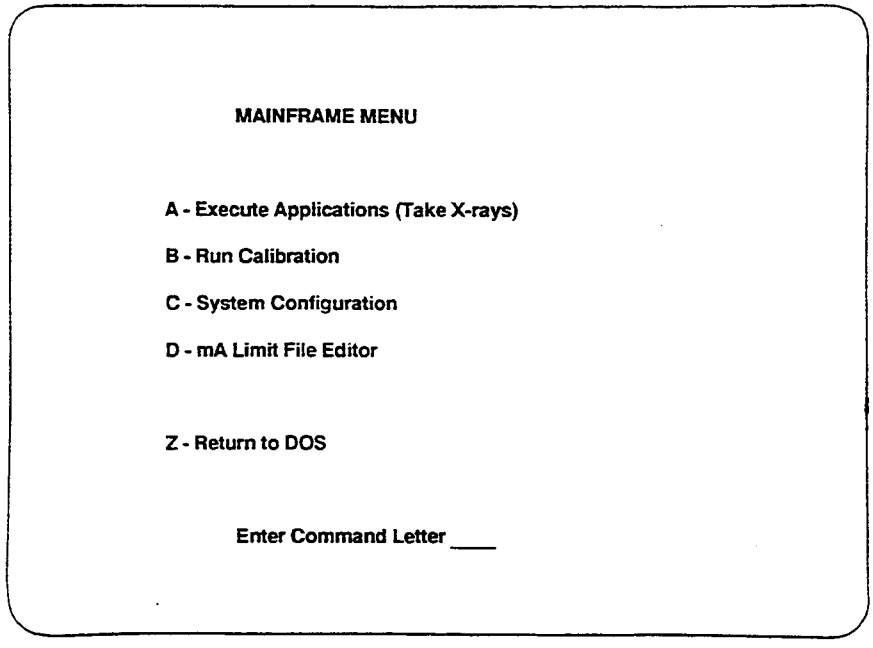


Figure 9-9 - *Dynalyzer II Digital Display. Refer to the text for the proper switch settings.*

9.8.4 Getting Started

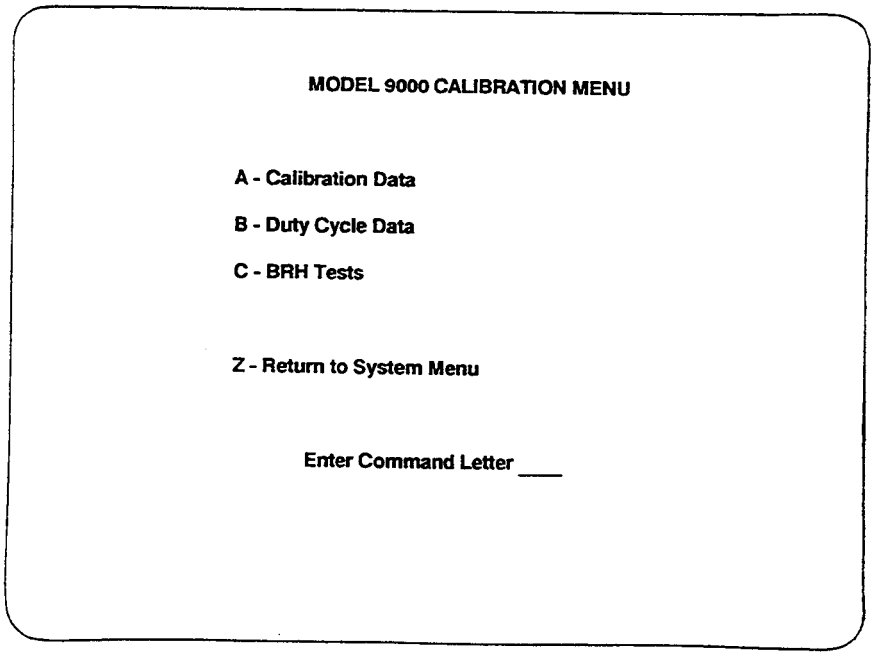
1. Connect the computer terminal to the monitor cart. Instructions for connecting and using the external computer terminal are found in the Appendix.
2. Press *[ESC]*.
3. Select: *Z - Return to main menu.*
4. Select: *Y - Access Mainframe Menu.*

   The Mainframe Menu will appear:



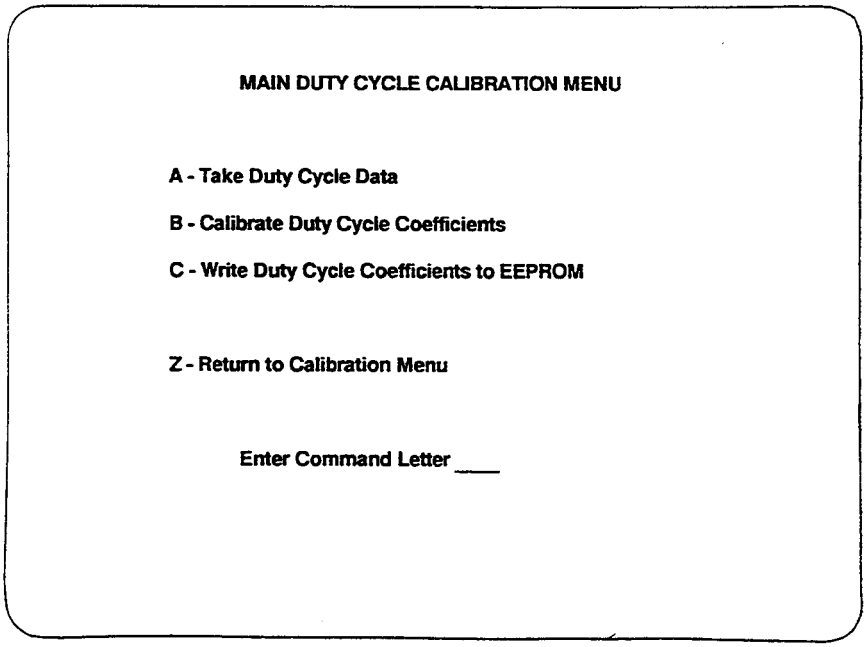
5. From the Mainframe Menu select: *B - Run Calibration.*
6. Enter your initials when prompted: *Enter initials please.*

7. From the *CALIBRATION MENU* select: *B- DUTY CYCLE DATA.*



9.8.5 Duty Cycle Calibration

The Duty Cycle Menu will next appear on the terminal screen:



9.8.5.1 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).

2. Zero the Dynalyzer high voltage unit.

Note: Zero *both* the FLUORO and RADIOGRAPHIC settings on the Model III.

3. Depress the footswitch (or X-ray On button) when ready.

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].

6. The Dynalyzer II tank must be switched between FLUORO and RAD to accommodate filament size changes during calibration. When this is required, The following prompt will appear on the terminal screen:

   *** SWITCHING FILAMENTS ***
   Change tank setting to ___ (FLUORO or RAD) for ___ (small or large) spot calibration. Press [ENTER] when ready to continue.

   When beginning the calibration procedure using a Dynalyzer III, the on-screen instructions will indicate the switch setting (FLUORO or RAD) with which to start.

9.8.5.2 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.

9.8.5.3 Write Duty Cycle Coefficients to EEPROM

1. When the calculations are complete, you will be returned to the Duty Cycle Calibration Menu.

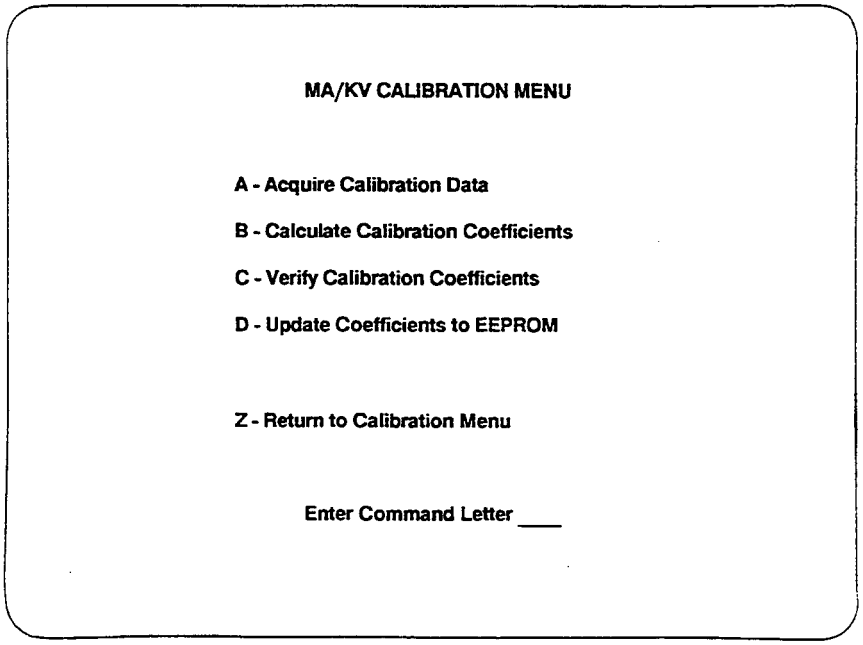
2. Select: *C - Write Duty Cycle Coefficients to EEPROM.*

3. This takes only a blink of the eye.

4. Select: *Z - Return to Calibration Menu.*

9.8.6 mA/kV Calibration

Technique calibration uses the mA/kV Calibration Menu:



9.8.6.1 Acquire Calibration Data

1. From the Main Calibration Menu select: *A - Calibration Data.*
2. From the mA/kV Calibration Menu select: *A - Acquire Calibration Data.*
3. Remove the mA servo-disable jumper E3.
4. Zero the Dynalyzer (both settings on the Model III).
5. Depress the footswitch when ready.
6. The system automatically takes 38 predefined exposures.

   The calibration software will prompt you to change the Dynalyzer setting (FLUORO/RADIOGRAPHIC) as needed.
7. Observe the results reported on the screen. The technique values should be similar to those read on the control panel and the Dynalyzer readout.
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].

9.8.6.2 Calculate Calibration Coefficients

1. Select: *B - Calculate Calibration Coefficients.*
2. The coefficients will be displayed briefly on the monitor.

9.8.6.3 Update Coefficients to EEPROM

1. Select: *D - update coefficients to EEPROM.*
2. This step is performed before the verification data is acquired.

Note: Menu item *C - Verify Calibration Coefficients* is not implemented for field use. Proceed with the manual verification procedure given below.

9.8.7 Verify Calibration

9.8.7.1 General Information

Calibration must be verified following regular calibration procedures or when any of the following components are replaced:

- X-ray Tube
- Generator Controller PCB
- High Voltage Regulator Components
- High Voltage Tank

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.*

9.8.7.2 KVP Accuracy Tests

The tests in this section are designed to measure the kVp accuracy of the system. Perform the tests indicated and 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. Slew the mA to maximum at each kVp.
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 @ 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.

9.8.7.3 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. Select the small field.
2. Take exposures at 5 mAs 50 mAs, and at 200 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. Select the SMALL field.
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.

9.8.7.4 Fluoro MA Accuracy Test

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.

9.9 Entrance Exposure Calibration

Entrance Exposure Limitation Tests

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.

Entrance Exposure Calibration

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.

Measurement Position The entrance exposure for the system is measured 30 cm (12 inches) from the input surface of the imaging assembly.

NOTE: Remove the dynalyzer prior to execution of this procedure.

Equipment Required The following equipment is required to perform the entrance exposure tests:

* Keithley Model 35050 dosimeter with Model 96030 ion chamber or equivalent (Calibration must be current).

* Metric Scale or Ruler

* Lead Apron or lead plate

* 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 such 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 4.69 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: *D - mA Limit File Editor.*

11. For each value listed by the mA Limit File Editor, select the kVp index number and enter the mA found in the steps above.

12. Enter the data obtained every five kVp (recorded in the worksheet table) and interpolate the remaining values.

13. When the table on the screen is complete, press [ENTER].

14. Follow the instructions on the screen to save the editing changes.

9.10 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.

9.10.1 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:

   1. Place the dosimeter 30 cm. (12 inches) from the input surface of the image intensifier.
   2. Adjust the technique factors to produce the required radiation level.
   3. Then LOCK the technique and remove the dosimeter for the tests.

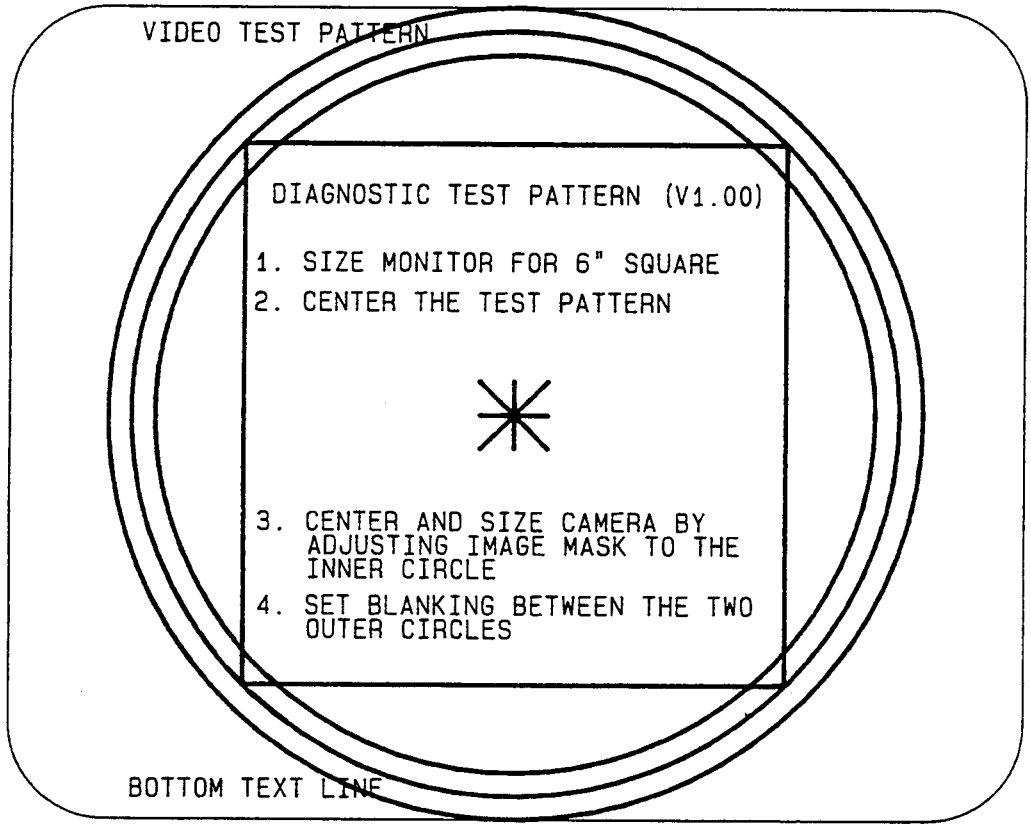
3. Unless otherwise noted, all radiation measurements are made 30 cm. (12 inches) above the input surface of the image intensifier.
4. The camera lens aperture is set to f/2.0.
5. X-ray beam alignment has been performed with satisfactory results.
6. On 6/9-inch fluoroscopy systems, all camera tests and 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.

9.10.2 Monitor Raster Size Adjustment

1. Place the video selector switch on the rear of the monitor cart in the "NORMAL" position.
2. Put the monitor cart into the diagnostics mode. Follow the instructions in the Monitor Cart Service Section for using either the **Front Panel** or **Terminal Diagnostics**.
3. Select test *23 - VIDEO TEST PATTERN.*
4. While viewing the test pattern, adjust the *VERT SIZE* and the *WIDTH* controls on the left monitor to produce a 6-inch square in the center of the screen.
5. It may be necessary to adjust the centering magnets on the CRT neck to hide the raster edges, and to correctly display the text lines.
6. Repeat this procedure for the right monitor.

NOTE: Adjust the TV monitor size controls before any other size adjustments are performed.

Figure 9-10 - *TEST 23 - VIDEO TEST PATTERN is used for video alignment, sizing and centering.*



9.10.3 Camera Sizing and Optical Adjustments

9.10.3.1 Camera Rotation Axis Offset (mirror axis alignment)

Test Spec:
Less than 1/4" axis shift on the monitor as the camera is rotated through its 360 degree range.

1. Place the alignment tool on the image intensifier input surface.
2. Loosen the camera drive belt and disengage it from the drive gear. This will prevent damage to the rotation drive motor.
3. Continue using the VIDEO TEST PATTERN - Test 23, described in the previous procedure.

4. Rotate the camera to one extreme, make a fluoro exposure and with a felt-tip pen, place a mark on the monitor screen at the center of the alignment tool image.

5. Rotate the camera 90 degrees and mark the center again. Repeat this every 90 degrees throughout the 360 degree range.

6. Make a cross by connecting the diagonally opposite marks, and measure the length of the longest diagonal.

7. If this dimension is less than 1/4 inch, no further adjustment will be necessary.

8. Adjustment is made while making an exposure by varying the jackscrew settings supporting the mirror and aligning the center of the tool image with the center of the marked cross. When complete, re-check allignment.

9. Center the alignment tool crosshair in the center of the video test pattern by adjusting the horizontal and vertical centering on the camera Deflection PCB. Camera centering controls are further described in a following procedure.

NOTE: Be careful not to over-tighten the compression washers.

10. Replace the camera drive belt over the drive gear.

9.10.3.2 Camera Lens Aperture Setting

Set the camera lens aperture to f/2.0.

9.10.3.3 Active Image Size and Centering

Adjust the camera image size and centering according to the Video Test Pattern Instructions.

Spec: Diameter = 8.25 inches +/- .125

Camera Size and Centering Controls (Deflection PCB):

R-40	Hor. Size - normal
R-38	Hor. Centering - normal
R-39	Hor. Centering - reversed
R-19	Vert. Size
R-37	Vert. Centering

9.10.4 Image Circular Masking

Spec: Less than 2% of SID (.72 inch for 9-inch system, .76 inch for 6-inch system).

1. With the BYPASS switch in the "NORMAL" position, the image edges will be hidden by the circular blanking window. The blanking should cover the image edge at all points throughout a complete rotation of the camera.

2. In no case should there be more that 2% of the SID (referred to the input of the image tube) masked. This refers to areas radiated, but not imaged as a result of circular blanking or other masking.

3. Set the circular blanking on the monitor cart AD/DA PCB with the potentiometers listed below.

R45	Vertical Offset
R47	Vertical Size
R48	Horizontal Size
R50	Horizontal Offset

4. Press the *HELP* button to *exit Test 23*. Then select *Option 99 - Return to System*.

9.10.5 Camera Electrical Adjustments

Test Conditions:

1. Contrast Grid installed
2. No other filters in beam except aluminum collimator filter
3. Shading jumper out (disabled)
4. Auto gain jumper out (disabled)
5. Black level control disabled (jumper TP2 to TP7)
6. Camera input power = 24 +/- 1.0 VDC

9.10.5.1 +500 Volt Supply Adjustment.

1. Adjust R-13 to the maximum voltage extreme.

2. Reduce the "BEAM" (R-14) setting to minimum (blanked).

3. Measure the voltage at TP-6.

4. Adjust R-13 for 25 volts below the voltage measured above at TP6 or +500 VDC, whichever is less.

Figure 9-11 - *This view of the camera shows the location of the a) Video Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.*

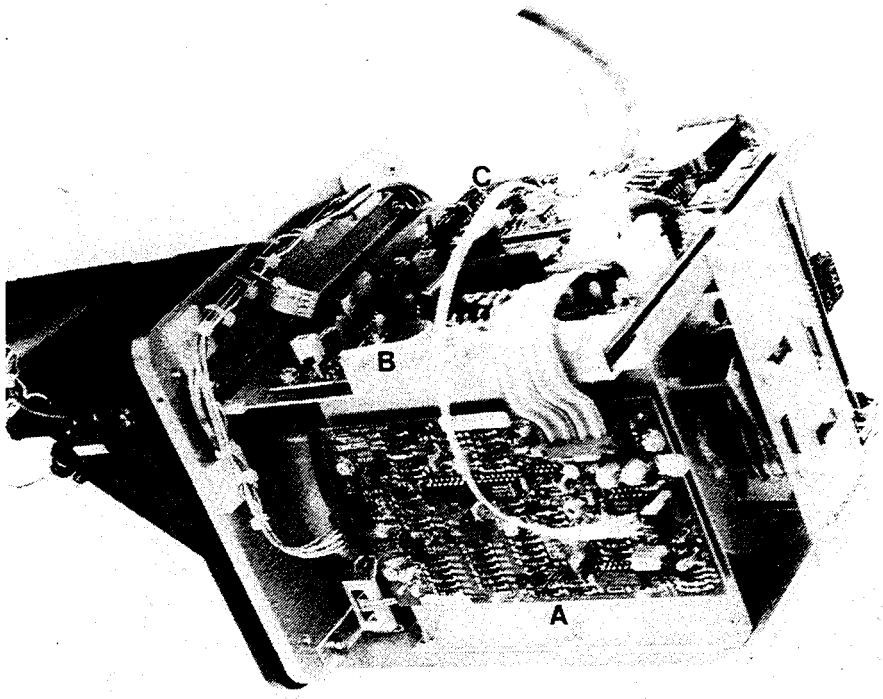
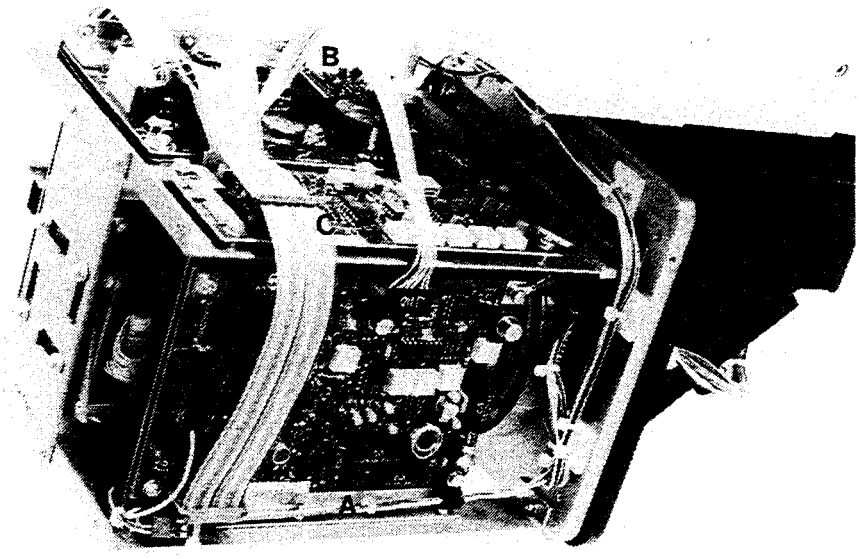


Figure 9-12 - *This view of the camera shows the a) Deflection Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.*



9.10.5.2 Beam Discharge

1. Adjust beam discharge current with the beam discharge pot R14 on the Camera Supply PCB.

2. Be sure there is sufficient beam current to discharge video amplitudes of 500 mv p-p as measured at TP-3.

3. While making an exposure and observing TP1, adjust R14 until the beam is fully discharged, then 1/8th turn beyond that point. The video level at TP3 will be observed to peak near this point.

9.10.5.3 Target Adjustment

Spec: 350 +/- 20 mv. at TP-3 on Video Processor PCB.

On the Video Processor PCB adjust the target voltage with R-43 while making an exposure to produce 350 mv p-p at TP-3.

9.10.5.4 Black Level

Spec: 75 +/- 10 mv at TP-1.

Adjust the Black Level Control (R-44) for 75mv black level as seen at TP-1 on the camera Video Processor PCB.

9.10.5.5 Camera Video Output

Spec: 850 +/- 40 mv peak video measured at J-8 of the AD/DA.

Adjust the Video Gain with R-9 on the Video Processor PCB to produce the video output measured at J8 on the AD/DA PCB.

9.10.5.6 Verify Dark Current Compensation

1. Monitor J8 on the AD/DA PCB.

2. While observing the composite video waveform during an exposure, temporarily remove the jumper between TP7 and TP2 on the camera Video PCB.

3. The black level should change, correcting to 50-150 mV above the video blanking level.

9.10.5.7 Video Output with Auto-brightness Enabled

Test conditions:
Auto-Gain enabled
Black level control enabled
Shading enabled.

Under the test conditions listed above, measure the video amplitude at J8 on the AD/DA PCB. The output video amplitude, with auto brightness enabled, should be 820 +/- 60 mv. peak.

9.10.6 Shading (Image Brightness Uniformity)

Test Conditions:
1. Contrast Grid installed
2. No other filters in beam except the aluminum collimator filter
3. * Shading jumper in (enabled)
4. Auto gain jumper out (disabled)
5. Black level control disabled (jumper TP2 to TP7)

* Shading controls adjusted for minimal shading error.

Spec:

Vertical shading component:	less than 100 mv p-p
Horizontal shading component:	Less than 100 mv p-p
Video amplitude:	850 +/- 40 mv peak (J-8 of the AD/DA)

Adjustment procedure:

1. With the horizontal sweep orientation "normal" and the scope sweep rate set to view horizontal (20 us/div) and triggered, adjust R-40 (Horiz. sawtooth) and R-42 (Horiz. parabola) for uniform amplitude across the video waveform.

Refer to Figure 9-13.

2. Restore the video amplitude with R-57 (BIAS).

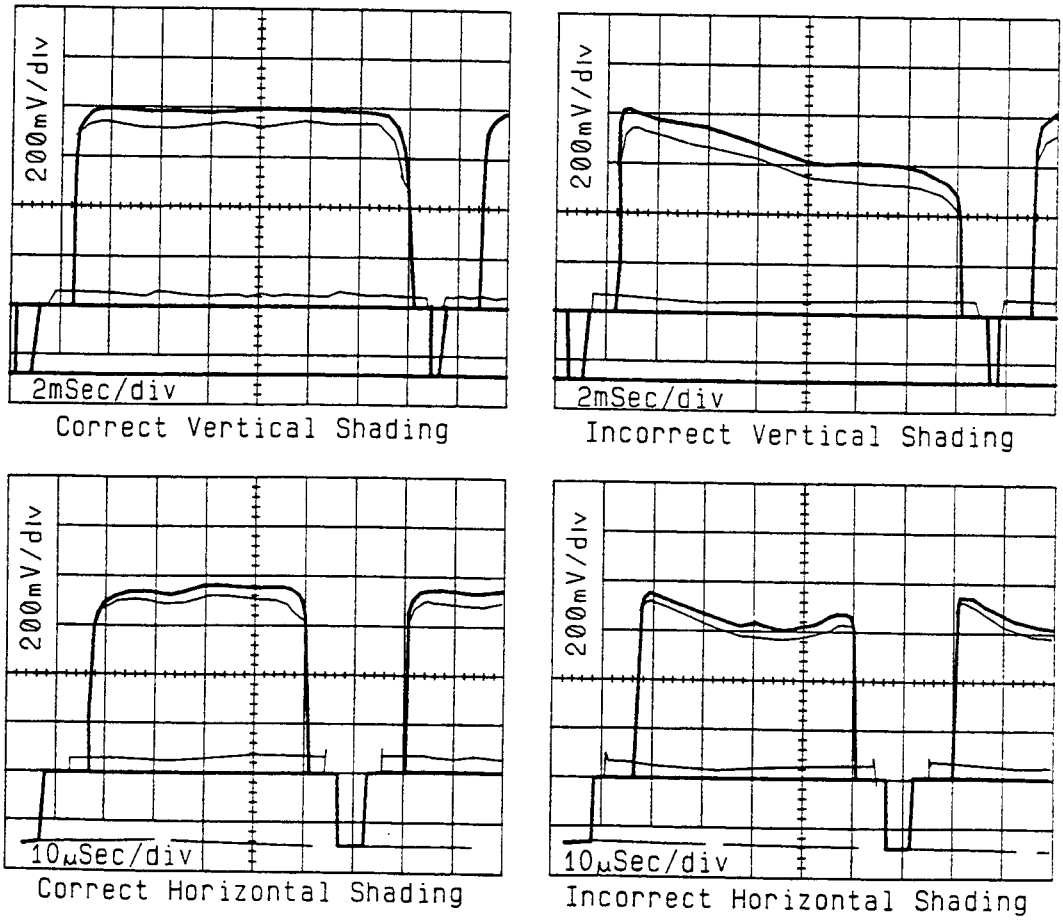
3. Change the scope sweep rate to view the vertical rate. (5 ms./div.) and adjust R-10 (Vert sawtooth) and R-15 (Vert parabola) for uniform amplitude across the video waveform.

4. Restore the video amplitude with R-57 (BIAS).

5. Repeat steps 1 and 2 with the horizontal orientation "reversed" using R-41 (horiz. sawtooth) and R-57 (BIAS) respectively.

NOTE: The shading specifications refers to the central 70% of the illuminated area in each axis. Some rounding at the edges is acceptable. It is generally helpful to "dip" the center just a little (approx. 50 mv.) to meet this specification.

Figure 9-13 - *Correct and incorrect shading waveforms are illustrated here.*



9.10.7 Resolution

Test Conditions:

1. Shading jumper in (enabled).
2. Video selector switch in the "BYPASS" position.
3. NO Contrast Grid.
4. Wisconsin Resolution Tool installed.
5. Adjust technique for 50 kVp @ 200 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 the technique for 200 +/- 10 mr./min. at 50 kVp. in "MANUAL" mode.

9.10.7.1 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.

3. Adjust C-3 (peaking capacitor) on the Preamp and Yoke assembly until the black image edges, viewed on the monitor, bleed white. Back off the adjustment of C-3 until the smearing just disappears. This will provide optimum preamp bandwidth without oscillation occurring.

Note: Use a nonmetallic adjustment tool on C-3.

9.10.7.2 Image Intensifier Focus

If this adjustment is necessary refer to the *Mainframe Service Section.*

Rotate the C-arm assembly to place the X-ray tube/image intensifier axis parallel to the floor with the X-ray tube port pointing away from the control panel.

9.10.7.3 Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

Test Specs:

(6" machine) -	40 linepairs/inch
(6/9" machine) -	40 linepairs/inch in 6" mode 35 linepairs/inch in 9" mode

9.10.8 Contrast Sensitivity Test

Test Conditions:
1. Technique factors adjusted to produce 80 kVp @ 1R/min.
2. 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 with the cart in the "NORMAL" mode and examine the stored image. Adjust the brightness and contrast controls on the monitor as necessary to optimize the image.

9.10.9 Image Noise, Correlated

Test Conditions:
1. Black level control enabled.
2. Shading jumper in (enabled).
3. Auto-gain enabled
4. Monitor Cart in BYPASS mode.

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.

9.10.10 Video Sampling Window Size and Centering

1. Connect a 2.2 Kohm resistor between TP-11 and TP-13 to see the video sampling window.

2. Put the monitor cart in "NORMAL" mode.

3. The window should now be visible when exposures are made. Adjust R-38 "H-CAL" and R-39 "V-CAL" to center this rectangular window within the viewed area.

4. 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.

9.10.11 Video Level Control and Auto Technique Tests

Test Conditions:

1. Auto-technique mode
2. Auto-gain enabled
3. Black level control enabled
4. Shading enabled
5. Contrast Grid installed.

1. Make an exposure with no filter in the beam and record the resulting kVp.

2. Make an exposure with the Aluminum filter (6" x 6" x .125") in the beam and record the resulting kVp.

3. Make an exposure with one (1) copper filter (6" x 6" x .093") in the beam and record the resulting kVp.

4. Make an exposure with two (2) copper filters (6" x 6" x .093") in the beam and record the resultant kVp.

5. The peak output video amplitude at (J8 on the AD/DA PCB) shall be 820 mv +/- 60 mv for each of the four conditions.

6. The resultant kVp readings for each of the four conditions shall be:

No filter	43+/-3 kVp
Aluminum	47+/-3 kVp
1 Copper filter	66+/-3 kVp
2 Copper filters	79+/-4 kVp

9.10.12 Camera Drive Chain Tension

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. Rotate the camera through 360 degrees and verify that the rotation motor is switched off at each limit. Verify that the chain tension allows free rotation in all positions. *Damage to the rotation motor and gear can result if the camera is rotated by hand.*

9.11 Image Processing and Monitor Cart Tests

9.11.1 AD/DA PCB Calibration

1. Place the PCB on an extender card and replace the regular daisy chain cable with the test ribbon cable (which is longer to accommodate the extender card).

2. Measure the following voltages on the AD/DA PCB:

TP-21	digital to analog reference	-1.0 VDC
TP-23	analog to digital reference	-2.0 VDC

3. Adjust R-1 (video offset adjust) so that the video baseline at P-6 (right video output) is at ground.

4. Adjust **R-2** (video offset adjust) so that the video base line at P-5 (left video output) is at ground.

5. While making a fluoro exposure observe the live video waveform, in-line, at P6 and P5 of the AD/DA PCB.

6. Verify a video amplitude of 850 mVpp +/- 50 mV and the sync portion, 400 mVpp +/- 50 mV. Observe a baseline at 0 volts.

9.11.2 Verify External Video

1. Check for the presence of an EIA RS170 composite video signal at the video output jacks on the rear of the monitor cart.

2. Verify a video amplitude of 850 mVpp +/- 50 mV and the sync portion, 400 mVpp +/- 50 mV. Observe a baseline at 0 volts.

NOTE: The video signal must be terminated with 75 ohms to correctly measure the amplitude.

9.11.3 Image Processor PCB

1. Place a scope probe on TP27 and TP5 (ground). Verify that the following TV signals are present:

TP-9	Composite sync
TP-10	Composite blanking
TP-7	Horizontal drive
TP-6	Vertical drive

2. Adjust C-6 for +2.5 VDC measured on TP27. Verify that the video is stable and displayed in the center of circular blanking.

9.11.4 Front Panel Diagnostics

1. Access the Software Diagnostic Tests from the front panel of the monitor cart by pressing the HELP key and then selecting the "Front Panel Diagnostics" from the menus. These tests can also be selected from the Terminal Controlled Diagnostics.

2. The Front Panel Diagnostics contain tests of the image/memory transfers which occur in normal operation.

   These tests are fully described in the Monitor Cart Service Section. Read the descriptions and follow the instructions for these tests.

3. There are also tests from this menu of the switches and LEDs on the Front Panel:

   Run the Front Panel LED Test to verify that all LEDs operate.

4. Generate a gray scale image from the test menu.

5. Swap the image from one monitor to the other (using the M1-M2 swap test) and examine the image for any signs of tear or jitter.

9.11.5 Monitor Cart Imaging Function Checks

A variety of image processing functions may be available on a given system. Refer to the Operator's Manual for instructions on using the available functions.

1. Enable each function on the front panel and using a suitable test image (such as the Wisconsin Copper Mesh Test Grid), evaluate the operation of the function. Camera rotation may be used to simulate motion when evaluating some functions.

2. Verify that the LIVE FLUORO (left) Footswitch generates a live fluoro image on the left monitor regardless of the status of the image processing controls.

3. Depress the PROCESS (right) Footswitch to initiate the selected image processing.

4. Enable the WINDOW and LEVEL functions and take another image. The WINDOW and LEVEL arrow buttons should change the dynamic range and brightness level of the image presented on the left-hand monitor.

5. Verify that the Negative Image (NEG) function reverses the lights and darks in the image.

6. Verify operation of both the INTEGRATE and the AVERAGE functions for all levels of averaging (number of frames).

7. Verify operation of the SHARPEN function.

9.11.6 Image Storage on Hard Disk

If the system is equipped with the option to store images on the hard disk, check its operation as follows:

1. Verify that the Manual SAVE function stores the image on the hard disc.
2. RECALL the image stored in the previous step.
3. Verify that the image counter increments and decrements, and that additional images can be recalled. "d0" error message displayed on the LED's indicates that no image was found in the specified location.
4. Enable the AUTO save function. Generate a picture on the left monitor, and press the L->R function switch. Verify that the image is auto-saved and that the LED image counter is incremented by one.
5. Time the transfer while saving an image to disk. The transfer should take less than 10 seconds, thus verifying disk transfer DMA.

9.12 Image Storage Options

Refer to Section 11, System Options.

9.12.1 AngioStor

Check out the operation of the AngioStor videodisk recorder described in the Options Section.

9.12.2 VTR

1. Verify VTR control operation as described in the operator's manual.
2. Check that the playback level is correct.

   Level adjustment instructions are found in the Options Section of the Service Manual.

CALIBRATION WORKSHEETS

Series 9000 - Serial Number _____

Calibration Performed By: _____

Location _____ *Date:* _____

Introduction

These worksheets accompany the Series 9000 system calibration procedures found in Section 9 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.

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 9000 System.

9.3 Preparation and Setup

9.3.1 Record the Test Equipment Used

Dynalyzer Model _____ S/N _____

Dynalyzer Display Model _____ S/N _____

Autocal Interface Box S/N _____

DVM/DMM Model _____ S/N _____

Oscilloscope Model _____ S/N _____

Dosimeter Model _____ S/N _____

Ion Chamber Model _____ S/N _____

9.3.2 Preparation and Inspection

___ *Steps 1 thru 9 completed.*

9.4 Electrical Tests

9.4.1 Leakage Current Testing

Leakage Current _____ Pass/Fail _____

9.4.2 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 = _____

9.4.3 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

9.4.4 Monitor Cart Power Supplies

___ *Steps 1 thru 3 completed.*

AC voltage at the AUX outlets _____ VAC

Measure the following voltages relative to DC Common (PS-1 pin 7):

PS-1 pin 12	red wire	_____ VDC
PS-1 pin 6	gray wire	_____ VDC
PS-1 pin 5	violet wire	_____ VDC
PS-1 pin 4	yellow wire	_____ VDC
PS-1 pin 3	blue wire	_____ VDC
TV monitor power supply		_____ VDC

9.4.5 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.

9.5 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

9.6 Functional Checks

9.6.1 Self-tests

___ Self-tests during powerup successfully completed.

9.6.2 Emergency Off and Processor Reset Test

___ Left Emergency Off breaks interlock circuit
___ Processor resets and runs.
___ Right Emergency Off breaks interlock circuit

9.6.3 Status Mode Tests

Refer to the Mainframe Service Section for instructions on using the Status Mode.

___ LED Test
___ Panel key test
___ Panel knob test

Date and initials listed for last calibration _____

Total RAM _____ Total disk space _____

9.6.4 Film Cassette Test (6-inch systems only)

___ *Steps 1 thru 6 completed.*

9.6.5 Verify Operation of Mainframe Controls

___ *Steps 1 thru 7 completed.*

9.6.6 Field Solenoid Position Test

___ *Steps 1 thru 7 completed.*

9.6.7 Verify Controls in MANUAL FLUORO

___ *Steps 1 thru 2 completed.*

9.6.8 AUTO FLUORO Tests

___ *Steps 1 thru 9 completed.*

9.6.9 Fluoro Boost Option

___ *Steps 1 thru 4 completed.*

9.6.10 Pulsed Operation

___ *Steps 1 thru 2 completed.*

9.6.11 Verify Fluoro Timer and Timer Reset

___ *Steps 1 thru 3 completed.*

9.7 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

9.7.1 Preparation

___ *Steps 1 thru 2 completed.*

9.7.2 Radiographic Beam Alignment

___ *Steps 1 thru 19 completed.*

Measure the dimensions of each field:

Minimum field - less than 1.97" square * _____
4-inch field - 4" +/- 0.50" square _____
6-inch field - 6" +/- 0.50" square _____
8-inch field - 8" +/- 0.50" square _____

* 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.

Note: The corners of the 8" field will be clipped by the 10" collimating ring on 6" image intensifiers.

9.7.3 Fluoroscopic Beam Alignment

___ *Steps 1 thru 6 completed.*

9.8 X-ray Calibration

9.8.2 Connections

___ The Dynalyzer, digital display, and autocal interface box are connected according to the instructions in this section.

9.8.3 Setup

___ General Setup

___ Autocal Interface Box

___ Dynalyzer High Voltage Unit

___ Dynalyzer DRO (Digital Display Unit)

9.8.4 Getting Started

___ *Steps 1 thru 7 completed.*

9.8.5 Duty Cycle Calibration

___ (9.8.5.1) Take Duty Cycle Data

___ (9.8.5.2) Calculate Duty Cycle Coefficients

___ (9.8.5.3) Write Duty Cycle Coefficients to EEPROM

9.8.6 Calibration Data

___ (9.8.6.1) Acquire Calibration Data

___ (9.8.6.2) Calculate Calibration Coefficients

___ (9.8.6.3) Update Coefficients to EEPROM

9.8.7 Verify Calibration

The following tests for kVp, mA and mAs accuracy require installation of a dynalyzer; the Autocal Interface Box is not required. *Refer to the Dynalyzer Instructions in the Appendix.*

Perform the tests indicated and record the results on the calibration worksheet. Verify that the system meets the specifications given with the tables below.

9.8.7.2 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 @ 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

9.8.7.3 MAS Accuracy Tests

mAs Accuracy @ 50 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp
200 mA	_____ mA (+/-10.0 mAs)	_____ kVp

---

mAs Accuracy @ 90 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp
200 mA	_____ mA (+/-10.0 mAs)	_____ kVp

---

mAs Accuracy @ 120 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp

9.8.7.4 Fluoro mA Accuracy Test

Fluoro mA Accuracy @ 50 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

Fluoro mA Accuracy @ 90 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

Fluoro mA Accuracy @ 120 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

9.9 Entrance Exposure Calibration

Fill in the worksheet table by determining the mA needed to produce 4.69 R/minute at increments of every five kVp. Do this across the range from 40 to 120 kVp.

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.

9.10 Imaging System Calibration

9.10.1 General Test conditions:

___ Conditions 1 thru 8 are being observed for the tests in this section.

9.10.2 Monitor Raster Size Adjustment

___ *Steps 1 thru 6 completed.*

9.10.3 Camera Sizing and Optical Adjustments

9.10.3.1 Camera Rotation Axis Offset (mirror axis alignment)

___ *Steps 1 thru 10 completed.*

9.10.3.2 Camera Lens Aperture Setting

___ Camera lens aperture set to f/2.0.

9.10.3.3 Active Image Size (camera size adjustments)

___ Adjust the camera image size according to the Video Test Pattern Instructions.

9.10.4 Image Circular Masking

___ *Steps 1 thru 4 completed.*

9.10.5 Camera Electrical Adjustments

___ Conditions 1 thru 6 are being observed for the tests in this section.

9.10.5.1 500 Volt Supply Adjustment

___ *Steps 1 thru 4 completed.*

9.10.5.2 Beam Discharge

___ *Steps 1 thru 3 completed.*

9.10.5.3 Target adjustment

___ Target voltage adjusted.

9.10.5.4 Black Level

___ Black Level Control adjusted.

9.10.5.5 Camera Video Output

Video output measured at J8 = _____ mVp

9.10.5.6 Verify Dark Current Compensation

___ *Steps 1 thru 3 completed.*

9.10.5.7 Video Output with Auto-brightness Enabled

Video output measured at J8 with Auto brightness enabled = _____ mVp.

9.10.6 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.

9.10.7 Resolution

___ Conditions 1 thru 5 are being observed for the tests in this section.

9.10.7.1 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.

9.10.7.2 Image Intensifier Focus

Adjustment **was/was not** neccessary (circle one).

9.10.7.3 Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

(6-inch machine) - _____ linepairs/inch

(6/9-inch machine) - _____ linepairs/inch in 6" mode
_____ linepairs/inch in 9" mode

9.10.8 Contrast Sensitivity Test

___ Conditions 1 thru 2 are being observed for the tests in this section.

# of penetrometer spots discernible = _____

9.10.9 Image Noise, Correlated

___ Conditions 1 thru 4 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.

9.10.10 Auto Brightness

9.10.10.1 Video Sampling Window Size and Centering

___ *Steps 1 thru 4 completed.*

9.10.11 Video Level Control and Auto Technique Tests

___ Conditions 1 thru 5 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
Aluminum	_____ kVp	_____ mVp
1 Copper filter	_____ kVp	_____ mVp
2 Copper filter	_____ kVp	_____ mVp

9.10.12 Camera Drive Chain Tension

___ *Steps 1 thru 3 completed.*

9.11 Image Processing and Monitor Cart Tests

9.11.1 AD/DA PCB Calibration

___ *Steps 1 thru 6 completed.*

9.11.2 Verify External Video

___ *Steps 1 thru 2 completed.*

9.11.3 Image Processor PCB

___ *Steps 1 thru 2 completed.*

9.11.4 Front Panel Diagnostics

___ *Steps 1 thru 5 completed.*

9.11.5 Monitor Cart Imaging Function Checks

___ *Steps 1 thru 7 completed.*

9.11.6 Image Storage on Hard Disk

___ *Steps 1 thru 5 completed.*

9.12 Image Storage Options

Refer to Section 11, System Options.

9.12.1 AngioStor

Check out the operation of the AngioStor videodisk recorder described in the Options Section.

9.12.2 VTR

___ *Steps 1 thru 2 completed.*

SECTION 10
UNPACKING AND INSTALLATION

This section describes the installation of the OEC-Diasonics mobile C-arm system. Included are instructions for unloading and unpacking, startup after long term storage, and guidelines for moving the system.

Site requirements and the Installation Checkout Procedure are found at the end of this section.

10.1 Responsibility

The customer must provide the labor and equipment necessary to unload the system from the transport vehicle and move it to the final location. The customer is responsible for obtaining all permits and for meeting all other requirements of state and local codes, regulations, and ordinances with respect to the installation and operation of the system.

The Installation Checkout Procedure should be performed only by a qualified service technician.

10.2 Unloading and Inspecting the Shipment

Before unpacking, the customer should inspect the shipping containers and exposed system components for any apparent damage. Any shipping container that appears damaged should be unpacked with the carrier's agent present. The customer should also ensure that all equipment specified in the purchase order has been delivered.

If any part of the shipment is damaged or missing, immediately notify the carrier and the nearest OEC-Diasonics regional service office or representative. Retain the shipping container and packing material for the carrier's inspection.

10.3 Domestic Unpacking Instructions

10.3.1 Unpacking the Mainframe Assembly

1. Remove the plywood ramp and place it at the rear of the palette base. *(Refer to Figure 10-1).*

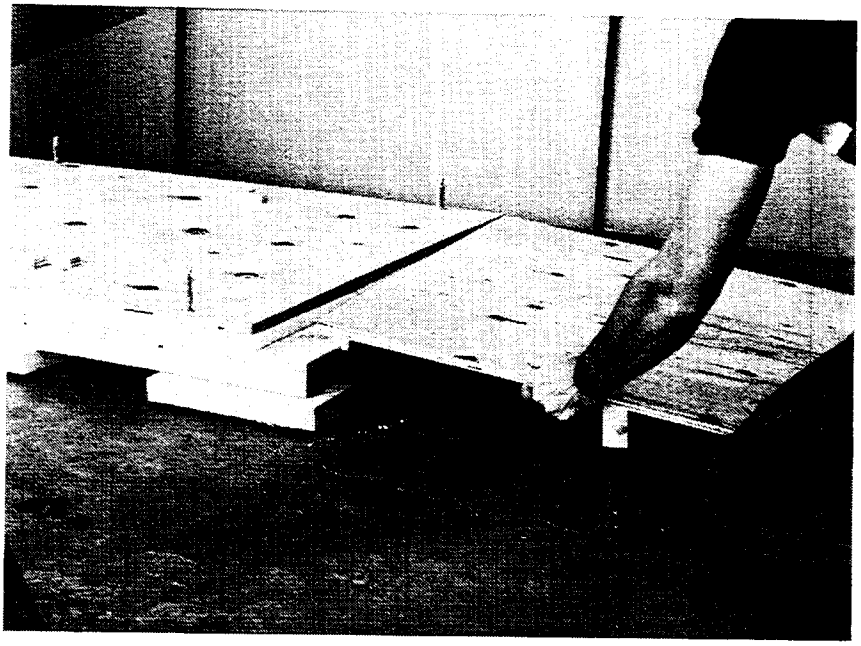


Figure 10-1 - *Place the plywood ramp at the rear of the palette base.*

2. Remove the image intensifier assembly from the palette and place it out of the way for now.

3. Remove the bolts and strap holding down the X-ray tube assembly.

4. Remove the metal straps holding the front and rear wheels in place. *(Refer to Figures 10-2 and 10-3).*

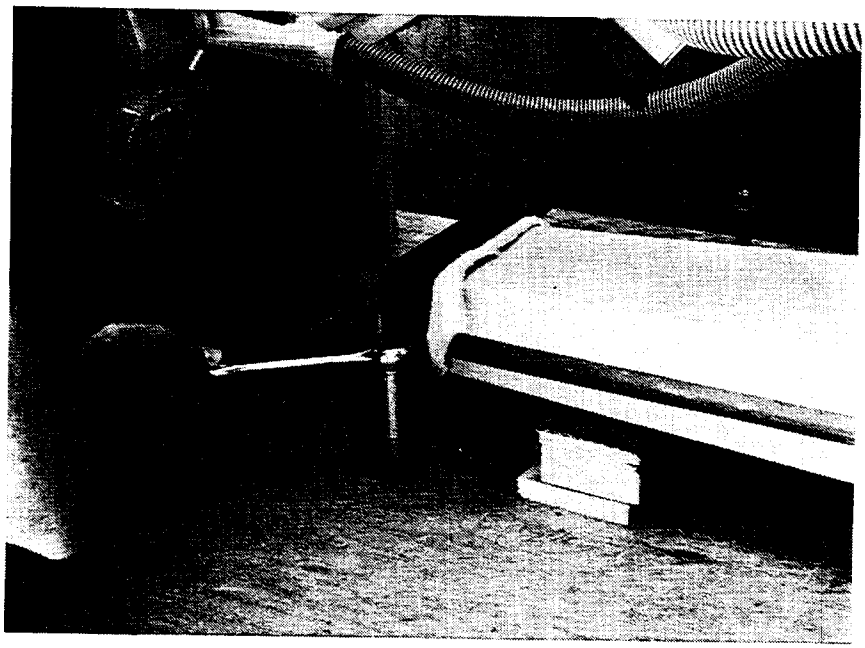


Figure 10-2 - *Remove the metal strap holding the front wheel in place.*

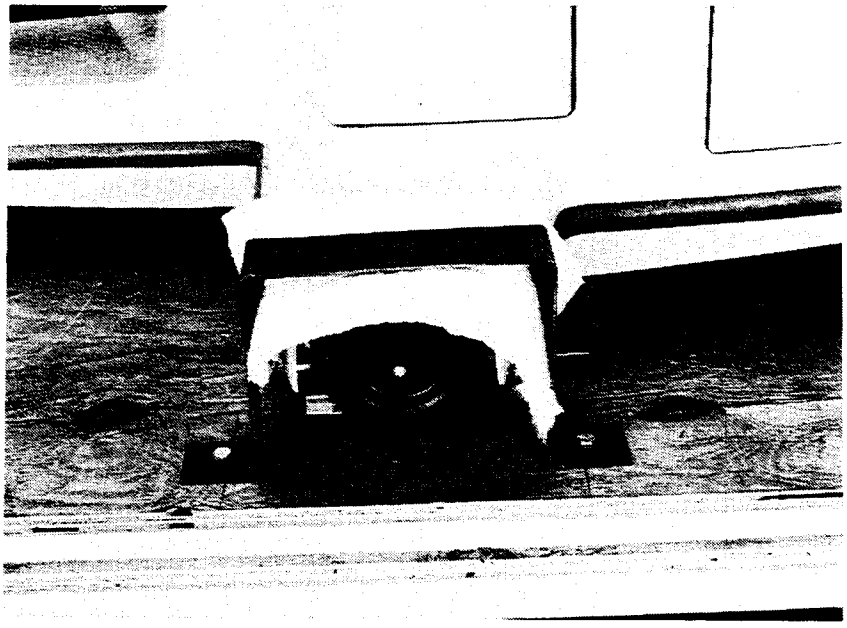


Figure 10-3 - *Remove the metal straps holding the rear wheels in place.*

5. Using the 3-ft. length of 2x4 as a lever, carefully lift up the front wheel and remove the support blocks. *(Refer to Figure 10-4)*.

6. Again using the 2X4 as a lever, lift up each rear wheel and remove the support blocks on both sides. *(Refer to Figure 10-5)*.

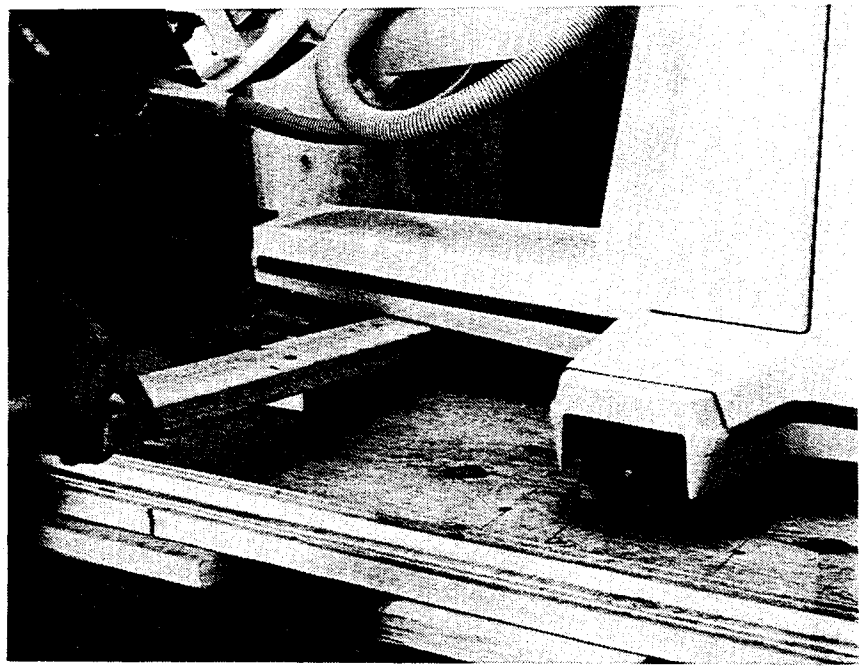


Figure 10-4 - *Use the length of 2x4 as a lever.*

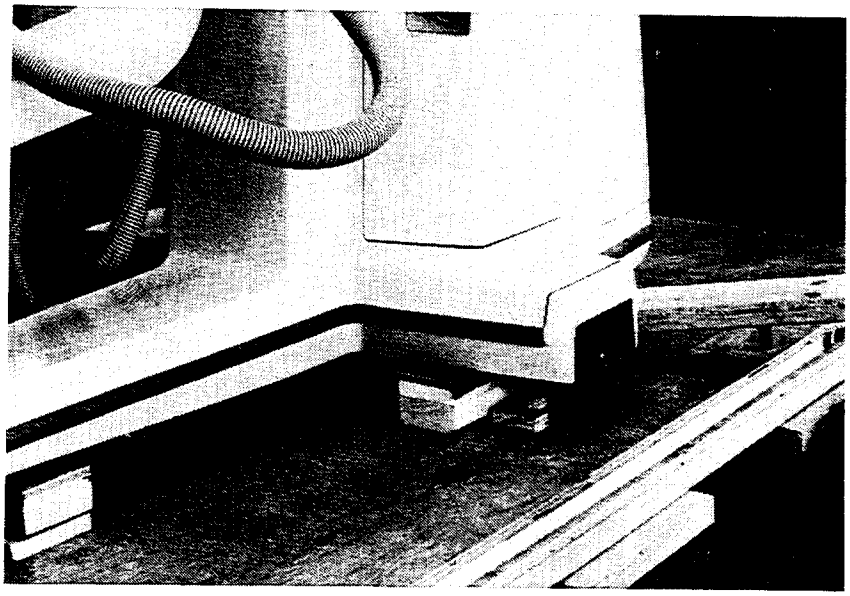


Figure 10-5 - *Use the length of 2x4 as a lever under each rear wheel to remove the blocks.*

7. Position the front and rear wheels in a straight line using the foot lever and the steering handle.

8. Pull the mainframe gently down the ramp. *(Refer to Figure 10-6).*

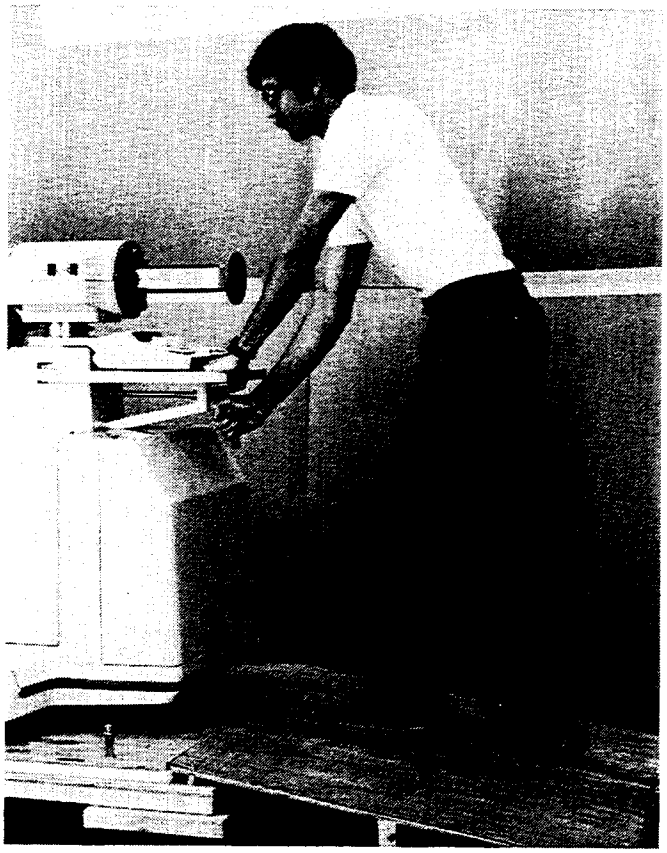


Figure 10-6 - *Carefully back the mainframe down the ramp.*

CAUTION: *Don't let the C-arm roll down the ramp too fast. Keep it in a straight line aimed straight back to avoid rolling off the side of the ramp.*

CAUTION: *Keep the base of the ramp clear of obstacles.*

9. After leaving the ramp, lock the C-arm wheels at right angles to each other to prevent the C-arm rolling.

10. Rotate the C-arm to place the imaging axis vertically with the image tube mount on the bottom.

CAUTION: *When the C-arm brakes are loosened the C-arm may pivot out of balance. Be sure the brakes are tight before attaching the weight of the image tube assembly to the C-arm.*

11. Locate the four Nylock screws in the shipping kit. Place the image intensifier assembly on the C-arm mount and insert and tighten the four Nylock screws.

12. Remove the protective bubble pack from the high voltage cable assembly, extension arm, and control panel. *(Refer to Figure 10-7).*

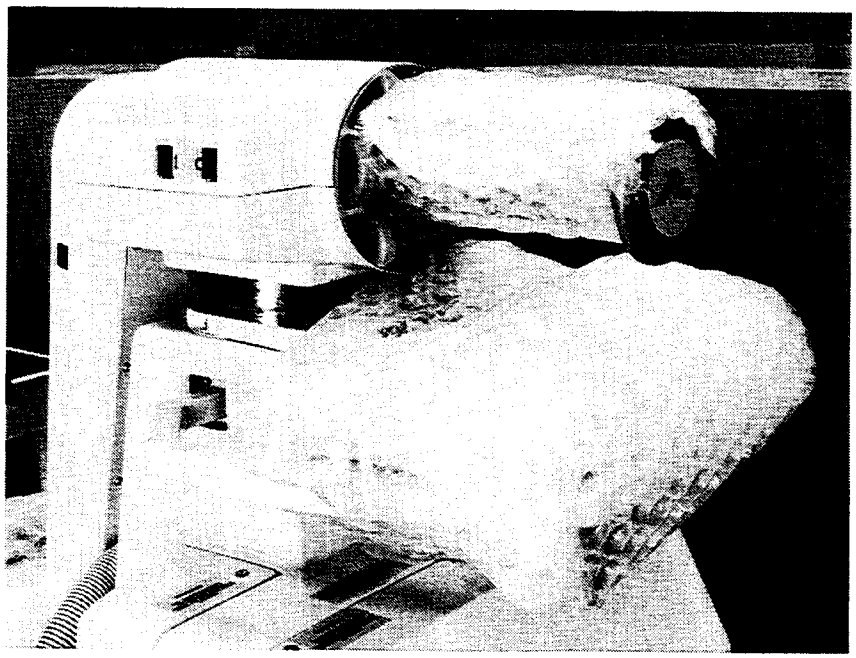


Figure 10-7 - *Remove the bubble packing.*

13. Remove the wood brace from the extension arm. *(Refer to Figure 10-8).*

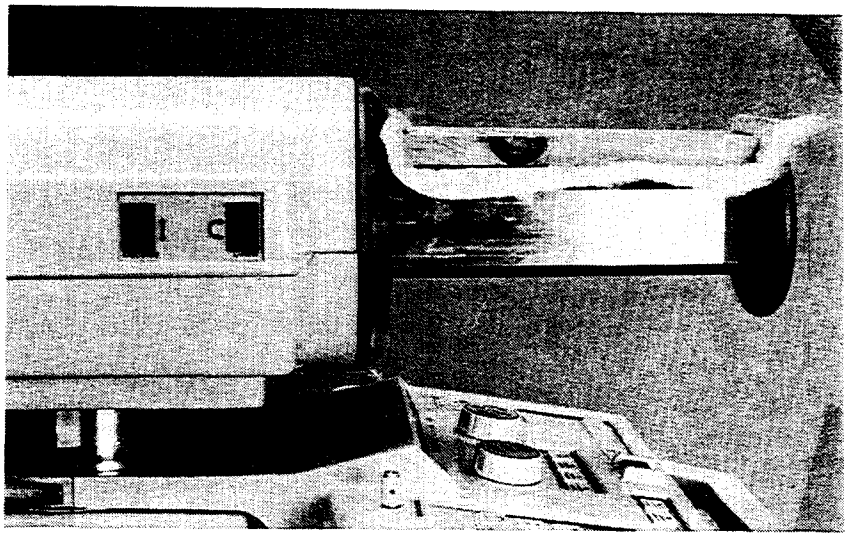


Figure 10-8 - *Remove the wooden brace.*

10.3.2 Repacking the Mainframe

Reverse the order of the above steps.

NOTE: *When placing the wood blocks under the three wheel assemblies, note that the front wheel block is higher than the two rear wheel blocks.*

WARNING: When removing the image intensifier, do not let the C-arm pivot unbalanced - make sure the C-arm brakes are tight.

10.3.3 Unpacking the Monitor Cart Assembly

1. Carefully cut away the shrink wrap covering the monitor cart. *(Refer to Figure 10-9).*

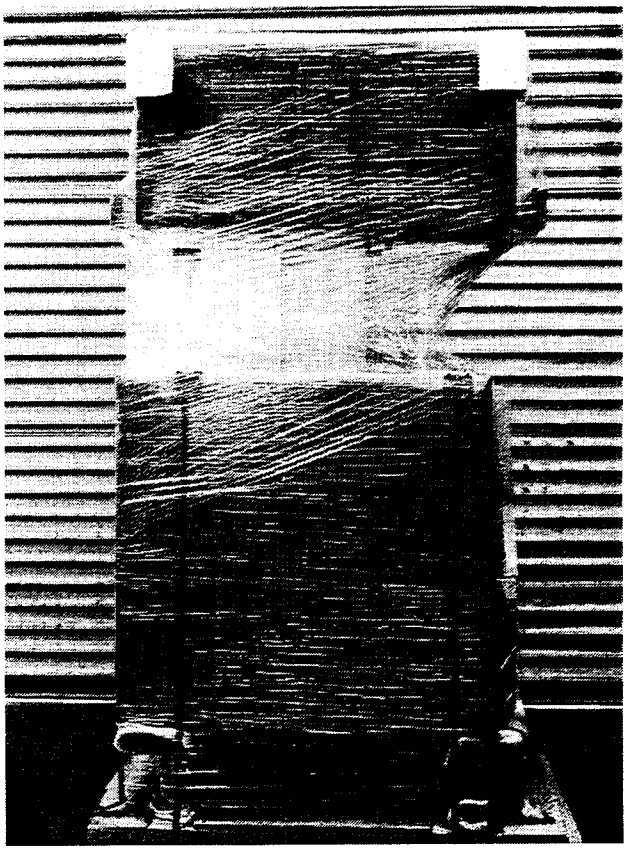
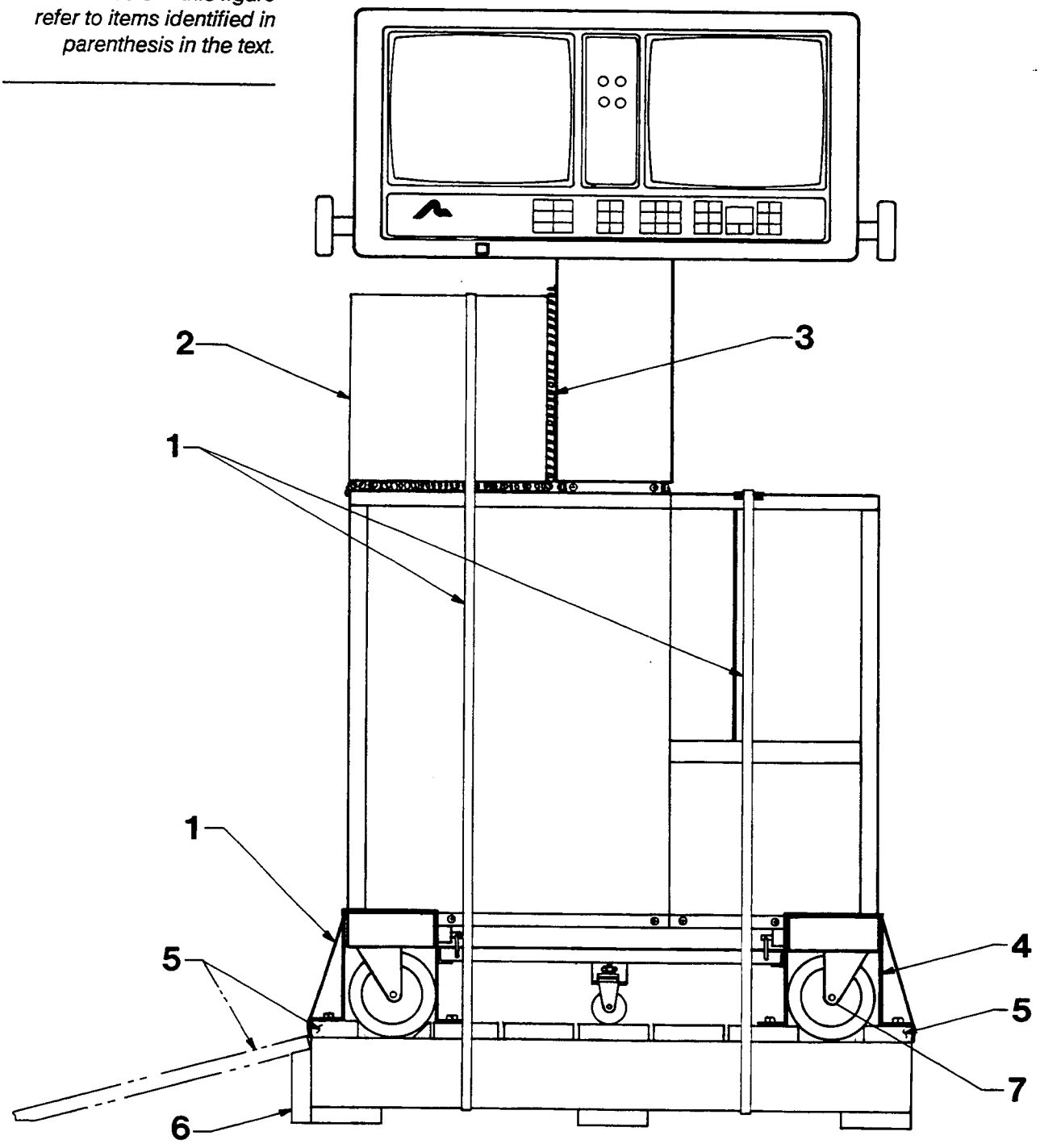


Figure 10-9 - *Remove the shrink wrap plastic covering the monitor cart.*

2. Cut the plastic straps secured around the monitor cart and the cardboard shipping box.

   If the cart has been shipped on a palette, follow steps 3 thru 7. *(Refer to Figure 10-10).*

Figure 10-10 - *Remove the monitor cart from the palette. The numbers in this figure refer to items identified in parenthesis in the text.*



3. Remove the shipping (accessory) kit (2) from the shelf top. Cut the nylon reinforced tape and remove the protective covering (3) from the shelf top.

4. Remove the two lag screws, metal strap and felt pad from each of the front wheels (4). *(Refer to Figure 10-11).*

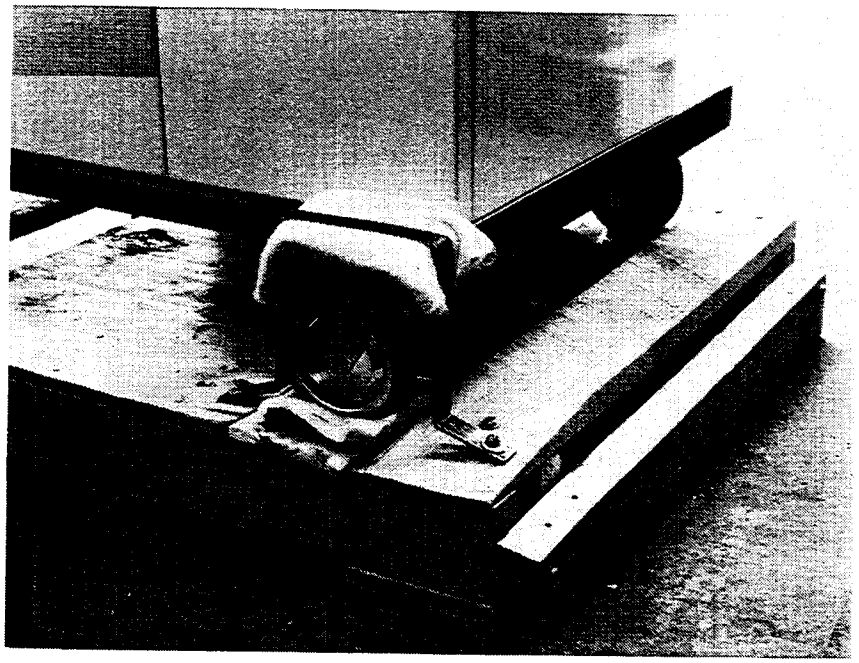


Figure 10-11 - *Remove the metal straps from each of the front wheels.*

5. Remove the lag screws and ramp planks (5), reposition the ramps on the ramp support (6), and secure in place using the 4 lag screws obtained during plank removal.

6. Unlock the rear wheel brakes. Unlock the caster swivel lock on the front wheel furthest from the ramp (7). Turn the caster 180 degrees and relock its swivel.

CAUTION: *The following steps require two strong people capable of controlling the cart as it is rolled out of its retension groove and down the ramp (the monitor cart weighs approximately 360 lbs.). Care must be taken to prevent the cart from rolling off the pallet and ramps.*

7. Roll the monitor cart up and over the center pallet planking and down the ramps to the floor.

8. Check for any unremoved packing materials on the cabinet. Unpack the accessory kit and the optional accessories.

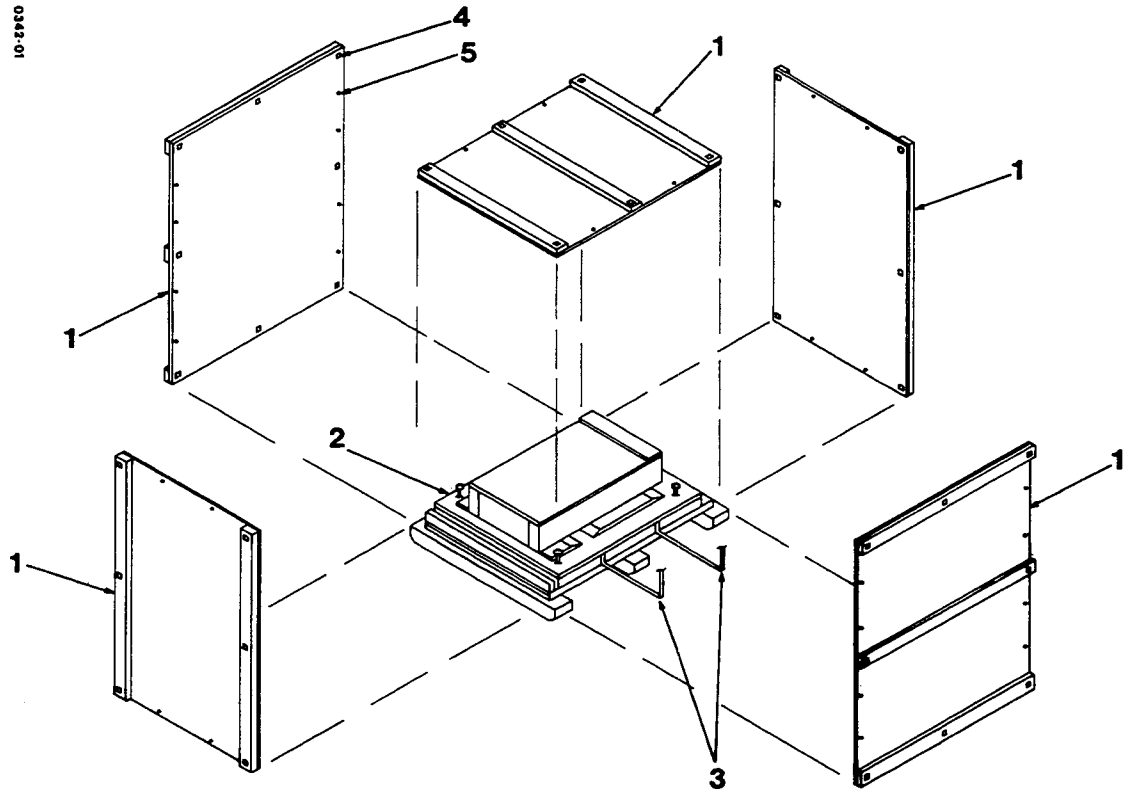
9. Install the top covers. Refer to the Assembly/Disassembly section in the Service Manual for instructions.

10. The monitor cart can now be moved to the installation site.

10.4 Foreign Export Unpacking Instructions, Mainframe and Monitor Cart Assemblies

The shipping containers consist of side and top pieces secured to the shipping palette with lag screws. *(Refer to Figure 10-12).*

Figure 10-12 - *Foreign export packing.*



1. Remove the lag screws which secure each panel to the wooden shipping palette.

2. As each panel is freed by removing the lag screws, lift the panel out of the way.

3. Follow the instructions previously given in this section for removing the equipment from the palettes and removing protective wrapping materials.

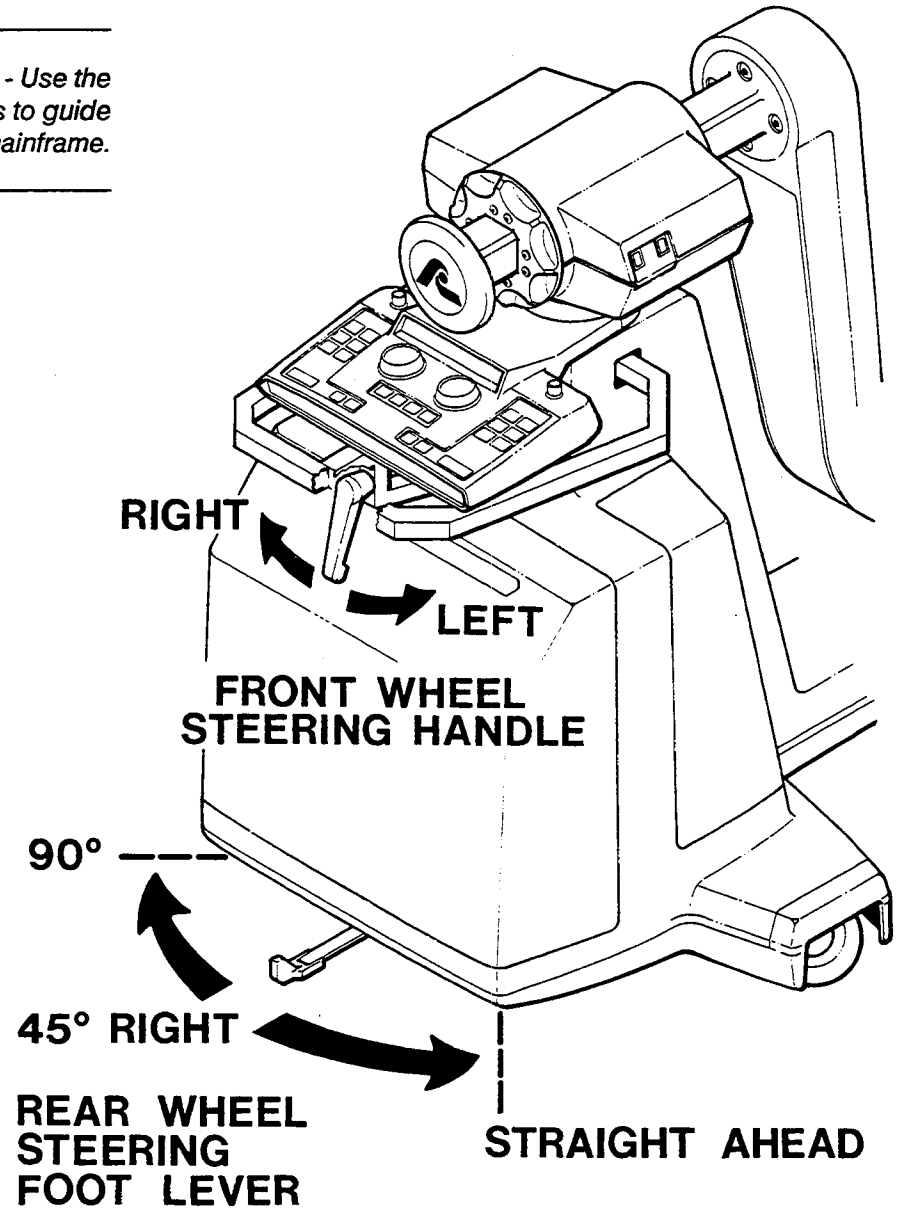
10.5 Moving the System

1. Place the C-arm and L-arm in their most compact positions. If the system has just been unpacked it is already in this configuration.

2. Lock all movable mechanical assemblies, such as the extension arm, in place. Tighten all locking handles.

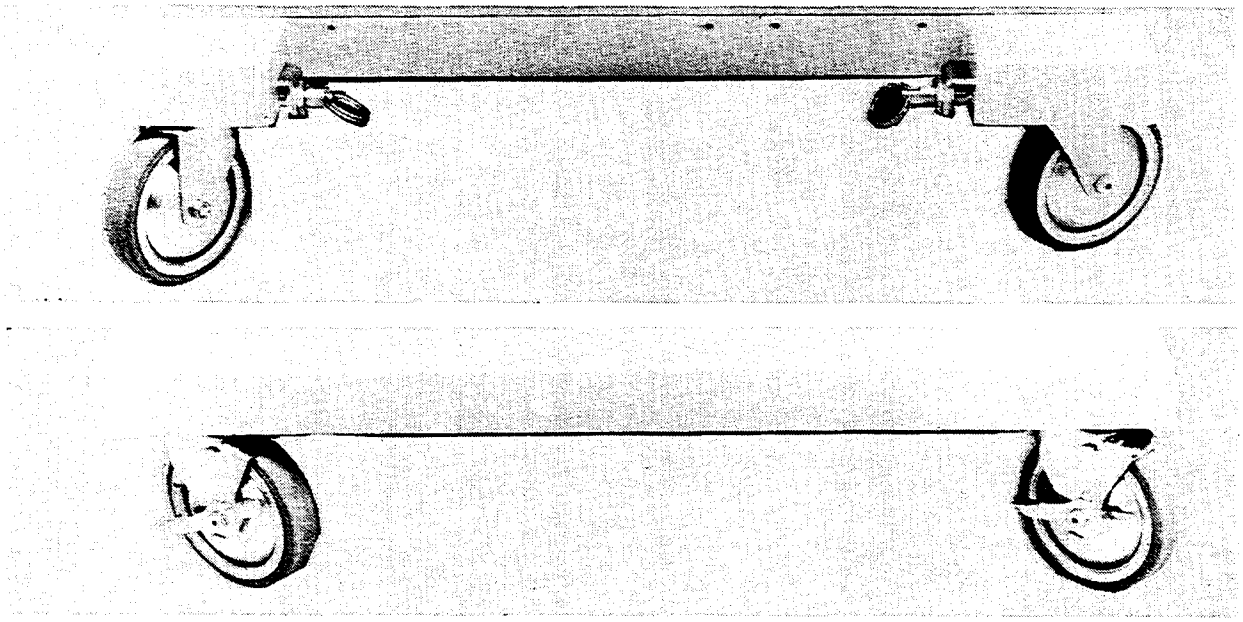
3. Steer the mainframe with the controls. The operation of the steering controls is demonstrated in Figure 10-13.

Figure 10-13 - *Use the steering controls to guide the mainframe.*



4. Unlock the monitor cart wheels and guide it carefully as you push. *(Refer to Figure 10-14).*

Figure 10-14 - *The front and rear wheel locks.*



5. When the system is finally in place, apply the friction wheel locks on the monitor cart and lock the mainframe front and rear wheels at right angles to each other.

Take These Precautions When Moving the System

- Two people should guide the mainframe and then return to guide the monitor cart when moving up or down an incline.

- Never move the system by pushing the mainframe ahead of you while pulling the monitor cart behind.

- Clear all hazards (this may mean both people and equipment) from the base of a ramp before moving the system along the incline.

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

- Never lock the mainframe or cart in place on an incline. It may roll out of control.

- Always apply the friction locks on the monitor cart and lock the front and rear wheels on the mainframe at right angles to each other when the system is in its final location.

10.6 Startup After Long Term Storage

Follow these steps if the system has been in storage for more than 60 days:

1. Plug in the system.
2. Follow the normal setup procedure.
3. Leave the system powered up in the FLUORO mode for at least four hours. (This allows for proper ion removal from the image intensifier tube).

If the system has been in storage for more than six months, condition the batteries and ensure their full charge before use:

1. Connect the interconnect cable between the mainframe and the monitor cart.
2. Plug in the monitor cart power cord. (The battery charger circuit will apply the charging current to the batteries in the mainframe).
3. Allow the batteries to charge in this manner for 24 hours.
4. Follow the normal setup procedure.
5. Leave the system in the FLUORO mode for at least four hours. (This allows for proper ion removal from the image intensifier tube).

10.7 Site Requirements

The major considerations for installation of the system are:

1) electrical power requirements,
2) environmental conditions, and
3) safety precautions.

The system power and operating environment requirements are listed in the *System Specifications*.

To satisfy its electrical requirements the system requires an input power source capable of providing:

115 VAC, 20 Amps or
230 VAC, 10 Amps.

Line voltage regulation requirements must be met as described in the Installation Checkout Procedure.

The customer is responsible for preparing the building, equipment environment and services required to install and operate the system.

10.8 Installation Checkout Procedure

As the steps in this procedure are performed, check them off on the Installation Checklist at the end of this section. You should make a photocopy of this checklist for use and save the original for reference.

10.8.1 Verify the Contents of the Accessory Kit

Verify that the following materials have been included in the System Accessory Kit (part # 870729). Note any shortages on the Checklist.

Two Operator's Manuals
Two Service Manuals
Two schematic Packages
Two mainframe keys
Footswitch assembly
Cassette holder (OEC-Diasonics metric or standard)
30 cm. skin spacer assembly
Eight socket-head Nylock screws
Copy of Configuration Sheet

Field Service Documentation Package:

- FDA form 2579
- Installation report (QAI 1003)
- Film identification stickers
- Various envelopes
- X-ray installation documentation instructions
- Instructions for Installation (QAI 1006)

10.8.2 Inspection and Setup

1. Install the skin spacer on the collimator assembly.

   Verify the presence of an aluminum filter at the bottom surface of the collimator and another aluminum filter located between the X-ray tube and the X-ray tube mounting bracket. The second filter can be seen after removing the aluminum filter from the bottom surface of the collimator. Look into the collimator and up toward the X-ray tube window.

2. Check the conductive casters on both the mainframe and the monitor cart for proper pressure and freedom of movement.

3. Inspect the interconnect cable; make sure the interconnect cable is permanently attached by its bracket to the monitor cart.

4. Remove the front, rear, and left side panels from the monitor cart and the left, right and rear covers from the mainframe. Inspect for loose hardware and shipping damage.

5. Inspect both the monitor cart card rack and the mainframe card rack. Verify that the extender board is present and that the retaining bars are screwed in place.

6. Replace all covers on the mainframe.

7. 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.*

10.8.3 Line Voltage Compatibility Check

The line voltage must be checked in each room where the equipment is to be used. Do not assume the line voltage will be constant throughout the hospital.

Verify voltage compatibility in all rooms where this machine will be used in the hospital. If a particular room is unavailable, write "NOT KNOWN" in the line voltage blank and put "NK" in the voltage and plug compatibility blanks on the checklist. A room is not plug compatible if it requires an adapter to be used. If any rooms are not voltage compatible, the hospital must be made aware of it.

10.8.4 Wiring the Isolation Transformer

1. The secondary voltage, measured on each leg referenced to neutral, should fall within the range 110-120 VAC. Wire the transformer to obtain a voltage as close to 115 VAC as possible.

   If the AC voltage range is:

94-102 VAC	wire T1 for 98 VAC
100-108 VAC	wire T1 for 104 VAC
105-115 VAC	wire T1 for 110 VAC
115-125 VAC	wire T1 for 120 VAC
122-134 VAC	wire T1 for 128 VAC

   If the AC voltage range is:

186-206 VAC	wire T1 for 196 VAC
200-218 VAC	wire T1 for 208 VAC
209-232 VAC	wire T1 for 220 VAC
228-252 VAC	wire T1 for 240 VAC
243-269 VAC	wire T1 for 256 VAC

2. Connect the interconnect cable to the mainframe and plug the power cord into the wall outlet. Check and record the voltages at the primary and secondary of the isolation transformer (T1).

3. Replace the covers on the monitor cart.

10.8.5 Basic Setup Checks

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 front panel. Refer to what these codes mean in the Service Section of this manual.

   Observe the Boot Codes on the mainframe LED panel and the Progress Codes on the monitor cart LED display as the operating software is loaded and the system is initialized.

   If any of these codes remains on the LEDs and the system fails to complete its booting and initialization, refer to the listing of boot codes in the Mainframe Service section or the listing of progress codes in the Monitor Cart Service section.

3. Check for correct AC voltage at the rear monitor cart AUX outlets.

10.8.6 Mechanical Checks

In the steps below, check for ease of movement without excessive play.

1. Check the **foot lever and steering handle** for proper movement. Then lock the C-arm in place by setting the wheels at right angles to each other.

2. Check **Wig Wag** - horizontal swing of the C-arm from side to side.

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 proper action of the pivot lock.

5. Check radial movement of the C-arm on the **cradle bearings** with proper holding action of the brakes.

6. Raise and lower the **L-arm.** The switch is located on either side of the extension arm assembly.

7. Rotate the **L-arm** 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

10.8.7 Verify Operation of Mainframe Controls

Warning: This procedure produces X-rays. Take the 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 an LED or beep response), indicating that the microprocessor is responding to the input.

3. Verify that the LARGE field switch removes the 6-inch collimator by listening for the "thunk" sound produced.

4. Select FILM mode and enter a low power technique.

5. Verify that the X-RAY ON lamps on the X-ray tube assembly, control panel and monitor cart light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

6. Verify operation of the footswitch.

7. 6-inch Machine only - Verify that in FILM mode, X-ray operation only occurs when the film cassette is in place.

8. Verify that the EMERGENCY OFF buttons on the control panel break the interlock circuit and prevent X-ray operation. (The message *INTLCKS BROKEN* will be displayed on the LED panel).

10.8.8 Verify Controls in MANUAL FLUORO

1. Select MANUAL FLUORO mode.

2. Verify that kVp and mA can be controlled with the control panel knobs.

10.8.9 AUTO FLUORO Tests

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Select AUTO FLUORO mode.

2. Using different thicknesses of copper filters, verify that the kV tracks up and down during X-rays as material thickness is increased and decreased.

3. Remove the copper filters.

4. Switch to live video using the VIDEO BYPASS switch (on the monitor cart rear) and verify that true live video appears on the left monitor and that the system does not lose synchronization.

5. Place the Wisconsin Copper Mesh Test Tool on the image intensifier assembly. Check image resolution during live imaging (video bypass mode). Minimum acceptable resolution is 35 line pairs per inch in the live mode.

6. Switch the VIDEO BYPASS switch to NORMAL. Check for proper operation of these mainframe controls:

   a. Left to right sweep reversal
   b. L -> R memory swap
   c. SHARPEN (if provided)

7. Verify operation of the motorized collimator and camera controls with the control panel switches.

8. Verify operation of the left monitor's remote contrast and brightness controls on the control panel. (Set the control on the monitor cart to REMOTE).

10.8.10 Verify Image Processing and Storage Features.

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Switch the VIDEO BYPASS switch to NORMAL.

2. Make a fluoro exposure and transfer the image to the right-hand monitor.

3. Make another exposure. The image will appear on the left monitor.

4. Enable the WINDOW and LEVEL functions and take another image. The WINDOW and LEVEL arrow buttons should change the dynamic range and brightness level of the image presented on the left-hand monitor.

5. Verify that the Negative Image (NEG) function reverses the lights and darks in the image.

6. Verify operation of both the Integration and the Averaging functions for all levels of averaging (number of frames).

7. Verify operation of the SHARPEN function.

8. 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.

9. *On systems equipped with hard disk image storage*, verify that the Manual SAVE function stores the image on the hard disc.

10. RECALL the image stored in the previous step.

11. *On systems equipped with hard disk image storage*, verify that the image counter increments and decrements, and that additional images can be recalled. "d0" error message displayed on the LED's indicates that no image was found in the specified location.

12. *On systems equipped with hard disk image storage*, enable the AUTO save function. Generate a picture on the left monitor, and press the L->R function switch. Verify that the image is auto-saved and that the LED image counter is incremented by one.

13. Time the transfer while saving an image to disk. The transfer should take less than 10 seconds, thus verifying disk transfer DMA.

14. Verify that the LEFT Fluoro footswitch generates a live fluoro image on the left monitor regardless of the status of the image processing controls.

15. Select an image processing mode (such as integrate). Press the RIGHT footswitch and verify that the selected image processing occurs.

16. Verify that the circular blanking is set as close as possible to the actual image edges throughout a full rotation in both normal and reversed image modes.

17. Check for presence of an EIA RS170 composite video signal at the video output jacks on the rear of the monitor cart.

NOTE: The video signal must be terminated with 75 ohms to correctly measure the amplitude.

10.8.11 Additional Image Processing Tests

An extensive set of tests are available through the Front Panel HELP function. These tests are described under Calibration and Diagnostic Software in the Monitor Cart Service section of this manual.

10.8.12 Fluoro Boost Option

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Enable boost on the control panel. Press down into the second position on the right footswitch.

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 image doesn't "burn out" or appear too dark.

10.8.13 Radiographic Beam Alignment Check

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Attach the beam alignment fixture to the face of the image intensifier assembly. Rotate the C-arm until the beam axis is perpendicular to the floor.

   On 6-inch models only: Verify that the cassette interlock switch is activated .

2. Make an exposure with the collimators fully open and the LARGE FIELD switch activated. Use 50 kV and 5 mAs. (The technique may vary depending on the type of film used.)

3. Close the collimators to their minimum field. Align the collimator assembly parallel to the cassette holder and repeat the exposure.

4. Develop the film.

5. Verify that the minimum field is contained within the target square (this must be less than 4.7 cm in each dimension measured on the film), that all of the innermost ring can be seen in the large field and none of the outer ring is visible.

6. Press the SMALL FIELD switch.

7. Install a new film cassette and repeat steps 2 thru 5 using the same technique.

8. Develop the film.

9. Verify that all the inner 6-inch ring is visible, and that none of the outer 6-inch ring is visible.

   The films are to be returned to the OEC-Diasonics Compliance Department per the instructions provided in the Field Service Documentation Package.

10.8.14 Fluoroscopic Beam Alignment Check

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. With the beam alignment fixture in place, select MANUAL FLUORO and set the technique at 45 kVp and 1 mA.

2. Bring up the Video Test Pattern on the monitor using the Monitor Cart Diagnostics described in the Monitor Cart Service section.

3. Make a fluoroscopic exposure and examine the test pattern image on the monitor. There should be no distortion of the image field and the inner circle of the beam alignment fixture reticle should be visible throughout its circumference.

10.8.15 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 check list:

   100 (Vn - V1)/ (V1)

   where: Vn = No load voltage
   V1 = 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.

10.8.16 Install and Verify System Options

Options provided may include:

Video Tape Recorder
AngioStor Video Disk
Hard Disk Image Storage (installed at the factory)
Patient Annotation (installed at the factory)

The installation of these options is described in Section 12 - Options.

10.8.17 Reporting

1. Return the assembler's copy of the Report of Assembly of Diagnostic X-ray (FDA form 2579), the Beam Alignment Radiographs (films), the completed Installation Report, and the Installation Checklist to OEC/Diasonics, Attention: Compliance Department, in the stamped, manila envelope provided in the Field Service Documentation Package.

2. Distribute the various remaining copies of the Report of Assembly of Diagnostic X-ray (FDA form 2579), per the documentation instructions included in the Field Service Documentation Package.

3. Verify the serial and model numbers listed and the control numbers on the Main Frame and Collimator. These should agree with those listed on FDA form 2579.

4. Record the installation in the service log.

   The OEC Representative MUST sign the last page of the Installation and Checkout Checklist, verifying acceptance of the unit. If, for any reason, installation can not be completed, the OEC Representative MUST be notified that unit is not yet ready for use. (A copy of the Installation and Checkout Procedure Checklist is found at the end of this section).

INSTALLATION CHECKLIST

Check off these steps as you perform the Installation Checkout Procedure in the service manual. Paragraph numbers are provided to make it easier to correlate the checklist to the procedure. Fill in specific data where requested.

Date - _____ S/N - _____

10.8.1 Verify the Contents of the Accessory Kit

Verify that the following materials have been included in the System Accessory Kit (part # 870729). Note any shortages below.

___ Two Operator's Manuals
___ Two Service Manuals
___ Two schematic packages
___ Two C-arm keys (inside ring binders)
___ Footswitch assembly
___ Cassette holder
___ 30 cm. skin spacer assembly
___ Eight Nylock socket-head screws
___ Copy of Configuration Sheet

___ Field Service Documentation Package:
___ FDA form 2579
___ Installation report (QAI 1003)
___ Film identification stickers
___ Various envelopes
___ X-ray Installation documentation instructions
___ Instructions for Installation (QAI 1006)

10.8.2 Inspection

___ 1. Check skin spacer, primary and secondary filters.
___ 2. Check conductive casters on cart and mainframe.
___ 3. Check interconnect cable attached to monitor cart with bracket.
___ 4. Remove panels and covers; inspect the interior of mainframe and cart.
___ 5. Inspect the card racks in monitor cart and mainframe.
___ 6. Replace all covers.
___ 7. Inspect AC power cable and the high voltage cable.

10.8.3 Line Voltage Compatibility Check

Verify voltage compatibility in all individual rooms where this machine is intended to be used in the hospital. If a particular room is unavailable, write "NOT KNOWN" in the line voltage blank and put "NK " in the voltage and plug compatibility blanks. A room is not plug compatible if it requires an adapter to be used. If any rooms are found not voltage compatible, the hospital must be made aware of it.

Location	Compatible ?	
	Voltage	Plug
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___

10.8.4 Wiring the Isolation Transformer

Primary _____ VAC

Secondary _____ VAC

___ 1. The secondary voltage measured on each leg should fall within the range of 110-120 VAC referenced to neutral.
___ 2. Replace the monitor cart covers.

10.8.5 Basic Setup

___ 1. Power up the system as usual.
___ 2. Monitor cart and mainframe complete their software boot and initialization with no self-test errors reported on the displays.
___ 3. Check for AC voltage at the rear monitor cart AUX outlets (110-120 VAC).

10.8.6 Mainframe Mechanical Checks

___ 1. Footlever and steering handle.
___ 2. Inspect the wig-wag.
___ 3. Inspect the extension arm
___ 4. Inspect the flip-flop and C-arm pivot point.
___ 5. Check C-arm movement in the cradle.
___ 6. Check L-arm lift movement.
___ 7. Check L-arm rotation.

10.8.7 Verify Operation of Mainframe Controls

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

___ 1. Verify that the anode is rotating.
___ 2. Check all control switches.
___ 3. Verify that the LARGE field switch removes the 6-inch collimator - listen for the "thunk" sound produced.
___ 4. Select FILM mode.
___ 5. Verify that the X-RAY ON lights on the X-ray Head, Control Panel and Monitor Cart light when the X-RAY ON button is pressed. The audible beep should also be heard.
___ 6. Verify operation of the footswitch.
___ 7. 6-inch Machine only - Verify that FILM Mode operation only occurs when the film cassette is in place.
___ 8. Verify that the EMERGENCY OFF buttons break the interlock circuit.

10.8.8 Verify Controls in MANUAL FLUORO

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

___ 1. Select MANUAL FLUORO mode.
___ 2. Verify control with the control panel knobs.
___ 3. Observe fluoro image on the left monitor.

10.8.9 Auto Fluoro Tests

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

___ 1. Select AUTO FLUORO mode.
___ 2. Verify that the kV tracks up and down as material thickness is increased and decreased.
___ 3. Remove copper filters.
___ 4. Verify operation of VIDEO BYPASS switch.
5. Check resolution during video bypass.

_____ line pairs per inch.

6. Check operation of mainframe video controls.

___ a. Left to right reversal
___ b. L->R Swap
___ c. SHARPEN (if provided)

___ 7. Check operation of the motorized collimator and camera controls.
___ 8. Check remote contrast and brightness controls.

10.8.10 Verify Image Processing and Storage Features

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

___ 1. Set video bypass switch to normal.

___ 2. Make an exposure and transfer image to right monitor.
___ 3. Make another exposure.
___ 4. Check operation of WINDOW and LEVEL.
___ 5. Check NEG function.
___ 6. Verify operation of INTEGRATION and AVERAGING.
___ 7. Check operation of SHARPEN.
___ 8. Check operation of L->R function from the monitor cart front panel.
___ 9. *On systems equipped with hard disk image storage*, verify operation of SAVE.
___ 10. *On systems equipped with hard disk image storage*, verify operation of RECALL.
___ 11. *On systems equipped with hard disk image storage*, verify operation that the image counter increments and decrements.
___ 12. *On systems equipped with hard disk image storage*, verify operation of AUTO.
___ 13. *On systems equipped with hard disk image storage*, verify operation of DMA.
___ 14. Verify operation of the FLUORO ONLY footswitch.
___ 15. Verify operation of the PROCESS footswitch.
___ 16. Check circular blanking.
___ 17. Verify proper video signal on the video output jacks (when terminated with 75 ohms).

10.8.11 Additional Image Processing Tests

___ As required.

10.8.12 Fluoro Boost Option

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

___ 1. Enable BOOST on the control panel.
___ 2. Alarm beeps at twice the normal rate.
___ 3. Verify that boost works in both auto and manual X-ray modes.
___ 4. Image doesn't "burn out" or appear to dark.

10.8.13 Radiographic Beam Alignment Checks

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

___ 1. On the first film - Verify that the minimum field is contained within the target square (this must be less than 4.7 cm in each dimension measured on the film), that all of the innermost ring can be seen in the large field and none of the outer ring is visible.

___ 2. On the second film - Verify that all the inner 6-inch ring is visible, and that none of the outer 6-inch ring is visible.

The films are to be returned to the OEC-Diasonics Compliance Department per the instructions provided in the Field Service Documentation Package.

10.8.14 Fluoroscopic Beam Alignment Check

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

___ 1. Bring up the Video Test Pattern, make a fluoroscopic exposure, and examine the image within the video test pattern.
___ 2. Circular blanking is correct.
___ 3. Image size is correct.

10.8.15 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. Calculate the percentage line voltage regulation and record the results below.

   100 (Vn - V1)/ (V1)

   where: Vn = No load voltage
   V1 = Max load voltage

   Vn=_____
   V1=_____

   Regulation = _____%

   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.

2. Measure the voltage on the isolation transformer secondary under maximum radiographic load. It must not fall below 100 VAC.

   Secondary voltage under max. load = _____ VAC

10.8.16 Install and Verify System Options

___ Install and verify options. The installation of options is described in Section 12, Options.

10.8.17 Reporting

___ 1. Return the assembler's copy of the Report of Assembly of Diagnostic X-ray (FDA form 2579), the Beam Alignment Radiographs (films), the completed Installation Report, and the Installation Checklist to OEC-Diasonics, attention: Compliance Department, in the stamped, manila envelope provided in the Field Service Documentation Package.

___ 2. Distribute the various remaining copies of the Report of Assembly of Diagnostic X-ray (FDA form 2579), per the documentation instructions included in the Field Service Documentation Package.

___ 3. Verify the serial and model numbers listed and the control numbers on the Main Frame and Collimator. These should agree with those listed on FDA form 2579.

___ 4. Record the installation in the service log.

___ 5. OEC Representative and hospital representative MUST sign last page of Installation Checklist, verifying acceptance of unit. If, for any reason, installation could not be completed, both OEC Representative and hospital representatives MUST be notified that unit is not yet ready for use.

This system is now installed and is operating in a satisfactory manner. The hospital representative acknowledges any limitations due to voltage incompatibilities between different areas of projected use.

OEC-DIASONICS Field Service Representative

_____

OEC Applications Representative

_____

Hospital Representative

_____

9000 SERVICE MANUAL

UPDATE
00-876628-01
REV. A

INSTRUCTIONS:

1. Insert this -01 Update tab and text at the back of the manual, after the last page.

Date of Issue: November 1993

OEC MEDICAL SYSTEMS, INC.

384 Wright Brothers Drive
Salt Lake City
Utah
84116

(801) 328-9300

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Revision History

Update PN & Rev.	Manual PN	Manual Revision
00-876628-01, Rev. A	00-870820-01	C

UPDATE

1. BATTERY REPLACEMENT, TECHNIQUE PROCESSOR BOARD

The real time clock battery, B1, on the technique processor board should be replaced every two years. The age of the battery can be derived from either the delivery date, for a recently purchased unit, or from the dated label that is applied during battery service. Under normal operating conditions, the expected life of the battery is well in excess of two years. However, replacement every two years insures that the battery will not deplete during usage.

9000/URO1000 BATTERY REPLACEMENT KIT, 00-876434-03:

Quantity	Part Number	Description
1	74-122902-00	3V Lithium Battery
1	32-301420-00	2KΩ, 1/4W Resistor
1	88-359989-00	Self Adhesive Label
2	00-876488-01	Operator's Mnl. Replacement Pages
2	00-876801-01	Operator's Mnl. Replacement Pages

BATTERY REPLACEMENT KIT, 00-876434-02*:

Quantity	Part Number	Description
1	74-122902-00	3V Lithium Battery
1	88-359989-00	Self Adhesive Label

*See NOTE on the following page which explains when the -02 Kit is needed.

PARTS/TOOLS REQUIRED:

Indelible Marker

Soldering Iron

Solder

1.1 PROCEDURE

NOTE:

The following procedure is for first-time installation of a new battery on the PCB. It assumes that the 2KW resistor has *not* yet been installed near IC U79 and that you are using Battery Replacement Kit PN 00-876434-03. If this resistor has already been installed and you are only replacing the battery, you need to use Battery Replacement Kit PN 00-876434-02 which includes the new battery and label. Be sure to write the date of installation on the new label and place the label on U79 after replacing the battery.

1) Turn off all power to the system.

2) Remove the Technique Processor PCB from the generator card rack (see Figure 1, page 7).

3) Carefully remove U79 from the socket on the Technique Processor PCB and set aside (see Figure 2, page 8).

4) Locate the battery (B1) on the Technique Processor PCB (see Figure 2, page 8) and carefully remove the battery from the Technique Processor PCB by cutting the battery leads. After you remove the battery, carefully remove the leads of the battery from the Technique Processor PCB with your soldering iron and clean the solder holes so that the new battery can be installed.

5) While looking at the component side of the Technique Processor PCB locate the socket for U79. Near pin 12 of the socket for U79 is a short solder trace with a solder pad at both ends of the trace. Electrically this trace goes from U79 pin 14 to the battery B1. Refer to Figure 3, page 9, for the location of this trace.

6) Carefully cut the middle of the solder trace from step 5. Refer to Figure 3, page 9. Use your soldering iron to carefully remove the solder from the solder pads at the ends of the trace you cut.

7) Install the 2KΩ resistor (32-301420-00) provided with the Battery Replacement Kit on the component side of the Technique Processor PCB by inserting the leads of the resistor through the holes of the solder pads of the trace you cut in step 6. Carefully solder the resistor into place. Electrically this resistor is now in series between U79 pin 14 and the battery B1.

8) Install the new 3V battery (74-122902-00) provided with the Battery Replacement Kit on the Technique Processor PCB into the same location as the old battery. Carefully solder the battery onto the Technique Processor PCB.

9) Install U79 back into the socket on the Technique Processor PCB.

10) Using an indelible marker write the current date on the self adhesive label (88-359989-00) provided with the Battery Replacement Kit. Affix the self adhesive label to the top of U79 on the Technique Processor PCB.

11) Carefully install the Technique Processor PCB back into the system.

12) Turn the system on and allow it to boot completely. You may get a message on the control panel that says the system needs 24 hours to recharge. You may ignore this message and get past it by pressing any key on the control panel.

13) Enter the STATUS mode of the system through the control panel and set the time and date. Instructions on entering the STATUS mode for your particular system may be found in the Maintenance section of the Operator's Manual.

14) Reboot the system and make sure it boots up completely. Make sure the system operates correctly by verifying fluoro operation, film operation, image storage, etc.

15) After upgrading the 9000, leave the Operator's Manual Replacement Pages (00-876488-01) and (00-876801-01) that were sent as part of the upgrade kit with the customer.

Figure 1 - Technique Processor PCB location in 9000 Electronics Cabinet

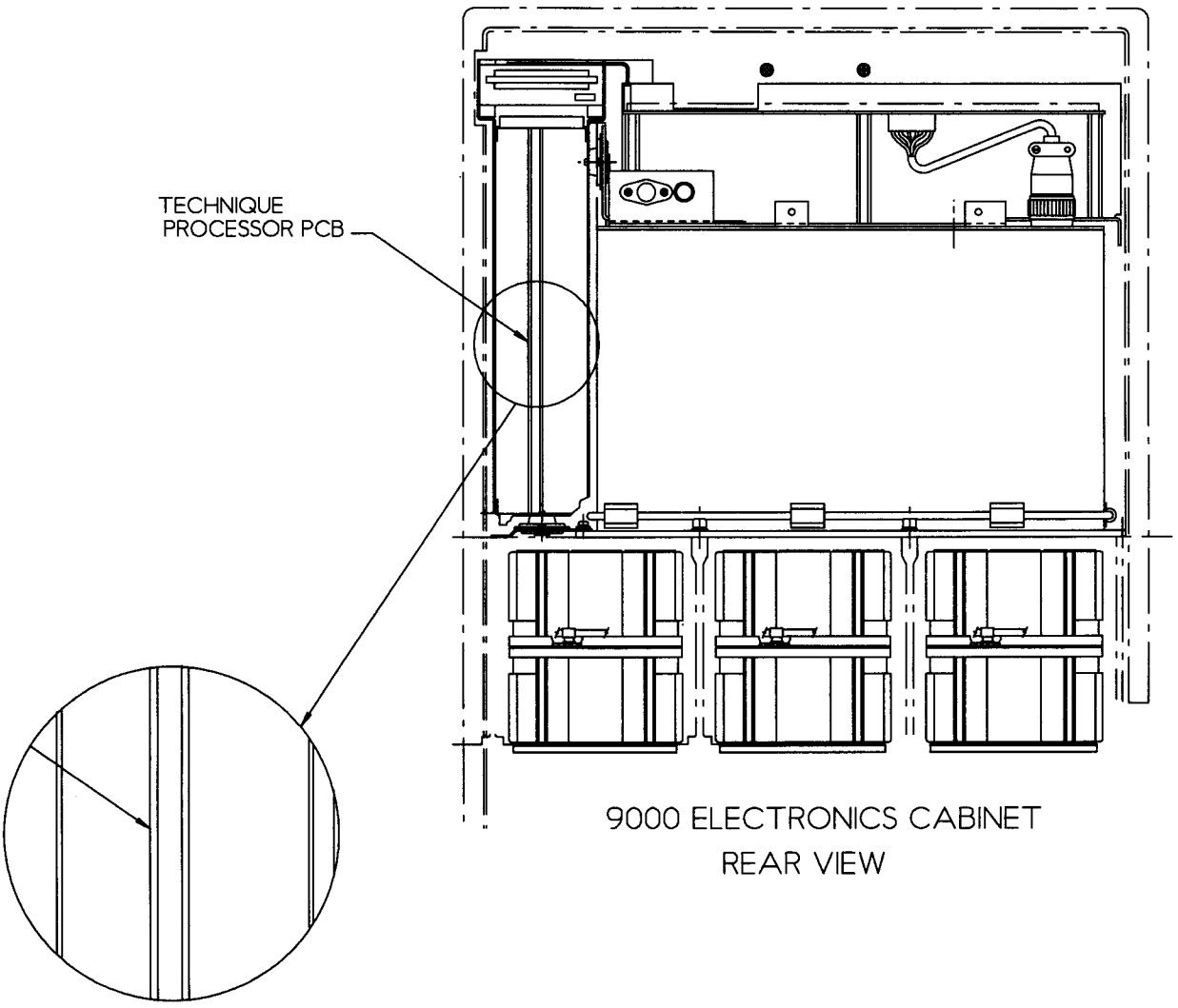


Figure 2 - Battery and Real Time Clock IC locations on Technique Processor Board

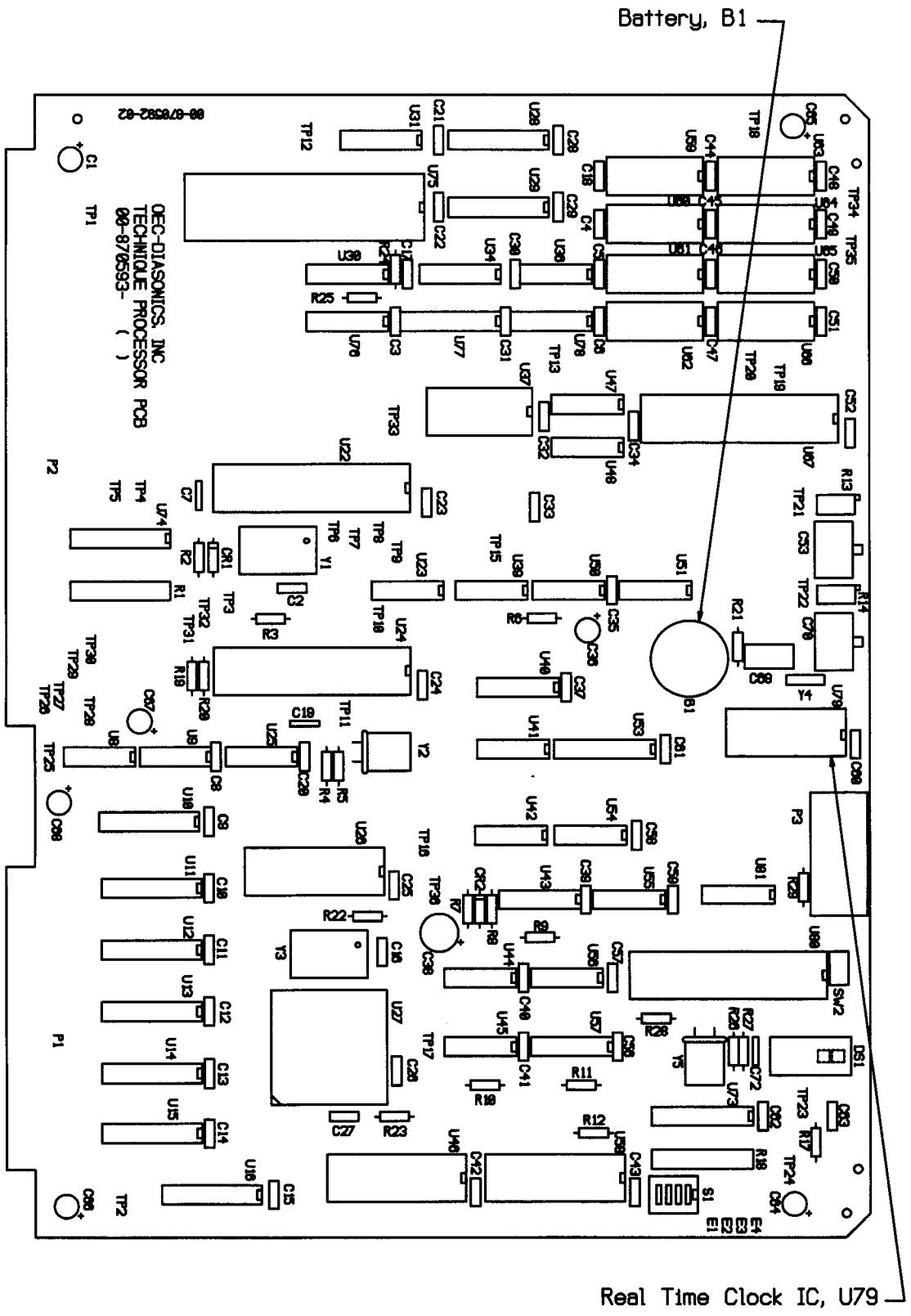
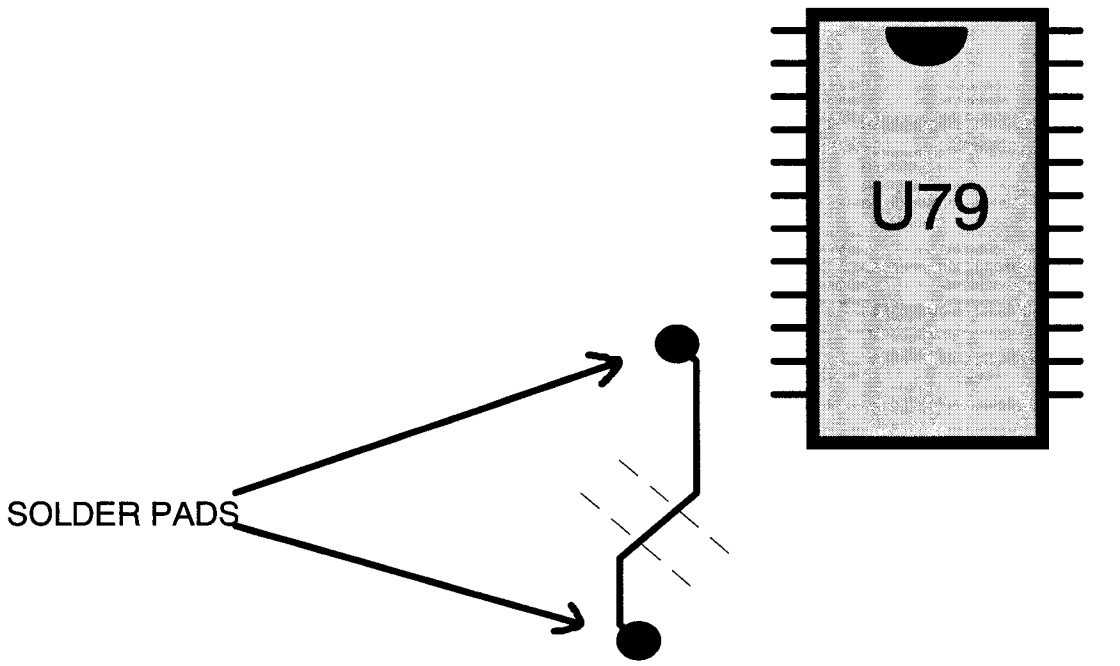


Figure 3 - Location of 2KΩ Resistor installation on the Technique Processor PCB



CUT TRACE BETWEEN DASHED LINES

INSTALL RESISTOR BETWEEN SOLDER PADS

SERVICE MANUAL

00-870820-01

SERIES 9000

X-RAY IMAGING SYSTEM

Effectivity:

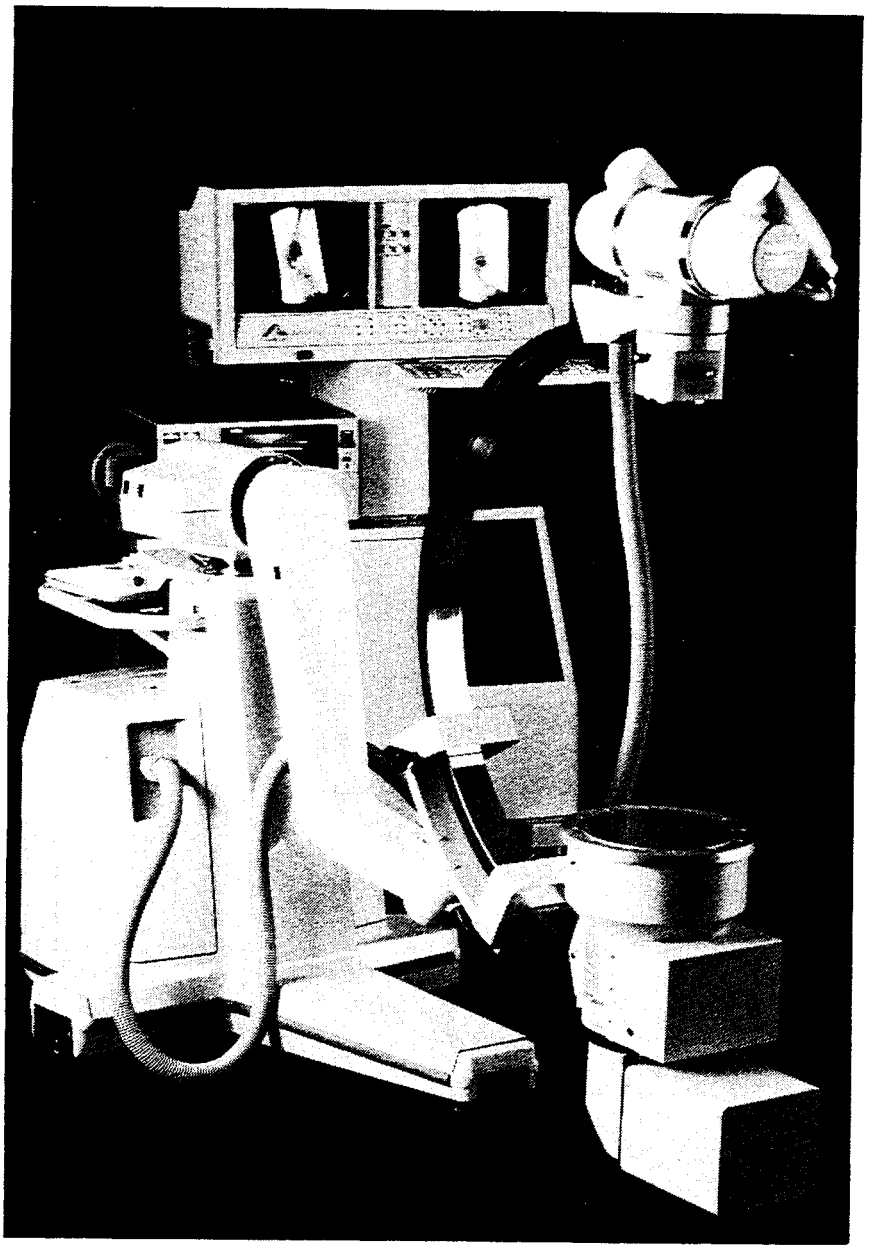
This manual contains descriptions, instructions and procedures which apply only to Series 9000 systems with serial numbers in the 96-000 and 99-000 series.

Date of Issue: September 1987

OEC-DIASONICS

384 Wright Bros Drive
Salt Lake City
Utah
84116

(801) 328-9300



SERIES 9000 X-RAY IMAGING SYSTEM (Details of this photograph may vary depending on options).

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 the properly trained service engineer who 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 Series 9000 system.

This manual is intended to compliment the training offered by OEC-Diasonics. You should not attempt any of the procedures in this manual unless you have received this training on the Series 9000 System. Reading this manual does not alone 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.

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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 the properly trained service engineer who 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 Series 9000 System.

This manual is intended to compliment the training offered by OEC-Diasonics. Reading this manual does not alone 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.

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 certain hazards, emergency procedures and instructions for accident reporting.

Section 3
Mainframe 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.

Section 4
Monitor Cart Theory of Operation
A description of the hardware and software is provided to facilitate an understanding of the maintenance, calibration and repair of the monitor cart. Optional patient annotation and hard disk image storage are covered.

Section 5
Mainframe Parts, Disassembly and Replacement
Step by step instructions for removing and replacing field serviceable parts.

The major field replaceable parts are pictured and identified with their OEC-Diasonics part numbers.

Section 6
Monitor Cart Parts, Disassembly and Replacement
Step by step instructions for removing and replacing field serviceable parts.

The major field replaceable parts are pictured and identified with their OEC-Diasonics part numbers.

Section 7
Mainframe Service and Diagnostics
Mainframe boot and error codes, event codes and warning messages. Using the control panel Status Mode. Tables of adjustments, switches and jumpers.

Section 8
Monitor Cart Service and Diagnostics
How to change the monitor cart option configuration. Front Panel error messages. Built-in test and diagnostic software. Shot logging.

Section 9
Mainframe Calibration
Calibration procedures for the system are provided. A calibration worksheet is included.

Section 10
Installation
Unpacking, repacking, installation and on-site checkout instructions are provided.

Section 11
Options
Installation of options, interfaces, special troubleshooting and maintenance notes. Options include: VTR, AngioStor, multiformat camera.

Appendix
Recommended tools and test equipment. Installation and Use of Special Equipment. Printer Installation. Terminal installation and use. Test Log.

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 00-870820-01). Operating instructions for the system are contained in the Operator's Manuals for each member of the Series 9000 family:

9000 basic model - 00-871352
9000 with E.S.P. Option - 00-871353
9000 with E.S.P. and Vascular or Neuro-Vascular Option - 00-871354

Schematic diagrams for the system are contained in the schematic package, part number 00-870822.

The system contains some equipment and assemblies manufactured by original equipment manufacturers (OEM's) and not OEC-Diasonics. 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 maintenance 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 (21CFR 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, Generator Controller 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

Figures 1, 2, and 3 illustrate the major assemblies of the OEC-Diasonics Mobile C-arm X-ray System. The two major assemblies, the mainframe and the monitor cart, are connected by an 18 foot interconnect cable which carries power, video and communications signals.

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 to provide static grounding in an operating room environment.

1.5 Standard Equipment

Table 2 Standard Equipment

ITEM	*PART NUMBER*
C-arm Assembly	00-870724
Monitor Cart Assembly	00-870727
Collimator and Plate Assembly	
(6-inch)	00-870472
(6/9-inch)	00-870472
Image Intensifier Asm w/ Vidicon	
(6-inch)	00-870725
(6/9-inch)	00-870817
Cassette Holder	
(6-inch standard)	00-861095
(6-inch metric)	00-871096
(9-inch standard)	00-871138
(9-inch metric)	00-871139
Accessory Parts Kit	00-870729
Conductive Caster Asm	00-860092
Foot Switch Assembly (Dual Stage)	00-900012
30 cm Extension Spacer	00-837201

Figure 1 - *The mainframe is shown in this drawing.*

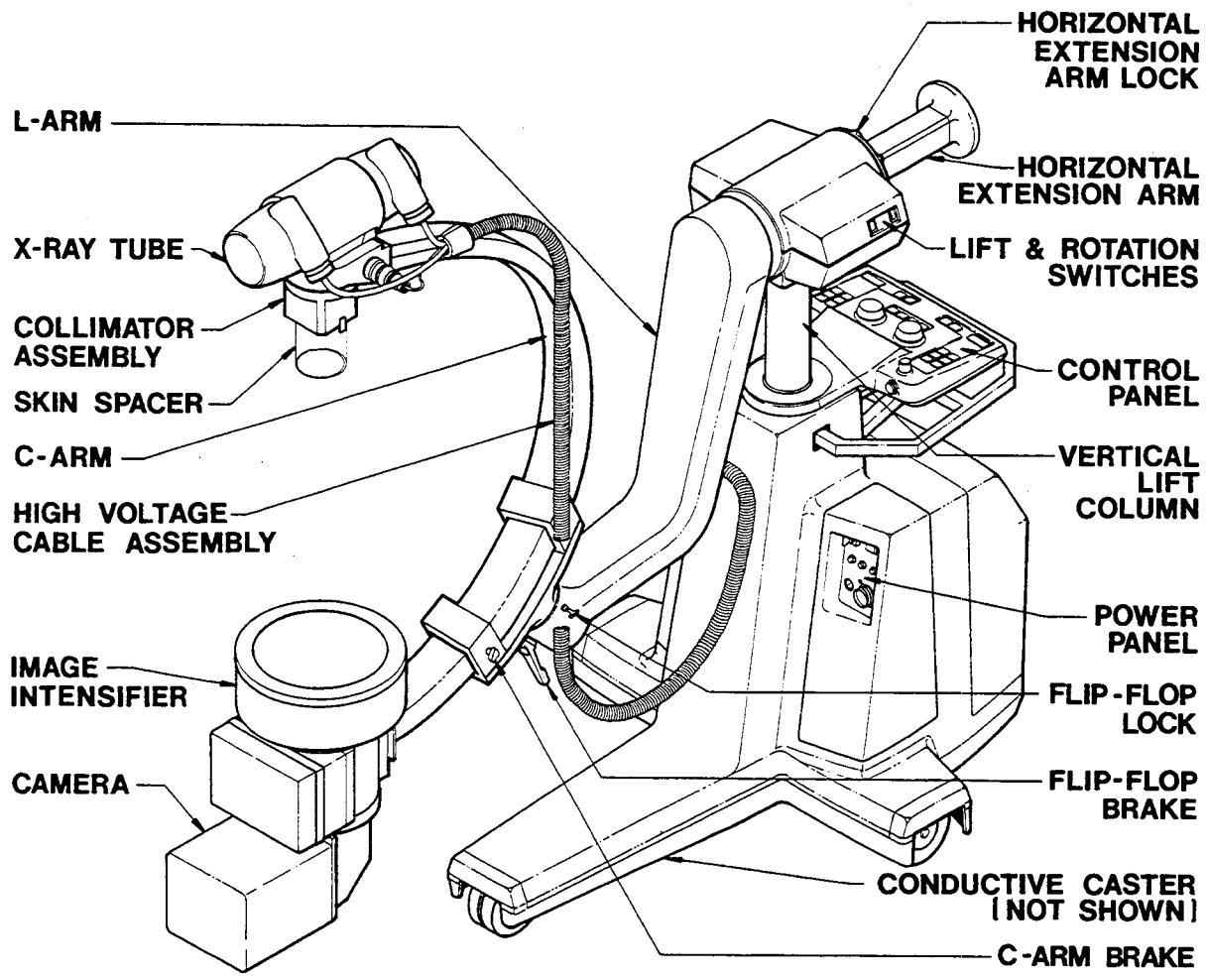


Figure 2 - *Front view of the monitor cart.*

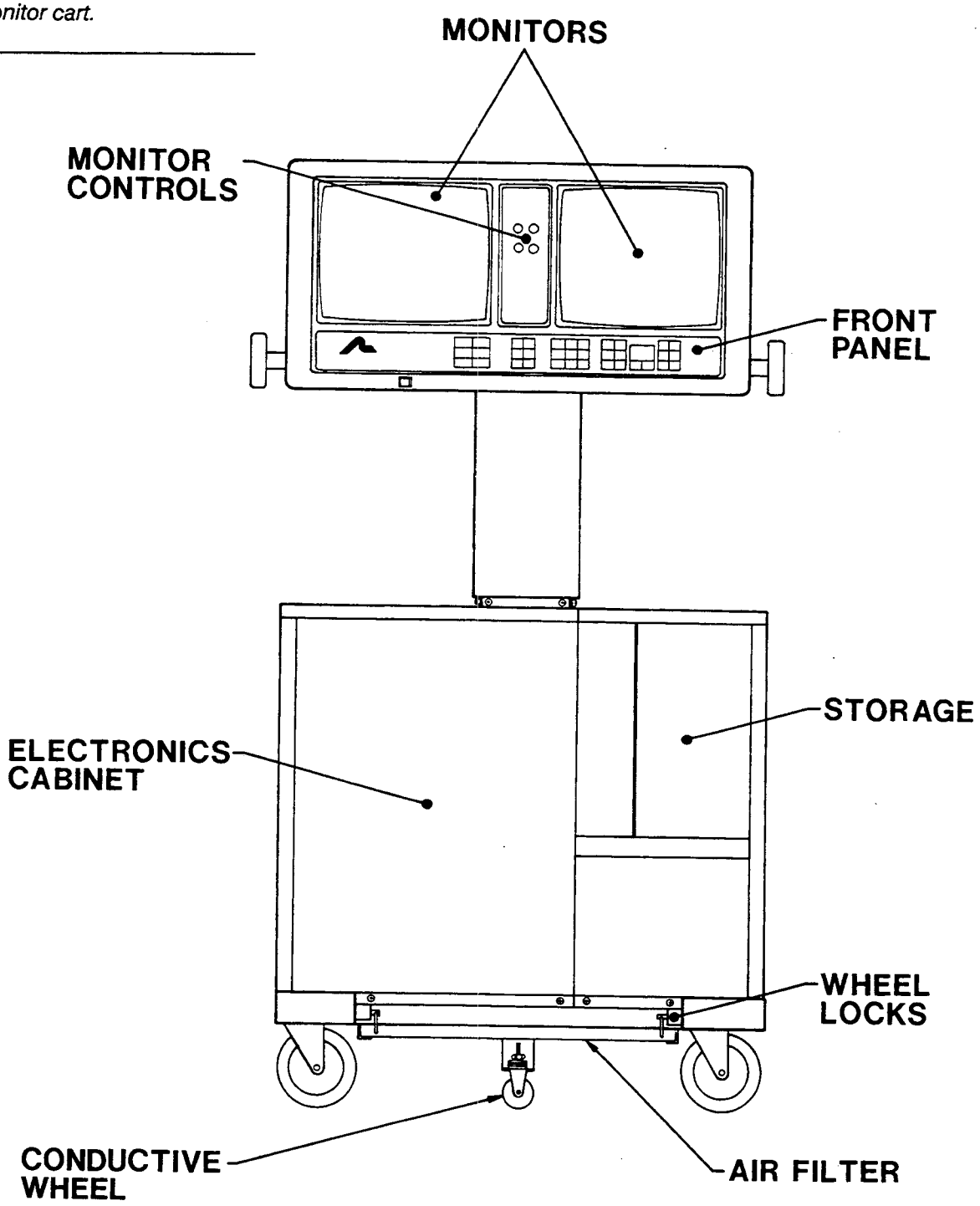
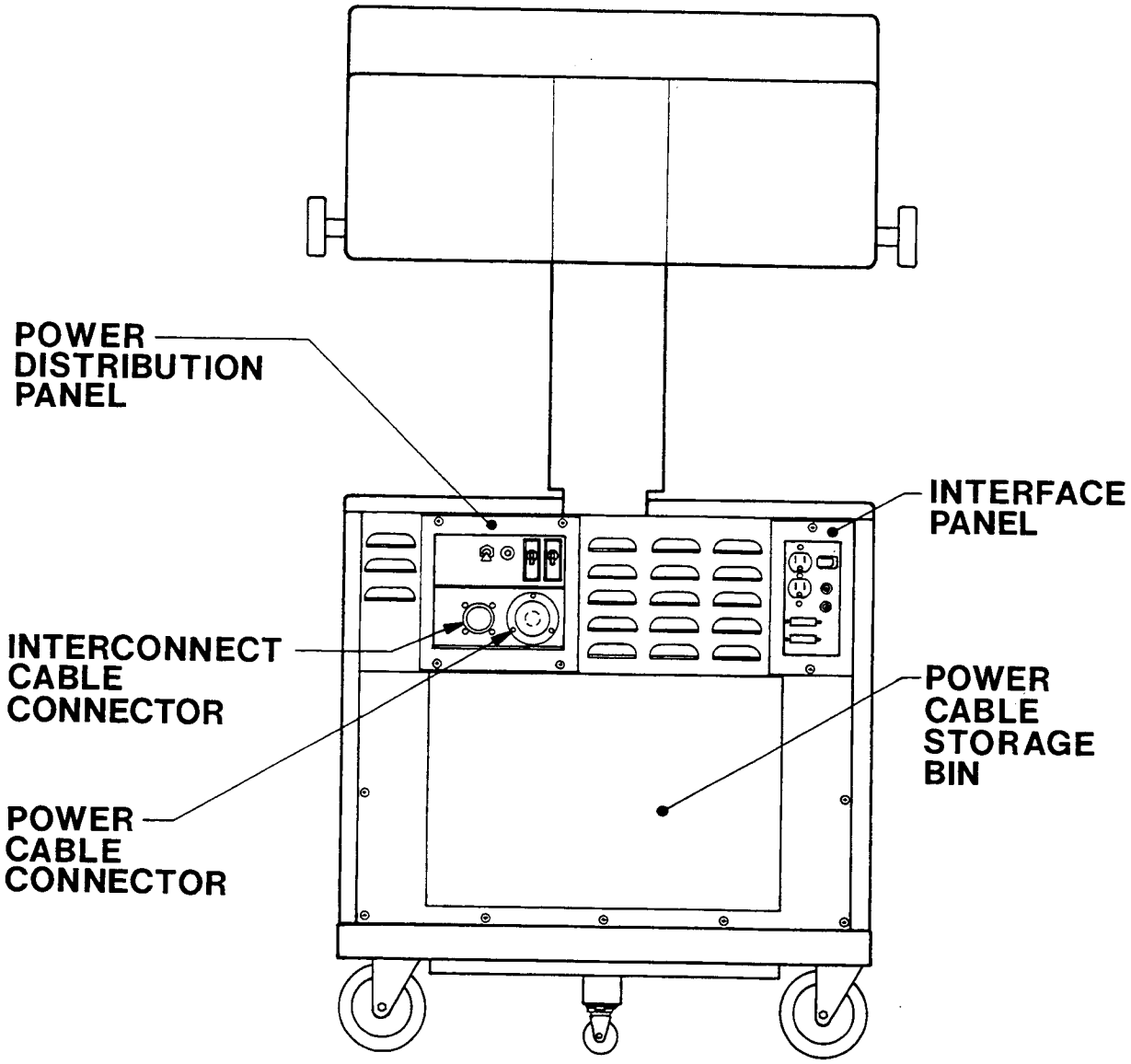


Figure 3 - *Rear view of the monitor cart.*



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 connecting an external terminal. The option files are described in the sections of this manual: "Mainframe Service" and "Monitor Cart Service."

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 dual mode 6/9-inch image intensifier. Serial numbers in the 63-000 range identify systems equipped with 6-inch image tubes. Serial numbers in the 93-000 range identify those equipped with 6/9-inch image tubes.

1.9 Monitor Cart Options

Image Storage

Images may be stored by several means, in analog or digital format, depending upon the system configuration.

Internal Hard Disk Image Storage - a hard disk memory system capable of storing sixty 512 x 512 x 8 bit matrix images. The digitized image can be saved on the hard disk and later recalled.

Video Tape Recorder - The undigitized image is available for storage on a video tape recorder or AngioStor.

AngioStor - Up to 20 seconds of high resolution video can be stored and reviewed. Playback can be continuous or stepped a single frame at a time.

Multi-format Camera - Several models are available to make hard copy films of fluoro images.

Patient Annotation - Images can be annotated with identifying information on the screen or on hard disc. A swing out keyboard is used with special software.

Image Processing

The circuits and software in the monitor cart perform image processing on the video signal. The specific operations, which may include frame integration, frame averaging, image subtractions, and "window" and "level" control of the gray scale, are selected from the monitor cart front panel.

Most image processing options can be identified by examining the monitor cart front panel.

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 all safety requirements applicable to medical electronic equipment of this type.

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

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 who has been trained to troubleshoot and repair the Series 9000 System.

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

WARNING: **The procedures in this manual should not be attempted by anyone who is not specifically trained by OEC-Diasonics to work on the Series 9000 System.**

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; nor can it be responsible 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.
P.O.Box 25296
Salt Lake City, Utah
84125-0296
801-973-6800

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 who work with or are exposed to X-ray tubes must take precautions to protect themselves against serious injury. Do not be careless.

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.

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.

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: **This equipment contains very high power electrical components and should be serviced only by personnel intimately 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.**
- Video monitors (monitor cart) - **25,000 volts.**
- Transformers (especially the isolation transformer in the monitor cart) - **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.**

WARNING: **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.**

WARNING: **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.**

WARNING: **Do not remove the interconnect cable from its connector on the monitor cart. Hazardous voltage (120 VAC) is present on the pins of this connector when the monitor cart is plugged into a power outlet. These pins are exposed when the interconnect cable is not in place.**

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.

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

Federal DHHS guide lines specify that the minimum source-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-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 Emergency Power Off

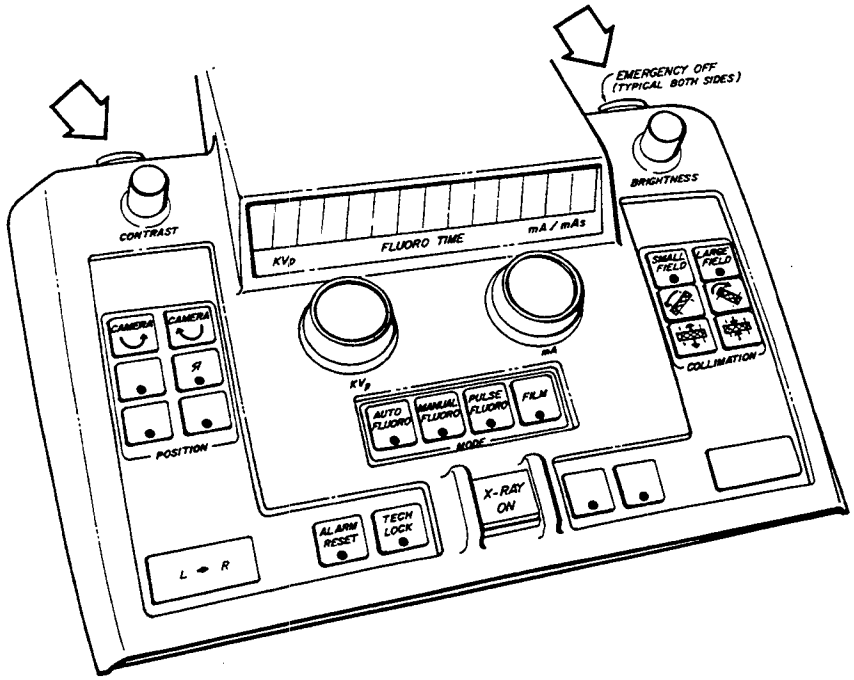
Refer to Figure 1.

The system has two EMERGENCY OFF buttons located on the C-arm control panel. When either button is pressed, operation of the system 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.

In the unlikely event that a malfunction in the motor control circuitry causes a motor to drive without an operator command, it is important to train all operators to respond by pressing the EMERGENCY OFF switch.

The monitor cart electronics are separately controlled by the cart power breaker on the cart power panel. To remove power only from the monitor cart electronics turn this breaker off.

Fig. 1 - The locations of the two emergency off buttons are shown here.



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 by a qualified service technician.

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 System Failure During Fluoroscopic Use

If the system image processing electronics fail during a critical operative procedure, set the toggle switch on the rear of the monitor cart to BYPASS. This will direct undigitized live fluoro images to the left monitor, bypassing the image processing electronics.

NOTE: Last-image-hold will not operate in BYPASS.

2.5.4 System Malfunction

If a fuse is blown repeatedly or a circuit breaker trips after being reset, it may indicate an equipment malfunction. Do not attempt to operate the system until it has been checked out by a qualified service technician.

If any of the system controls fail to respond as indicated in the Operator's Manual, the operator should, if the immediate circumstances allow:

1. Turn the power off.
2. Unplug the system from the wall outlet.
3. Notify a qualified service technician immediately.
4. Do not attempt to operate the system until the service technician has advised that it is operating properly.

The system should not used beyond the immediate situation if any system control failure occurs.

2.5.5 Electrical Fire

The owner should develop an emergency procedure for the area in which the system is installed that includes the following safety measures:

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 *The use of 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.*

2.5.6 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.

2.6 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:

- The potential for death or the type of serious injury that may result is specified in the labeling for the system.

- The malfunction and the routine service, repair, or maintenance instructions to correct the malfunction are described in the labeling for the system.

- The malfunction has occurred at or below its expected rate of frequency and severity.

- 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.

2.7 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
MAINFRAME
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 in understanding the maintenance and calibration procedures in this manual.

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

The software plays a central role in the operation of the system. Therefore discussion of software is combined with the hardware theory of operation.

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 (00-870735) and the Image System Interconnect Diagram (00-871059).

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. The connectors J1, J2, J3 and J4 provide the internal computer bus.

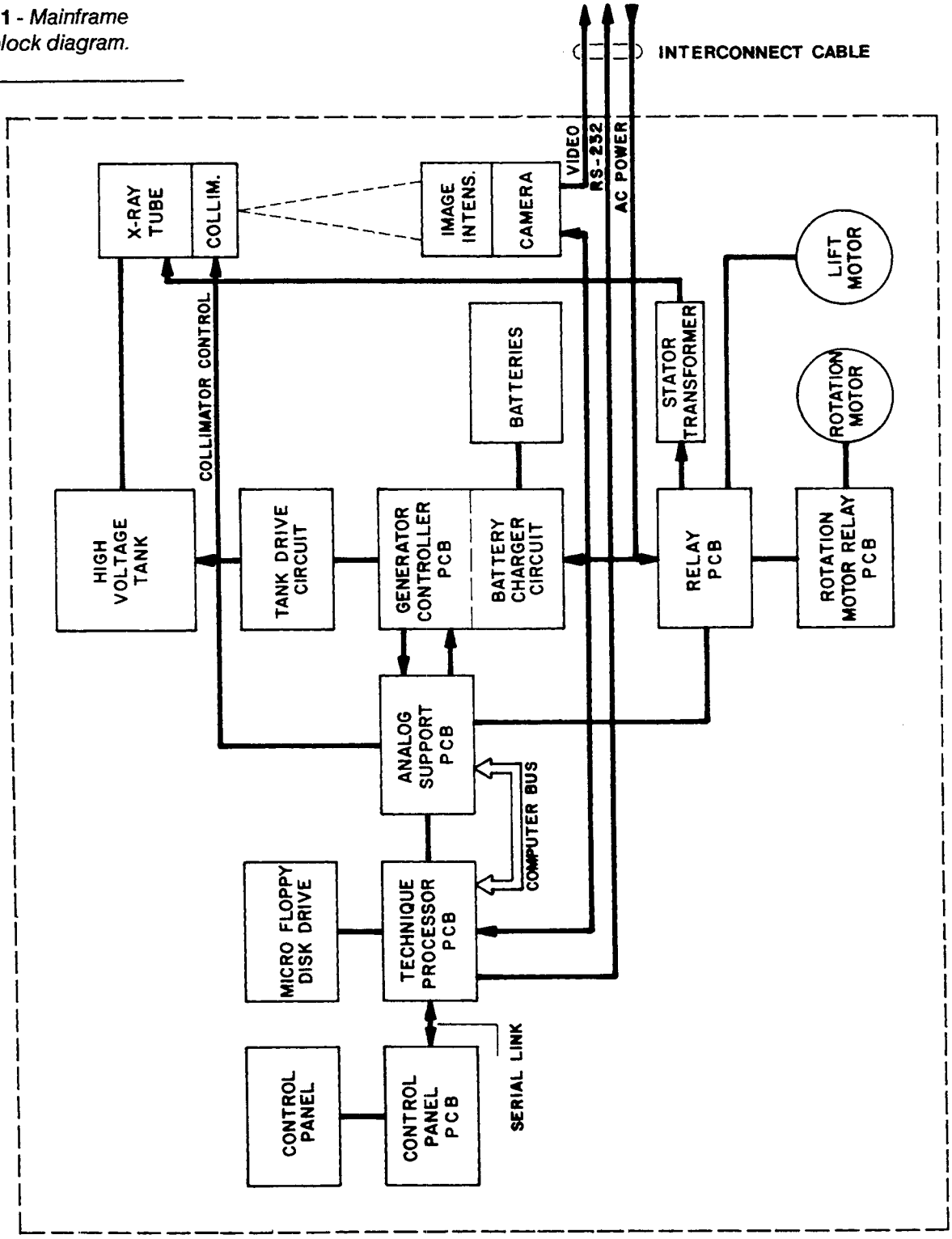
Floppy Disk Drive - Mainframe operating and application software is contained on a 3 1/2-inch microfloppy disk. Each time the system is started, the software is loaded from the disk drive.

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 Controller PCB - the filament control, high voltage control, mA and kVp sensing and battery charger are combined on this board.

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.

The mainframe and monitor cart are interconnected by an 18-foot cable which carries power, video and communications signals. Both ends are interchangeable. The monitor cart end is normally locked in place to prevent the electrical shock hazard that could result from accidentally contacting the line voltage pins on the connector. A stand-alone adapter is not required to operate the monitor cart for post-processing without the mainframe attached.

3.2 Power Distribution

3.2.1 AC Power

Refer to the Mainframe Interconnect Diagram 00-870735.

Power is obtained from the AC line by the isolation transformer in the monitor cart and applied to the mainframe through an 18-foot interconnect cable. In the mainframe, 115 VAC (optimal) is distributed to the battery charger circuit on the Generator Controller PCB, 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.

Table 1 Interconnect Cable Wiring List

PIN	*FUNCTION*
1	X-ray disable
2	video stable
3	L>R
4	spare
5	store
6	spare
7	RTS cart
8	TXD cart
9	CTS cart
10	RXD cart
11	brightness
12	contrast
13	X-ray lamp 3
14	n.a.
15	n.a.
16	n.a.
17	n.a.
18	n.a.
19	n.a.
20	n.a.
21	n.a.
22	n.a.
23	n.a.
24	n.a.

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. EMERGENCY OFF 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 portion of the Generator Controller 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 00-870735.

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 to the six 30-volt battery packs.

3.2.3 Battery Packs

Six 30 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 on the Generator Controller PCB 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 these batteries. Remember that they are a source of high voltage (180 VDC) and high current which can be hazardous even when the system is not plugged in.

NOTE: The condition of the six 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. Many of these circuits provide redundant protection.

3.3.1 24 Volt Interlock

Refer to Figure 3-2.

The 24 volt interlock circuit passes through the Relay PCB, Technique Processor PCB, Analog Control PCB, and the motherboard. This provides the means to halt system operation when the EMERGENCY OFF 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 signal to the Relay PCB.

The 15 volt 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 15 volt interlock passes through both EMERGENCY OFF switches and the START switch.

When the START switch is pressed, relay K2 latches, supplying +24 volts to relays K1, K3, K4 and K5. If the interlock loop is broken, 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 same 24 volts is also supplied to the *Generator Controller PCB* where it latches relay K2. If this relay opens, it disables the high voltage generator by disconnecting the 15 volt return path from transistors Q14-Q17.

The B+ charge and B+ contactor relays, mounted below the Generator Controller PCB, also obtain 24 VDC from this 24 volt interlock circuit.

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 imbeded 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.*

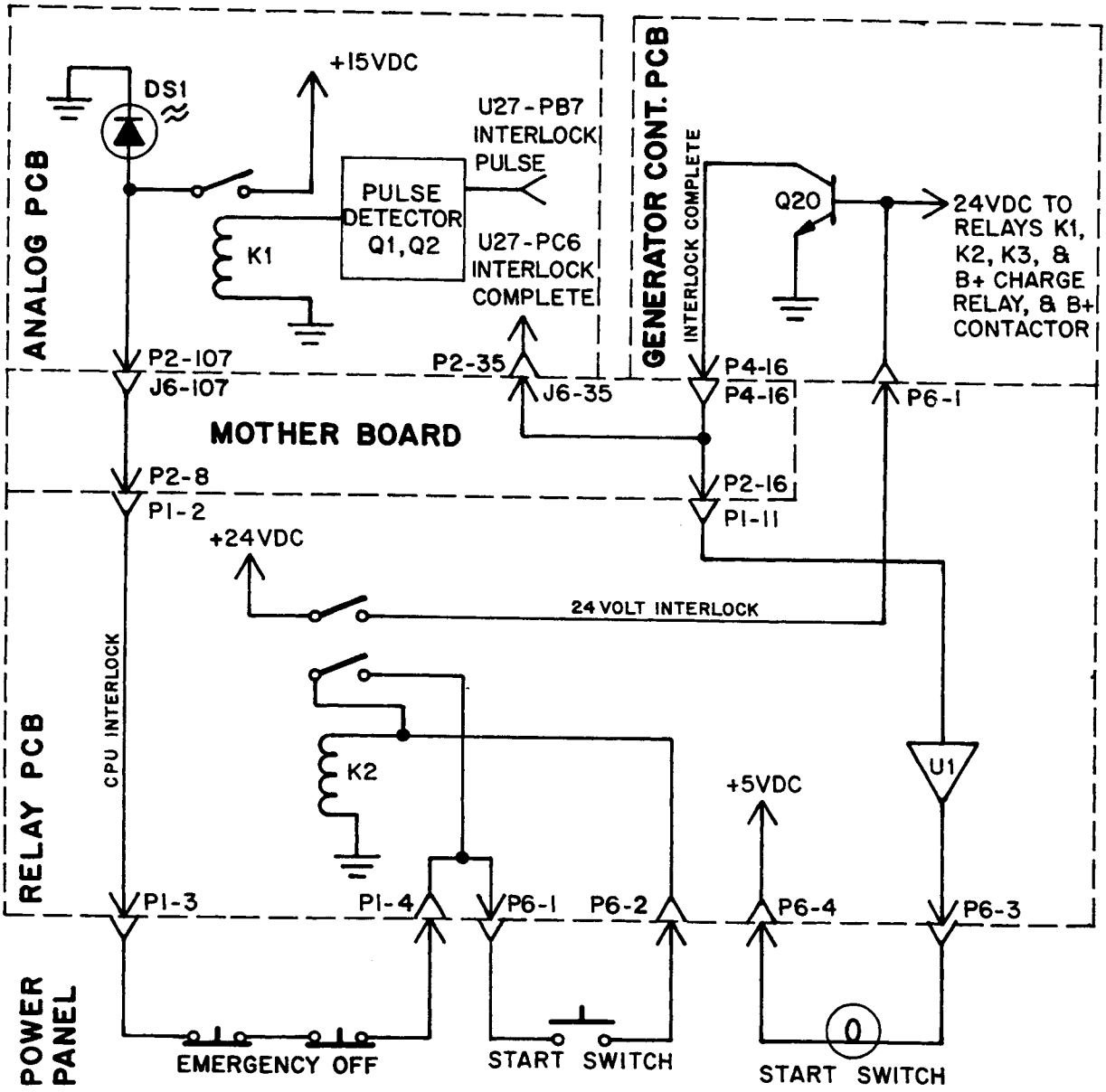
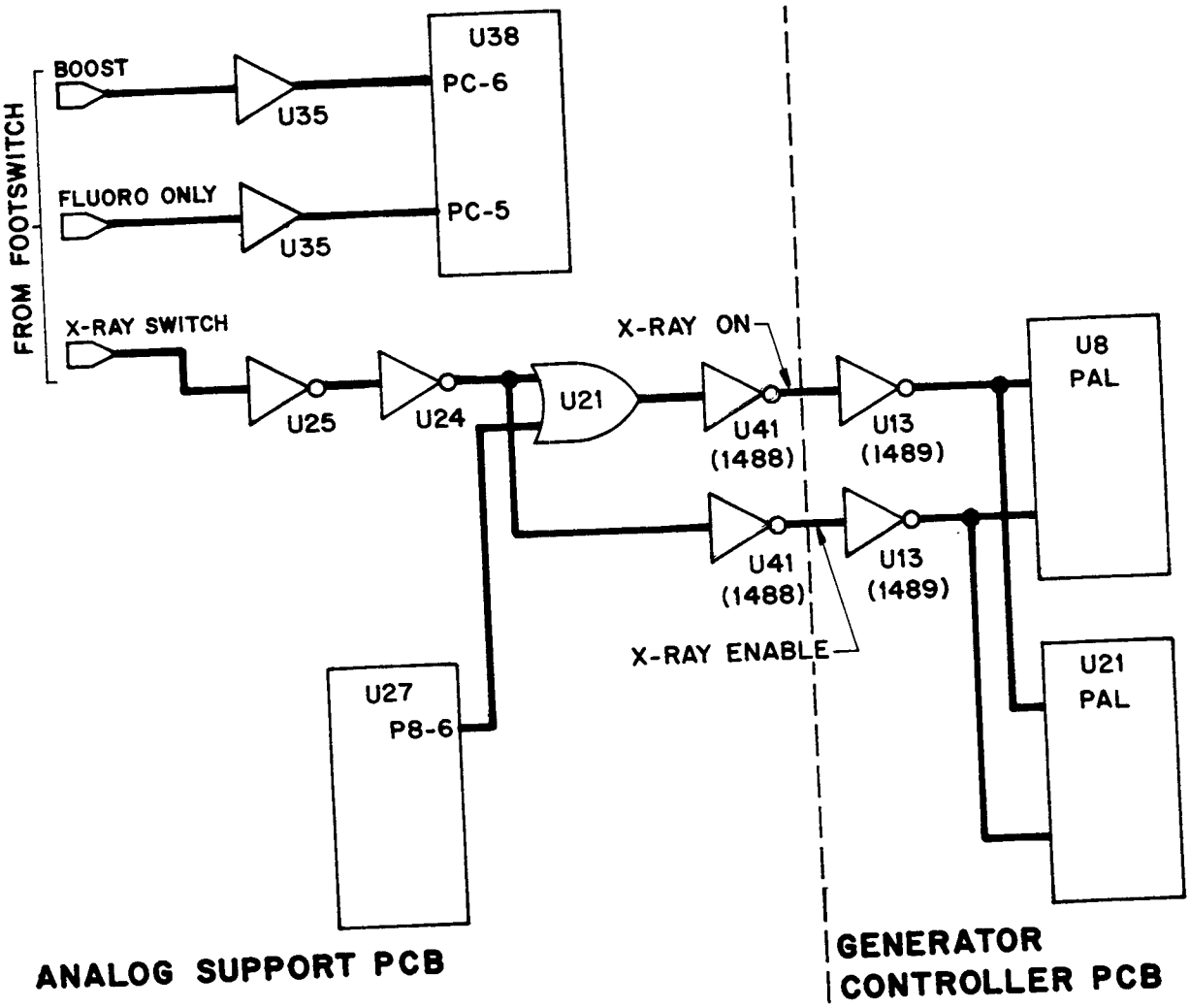


Figure 3-3 - *Block diagram of the footswitch logic.*



3.3.3 Footswitch Logic

Refer to Figure 3-3.

Protection logic on the Generator Controller PCB 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 Generator Controller PCB where they are inverted and input to the PAL logic at U21 and U8. The outputs from these PALs form the filament and high voltage drives.

6. Faults on the Generator Controller PCB are sensed by fault PAL U32.

7. If X-RAY ON and X-RAY ENABLE are true and there are no faults reported to PAL U21 pin-9 from the FAULT output of U32, then U21 output HV GEN ON will be true.

8. HV INV ON is sensed by the processor at Analog Support PCB, PIO U27-PC4.

3.3.4 Fuse Protection

In the unlikely event of multiple catastrophic failures, the 50 Amp circuit breaker in the connection to the battery pack provides fire protection.

Fuses F1, F3, F4 and F5 on the Generator Controller 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 Controller PCB 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 bring the system to a de-energized stand still. Warning messages are displayed on the control panel. These are listed and described in the section Mainframe Service and Repair.

Conditions which are monitored include:

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

When a fault is detected severe enough to cause the system to shut down, a complete restart of the system is required.

3.4.1 KVp Overvoltage

If the voltage sensed on the SECONDARY TAPS 1 and 2 of the high voltage tank exceeds about 135 kVp, comparator U3 on the Generator Controller PCB will trip the OVERVOLTAGE input to PAL U32. The FAULT output from U32 disables the high voltage drives from the output of PAL U21.

NOTE: If the secondary tap 1 and 2 signals carried through P1 on the Generator Controller PCB are disconnected, pullup resistors R1 and R3 will cause comparator U3 to trip the the OVERVOLTAGE line. This is an important safety factor; all signals on connector P1 must be connected for the generator to operate without damage.

3.4.2 Short Circuit Protection

A winding on the series tuning inductor L1, in the tank circuit input, senses the differential voltage across the inductor. This CURRENT LOOP signal is integrated on the Generator Controller 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 Output Transistor On-State C-E Voltage Fault

This circuit, also known as the saturation fault detector, is found on the Generator Controller PCB. The main power transistors, Q1 and Q2, each contain two darlington pairs, and drive the primary of the high voltage transformer (tank). Bridge rectifier VR2 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 R147 to the ground referenced R149. The open collector buffer U6 enables the input of comparator U42 only during the output stage drive period. At this time, rectifiers CR50 and CR53 can cause comparator U42 to trip the FAULT 1 line, feeding PAL U32.

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 10 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 high voltage, filament current and anode rotation are turned off and the collimator is returned to the small field position. 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 are dependent upon which technique has been selected. In all cases, 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 Manual Continuous except that the exposure is generated only for the duration of a pulse. The pulse is repeated each second with the ON button or footswitch depressed.

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 is repeated each second with the ON button or footswitch depressed.

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.

Film Mode

The presence of a film cassette is required in this mode. The 6-inch, but not the 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 prearm 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 prearmed, however, exposures are immediate, 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 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 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 for the first several seconds, then gradually increasing the duty cycle, and consequently the temperature, to the required value over 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. Hardware is again initialized as a precaution.
2. The 40 kHz clock on the Analog Support PCB is started.
3. Interlocks are made.
4. The stator line is pulsed.
5. Small filament is preheated
6. B+ capacitor is charged.
7. Generator and X-ray tube control signals are initialized. After a pre-charge cycle the B+ Contactor is closed.
8. EEPROM is checked.
9. Footswitch is checked (for footswitch stuck fault).
10. Heat units are computed for the anode.
11. Tests are run to determine if the system is capable of functioning. In detail the tests are:
    a. Scroll sign on message
    b. Verify that the kVp and mA sense are near zero.
    c. Check for inadvertent presence of X-ray Activate Jumper which will appear as "Stuck Footswitch".
    d. Verify HV Generator Line OFF
    e. Start interlock pulses and scroll message "PRESS START." Operator presses START SWITCH.
    f. Turn on B+ Precharge. Check batteries during precharge.
    g. Close Main Contactor. Check B+ voltage
    h. Check flipper circuits.
    i. Check EEPROM integrity.
    j. Check EEPROM disk image.
    k. 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:

1. Small field flipper
2. X-ray tube heating
3. Camera dark current compensation - dark current compensation tables are built every 120 seconds after the last fluoro exposure.
4. Monitor battery voltage and current.
5. 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:

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

15. System serial number

16. 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

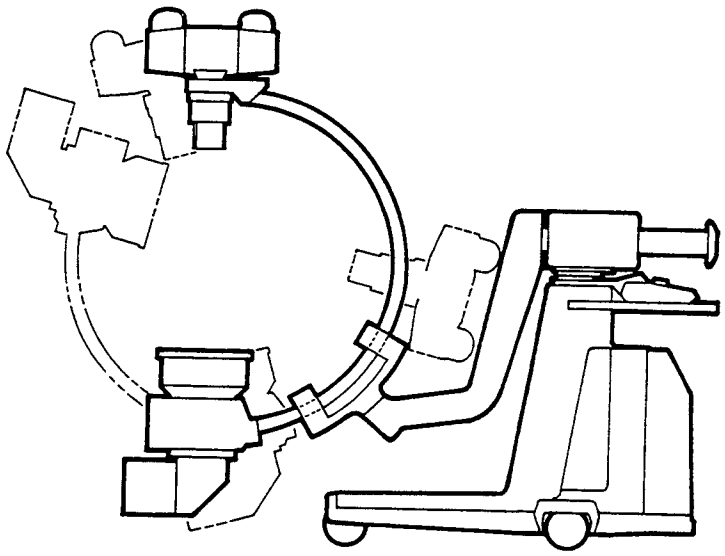
Refer to Schematic 00-870735.

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.

C-arm Radial Movement

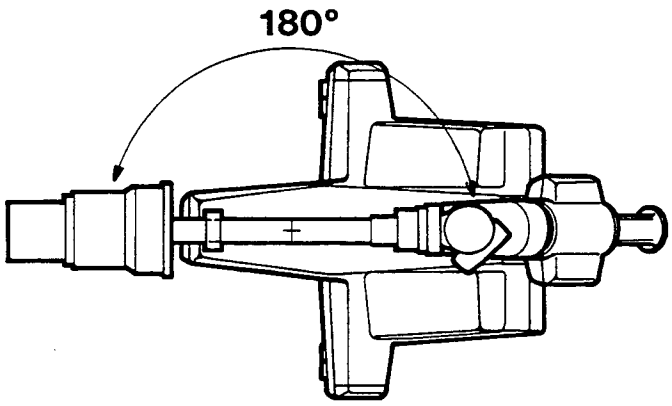
Figure 3-4 - *The C-arm can rotate in its cradle 111 degrees.*



C-arm Flip-Flop Positioning

Figure 3-5 - *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.*



L-arm Rotation

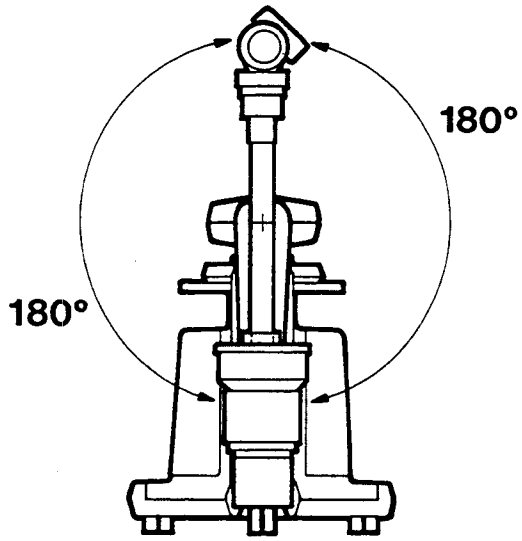


Figure 3-6 - *The L-arm can be rotated 180 degrees in either direction (for a total of 360 degrees).*

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

Vertical Lift Travel

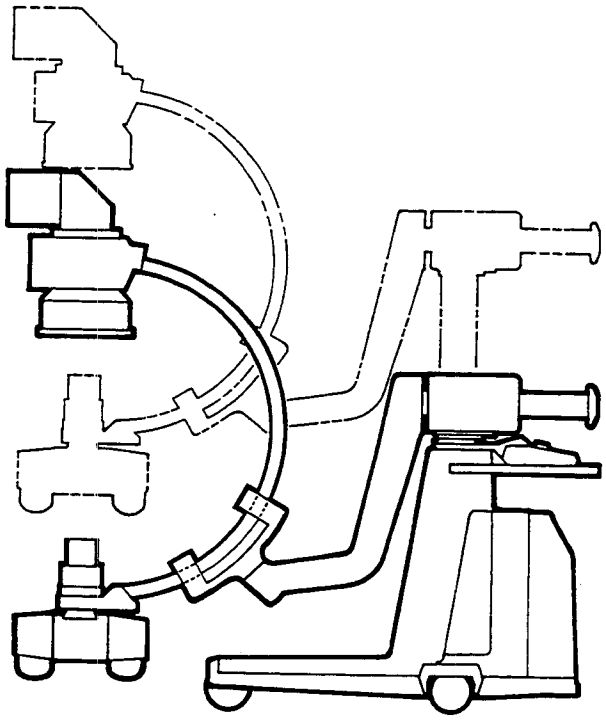


Figure 3-7 - *The entire C-arm and L-arm assembly can be raised up to 18 inches on the central column.*

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

Horizontal Travel (Extension)

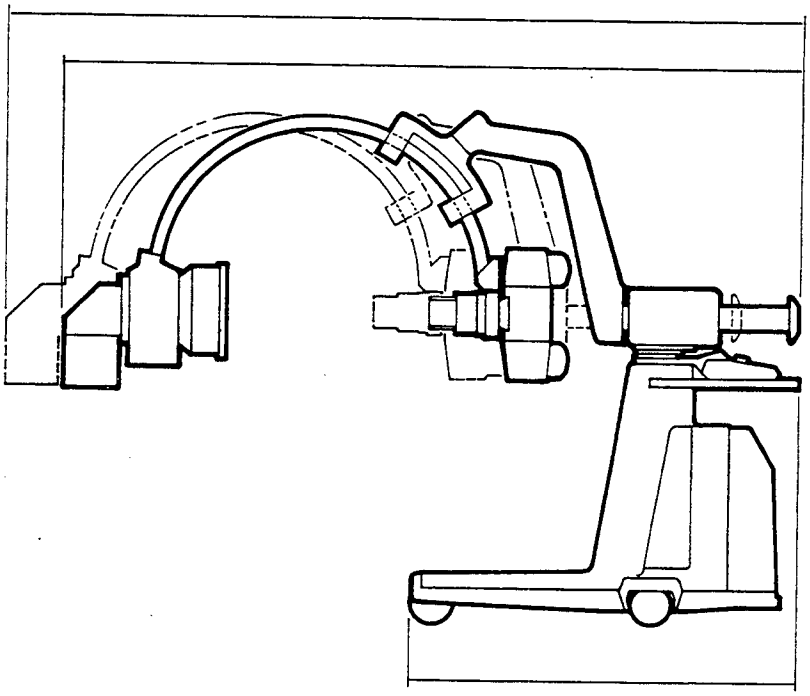


Figure 3-8 - *The L-arm and C-arm assemblies can be extended horizontally up to 8 inches.*

Release the locking ring by turning it counter-clockwise about 15 degrees.

Push or pull on the extension arm to the desired position,

then retighten the locking ring by turning it clockwise until it is fingertight.

Wig-Wag (side-to-side swing)

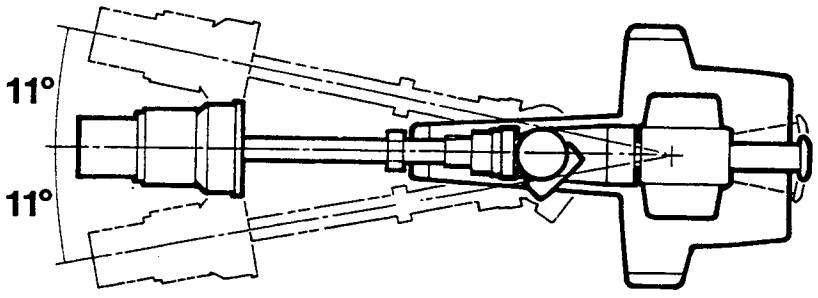


Figure 3-9 - *The entire extension, L-arm, C-arm assembly can swing, or wig-wag, from side to side 11 degrees in either direction for a total of 22 degrees of motion.*

Pull out the locking pin and turn its handle 1/4 turn to latch it open. Loosen the wig-wag brake on the column.

Retighten the brake handle when the desired position is reached.

Control Panel Positioning

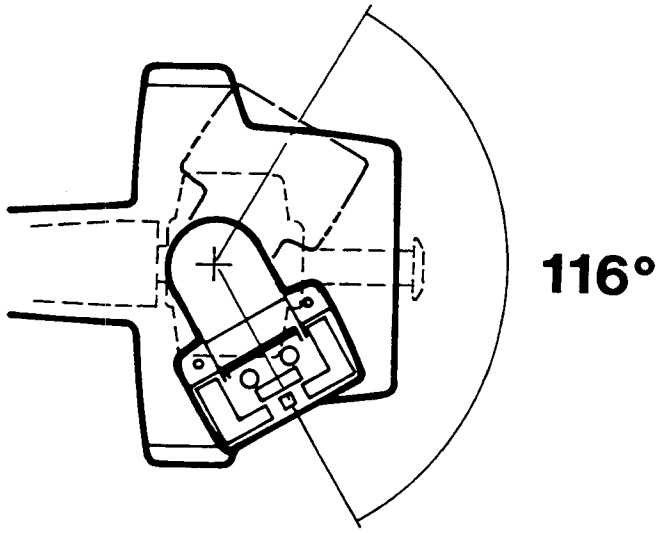


Figure 3-10 - *The control panel can be swung 58 degrees to either side, for a total of 116 degrees of movement. This provides the operator with easy access to the controls.*

The control panel is not locked in position, move it freely as needed.

Steering Control

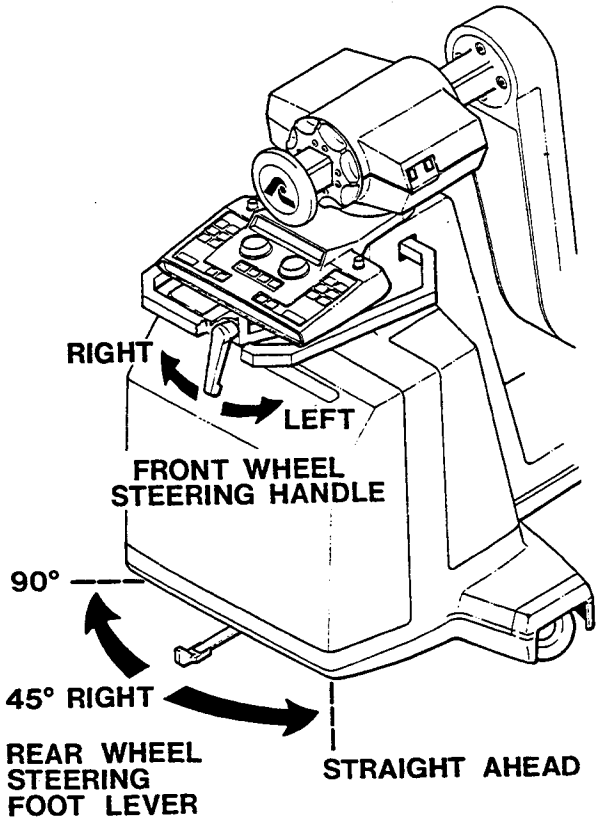
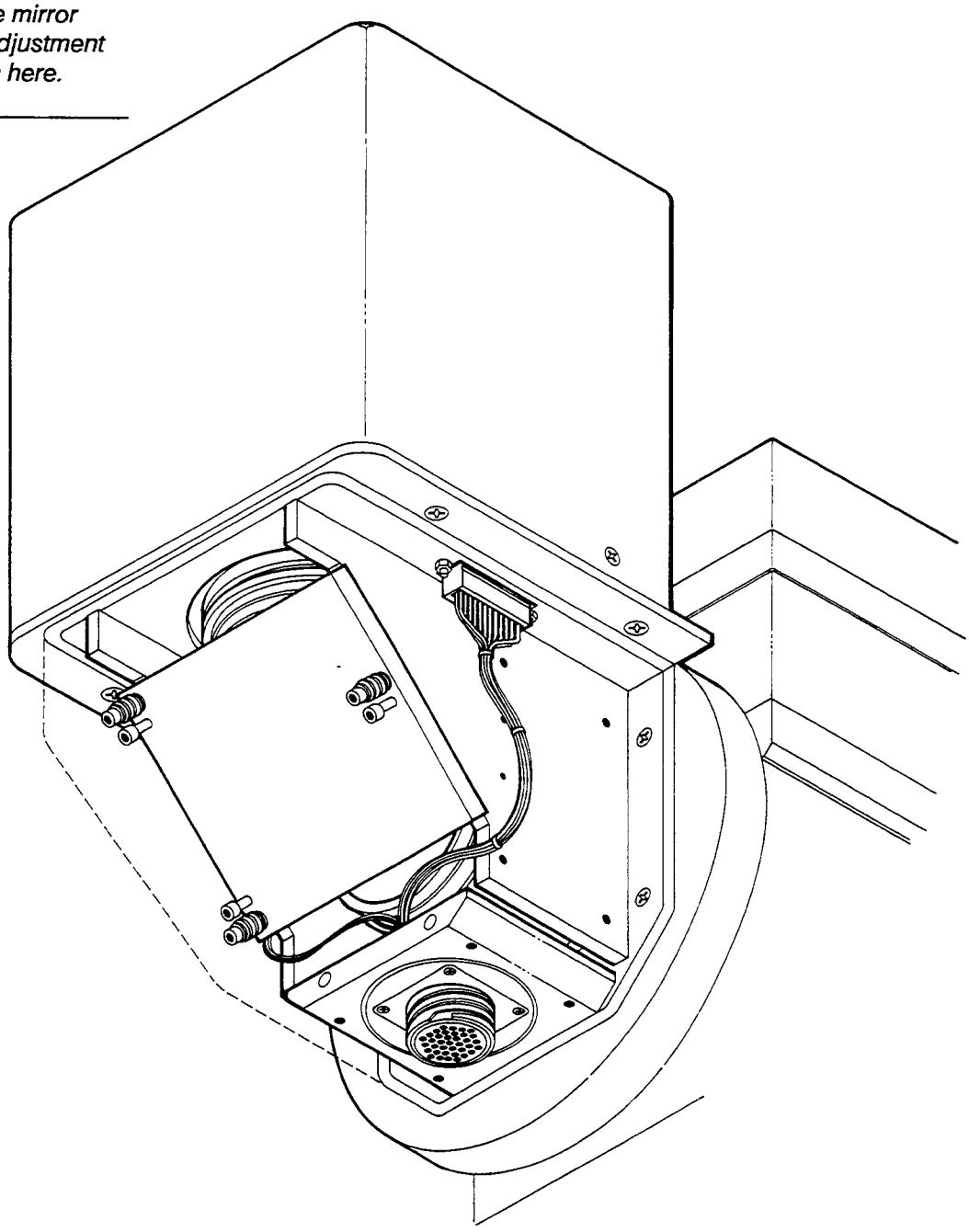


Figure 3-11 - *A steering handle and foot lever are used to control the orientation of the front and rear wheels.*

3.7.2 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 3-12 - *The mirror mounting plate adjustment points are shown here.*



3.8 X-ray Tube

Refer to Figures 3-13 and 3-14.

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 40VAC 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 3-13 - *Cutaway view of the X-ray tube.*

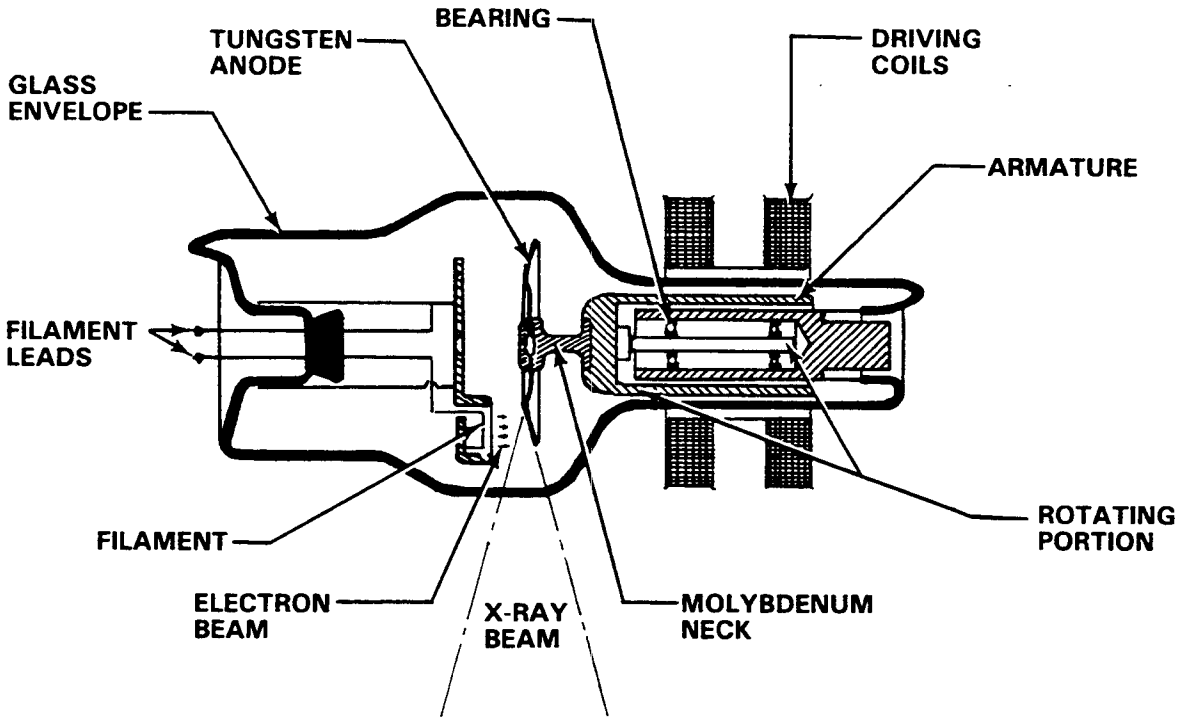
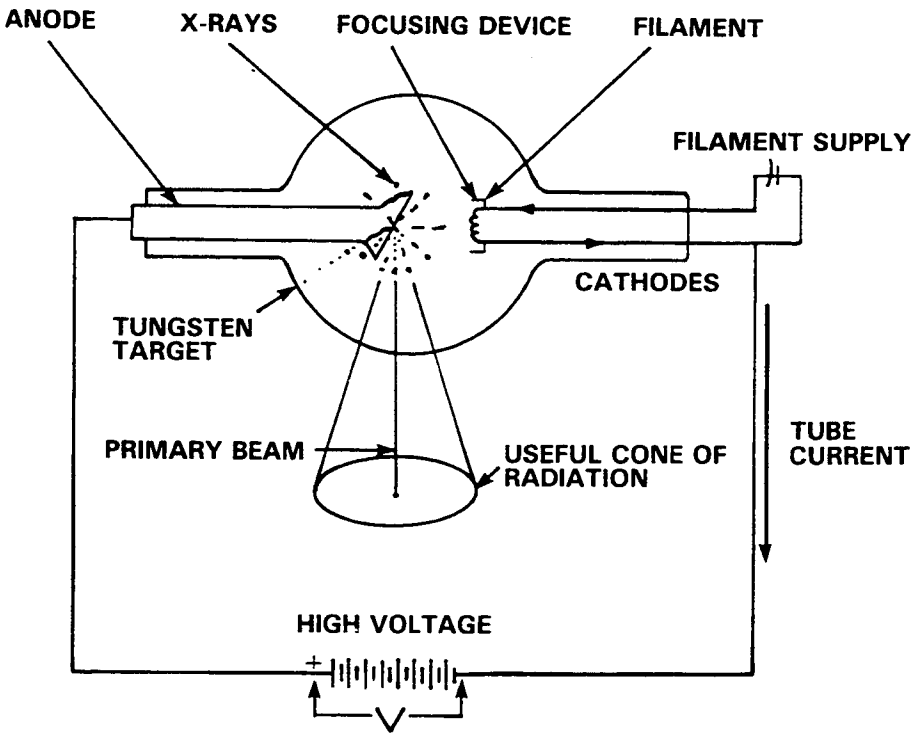


Figure 3-14 - *Schematic of the X-ray tube.*



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 3-15.

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.

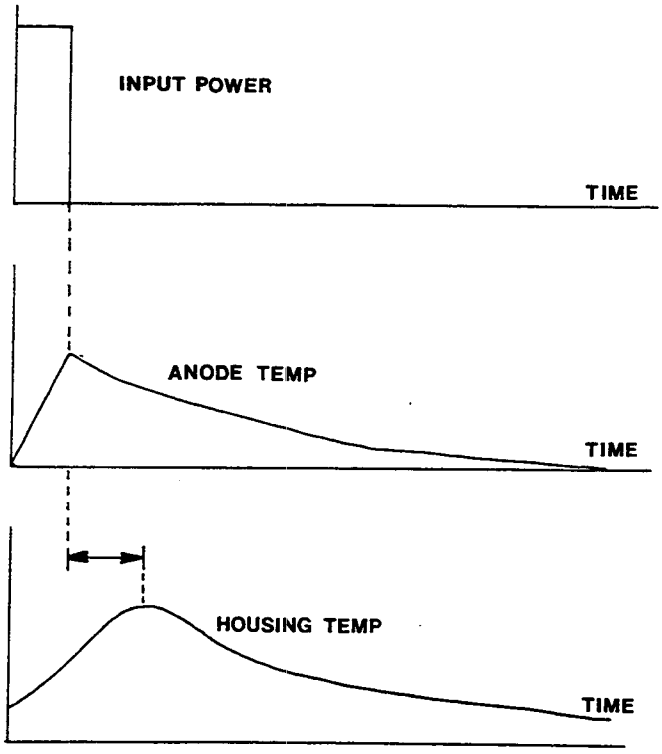


Figure 3-15 - *The relationship of input power, anode and housing temperatures is shown in these graphs.*

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 75 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 3-16 to trace this 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 collimator (3), located within the X-ray tube mounting head, is moved in or out of the beam path to switch between large and small beam diameters. 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 X-ray tube housing.

The minimum beam size of less than 5 X 5 cm square is measured at the source to image receptor distance (SID). The face of the fluoro image intensifier lies slightly outside the film SID and this factor is accounted for at calibration.

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

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

Beam Collimation
Refer to Figure 3-17.

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

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 a five x five centimeter square.

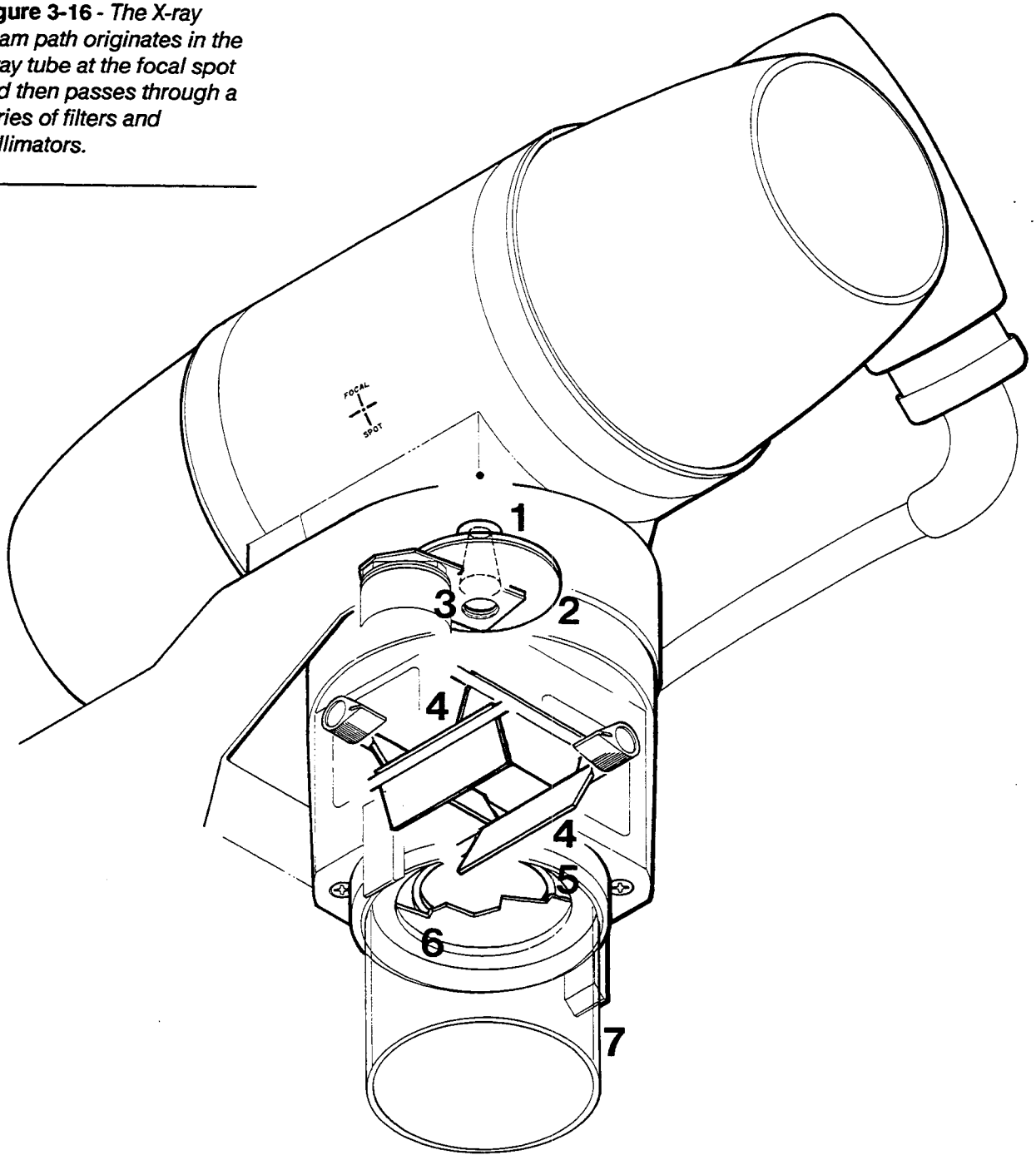
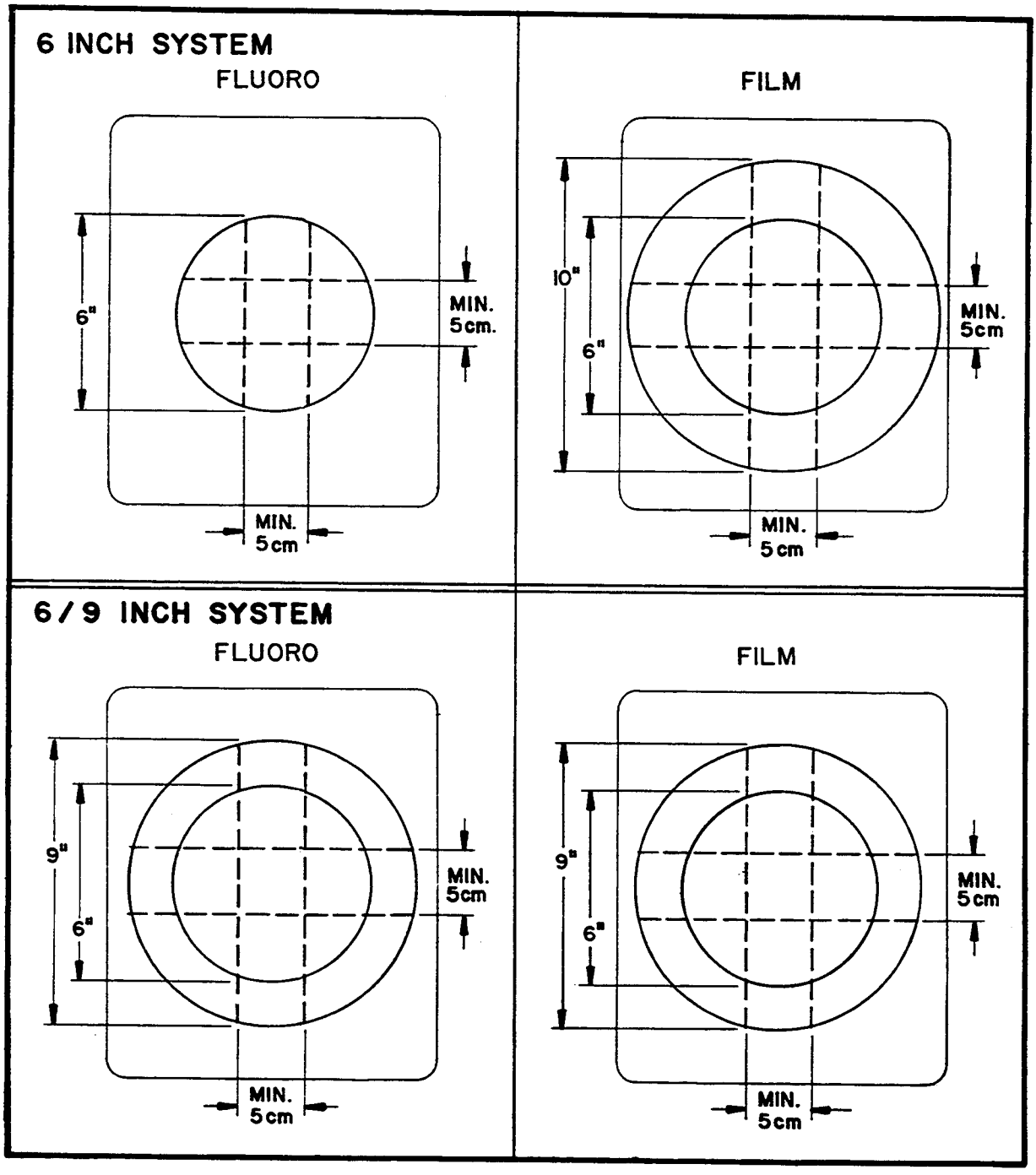


Figure 3-16 - *The X-ray beam path originates in the X-ray tube at the focal spot and then passes through a series of filters and collimators.*

Figure 3-17 - *The X-ray fields produced by varying degrees of collimation are different for 6-inch and 6/9-inch systems.*



The X-ray fields produced by varying degrees of collimation are different for 6-inch and 6/9-inch 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-inch field can be used in the FLUORO mode. The LARGE field on these models is approximately 10 inches in diameter.

6/9-inch Image Intensifier Models - the uncollimated beam is 9 inches in diameter when the small field collimator is retracted. When the small field collimator is in place, the beam is reduced to 6 inches.

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-inch 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-inch image intensifier, the final collimator limits the X-ray beam size and shape to a 9-inch 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 can also be done manually.

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 U26, U36, U37. These devices are integrated motor controllers.

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 low light level lenses and a right angle mirror. The first lens is focused at infinity and the camera 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 3-18 - *The right angle optics consist of a mirror and the camera and image tube lenses.*

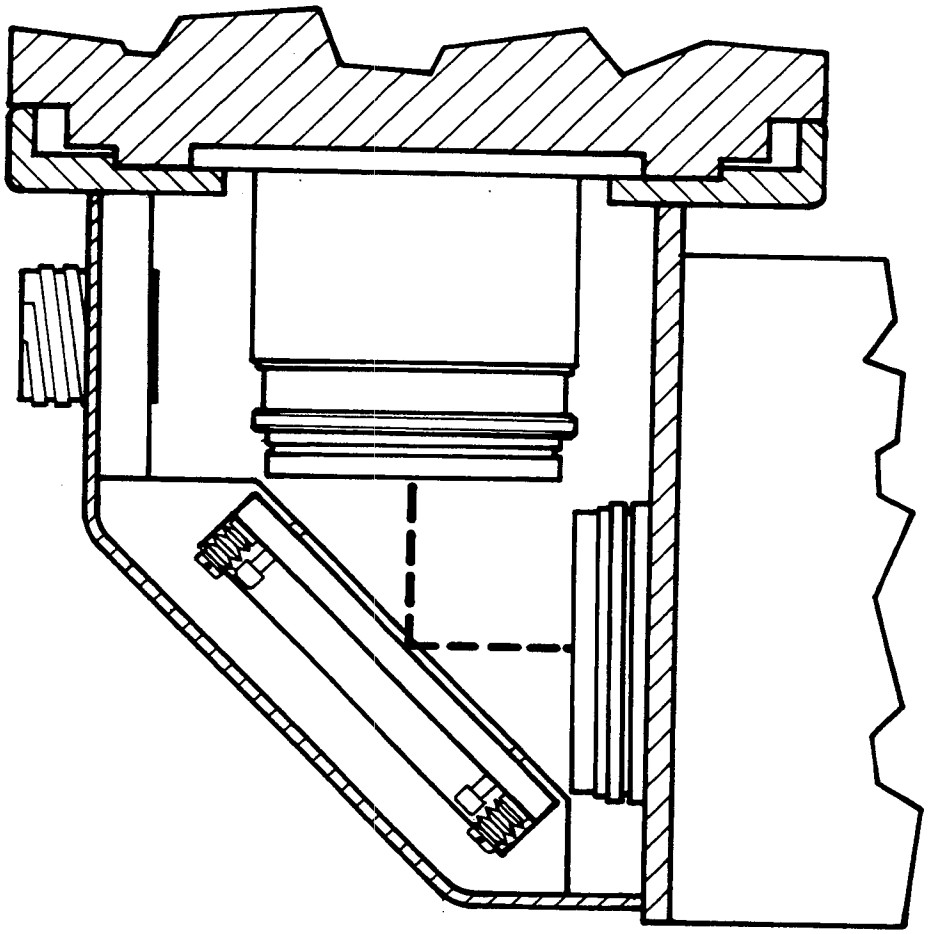
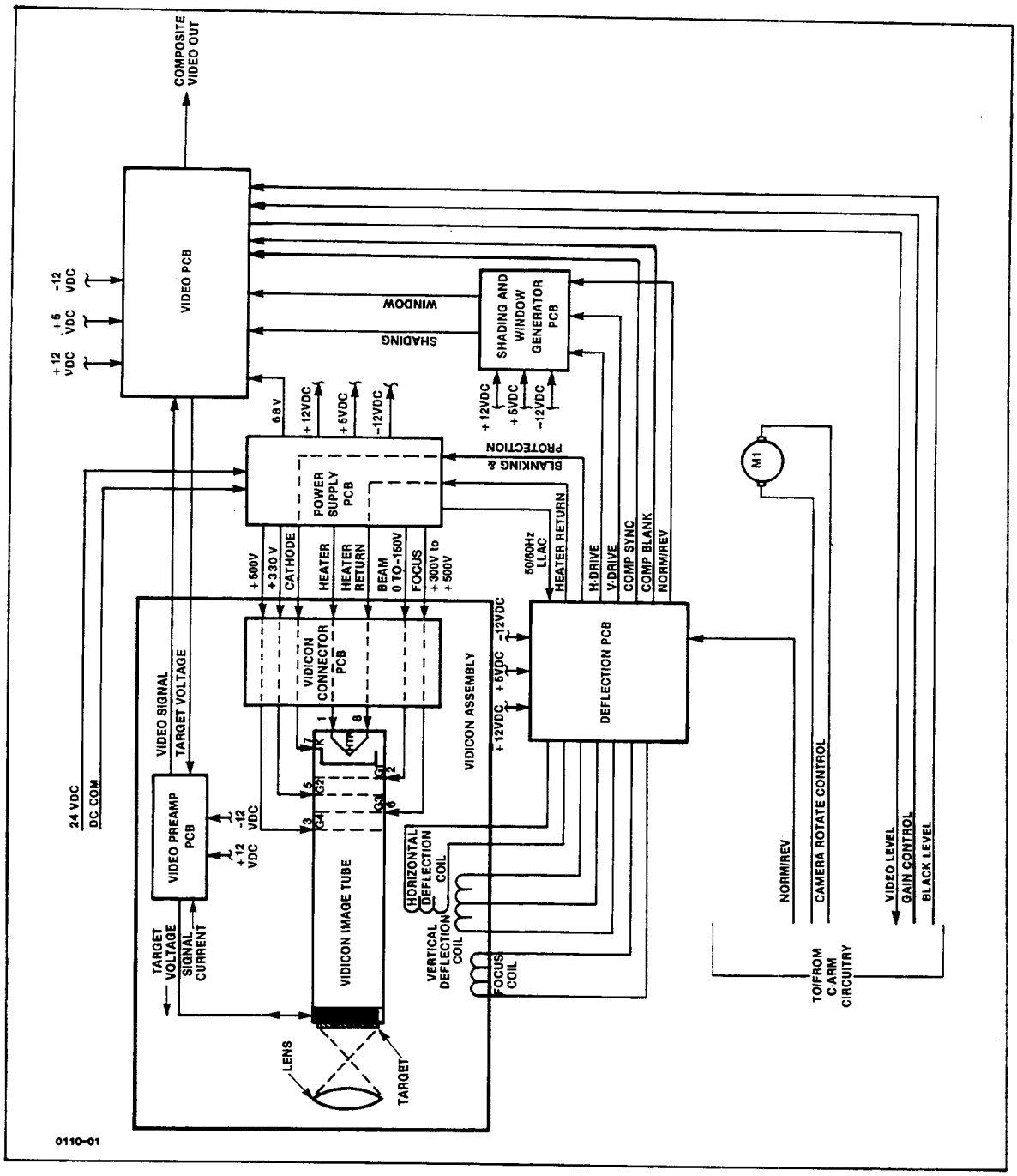


Figure 3-19 - *Camera Block Diagram.*



3.11 Video Camera

Refer to Schematic 00-871059 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 3-19.

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 I\O Distribution\Video Switch PCB in the monitor cart.

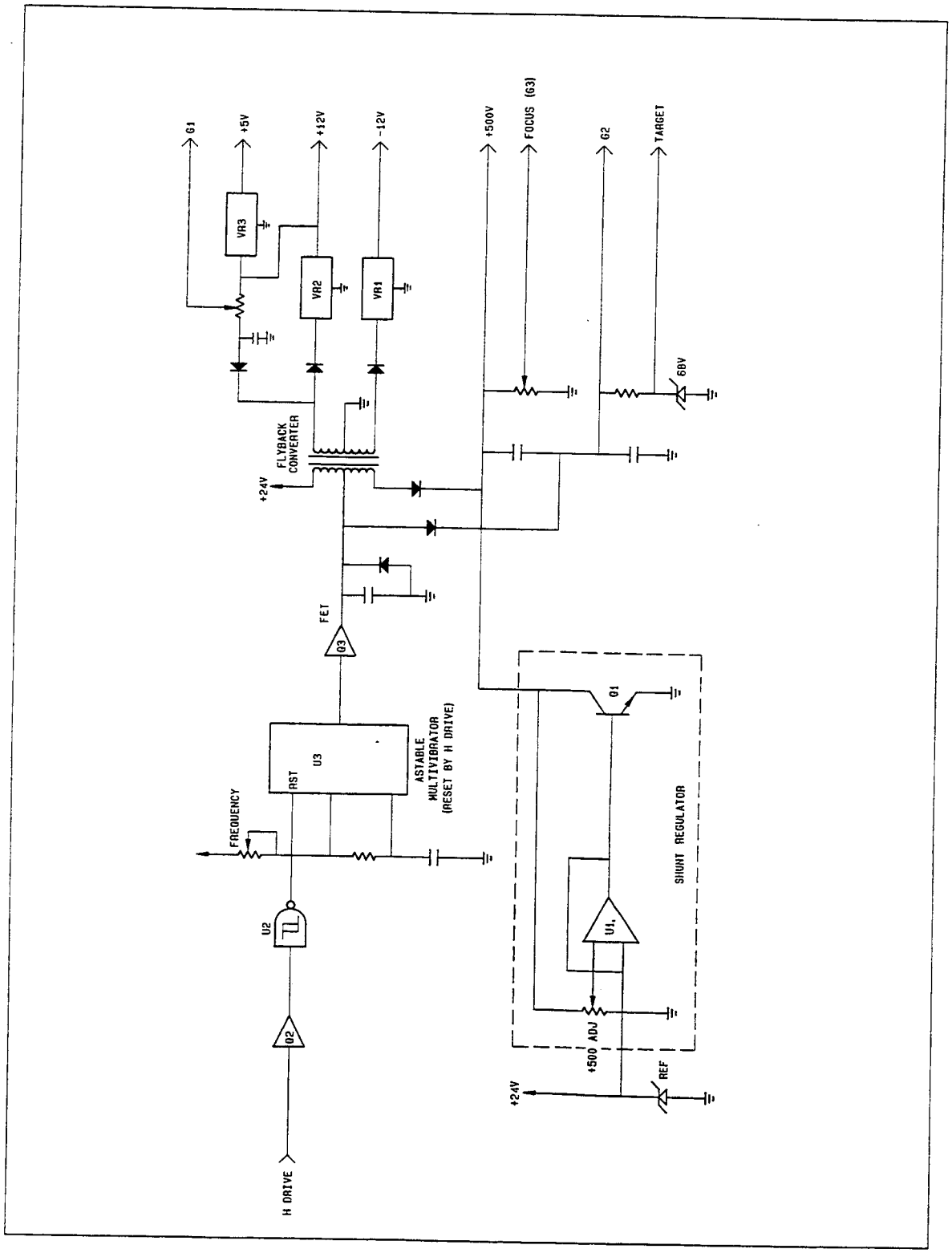
Another video signal, called video level, is produced which is proportional to the brightness within a sampled window area of the image. This is routed to the Analog Support PCB where it is digitized and read by the processor. Under software control, a camera gain control signal is fed back to the camera. 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 which would otherwise detract from the image.

The video sweep direction can be reversed 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.

Figure 3-20 - *Block diagram of the camera Power Supply PCB.*



3.11.2 Camera Power Supply PCB

Refer to Schematic 00-870813 and Figure 3-20.

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

Flyback Regulator

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 H drive rate. Both halves of the T1 primary are flyback inductors which develop high voltage AC waveforms when the centertap switches to 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. 00-860387 and Figure 3-21.

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

1. Sync generator
2. Horizontal deflection coil driver
3. Vertical deflection coil driver
4. Vidicon blanking and protection
5. Focus coil voltage regulator

Sync Generator Section

The video sync generator U2 is clocked by crystal Y1 for 60 Hz operation and Y2 for operation in 50 Hz systems.

Horizontal Deflection

The horizontal deflection driver consists of Q5, Q6, and U1. When the camera beam is scanning horizontally, Q5 is turned off and Q6 is turned on - a linearly increasing current flows in the horizontal deflection coil. When HOR DRV/ occurs, at the start of horizontal retrace, Q5 is turned on and Q6 is turned off. The width of the horizontal scan is proportional to the current supplied to the deflection coil by Q6. This current depends on the Q6 collector voltage set by L5 and the H SIZE potentiometer R40. The horizontal position of the scan is set by the level of the sawtooth current waveform in the deflection coil. The DC current is supplied by L3 and is determined by the setting of the H CENT potentiometers R38 and R39.

Sweep Reversal

Horizontal sweep reversal is accomplished by reversing the direction of the current through the deflection coils. The HORIZ REV control line selects the reverse direction of sweep.

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.

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.

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 3-21 - *Block diagram of the Deflection PCB.*

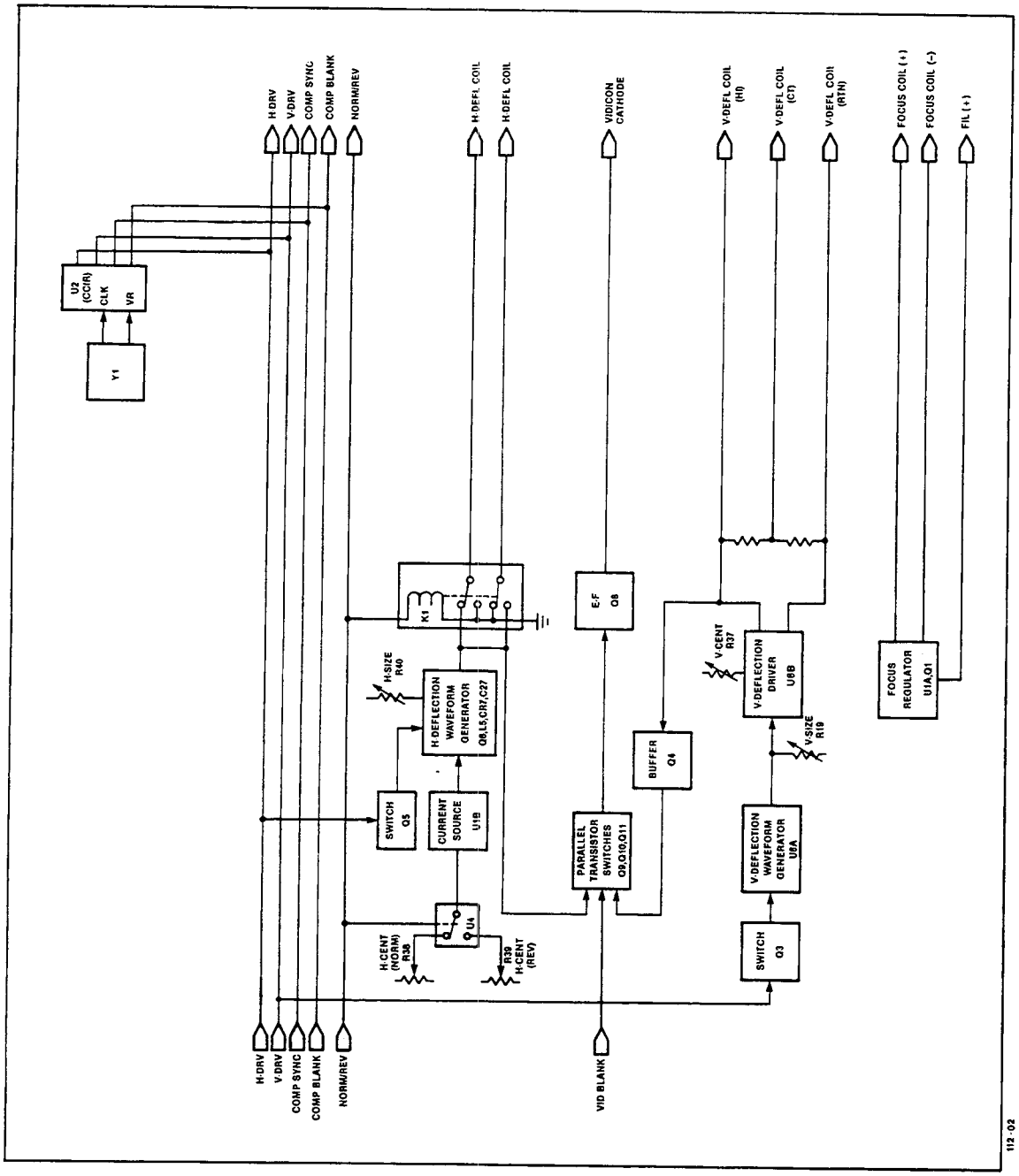
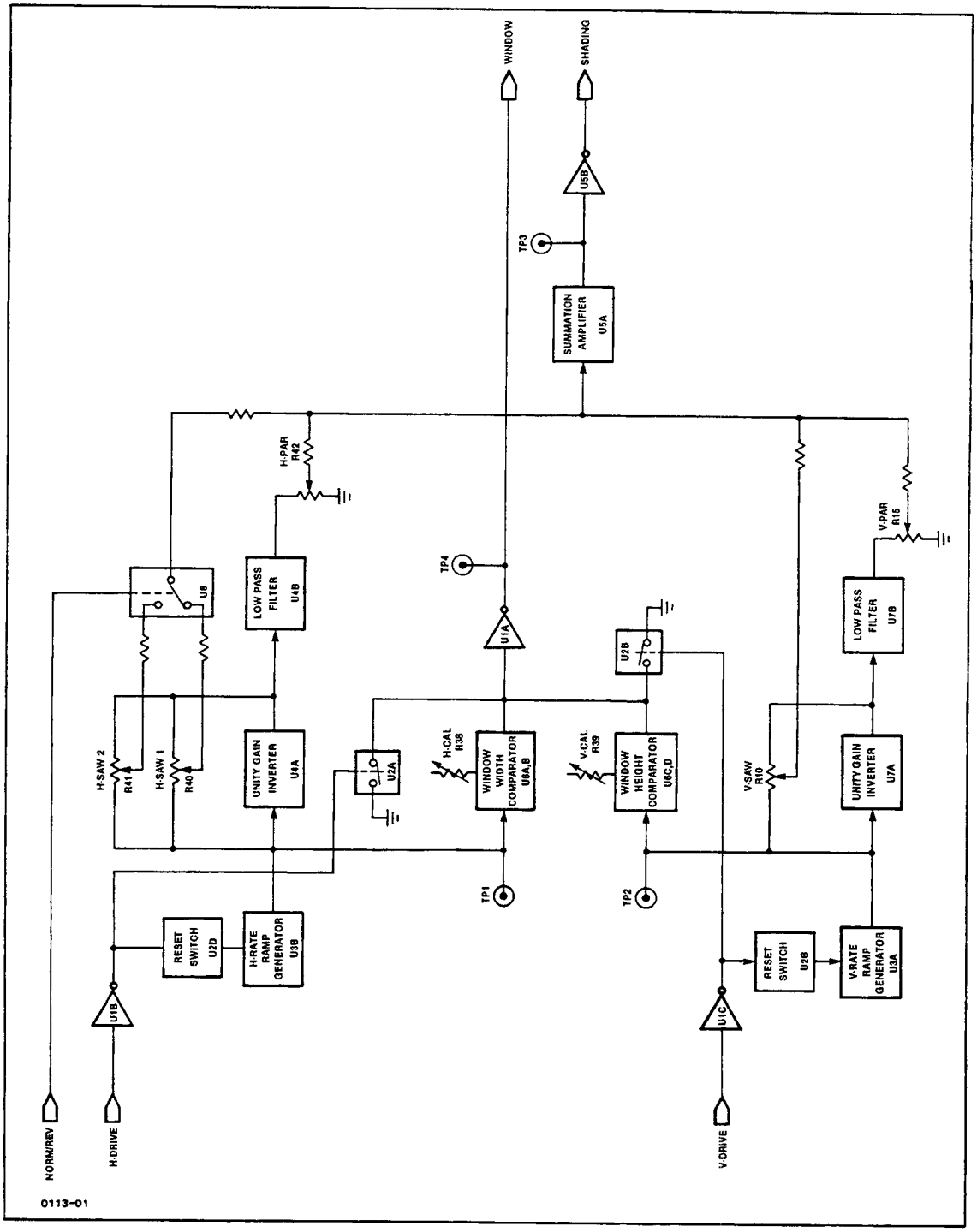


Figure 3-22 - *Block diagram of the Window Shading PCB.*



3.11.4 Shading/Window Generator PCB

Refer to Schematic No. 00-860384 and Figure 3-22.

The Shading/Window Generator PCB provides two functions required for fluoroscopy:

Correction for aberational brightness variations across the image plane (shading).

Generation of a video level sampling window used for camera gain control.

Shading Parabola Generation

The shading function makes use of 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 is generated by U3 and reset by U2. After reset, a positive-going ramp is generated by U3. This ramp is applied through C6 to U7, a unity gain inverting amplifier. Both the input and the output of U7 are applied across R10, the VERT SAWTOOTH adjustment potentiometer. The signal from the output of R10 is summed at the summing junction of U5. At the same time the output of U7A is applied the the input of U7B. The resulting parabolic waveform is applied to R15, the VERTICAL PARABOLA potentiometer. The wiper of R15 provides another waveform to be summed by U5. The combination of this signal and that from the wiper of R10 form the vertical shading waveform. The horizontal shading circuit operates similarly. 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.

Because of the cameras ability to reverse sweep direction, the horizontal sawtooth must be set for both directions (R40 and R41).

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. 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 cascade input stage Q2 and Q3. The signal current through Q1 and through the drain connections of Q2 and Q3 is direct coupled to Q4.

White clipping occurs when the emitter of Q1 goes more positive than -0.7 volts. The unclipped 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 mid-range gain of the preamplifier is fixed; the output of Q5 is 250 millivolts when the target current is 300 nanoamperes. The peaking control C# compensates for high-frequency rolloff and provides a uniform frequency response from the preamplifier.

3.11.7 Video PCB

Refer to Figure 3-23 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 each minute, 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 settings between these two extremes the dark-current compensation is interpolated.

Black Level

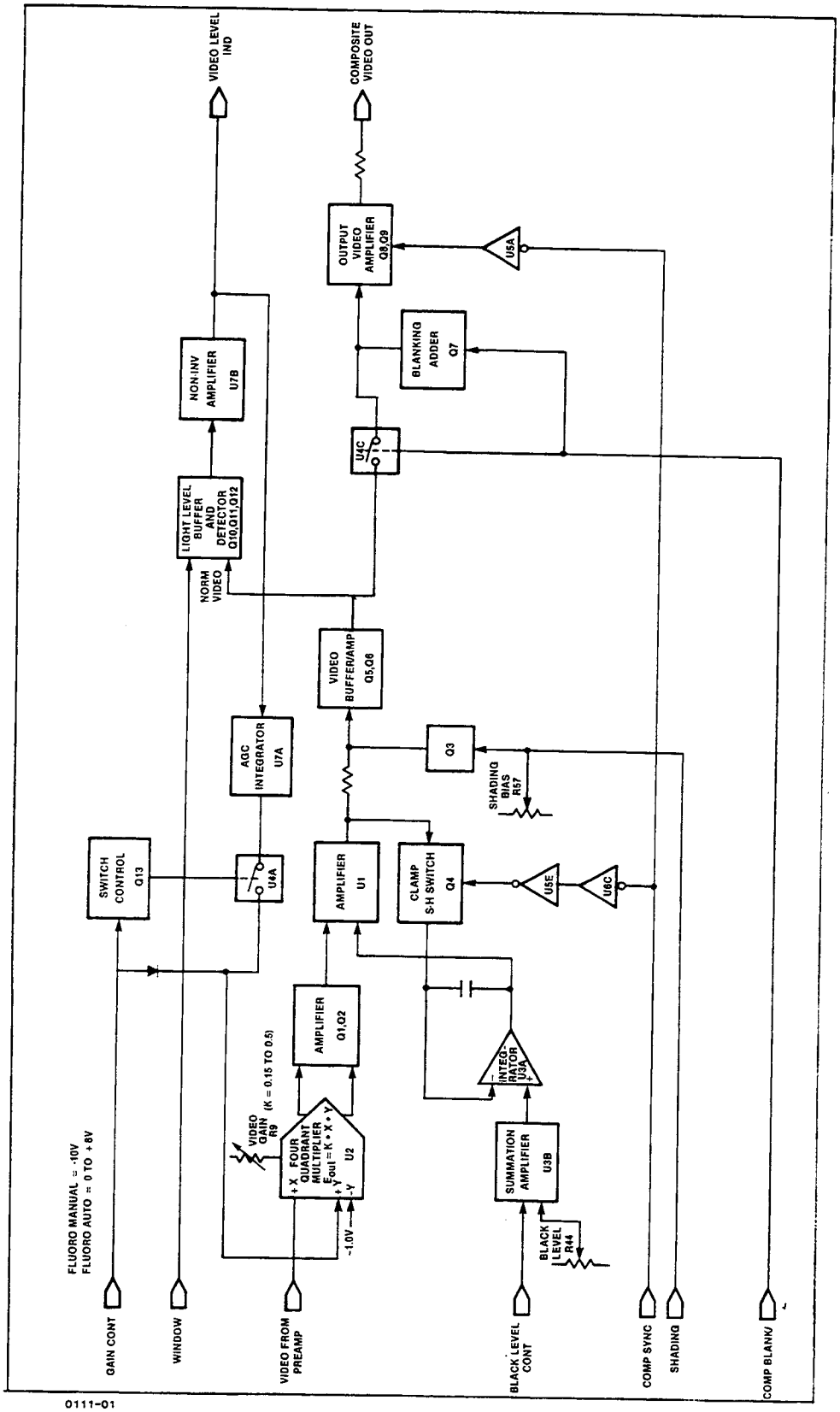
A black level adjustment is provided by R44. The output of U3 combines both black level adjustment and dark-current compensation. If the shading jumper is in place, a bias adjustment, set by R57, enables gain control through Q3. The input to Q3 is received from the Shading PCB.

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 3-23 - *Block diagram of the Video PCB.*



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 frequency current that is applied to the primary of a high voltage transformer. The transformer steps up the primary voltage from about 400 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 currents 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

Refer to Schematic 00-870779 and Figure 3-24.

Overview

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 14 character alphanumeric display, 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.

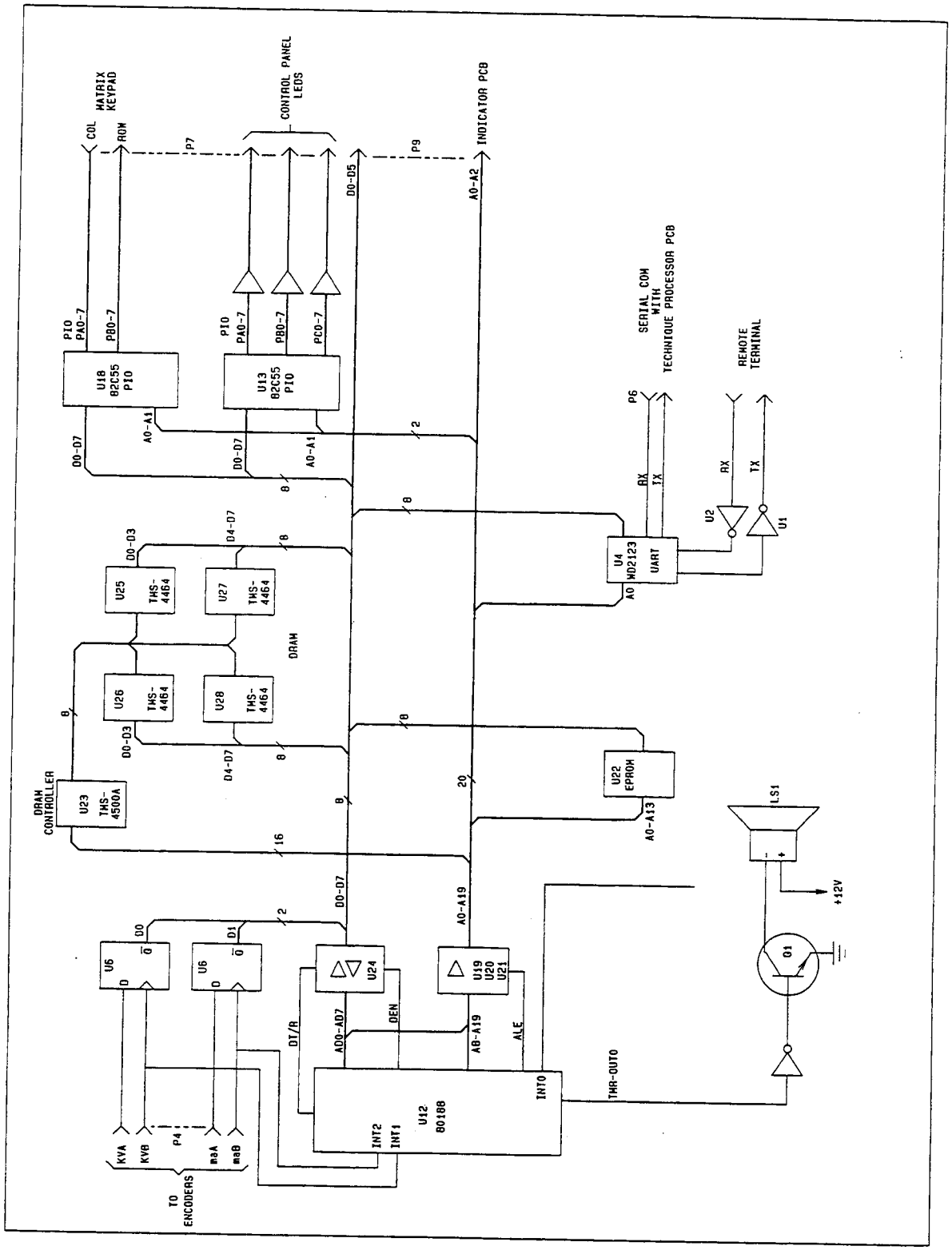
Switch Matrix Interface

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 Indicator PCB

Refer to Schematic 00-870916.

The Indicator PCB contains fourteen 16-segment LED modules with multiplexed text and decimal points. These operate in two different modes:

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.

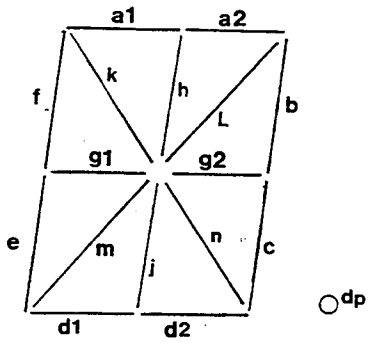


Figure 3-25 - *The LED character segments.*

The 14 character alphanumeric display located on the Indicator PCB is controlled by the 80188 on the Control Panel Processor PCB. Character multiplexing is handled by the PAL output on pin U6-14, which clocks the latches of U7 and the demux chip U11. Character segments are multiplexed in three groups, A1-D2, E-H, and L-DP by the PAL outputs on pins U6-13, 12, 11. DATA 0 through DATA 5 is latched into U1, U3 and U5 according to these PAL outputs.

The common cathode LED module segments are driven by UDN-2981 current drivers U2 and U4. Input P1-8 is a powerup reset which clears the latches. The decimal points are driven by Q1.

3.12.3 Technique Processor PCB

Refer to Schematic 00-870591 and Figure 3-26.

Overview

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

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 3-26 - *Technique Processor PCB block diagram.*

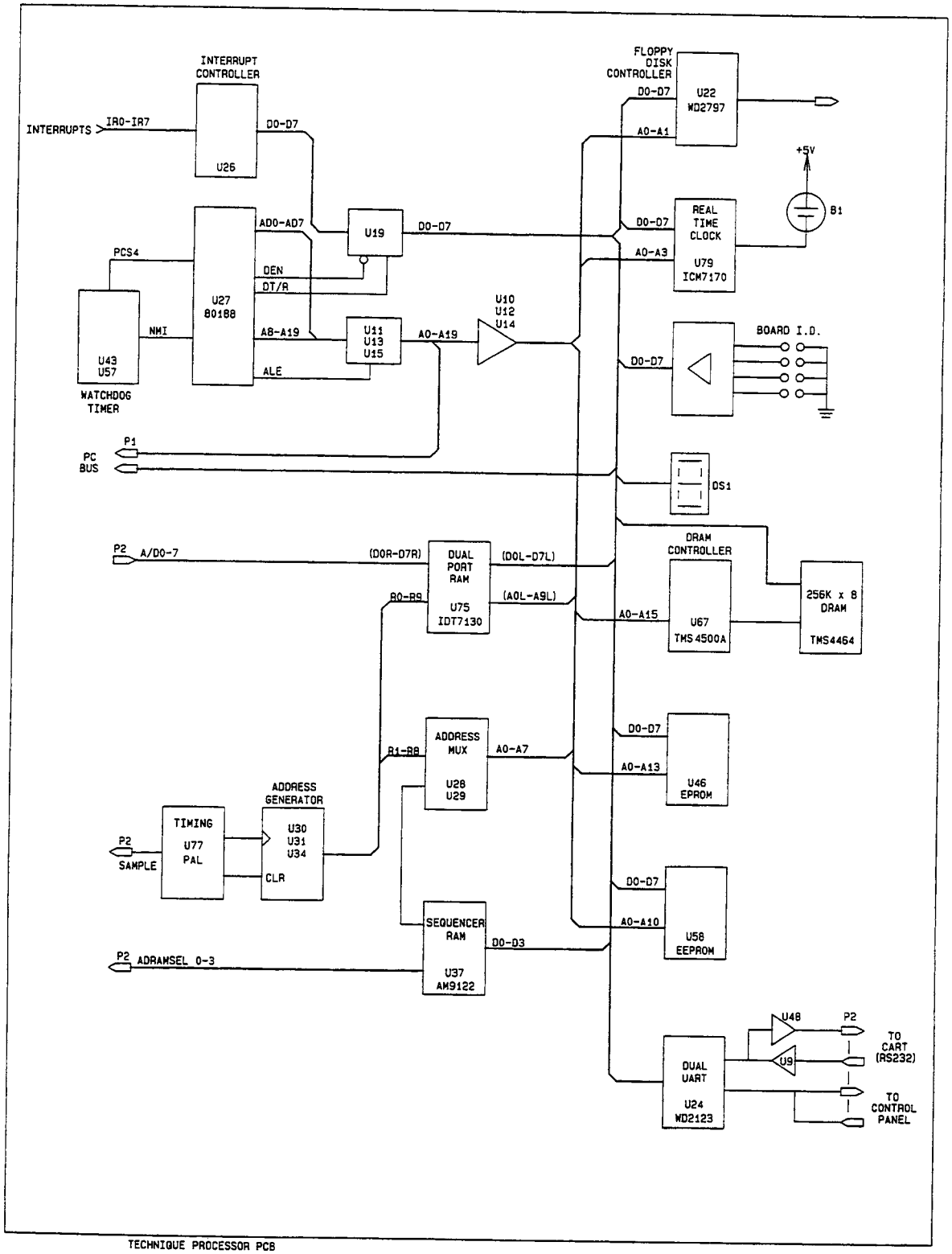


Table 2 Technique Processor Memory and Peripheral Chip Decoding

Memory

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

Peripherals

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 2 (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

DMA Channels

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

Figure 3-27 - *Block diagram of the Analog Support PCB.*

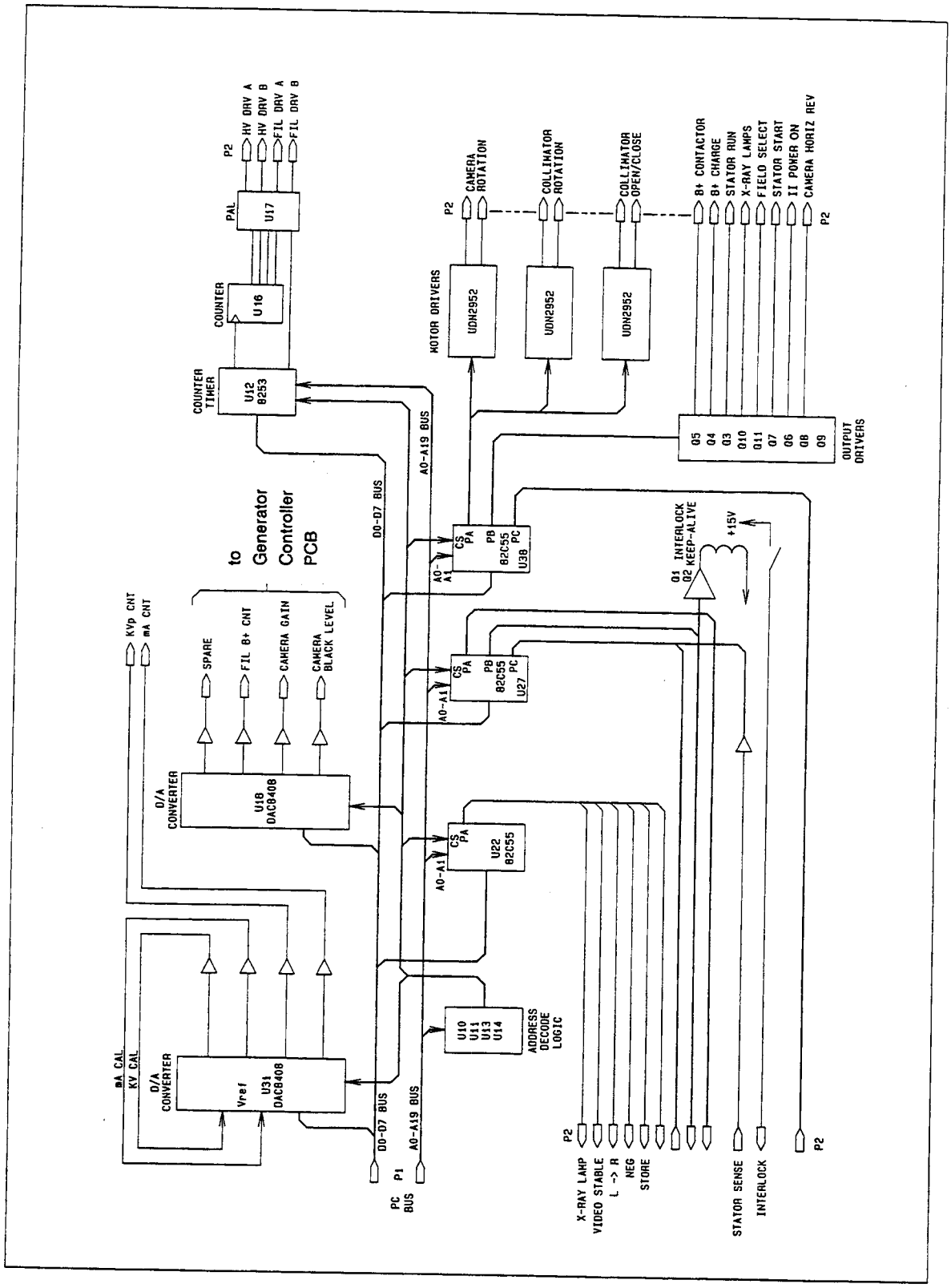
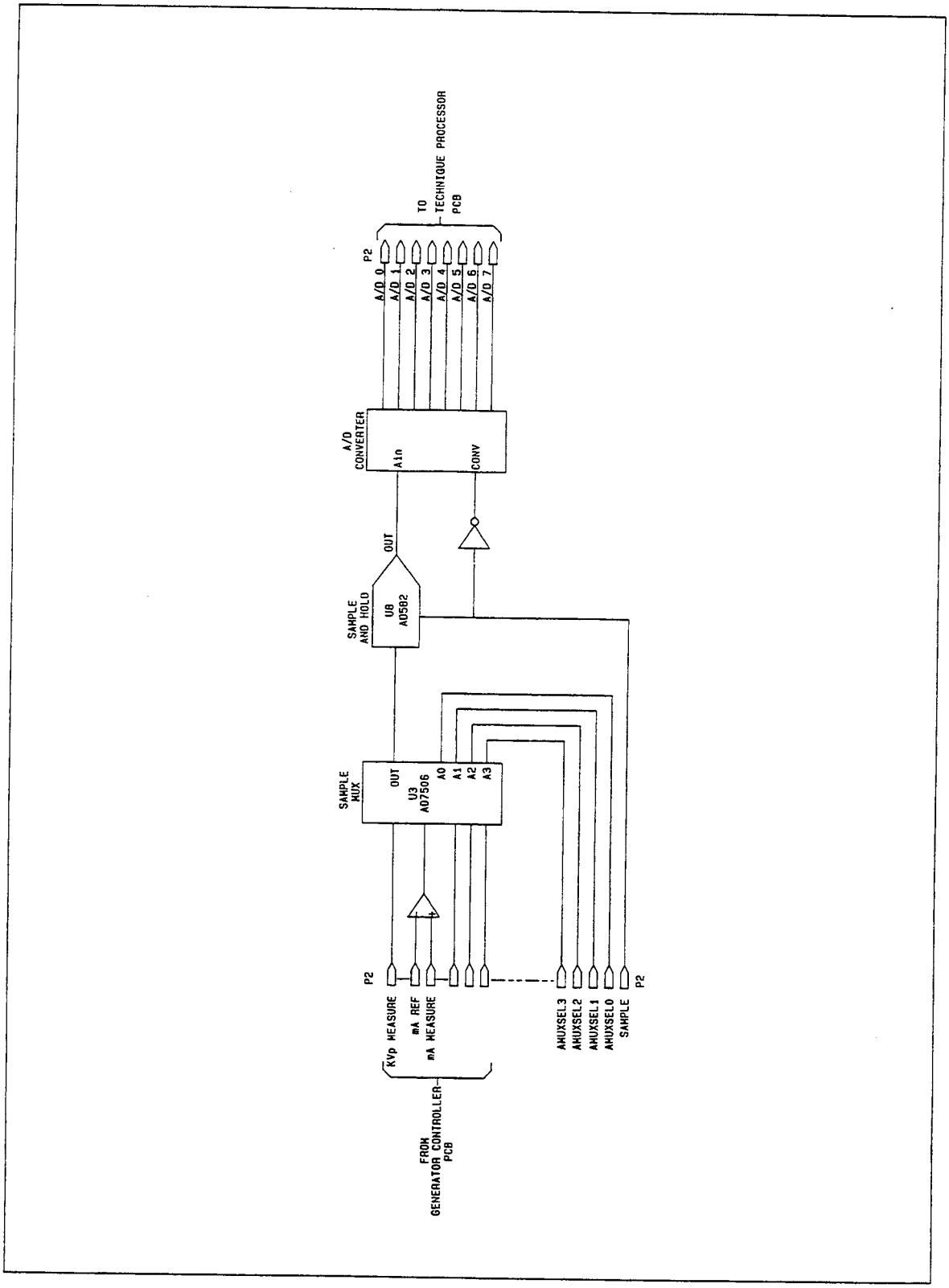


Figure 3-28 - *Block diagram of the A/D portion of the Analog Support PCB.*



3.12.4 Analog Support PCB

Overview

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

Refer to Schematic 00-870771 and Figures 3-28 and 3-29.

The Analog Support PCB performs the following functions:

1. Sample and digitize signals from the Generator Controller PCB to be read by the Technique Processor PCB.
2. Convert data bytes from the Technique Processor into analog signals for such functions as camera gain control, kVp control, and filament control.
3. Generate the high voltage drive and filament drive signals.
4. Provide a digital interface between the Technique Processor and discrete digital signals such as *STORE* and *B+ CONTACTOR*.
5. Control the camera and collimator motors.
6. 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
U26	Motor Controller	UDN 2952
U37	Motor Controller	UDN 2952
U39	Motor Controller	UDN 2952

Transistors Q3 - Q11 drive individual control lines.

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, 9, 10, and 11 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.

UDN-2952 Full-Bridge Motor Drivers

These integrated circuits combine low-level logic circuitry compatible with TTL and CMOS levels. They allow bidirectional control of DC motors with continuous load currents of up to 2 A. Internal protection includes thermal shutdown and transient suppression.

Sample Mux

Refer to Figure 3-28.

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.

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 3 A/D Sense Lines

A/D CHANNEL	*FUNCTION*
U3-S1	kVp measured
U3-S2	mA measured
U3-S3	filament B+ sense
U3-S4	video level
U3-S5	housing temperature
U3-S6	dosimeter
U3-S7	spare
U3-S8	spare
U3-S9	secondary tap voltage
U3-S10	line voltage
U3-S11	charger current
U3-S12	battery voltage
U3-S13	filament current
U3-S14	spare
U3-S15	spare
U3-S16	spare

Table 4

PIO 1, U38 Summary

BIT	*PIN*	*FUNCTION*	*COMMENT*
PA0	4	camera rotate CW	see state table
PA1	3	camera rotate enable	
PA2	2	collimator rotate CW	
PA3	1	collimator rotate enable	
PA4	40	collimator open	
PA5	39	collimator enable	
PA6	38	iris open	
PA7	37	iris enable	
PB0	18	B+ contactor	active hi
PB1	19	B+ charge	
PB2	20	stator run	
PB3	21	X-ray on lamps	not used
PB4	22	field select	
PB5	23	stator start	hi for 2 sec
PB6	24	II power	used in fluoro
PB7	25	camera horizontal reverse	
PC0	14	spare	sense
PC1	15	spare	sense
PC2	16	cassette detect	sense
PC3	17	field detect	sense
PC4	13	not used	
PC5	12	fluoro only	left footswitch sense
PC6	11	boost	boost sense
PC7	10	X-ray switch	switch or footswitch sense

Table 5

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	camera vertical reverse	
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	overvoltage 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 6

PIO 3, U22 Summary

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

Signal Descriptions

Charger Control

Charger Disable.....U27-PB0
when high: causes the charger to stop charging the batteries. On the Generator Controller PCB this line is connected to the shutdown pin on U22, a current mode PWM controller.

X-ray Tube Control

Stator Start.....U38-PB5
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-PB2
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.

Start/Run Logic Table

	PB5	PB2
OFF	0	0
RUN	0	1
ILLEGAL	1	0
START	1	1

Stator Sense.....U27-PC7
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.

Generator Control

B+ Charge.....U38-PB1
When active, a high is applied to the base of Q4. Q4 collector (B+ Charge) is looped through the Generator Controller PCB and routed to the charging relay K1 mounted below the Generator Controller PCB. 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-PB0
When active, a high is applied to the base of Q5. Q5 collector (B+ Contactor) is looped thru the Generator Controller PCB and routed to the relay K2 located under the Generator Controller PCB. 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-PA7
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 Controller PCB and applied to the fault protection logic PAL U32.

KVP Control.....U31-CH3
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 Controller PCB.*

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

mA Control.....U31-CH4
Delivers a control voltage to the filament regulator circuit. Measure this voltage at TP18. *Refer to the filament control circuit on the Generator Controller PCB.*

mA Reference (mA Cal) U31-CH2
Sets the reference voltage for the DAC used to generate mA CONTROL. Measure this voltage at TP16.

Filament B+ Control.....U18-CH2
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 Controller PCB.*

Focal Spot.....U27-PA1
The state of this line selects the focal spot size.

1 = 0.3 mm spot
0 = 1.0 mm spot

On the Generator Controller PCB - 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. Refer to be Generator Controller PCB.

Generator Shutdown (Shutdown Command).....U27-PA3
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 Controller PCB 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 Controller PCB.*

mA Scale Factor.....U27-PA0
Selects the mA scale factor for film or fluoro - 1 = Fluoro, 0 = Film.

HV Drive.....U12
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 Controller PCB, 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 Controller PCB.*

HV Generator On.....U27-PC4
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 Controller PCB at PAL U21, which monitors the states of the HV Drives, X-ray On, X-ray Enable, and other lines.

Generator Fault.....U27-PC3
Indicates that one of the fault conditions has been detected and the generator has been shut down. Originates on the Generator Controller PCB at PAL U32.

Overload Fault.....U27-PC0
Indicates that the generator has detected an overload and shutdown. Originates on the Generator Controller PCB at PAL U32.

Saturation Fault.....U27-PC1
Indicates that the generator has detected a saturation fault and shut down. Originates on the Generator Controller PCB at PAL U32.

Filament Fault.....U27-PC2
Indicates that a filament fault has been detected and the generator has been shutdown. Originates on the Generator Controller PCB at PAL U32.

mA Test.....U27-PA4
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 Controller PCB.

Generator Mode (High Power Mode).....U27-PA2
When high, this line causes the generator to use the full bridge configuration to drive the output transistors. When low, causes the generator to use the half bridge configuration to drive the output transistors. The signal is applied to Q10 on the Generator Controller PCB. The collector of Q10 controls relay K3.

Camera/Image Intensifier Control

Camera Horizontal Sweep Control..... U38-PB7
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.

Camera Rotate Direction U38-PA0
The camera will rotate CW or CCW according to the table below.

Camera Rotation Enable.....U38-PA1
Enables camera rotation, see the table below.

PA1	*PA0*	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

PA0 AND PA1 are applied to the phase and enable inputs of the motor control IC U26. The direction of current flow from out1 and out2 on this IC determines the direction of motor rotation.

Disregarding slippage, camera rotation speed is about 8 degrees per second. Coast is about 3 degrees (maximum). The camera motor has limit switches that activate at either end of the rotational limits.

The direction of camera rotation depends on both the control command and the direction of camera horizontal sweep.

Camera Rotate	CW	CCW	CW	CCW
Reverse Sweep	No	Yes	Yes	No
Actual Direction	CW	CW	CCW	CCW

Camera Mode..... U27-PB1
Not currently used, should be set low.

Camera Gain.....U18-CH3
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-CH4
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-PB6
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.

Iris Aperture.....U38-PA6,PA7
Not installed.

Camera/Image Intensifier Sensing

Film Cassette U38-PC2
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.

Collimator Rotation Direction U38-PA2
Determines the direction of collimator rotation according to the table below.

Collimator Rotation Enable U38-PA3
Enables collimator rotation according to the table below.

PA3	PA2	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

PA2 and PA3 are applied to the phase and enable inputs of the motor controller IC U37. The direction of current flow from OUT1 to sT2 determines the direction of motor rotation.

Disregarding slip, the collimator rotation speed is about 8 degrees per second. Coast is approximately 3 degrees. The collimator rotation motor has no limit switches. Rotation is continuous obtaining power from slip rings.

Collimator Aperture Direction U38-PA4
Causes the aperture to open or close according to the table below.

Collimator Aperture Enable U38-PA5
Enables motorized collimation according to the table below.

PA5	PA4	
0	0	= OFF
1	0	= CW
1	1	= CCW
0	1	= ILLEGAL

Note: The collimator leaf motor speed is about 0.25 inches per second when viewed in the 6" field. The leaf motor has no limit switches.

Field Select U38-PB4
When low, the flipper is placed in the beam, restricting the field diameter. When high, the flipper is put out of the beam. This line is applied to the base of Q11. The collector of Q11 drives the field select solenoid at the collimator.

Note: When the large field is selected, the solenoid draws about 1 amp of current.

Field Detect U38-PC3
PIO input reads the status of the field size through a microswitch at the flipper. This line reads low when the flipper is out of the beam.

Cart Control and Sensing

Store U22-PA4
When low, informs the image processor that an exposure is being made.

Video Stable U22-PA1
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-PC5
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-PB7
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-PC6
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-PC7
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-PC6
PIO Input. Signals that the boost position of the footswitch has been pressed.

Fluoro Only U38-PC5
PIO Input. Signals that the left side of the footswitch, FLUORO ONLY, has been pressed.

3.12.5 Generator Controller PCB

Overview

Refer to Schematic 00-871044.

The major functions of the Generator Controller are:

1. Regulate Filament Current
2. Regulate X-ray tube high voltage
3. Charge the batteries
4. 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.

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 VR1. The rectified voltage is regulated by VR5 and VR6 to provide +/- 12 VDC. These are identified as +/- 12SEP and they power the battery charger circuits separately from the other voltages on the board.

The other supply voltages, +/- 12 VDC and +/- 6 VDC, are regulated by VR3 and VR4.

Grounding

The Generator Controller PCB 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:

Ground A: Battery minus (B-) and 115 VAC Neutral
Ground B: ground for the driver stage Q14-Q17
DC Common: ground for most low voltages, and forms the PCB ground plane

Be sure that voltage measurements are referenced to the correct ground.

Fault Detection Logic

Refer to *Section 3.4 - Fault Conditions and Error Checks* for a full description of the fault detection logic.

Battery Charger Circuit

Refer to Figure 3-29.

The battery charger is a boost regulator which provides a controlled current and voltage to the battery 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 U15, Q4 is turned on, placing R70 in parallel in the voltage feedback loop with R98 and R108. 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, Q4 turns off and regulates the charging voltage back to the 211 VDC level. Hysteresis is biased into the op-amp circuit of U26 causing this transition to occur gradually.

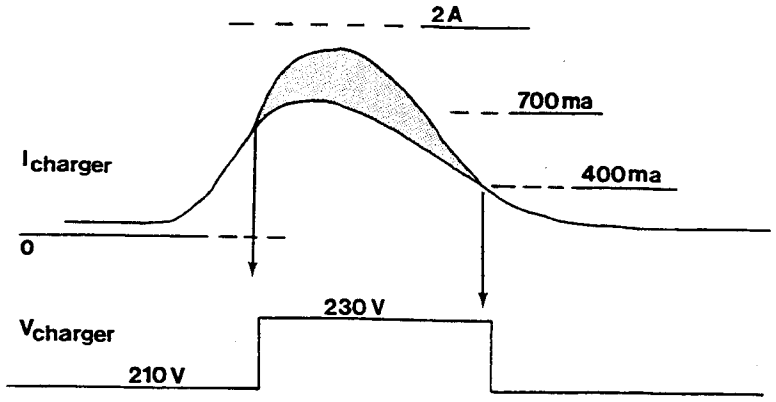
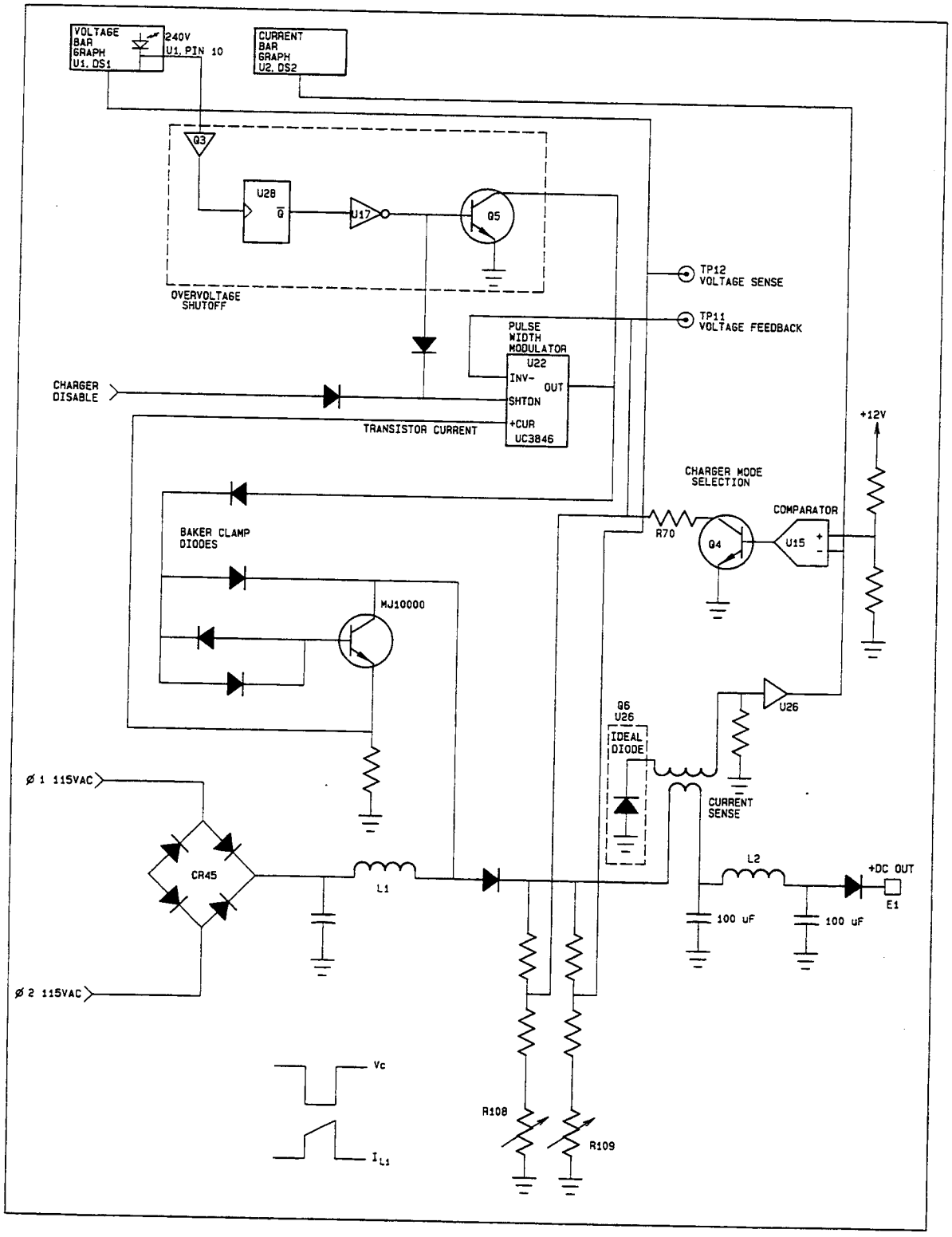


Figure 3-29 - *The current and voltage output during low and high charge.*

Pulse Width Modulator Circuit

U22 (UC3846) is a current mode, pulse width modulator with a built in 5.1 volt reference. The reference is accessible on pin 2 (Vr). U22 controls the duty cycle applied to the base of the MJ10000 transistor Q18 mounted above the board on a heat sink. When this transistor turns on, the current into L1 increases. The Baker clamp on the base of Q18 prevents saturation and speeds up the switching response.

Figure 3-30 - *Block diagram of the battery charger portion of the Generator Controller PCB.*



Boost Regulator Cycle

Line current is rectified by bridge rectifier CR45 and applied to the inductor L2. When The regulator transistor Q18 receives no drive voltage the rectified line voltage is lower than the battery voltage and diode CR67 is backbiased. There is no current flow.

When the transistor Q18 turns on, one side of the inductor is grounded thru resistor R122. There is a gradually increasing current flow through the inductor. When the transistor turns off, the inductor supplies current by flyback action which results in a voltage forward biasing CR67. Cycle variations are filtered by C59, L2 and C63. Note on the schematic that E1 is connected to the + side of the batteries and ground "A" is connected to the - side.

Transistor current feedback is obtained from the emitter resistor R122 and fed back to one side of the differential current sense input of U22-pin4. The other differential side is connected to ground A.

When Q18 turns off, the flyback action of inductor L1 boosts the voltage by an amount determined by the on-time. CR67 prevents backward current flow when Q18 is turned on and allows current flow to the batteries during the flyback phase.

Resistor network R111/R98/R108 provides feedback to the inverting voltage sense input of U22. *R108 is adjusted to produce 211 VDC output at E1 or 5.1 VDC at TP11, Voltage Feedback.*

Voltage is sensed for the charging voltage bar graph display by resistor network R94/R95/R109/R112. *R109 is adjusted for the correct display of the charging voltage on the bargraph.*

Charging Current Sense

T1 and the ideal (0 drop) diode formed by U26/CR19/Q6 develop a voltage across the resistor R86 proportional to the charging current in the T1 primary. U26 is a 2X voltage amplifier providing the CHARGER CURRENT SENSE signal. This signal is fed to comparator U15, which switches when current demand is increased, current indicator display U2, and is also available off board where it is digitized on the Analog Support PCB and read by the processor.

Protection

The overcurrent protection circuit consists of Q3, flip flop U28, inverter U17 and transistor Q5.

Flip flop U28 is reset by the powerup reset circuit C15/R30 and also when the processor toggles the reset line via Q18 and Q19. Resetting U28 enables the U22 output and turns off Q5.

The CHARGER DISABLE line from the processor (via the Analog Support PCB) is attached to the U22 pin-SHTDN. When held high by the processor, this disables the pulse width modulator.

If excessive charging current is sensed, overcurrent protection is provided in two steps: apply a high to the SHTDN pin of the PWM U22, and ground the U22 drive output through transistor Q5.

Excessive charging current is sensed when the highest segment on the voltage bar graph lights, causing Q3 to clock the flip flop U28.

Indicators

Charging current is indicated on the LED bar graph display U2. U2 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, U1, is driven by the VOLTAGE SENSE line. The indicator reads in 10 linear steps from 150 VDC to 240 VDC.

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.

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.

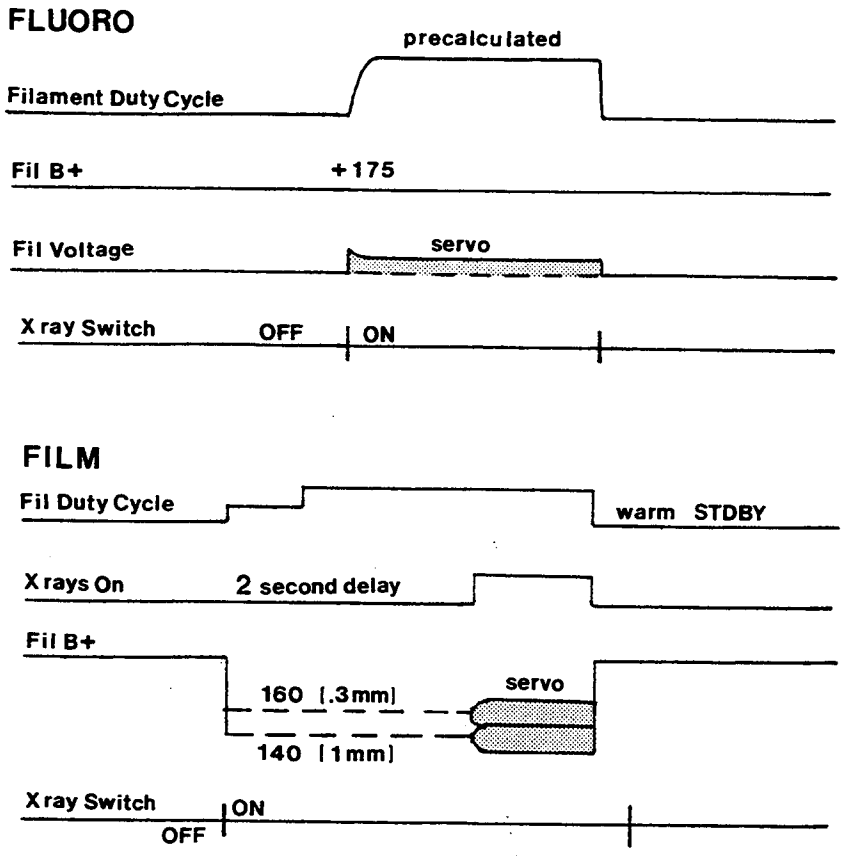


Figure 3-31 - *Filament duty cycle and filament B+ regulation before and during a shot.*

The filament B+ voltage is initially set to a low value by the processor: 140 volts for film mode and 175 volts for fluoro mode. As the shot begins the B+ is increased and 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.

In Other Words

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

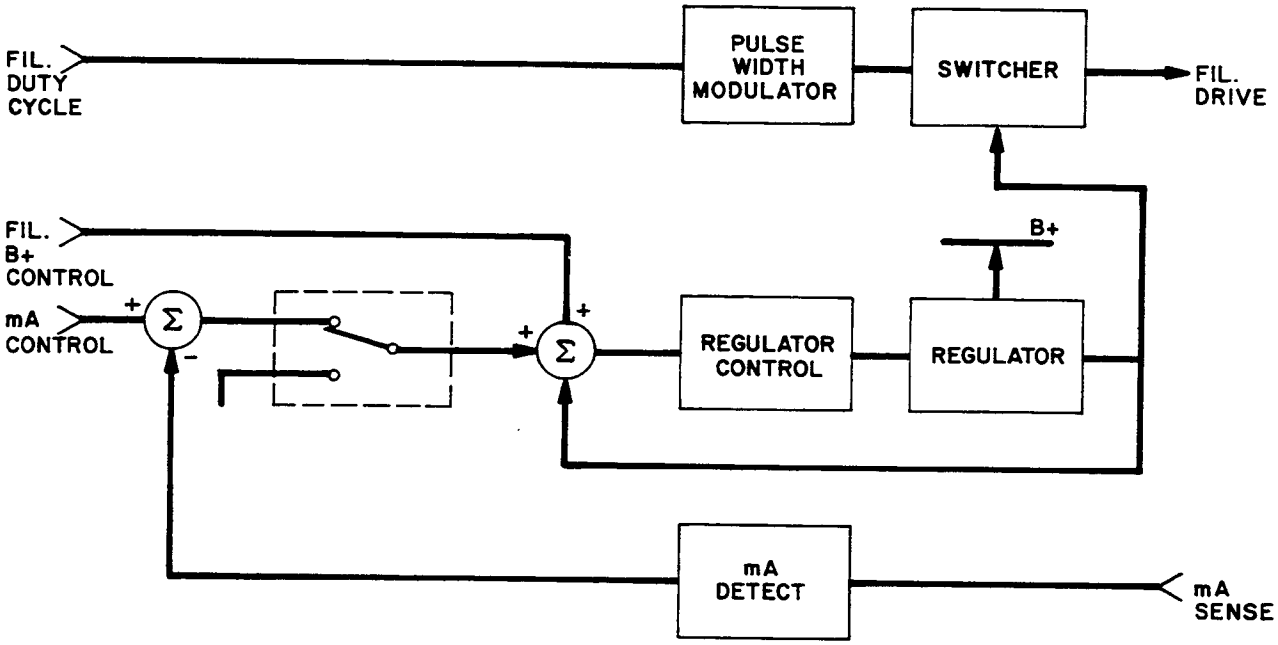
1. Vary the duty cycle of the output switcher stage comprised of transistors Q12 and Q13. This is the means the processor uses to preadjust the filament temperature, prior to a film shot and at the beginning of a fluoro shot, to an approximate value for the technique selected.

   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).

Figure 3-32 - *The filament dynamic regulation loop, compares the measured filament current (mA-sense) against the filament control signal (mA-control) obtained from the processor.*



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 U11, resulting in d.c. restoration. U11 acts as a current to voltage converter.

The two stages of U20 form a 4-pole low pass filter. The output of U20 is applied to film/fluoro scaling amplifier U10. U23 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.

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, opening analog switch U39. As the shot begins, switch U39 opens, enabling error amplifier U30. U30 compares the MA CONTROL voltage with the mA sense voltage obtained from op amp U10.

The difference, or error voltage, is applied to error amplifier U38 whose output controls the voltage on the base of transistor Q11.

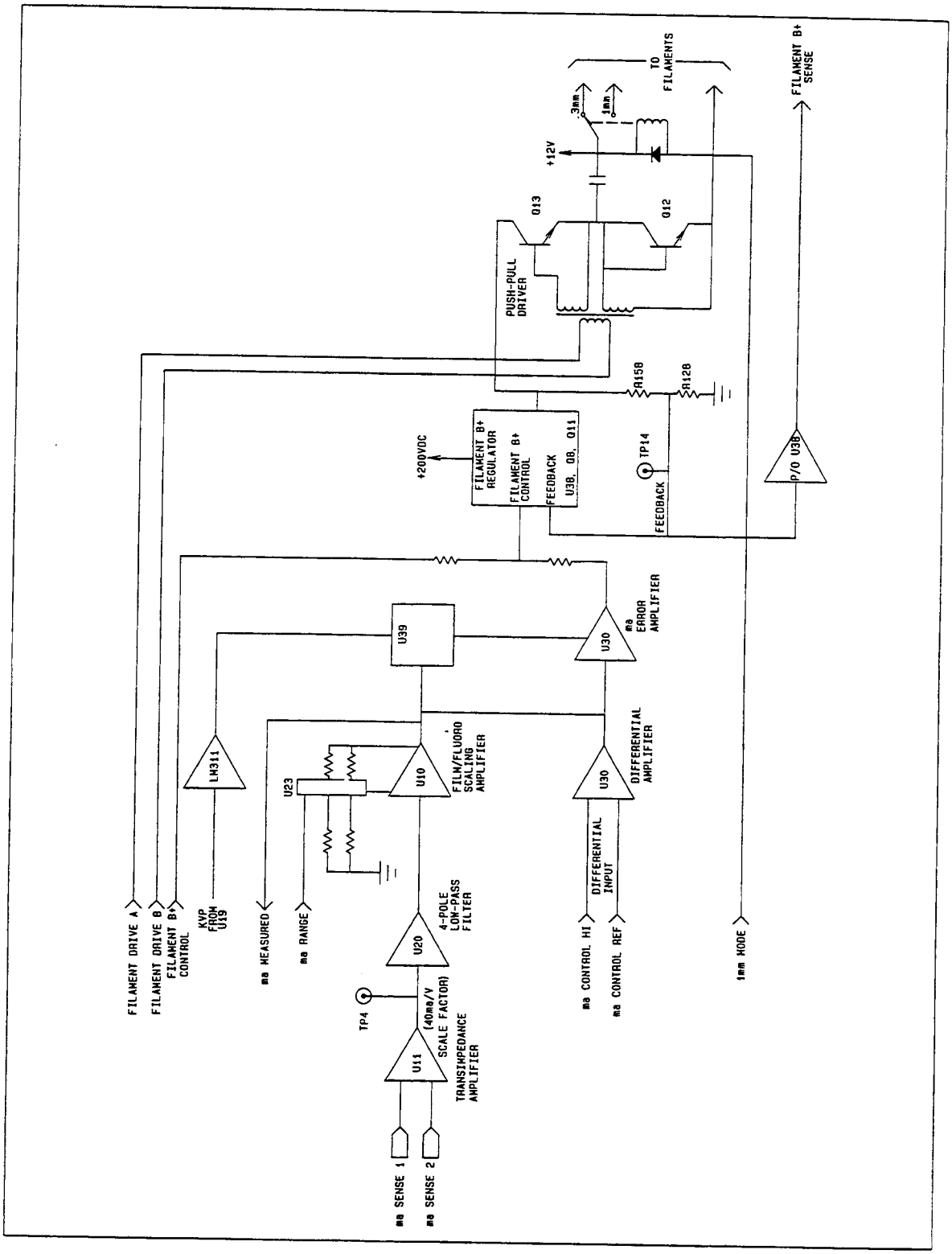
The signal applied to the base of Q11 regulates the B+ voltage applied to the filament driver stage Q12 and Q13.

The linear regulator circuit, Q8 and Q11, controls the battery B+ voltage applied to the push-pull filament driver circuit Q12, Q13.

The final output is applied through L4 and C77 to relay K1. According to the state of the 1mm 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.

Figure 3-33 - *Block diagram of mA regulation circuit.*



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 U23 and applies the MA TEST CONTROL VOLTAGE to op amp U7.

U7 and Q2 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 3-34 - *The mA test circuit.*

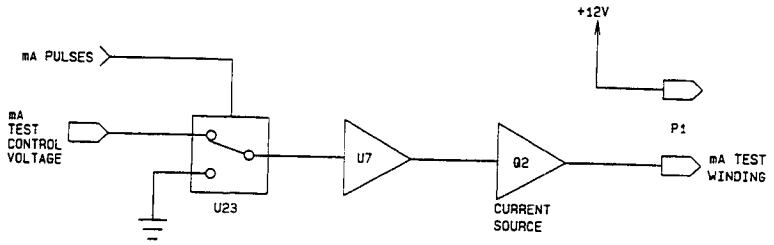
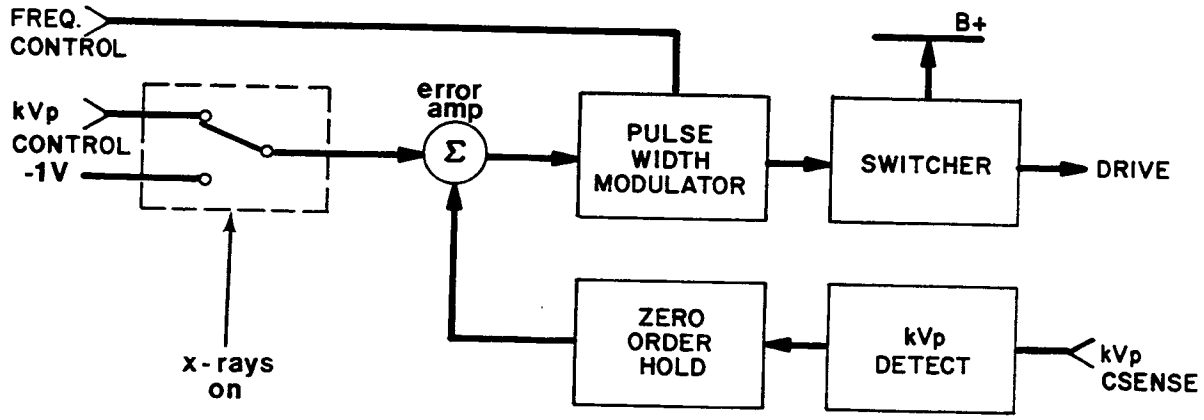


Figure 3-35 - *KVp regulation Loop.*



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 Controller PCB KV SENSE is applied across R42. The positive peaks of the KV SENSE waveform are buffered by U27 and peak detected by U24/U16. The negative peaks of the waveform are inverted by U27, and detected by U12/U27.

Both peaks are sampled and held by U29/U39, then combined and integrated by C49 and U19. The result is KVP MEASURED. This signal is then sampled and digitized on the Analog Support PCB.

Analog switch U45 is controlled by MA RANGE. With its associated RC network, its action is to reduce overshoot in fluoro modes.

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 U9, U18, and Q1. The PWM output PWM COMPARATOR forms a logic input to PAL U21, along with the signals HV DRIVE A and B, an X-RAY ON and X-RAY ENABLE. PAL U21 produces the signals HV DRV A and HV DRV B which determine the duty cycle of the switcher drives.

Error amplifier U19 compares the KVP MEASURED with the HV CONTROL signal. HV CONTROL is applied to the error amplifier by switch U23 controlled by the signal HV INV ON. When HV CONTROL is not applied to U19, a voltage set by resistive divider network R91/R105 is switched into the error amplifier input by U23 to prevent the regulation feedback loop from overcompensating for zero voltage sensed.

Comparator U9, transistor Q1, and flip-flop U18 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) U21. HV DRV A and HV DRV B are output by U21, buffered and inverted by U31. U40 provides current gain before applying the drive signals to Q14/Q15 and Q16/Q17.

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, since 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. U5 is a peak detector whose output, SECONDARY TAP VOLTAGE, is proportional to the kVp voltage from the tank. This signal is digitized on the Analog Support PCB and read by the processor.

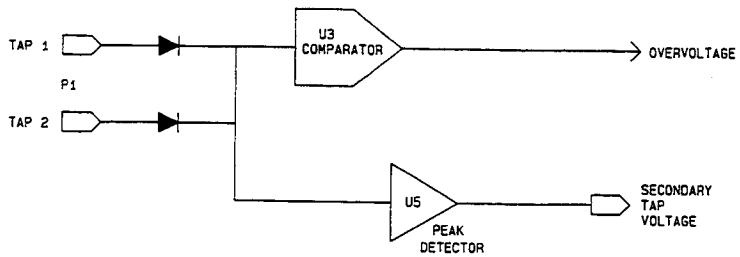
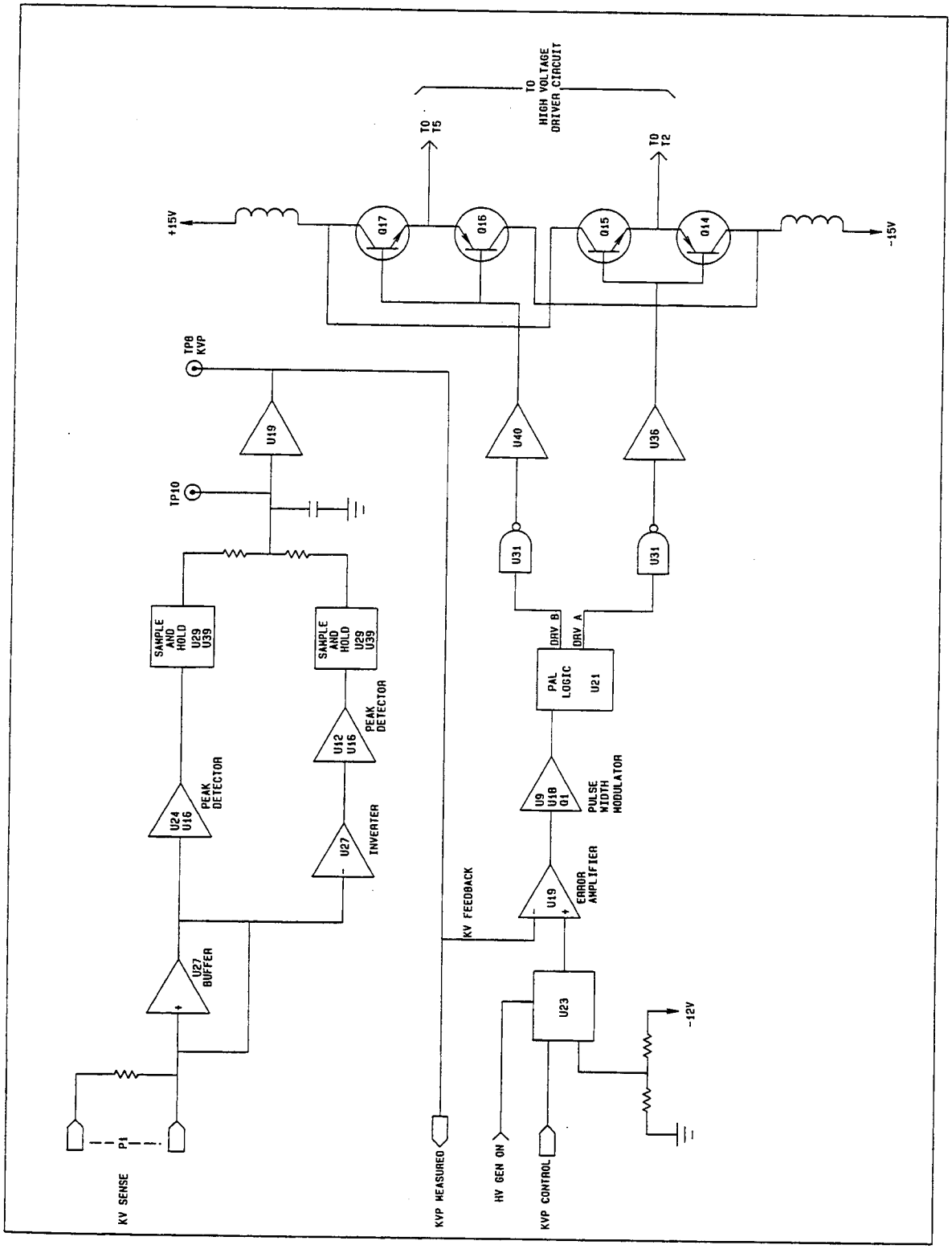


Figure 3-36 - *Secondary Tap Voltage Sense.*

Figure 3-37 - *Block diagram of the KVp regulation circuit.*



Overvoltage Protection Circuit

The SEC TAP V measurement is also used to test for an overvoltage fault, which if it occurs, disables the drives from PAL U32.

Comparator U3 senses an overvoltage fault condition which it signals on the OVERVOLTAGE line.

This line will then trip a latch in the fault detection PAL U32, resulting in loss of drive pulses at PAL U21 and hence loss of drive to the output stage. This can occur in as little as one drive cycle (400 microsecond) This latch must be reset by the processor in order to resume operation.

Calibration Issues

Refer to the section in this manual on *Calibration* for a discussion of the theory of 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.

Intermediate Driver Circuit

HV DRV A and HV DRV B are buffered by the inverting driver pair U31. More drive current amplification is provided by op amps U36 and U40.

After the driving op amps U36 and U40, a circuit has been added to protect the bridge circuit formed by transistors Q14, Q15, Q16, and Q17 on power-down. This transistor protection circuit is comprised of two 2N3906 transistors and associated 1N914 diodes.

Predrive Stage

Transistors Q14/Q15 and Q16/Q17 form a bridge circuit. Their emitters are coupled via C99 and C89 to transformers T5 and T2. 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.

High Voltage Drive Circuit

Refer to Figure 3-38.

T5 and T2 each have two secondary windings, individually fused, which drive the high power transistors Q1 and Q2

The main power transistors, Q1 and Q2, each containing two darlington pairs, 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, F3, F4, and F5 are located on the Generator Controller PCB in the secondary circuits of T2 and T5.

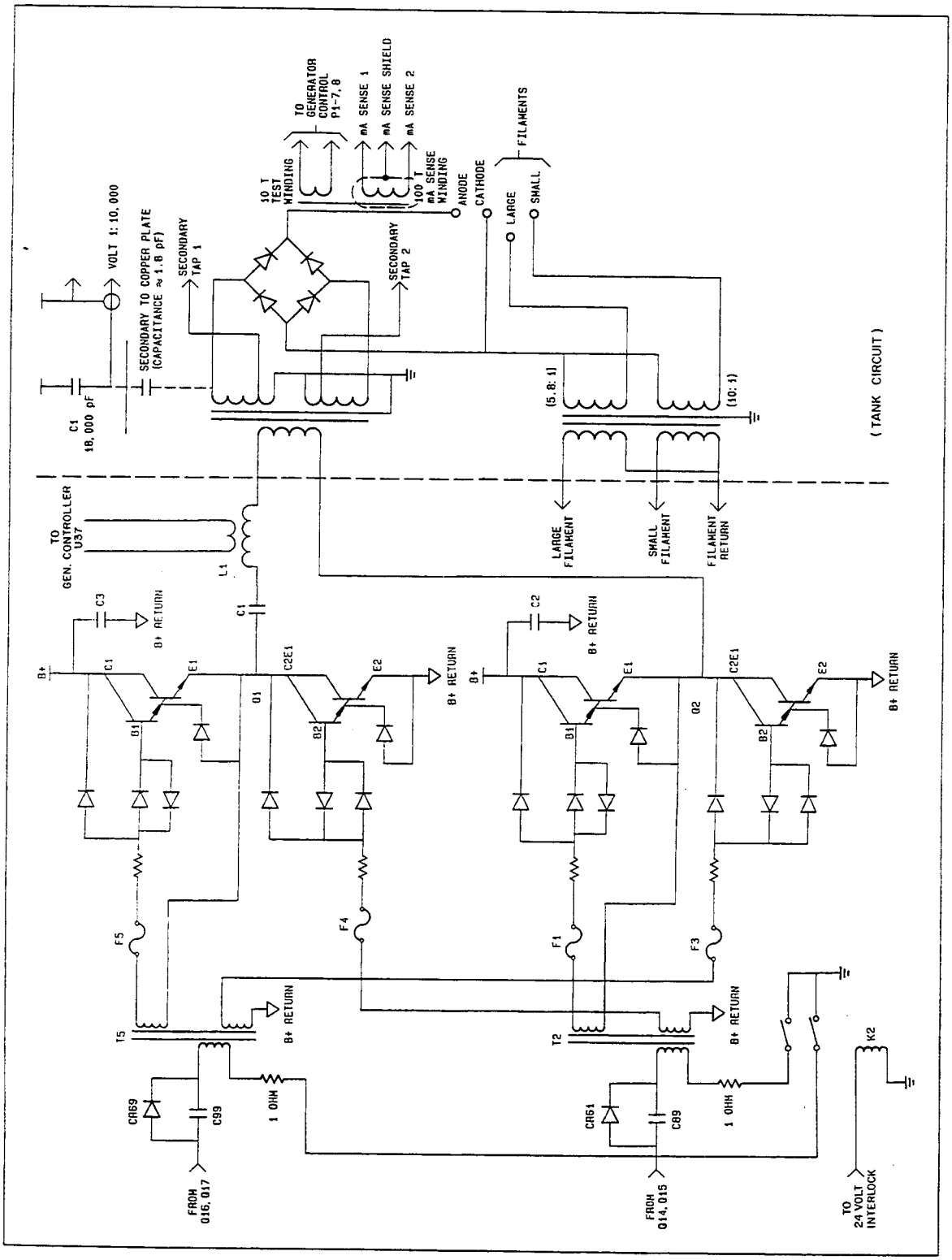
With the exception of the fuses and the baker clamping diodes, the high voltage driver circuit is constructed on the assembly below the Generator Controller PCB.

The large switching transistors Q1 and Q2 each contain two internally wired Darlington pairs. These form an H-bridge switching regulator. Baker clamp diodes are added externally to bias the darlington pairs for fast switching response.

The output legs of the H-bridge individually display ringing in the current waveforms. However when these are combined on the primary winding of the tank transformer, the ringing cancels out. C1 and L1 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 sinewave across the tank transformer primary.

Figure 3-38 - *Block diagram of the high voltage drive and tank circuits.*



3.12.6 High Voltage Circuit (Tank)

Refer to Figure 3-38. 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:

* Filament transformer with secondary windings for both filaments.
* High voltage transformer
* High voltage rectifier
* Capacitive voltage divider for voltage sensing with a divider ratio of 1:10,000 volts.
* 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.
* Secondary winding taps for voltage sensing.

Note: The Cathode connection is also the common filament return.

3.12.7 Battery Circuit

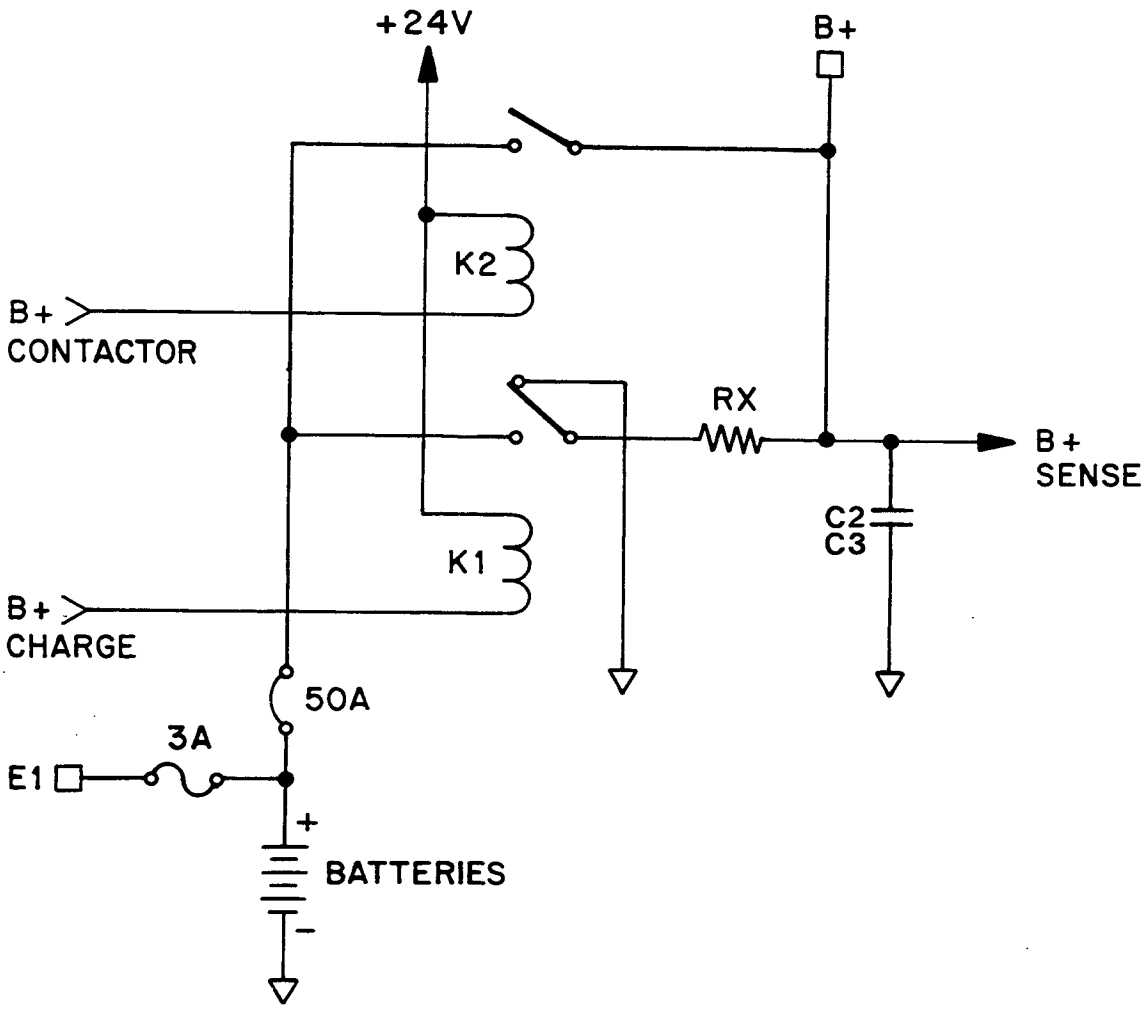
Refer to Figure 3-39. The battery circuit is comprised of:

* Six 30 volt battery packs
* Capacitor C4
* Charging resistor Rx
* 50 Amp contact closure fuse
* 3 Amp charger fuse
* B+ charge relay
* 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 200 VDC stack. This provides nearly 3.6 million watt-seconds of capacity, well beyond the tube rating. Each exposure draws from this energy source. The batteries are continuously recharged from the line at a 400 watt-second rate. 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, the batteries and the capacitor C4 provide energy for the X-ray shot.

Figure 3-39 - *Block diagram of the battery circuit.*



The charger circuit (E1) is connected through a 3 Amp fuse to the positive side of the battery pack. When K1, the B+ charge relay, is closed, the B+ voltage is applied through the 1 kOhm resistor Rx to charge the capacitor C4. C4 buffers the B+ line under rapidly varying current loads. After C4 has been precharged, the B+ CONTACTOR relay K2 is closed, finally connecting the battery, battery charger, and C4 all up to the B+ line, ready to supply 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

The 24 volt interlock line, the START switch, and the EMERGENCY OFF 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.

SECTION 4
MONITOR CART
THEORY OF OPERATION

This section provides technical descriptions of the hardware and software used in the OEC-Diasonics Mobile C-arm Imaging System. The purpose is to assist the service technician or field engineer in understanding the maintenance and calibration procedures in this manual.

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

The software plays a central role in the operation of the system. Therefore discussion of software is combined with the theory of operation of the hardware in this section.

4.1 Major Components and Options

4.1.1 Major Components

Figure 4-1 is a block diagram showing the major components and some options available on the monitor cart. The major control, data, and address busses within the system are illustrated. The bit width of these busses is indicated in parentheses. The serial links employ subsets of standard RS-232 serial interfaces.

The monitor cart contains the following major components:

Disk Interface PCB - coordinates image and data transfers between the system hard disk and memory; also programs image processing operations.

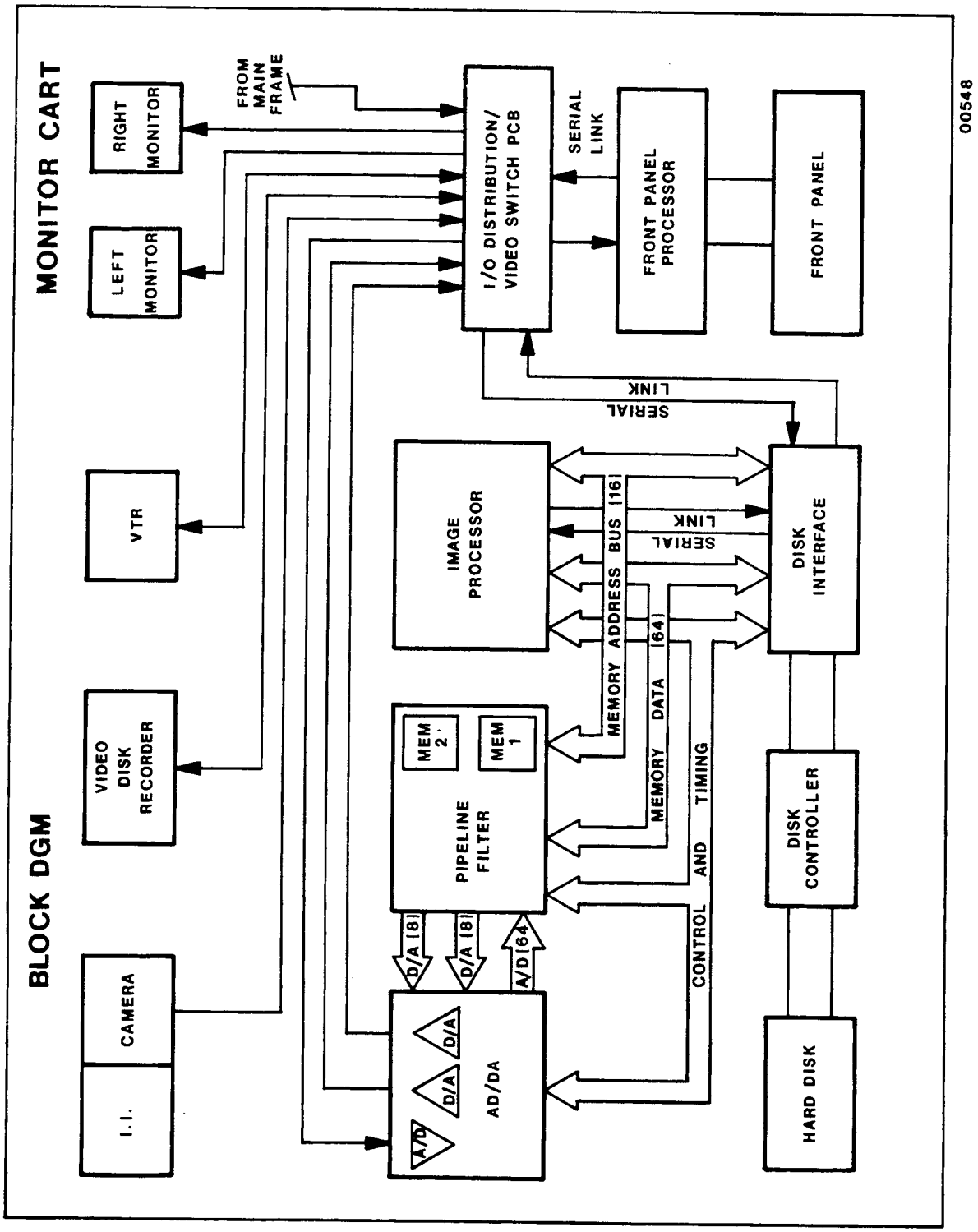
Front Panel Processor Assembly - consists of the control panel switches, LEDs, and the Front Panel Processor PCB.

Image Processor PCB - a board level microcomputer that controls the special functions of the digital processing circuits.

I\O Distribution\Video Switch PCB - controls the distribution of the video inputs and outputs of the image processing circuits.

AD\DA Converter PCB - digitizes the incoming composite video signal for processing and converts the digital image data into a composite video signal for display on the TV monitors.

Figure 4-1 - *Block diagram of the major components of the monitor cart.*



Pipeline Filter PCB - performs algorithms on the digital image data and also contains the image memories.

Disk Controller PCB - an OEM circuit board that controls the hard disk and also controls a floppy disk when connected.

OEM components - which include DC power supplies, the isolation transformer and the two TV monitors.

4.1.2 Image Storage Options

Various options may be installed depending on the system configuration:

Hard disk image storage for up to 60 digitized images.

Video tape recorder for real time storage of the composite video signal.

AngioStor video disk recorder for high resolution storage of video frames.

Multi-format camera to make hard copies of fluoro images.

Patient annotation for identifying and commenting stored images.

4.1.3 Image Processing Options

The major image processing and image storage options can be identified by referring to the front panels shown in Figure 4-2. Model upgrades can be performed by replacing these panels and their associated electronics and software.

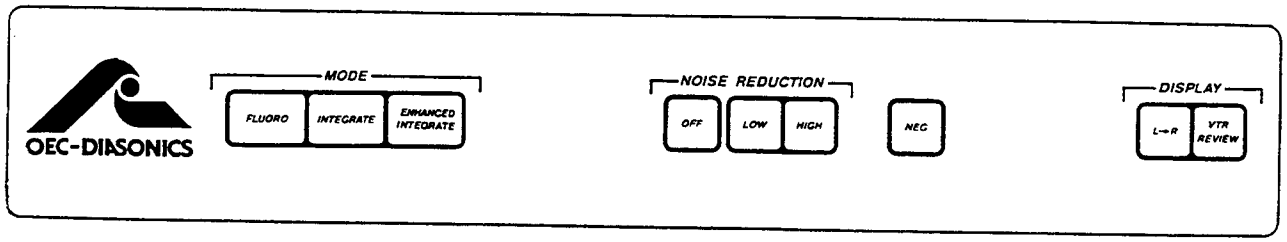
In Figure 4-2 the following panels are identified:

1 - Basic 9000 system

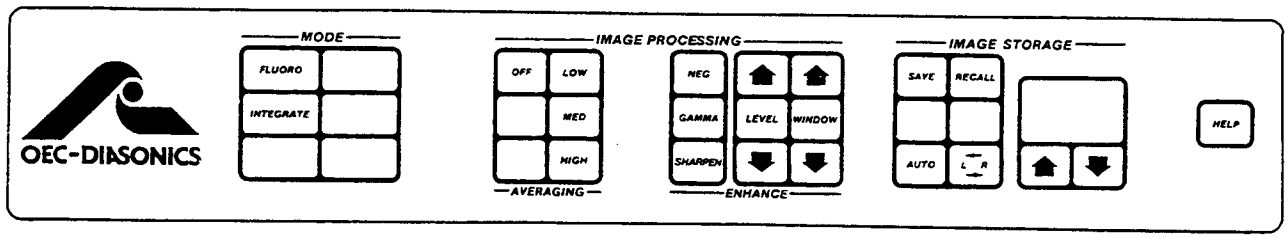
2 - Expanded Surgical Package

3 - Expanded Surgical Package with Vascular or Neurovascular Options

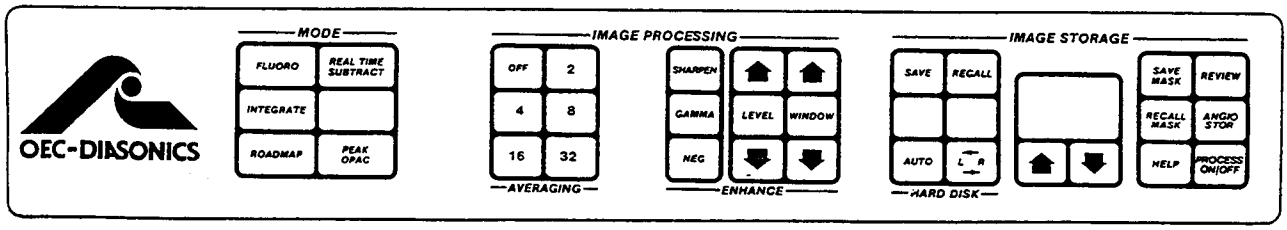
Figure 4-2 - *The major image processing options can be identified by their different front panels.*



1



2



3

4.1.4 Major Connections

Interconnect Cable

Refer to Drawing 00-870735.

The interconnect cable provides AC power to the mainframe, control communications between the mainframe and monitor cart and the video signal to the monitor cart. This is described further in the *Mainframe Theory of Operation.*

Other Connections

The following tables describe the connectors located on the interface panel on the rear of the monitor cart.

Table 1 RS232 Connector

PIN	*SIGNAL*
3	RXD
5	TXD
7	RTS
9	CTS
11	DSR
13	COM
14	DTR
15	DCD

Table 2 AUX Connector

PIN	*SIGNAL*
3	spare
5	stop
7	record
9	search
10	VTR clock
11	pause
12	ground
13	play
14	ground
15	f. forward
16	ground
17	reverse
18	ground
20	ground
22	ground
24	ground

Table 3 **VTR - J34**

PIN	*SIGNAL*
3	shield
4	video to VTR
2	video from VTR
6	shield

Table 4 **Video Out**

PIN	*SIGNAL*
J36	video out 1
J35	video out 2

Table 5 **Video Disk J37**

PIN	*SIGNAL*
1	record enable
5	ground
4	video to AngioStor
3	shield
2	video from AngioStor
6	shield
8	composite sync
7	shield

4.2 Power Distribution

AC Power Input power is supplied via the isolation transformer T1 located in the base of the monitor cart assembly. Taps on the primary and secondary windings of T1 allow system connection to various line source voltages.

DC Power DC voltages for circuit board operation (+5, -5, +/- 15 VDC) are obtained from the switching power supply located on the side of the card rack.

A 24 VDC supply in the base of the monitor cart supplies power to the tv monitors.

4.3 Monitor cart operation

4.3.1 Image Processing Functions

The image processing functions, selected from the front panel, may include the following, depending on system options and model:

Averaging Real-time video frame averaging is used to improve signal to noise ratio and reduce motion artifacts. A running average is calculated for each pixel to be displayed. The average can be obtained over a variable number of frames: 2, 4, 8, 16, 32. Noise and motions which are not correlated with structures in the image are averaged out. Since it is a real-time average, the pixel values used in the calculation are constantly changing and the average is recalculated each time a new frame is added.

Integration Frame integration is similar to frame averaging. The main difference is that integration stops after a specific number of frames have been averaged. The last image displayed when integrating results from averaging the previous frames.

Real-time Subtraction Real-time subtraction allows successive images to be subtracted from a mask image. Perfect subtraction results in a gray-scale value which is off-set to 80 Hex, a mid-range gray.

Roadmapping Roadmapping is similar to real time subtraction, but the mask image is negated and reused for successive subtractions until another mode of processing is selected.

Peak Opacification Peak Opacification can be performed on successive frames. The darkest value for each pixel in the image is saved and displayed.

Gamma The gamma function maps the gray scale range as an exponential function. This results in a compression of the dynamic range when dealing with an image where the brightness range is large. Linear gray scale mapping is used when gamma is not enabled.

Sharpen Image sharpening is achieved by an algorithm which emphasizes image edges. This process involves translations of horizontal and vertical pixel locations. The circuitry to perform these translational movements is divided between the Image Processor PCB and the Recursive Filter PCB. This requires executing an algorithm which shifts the image a certain number of pixels in the X axis and a number of lines in the Y axis. The Y shift is set by changing the beginning pixel address generated by the address counters on the Image Processor PCB.

Window and Level Window and Level controls are used to remap the gray scale to upper and lower portions of the gray range and to alter the slope of the video transfer function. These are analogous to contrast and brightness controls.

Subtraction With Averaging and Peak Opacification Averaging and peak opacification can be selected from the front panel for use during real time subtraction and roadmapping. These are applied selectively during the mask and subtraction phases as shown below:

	REAL TIME SUB		ROADMAPPING	
PHASE	*MASK*	*SUB*	*MASK*	*SUB*
AVG		X		X
		or		
PK OPAC		X	X	

4.3.2 Image Memories

The fluoro image is transferred between several memories during processing. These memories are described below:

Segment Ram Sixteen kbytes of static ram located on the Disk Interface PCB are used to read and write segments of data to the Pipeline Filter memory from the hard disk. The 16 kbytes translates to the monitor as an image segment 32 lines down x 512 pixels across. Only Pipeline Filter memory M1 can be written to or read from via the segment ram.

Pipeline Filter Memory 512 kbytes of ram is mapped into two pairs of memory (M1 and M2) for a total of four 128 kbytes image frames.

Image Frame Each 128 kbyte memory frame is large enough to store a 512 x 512 byte image. Whichever frame is currently mapped to the monitor is considered the foreground frame, while the other 128k block is the background frame. The Image Processor can switch the address lines so that these memory blocks exchange roles.

DRAM 64 kbytes of dynamic ram located on the Disk Interface PCB is not used for image storage but is where the system software resides after boot-up.

4.3.3 Serial Links Between Boards

Monitor Cart-Mainframe The serial communications port between the monitor cart and the mainframe uses hardware handshaking and operates at 9600 baud.

I.P. - Disk Interface Serial communications between the Disk Interface PCB and the Image Processor PCB operates at 1200 baud and supports XON/XOFF handshaking. The Image Processor also has a 128 byte buffer for this port.

Front Panel - Disk Interface PCB Serial communications between the Front Panel Processor and the Disk Interface PCB operates at 1200 baud and supports XON/XOFF handshaking.

4.4 Monitor Cart Software

The monitor cart software can be divided into three major functional areas:

1. Main program software
2. Image processing software
3. Front Panel software

4.4.1 Main Program Software

The main program consists of system operating software and application programs which are stored on the hard disk and loaded into the Disk Interface board DRAM for execution. The transfer occurs during the monitor cart booting process and is directed by a smaller program in EPROM on the Disk Interface PCB. When executed by the processor on the Disk Interface PCB, the application program issues commands to the other processors on the Image Processor and Front Panel Processor PCB's. The operation of the I/O Distribution - Video Switching PCB is also controlled by the main program.

4.4.2 Image Processing Software

This software resides in EPROM on the Image Processor PCB and controls the operation of the Pipeline Filter and Image Processor PCB's. For some processing applications it receives function calls from the application program running on the Disk Interface PCB.

4.4.3 Front Panel Software

The Front Panel Processor PCB executes a program which resides in EPROM. It scans the front panel keys and sends the scan codes to the application program for interpretation. The application program, in turn, issues commands to the Front Panel Processor PCB to update the LEDs and the alphanumeric display on the front panel. The Front Panel Processor PCB also sends commands to the Disk Interface PCB for image processing selection.

4.4.4 System Initialization

When power is first applied, each microprocessor starts an initialization or "boot" sequence by executing software code which resides in EPROM.

Disk Interface Initialization: Commands are issued to the Disk Controller PCB, via a parallel port on the Disk Interface PCB, to read the first sector from the hard disk into memory. If a floppy disk drive is installed during service procedures, the first sector of the floppy disk will be read instead.

If the disk read operation is unsuccessful, an error message is issued to the AUX port, which may be read on an external terminal during service procedures. The system then enters the monitor program, contained in EPROM on the Disk Interface PCB.

The code read from the first sector directs the transfer of the rest of the operating system into memory and transfers control to the Disk Operating System. The function of the Disk Operating System is to load various utilities, diagnostic, and application programs into RAM for execution. In normal operation, the Disk Operating System then executes the application program.

Image Processor Initialization: The monitors are cleared, gray scale and log table RAM's are loaded on the AD/DA and Pipeline Filter PCB's, and communication ports are initialized. The Image Processor PCB then waits for function calls from the Disk Interface PCB, and Front Panel commands.

Front Panel Processor Initialization: The Front Panel Processor initialization consists of clearing all I/O ports to turn off all LEDs. It then begins scanning the keyboard and multiplexing the LEDs. Commands are exchanged with the Disk Interface PCB through a serial data interface.

4.5 Monitor Cart Electronics

4.5.1 Disk Interface PCB

Refer to Figure 4-3 and Schematic 00-870013.

The Disk Interface PCB is a Z80-based board level computer. Its main tasks are to load and execute the disk operating system and applications software from the hard disk and to control image transfers between the hard disk and memory. Data transfers between the hard disk and memory are accomplished via the Disk Controller PCB. Handshaking occurs between the Disk Interface and Disk Controller PCBs to control the data transfer with the hard disk.

The Disk Interface PCB communicates with the Front Panel Processor PCB, with the Image Processor PCB, and with the main frame X-ray Processor PCB via RS 232 serial data links. The Front Panel Processor PCB reads the switch panel and passes the data to the Disk Interface PCB. The Disk Interface PCB then selects the appropriate image processing program segment and sends it to the Image Processor PCB.

CPU

The CPU, U60 is a Z80A. It uses an 8-bit data bus and 16-bit address bus.

The CPU is reset in either of three ways:

1. At power-up, by the charge time of C137 through R20.

2. On manual reset, during tests and adjustment of the system. Closing S1 discharges C137, and allows it to recharge through R20.

3. By the watchdog timer, U75, when its Q7 output goes active (high).

Watchdog Timer

In order to prevent the watchdog timer from resetting the CPU during normal operations, the CPU periodically resets counter U75 via I/O 4 (U77E).

DMA Controller

The direct memory access (DMA) controller, U59, emulates the Z-80 CPU during fast data transfers. Wait requests from the DRAM controller are applied to U80-10 when the controller forces an internal refresh. The DMA can perform memory to memory, and memory to I/O transfers at a rate of up to one megabyte per second.

Multiplexer U67 selects either the wait state or I/O 70 as the chip enable input to the DMA based upon the state of the BUSAK control signal. When the BUSAK output from the Z-80 is low, the output of the wait-state generator (U78C-8) is applied to the DMA controller U59. During DMA accesses, the interrupt line is pulsed periodically by the DMA controller (U59). These are gated through U79C to provide a reset to the watchdog timer, preventing it from timing out. Since the CPU is held in the wait state by the output from U78C, it does not sense the interrupt pulses from the DMA.

Programmable Counter and Baud Rate Generator

Counter timer circuit (CTC) U61 contains three independently programmable counters. The output of counter "0" provides a non-maskable interrupt to the CPU.

Counter "1" provides a software controllable baud rate clock to the auxiliary serial communications port U30. Counter "2" provides a standard baud rate clock (307.2 kHz) to counter U52.

Counter U52 is operated as an 8-bit binary counter. It provides output clock signals for baud rates of 9600, 4800, 2400, 1200, 600, 300, 150, and 75. (The actual clock signal is 16-times the Baud rate.) The outputs of U52 are configured with jumpers so that two separate baud rates can be selected, EE to serial communications port U31, and FF to serial communications port U30.

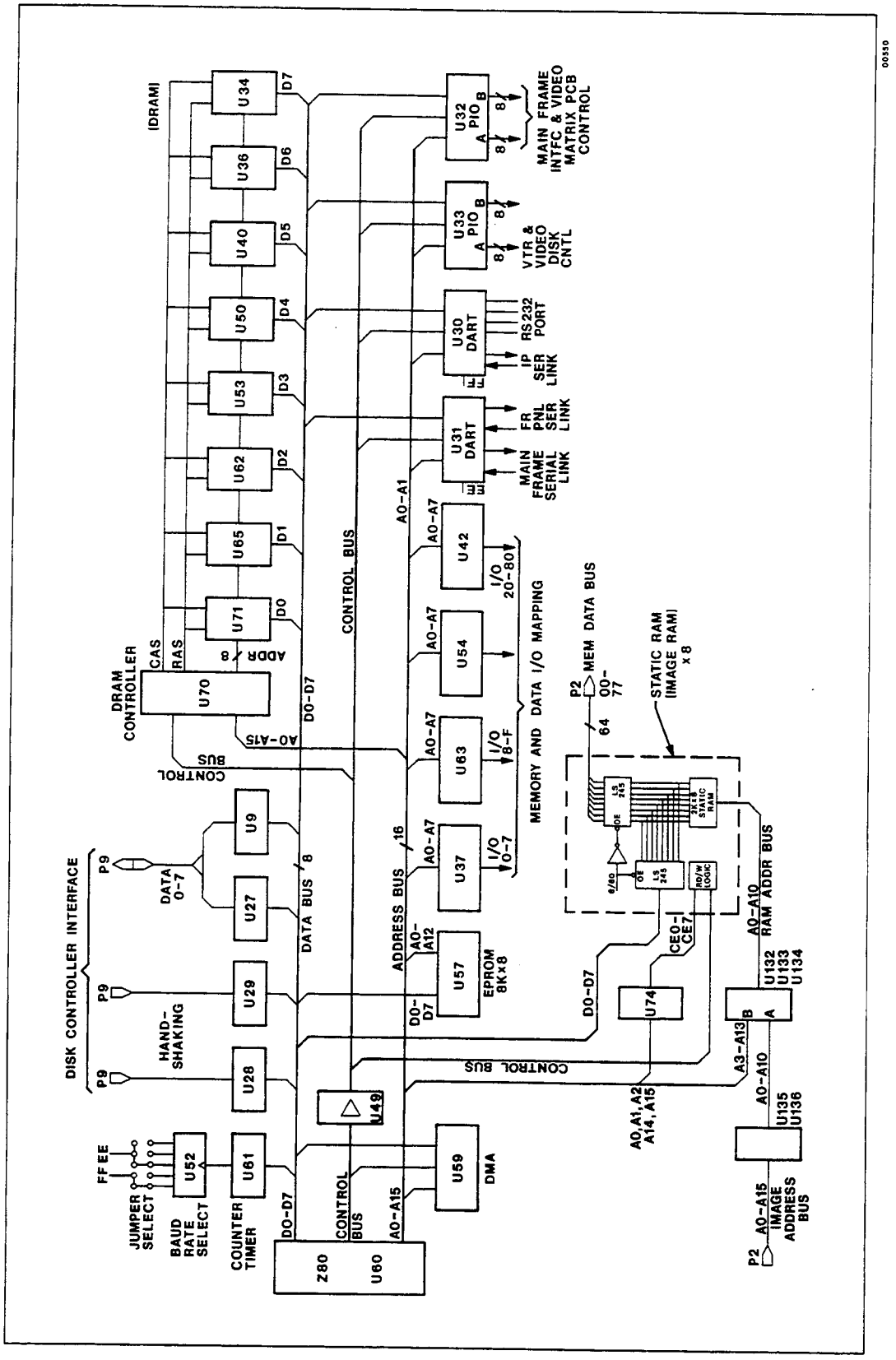
Disk Controller Interface

Communications between the Disk Interface PCB and the Disk Controller PCB is via bi-directional open-collector TTL lines. The open-collector lines are balanced with 220 ohm pull-up resistors to +5V, and 330 ohm pull-down resistors to ground. All control signals between the two devices are active low.

For DMA writes to the Disk Controller PCB, the D0-7 bits on the internal data bus are clocked into U27 by the negative true I/O 2. For DMA reads of data from the Disk Controller PCB, the input DATA 0-7 bits are enabled through buffer U9 by the negative true I/O 3.

The handshake function is provided by flip-flop U1A and gates U12A and U23C. This circuit provides an automatic acknowledge every time the DMA writes a data byte to, or reads a data byte from the Disk Controller PCB.

Figure 4-3 - *Block diagram of the Disk Interface PCB.*



Boot PROM

The boot PROM (U57) occupies memory space from "0" to "1FFF" (HEX), and is controlled by the memory map I/O circuit. The boot PROM contains the program necessary to load the disk operating system from the hard disk into RAM. Execution then jumps to the newly located code in the disk operating system program. The boot PROM is disabled until the next time the system is reset.

Parallel Interface

Parallel interface is provided by two Z80 PIO's, U32 and U33. U32 port A is assigned as the interface for data to and from the mainframe, U32 port B interfaces various functions such as X-RAY ON AND DISABLE/, SWITCH DATA, SWITCH CLOCK, SWITCH LATCH, IM- REQ/, TIMER and VERT INT. Bit 7, VERT INT, is dedicated to the vertical reset which provides a 60 Hz clock to allow the system to synchronize any necessary software functions to the vertical field rate of the imaging system. U33 port A is assigned as a VTR remote control interface. U33 port B is assigned to an auxiliary device output connector and serves as a printer port.

Memory Map

The memory map circuit consists of memory chip enable PROM U39, the flip-flops of U38 and gate U43C. There are three memory spaces on the Disk I/O Interface PCB. The three memory spaces are occupied by:

* 8k x 8 boot PROM
* 16k x 8 image memory, static RAM
* 64k x 8 DRAM

When I/O 6 is asserted true, U38B is set and U39 selects the DRAM for the entire 64k memory space. When I/O 7 is asserted, U38A is set, the 80/8 signal is high and U39 enables the lower 16K memory space as image memory in the 8-bit wide mode, and the remaining memory space is dedicated to the DRAM. In all configurations of the memory map, the DRAM occupies the block of memory address space above that used by either the boot PROM or the image memory.

When the image RAM is not selected, and thus not mapped into the addressable memory, the DRAM is configured in the 64-bit wide mode and is available for data transactions with the image memory data bus.

I/O Decoders

The data and memory mapping I/O signals for the Disk Controller PCB are decoded by PROMs U37, U42, U54, and U63. The I/O decoder PROMs are enabled when the IORQ/ signal is true and the inverted M1/ output of U45D is low; and they are addressed by the A0-7 address bus bits.

Image Memory

Depending on the state of the 80/8 signal, the image memory RAMs are either connected in parallel with the 64-bit wide image memory bus, or connected sequentially with the Z80 data bus.

Memory Control Logic

When the system is in the 80-wide mode, it is reading 64 bits at a time. When in the 8-bit wide mode, 8-bit pixels are read in sequential order. PROM U74 provides chip enable signals based on this system status. In the 80-wide mode CE0-7 are issued simultaneously. In the 8-bit mode, CE0-7 are issued sequentially when memory is being accessed by the Z-80 DMA. Addresses are selected by multiplexers U132/133/134 from the internal address bits A3-A13 and the system image address bits A0-A10.

Image transfer from buffer to system image memory is implemented in hardware. The Z80 determines and preloads a segment number of the image (there are 16 segments in an image). The segment number is held in latch U81 and compared with the image address bus A11-A14. When the two are equal, a high level is asserted at U97-6 (OUT). The OUT signal triggers the circuits for reading or writing an entire segment to the main image-memory.

The Image Processor PCB controls the main image-memory data by providing RAS, CAS, READ ENABLE, WRITE ENABLE, and address control.

DRAM

The 64k x 8 dynamic RAM section consists of the eight 64k x 1 RAMs U34-/36/40/50/53/62/65/71. U70 is a TMS4500A dynamic RAM controller. U70 generates all of the RAS and CAS signals, and multiplexes the A0-15 address bits. It also provides refresh and arbitration logic to the DRAM's.

U70 is enabled or disabled by the memory mapping circuit via U77D and U68B. U70 is clocked by the 8 MHz clock signal so it can generate RAS and CAS pulses with adequate system timing for the DRAMs to be accessed without wait states.

Serial Communications

Serial communications occur via two dual asynchronous receiver /transmitters (DARTs) U30 and U31.

Channel A of U31 is a buffered serial RS-232 port dedicated to two-way communications with the mainframe X-ray Processor PCB. Channel B of U31 is TTL open-collector buffered, serial RS-232 port, dedicated to two-way communications with the Front Panel Processor PCB.

Channel A of U30 is a buffered TTL serial RS-232 port, dedicated to two-way communications with the Image Processor PCB. Channel B of U30 is a buffered serial RS-232 port with selectable baud rate, for two-way communications with an external terminal.

4.5.2 Front Panel Processor Assembly

Refer to Schematic No. 870507 and Figure 4-4.

The Front Panel Processor Assembly consists of the following:

* Front Panel Processor PCB, No 00-870507
* Overlay, Front Panel, SCD No. 00-870481
* LED Display PCB, Schematic No 00-870392

The Front Panel Processor Assembly provides the interface between the touch-sensitive membrane switches of the monitor cart front panel and the Disk Interface PCB. It senses front panel switch closures and reports the results to the Disk Interface PCB, which in turn provides commands to the Front Panel Processor to drive the LED indicators, the two digit numeric display, and the beeper.

Front Panel Processor PCB

Refer to Figure 4-5.

The Front Panel Processor PCB is based on the Z8 microcomputer, U20, a Z8682. The Z8682 data bus is multiplexed with the lower A0-A7 address bits. Demultiplexing of the AD bus is achieved by latch U3.

Processor I/O Ports

Communications between the Front Panel Processor PCB and the Disk Interface PCB takes place over a serial RS-232 link. U20 can be programmed to function as a universal asynchronous receiver/transmitter (UART) for serial RS-232 data by using its built-in I/O ports P3-0 and P3-7. The internal UART baud rate clock is software controlled and is generated by one of two timers that are part of U20.

Clock Generator

The clock signal for U20 is derived from 8 MHz crystal Y1.

Program Storage

Program storage is provided by the 4K x 8 EPROM U13. U12 is an 8 2K RAM.

LEDs and Alphanumeric Display

The LED indicators and the two numeric displays are driven by a time-multiplexed refresh technique. Each LED is associated with a position in an 8 x 8 matrix. The position within the matrix is determined by a row number (R0 - R7) and a column number (C0 - C7). To light a particular LED, both of its associated row and column drivers must be on.

The row driver U10, consists if eight common emitter current sources. The contents of the row register U9 control the row drivers of U10. A high output from U9 turns its associated row driver on; a low output turns its driver off, placing the outputs of U9 in the high Z state. A high applied to U9-1 (OE) also disables the row drivers of U10.

The column drivers of U7 and U5 are open-collector inverting drivers. They are controlled by the outputs of column register U14. A high output from U14 turns its associated column driver on (low impedance to ground); a low outputs turns its driver off.

The outputs from the LED drivers are connected with the LED Display PCB via connectors P27 (column bits C0-C7) and P28 (row bits R0-R7).

If the LED refresh fails, the LEDs are protected by the watchdog timer U4A, which will turn off all of the row drivers, setting the outputs of U9 to the high Z state.

Figure 4-4 - *Block diagram of the Front Panel Assembly.*

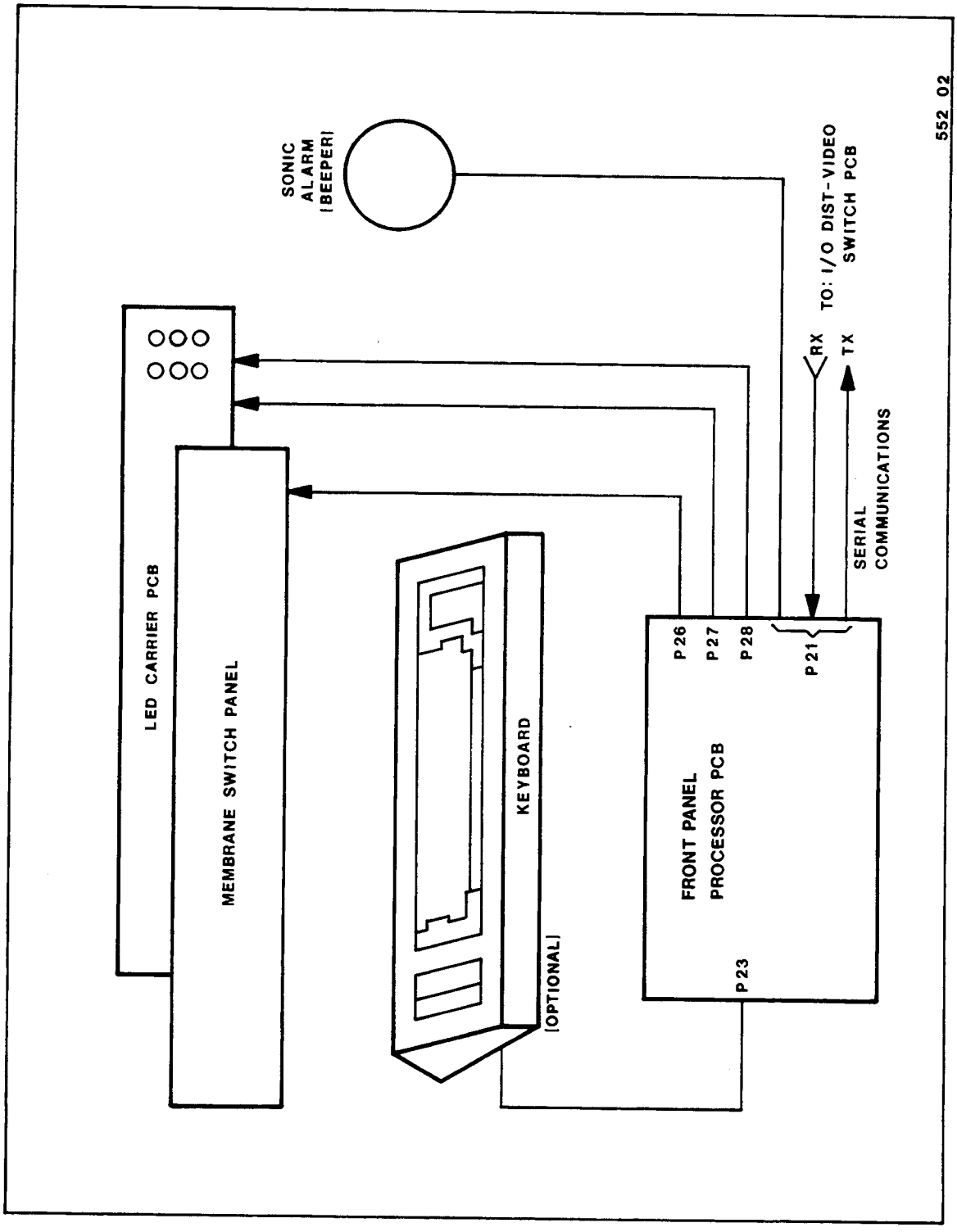
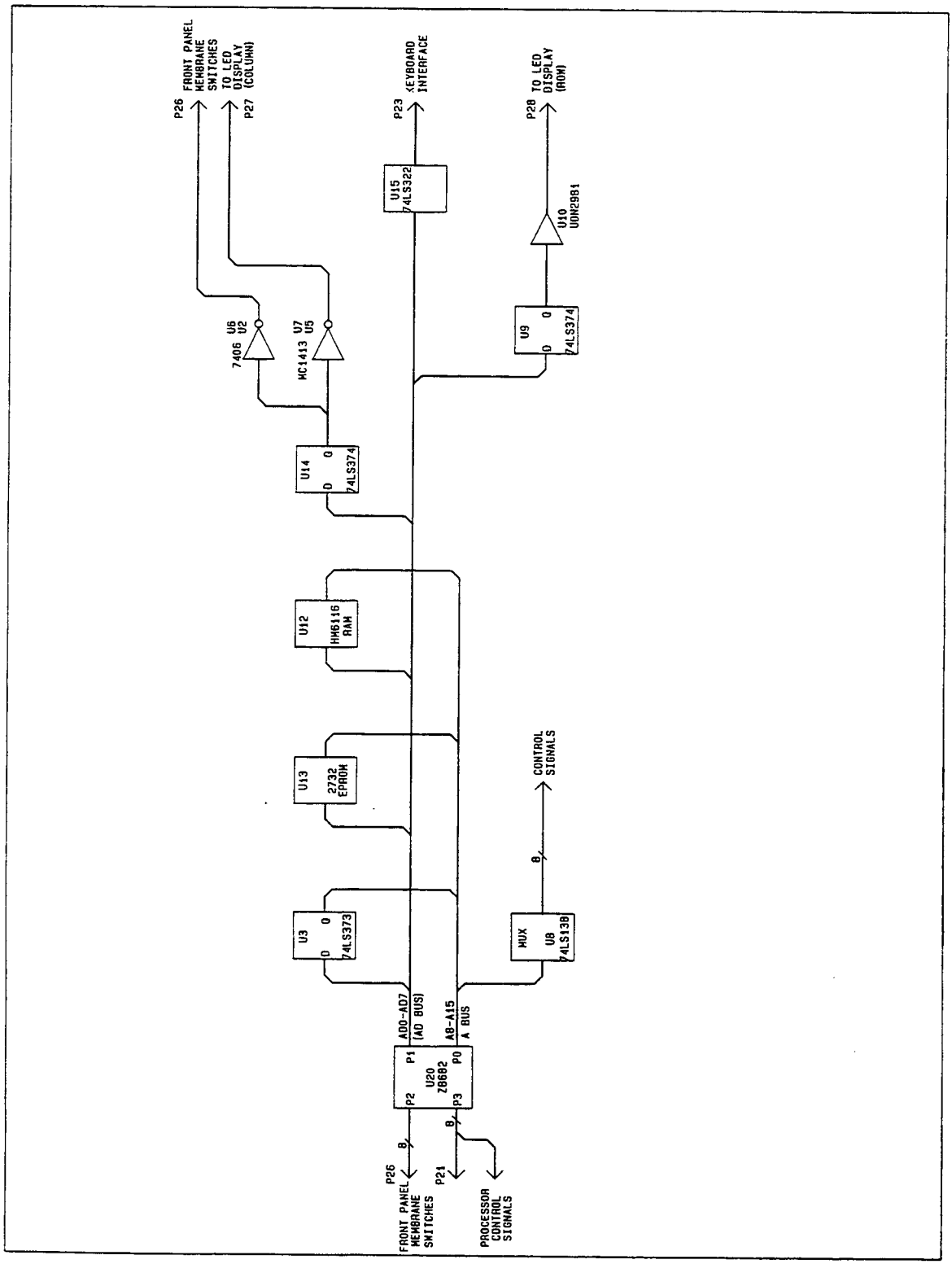


Figure 4-5 - *Block diagram of the Front Panel Processor PCB.*



Beeper (Sonic Alarm) Driver

The beeper is driven by the P3-5 output of U20-10. A high level output at U20-10 turns the driver U5G on, providing a return path to ground for the device.

Front Panel Switch Matrix

The switches on the front panel are arranged in a matrix similar to the LED matrix. Each switch is identified by a row and column number. The switch matrix is scanned using a time-multiplexed technique.

Optional Keyboard Interface

P23 provides a connection for the optional keyboard used for patient annotation. Three signals are required for keyboard operation: KBDATA, KBCLK, and RESET.

4.5.3 Image Processor PCB

Refer to Figures 4-6 and Schematic 00-870388.

The Image Processor PCB is a Z80 based board level computer which controls the operation of the I/O Distribution/Video Switch PCB, AD/DA Converter PCB and Pipeline Filter PCB, and executes data transfers with the 64-bit system memory bus. It communicates with the Disk Interface PCB via an RS-232 serial data link and the system control bus. The image processing program-segment is received from the Disk Interface PCB via the serial link.

Reset

The CPU can be reset by the EXT RESET/ signal. A low level is applied to the RESET input of the CPU, U80.

Data Bus

The Image Processor PCB has two internal data buses: a bidirectional data bus (to/from the CPU) identified by D0-D7 and a uni-directional bus (from the CPU) identified by DB0-DB7.

The D0-D7 internal bus interfaces data with the PROM, the Serial Timer and Interrupt Controller, and the RAMs. The 8-bit internal data bus is interfaced with the 64 bit memory data bus by latches U100 - U107 and U110 - U117.

The unidirectional internal data bus (BD0-BD7) is interfaced with the bidirectional data bus through 8-bit buffer U109. The data on the BD0-BD7 internal bus is applied directly to the system control bus through pins 1-8 of connector P3, the daisy-chained ribbon cable. The system control data bus is used to write log-RAM and processing control data to registers on the Pipeline Filter PCB. Grayscale-RAM data is also written to the AD/DA PCB from the Image Processor PCB.

Memory Data Bus

The 64-bit wide image-memory bus is read and written to by latches U110-U117 and U100-U107. The read and write data transfers between the latches and the memory data bus are controlled by the RMD (read memory data) and EMD (enable memory data) signals. The sequential transfer of data in 8-bit bytes between the latches and the internal data buses D0-D7 and DB0-DB7 is determined by the sequence of the OUT 00-07 and IN 00-07 signals from the I/O port decoders.

Memory Addressing

Latches U95 and U96 multiplex the 8-bit BD data bus onto the 16-bit memory address bus. U95 and U96 are also used to initialize the address counters U84, U85, U88, and U89.

Edge Enhancement Pixel Shift

Address counters may be initialized with an offset count which produces a line shift in the vertical image axis. This is used by the edge enhancement algorithm when combined with the horizontal axis shifting performed on the Pipeline Filter PCB.

PROMS

Programming on the Image Processor PCB resides in the PROM U50 (2764). This PROM based software directs much of the image processing on the Pipeline Filter PCB.

RAM

The Image Processor PCB has three 2K X 8 static RAMs, U31, U32, U51. These RAMs serve as a scratch pad memory for the CPU.

Serial Timer and Interrupt Controller

U73 provides a serial RS-232 data link with the Disk Interface PCB and the Front Panel Processor PCB. Data received over this link includes function calls from the Disk Interface PCB and scan codes from the Front Panel.

Memory Control Logic

The memory control logic is synchronized to the video rates by composite blanking (C BLANK, H-rate) and vertical drive (VR DRV, V-rate).

Video Sync Generator

Refer to Figure 4-7 and Schematic 00-870388.

The 82 MHz clock signal produced by VCO U5 is applied to a binary divider which provides three outputs: 10.25 MHz (PC1), 5.125 MHz (PC2), and 2.58 MHz. The 2.58 MHz signal is applied as the clock input to TV sync generator U8 which in turn provides five TV signal outputs: C SYNC, C BLANK, HR DRV, VR DRV, and an even field signal E FLD. These signals are synchronized with the incoming video signal through the phase comparator circuit U3, Q2 and U4. Adjustment of C6 changes the frequency of the VCO until the incoming video rate and the U8 video rate are in phase.

Figure 4-6 - *Block diagram of the Image Processor PCB.*

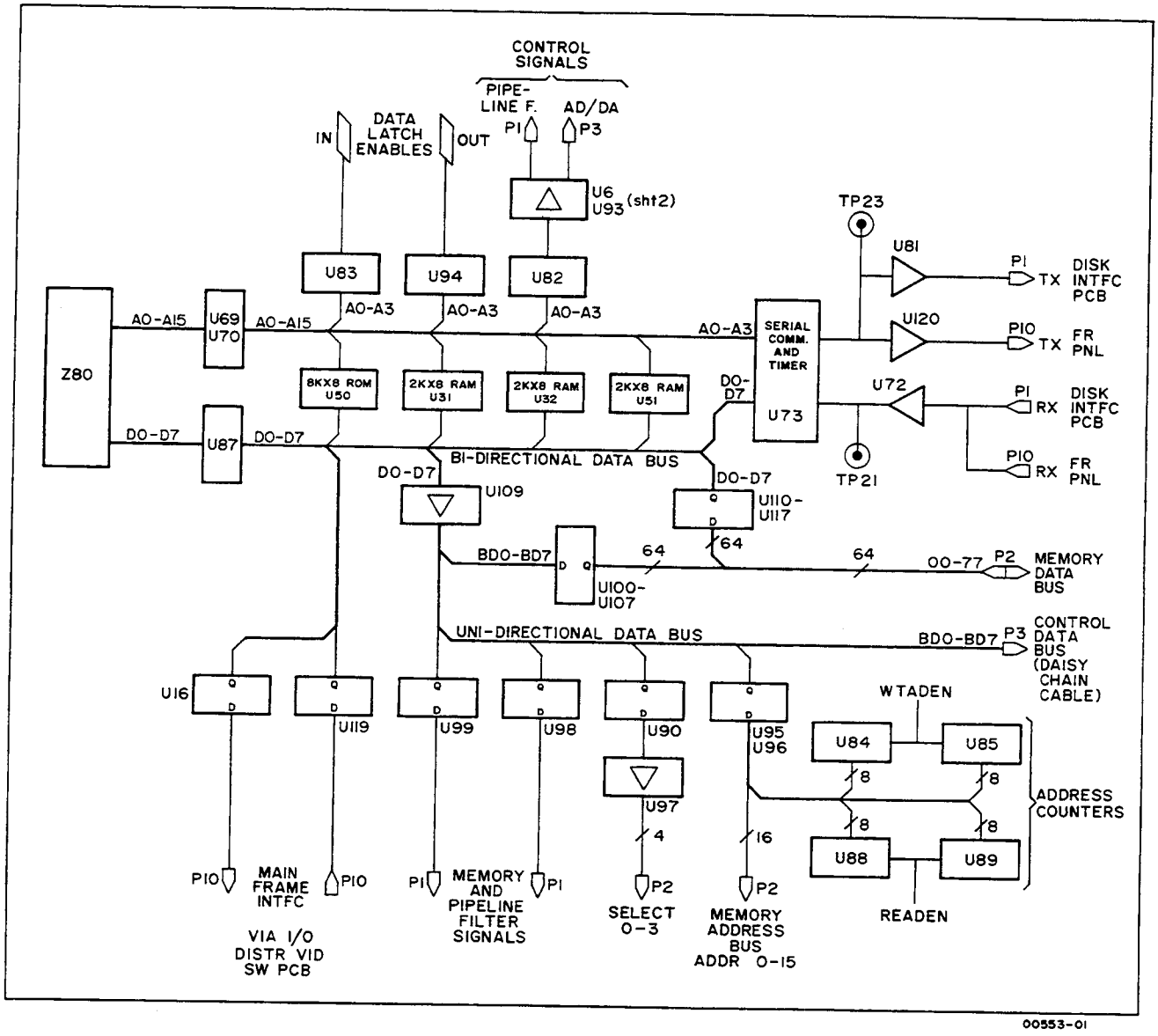
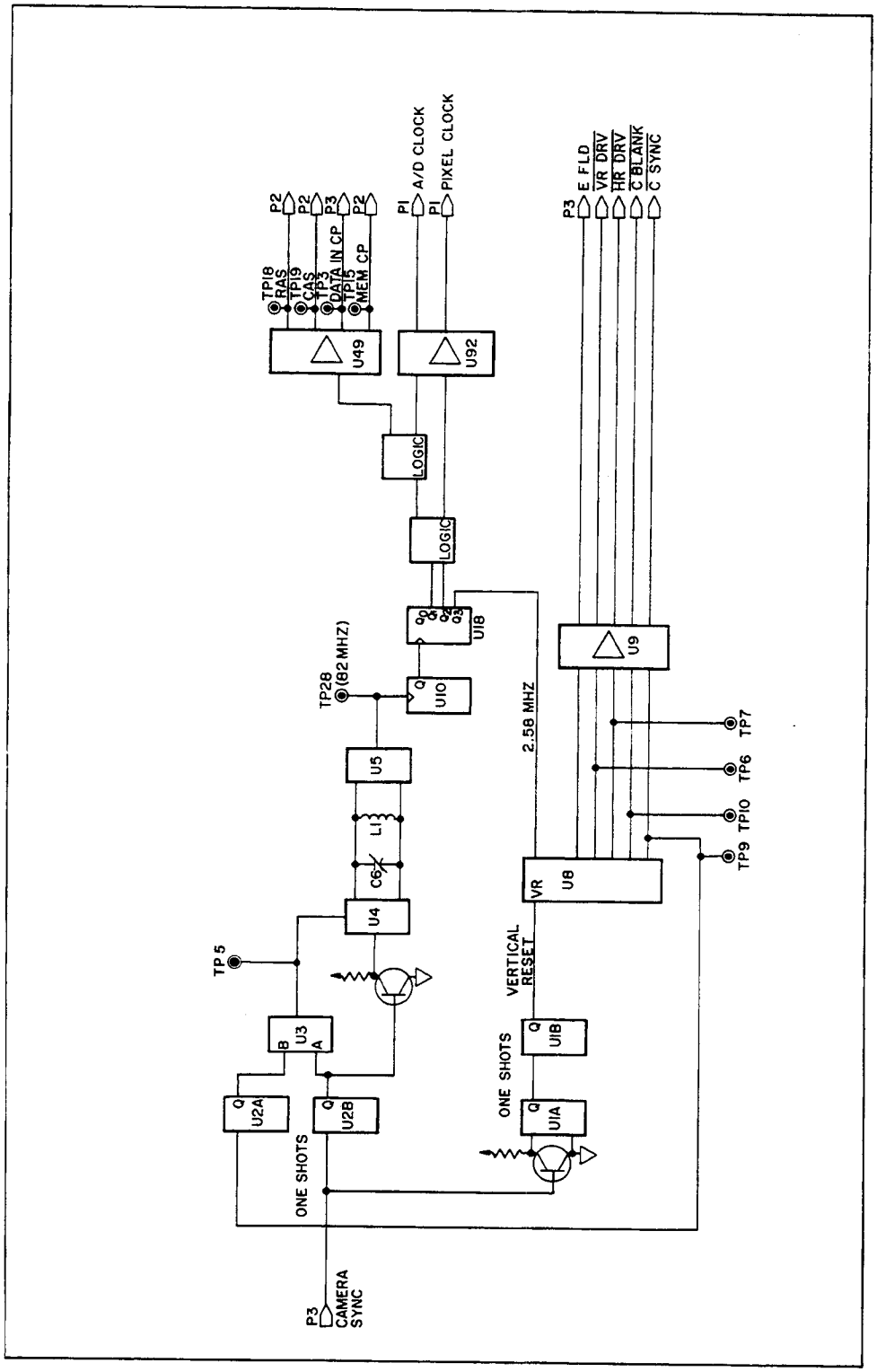


Figure 4-7 - *Block diagram of the Image Processor PCB, Video Sync Circuit.*



4.5.4 I/O Distribution/Video Switch PCB

Refer to Figure 4-8 and Schematic 00-870185.

The I/O Distribution/Video Switch PCB contains five primary circuits:

* Voltage Regulator Circuit
* Connector Interface Circuit
* Control Word Serial-to-Parallel Shift Register
* Video Switching Relay Matrix Circuit
* Video Buffer/Driver Circuit.

Voltage Regulator

Potentiometer R24 is adjusted so that the output of VR1 (TP19) provides +12 VDC at the input connector to the hard disk drive assembly.

Other DC inputs on the PCB are: +5 VDC, -5 VDC, -15 VDC, and the switched +5 VDC which is applied to the switching relays.

Connector Interface

The connector interface allows routing a number of mainframe control signals to the Disk Interface PCB where they are used to coordinate image processing with X-ray exposures.

Control Word Shift Register

U7 through U10 comprise a 16-bit serial-to-parallel shift register for the switching relay matrix control word. The word is latched at the outputs of U7 and U8 as a 16-bit wide parallel word and is applied to inverting buffers U1-U4. Each inverter output drives an associated video switching relay. Note that some of the relays are normally open and some are normally closed.

Switching Relay Matrix

Note: Only the following relays are installed:

K1, K4, K7, K8, K10, K15, K16, K18, K19, K20, K24, K25, K28, K30, K31.

There are five possible video sources in the imaging system:

* Camera (live video)
* Left D/A channel
* Right D/A channel
* VTR option
* AngioStor option

There are six possible video destinations:

* A/D converter (for digital processing)
* left monitor
* right monitor
* VTR
* AngioStor
* VIDEO OUT 1 and 2, BNC connectors on the monitor cart rear panel.

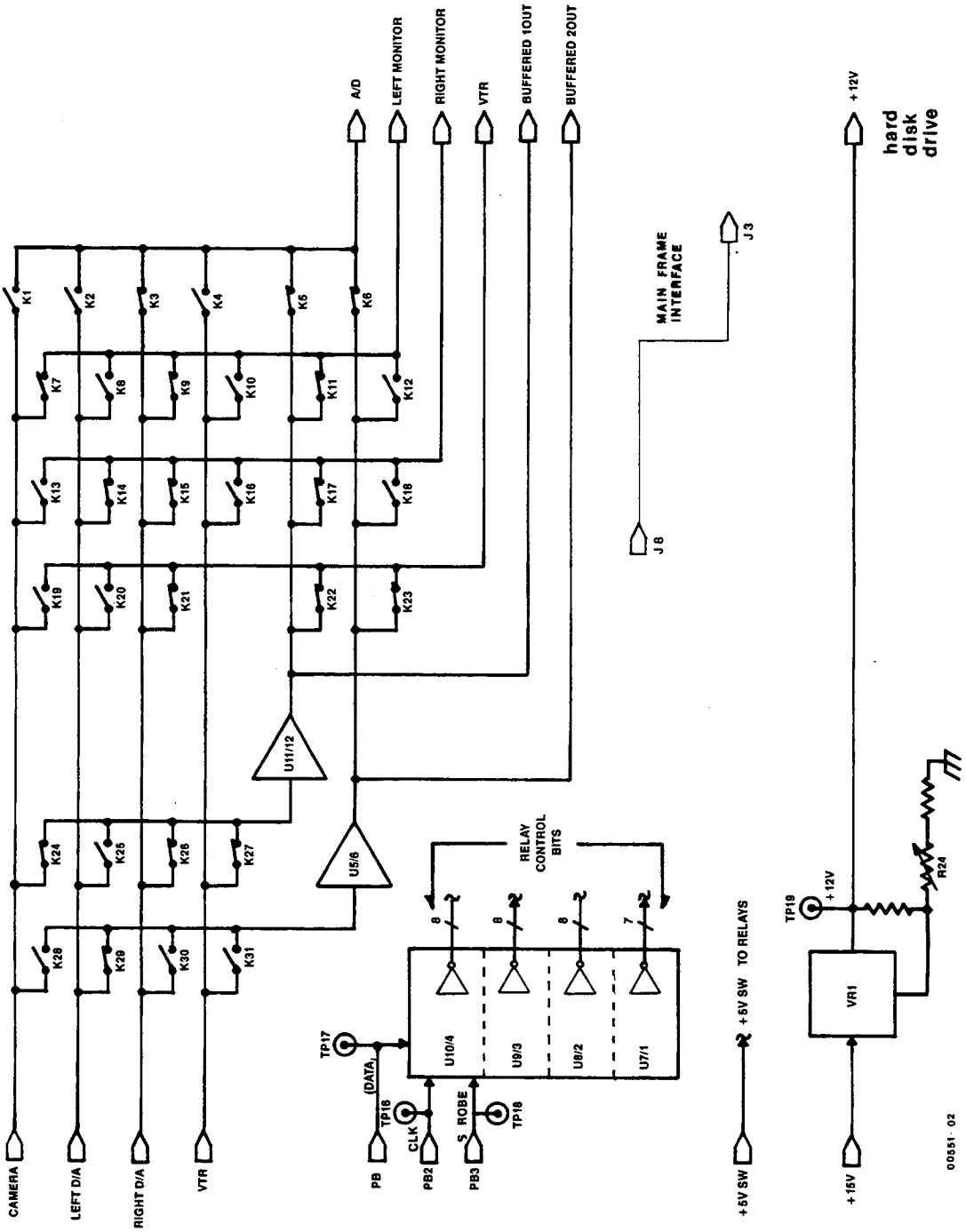
Note that the camera (live) video output is applied directly to the input of the AD/DA Converter PCB, but to the VTR through a buffer. This circuit configuration prevents double termination of the camera video output. The software control of the relays prevents undesirable double termination of any of the video sources. The video output of the VTR can be selected through K4 and applied to the analog input of the AD/DA Converter PCB and processed in the same manner as the camera video.

AngioStor Interface

Refer to Schematic 00-870543.

Additional video buffering and sync circuitry for the AngioStor disk recorder is provided by the piggy-back PCB installed on the right side of the I/O Distribution-Video Switching PCB. Refer to the *Options* section of this manual.

Figure 4-8 - *Block diagram of the I/O Distribution Video Switch PCB.*



4.5.5 AD/DA Converter PCB

Refer to Figures 4-9, 4-10 and Schematic 00-860896.

The AD/DA Converter PCB contains circuits that perform the following functions:

1. Conversion of the incoming composite video from the I/O Distribution/Video Switch PCB to digital data which is then available to the Pipeline Filter PCB on the 64 bit wide A/D bus.
2. Generation of a circular blanking window.
3. Subtraction of two separate images (D/A OUT 1 and D/A OUT 2, from the Pipeline Filter PCB) from each other.
4. Detection and removal of the sync pulses from incoming video signal.
5. Gray scale correction of the digital data output from the Pipeline Filter PCB.
6. Conversion of the digital image-data from the Pipeline Filter PCB into a composite analog video signal which is routed through the I/O Distribution/Video Switch PCB for display on the TV monitors.

A/D Conversion

The incoming video signal is AC coupled to buffer Q2. The Q2 output is applied to comparator U19 which is biased to strip the inverted sync signal. The video signal is amplified by U18, and a porch is added by clamping the output to ground before the C-SYNC pulse. The clamped video signal is buffered through U33 and applied to the analog input of A/D converter U32 and also to analog mux U24 for raw display.

The analog input to U32 is converted into 8 bit data words at the 10 mHz clock rate of the A/D CLOCK signal and is applied to 8-bit tri-state buffer U54. The outputs of U54 are enabled only during the video window of the circular blanking signal (CIRC BLANK/).

Circular Blanking

U28a and U29a produce a ramping voltage, reset at the CSYNC rate, which is applied through U73a to the input of multiplier U34. Similarly, U29b and U28b produce a ramp, reset at the vertical rate, which is applied through U73b to the input of multiplier U35.

The outputs of U34 and U35 are parabolas which are then applied to the summing node of U36. The result, at the output of U36, is the circular blanking signal (CIRC BLANK/) used to control the size of the video window.

A/D Clock and Data Latches

The AD PIXEL MR signal clears 8-bit flip flop U52. When U52 is enabled, it generates eight separate A/D clock signals. The sequential outputs from U52 convert the digital video data from U32, and the digital blanking data from U72, into the eight 8-bit parallel channels for transfer to the 64-bit video data bus.

Data Bus Interface

Data on the system data bus is buffered through U16 and applied to the internal data bus. Control and clock signals are buffered through U7. The gray scale data is clocked into latch U15 by the GRAY DATA LCH signal. The gray scale address data is clocked into latch U17 by the ADDA CONT LCH. The blanking level data (for the area outside of circular blanking) is clocked into latch U72 by the BLNK LEVEL SET clock signal.

Digital Image Subtraction

D/A DATA 1 processed digital image data is clocked into latches U50, U56 and U70 by the D/A clock signal. D/A DATA 2 is clocked into latches U49, U50, and U68. The two data channels may be subtracted by the ALU U51, U57. The output of the ALU is applied to the left monitor processing channel.

Gray Scale RAMS

Each monitor channel has a dedicated 256 x 8 gray scale RAM: U26, U30 for the left monitor, and U39, U46 for the right. The gray scale RAMs contain a 256-value gray scale table which performs the WINDOW, LEVEL, and NEGATE mapping functions on the digitized video. Gray scale data is addressed by the image data.

Left D/A Channel

The digital output from U26, U30 (gray scale data addressed by image data) is applied to the digital input of D/A converter U25 and clocked by the D/A CLK signal. Delayed composite blanking (DLY C BLNK) is applied to the disable input of U25 which sets the level of the analog output during blanking. The resultant video signal is buffered through U10 which provides a source terminated composite video output.

Right D/A Channel

The digital output from U39, U46 (gray scale data addressed by image data) is applied to the digital input of D/A converter U38 and clocked by the D/A CLK signal. Delayed composite blanking (DLY C BLNK) is applied to the disable input of U38 which sets the level of the analog output during blanking. The resultant video signal is buffered through U8 which provides a source terminated composite video output.

Figure 4-9 - *Block diagram of the AD/DA Converter PCB, A/D circuits.*

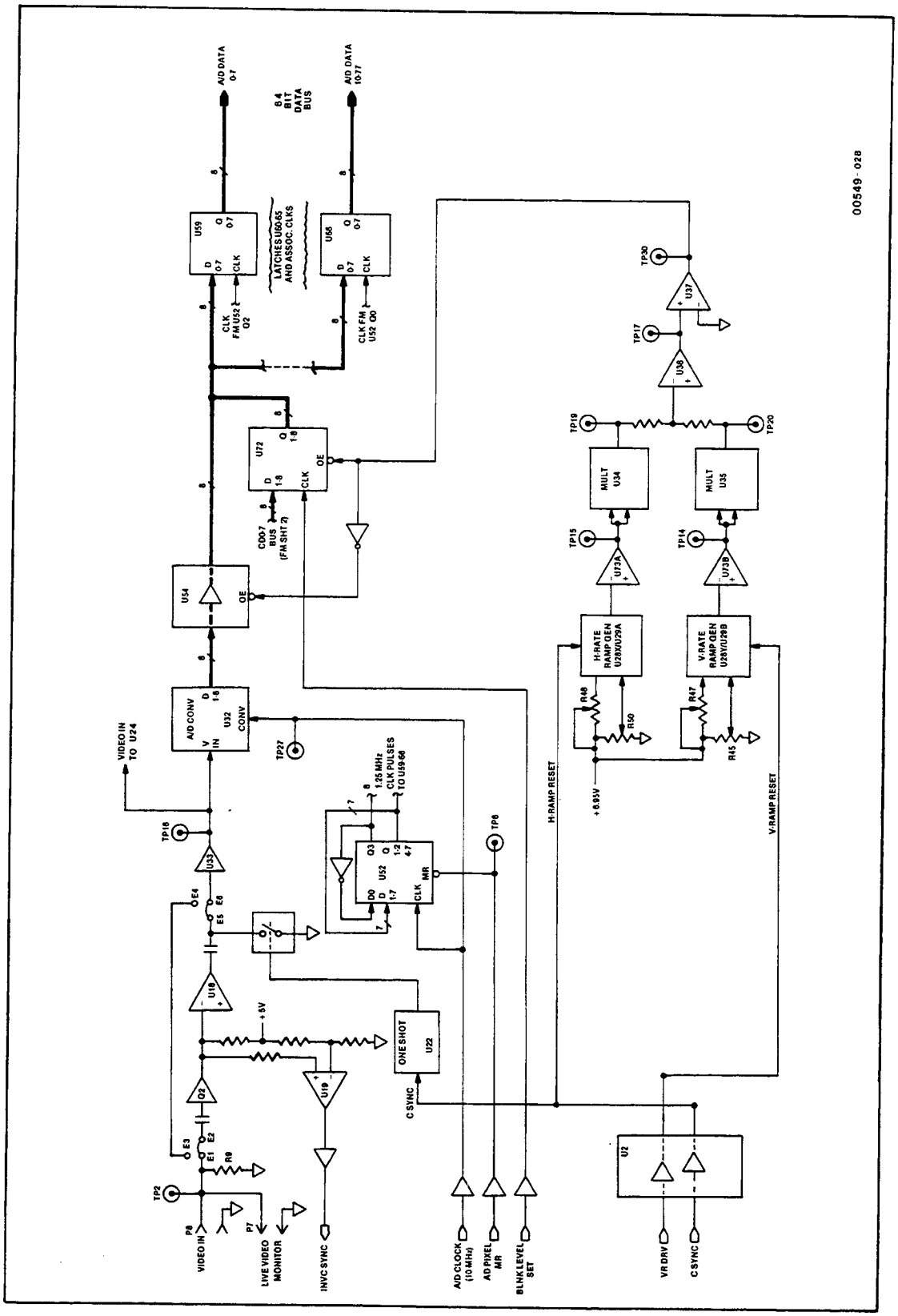
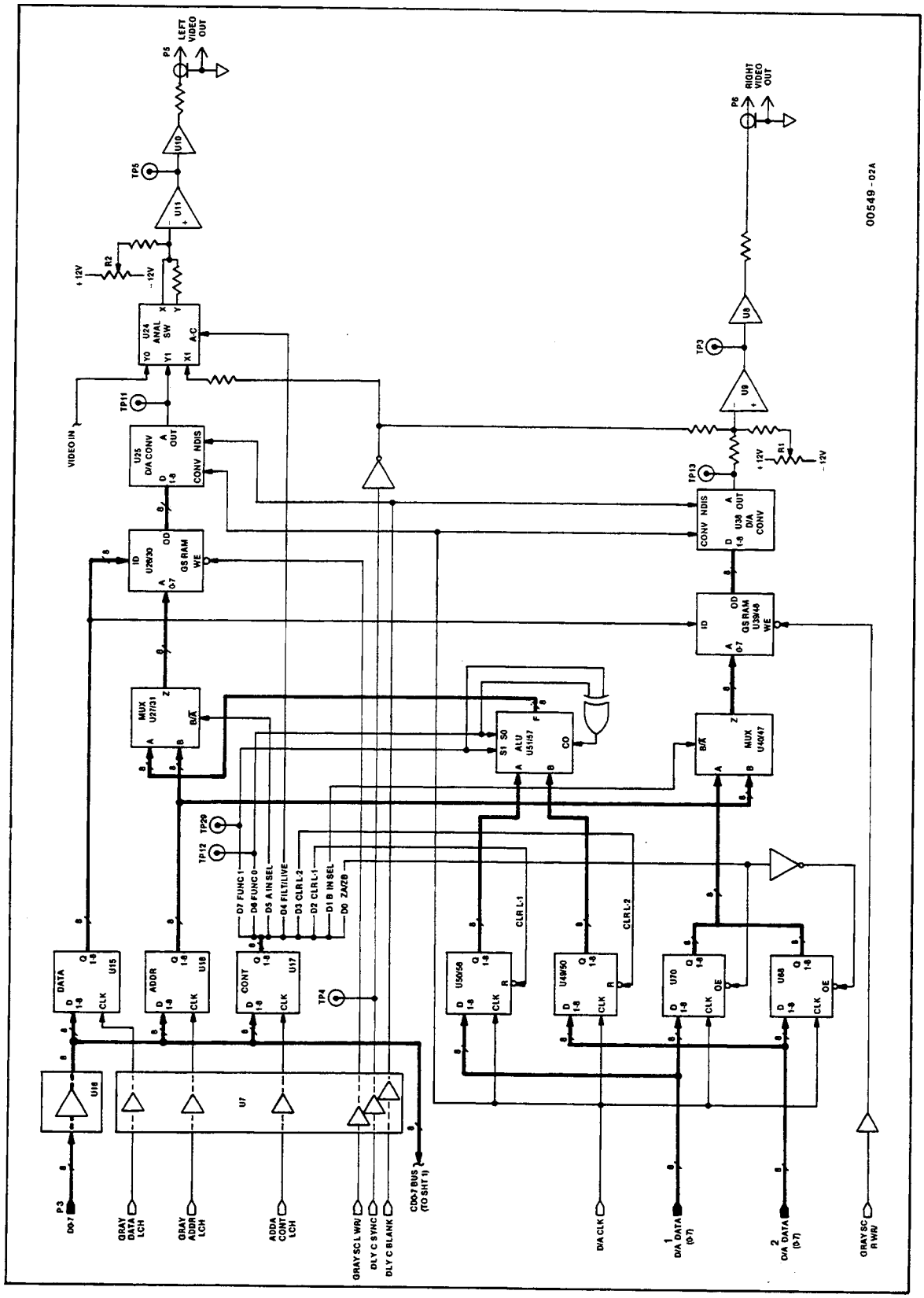


Figure 4-10 - *Block diagram of the AD/DA Converter PCB, D/A circuits.*



4.5.6 Pipeline Filter PCB

Circuit Functions

Refer to Figure 4-11 and Schematic 00-870501.

Referring to the block diagram, the hardware on the Pipeline Filter PCB may be divided into five functional areas:

The Filter Circuit - consists of the adder/subtractors, shifters, and assorted registers and selectors that control the data flow in the top half of the block diagram. The filter is used for averaging, opacification, edge sharpening, motion artifact reduction, and integration. The output of the filter is channeled through a log-table RAM, into either of the frame memories, and out to the AD/DA PCB to be displayed as an image. The log-RAMs are updated during the vertical interval.

The Buffer - consists of the selectors, adder/subtractors, shifters and latches that control the data flow on the lower half of the block diagram. Normally the Buffer simply passes a saved image to the AD/DA PCB to be displayed. However the Buffer can be used for live-digitizing, integration, and single frame subtraction processing.

Memory 1 - holds two frames of data. Incoming data can come from either the filter or the buffer. The memory bus connects with the Disk Interface and Image Processor PCB's. The memory output bus is also connected to the buffer inputs.

Memory 2 - Holds two frames of data. Incoming data can come from either the filter or the buffer. The memory 2 output bus is connected back to the filter circuit inputs.

Control Signals - Control timing and functions of the filter, buffer, and memories.

Pipeline Filter Buses

The following data busses can be identified in the block diagram.

R0 - R7: Filtered, integrated, shifted, or live data that is input to the log-RAMs.

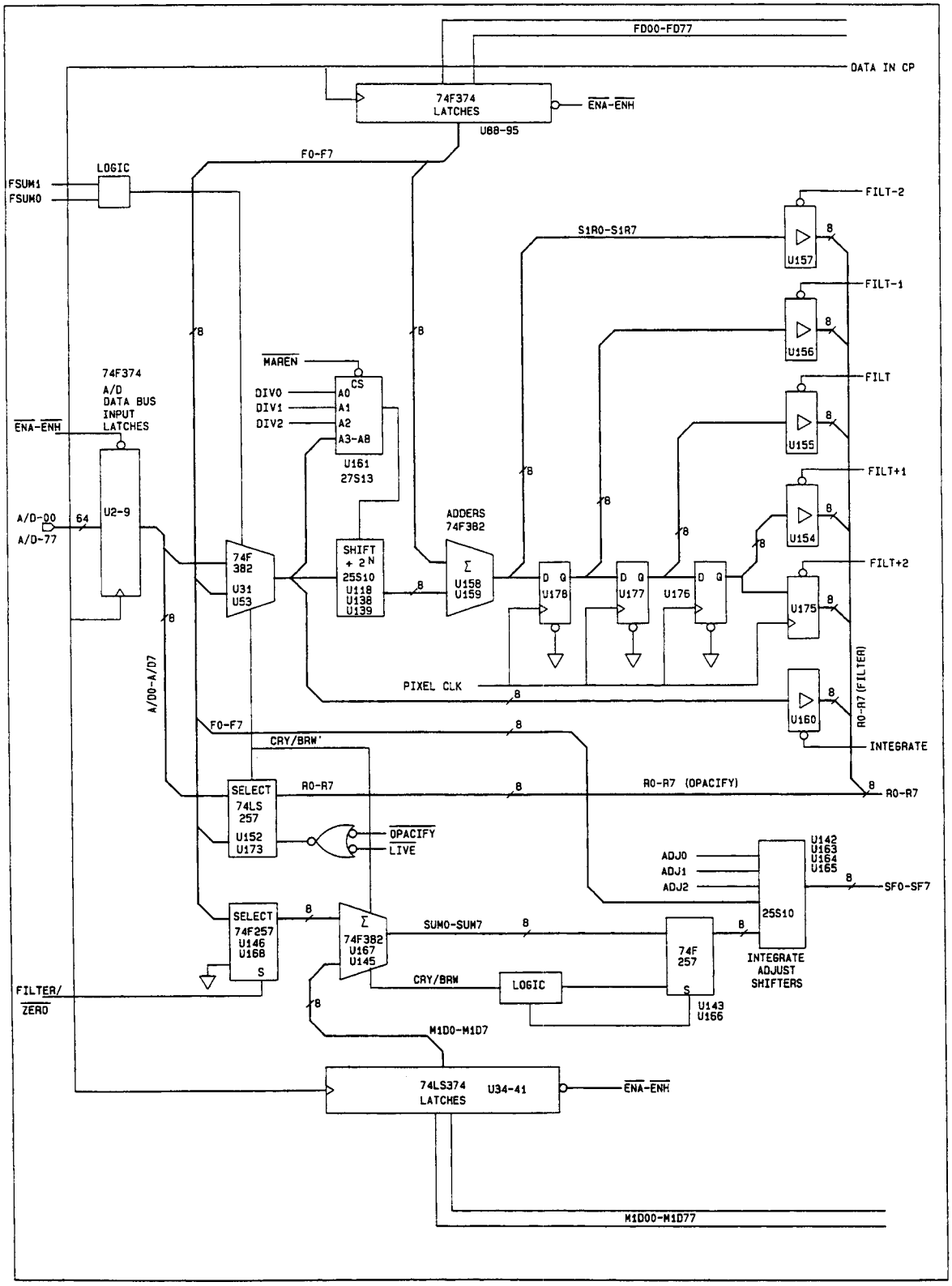
S1R0 - S1R7: The sum of M2 data (F0-F7) and shifted or subtracted A/D data. Used to implement normal averaging.

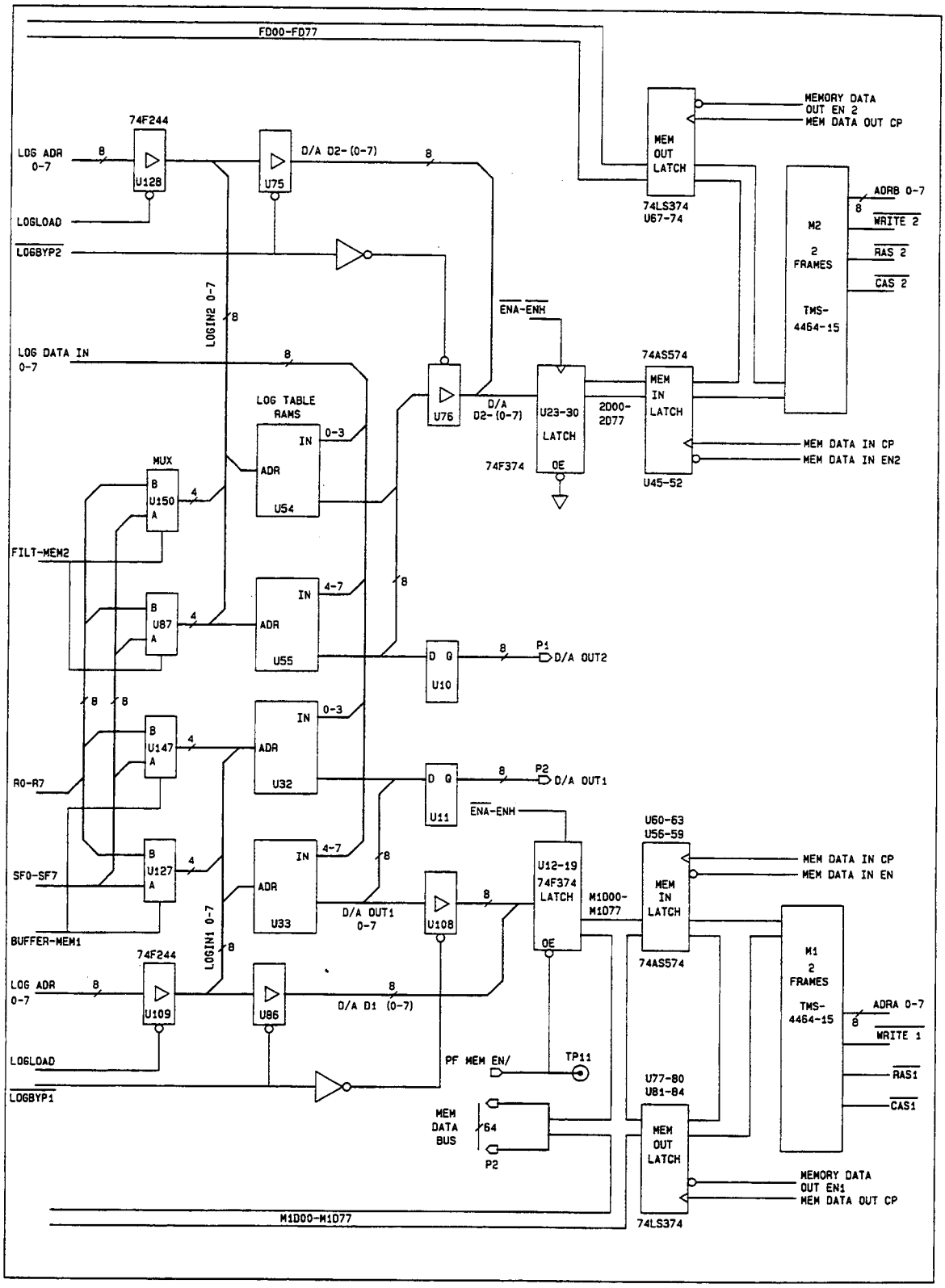
F0 - F7: Data bus from M2, demultiplexed to sequentially transmit the 64-bit bus as eight 8-bit bytes.

SF0 - SF7: Output from integration adjust shifters.

A/D0 - A/D7: Demultiplexed A/D data from AD/DA PCB.

Figure 4-11 - *Block diagram of the Pipeline Filter PCB (two pages).*




FD00-FD77
74F244
LOG ADR 0-7
8
U128
LOGLOAD
LOGBYP2
U75
D/A D2-(0-7)
8
MEM OUT LATCH
74LS374 U67-74
MEMORY DATA OUT EN 2
MEM DATA OUT CP
M2 2 FRAMES TMS-4464-15
ADRB 0-7
8
WRITE 2
RAS 2
CAS 2
LOGIN2 0-7
8
ENA-ENH
LOG DATA IN 0-7
8
LOG TABLE RAMS
U76
D/A D2-(0-7)
U23-30 LATCH
74F374
OE
2D00-2D77
74AS574
MEM IN LATCH
U45-52
MEM DATA IN CP
MEM DATA IN EN2
MUX
B
U150
A
4
IN
ADR
U54
0-3
FILT-MEM2
B
U87
A
4
IN
ADR
U55
4-7
8
D Q
U10
8
P1
D/A OUT2
8
8
B
U147
A
4
IN
ADR
U32
0-3
D Q
U11
8
P2
D/A OUT1
R0-R7
ENA-ENH
B
U127
A
4
IN
ADR
U33
4-7
8
D/A OUT1 0-7
U108
8
U12-19 74F374 LATCH
OE
M1D00-M1D77
U60-63
U56-59
MEM IN LATCH
74AS574
MEM DATA IN CP
MEM DATA IN EN
SF0-SF7
BUFFER-MEM1
LOGIN1 0-7
8
74F244
LOG ADR 0-7
8
U109
U86
8
D/A D1 (0-7)
M1 2 FRAMES TMS-4464-15
ADRA 0-7
8
WRITE 1
RAS1
CAS1
LOGLOAD
LOGBYP1
PF MEM EN/
TP11
U77-80
U81-84
MEM OUT LATCH
74LS374
MEM DATA BUS
64
P2
MEMORY DATA OUT EN1
MEM DATA OUT CP
M1D00-M1D77

M1D0 - M1D7: Data bus from M1. demultiplexed to sequentially transmit the 64-bit bus as eight 8-bit bytes.

D/A D1-0 - D/A D1-7: Output from log-RAMs or output obtained bypassing log-RAMS. Will be multiplexed onto 64-bit M1 data bus.

D/A D2-0 - D/A D2-7: Output from log-RAMs or output obtained bypassing log-RAMS. Will be multiplexed onto 64-bit M1 data bus.

Overall Operation

The Pipeline Filter latches a 64-bit wide data path (A/D00-A/D77) originating from the AD/DA PCB. This is read from the latches in 8-bit wide pixel bytes to be processed sequentially, as if on a pipeline. The 64-bit words are clocked into latches U2 through U9 by DATA IN CP. 8-bit pixel bytes are enabled onto the internal A/D0-A/D7 bus by ENA - ENH.

Data transfers between the 8-bit and 64- bit buses are controlled throughout the board by the DATA IN CP and the eight enable signals: ENA-ENH. ENA-ENH are derived from the pixel clock and the DATA IN CP by counter U153 and mux U1.

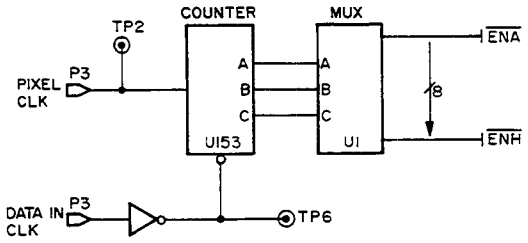
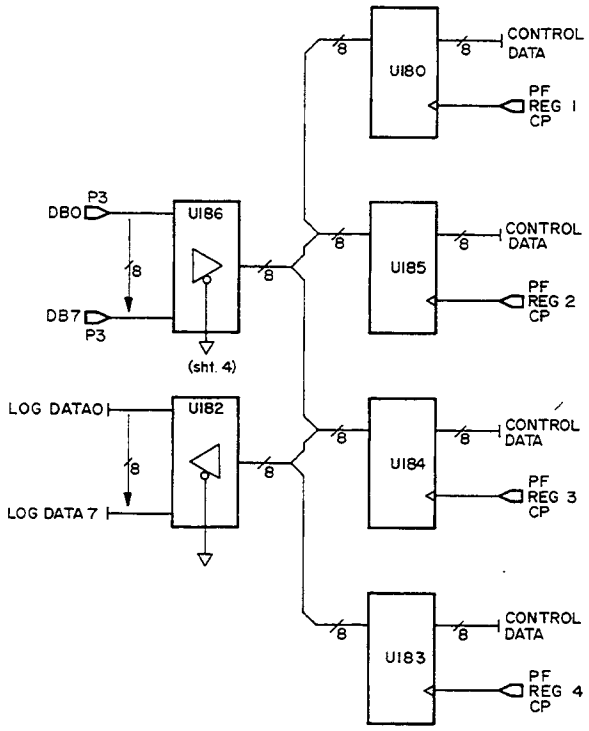


Figure 4-12 - *Decoding the eight enable signals, ENA-ENH.*

Processing command words are received from the Image Processor PCB via the daisy chained ribbon cable at P3. These are addressed to four control data registers PF REG 1-4. Log Data LOG DATA 0-7 (for the Gamma function) is also received from the Image Processor PCB and loaded into the log-RAMS.

Figure 4-13 - *The four control data registers, PF REG 1- PF REG 4.*



Memory control signals, the pixel clock, and DATA IN CP are generated on the Image Processor PCB. They are transmitted to the Filter PCB via P3, the daisy-chain ribbon cable connector.

After processing, the data is again clocked onto a 64 bit wide bus before being stored in memory or placed on the system image-data bus.

But the pixel data is passed in 8-bit bytes to the AD/DA via P1 (D/A OUT2) and P2 (D/A OUT1).

Memory consists of dynamic RAM TMS-4464 (4-bit x 64 k), in two separate banks of 16 each. ADRA0-ADRA7 is multiplexed with the RAS and CAS signals to address memory 1. ADRB0-ADRB7 is multiplexed with RAS and CAS to address memory 2.

Figure 4-14 - *Addressing memories 1 and 2.*

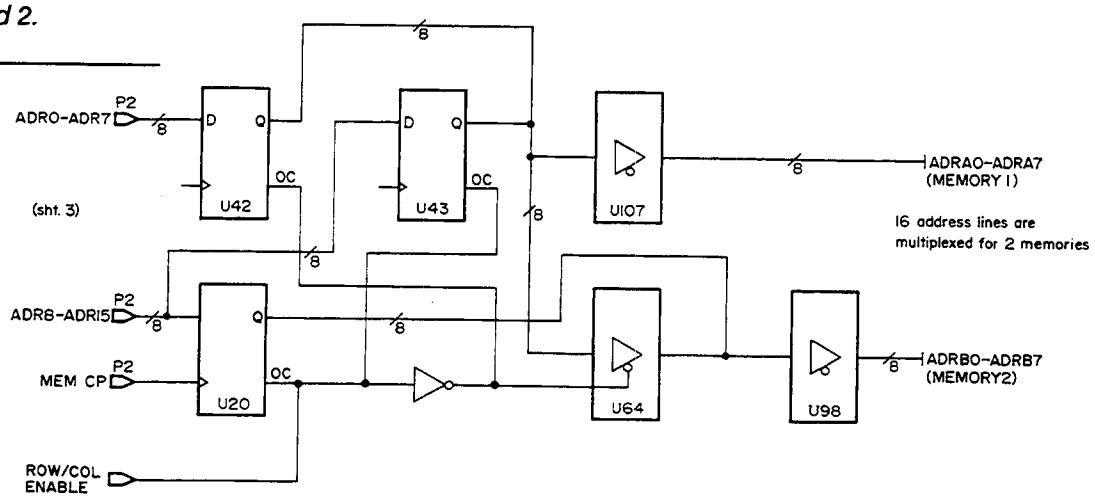


Image Processing Functions

Under software control the image data is routed through the circuits described above to provide the following:

Live Digitized Output — A/D0-A/D7 is selected by U152/U173. The pixel data is passed to the log RAMs for application of any selected gamma function, and then is output at P1, D/A OUT 2.

Stored Image Output from M1 and M2 — Memory contents are routed via the internal buses through the log RAMs. Memory 1 appears on D/A OUT1, Memory 2 appears on D/A OUT1.

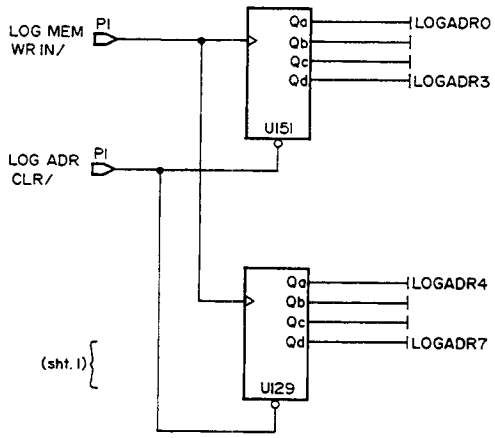
Frame Averaging — An algorithm is performed in which incoming pixel data is combined with the running average for that pixel. The subtraction algorithm D-M(t)/N + M(t) is performed as follows, where D= D/A data, M(t) = old memory value, M(t+1) is the new memory value, and N is the number of frames averaged.

Memory Swap — Image transfer between memories, M1 to M2 or M2 to M1, bypasses the log RAMs. The bypass control lines LOGBYP2 and LOGBYP1 are active. LOGBYP2 enables U75 to buffer the data onto the D/A D2 bus where it is latched onto the 64-bit bus 2D00-2D77 and into M2. LOGBYP1 enables U86 to buffer the data onto D/A D1 where it is latched onto the 64-bit bus M1D00-M1D77.

Gamma — The log RAMS on the Pipeline Filter PCB are loaded with a table from the Image Processor PCB according to which the image pixel values are mapped to an exponential gray scale.

LOG ADR 0-7 are generated by address counters U151 and U129.

Figure 4-15 - *Log RAM address counters.*



Motion Artifact Reduction

When the difference between the incoming and previous images is large, there is an adjustment of the averaging algorithm divisor. MARS is enabled by setting MAREN/ low.

Opacification

The incoming pixel value is compared against the previous value for that pixel in the image. The darker value of the two is kept. When (AD0-AD7) is greater than (F0-F7), summer U31,U53 generates a carry/borrow signal. This selects the source of the pixel placed on the R0-R7 bus by selector U152, U173.

Integration

Allows an average to be computed over a predetermined number of image frames. Result of addition step is a 16-bit word, overflow occurs into the upper eight bits. Last step is a division performed by right justifying into the upper byte.

Single Frame Subtraction

This subtraction is performed on the Pipeline Filter PCB alone. M2-M1 or M1-M2. Subtraction from both memories occurs a byte at a time by Adders U145 and U167. The result is placed on the SUM0-SUM7 bus and routed back into memory.

Edge Enhancement

This requires executing an algorithm which shifts the image a certain number of pixels in the X axis and a number of lines in the Y axis, and adds the original pixels with those at the shifted position. The Y shift is determined by changing the beginning storage address generated by the address counters on the Image Processor PCB. The X shift is produced with delay flip flops (U175-U178). which are selected by the FILT/ controls. FILT select lines are generated by 3 to 8 line decoder U179 which multiplexes control data latched from the Image Processor DB 0-7 control bus.

4.5.7 TV Monitors

The two TV monitors are designed especially for medical diagnostic applications. These provide:

* 75 ohm terminated input impedance
* RS170 standard negative sync
* Composite input video range of 0.3 to 2.5 volts p-p;
* Bandwidth in excess of 15 MHz at -3 dB
* Full genlock synchronization (vertical and horizontal).

4.5.8 Remote Contrast/Brightness Control PCB

Refer to Schematic 00-870928.

This PCB is located below the left monitor and allows the left monitor to be adjusted from either the mainframe or the monitor cart.

4.6 Image Storage

4.6.1 Hard Disk (Winchester Drive)

The hard disk unit contains space for storage of up to 60 images in digital format which can be recalled and displayed at a later time for further review. In addition, interfaces are provided for non-digital storage of images on video tape recorder or video disk.

The hard disk has a storage capacity of 20 megabytes, 15 megabytes of which are dedicated to image storage. The remaining 5 megabytes serve as program storage.

4.6.2 Video Tape Recorder (VTR)

The VTR may be used to store real time images on magnetic tape. The storage format is not digital. Successive video frames at a rate of 30 per second can be continuously recorded for up to one hour on a single cassette. Single frames cannot be randomly accessed. The tape counter offers an approximation of frame location and must be referenced against an external log of image contents.

4.6.3 AngioStor Video Disk Recorder

The AngioStor Video Disk Recorder may be used to store real-time images in a non-digital format. Up to 600 frames may be stored and later played back at rates of 30, 15, 6 and 4.5 frames per second.

4.6.4 Multi-Format Camera

The multi-format camera is provided with the same video signals which are displayed on the monitors. These signals are displayed on an internal monitor screen which is photographed. The format and number of images which are placed on the photographic film vary depending upon the camera model.

SECTION 6
MONITOR CART PARTS, DISASSEMBLY AND REPLACEMENT

The information in this section will help you identify, disassemble and replace parts on the monitor cart. Section 6.2 contains assembly and disassembly instructions. Section 6.3 provides an illustrated parts list.

6.1 Safety

It is very important that you read and understand the emergency and safety procedures described in the Safety Section of the service manual.

WARNING: **Circuits inside the equipment use voltages which are capable of causing serious injury or death from electrical shock. To avoid this hazard always unplug the AC power cable before opening, removing, or replacing equipment covers or doors.**

There are no procedures in this section of the manual which should be attempted by anyone other than a properly trained service technician.

6.2 Monitor Cart Assembly/Disassembly

6.2.1 Removing the Access Panels

Refer to Figures 6-1 through 6-3.

The electronics of the monitor cart are accessed by removing sectional panels and covers.

Generally, all these panels attach in the same manner: interlocking tabs are attached to the frame along one edge, and the panel is secured with screws along the opposite edge.

6.2.1.1. Front Panel Removal for Access to Card Rack

Refer to Figure 6-1.

1. Remove two screws from the bottom of the panel and tilt the bottom edge of the panel out slightly.
2. Lift up on the panel to clear the tabs along the top edge and remove the panel.

6.2.1.2 Right Front Panel Removal for Access to Monitor Power Supply

Refer to Figure 6-1.

1. Remove two screws from the bottom of the panel.
2. Lift the panel up slightly, and then off.

6.2.1.3 Rear Panel Removal

Refer to Figure 6-2.

Removing the rear panel allows access to the Isolation Transformer T1 and the rear of the card cage.

1. Remove the seven screws along the bottom and sides of the rear panel.
2. There are no locking tabs, the panel can be simply lifted off.

6.2.1.4 Left Side Panel Removal for Access to Disk Interface and Video Switching PCB'S

Refer to Figure 6-3.

1. Remove the front panel.
2. Remove the two screws inside the left front cart frame.
3. Slide the panel toward the rear of the cart about 1 inch to clear the tabs.
4. Lift off the side panel.

6.2.2 Replacing the Air Filter

1. Face the front of the monitor cart and locate the air filter underneath the cart cooling fans.
2. Pull the air filter straight out.
3. Replace the air filter when it has become dirty enough to impair the flow of air through the fans.

Figure 6-1 - *Monitor cart covers, front view.*

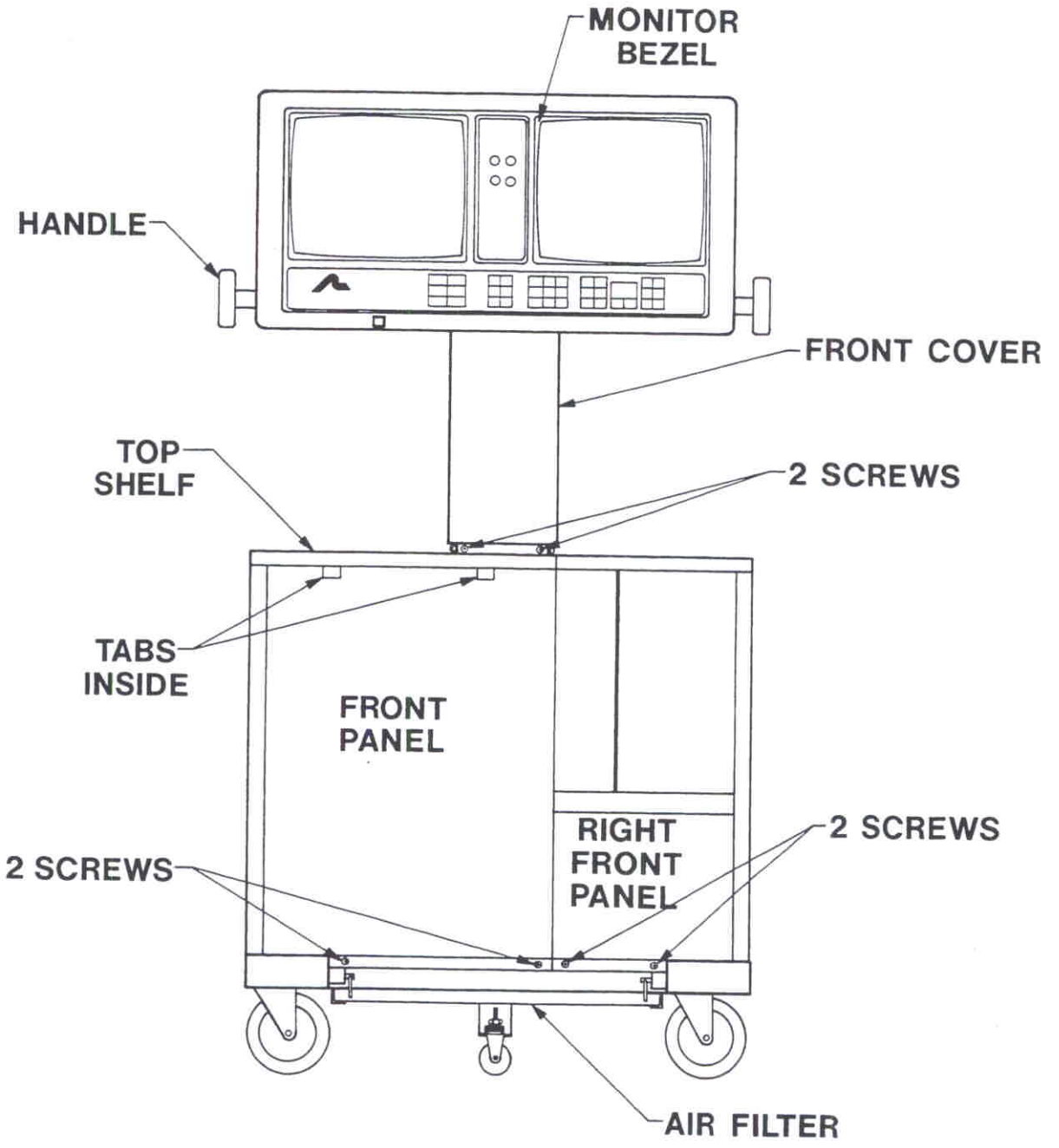


Figure 6-2 - *Monitor cart covers, rear view.*

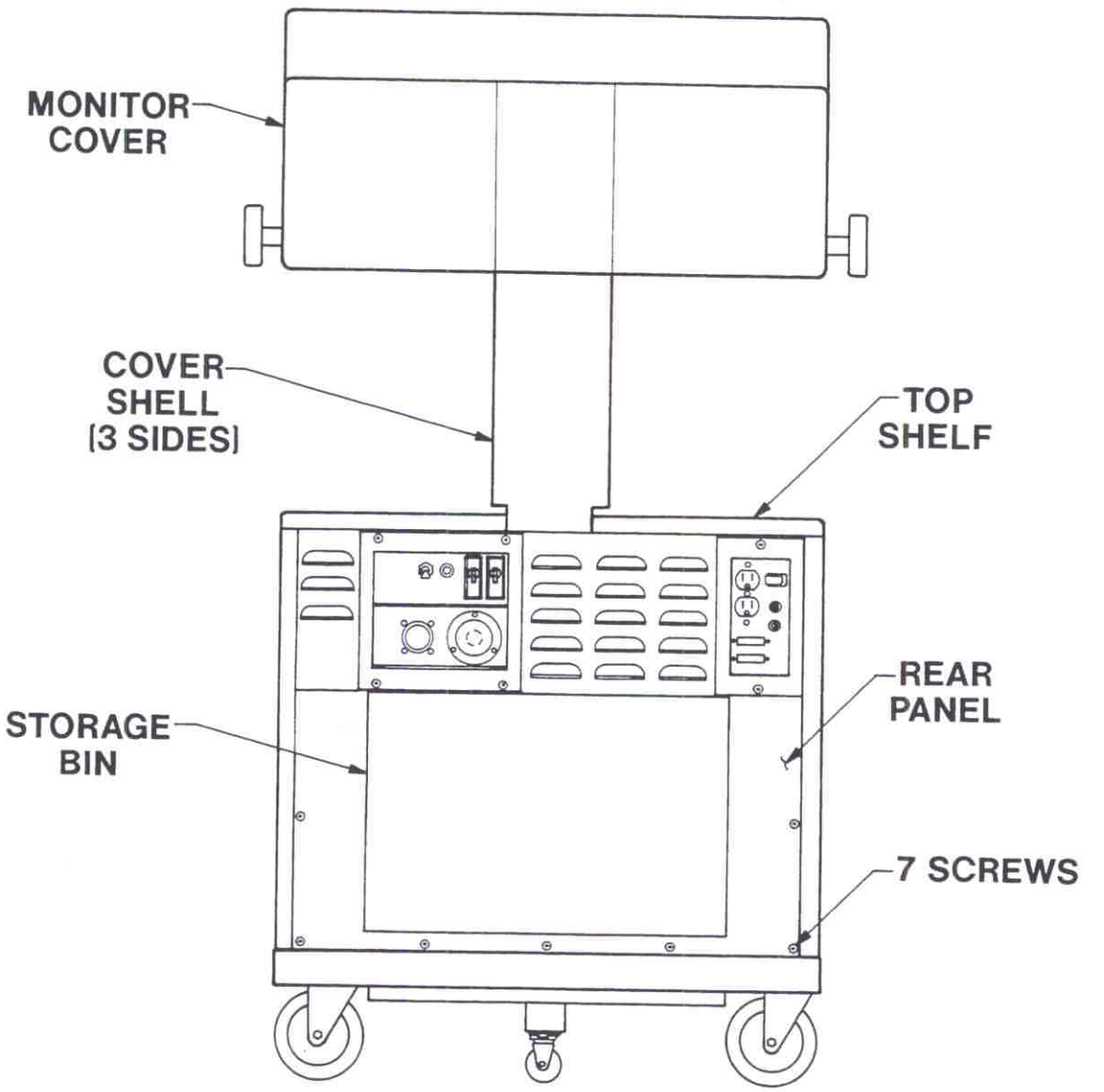
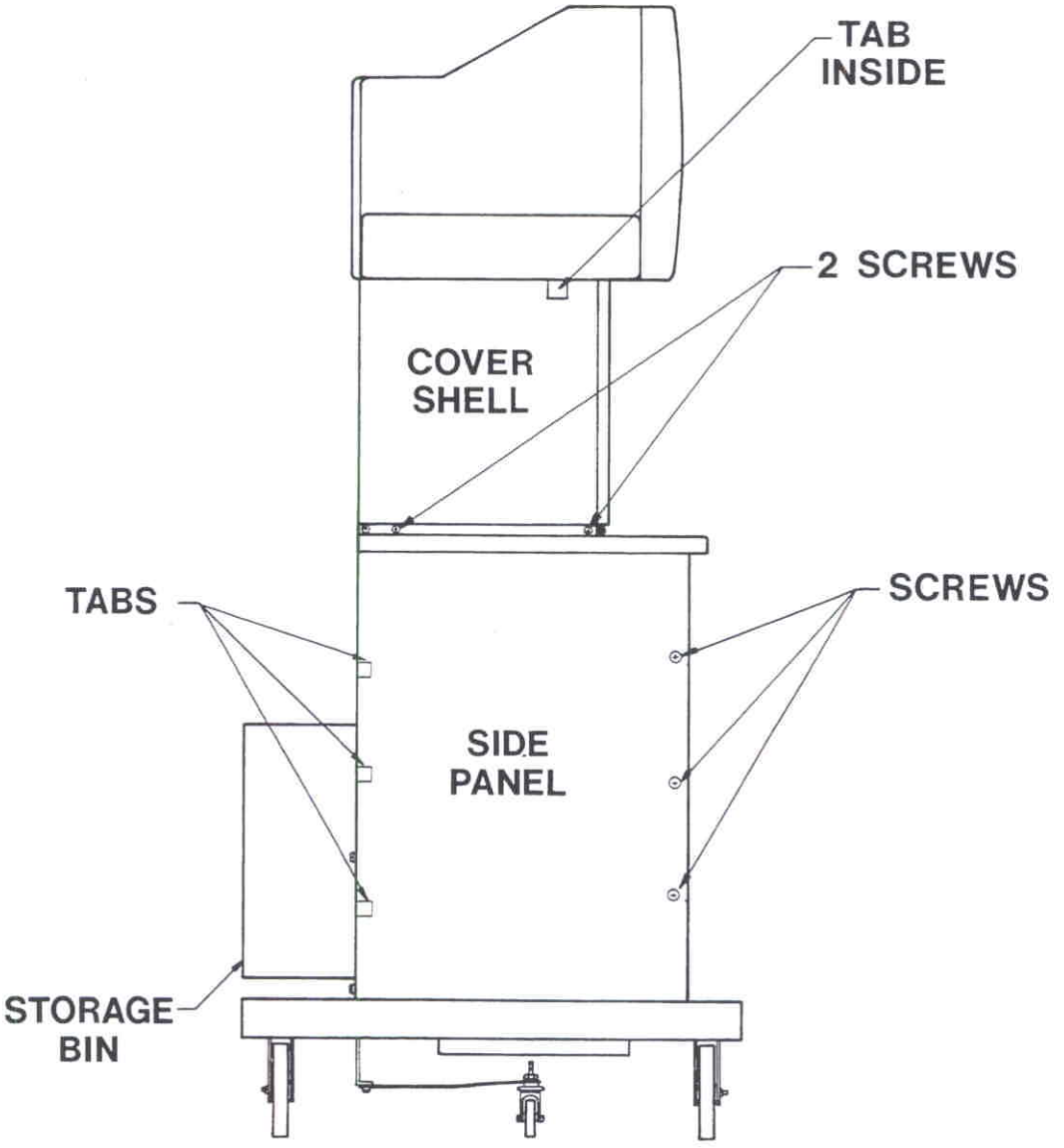


Figure 6-3 - *Monitor cart covers, side view.*



6.2.3 Removing the Monitor Covers

Refer to Figure 6-4.

1. Remove the four screws and grillwork from the bottom of each monitor.
2. Remove the two screws from the rear inside corners of the monitor cover.
3. Remove the two screws from the front inside corners of the monitor cover.
4. Lift the front edge of the cover up about 1/16 inch, to avoid trapping the cover tab on the monitor base.
5. Slide the cover back from the monitors and lift it away.

6.2.4 Removing the Monitors

Refer to Figures 6-5 and 6-6.

1. Remove the monitor cover as described in procedure 6.2.2 above.

WARNING: Observe the high voltage and implosion hazard warnings for handling CRTs.

2. Disconnect the brightness and contrast control connectors and the 2-pin Molex video connector going to the circuit board mounted on the monitor.
3. Disconnect the 3-pin Molex power connector.
4. Remove the nylon tie wraps as needed to free the disconnected wiring from the monitor frame.
5. Remove 3 screws on each side of the monitor base (6 screws total).
6. Carefully remove the monitor.
7. When replacing a monitor make sure that the front of the tube is firmly seated forward against the bezel. The monitor can be positioned with the screws on the monitor base brackets.

Figure 6-4 - *The attachment points for the monitor cover and grillwork are shown in this photo. With the grillwork removed, the Front Panel Processor PCB and the Remote Contrast/Brightness PCB are visible on their mounting plates.*

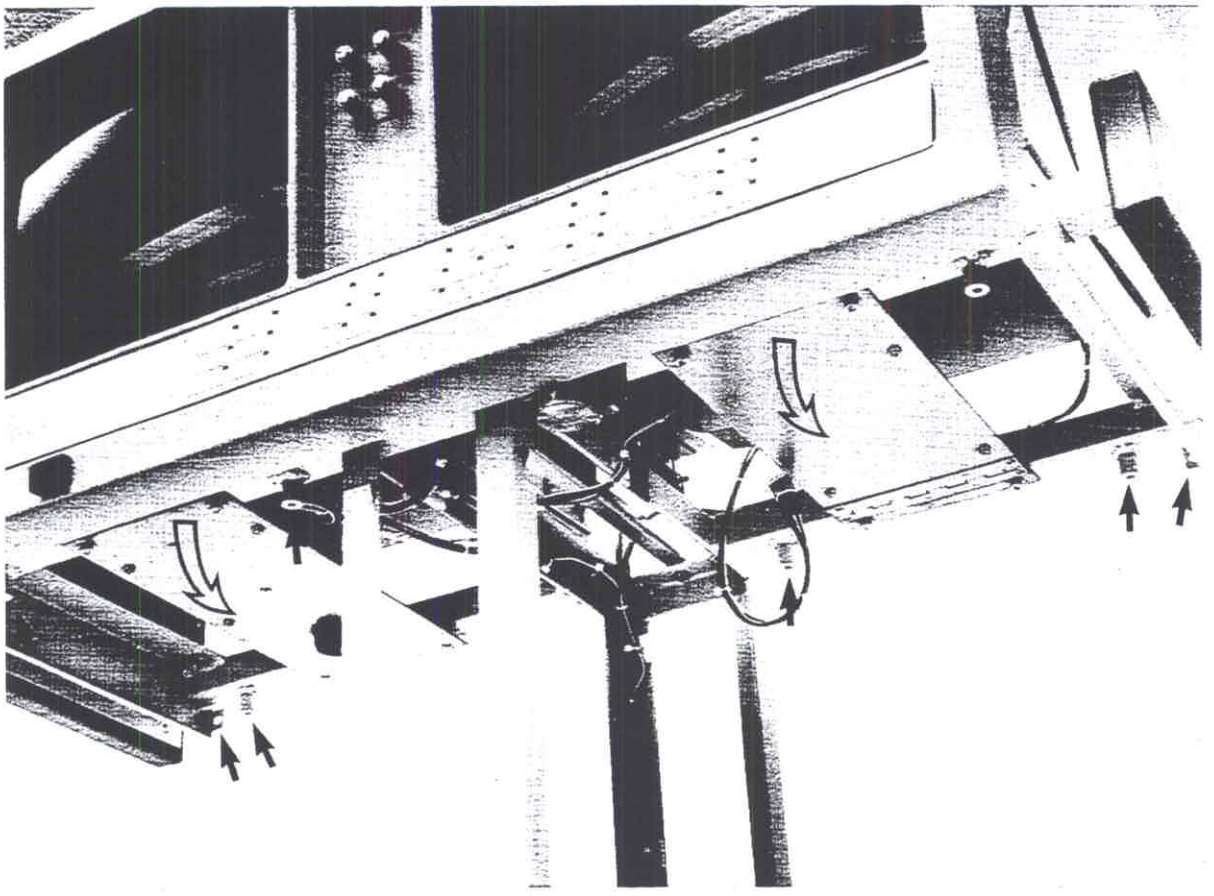


Figure 6-5 - *Remove the six screws holding each monitor as indicated in these photos.*

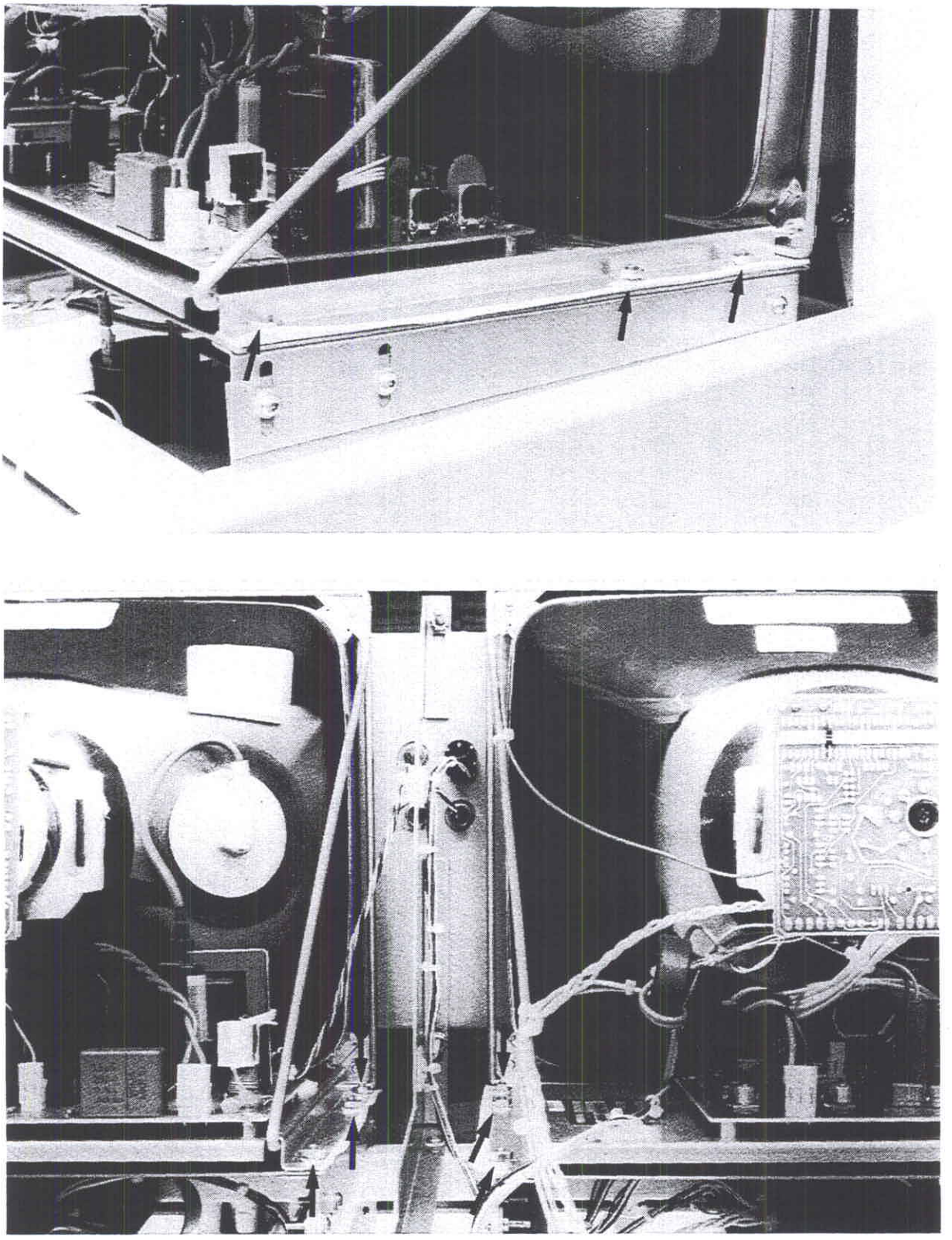
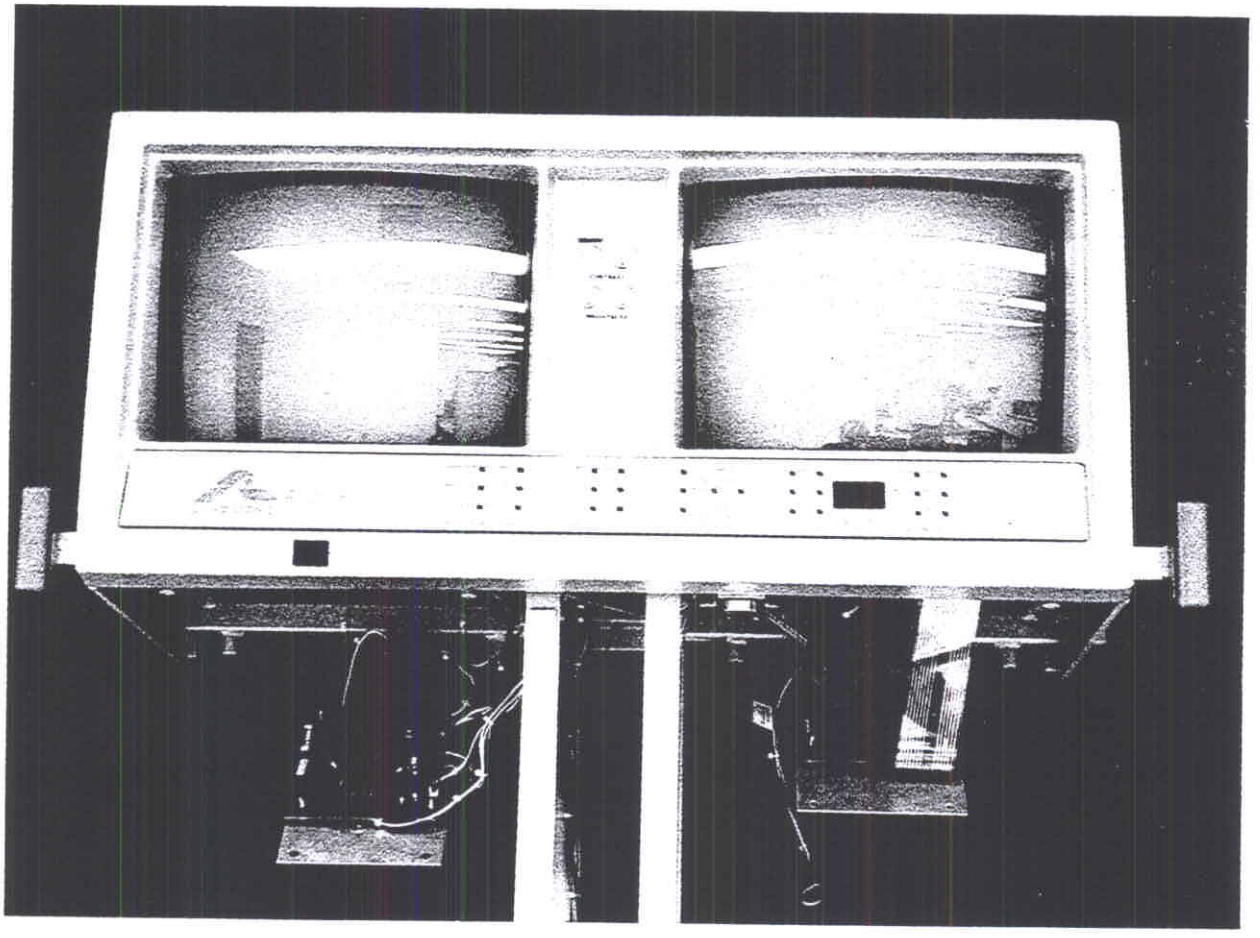


Figure 6-6 - *The panels below each monitor drop down to expose the Front Panel Processor PCB and the Remote Contrast/Brightness Control PCB.*

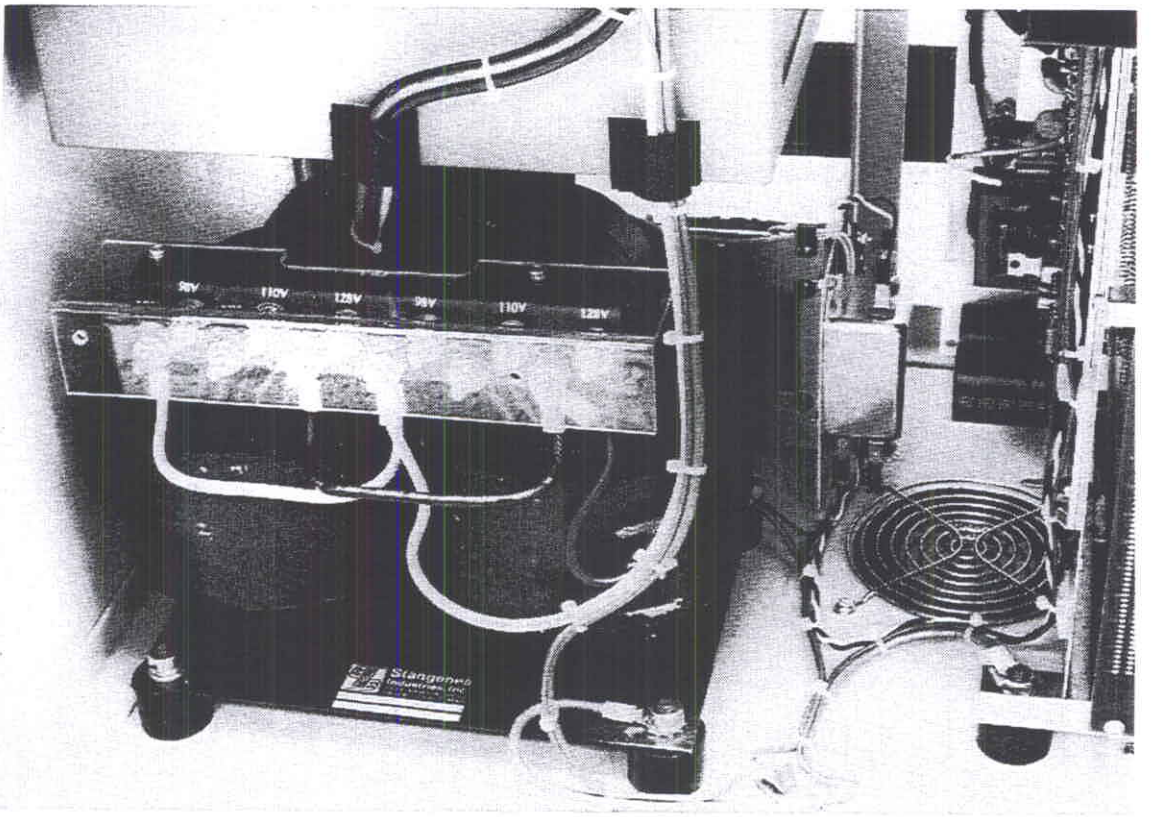


6.2.5 Removing the Isolation Transformer

Refer to Figure 6-7.

1. Unplug the main power cable from the wall outlet.
2. Remove the rear access panel.
3. Label all wires before removing them from the transformer. Disconnect the wires from the isolation transformer terminals.
4. Remove the four nuts securing the transformer to the shock mounts in the base of the cart.
5. Lift the transformer off the shock mounts and out of the cart. The transformer is heavy - lift it carefully.

Figure 6-7 - *Removing the isolation transformer.*



6.2.6 Access to the Front Panel Processor PCB

Refer to Figure 6-6.

1. Remove the grillwork below the right monitor.
2. Locate the Front Panel Processor PCB on the hinged panel under the monitor. Remove the 2 screws and swing the panel and PCB assembly down on its hinge.
3. Use care not to strain the cables and their connectors which are plugged into the PCB.

6.2.7 Access to the Remote Contrast/Brightness PCB

Refer to Figure 6-6.

1. Remove the grillwork below the left monitor.
2. Locate the PCB on the hinged panel below the monitor. Remove the two screws and swing the panel down on its hinge.
3. Use care not to strain the cables and their connectors which are plugged into the PCB.

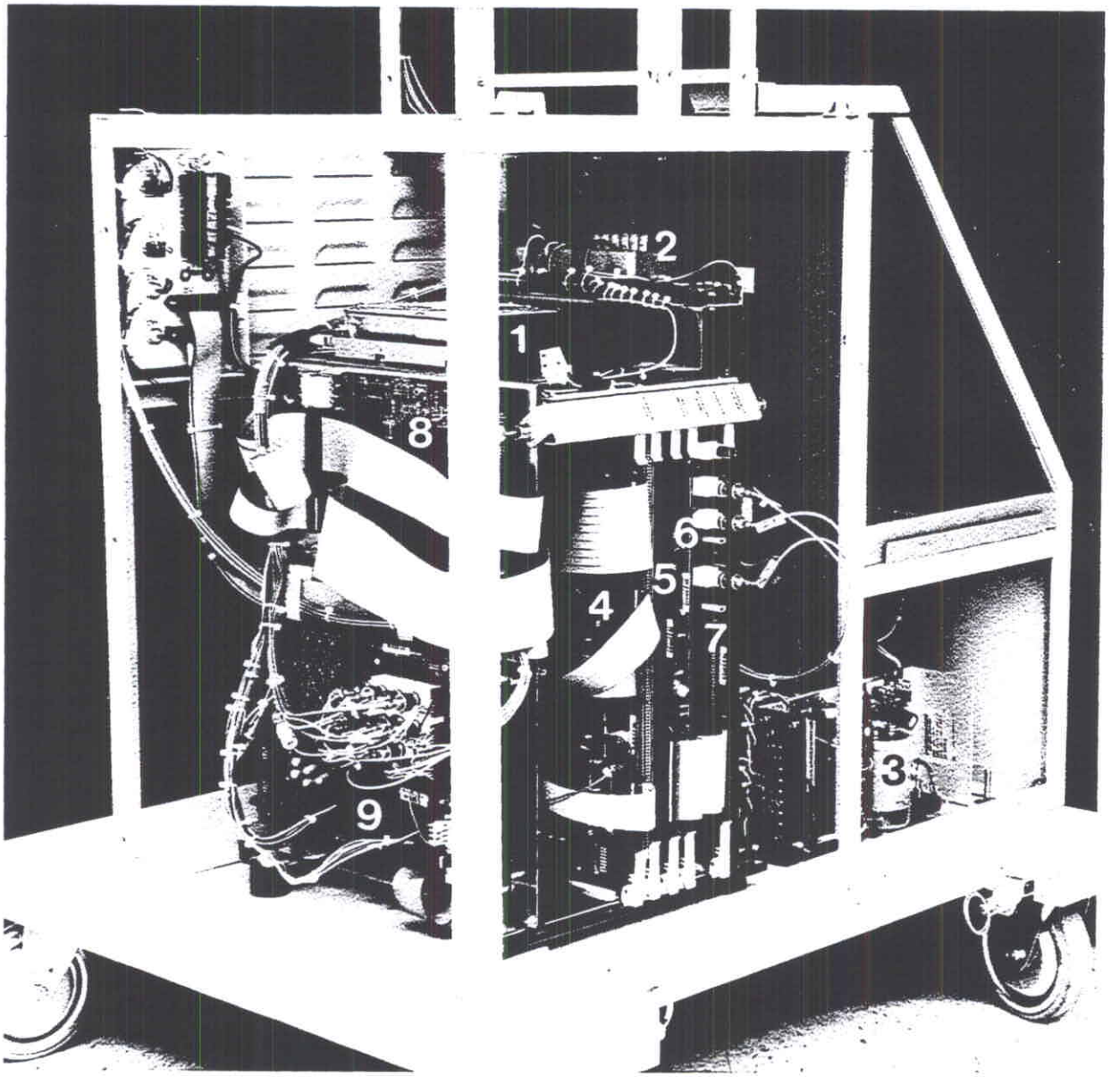
6.2.8 Removing the Card Rack Power Supply

Refer to Figure 6-8.

1. Remove all wiring from their push on connections at the terminal strip on the bottom of the power supply.
2. Remove the circuit boards from the card rack.
3. Reach inside the card rack and remove the 2 screws securing the lower end of the power supply.
4. Remove the screws securing the hard disk drive on the top of the card rack and shift it to the side to access the two screws holding the top of the power supply. It is not necessary to disconnect the cables to the disk drive.

Figure 6-8 - *The components in the base of the monitor cart are identified in this photo.*

1- Hard disk, 2- card rack power supply, 3- monitor power supply, 4- Disk Interface PCB, 5- Pipeline Filter PCB, 6-Image Processor PCB, 7- AD/DA PCB, 8- Disk Controller PCB, 9- IO Distribution/ Video Switch PCB



6.2.9 Removing the Hard Disk Drive

Refer to Figure 6-8.

1. Disconnect the two ribbon cables and the power cable connection to the hard disk drive.

   (Note that different drives may be mounted with the connectors to the front or the rear). *If the connectors are inaccessible, then perform the following removal steps 2 and 3 and then turn the drive to access the connectors.*

2. Remove the circuit boards from the card rack.

3. Reach up from inside the card rack and remove the four screws securing the Hard Disk Drive to the top of the rack.

4. Remove the drive.

6.2.10 Removing PCBs From the Card Rack

Refer to Figure 6-8.

1. Remove the front access panel.

2. Loosen the knurled screws at each end of the retaining bar, and swing it up on its hinge.

3. Remove the ribbon cables from their their front edge connections. Be sure they are adequately labeled for later reconnection.

4. Pull out on the card ejectors to disengage the PCBs from their rear edge connectors on the motherboard.

6.2.11 Installing PCBs in the Card Rack

Refer to Figure 6-8.

The PCBs which slide into the card rack slots are from left to right:

Disk Controller PCB
Extender Board
Pipeline Filter PCB
Image Processor PCB
AD/DA PCB

1. Make sure that the rear edge connectors are clean and bright. Clean with a soft eraser and a cloth with solvent.

2. Line up each PCB with the top and bottom card edge guides and slide the cards into the rack until the rear edge connectors engage the motherboard.

3. Press firmly on the card ejectors until the PCB is fully seated in both rear edge connectors on the motherboard.

4. Reconnect all ribbon cables. Be sure that pin 1 of each ribbon cable connector matches up with pin 1 of each PCB connector.

   Connect the short, multiconnector daisy-chain cable to the P-3 connectors of the Image Processor, Pipeline Filter, and AD/DA PCBs.

   Attach the ribbon cables to P-9, P-10, P-11 and P-12 on the Disk Interface PCB.

   Attach the coaxial cables to J-5, J-6 and J-8 on the AD/DA PCB.

5. Swing down the PCB retaining bar and lock it in place by tightening the knurled screws.

6.2.12 Removal of the I/O Distribution-Video Switching PCB

Refer to Figure 6-8 and Figure 6-9.

The I/O Distribution-Video Switching PCB is mounted on standoffs attached to the left side of the card rack.

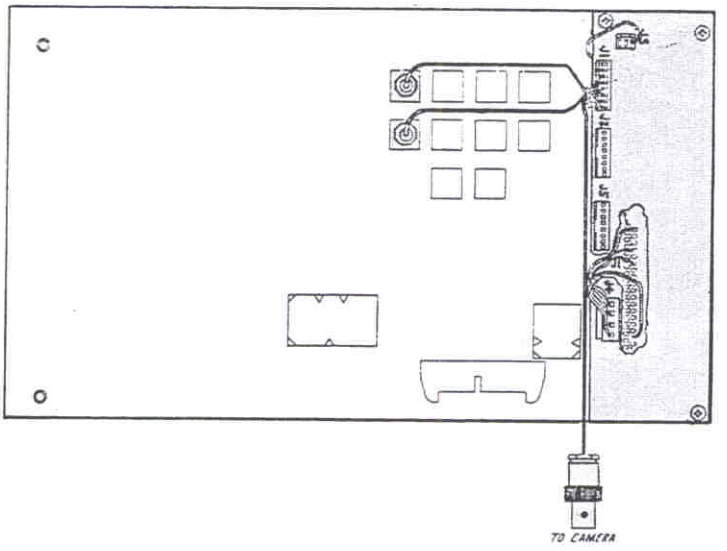
1. Remove the front and the left side access panels.

2. Remove the PCBs from the card rack as required to reach the screws which secure the I/O Distribution-Video Switching PCB standoffs.

3. Disconnect all BNC, ribbon, and power cables from the PCB. *Refer to Figure 6-9 for connector replacement.*

4. Remove the screws securing the PCB standoffs to the card rack and remove the PCB.

Figure 6-9 - *I/O Distribution Video Switch PCB connections are shown below; detail on right shows connections to the Sync Separator PCB*



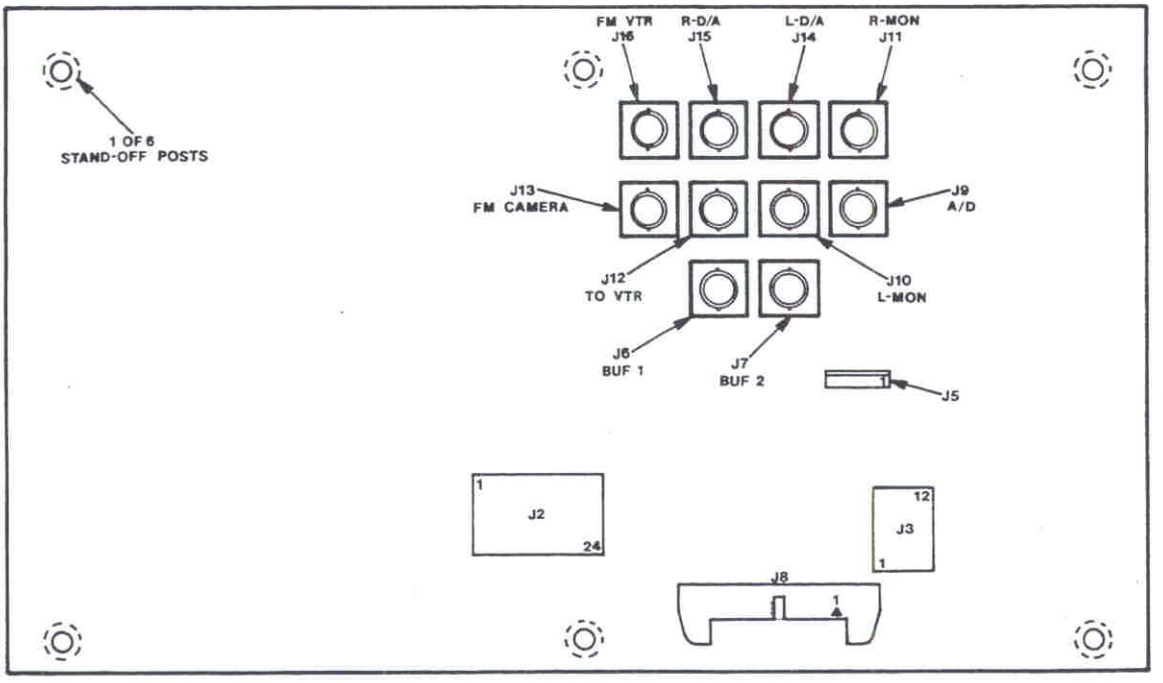
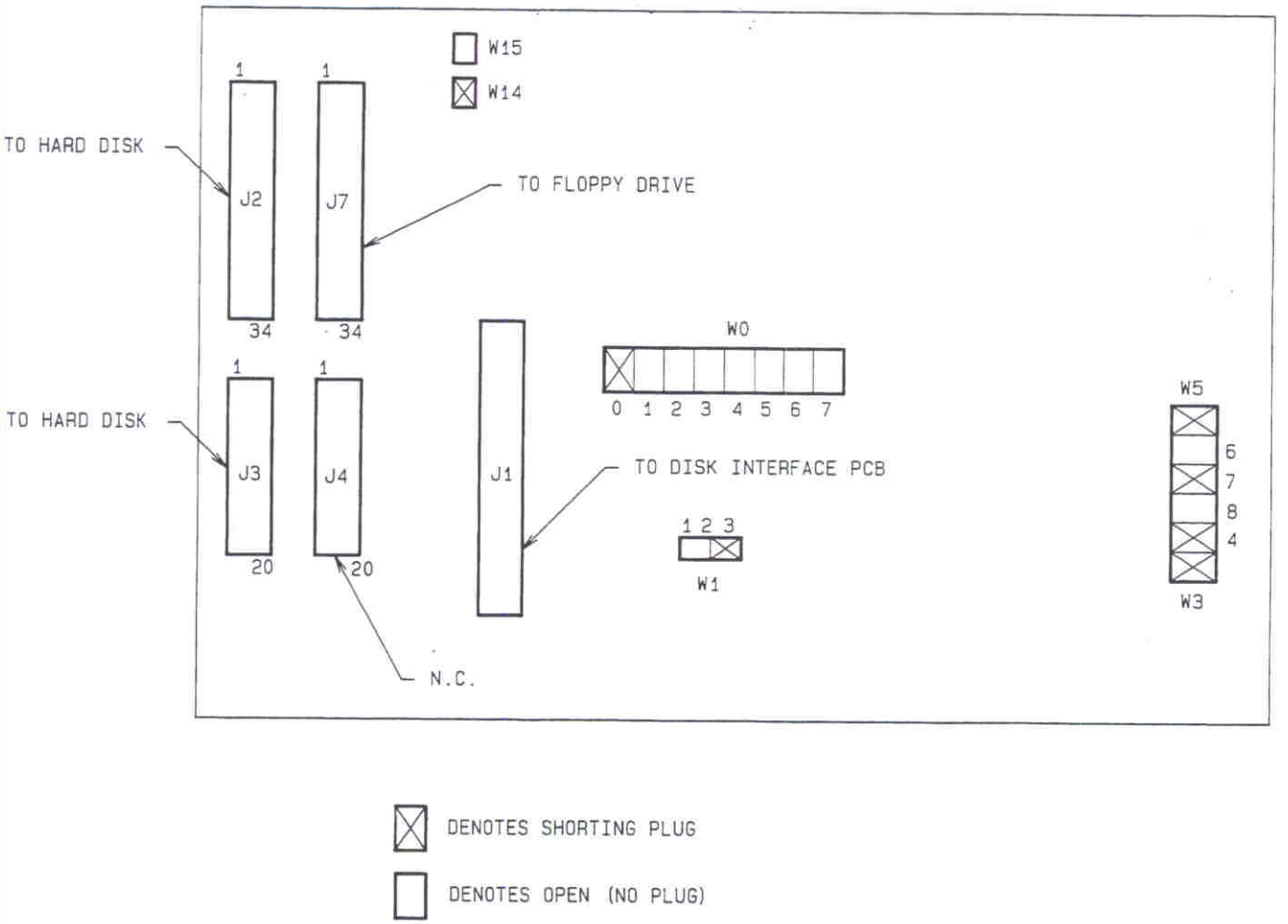


Figure 6-10 - *The connector placement on the Disk Controller PCB is shown in this drawing.*



6.2.13 Sync Separator (AngioStor Interface) PCB

Refer to Schematic 00-870543, and Figures 6-8 and 6-9.

On systems equiped with the AngioStor Disk Recorder, an interface PCB is mounted piggyback on the I/O Distribution PCB. The connections between the Interface PCB and the I/O Video Switch PCB are as follows:

I/O Dist Video Switch PCB	AngioStor Interface PCB
J1-19	J3-1
J1-21	J4-1
J1-34	J4-2
J1-32	J4-3
J1-37	J4-4
J16	J1-3, J1-4
J-13	J1-5, J1-6

6.2.14 Removal of the Disk Controller PCB

Refer to Figure 6-10.

1. Remove the left side panel to access the PCB.
2. Disconnect all connections to the PCB. *Refer to Figure 6-10 for connector placement.*
3. Remove the 4 sets of screws and insulating washers. Each screw is insulated from the PCB with nylon washers on both sides of the board. *When the board is reinstalled be sure that these insulating washers are in place.*

6.3 Illustrated Parts List

The major replacable assemblies are illustrated on the following pages.

Part numbers are subject to change. Contact Technical Support for assistance with part interchangeability.

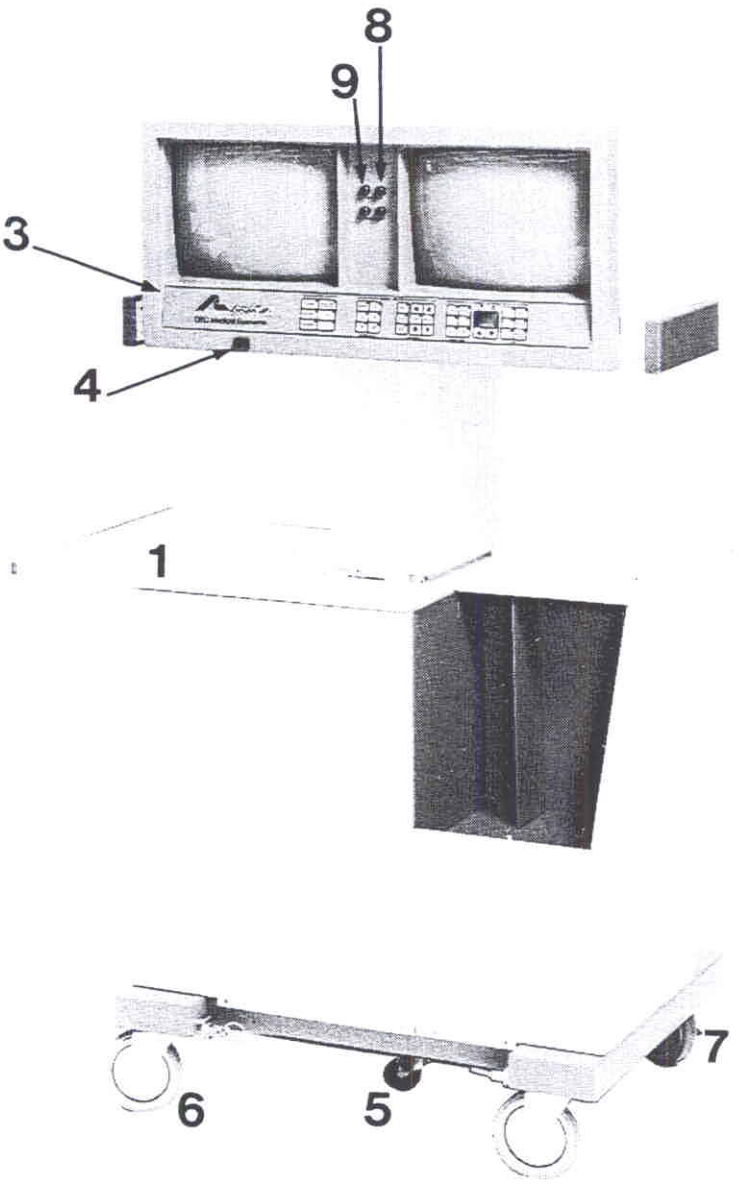
Fig. 1 Monitor Cart

1.	shelf, accessory, monitor cart	00-870523
2. *	shelf, accessory, RH, monitor cart	00-870541
3.	front panel assembly	00-870398
	membrane switch panel sub-asm	00-870397
	LED PCB display	00-870394
	display, 7-segment LED	67-480626
	lamp, red LED, MV5753	67-499845
4.	indicator, rectangular	71-229509
	cap, lens, red	00-870739
	lamp, 6.3VDC	71-229506
5.	conductive caster asm	00-860092
6.	casters, front	10-08-390
7.	casters, rear w/ brakes	10-08-391
8.	knobs 1/8-inch shaft	23-519934
9.	knobs 1/4-inch shaft (remote)	23-519931

Overall View

* Item 2 is not shown in this photo.

Monitor Cart



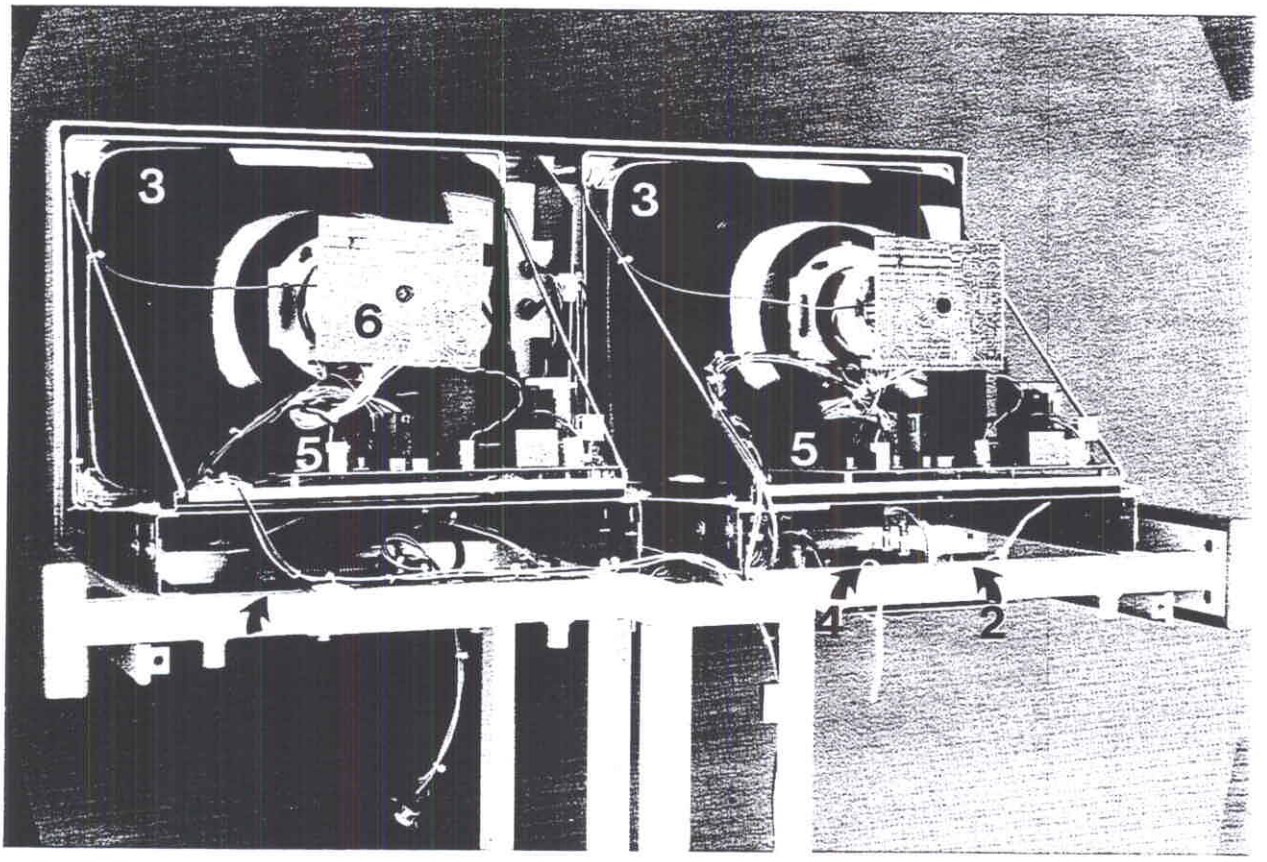
Overall View **Fig. 1**

Fig. 2 Monitor Cart

1.	Front Panel Processor PCB	00-870509
2.	Remote Contrast Brightness Control PCB	00-870930
3.	TV monitor	00-860364
4.	audio alarm	76-829967
5.	Dataray Video Procesor PCB	00-900036
6.	Dataray Deflection PCB	00-900035

Rear Exposed Monitor View

Monitor Cart



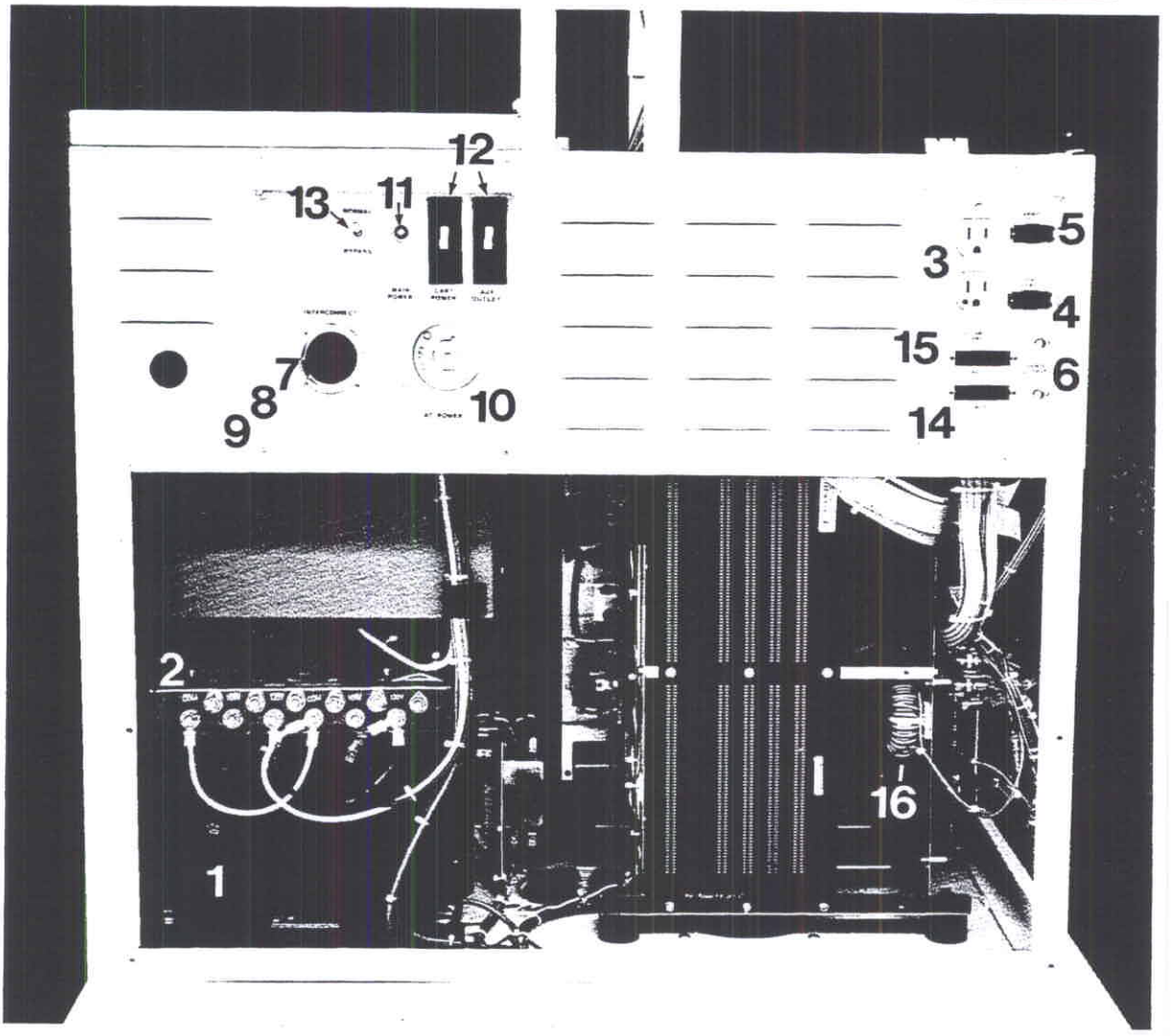
Rear Exposed Monitor View **Fig. 2**

Fig. 3 Monitor Cart

1.	isolation transformer	00-860736
2.	transformer terminal cover	00-870136
3.	duplex outlet, 3-wire	51-433989
4.	connector jack, 8-pin VTR	00-900047
5.	connector jack, 8-pin AngioStor	00-900047
6.	connector jack, BNC	58-018941
7.	connector, receptacle, circ	52-998346
8.	contact pin	52-998300
9.	bracket, retainer, interconnect cable	00-871331
10.	connector, inlet, 3-pin M	51-332981
11.	ckt breaker, 10 A	55-700448
12.	ckt breaker, 5A	55-700032
13.	toggle switch, DPDT	71-149970
14.	cable asm, AUX	00-870117
15.	cable asm, RS232	00-870118
16.	video balun	00-870370

Rear Lower View

Monitor Cart



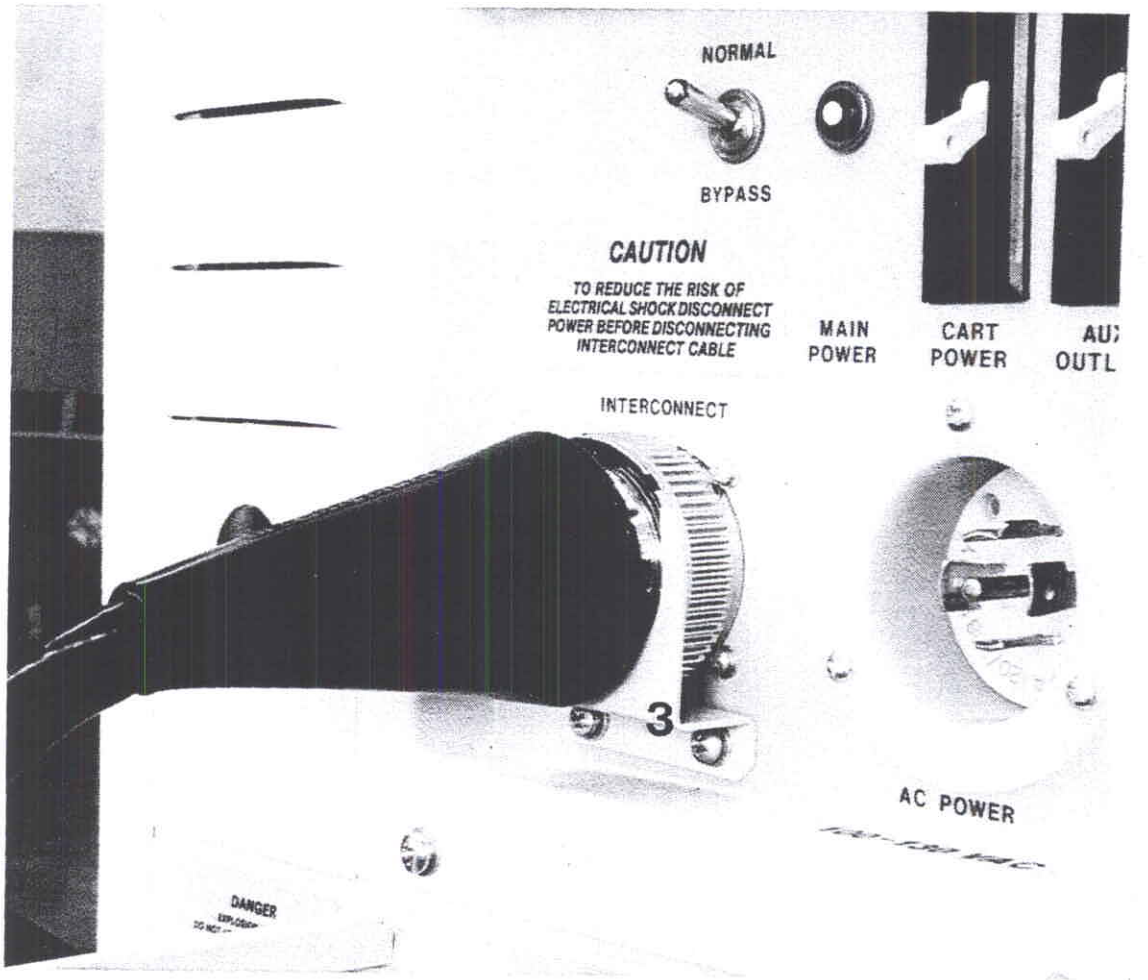
Rear Lower View

Fig. 3

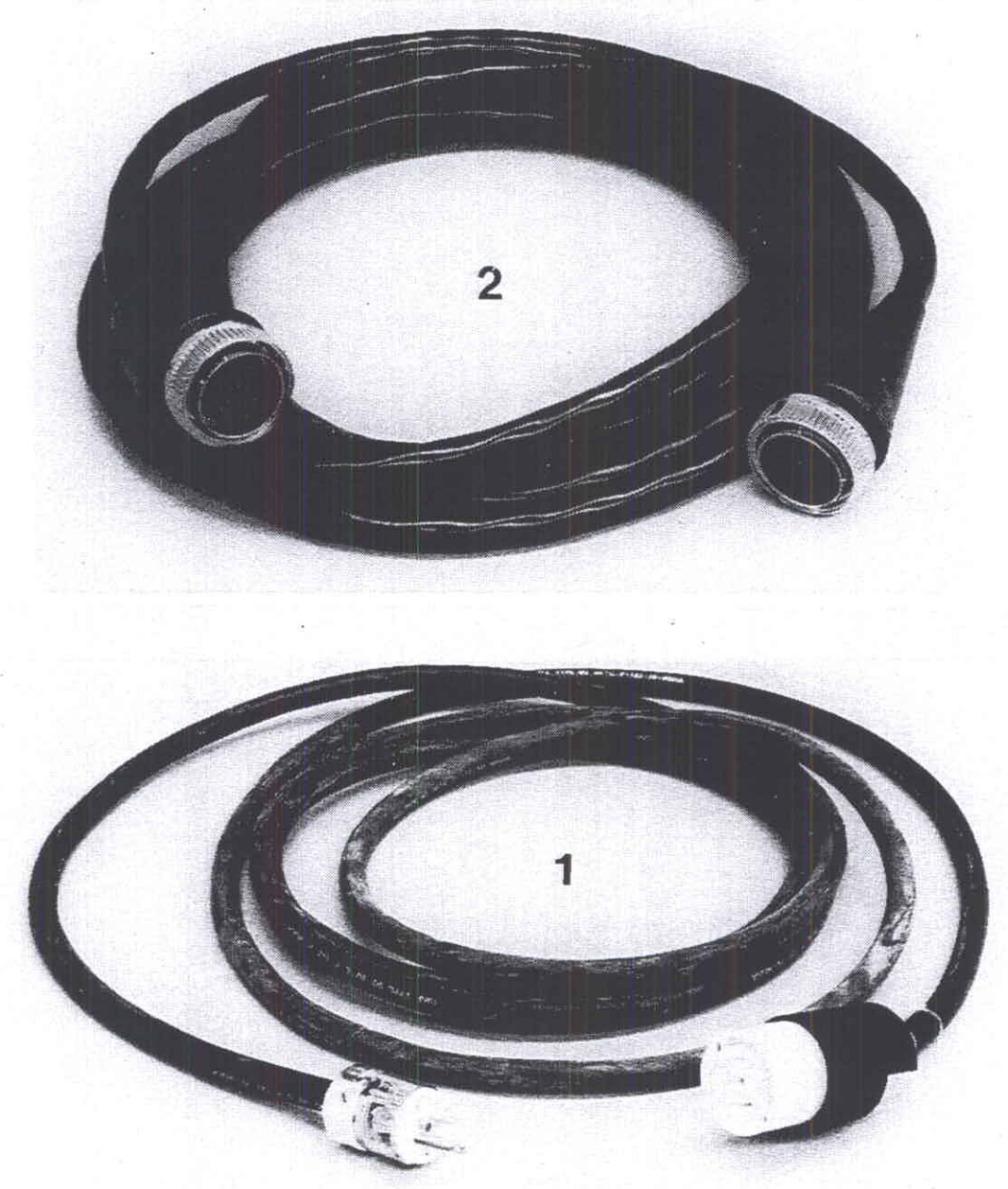
Fig. 4 a, b, c Power and Interconnect Cables

1.	asm, power cable	00-871369
2.	asm, interconnect cable	00-900101
3.	bracket, retainer, interconnect cable	00-871331

Fig. 4a



Monitor Cart



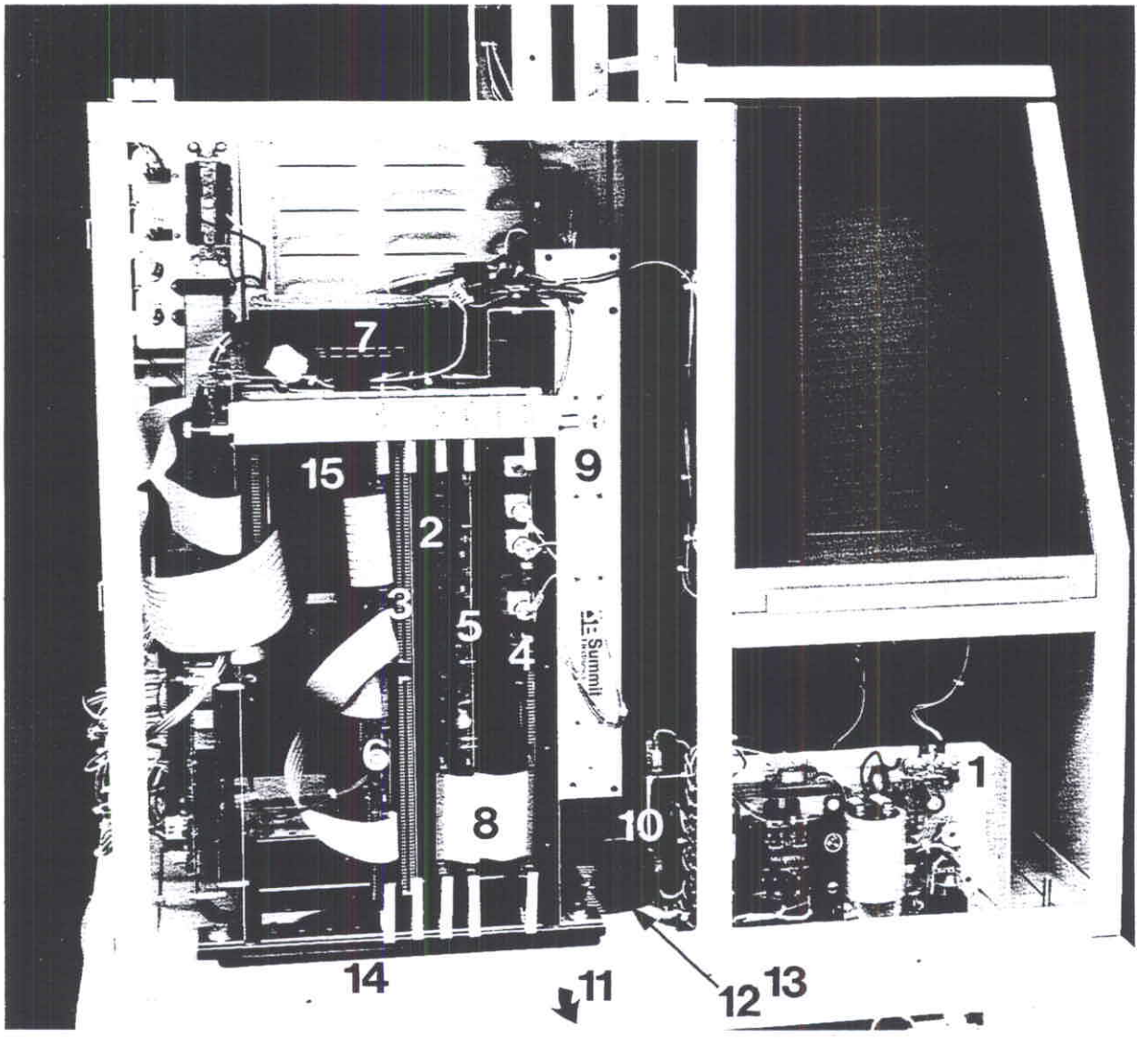
Power and Interconnect Cables **Fig. 4b, c**

Fig. 5 Monitor Cart

1.	24 Volt power supply	00-870285
2.	pipeline filter PCB	00-870503
3.	extender pcb	00-860893
4.	AD/DA converter pcb	00-860898
5.	image processor PCB	00-870390
6.	disk interface PCB	00-870015
7.	disk drive, winchester, 1/2 height	00-900077
8.	daisy chain cable	00-870556
9.	power supply, 5 VDC	00-870065
10.	filter, pwr line, 10 A	43-399887
11.	air filter asm	00-870386
12.	finger guard	20-839926
13.	fan, 4" axial	20-839955
14.	card guides	22-319805
15.	disk controller adapter PCA	00-900075

Lower Electronics, Front View

Monitor Cart



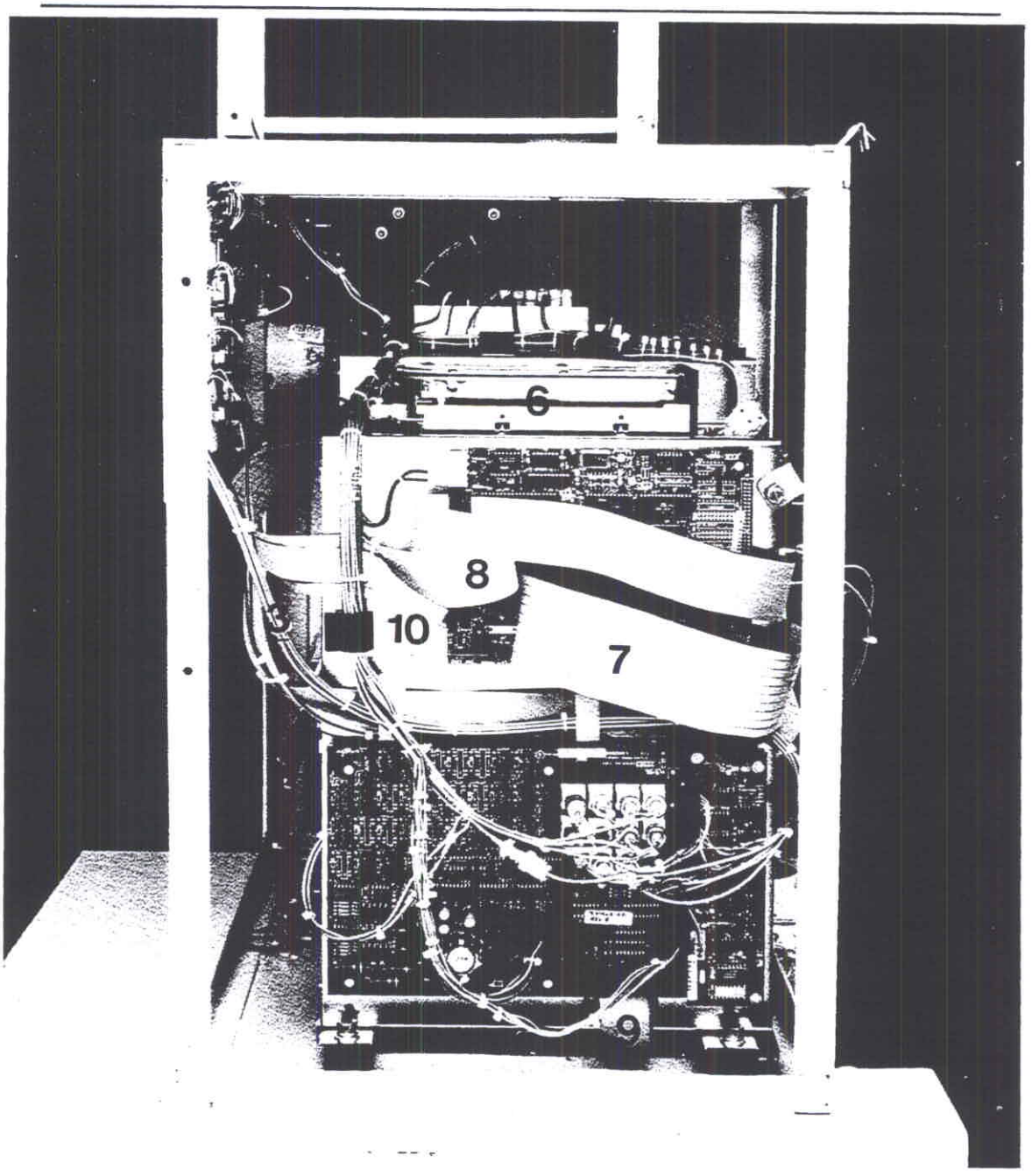
Lower Electronics, Front View **Fig. 5**

Fig. 6 Monitor Cart

1.	OMTI disk controller PCA	00-900079
2.	cable asm, AUX	00-870117
3.	cable asm, RS232	00-870118
4.	asm, PCB, I/O DIST/VIDEO SW	00-870187
5.	sync-separator PBC	00-870545
6.	disk drive, winchester, 1/2 height	00-900077
7.	cable asm, 50 pin ribbon	00-870024
8.	cable asm, disk control	00-870121
9.	cable asm, image processor interface	00-870119
10.	cable asm, disk data	00-870120

Lower Electronics, Side View

Monitor Cart



Lower Electronics, Side View **Fig. 6**

SECTION 7
MAINFRAME
SERVICE AND DIAGNOSTICS

7.1 Safety Procedures During Service

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 adjustments 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 can result if such metal articles are placed across the battery terminals.

7.2 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 however, 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.

7.2.1 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

7.2.2 Technique Processor Boot Codes

These codes are 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

7.2.3 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

7.2.4 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

7.2.5 Misc 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.

7.3 Event Codes and Warning Messages

7.3.1 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 7.4.

Event Code Table

Refer to Table 1; 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 a * in the table.

Table 1 Event Code Listing

01	not used	
02	not used	
03	not used	
04*	X-RAY JUMPER ON	jumper left in after calibration
05	SWITCH STUCK	x-ray switch is sensed as on improperly
06*	PRECHARGE FAIL	precharge cycle has failed
07*	HV INVERTER ON	high voltage generator is on
08	not used	
09	MAIN PGM LOAD	main program is loaded to RAM
0A	INIT COMPLETE	hardware initialization is complete
0B	not used	
0C	D CURRENT FAIL	dark current cannot be calculated
0D	not used	
0E	FLUORO-PREP	indicates software state
0F	FLUORO-INIT	indicates software state
10	FLUORO-READY	indicates software state
11	FLUORO-XRAY	indicates software state
12	not used	
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	not used	
18	not used	
19	FLUOROS FILM	indicates transition: standby to film
1A	not used	
1B	not used	
1C	not used	
1D	BOOST FOOT UP	boost switch released
1E	BOOST OVERTIME	boost terminated at 30 seconds
1F	HOUSING 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 OVERHEAT	heat integrator warning
24	HOUSE OVERHEAT	heat integrator warning
25	WILL OVERHEAT	film mode warning
26	CP DEAD	control panel dead
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 was terminated from front panel
2A	not used	
2B	X-RAY ARMED	instant on is prearmed
2C	FILM - PREP	indicates software state
2D	FILM - INIT	indicates software state
2E	FILMX - FLUORO	indicates software state

Table 1 (continued) Event Code Listing

2F	FILM - READY	indicates software state
30	not used	
31	FILM - WARMUP	indicates software state
32	FILMS - FLUORO	indicates software state
33	FILM - XRAY	indicates software state
34	FILM - INST ON	indicates software state
35	FILM XOFF	indicates software state
36	XRAY COMPLETE	exposure has ended
37	FOOT RELEASED	x-ray switch released early in film mode
38	XRAY OVERTIME	film mAs integration error has occurred
39	not used	
3A	not used	
3B	not used	
3C	not used	
3D	EXCESS FILM KVP	a calibration error has occurred
3E	LOW FILM KVP	a calibration error has occurred
3F	EXCESS FILM MA	a calibration error has occurred
40	LOW FILM MA	a calibration error has occurred
41	not used	
42*	FLIPPER STUCK	the flipper collimator is stuck
43	MA ON IN ERROR	improper generator operation
44	not used	
45	KV ON IN ERROR	improper generator operation
46*	STATOR NOT ON	rotating target stator is not running
47*	OVERLOAD FAULT	generator fault detected
48*	SATURATION FLT	generator saturation fault detected
49*	FILAMENT FAULT	generator fault detected
4A*	INTRLKS BROKEN	interlock circuit was interrupted
4B*	HV INVERTER OFF	high voltage generator is on
4C	not used	
4D*	OVERVOLTGE FLT	generator overvoltage fault
4E*	NO SERVO TABLE	disk software failure
4F*	NO MUXRAM DATA	disk software failure
50	NO OPTIONS FILE	no default parameters
51	USER END	normal operation has been interrupted
52	EXIT PROGRAM	exit program from terminal
53	NO CASSETTE	
54	LOADING STATUS	control panel is entering the status mode
55	NO SYSTEM FILE	disk software failure
56	NO MA LIMITS	disk software failure

* Fatal Errors

7.3.2 Warning Messages During Operation

Follow the recommendations below for remedying 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.

7.3.3 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. These conditions can be remedied by allowing time for the X-ray tube to cool. These messages alternate with the normal information displayed on the LED panel.

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.

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.

7.3.4 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 provide additional recharging time, leave the system plugged in with the interconnect cable in place overnight.

7.3.5 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 Generator Controller PCB has been left in place, disabling regulation. Results in automatic shutdown.

SWITCH 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.

BPLUS FAULT
The battery voltage is low; the batteries may be weak. Results in automatic shutdown.

SHOT TOO LONG
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.

LG FIELD STUCK
The collimator is stuck in the large field position. 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 FLT
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.

INTRLKS 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.

7.4 Control Panel Status Mode

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.

If the mainframe fails at the "Press Start" prompt during startup, the Status Mode can still be entered in the manner described below.

7.4.1 To Enter the Status Mode:

1. PRESS and HOLD the unlabeled button below the image reversal button for five seconds.
2. The message *STATUS V n.n* indicates that you have entered the status mode. Once in this mode, turn either the right or left knob 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 knob.
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, scroll the menu item *EXIT THIS MENU* onto the display 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*.

7.4.2 Status Menus

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

7.4.2.1 Battery Status

When this menu is entered, you are instructed to press START. This completes the interlock circuit and allows battery measurement. If no action is taken within ten seconds, the message PRESS START is replaced by INTERLOCK TIMEOUT, and you are returned to the the status menu level.

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

7.4.2.2 Camera Status

VIDEO LEVEL
DARK CURRENT
CAMERA GAIN
EXIT THIS MENU

7.4.2.3 Heat Status

HOUSING HEAT
ANODE HEAT
THERMISTOR
EXIT THIS MENU

7.4.2.4 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 NUMBER	
0	*MEASURED KVP*
1	*MEASURED MA*
2	*FILAMENT B+*
3	*VIDEO LEVEL*
4	*HOUSING TEMPERATURE*
5	*DOSIMETER*
6	*SPARE*
7	*SPARE*
8	*TAP VOLTAGE*
9	*LINE VOLTS*
10	*CHARGE CURRENT*
11	*CHARGE VOLT*
12	*FIL CURRENT*
13	*SPARE*
14	*SPARE*
15	*SPARE*

EXIT THIS MENU

7.4.2.5 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 and 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

7.4.2.6 Control Panel Diagnostics

PANEL LED TEST
PANEL KEY TEST
PANEL KNOB TEST
PANEL CLOCK TEST
SPEAKER TEST
CLOCK TEST
REMOTE BAUD CHECK
EXIT THIS MENU

7.4.2.7 Date/Time Set

SET TIME
SET DATE
EXIT THIS MENU

7.4.2.8 System Options

(XXXX below indicates the current option setting).

ABS TABLE XXXX
ABS BOOT XXXX
CAM GAIN XXXX
LENGTH OF PULSED MODE PULSE
EXIT THIS MENU

7.4.2.9 Examine Calibration Parameters

TABLE A	*TABLE B*
TABLE C	*TABLE D*
TABLE E	*TABLE F*
TABLE G	*TABLE H*
TABLE I	*TABLE J*
TABLE K	*TABLE L*

LAST CAL DATE and TECHNICIAN
NUMBER OF CALIBRATIONS

7.4.2.10 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 - (last 128, beginning with most recent stored in EEPROM. This table is only updated when a fatal system error occurs.)

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

NUMBER OF FATAL EVENTS (accumulated number of fatal event occurances).

DATE AND TIME OF LAST FATAL ERROR

7.4.2.11 Miscellaneous

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

MODEL NUMBER
SERIAL NUMBER
TOTAL RAM
FREE RAM SPACE
TOTAL DISK SPACE
FREE DISK SPACE
INSTALLATION DATE AND TECH
NUMBER OF FILM EXPOSURES
EXIT THIS MENU

7.5 Internal LED indicators

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

The Technique Processor LED digit - This LED echos 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 interlock circuit is complete. 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 Generator Controller PCB.

7.6 Video Camera - Jumpers and Adjustments

7.6.1 Video PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1	IN	Shading
E2	IN	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

7.6.2 Preamp and Yoke ASM

FUNCTION	*ADJUSTMENT*
Peaking	C3

7.6.3 Power Supply PCB

FUNCTION	*ADJUSTMENT*
Beam Discharge	R14
+500 VDC	R13
Focus	R11
H-drive Sync	R25

Adjustment **H-Drive Sync Frequency**

1. Disconnect the H-drive.
2. Adjust R25 to obtain 14.5 kHz at TP14.

7.6.4 Shading/Window PCB

FUNCTION	*ADJUSTMENT*
H- Sawtooth #1	R40
H- Sawtooth #2	R41
H- Parabola	R42
H- Window Cal.	R38
V- Sawtooth	R10
V- Parabola	R16
V- Window Cal.	R39

7.6.5 Deflection PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1	AFC	line Lock/Auto Freq Cntl
E2	525 (60 Hz)	line rate select
	625 (50 Hz)	line rate select
E3		unused
E4		unused
E5-E6	OUT	U2 clock source
E7-E8-E9	E7-E8	50 HZ
	E8-E9	60 HZ
E10-E11-E12	E11-E12	Clock
E16-E17-E18	E16-E17	Horiz reversal

FUNCTION	*ADJUSTMENT*
H- Size	R40
H- Normal Centering	R38
H- Reverse Centering	R39
V- Size	R19
V- Centering	R37
AFC Tuning	L1

7.7 Image Intensifier Adjustments

7.7.1 6-inch Image Intensifier

ELECTROSTATIC FOCUS ADJUSTMENT

Refer to figure 7-1 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.

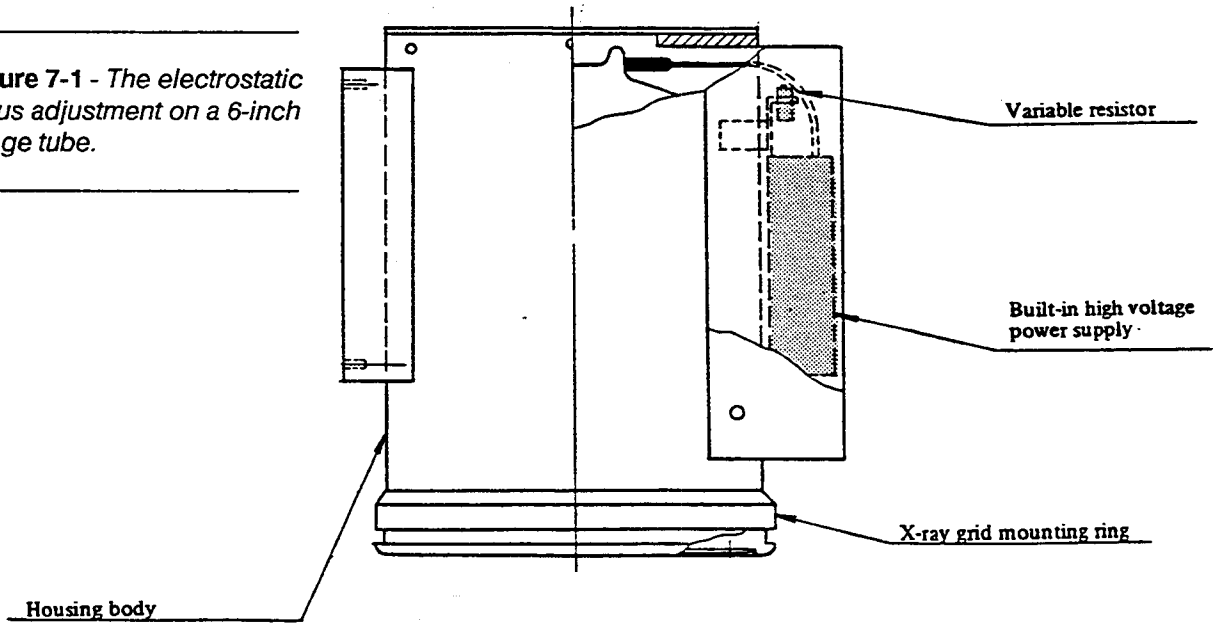


Figure 7-1 - *The electrostatic focus adjustment on a 6-inch image tube.*

7.7.2 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. Refer to Table 2.

Table 2 6/9-inch Image Tube Adjustments

The 6-inch mode adjustments are made to the pots labeled M1; 9-inch mode adjustments are made to the pots labeled N. The M2 adjustments are not applicable.

MODE	*OVERALL SIZE*	*OVERALL FOCUS*	*EDGE FOCUS*
6-INCH	G3	G2	G1
9-INCH	G3	G2	G1

Note: G3 (overall size) may only need adjustment in the 9-inch mode to make the image slightly smaller.

7.8 High Voltage Generator and Generator Controller PCB

These procedures are recommended if the Generator Controller PCB or any High Voltage Generator major component is replaced. Follow these procedures in order.

WARNING: This equipment contains very high power electrical components and should be serviced only by personnel intimately familiar with the circuitry and its operation. The voltages and power levels attainable are capable of causing serious injury, burns, and electrocution. At certain locations, these voltages are present EVEN WITH POWER CORD DISCONNECTED.

WARNING: Due to the high power delivery capability of the battery, and the hazardous voltages present, the mainframe high voltage circuitry should be approached in a cautious and orderly manner.

When energizing a system for the first time following a major repair of the high power or control circuitry, it is important that power limiting techniques be applied until proper functioning can be determined.

7.8.1 Checkout Preparation:

CAUTION: **These checkout tests are to be conducted with the battery and the battery charger disconnected. Do not reconnect the battery or power the charger until directed to do so in these procedures.**

1. Unplug the system from the wall outlet.
2. Disconnect the red connector to the positive lead of the battery, and remove the fuses F2 and F3 in the A.C. power path of the battery charger circuit (these fuses are located on the front of the power panel).

7.8.2 High Power Driver Stage Tests

1. With the high voltage supplies disconnected (as described above) boot the system by running "MAIN 0 " from the external terminal according to the instructions in Section 7.12. The "0 " argument allows the software to operate with no high voltage present.

2. Press START to engage the interlock circuit when prompted on the control panel.

3. Press the "X-RAY ON" switch; with an oscilloscope, the drive pulses at R139 and R156 (ungrounded end) should measure 2.6 +/- .3 volts peak.

4. Measure the turn-off pulse at the trailing edge of the drive pulses seen at R139 and R156. This should be a negative going spike, greater than -1.0 volt in amplitude, and greater than 5 usec. in duration.

5. Disable kV servo by installing jumper E5 on the Generator Controller PCB.

6. Measure the duration of the on-pulses. The duration should be approximately 20 usec.

7. Check that the on-pulse duration can be varied by turning the kVp Knob on the control panel.

8. Remove the jumper from E5.

7.8.3 Power Limited Functional Test

1. Disable the kVp servo by installing a jumper at E5 on the Generator Controller PCB.

2. Set the fluoro technique to: 50 kVp and 0.5 mA.

3. Connect one battery (60 VDC) into the circuit with a 12 ohm 100 watt resistor wired in series with the positive battery lead. (Bypass the other two battery packs).

4. Boot the system by running "MAIN 40 " from the external terminal according to the instructions in Section 7.12. The "40 " argument allows the software to operate with a lower battery voltage present.

5. Make an exposure while observing the following:

   There should be no fault messages on the control panel display and a sinewave should appear at P1-4 and P1-5 of the Generator Controller PCB.

6. Make a fluoro exposure and observe the waveform at TP-13 on the Generator PCB for the following:

kVp Sensor Functional Test A sinewave equal to 42 to 48 percent of the amplitude seen in step 5 should be present during the exposure.

7. Remove the jumper at E5.

8. Make an exposure and observe the following:

kVp Regulation Test The amplitude of the waveform at TP-13 should be 5.0 +/- .20 Vpp, and its amplitude should be adjustable by varying the "KV" knob on the control panel.

NOTE: *It will not be possible to obtain more than about 6 volts p-p with only one battery connected.*

9. Verify the waveform at P1-12 (small filament output) without making an exposure.

Filament Drivers

There should be no signal at P1-11 (large filament) in this mode.

10. Put the system in "FILM" mode and arm for "instant on". This is done by pressing the X-RAY ON switch and releasing it before the exposure actually occurs.

11. Verify the waveform at P1-11 without making an exposure.

Filament Drivers There should not be a signal at P1-12 (small filament) in this mode.

7.8.4 High Voltage Application

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

1. Open the interlock circuit by pressing EMERGENCY OFF. Wait one minute to discharge the filter capacitance. Reconnect all batteries but leave the 12 ohm 100 watt resistor in series.

2. Jumper E5 should be removed and Jumper E3 installed. Set the technique for FLUORO and 50 kVp, 0.5 mA.

3. Reboot the system by typing MAIN at the terminal. (Refer to the instructions in Section 7.12).

CAUTION: *Do not use the "0 NOCAL" argument this time, as this will close the large contactor prematurely, resulting in very large inrush currents.*

4. Make a fluoro exposure and observe that no fault messages appear on the control panel display.

5. Turn off the keyswitch. Disconnect the power cord from the wall outlet. Wait one minute to discharge the filter capacitance. Remove the series 12 ohm resistor, reconnecting the batteries in their normal configuration.

6. Remove both jumpers E3 and E5 from the Generator Controller PCB.

7.8.5 Adjusting Charger Output Voltage

1. The batteries are connected in their normal configuration prior to this procedure (see step 5 of the previous procedure).
2. Unplug the power cord. Install F-2 and F-3 to provide A.C. power to the charger circuit.
3. Remove the panel mount fuse below the Generator Controller PCB.
4. Plug in the power cord. Leave the interlocks disengaged - DO NOT PRESS START.
5. Adjust R-108 for 211 +/- 3 VDC at C-63(+).

7.8.6 Adjusting Charger Voltage Readout (Bargraph)

1. Adjust R109 clockwise until the bargraph reads below 210 volts.
2. Then turn R109 counter-clockwise until the 210 volt LED just turns on.

7.8.7 Generator Controller PCB Jumpers

JUMPER	*SHOULD BE*	*FUNCTION*
E3	IN only for calibration	disables mA servo
E5	IN only for test	disables kV servo

7.9 Analog Support PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Counter Timer Clock-Input
E4-E11	TBA	Board Rev

7.10 Technique Processor PCB

Switch Settings

SWITCH	*SHOULD BE*	*FUNCTION*
S1		reserved
S2		reserved
S3	OFF	real time clock disable
S4	ON	autoboot switch, if off mainframe will boot in monitor program
E0-E3		Board Rev
E9, E10	IN, IN	Real Time Clock Oscillator

Adjustment

Disk Drive Interface - Read/Write Pulses

Use this procedure to adjust the read/write data pulse widths. Measure frequency and pulse widths at the test points indicated using an oscilloscope. To obtain proper accuracy in this measurement, set the horizontal scale as indicated in [brackets] below.

1. Connect the 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 [set scope on 100 ns/div].

7.11 Control Panel Processor PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E3	IN	Dual UART Oscillator Circuit

Switch Settings

SW8	*SW7*	*BAUD RATE*
off	off	9600 baud (normal)
off	on	4800 baud
on	off	2400 baud
on	on	1200 baud

SW5	SW4	COMMUNICATION DIAGNOSTICS
off	off	disabled (normal)
off	on	echo key request to terminal
on	off	echo T.P. commands to terminal
on	on	undefined

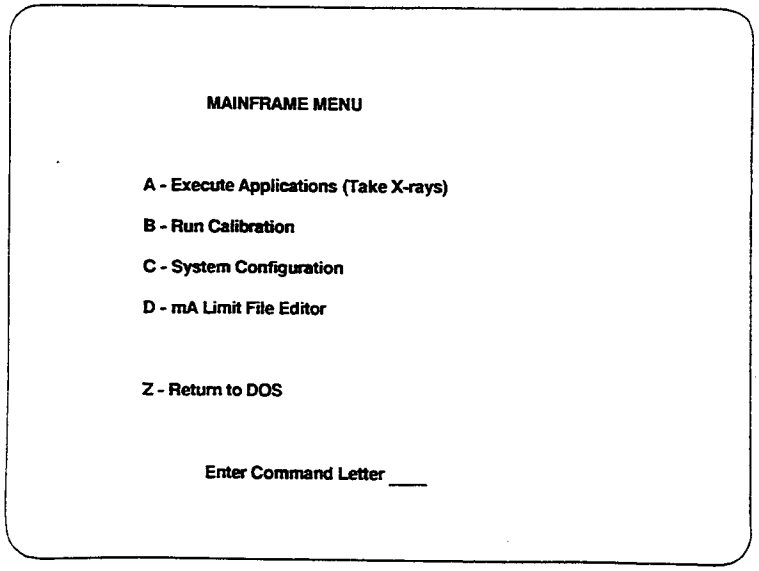
SW3	SW2	SW1	DIAGNOSTIC MODES
off	off	off	normal operation
off	off	on	segment & LED check
off	on	off	keyboard diagnostics
off	on	on	clock & speaker checks
on	off	off	UART loop test
on	off	on	memory test
on	on	off	undefined
on	on	on	undefined

7.12 Accessing the Mainframe with the External Terminal

7.12.1 Mainframe Terminal Menus

Mainframe software menus are accessed from the monitor cart MAIN MENU by selecting "Access Mainframe Menu".

This Mainframe Menu will appear.



Refer also to Section 8.6.3 in *Monitor Cart Service* for a summary of the selections available from the monitor cart Main Menu.

7.12.2 To Access Mainframe DOS (MSDOS$_{TM}$)

1. Connect the external terminal by following the instructions given in the Appendix: *External Terminal Use*.
2. Press [ESC] to view the Program Access Menu.
3. From the Program Access Menu select: *Z-Return to Main Menu.*
4. From the Main Menu select: *Y-Access Mainframe Menu.*
5. From the Mainframe Main Menu select: *Z-Exit to DOS.*

7.12.3 Booting From the External Terminal

1. The system can be booted from the external terminal for certain test procedures. Do this only when specifically told to do so in the test procedure.
2. Enter the command line desired after performing step 5 in Section 7.12.2 above:

   Type *MAIN* to invoke the Main Program.

   Type *MAIN 0* when required by certain test procedures.

7.12.4 Exit Applications Software

If the mainframe fails at the "Press Start" prompt during startup, the Main Menu can be accessed by pressing [ESC] and typing END.

7.13 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 Generator Controller PCB.
3. The bargraph may indicate 160 or 170 volts during the exposure. If the voltage drops to 150 volts, there could be a problem with the batteries.

7.14 Evaluating the Battery Charger

The battery charger circuit on the Generator Controller 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 measured at E1 should be about 210 VDC.
2. Above 625 mA the voltage measured at E1 should rise to approximately 230 VDC.
3. Above about 2 amps charger current, the charger current limits and the charger voltage at E1 will decrease.
4. Overvoltage shutdown should occur above approximately 240 VDC, indicated by a sudden drop in output voltage at E1.
5. During mainframe boot, the charger output is shutdown momentarily; the output voltage should briefly drop to about 150 VDC.

7.15 Resetting the Battery Circuit Breaker

The 50 Amp battery circuit breaker will trip in the event of a major overload in the battery circuit. Determine the cause before resetting. *Refer to Figure 7-2.*

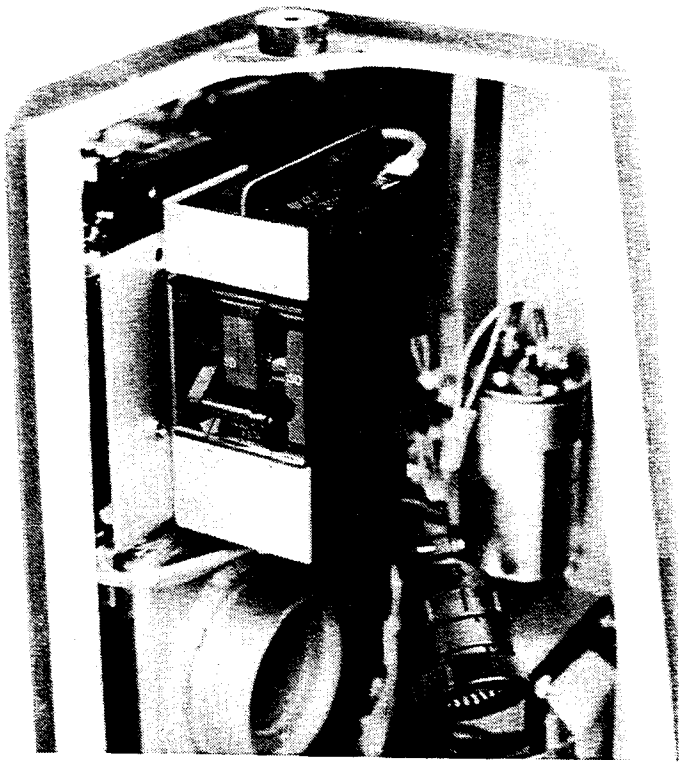


Figure 7-2 - *The battery circuit breaker is shown in this photo.*

7.16 Mainframe Mechanical Adjustments

7.16.1 Loosening a Stuck Lift Shaft

If either of the limit switches on the lift column are badly misadjusted, the column may bind at the top or bottom of its travel.

1. Directly above the top of the shaft, there is an access hole through which to insert a hex wrench.
2. Reach the wrench into the hole and onto the hex head at the top of the shaft. Turn the shaft in the direction opposite to the bind.

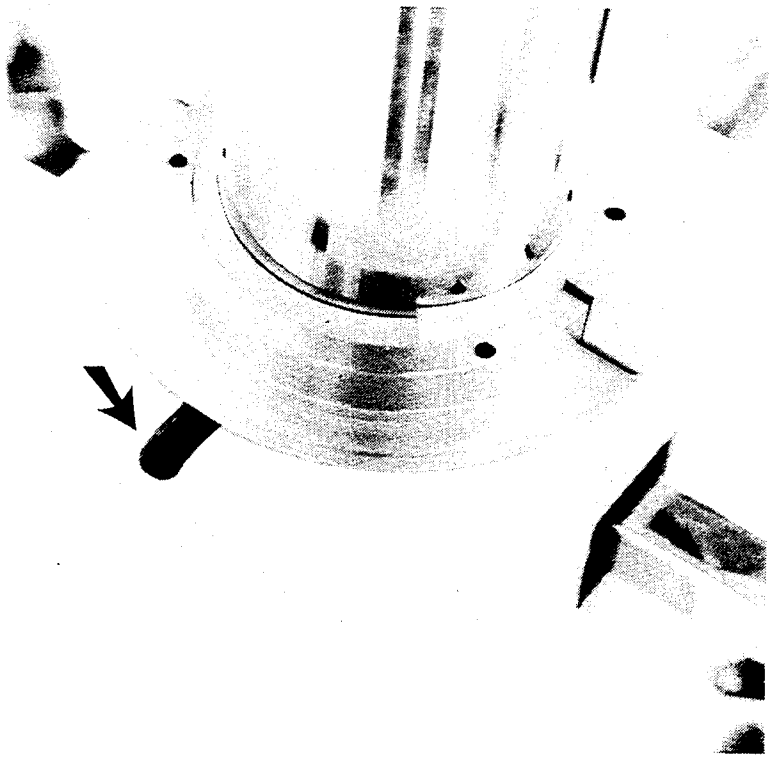


Figure 7-3 - *The lift shaft can be turned with a hex wrench inserted through this hole.*

7.16.2 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 blade screwdriver rotate each bearing to minimize sloppy, loose or irregular movement of the the C-arm within the cradle. Do not adjust these to cause overtight bearing contact.
3. Test the bearing contact through the full range of movement.
4. Tighten the set screws.

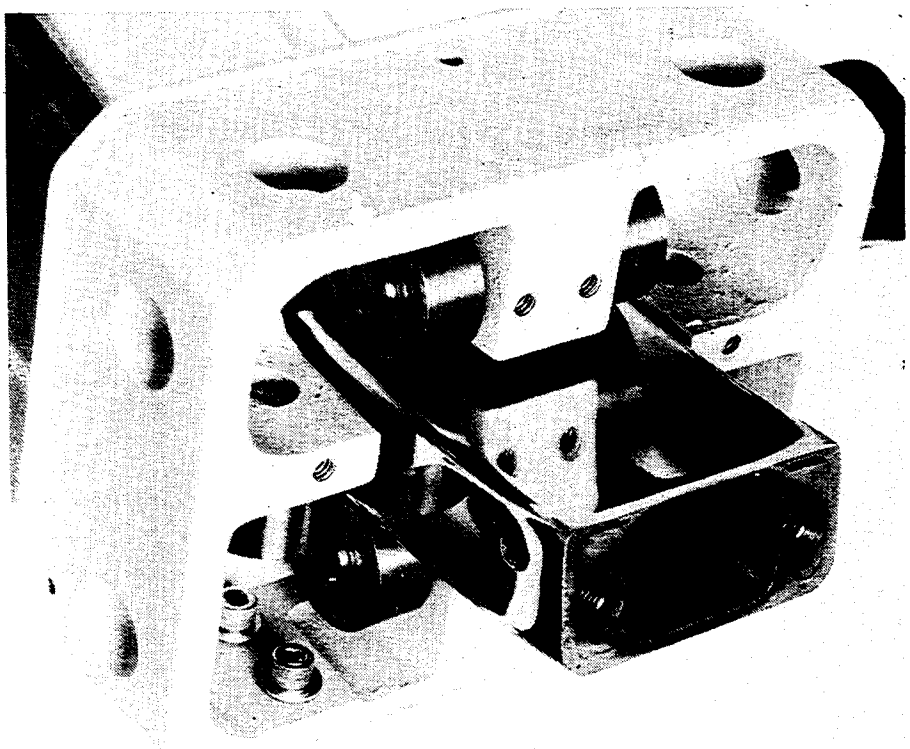


Figure 7-4 - *The cradle bearings can be exposed in the bearing blocks.*

SECTION 8
MONITOR CART
SERVICE AND DIAGNOSTICS

8.1 Safety Precautions During Service

Read the Safety section of this manual before attempting any service procedures which require removal of the electronics covers.

WARNING **Use extreme care if you must perform adjustments or tests on the electronics when power is applied.**

8.2 Monitor Cart Progress and Error Codes

The alphanumeric display on the monitor cart front panel will display error codes when faults occur with the monitor cart electronics. These are listed and described below.

8.2.1 Boot Progress Codes

During the software loading or boot process, the alphanumeric LEDs on the front panel will display "b" codes, indicating where in the boot sequence, code is being executed. Since these codes do not normally indicate an error, they are referred to as *progress codes*. Typically, these codes will be erased once normal program operation has begun. If the program does not complete the boot process, a "b" code will remain on the LED display, indicating the point where an error occurred. The meaning of each "b" code is described below.

b0 - Initial start from address 0000H.
b1 - Attempting to load from floppy disc drive
(may be connected during service or software installation).
b2 - Attempting load from hard drive.
b3 - Boot load failed.
b4 - Cold boot program loaded, attempting to load DOS.
b5 - DOS loaded.
b6 - SEARCH.COM has been loaded and is searching for the number of the last image saved to the hard disk.
b7 - SEARCH.COM has successfully completed the search.

8.2.2 Initialization Progress Codes

Once the main program has been loaded, a series of "A" progress codes will be displayed. When initialization is completed, the "A" code will be erased and the next available image location will be displayed. Each "A" code which occurs during the initialization process is defined below.

A1 - Overlay manager is loaded.
A2 - Memory is being initialized.
A3 - Video relays are being initialized.
A4 - Image Processor PCB is being initialized.
A5 - Initializing X-Ray system communications.
A6 - Initializing internal software error handler.
A7 - Initialize gray scales and log RAMS.
A8 - Initialize VTR.
A9 - Initialize HELP function.

8.2.3 Hard Disk Drive Error Codes

During initialization or program execution, unrecoverable hard disk errors may occur. An error will be reported on the monitor cart front panel LED display. "d" codes that might appear during initialization or operation of the system are described below.

d0 - No image was found at the location specified during a hard disk image recall. This is a user error which does not indicate a malfunction.
d2 - Cannot find the requested data block.
d3 - A bad data block was encountered.
d4 - A formatting error occurred.
d5 - The drive cannot find its alternate track.
d6 - A Disk Controller PCB time out error occurred.
d7 - An internal software error was detected.
d9 - The hard disk is not ready.
dA - A drive error occurred.
dB - A Disk Controller PCB error occurred.
dC - Attempting to recall an invalid image.
dD-dF - Reserved for future use.

8.2.4 Program Errors

Operator and program errors are displayed on the front panel. The following error codes all occur during execution of the main program:

ERROR: **E1**
CAUSE: The front panel has not responded to the host processor over the serial communication link.
CHECKS: Observe the serial data lines between the host and the front panel. Verify that the front panel software is correct and that the processor is running.

ERROR: **E2**
CAUSE: Repeated NAK response from the front panel to the host processor.
CHECKS: Same as error E1.

ERROR: **E3**
CAUSE: Repeated invalid response from the front panel to the host processor.
CHECKS: Same as error E1.

ERROR: **E4**
CAUSE: Image processor has not responded to the host processor over the serial communication link.
CHECKS: Check the serial data lines between the host and IP. Verify that the IP software is correct and processor is running.

ERROR: **E5**
CAUSE: Repeated NAK response from IP to the host processor.
CHECKS: Same as error E4.

ERROR: **E6**
CAUSE: Repeated invalid response from the IP .
CHECKS: Same as error E4.

ERROR: **E7**
CAUSE: X-ray System communications error.

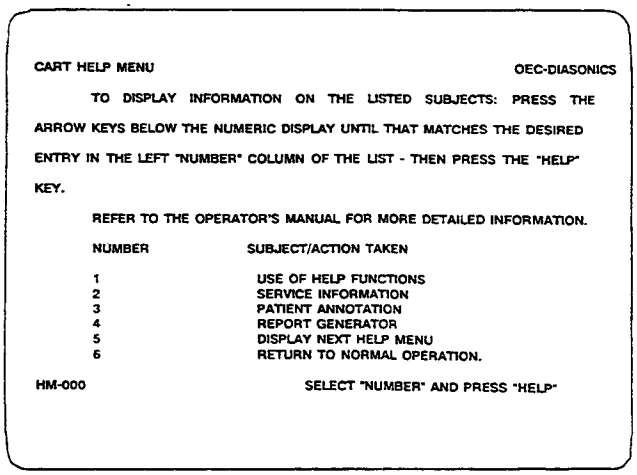
8.3 Monitor Cart Diagnostics Menus

The Diagnostics Menus provide access to:

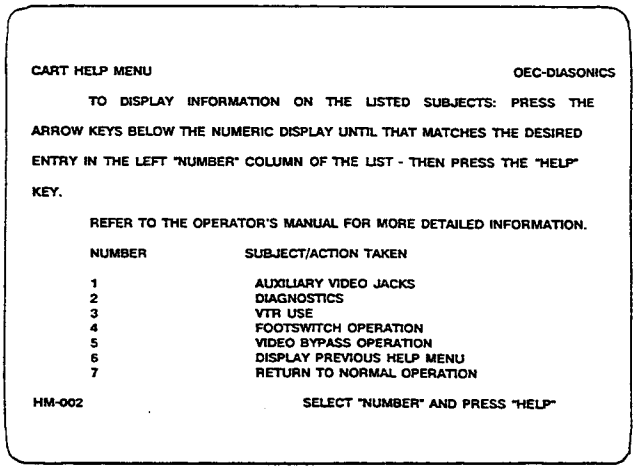
Front Panel Controlled Diagnostics
Terminal controlled Diagnostics

These are discussed in the following pages. The steps below describe how to select and use the Diagnostics Menus:

1. Press HELP HELP (HELP twice) to view the first menu, shown here. From this menu select entry NUMBER 5.

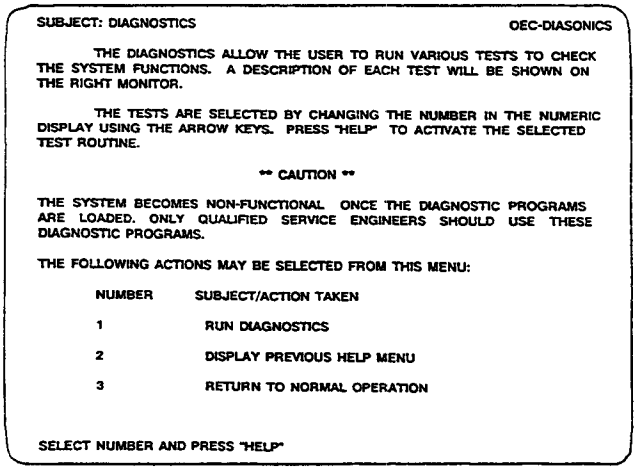


2. Select NUMBER 2 - DIAGNOSTICS and press HELP.



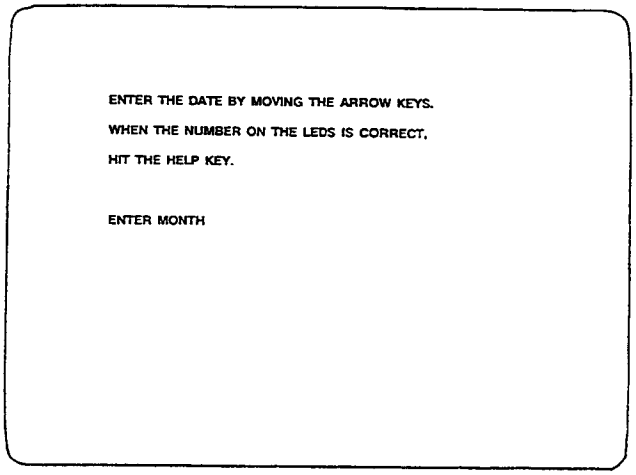
3. Select NUMBER 1 - RUN DIAGNOSTICS.

   The system cannot be operated for normal use when the diagnostic software is loaded. Only qualified service engineers should use these programs.

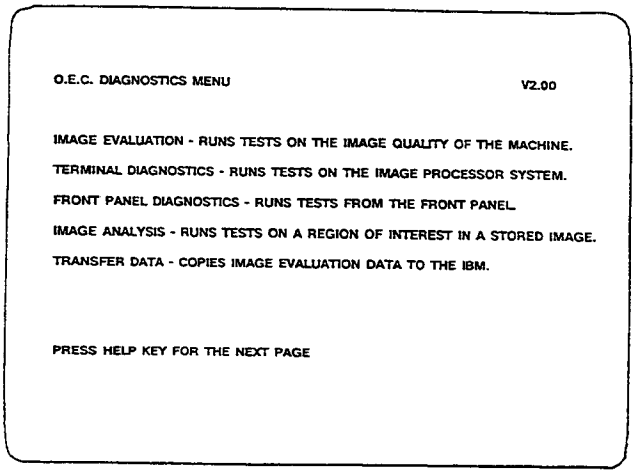


4. You are first asked to enter the date. Press the arrow keys, up or down, until the correct number is displayed on the LED readout. Then press HELP to complete the entry.

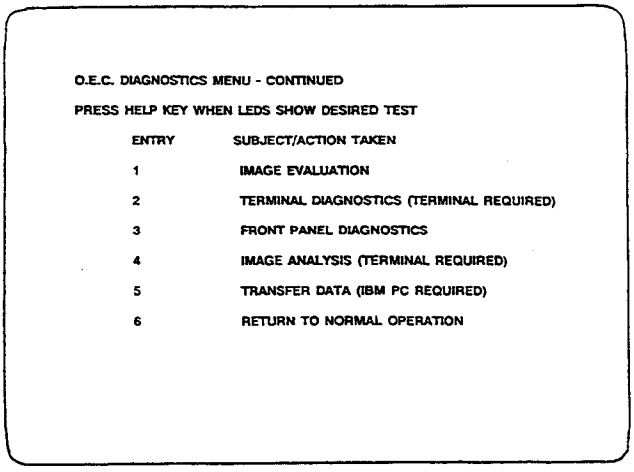
Enter the month.
Enter the day
Enter the year.



5. This help screen will appear with a brief description of the functions available in the next menu. Press HELP for the next screen.



6. Select the desired diagnostics from this menu. Each of the diagnostics is described in the following sections. Enter the number and press HELP. Entry NUMBER 6 will return you to normal operation.

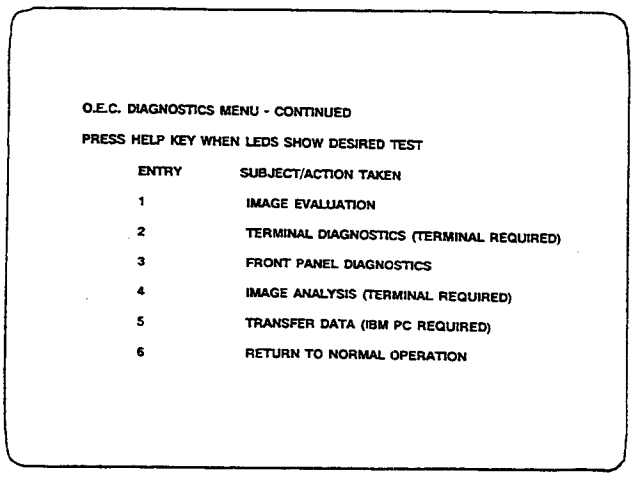


8.4 Front Panel Diagnostics

The Front Panel Diagnostics test the monitor cart electronics and are selected from the Front Panel Diagnostic Menu.

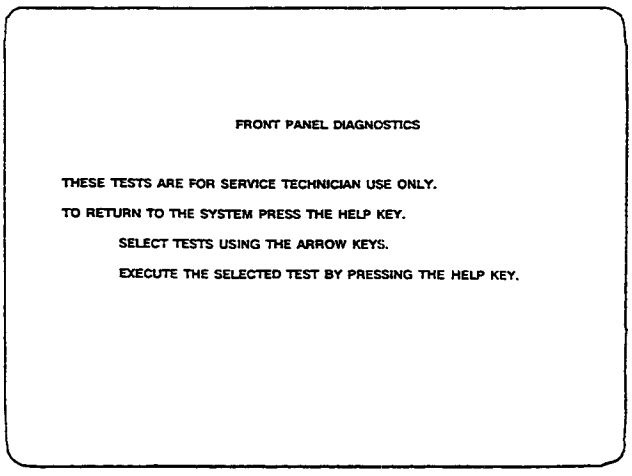
---

1. Select ENTRY 3 - FRONT PANEL DIAGNOSTICS from the Diagnostics Menu. (See above: *Entering the Diagnostics Menus*).



2. Refer to the list of Terminal Diagnostics given in the next section. These tests are identical, except where noted. (The cycle memory test #11, for example, is not available from the front panel).

3. Select the desired test number on the LED readout by using the arrow keys. Begin the test by pressing HELP.



8.5 Terminal Controlled Diagnostics

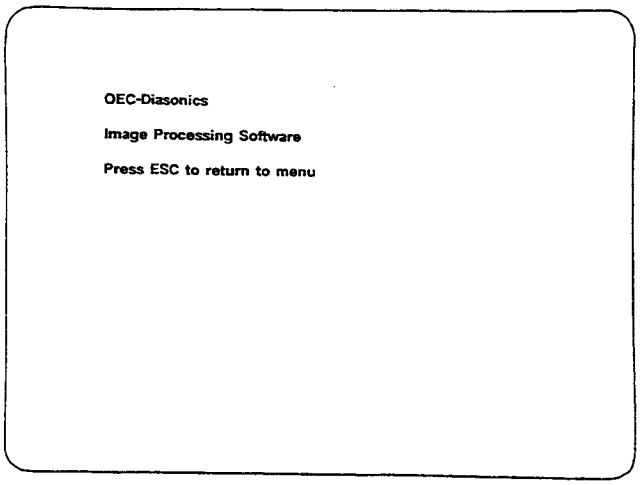
The Terminal Controlled Diagnostics test the monitor cart electronics. These same tests may be accessed from the front panel.

8.5.1 Using the Terminal Controlled Diagnostics

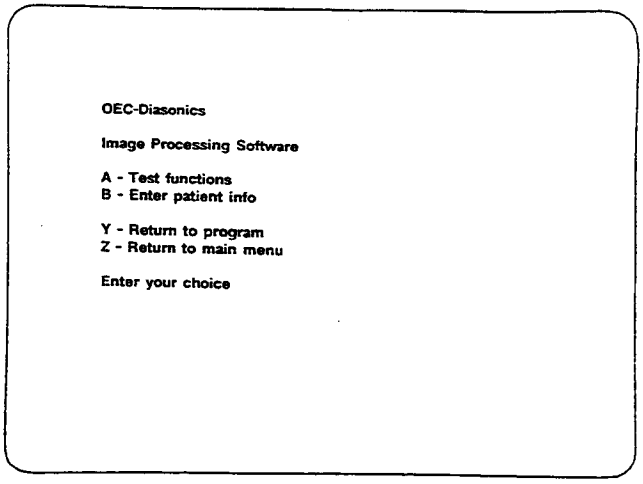
The Terminal Diagnostics require the use of an externally connected computer terminal. (Refer to the Appendix: *Terminal Installation and Use*).

---

1. Connect a terminal (such as the DXR keyboard terminal described in the Appendix), to the RS-232 connector on the rear of the monitor cart. The screen shown here will appear when the cart is booted. Press [ESC].

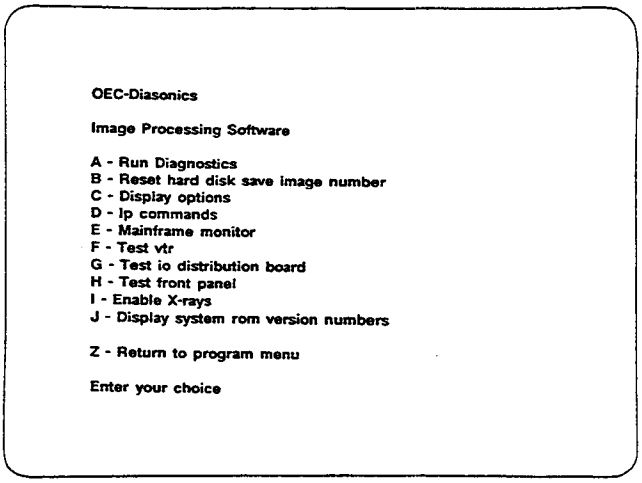


2. Select ENTRY A - TEST FUNCTIONS from the program access menu.



3. A list of choices will appear on the terminal screen (or the monitor screen if it is being used as the terminal).

Enter: A - RUN DIAGNOSTICS.



4. The following tests may be selected from the terminal screen. Type in the number and press [RETURN].

1 - Segment Ram Test	15 - Exchange M1 Data
2 - Memory Segment Read Test	16 - Exchange M2 Data
3 - Memory Segment Write Test	17 - Swap M1/m2 Data
4 - M1 Clear Test	18 - Left Monitor Live
5 - M1 Memory Test	19 - Left Monitor Digital
6 - M1 Exchange Test	20 - Select Gray Scale Val.
7 - M1/M2 Swap Test	21 - CRT Character Test
8 - M2 Clear Test	22 - Front Panel Test
9 - M2 Memory Test	23 - Video Test Pattern
10 - M2 Exchange Test	24 - Front Panel LED Test
11 - Cycle Memory Tests	
12 - Write Vertical Gray Scale	99 - return to system
13 - Write Horiz. Gray Scale	
14 - Invert M1 Data	

8.5.2 Explanations of the Terminal Diagnostics

This section briefly describes each diagnostic test. Note that options 1 thru 10 are memory tests that can be repeatedly cycled by selecting option 11. However, the cycle capability exists only when the external terminal is used. The front panel diagnostics will automatically jump over option number 11 (and option 20 which is also limited) while scrolling through the options.

Most tests listed below may be performed in any order required. The Video Test Pattern is one of the tests included in this group.

The order in which the memory tests are listed is the order in which they should be run. Their order must be followed since an error in a prior test will make the next test useless.

Error Messages - The errors that are detected during these tests are displayed in different ways depending on how the tests were originated. When using the terminal oriented diagnostics it is possible to relay more information about the error condition to the terminal than it is using the front panel diagnostics. The front panel diagnostics assume that there is not a terminal interfaced to the system, so all error messages are displayed on the front panel LED display. The first character of the display will be an "E" and the second digit will be a hex value between 0 and F that corresponds to the error found. If the error condition is a number greater than 15 (or F hex) then an F will be displayed. The cycle test mode also restricts the amount of error information displayed.

1- SEGMENT RAM TEST

This test first writes AA hex to every address in the segment ram. Each line is then read into a 512 byte buffer that was previously cleared to 0's. If each byte of the buffer now contains AA hex, then the same test is performed using 55 hex.

Error messages- In the terminal diagnostic mode text messages indicate the number of errors encountered for each bit mask. The cycle test returns 1 error for each bit mask test that failed, for a possible total of 2 errors per pass. The front panel diagnostics will return an error code of "E1" if any error occurred, or an error code of "E0" if no errors were detected.

2- MEMORY SEGMENT READ TEST

The function of this test is to verify that a segment can be read from the memory M1. This is accomplished by filling a 16k byte block of dram with the value FF hex (this sets all bits to 1), then clearing the memory, reading segment #0 of M1 into the DRAM block that previously contained all 1's, and then checking to see that all memory bits were cleared to 0.

Error messages- The error value returned by this test indicates the number of bytes in the segment that remained uncleared. In the front panel diagnostic mode, an error value greater than 15 will be displayed as

an "F". In the cycle mode, any number of errors found will be counted as a single error per pass.

3- MEMORY SEGMENT WRITE TEST

This test is to verify that a segment of data can be written to the memory M1. First M1 is cleared, then a 16k byte section of DRAM is filled with the alternating bit pattern of 55 hex. The entire segment is written to memory M1 segment #0, then read back into dram and checked to see if every byte was properly written. The test is then repeated using the bit pattern AA hex.

Error messages - The error value returned by this test indicates the number of bytes in the segment that was found to contain a value other than that which was written to it.In the front panel diagnostic mode an error value greater than 15 will be displayed as an "F". In the cycle mode, any errors found will be counted as a single error per pass.

4- M1 CLEAR TEST

This test checks to see that a "clear frame" operation can be performed on memory M1. The hex value FF is written to an address in segment #0 of memory M1, and then a clear frame operation clears the entire 128k block. The address previously written to is then checked for a value of 0.

Error messages - This test returns an error of 1 if it failed, and 0 if it passed.

5- M1 MEMORY TEST (takes approximately 3.5 min)

This test alternates every bit of the frame and checks the result. First the value 55 hex is written to each byte of the frame, and then read back and verified. The same is done using the hex value AA.

Error messages- Using the terminal diagnostics, an error message statement is returned for each segment declaring that either an error was found in that segment, or that the segment memory checked out OK. In the front panel test mode an error code of "E1" indicates that the failure occurred during the first pass when the hex value 55 was written, and an error code of "E2" means that the error was discovered when expecting to read back AA hex. In cycle mode the error value accumulated during a single pass indicates how many segment errors were found for both bit masks. For example, if the error total was incrementing by 32 for each cycle, that would indicate that all 16 segments had at least 1 error during both the AA and 55 bit tests.

6- M1 EXCHANGE TEST

This test verifies that the "exchange frame" function is working properly. When an exchange frame is performed on either M1, or M2, the address lines are changed so that the background frame becomes the foreground frame, and vice versa. First the hex value AA is stored in a single memory address in segment #0of M1. The foreground frame is then exchanged to the background, and the hex value 55 is stored in the new foreground frame. Another exchange frame is called which, if everything happened according to plan, should leave the AA back in the foreground memory.

After checking the AA, an exchange frame is called one more time, and the new foreground is checked for the 55 value that was stored there earlier. The same test is then repeated for the other 15 segments.

Error messages - In the terminal diagnostic mode, a message is displayed after checking each of the sixteen segments.The error message will either indicate that the segment checked out OK, or it will say that when it was expecting to read a hex value of ??, it in fact found a hex value of ??. In front panel mode, the error value represents the number of segments in which an error was encountered. In cycle mode, any errors are counted as 1 error per pass.

7- M1/M2 SWAP TEST

Because the only memory that can be read from, and written to directly is the foreground frame of M1, the M2 memories can only be accessed by swapping the information in M2 to M1. The result of a swap leaves the foreground of M2 in M1, and vice versa. The swap test first clears both M1 and M2 foreground memories, and then the value 55 hex is stored to a single address of segment #0, and written to M1. The entire frame is then swapped to M2, and a hex AA is stored in the same address of the cleared frame that is now in M1. A swap is performed again and a check is made to verify that the 55 was swapped back to M1. Once more a swap is performed and this time an AA is expected in M1.

Error messages- During the terminal diagnostic test an error message will be displayed indicating the result of the test. In front panel mode an error code "E1" means that an error was detected while trying to read the 55 hex, an "E2" means that the failure occurred when the AA was expected, and an "E3" indicates that both failed. Cycle mode returns a single error per pass if any errors occurred.

8- M2 CLEAR TEST

This test checks to see that a "clear frame" operation can be performed on memory M2. The hex value FF is written to an address in segment #0 of memory M1, then swapped to M2. M2 is then cleared using a clear frame operation, and swapped back to M1 to be checked for any bits that were not cleared.

Error messages- This test returns an error of 1 if it failed, and 0 if it passed.

9- M2 MEMORY TEST (takes approximately 3.5 min)

This test alternates every bit of the frame and checks the result. First the value 55 hex is written to each byte of the M1 frame, swapped to M2, swapped back to M1, read back and verified. The same is done using the hex value AA.

Error messages-Using the terminal diagnostics, an error message statement is returned for each segment declaring that either an error was found in that segment, or that the segment memory checked out OK. In the front panel test mode the an error code of "E1" indicates that the failure occurred during the first pass when the hex value 55 was written, and an error code of "E2" means that the error was discovered while expecting to read back AA hex. In cycle mode, the error value

accumulated during a single pass indicates in how many segments errors were found, for both bit masks. For example, if the error total was incrementing by 32 for each cycle, that would indicate that all 16 segments had at least 1 error during both the AA and 55 bit tests.

10- M2 EXCHANGE TEST

This test verifies that the "exchange frame" function is working for the M2 frames. First the hex value AA is stored in a single memory address in segment #0 of M1, and then M1 is swapped to M2. The foreground frame of M2 is then exchanged to the background. The hex value 55 is then stored in M1 and then swapped to M2. Another exchange frame is called, which should leave the AA back in the foreground memory of M2, with 55 in the background frame. After checking the AA, an exchange frame is called for M2, and the new foreground is checked for the 55 value that was stored there earlier. The test is repeated for the other 15 segments.

Error messages - In the terminal diagnostic mode, a message is displayed after checking each of the sixteen segments. The error message will either indicate that the segment checked out OK, or it will say that when it expected to read a hex value of xx, it instead read a hex value of yy. In front panel mode, the error value represents the number of segments in which an error was encountered. In cycle mode, errors are counted as 1 error per pass.

11- CYCLE MEMORY TESTS

The cycle mode repeats the memory tests, keeps track of the number of cycles performed, and accumulates the number of errors. This type of test is especially useful in tracking down system failures that are intermittent, or of a thermal nature. One useful feature of this mode is the ability to select the tests to be included in the cycle, while ignoring the others.

NOTE: Most of the following tests write data to the foreground of memory M1. Although it is not possible to write data directly to M2, a "SWAP M1/M2" (option 16) allows any data in M1 to be swapped into M2.

12- WRITE VERTICAL GRAY SCALE

A vertical gray scale is written to M1.

13- WRITE HORIZONTAL GRAY SCALE

A horizontal gray scale is written to M2.

14- INVERT M1 DATA

Inverts the data in the foreground of M1 byte by byte.

15- EXCHANGE M1 DATA

Exchanges the foreground memory of M1 for the background memory by switching address lines.

16- EXCHANGE M2 DATA

Exchanges the foreground memory of M2 for the background by switching address lines.

17- SWAP M1/M2 DATA
A processing function of the Image Processor swaps the data in the foreground memory of M1 with the data currently in the foreground memory of M2.

18- DISPLAY LEFT MONITOR LIVE
The left monitor displays a live non-digitized picture, and the system allows X-rays. X-rays are disabled upon exiting this option.

19- DISPLAY LEFT MONITOR DIGITAL
The left monitor displays a digitized picture, and the system allow X-rays. X-rays are disabled upon exiting this option.

20- SELECT GRAY SCALE VALUE
This option allows the technician to choose what gray scale value to write write to M1. The system allows a value between 0 (black) and 200 (white).

21- CRT CHARACTER TEST
A block of text characters is written to M1 which can be used to verify that the monitors have been set up properly, allowing all text lines to be clearly visible.

22- FRONT PANEL TEST
Using the terminal diagnostics, the scan codes for each front panel key is displayed on the terminal when each key is pressed. With the front panel diagnostics the scan codes are displayed as hex values on the LED display.

23- VIDEO TEST PATTERN
This test draws a special video test pattern to M1, and uses that pattern on M1 as a mask to do a digitized subtraction on M2. X-rays are allowed during this option so that the camera can be properly centered. The instructions to the technician for aligning both the monitors and the camera are written to the monitors along with the pattern. X-rays are disabled upon exiting this mode.

24- FRONT PANEL LED TEST
The front panel LED test turns on all of the front panel LED's. The LED`s are all turned off again when the test is exited. When this test is initiated using the front panel diagnostics, the "HELP" key LED will flash to remind the technician how to exit this mode.

99- RETURN TO SYSTEM
Places the system at the diagnostics menu, where Return to System can be selected, returning normal operation with the same defaults and parameters used to begin with at power-up.

8.6 Monitor Cart Terminal Mode

The Terminal Mode requires the use of an externally connected computer terminal. (Refer to this in the Appendix under *Terminal Installation and Use*).

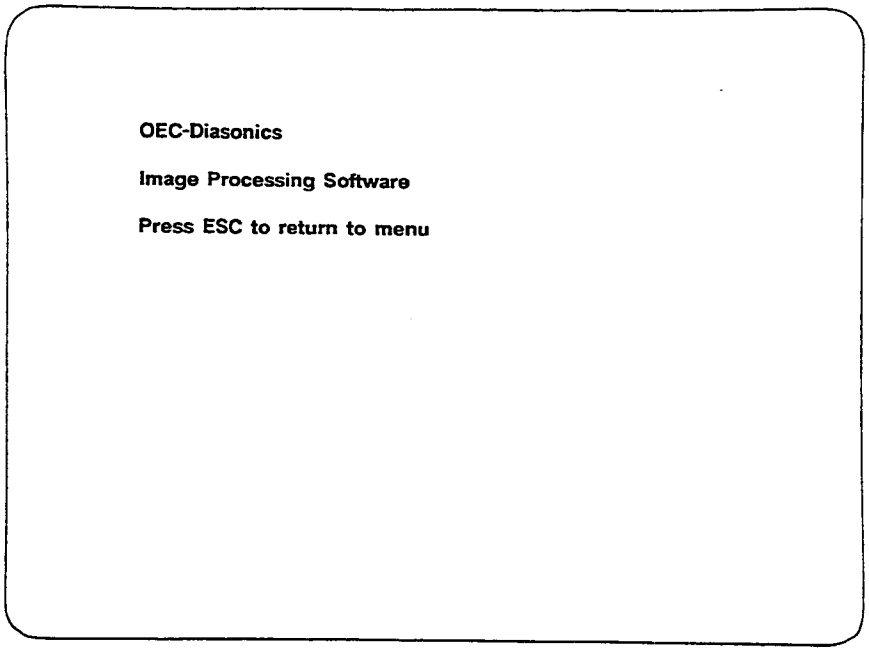
Some menu entries are passcode protected. Each attempt to select one of these protected entries generates an access code. A passcode is then required to unlock each access code. A new access code is generated with each access.

The major screen menus which can be accessed with a terminal are shown below.

8.6.1 Initial Menus

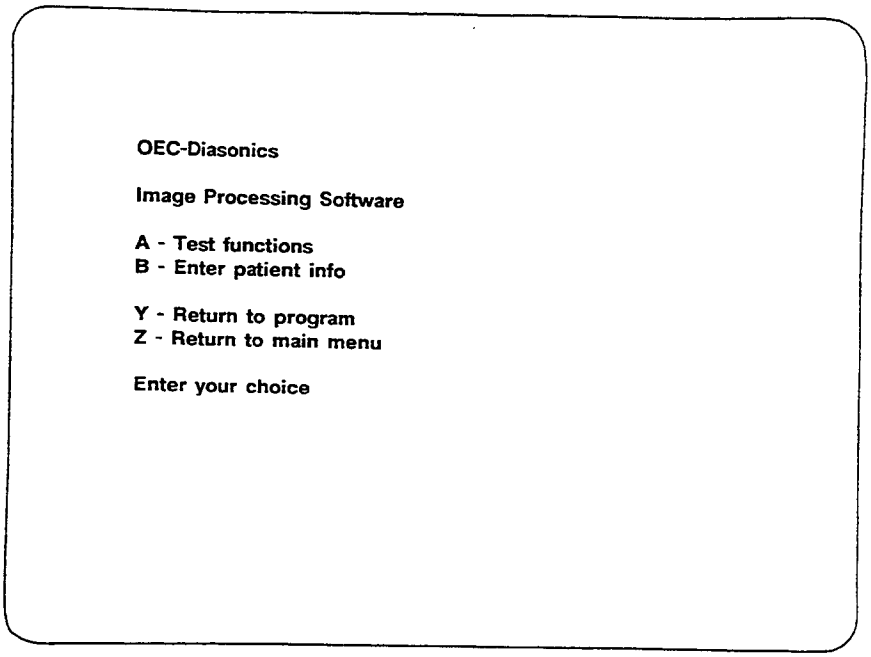
8.6.1.1 Powerup Screen Message

The powerup screen first appears when the terminal is turned on.



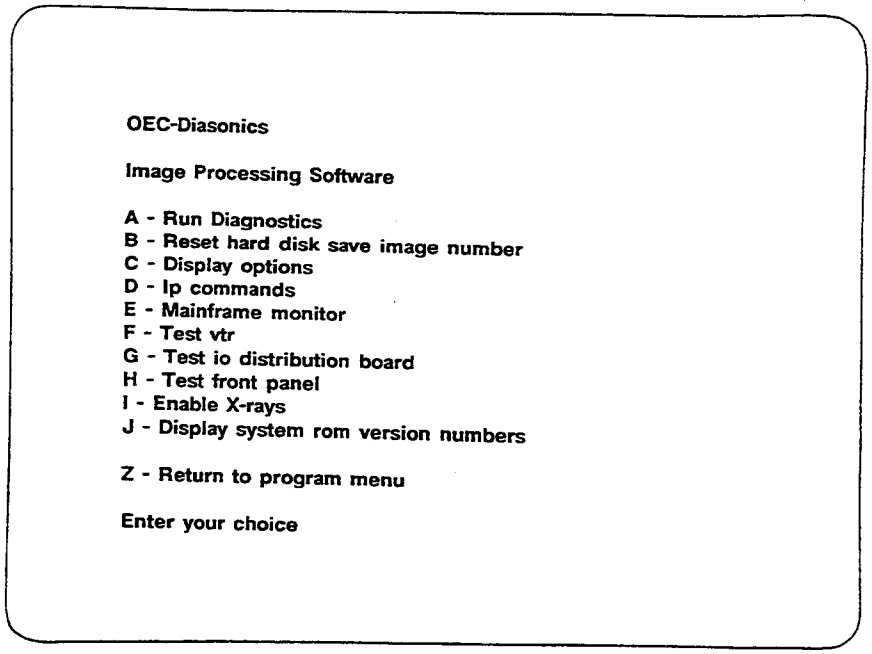
8.6.1.2 Program Access Menu

Press [ESC] for the Program Access Menu.

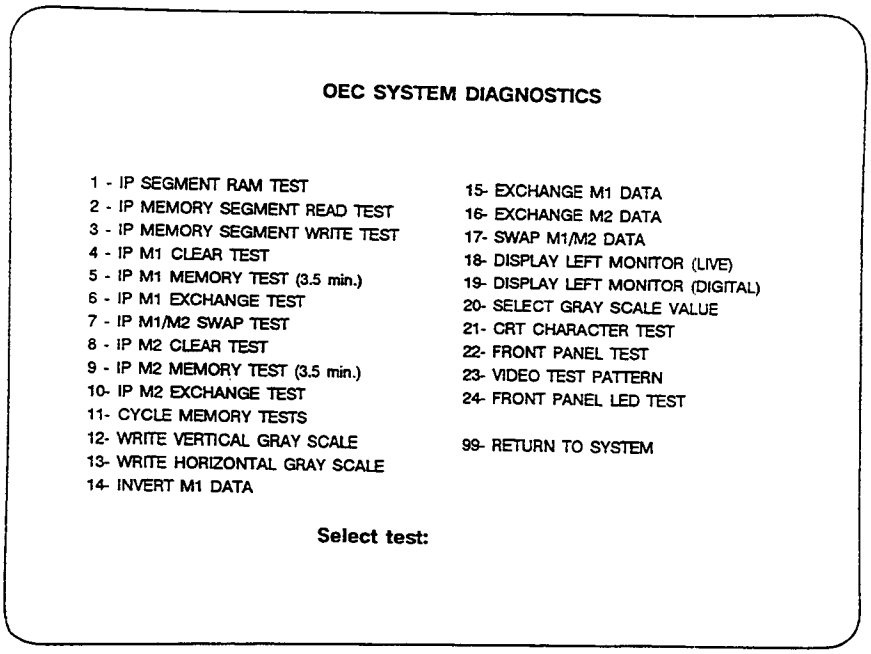


8.6.2 Test Function Menu

This menu lists test functions.

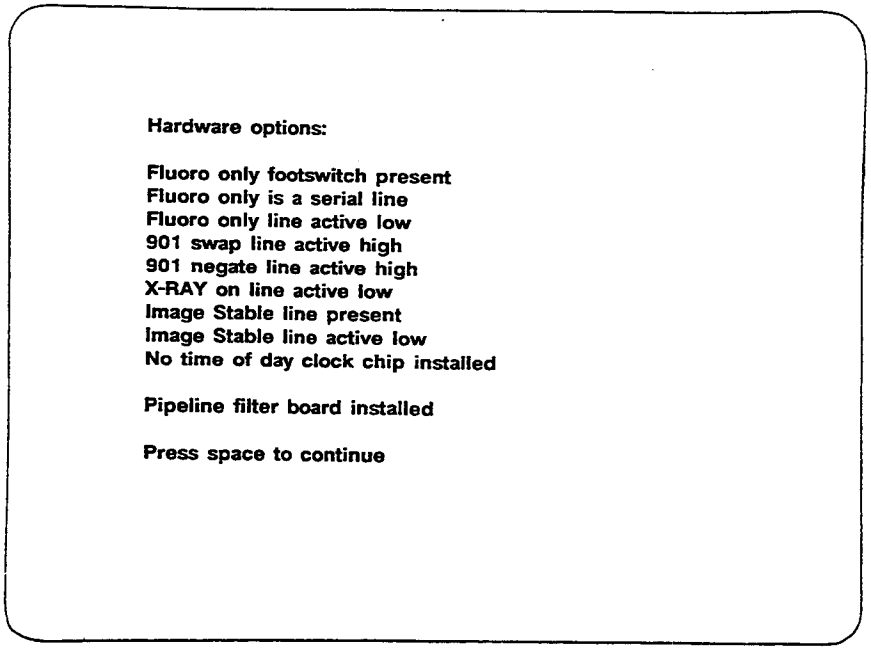


8.6.2.1 Run Diagnostics

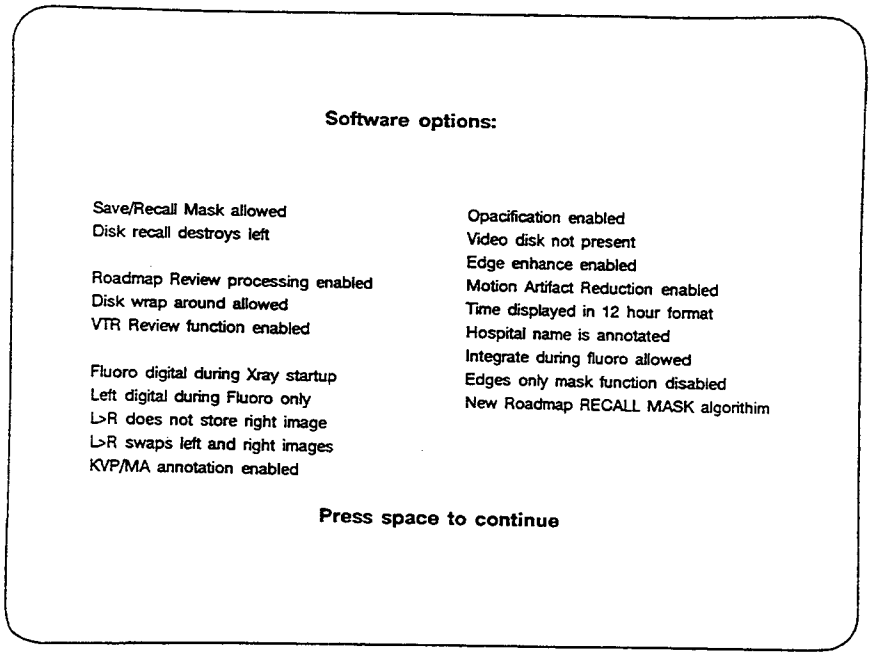


8.6.2.2 Display Options

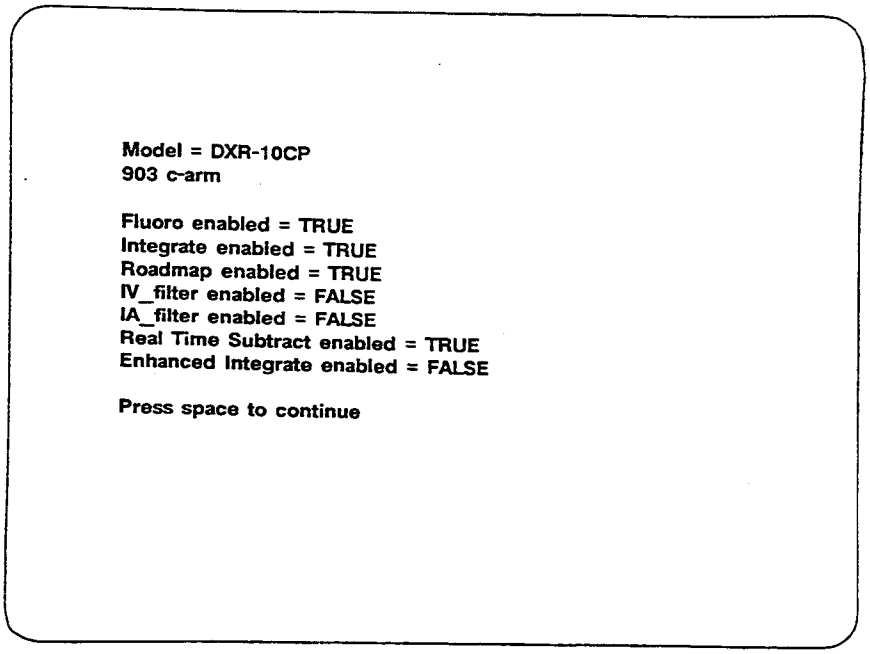
Hardware Options



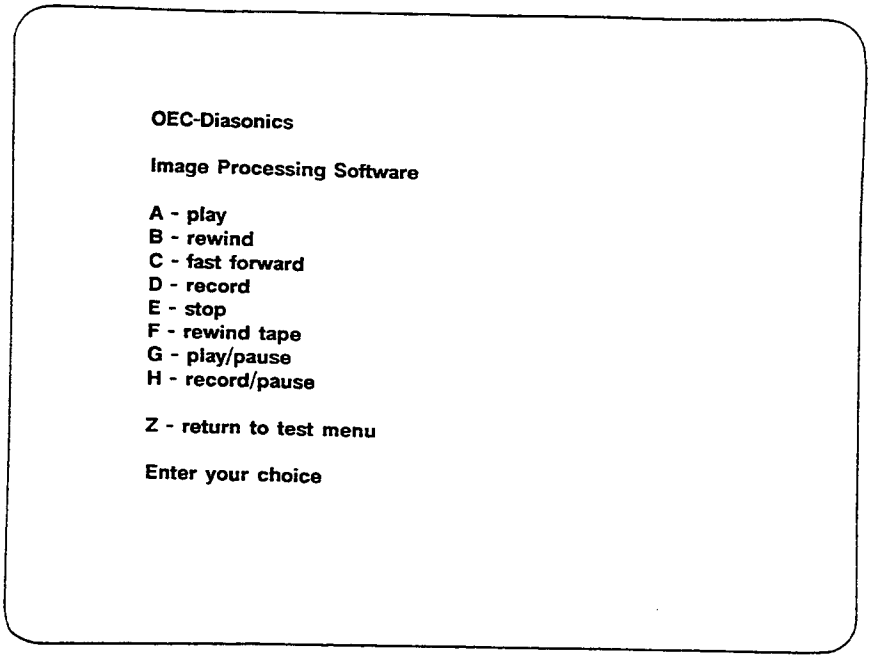
Software Options



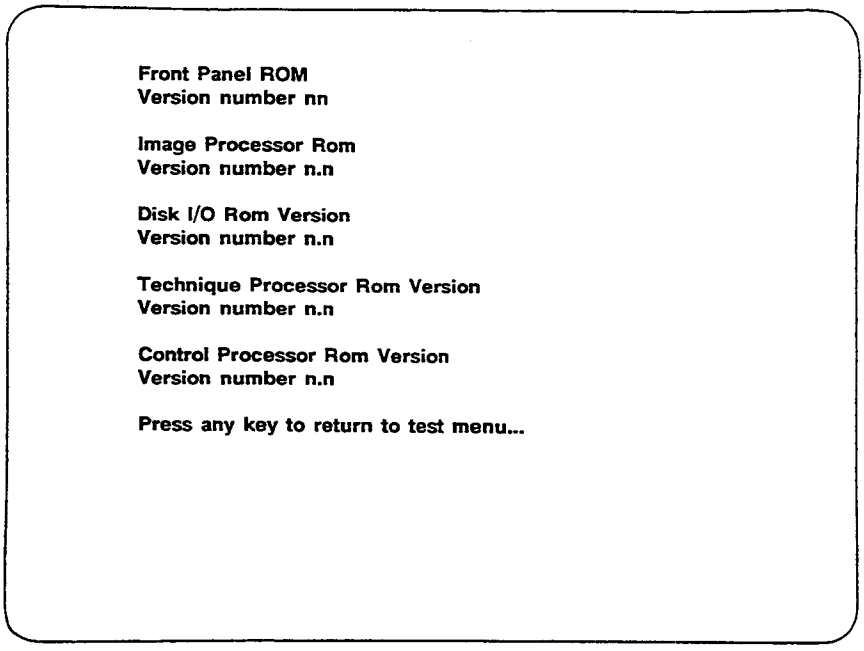
More Software Options



8.6.2.3 Test VTR



8.6.2.4 Display ROM Version Numbers



8.6.3 Main Menu

This menu can be accessed directly from the Program Access Menu.

```
OEC-Diasonics
System Software Manager
System ID Code:

A - Run Applications
B - Change system options
C - Run Diagnostics
D - Reboot to floppy disk
E - Load system software
F - Modify Terminal installation
G - Run Image Analysis
H - Examine shot log file
I - Erase shot log file
J - Transfer image files

Y - Access mainframe menu (903 only)
Z - Exit to DOS

Please make a selection:
```

8.6.3.1 Change System Options

```
OEC-Diasonics
Option change and display program
System Part No:

A - Hardware options
B - Software options
C - Mode options
D - Set power up default mode
E - Screen storage definitions
F - System relay definitions
G - Other byte options
H - Model number
I - Serial number

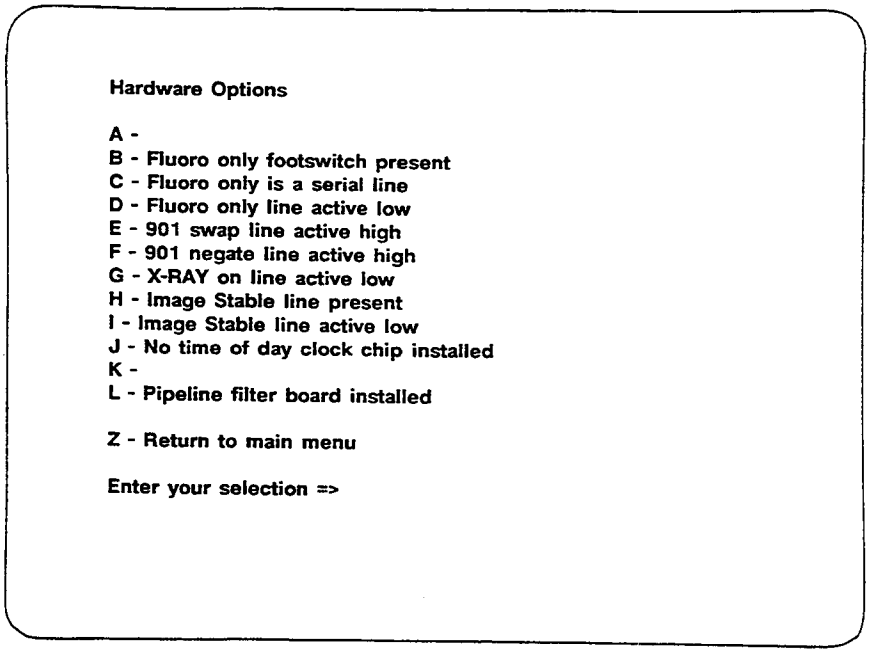
J - Hospital name

L - C-arm model number

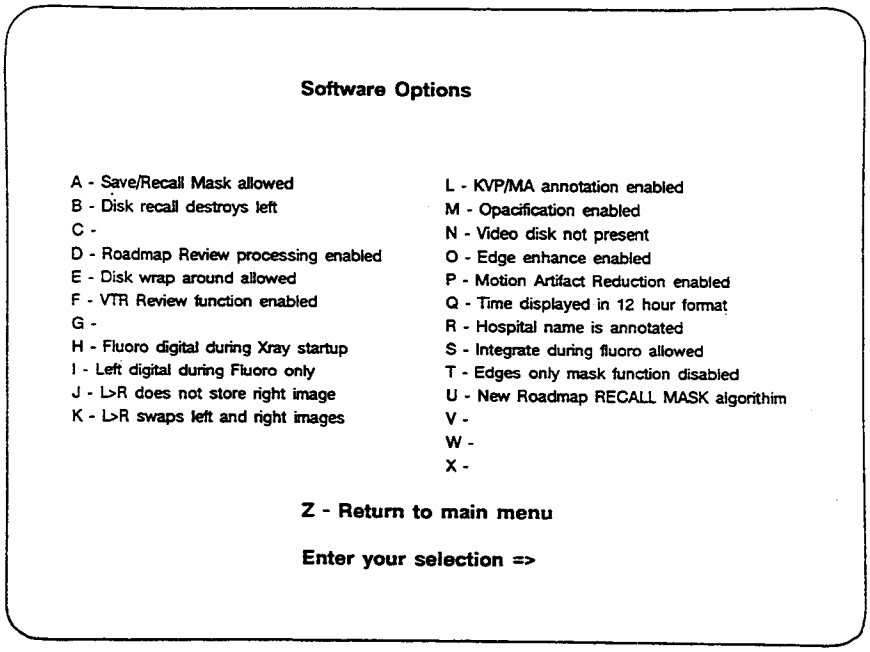
Y - Abort program, make no changes
Z - Exit program and update changes

Enter your selection =>
```

Hardware Options



Software Options



Mode Options (example)

```
Fluoro ENABLED

A - Enable Fluoro
B - Disable Fluoro
C - Change Fluoro default parameters

Z - Next processing mode

Enter your selection =>
```

Mode Options (example)

```
Integrate ENABLED

A - Enable Integrate
B - Disable Integrate
C - Change Integrate default parameters

Z - Next processing mode

Enter your selection =>
```

Set Powerup Default Mode

```
Current Power Up Mode = Fluoro

A - Fluoro
B - Integrate
C - Roadmap
D -
E -
F - Real Time Subtract
G -
H -

Z - No change

Enter your selection =>
```

Screen Storage Definitions

```
A - Pixels per scan line = 512
B - Scan lines per field = 240
C - Save and Recall start even field line number = 2
D - Save and Recall start odd field line number = 2
E - Display is    Interlaced

Z - Return to main menu

Enter your selection =>
```

System Relay Definitions

```
A - Normal closed relay setting
  = [K24,K22,K15,K7]
B - Normal video relay setting
  = [OUT,K30,K25,K22,K15,K8,K1,]
C - Xrays on relay setting
  = [OUT,K30,K24,K22,K15,K8,K1,]
D - Process video tape relay setting
  = [OUT,K30,K25,K15,K8,K4]
E - Review video tape relay setting
  = [OUT,K30,K25,K15,K10]
F - Process video disk relay setting
  = [K30,K25,K15,K8,K4]
G - Review video disk relay setting
  = [K30,K25,K15,K10]
Z - Exit

Enter your selection =>
```

Other Byte Options

This list is several screens in length and scrolls up as you progress down the list.

```
Log scale factor = 128
Change it? (Y or N) N

Fluoro window scale factor = 255
Change it? (Y or N) N

Fluoro level scale factor = 255
Change it (Y or N) N

Subtract window scale factor = 255
Change it? (Y or N) N

Subtract level scale factor = 160
Change it? (Y or N) N

Max hard disk value = 60
Change it? (Y or N) N

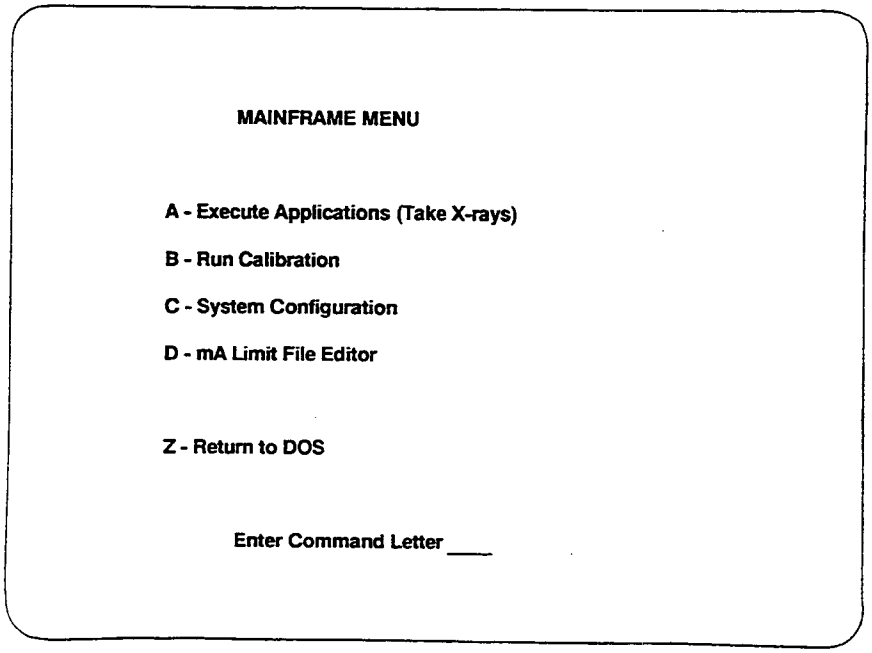
Subtract stable delay = 240
Change it? (Y or N)
```

8.6.3.2 Mainframe Access Menu

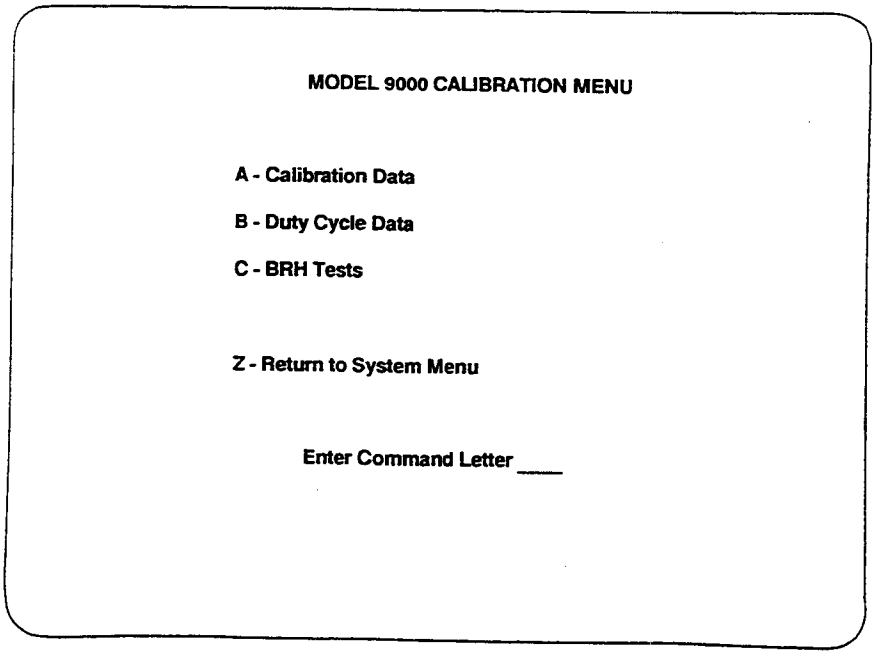
Select this menu from the monitor cart MAIN MENU.

When this menu is selected, the mainframe interlocks open to prevent X-rays.

To resume normal mainframe operation select "Execute Applications" from this menu.

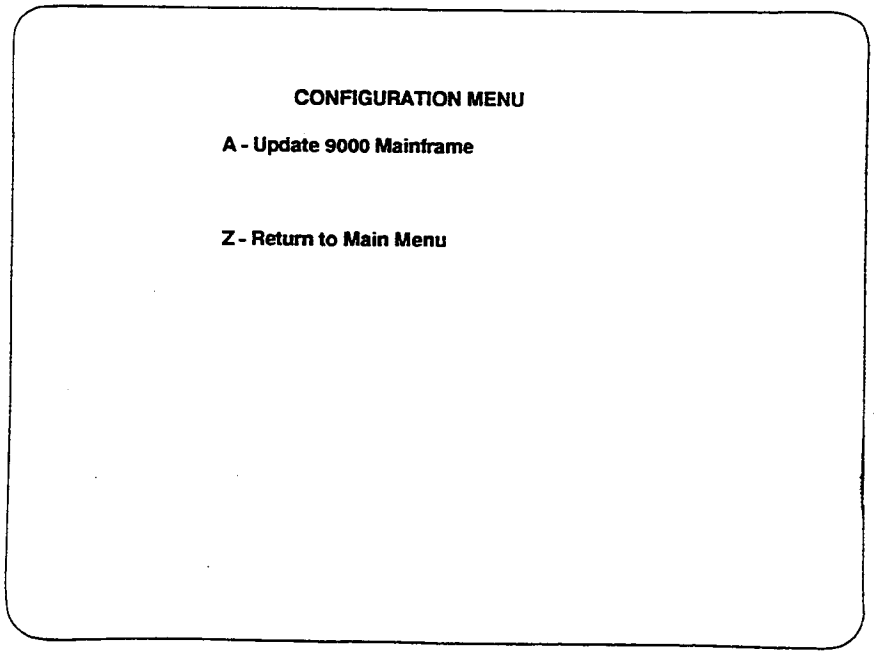


Model 9000 Calibration Menu



Configuration Menu

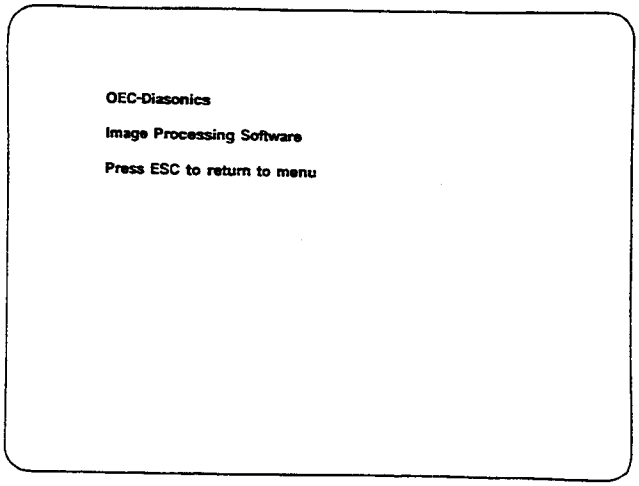
The Configuration Menu allows changes of boost operation and image tube size.



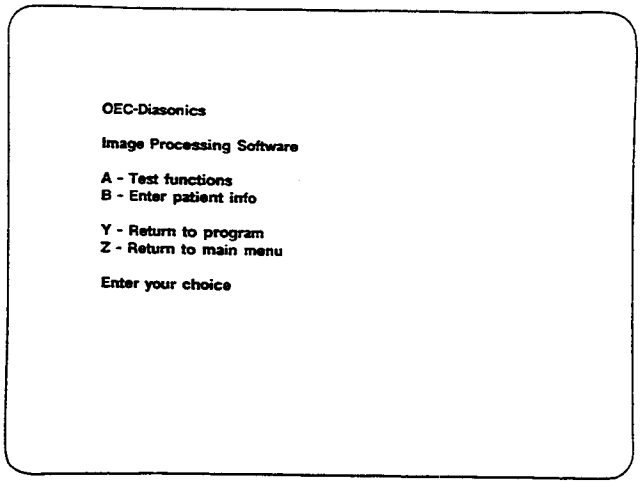
8.7 Examine Shot Log File

Shot Logging provides the field engineer with a record of the last 500 X-ray shots. This can be of value in evaluating X-ray tube history and performance.

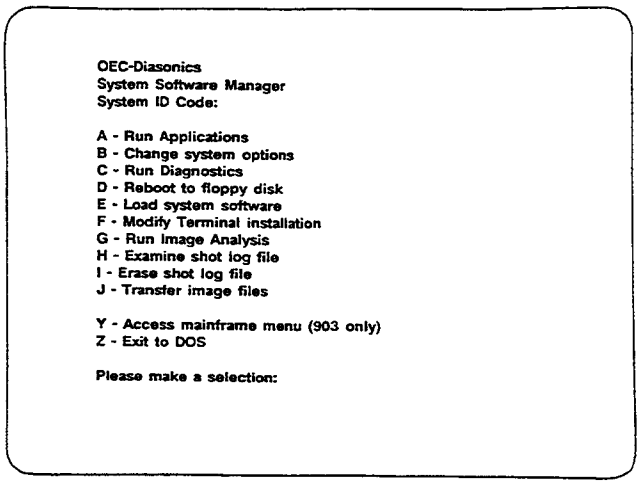
1. An external terminal must be connected to examine the shot log file. Press [ESC].



2. Enter [Z] and press [RETURN].

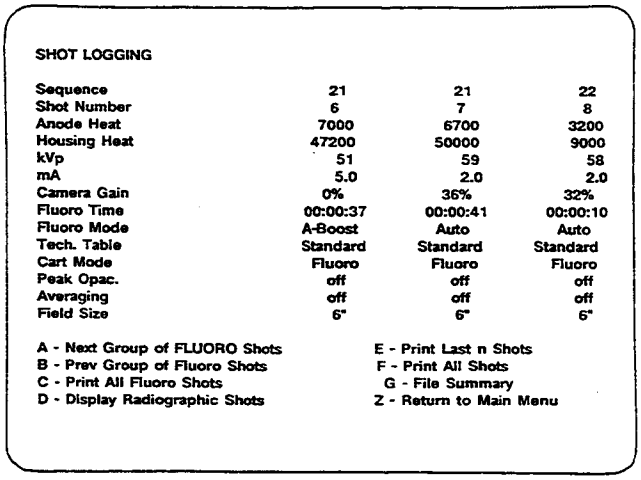


3. From the MAIN MENU, select entry [H] - EXAMINE THE SHOT LOG FILE.



4. A portion of the shot log file will appear on the screen with a command menu below.

From this menu enter:
C - Print all fluoro shots
E - Print last n shots
F - Print all shots
G - View overall shot summary
G, then P - Print shot summary



5. If a printout is desired, connect a printer using a printer cable such as P/N 870596 to the monitor cart AUX connector. Follow the instructions given in the Appendix for printer installation.

Figure 8-1 - *Here is a sample of a printout obtained by entering C - Print all Fluoro shots:*

10CPXXXX Cottonwood Hospital Page 1

Fluoro SEQ	Mode NUM	ANODE	HOUSING	KVP	MA	GAIN	ON-TIME	MD	CART-MODE	OPAC	AVG	FD
1	1	800	6500	61	2.2	36%	0:00:09	A	Fluoro	Off	Off	6"
2	1	400	19300	63	2.4	36%	0:00:05	A	Fluoro	Off	Off	6"
2	2	1400	21600	63	2.4	36%	0:00:13	A	Fluoro	Off	Off	6"
2	3	1300	27500	40	0.5	0%	0:00:13	A	Fluoro	Off	Off	6"
2	4	2000	29600	63	2.4	36%	0:00:19	A	Fluoro	Off	Off	6"
2	5	1400	45800	61	2.2	36%	0:00:22	A	Fluoro	Off	Off	6"
2	6	3000	50900	120	3.2	100%	0:00:29	A	Fluoro	Off	Off	6"
2	7	800	57800	40	0.5	0%	0:00:29	A	Fluoro	Off	Off	6"
2	8	3000	61300	40	15.0	0%	0:00:34	AB	Fluoro	Off	Off	6"
2	9	2900	61000	40	0.5	0%	0:00:47	A	Fluoro	Off	Off	6"
2	10	5500	66300	47	20.0	73%	0:00:51	AB	Fluoro	Off	Off	6"
2	11	13500	75800	47	20.0	44%	0:00:59	AB	Fluoro	Off	Off	6"
2	12	12900	79900	40	20.0	49%	0:01:01	AB	Fluoro	Off	Off	6"
2	13	23400	92500	40	20.0	73%	0:01:16	AB	Fluoro	Off	Off	6"
2	14	22300	95200	61	2.2	36%	0:01:24	A	Fluoro	Off	Off	6"
2	15	24100	98700	61	20.0	97%	0:01:26	AB	Fluoro	Off	Off	6"
2	16	32300	109300	61	20.0	88%	0:01:38	AB	Fluoro	Off	Off	6"
2	17	36000	119700	50	5.6	0%	0:01:49	AB	Fluoro	Off	Off	6"
2	18	37500	123600	42	20.0	58%	0:01:54	AB	Fluoro	Off	Off	6"
2	19	33700	130700	45	20.0	74%	0:02:00	AB	Fluoro	Off	Off	6"
2	20	29900	137300	120	3.2	100%	0:02:10	A	Fluoro	Off	Off	6"
2	21	29700	139100	62	2.3	36%	0:02:23	A	Fluoro	Off	Off	6"
2	22	28900	142600	64	2.5	36%	0:02:41	A	Fluoro	Off	Off	6"
2	23	17600	146600	62	2.3	36%	0:03:08	A	Fluoro	Off	Off	6"
3	1	0	11700	50	2.0	10%	0:00:00	P	Fluoro	Off	Off	6"
3	2	0	11700	50	2.0	43%	0:00:00	P	Fluoro	Off	Off	6"
3	3	0	11700	50	2.0	99%	0:00:01	P	Fluoro	Off	Off	6"
3	4	0	11600	50	2.0	99%	0:00:01	P	Fluoro	Off	Off	6"
3	5	0	11600	50	2.0	99%	0:00:02	P	Fluoro	Off	Off	6"
3	6	0	11600	50	2.0	99%	0:00:02	P	Fluoro	Off	Off	6"
3	7	0	11600	50	2.0	99%	0:00:03	P	Fluoro	Off	Off	6"
3	8	0	11600	50	2.0	99%	0:00:03	P	Fluoro	Off	Off	6"
3	9	0	11600	50	2.0	99%	0:00:04	P	Fluoro	Off	Off	6"
3	10	0	11600	50	2.0	99%	0:00:04	P	Fluoro	Off	Off	6"
3	11	0	11600	50	2.0	99%	0:00:05	P	Fluoro	Off	Off	6"
3	12	0	11600	50	2.0	99%	0:00:05	P	Fluoro	Off	Off	6"
3	13	0	11500	50	2.0	99%	0:00:06	P	Fluoro	Off	Off	6"
3	14	0	11500	50	2.0	99%	0:00:06	P	Fluoro	Off	Off	6"
3	15	0	11500	50	2.0	99%	0:00:07	P	Fluoro	Off	Off	6"
3	16	0	11500	50	2.0	99%	0:00:07	P	Fluoro	Off	Off	6"
3	17	0	13000	50	2.0	99%	0:00:08	P	Fluoro	Off	Off	6"
3	18	0	13000	50	2.0	99%	0:00:08	P	Fluoro	Off	Off	6"
3	19	0	13000	50	2.0	99%	0:00:09	P	Fluoro	Off	Off	6"
3	20	0	13000	50	1.5	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	0	13000	50	1.1	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	13000	50	0.7	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	36%	0:00:08	A	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0:00:10	A	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6"

Figure 8-2 - *Here is a sample printout obtained by entering G - File Summary, then P - Print Summary.*

10CPXXXX Cottonwood Hospital Summary

Total shots..... 190
Total sequences..... 25

Highest Anode Heat.... 37500
Sequence.... 2
Number.... 18
Average Anode Heat.... 4301

Highest Housing Heat.. 146600
Sequence.... 2
Number.... 23
Average Housing Heat.. 34455

Total Radiographic Shots....9
Neo-Natal Shots....0

	0.3mm	1.0mm
Number of shots	9	0
Average KVP used	57	0
Average MAS used	43	0

Total Fluoro Shots.....181

	Auto	Manual	A-Boost	M-Boost	Pulsed	One-Shot
Number of shots	128	12	19	0	0	22
Average KVP used	66	80	52	0	0	50
Average MA used	2	4	15	0	0	2
Average GAIN used	39%	74%	29%	0%	0%	92%

Technique Table	Standard	Modified	Custom
Number of shots...	181	0	0

	Fluoro	Integrate	Roadmap	IV-filter	IA-Filter	Subtract
Number of shots	134	8	17	0	0	22
Opacified shots	0	0	1	0	0	0
Averaging Off	126	0	12	0	0	21
Averaging of 2	0	0	0	0	0	0
Averaging of 4	1	2	4	0	0	1
Averaging of 8	2	0	1	0	0	0
Averaging of 16	0	0	0	0	0	0
Averaging of 32	5	6	0	0	0	0
Averaging of 64	0	0	0	0	0	0
Averaging of 128	0	0	0	0	0	0

8.8 Monitor Cart Adjustments, Switches and Jumpers

8.8.1 I/O Distribution/Video Switch PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	OUT	Bit PA7
E4-E5-E6	OUT	Bit PA6
E7-E8-E9	E8-E9	Bit PA5 X-ray On
E10-E11-E12	E11-E12	Bit PA4 Video Stable
E13-E14-E15	E14-E15	Bit PA3 Store

Adjustment **Floppy Disk Voltage Adjustment**

Adjust R24 on this PCB for +12 VDC between TP19 and TP20.

8.8.2 AD/DA Converter PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Video buffer and sync separator
E4-E5-E6	E5-E6	Buffered Video select
E7-E8-E9	E8-E9	Video Sync Select

Adjustment **Circular blanking**

Vertical	R47, R45
Horizontal	R48, R50

Adjustment **Offset Adjustment**

(Adjust blanking level to 0 VDC)

Left video (P5) offset	R2
Right video (P6) offset	R1

8.8.3 Sync Separator PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Video Source Select

8.8.4 Image Processor PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2	IN	U8 Vertical Reset
E3-E4	IN	Timing Clock Output
E5-E6	IN	U8 Horizontal Reset
E7-E8	IN	A12
E9-E10	IN	A13
E11-E12	IN	A14
E13	OPEN	Ground
E14-E15-E16	E15-E16	No CPU Wait States

Adjustment **Gen-lock Adjustment**

1. Place scope probe on TP27 and TP5 (ground) and adjust C-6 for + 2.5 VDC.

2. Verify that the video is stable and displayed in the center of the circular blanking window.

8.8.5 Disk Interface PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E58-E59	IN	Reset Circuit
E53-E54	OUT	Reset Circuit
E21-E29		
E28-E36	E25-E33	1200 Baud, Front Panel and Mainframe
E37-E45		
E44-E52	E41-E49	1200 Baud, External Ports
E17-E18-E19	E17-E18	DTR handshaking
E55-E56-E57	E56-E57	X-ray disable pullup
E62-E63-E64	E62-E63	DRAM Controller Reset

Disk Interface U8 DIP Switch Settings

(1=on 0=off)
8 7 6 5 4 3 2 1

1	autoboot
0	use DMA
1	50 Hz operation
0	60 Hz operation
0	1024 bytes/sector
x	reserved
0 0 0	Miniscribe HD
0 0 1	Fujitsu
0 1 0	Tandon, IMI, Seagate

8.8.6 Pipeline Filter PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Memory Out Disable

8.8.7 Remote Contrast/Brightness PCB

Set the following jumpers according to the type of monitor installed.

DATA-RAY MONITOR	*ELSTON MONITOR*
E2	E1
E7	E8
E5	E6
E3	E4

8.9 Formatting the Hard Disk

If the Hard Disk requires formatting (after replacement or because of a format problem) follow this procedure:

CAUTION **Formatting the hard disk will erase all data and programs. The monitor cart is then unusable until the software has been recopied from a source floppy disk.**

1. Connect an external computer terminal to the serial communications connector on the rear of the cart. Follow the instructions for using the external keyboard and monitor found in the Appendix.

2. Follow the instructions in the Appendix for installing the external floppy disk drive.

3. Insert the system floppy disk into the floppy drive.

4. Format the hard disk using the following menu sequence:

   (ESC) Select Program Menu
   (Z) Return to Main Menu
   (D) Create Hard Disk System

5. Enter the correct hard disk model, the correct line frequency, and hit the RETURN key. The hard disk will be formatted and system information will be copied to it. This takes about 20 minutes to complete.

6. After the format and copy sequence is complete, turn the video circuit breaker off. Disconnect and remove the floppy drive.

7. Turn the video circuit breaker on again and verify that the system will boot from the hard disk.

8. Enter the model number at the terminal using the following menu sequence:

   (ESC) Select Program menu
   (Z) Return to Main Menu
   (B) Change System Options
   (G) Model Number

9. After entering the correct access code, enter the model number. Access Codes are available by telephoning 800-453-8412.

10. Select (H) Serial Number. After entering the correct access code, enter the serial number of the machine.

11. Exit the main menu (Z) and update the changes made in the last two steps.

SECTION 9
CALIBRATION

9.1 Introduction

This section contains procedures used to test and calibrate the OEC-Diasonics Series 9000 System.

The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9000 System.

9.1.1 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 have been properly installed and correctly wired. It is further assumed that all subassemblies are without defect and 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 for use before beginning the calibration.

9.1.2 Test and Calibration Outline

The calibration procedures are presented in the following order:

i. Preparation
ii. Electrical Checks
iii. Mechanical Checks
iv. Functional Checks
v. Beam alignment
vi. X-ray Calibration
vii. Dose Calibration
viii. Imaging Chain
ix. Accuracy Verification
x. Special Image Processing and Monitor Cart Tests

9.2 Safety Precautions

WARNING: **The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9000 System.**

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.

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.

9.3 Preparation and Setup

9.3.1 Record the Test Equipment Used

Record the information requested on the Worksheet.

9.3.2 Preparation and Inspection

1. To prevent the mainframe from rolling, position the front and rear wheels at right angles to each other . To keep the monitor cart from rolling, engage the monitor cart wheel locks.
2. Turn the keyswitch to OFF.
3. Unplug the power cord on the monitor cart.
4. Inspect the interconnect cable; make sure the interconnect cable is permanently attached by its bracket to the monitor cart.
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 conductive casters on both the mainframe and the monitor cart for proper pressure and freedom of movement.
8. Remove the front, rear, and left side panels from the monitor cart and the left, right and rear covers from the mainframe.
9. Connect the terminal to the mainframe as instructed in the Appendix.

9.4 Electrical Tests

9.4.1 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 100 uA (or other value specified by the user) in any of certain standard test configurations. *Leakage currents in excess of 100 uA may be recognized as unsafe in equipment of this type.*

1. Unplug the line cord.

2. Complete the measurement according to the instructions applicable to the available test device.

3. If leakage currents exceed the user's specifications during any of the preceding tests, the system under test has failed this test section. Document the fault and corrective action taken on the worksheet.

9.4.2 Ground Continuity

1. Disconnect the power cord and connect the interconnect cable between the monitor cart and the mainframe.

2. Check the continuity of the system ground between the mainframe and the monitor cart. Resistance shall be less than 0.5 ohms.

3. Measure the continuity of each power plug ground pin to its corresponding chassis. Resistance shall be less than 0.5 ohms.

9.4.3 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:

$$100\ (Vn - V1)/\ (V1)$$

where: Vn = No load voltage
V1 = 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.

9.4.4 Monitor Cart Power Supplies

1. Unplug the system power cord from the wall outlet.

2. Inspect the following power supply connections to the monitor cart electronics:

Disk Controller PCB supply	P-10
Hard disk power supply	P-3
I/O Dist.-Video Switching PCB	P-2 & P-3
Front Panel Processor PCB	J-21
Black and yellow wires	TV monitors

3. Plug the power cord into the wall. Turn on the CART POWER circuit breaker. Verify that the three cooling fans in the base of the cart are running.

4. Measure the output of the TV monitor power supply. It should measure +24 volts DC.

5. Measure the following voltages relative to DC Common (PS-1 pin 7):

PS-1 pin 12	+5 volts DC	red wire
PS-1 pin 6	+15 volts DC	gray wire
PS-1 pin 5	-15 volts DC	violet wire
PS-1 pin 4	+24 volts DC	yellow wire
PS-1 pin 3	-5 volts DC	blue wire

6. Check for the correct AC line voltage at the rear monitor cart AUX outlets.

9.4.5 Mainframe Power Supplies

1. Turn on the mainframe keyswitch.

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

WARNING: * F2 and F3 carry line voltage whenever the power cord is plugged in.

9.5 Mechanical Checks

In the steps below, check for ease of movement without excessive play.

1. Check the **foot lever and steering handle** for proper movement. Then lock the C-arm in place by setting the wheels at right angles to each other.

2. Check **Wig Wag** - horizontal swing of the C-arm from side to side.

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 proper action of 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. 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. Rotate the **L-arm** 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

9.6 Functional Checks

9.6.1 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 front panel. Refer to what these codes mean in the service sections of this manual.

3. Observe the Boot Codes on the mainframe LED panel and the Progress Codes on the monitor cart LED display as the operating software is loaded and the system is initialized.

4. If any of these codes remains on the LEDs and the system fails to complete its booting and initialization, refer to the listing of boot codes in the Mainframe Service Section or the listing of progress codes in the Monitor Cart Service Section.

9.6.2 Emergency Off and Processor Reset Test

1. With the system powered up, depress the **left** EMERGENCY OFF switch and make sure that the interlock circuit breaks and the LED display reads *INTERLKS BROKEN*.

2. Press any key, and then press the START switch to resume operation.

3. Again, with the system powered up, repeat step one using the **right** EMERGENCY OFF switch.

9.6.3 Status Mode Tests

Refer to the Mainframe 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 *LED 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).

9.6.4 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 make sure that the *NO CASSETTE* message does not appear.
5. Remove the cassette and observe that the *NO CASSETTE* does appear.
6. Rotate the C-arm to return the image intensifier below the X-ray tube.

9.6.5 Verify Operation of Mainframe Controls

WARNING: These tests produces X-rays. Take the 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 an LED 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 LARGE FIELD switch removes the 6-inch collimator by listening for the "thunk" sound produced when you press the switch.

5. Verify that the X-RAY ON lamps on the X-ray tube assembly, control panel and monitor cart light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

6. Verify operation of the footswitch.

7. Verify that early footswitch release will terminate the FILM exposure. The message *FOOT RELEASED* should appear on the control panel display.

9.6.6 Field Solenoid Position Test

This test verifies that the system can sense the position of the SMALL FIELD collimator.

1. Remove the bottom filtration plate on the collimator.

2. Place the system in the FLUORO mode and select the SMALL FIELD. Verify that the flipper returns to the 6-inch position.

3. Reach into the collimator and move the flipper (small field) collimator out of the center.

   Verify that the control panel displays the message *FLIPPER STUCK.*

4. Release the collimator and allow it to return to center.

5. Place the system in the FILM mode and select the LARGE FIELD.

   Verify that the flipper (small field) collimator moves out of the center.

6. Reach into the collimator and hold the flipper in the LARGE FIELD position. While holding the flipper in this position, select the SMALL FIELD from the front panel. The control panel should display the message *FLIPPER STUCK.*

7. Replace the filtration plate on the collimator.

9.6.7 Verify Controls in MANUAL FLUORO

1. Select MANUAL FLUORO mode.

2. Verify that kVp and mA can be controlled using the control panel knobs.

9.6.8 AUTO FLUORO Tests

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

1. Select AUTO FLUORO mode.
2. Switch to live video using the VIDEO BYPASS switch (on the monitor cart rear) and verify that true live video appears on the left monitor and that the TV monitors do not lose video sync.
3. Switch the VIDEO BYPASS switch to NORMAL.
4. Make a fluoro exposure and transfer the image to the right-hand monitor.
5. Make another exposure. The image will appear on the left monitor.
6. 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. 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 one set 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.

9. Verify operation of the left monitor's remote contrast and brightness controls on the mainframe control panel. (Set the left contrast control near the monitor screen to REMOTE).

9.6.9 Fluoro Boost Option

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

1. Enable BOOST on the control panel (if provided). Then to make the exposure, press down into the second position on the right footswitch.
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 image doesn't "burn out" or appear too dark.

9.6.10 Pulsed Operation

1. Enter the PULSE FLUORO mode.
2. Press X-ray On and verify pulsed operation when the button is pressed.

9.6.11 Verify Fluoro Timer and Timer Reset

1. In fluoro mode the accumulated exposure time is displayed in the center of the LED 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 should stop but the accumulated exposure display should not reset.
3. Press and hold the ALARM RESET for three full seconds. The accumulated timer display should reset to 0.

9.7 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

9.7.1 Preparation

1. Position the X-ray tube/image tube axis at a 45-degree angle to the floor. *Refer to Figure 9-1.*

2. Attach the beam alignment fixture and a loaded film cassette to the image intensifier assembly.

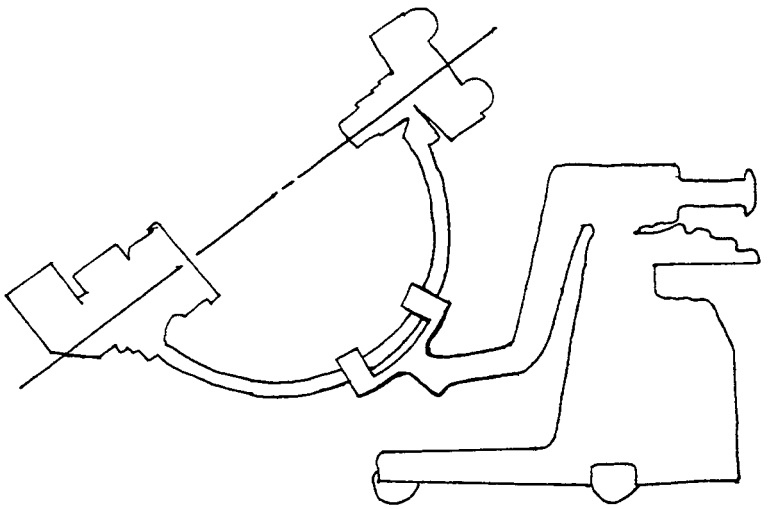


Figure 9-1 - *Position the imaging axis at a 45-degree angle to the floor.*

9.7.2 Radiographic Beam Alignment

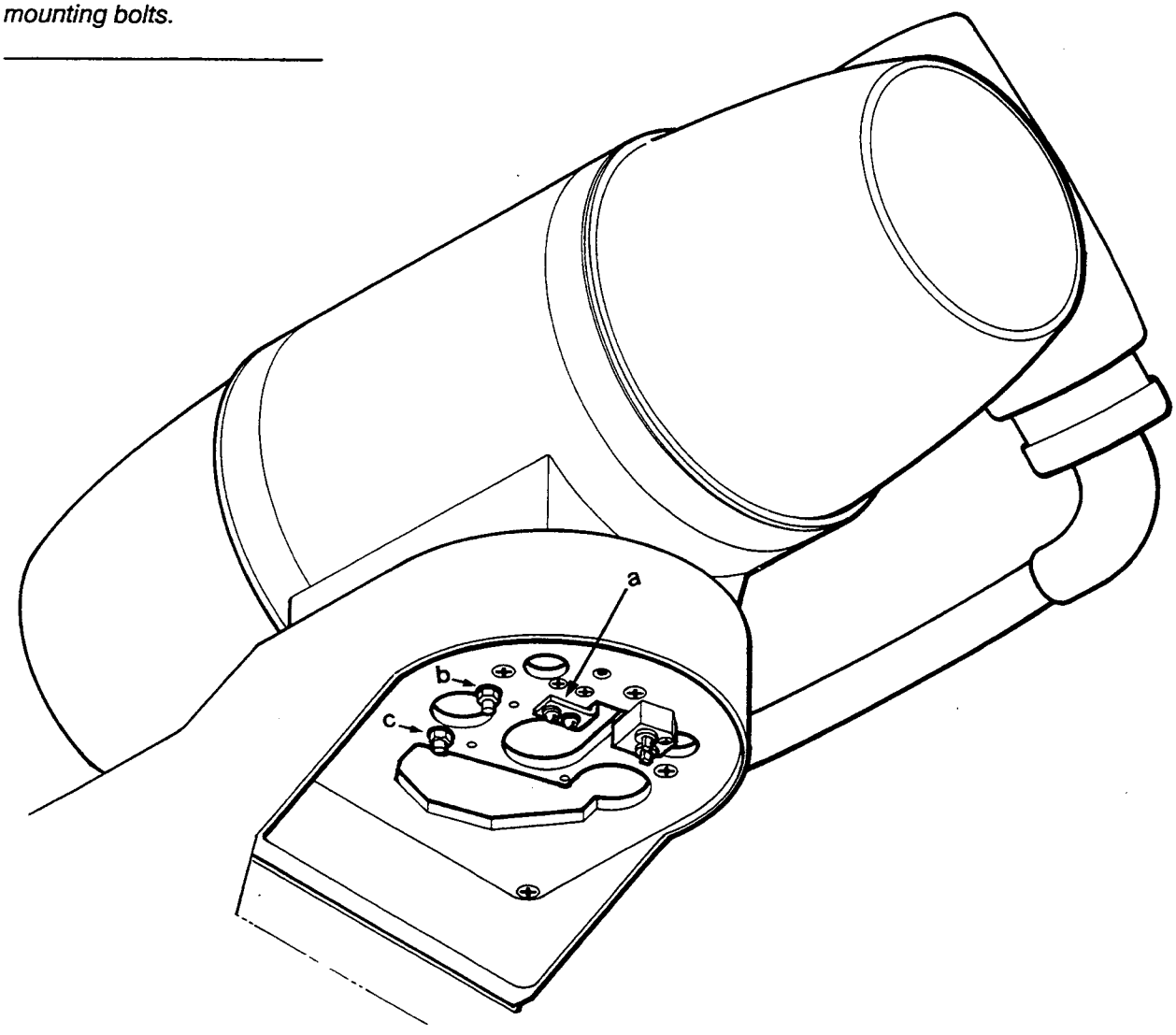
WARNING: This procedure produces X-rays. Take the appropriate precautions.

1. Set a radiographic technique of 50 kV 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 9-2 - *Adjust the shutter stop and the solenoid mounting bolts.*



4. Verify that the exposed area covers the entire large field.

5. If the beam is occluded 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:

   1. Remove the screws and cover plate from the X-ray head mounting assembly.

   2. 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.

   3. Make exposures as needed to verify the beam position.

   4. When the large field is properly centered, carefully retighten the locking screws avoiding any movement of the X-ray head as you tighten. Fine readustments may be needed as the eccentrics are tightened into place.

6. Remove the collimator assembly from the X-ray head, and select the small field.

7. Making exposures as required, adjust the 6-inch flipper stop (a) and the shutter solenoid mounting bolts (b & c) to center the 6-inch beam on the beam alignment fixture. *Refer to Figure 9-2.*

8. Check that the microswitch still functions properly.

9. Reinstall the collimator. Select the 6" field and make a radiographic exposure. Select the Large field and make another exposure on the same film.

   Check that the alignment of both fields is correct.

10. Complete the information on the film label and attach it to the upper right hand corner of the developed film.

11. Select the LARGE FIELD. Adjust the leaf collimator shutters to 6 x 6 inches and make an exposure.

12. Measure the actual size of the exposed area on the film. If necessary, loosen the set screws on the shutter adjustment knobs and adjust the collimator knobs to correspond to that size.

13. Tighten all set screws.

14. Set the radiographic technique to 50 kV and 1 mAs.

15. Make multiple exposures on a film with the shutters set to minimum, 4", 6" and 8". Label one shutter direction X and the other Y.

16. Measure the actual dimensions of the exposed areas. *The measured and actual dimensions should coincide within +/- 0.5 inch.*

    The dimensions of each field shall be as follows:

Minimum field -	less than 1.97", square *
4-inch field -	4" +/- 0.50", square
6-inch field -	6" +/- 0.50", square
8-inch field -	8" +/- 0.50", square

    * 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.

    Note: The corners of the 8" field will be clipped by the 10" collimating ring on 6" image intensifiers.

17. Record the measured values on the supplied label. Attach the label to the film.

18. On the exposed film obtained in step 15, mark each corner of the 6" area with a pen. Using a straight edge, connect the dots diagonally. *The intersection of the diagonal lines should fall within the center circle on the beam alignment fixture.*

19. Install the 0.5 mm aluminum filter on the collimator.

9.7.3 Fluoroscopic Beam Alignment

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

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. Set the video selector switch on the rear of the monitor cart to BYPASS.

5. 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 fluoroscopic test reticle should be visible around the entire input area of the image intensifier tube.

6. Return the video selector switch to NORMAL.

9.8 X-ray Calibration

9.8.1 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 is removed, disabling mA servo.
2. A series of exposures is 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.

Overview: mA/kVp Technique Calibration

1. mA servos are enabled (the mA jumper is replaced).
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.

9.8.2 Connections

Refer to Figures 9-3 and 9-4.

Connect the Dynalyzer III High Voltage Unit, Digital Display (DRO) III, Autocal Interface Box, and DVM to the mainframe electronics as shown in Figure 9-3.

NOTE: Refer to the general instructions for the Dynalyzer in the Appendix.

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.

Dynalyzer II

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.

Autocal Interface

Connect the autocal interface box to connectors J1 and J2 on the Analog Support PCB (cable part number 00-871432).

Figure 9-3 - *Connections between the Analog PCB and the calibration equipment.*

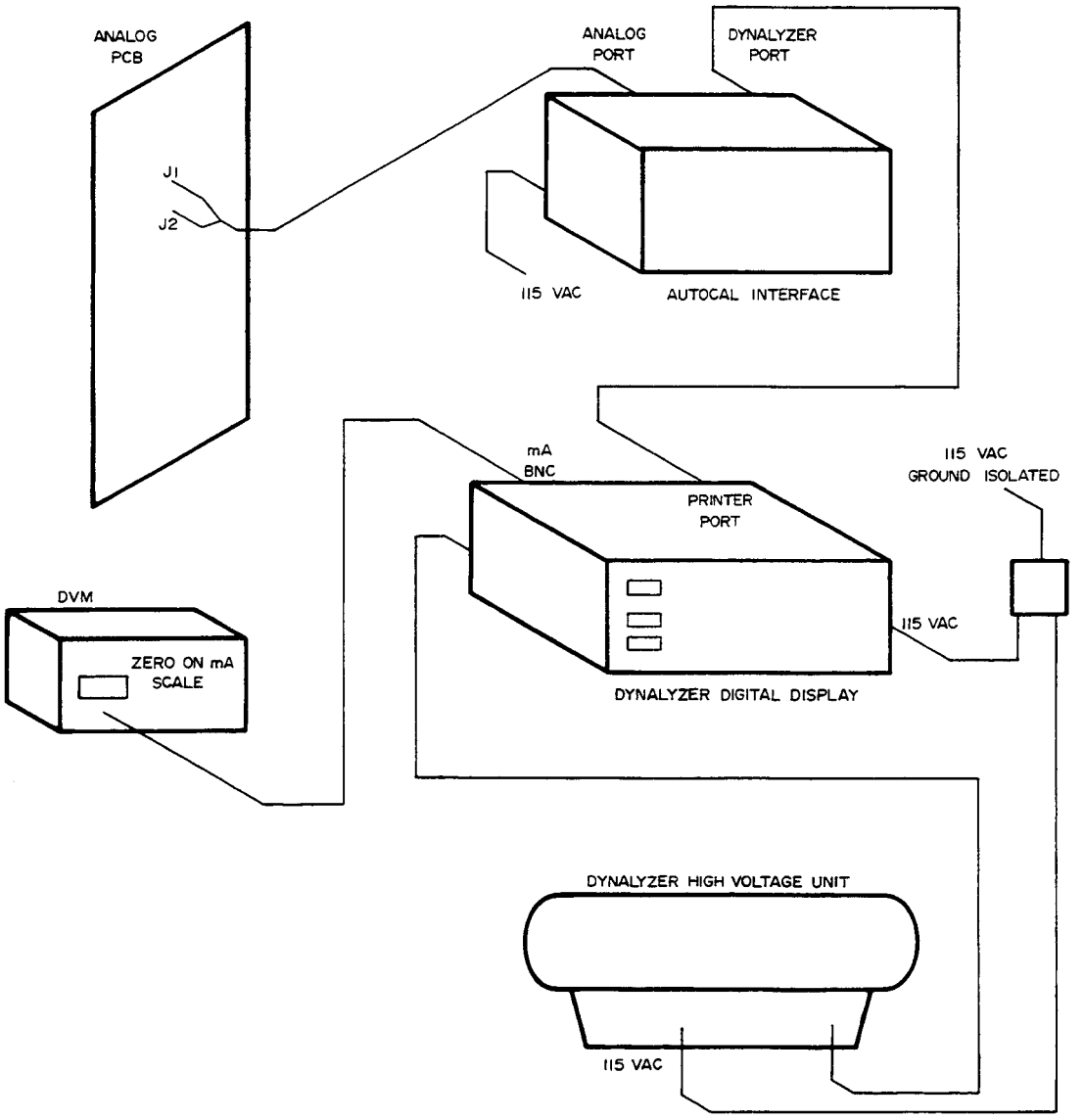


Figure 9-4 - *Connections are made between the back of the Analog PCB and the AutoCal Interface Box.*

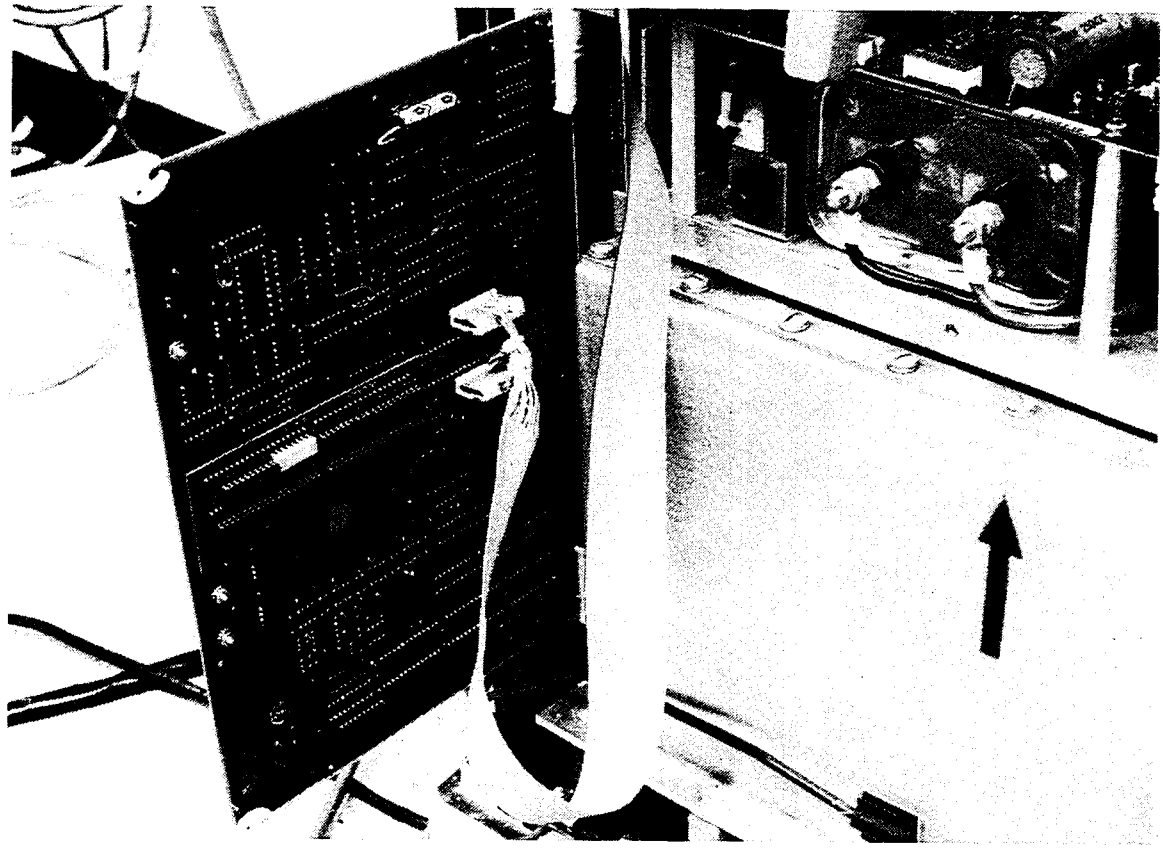
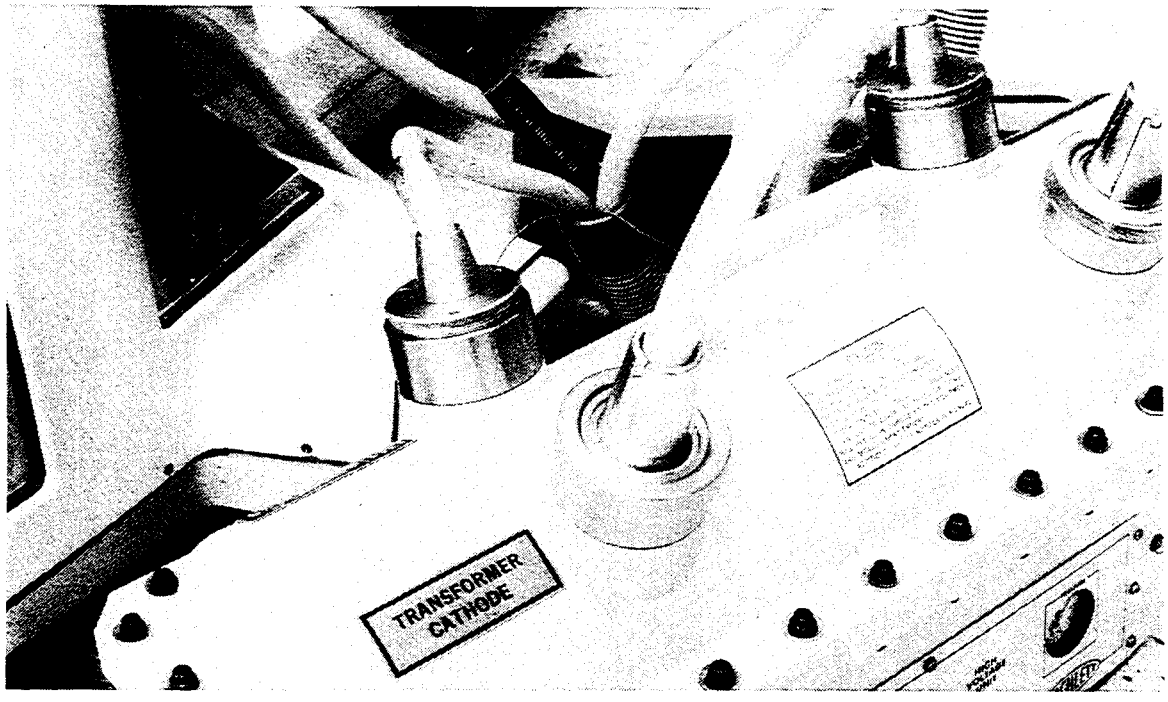


Figure 9-5 - *Refer to the Appendix for instructions on making the high voltage connections to the Dynalyzer High Voltage Unit.*



9.8.3 Setup

NOTE: Refer also to the general instructions for Dynalyzer use in the Appendix.

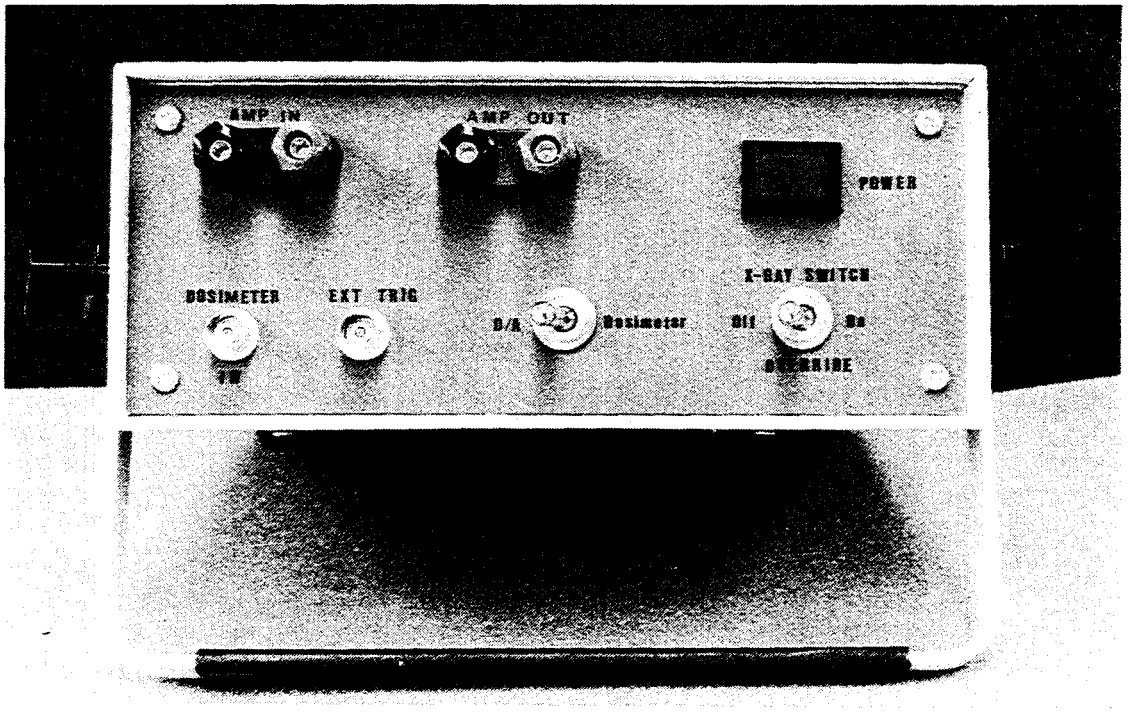
General Setup

1. Jumper across E3 on the Generator Controller PCB with a shorting plug to disable mA servo.
2. Turn on the power to all calibration equipment.

Autocal Interface Box

Refer to Figure 9-6. Turn X-ray Switch Override **ON**.

Figure 9-6 - *The AutoCal Box. Refer to the text for proper switch settings.*



Dynalyzer III High Voltage Unit

Refer to Figure 9-7. 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 9-7 - *The Dynalyzer III High Voltage Unit. Set the FLUORO/RAD switch as described in the text.*

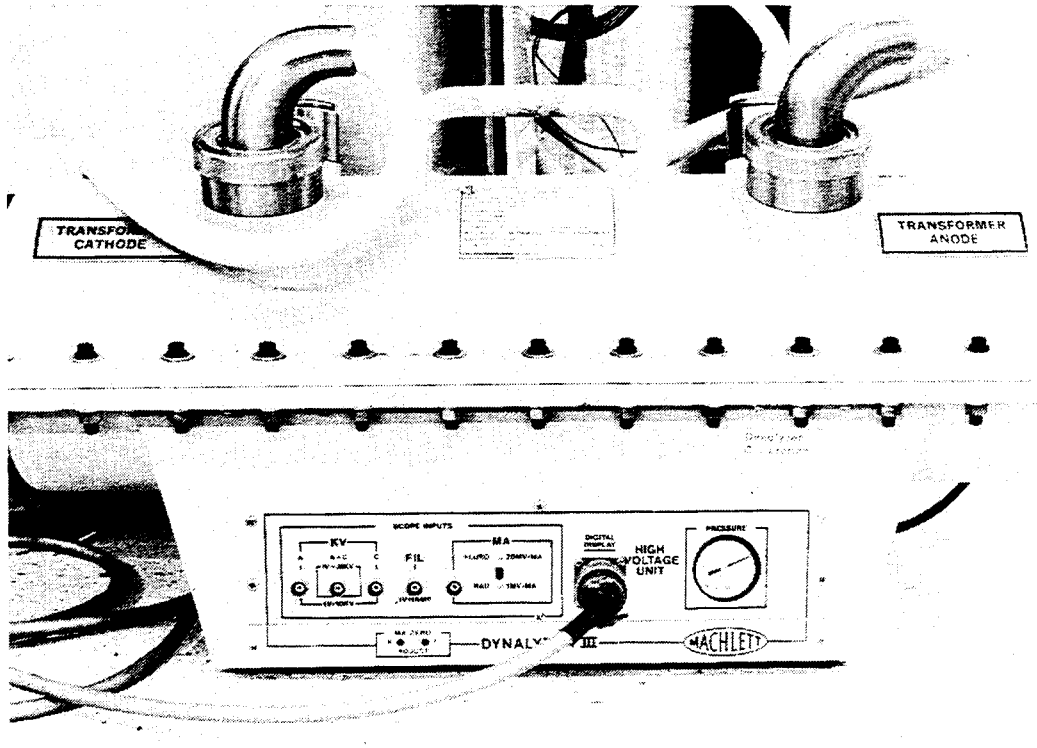
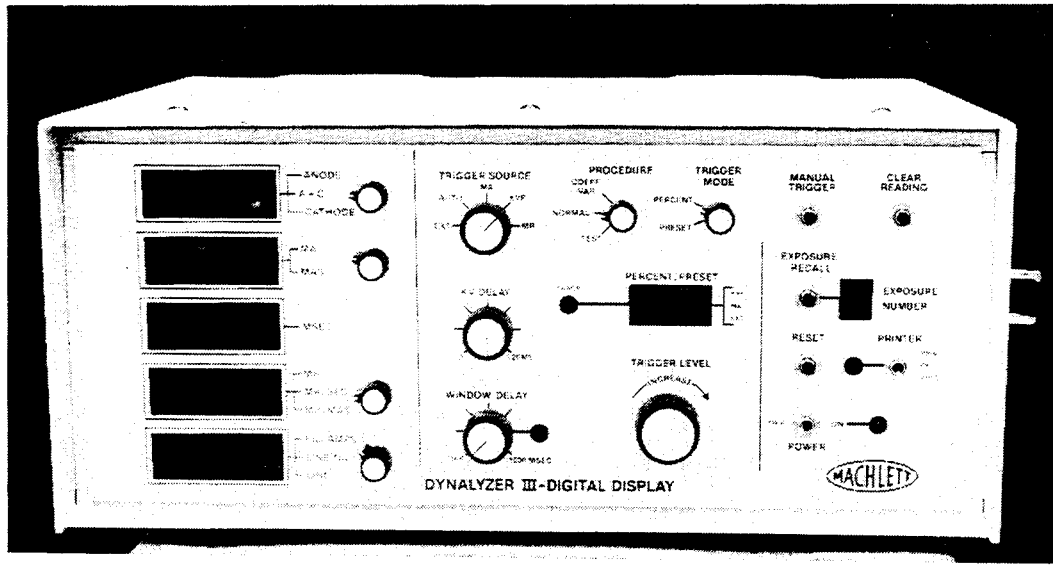


Figure 9-8 - *Dynalyzer III Digital Display*. Set the controls as described in the text.



Dynalyzer III DRO (Digital Display Unit)

Refer to Figure 9-8.

Set the controls as follows:

Displays:	**A+C,**	**mA**
Trigger Source:	**kVp**	
Procedure:	**NORMAL**	
Trigger Mode:	**PERCENT**	
kV Delay:	**20 ms**	
Window Delay:	**OFF**	
Trigger Level:	**50**	
Printer	**AUTO**	

Dynalyzer II High Voltage Unit

No special settings are required.

Dynalyzer II DRO (Digital Display Unit)

Refer to Figure 9-9.

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)		

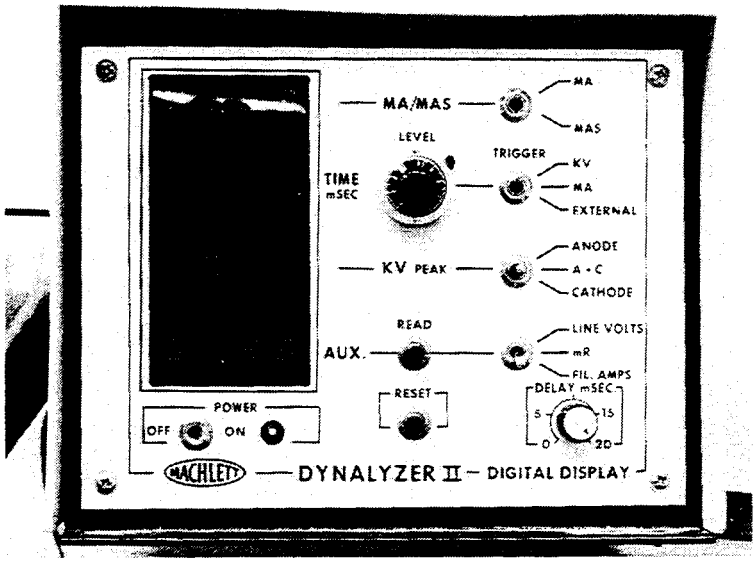
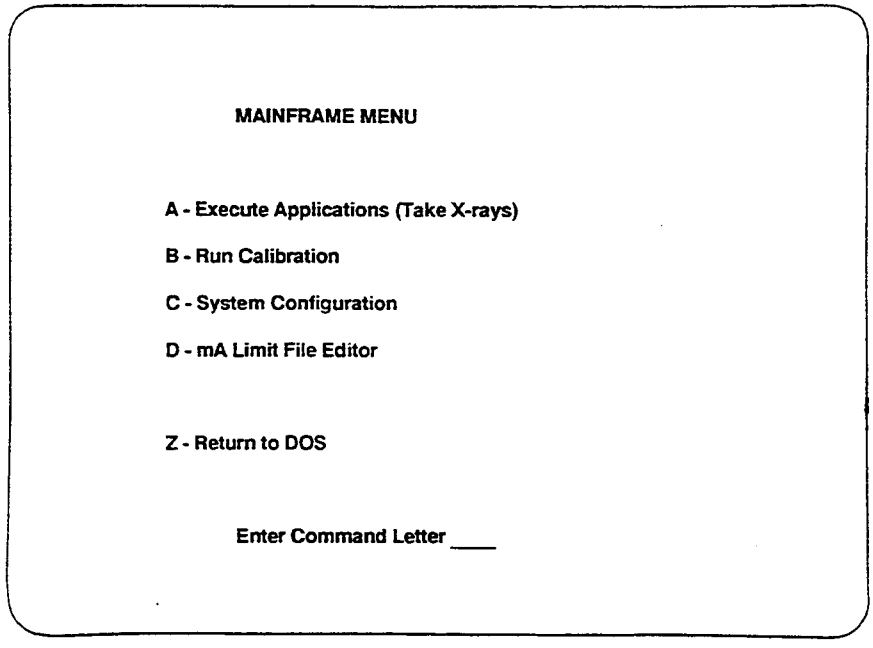


Figure 9-9 - *Dynalyzer II Digital Display. Refer to the text for the proper switch settings.*

9.8.4 Getting Started

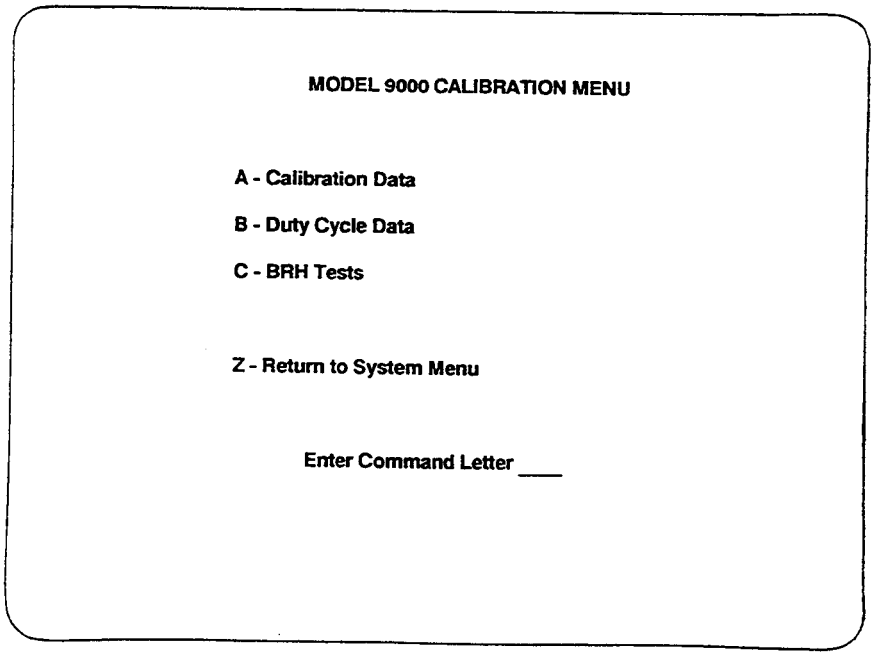
1. Connect the computer terminal to the monitor cart. Instructions for connecting and using the external computer terminal are found in the Appendix.
2. Press *[ESC]*.
3. Select: *Z - Return to main menu.*
4. Select: *Y - Access Mainframe Menu.*

   The Mainframe Menu will appear:



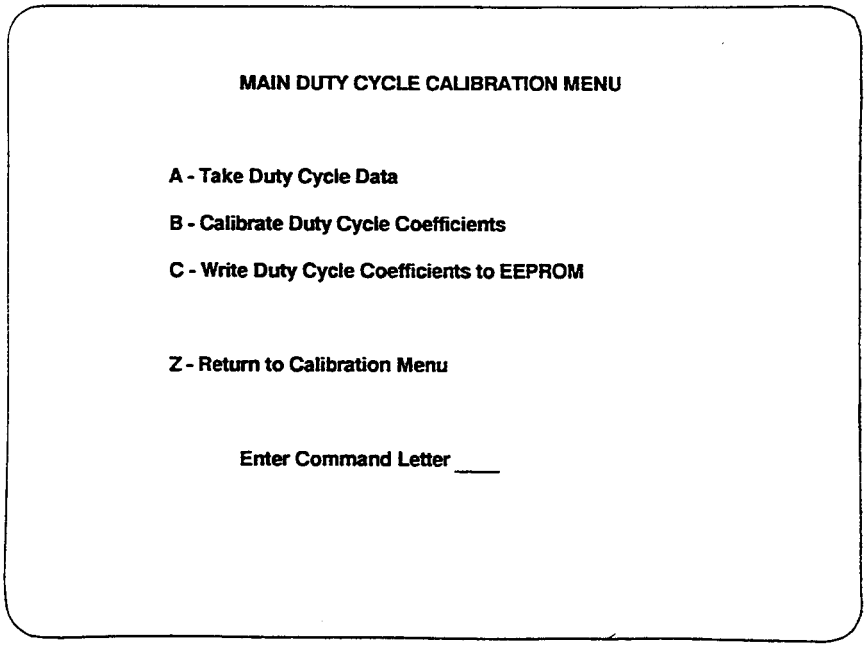
5. From the Mainframe Menu select: *B - Run Calibration.*
6. Enter your initials when prompted: *Enter initials please.*

7. From the *CALIBRATION MENU* select: *B- DUTY CYCLE DATA.*



9.8.5 Duty Cycle Calibration

The Duty Cycle Menu will next appear on the terminal screen:



9.8.5.1 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).

2. Zero the Dynalyzer high voltage unit.

Note: Zero *both* the FLUORO and RADIOGRAPHIC settings on the Model III.

3. Depress the footswitch (or X-ray On button) when ready.

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].

6. The Dynalyzer II tank must be switched between FLUORO and RAD to accommodate filament size changes during calibration. When this is required, The following prompt will appear on the terminal screen:

   *** SWITCHING FILAMENTS ***
   Change tank setting to ___ (FLUORO or RAD) for ___ (small or large) spot calibration. Press [ENTER] when ready to continue.

   When beginning the calibration procedure using a Dynalyzer III, the on-screen instructions will indicate the switch setting (FLUORO or RAD) with which to start.

9.8.5.2 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.

9.8.5.3 Write Duty Cycle Coefficients to EEPROM

1. When the calculations are complete, you will be returned to the Duty Cycle Calibration Menu.

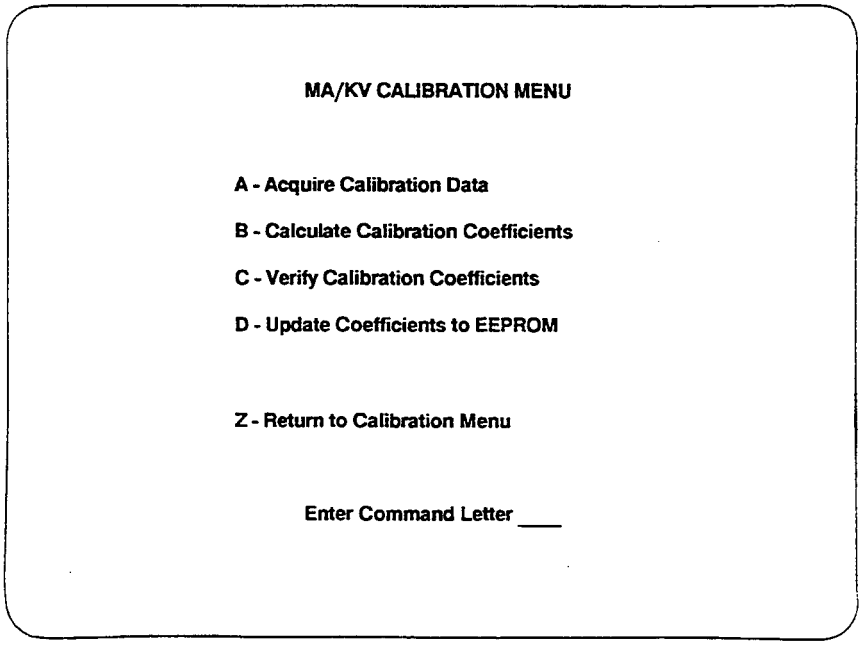
2. Select: *C - Write Duty Cycle Coefficients to EEPROM.*

3. This takes only a blink of the eye.

4. Select: *Z - Return to Calibration Menu.*

9.8.6 mA/kV Calibration

Technique calibration uses the mA/kV Calibration Menu:



9.8.6.1 Acquire Calibration Data

1. From the Main Calibration Menu select: *A - Calibration Data.*
2. From the mA/kV Calibration Menu select: *A - Acquire Calibration Data.*
3. Remove the mA servo-disable jumper E3.
4. Zero the Dynalyzer (both settings on the Model III).
5. Depress the footswitch when ready.
6. The system automatically takes 38 predefined exposures.

   The calibration software will prompt you to change the Dynalyzer setting (FLUORO/RADIOGRAPHIC) as needed.
7. Observe the results reported on the screen. The technique values should be similar to those read on the control panel and the Dynalyzer readout.
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].

9.8.6.2 Calculate Calibration Coefficients

1. Select: *B - Calculate Calibration Coefficients.*
2. The coefficients will be displayed briefly on the monitor.

9.8.6.3 Update Coefficients to EEPROM

1. Select: *D - update coefficients to EEPROM.*
2. This step is performed before the verification data is acquired.

Note: Menu item *C - Verify Calibration Coefficients* is not implemented for field use. Proceed with the manual verification procedure given below.

9.8.7 Verify Calibration

9.8.7.1 General Information

Calibration must be verified following regular calibration procedures or when any of the following components are replaced:

- X-ray Tube
- Generator Controller PCB
- High Voltage Regulator Components
- High Voltage Tank

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.*

9.8.7.2 KVP Accuracy Tests

The tests in this section are designed to measure the kVp accuracy of the system. Perform the tests indicated and 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. Slew the mA to maximum at each kVp.
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 @ 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.

9.8.7.3 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. Select the small field.
2. Take exposures at 5 mAs 50 mAs, and at 200 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. Select the SMALL field.
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.

9.8.7.4 Fluoro MA Accuracy Test

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.

9.9 Entrance Exposure Calibration

Entrance Exposure Limitation Tests

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.

Entrance Exposure Calibration

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.

Measurement Position The entrance exposure for the system is measured 30 cm (12 inches) from the input surface of the imaging assembly.

NOTE: Remove the dynalyzer prior to execution of this procedure.

Equipment Required The following equipment is required to perform the entrance exposure tests:

* Keithley Model 35050 dosimeter with Model 96030 ion chamber or equivalent (Calibration must be current).

* Metric Scale or Ruler

* Lead Apron or lead plate

* 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 such 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 4.69 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: *D - mA Limit File Editor.*

11. For each value listed by the mA Limit File Editor, select the kVp index number and enter the mA found in the steps above.

12. Enter the data obtained every five kVp (recorded in the worksheet table) and interpolate the remaining values.

13. When the table on the screen is complete, press [ENTER].

14. Follow the instructions on the screen to save the editing changes.

9.10 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.

9.10.1 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:

   1. Place the dosimeter 30 cm. (12 inches) from the input surface of the image intensifier.
   2. Adjust the technique factors to produce the required radiation level.
   3. Then LOCK the technique and remove the dosimeter for the tests.

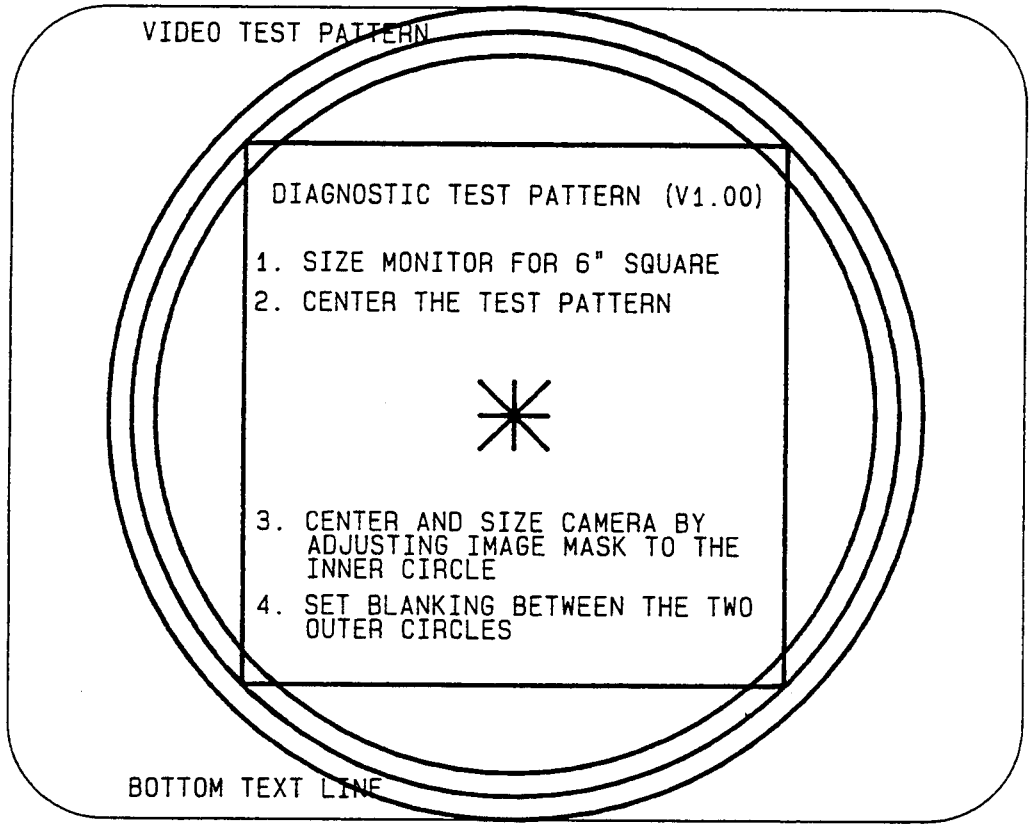
3. Unless otherwise noted, all radiation measurements are made 30 cm. (12 inches) above the input surface of the image intensifier.
4. The camera lens aperture is set to f/2.0.
5. X-ray beam alignment has been performed with satisfactory results.
6. On 6/9-inch fluoroscopy systems, all camera tests and 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.

9.10.2 Monitor Raster Size Adjustment

1. Place the video selector switch on the rear of the monitor cart in the "NORMAL" position.
2. Put the monitor cart into the diagnostics mode. Follow the instructions in the Monitor Cart Service Section for using either the **Front Panel** or **Terminal Diagnostics**.
3. Select test *23 - VIDEO TEST PATTERN.*
4. While viewing the test pattern, adjust the *VERT SIZE* and the *WIDTH* controls on the left monitor to produce a 6-inch square in the center of the screen.
5. It may be necessary to adjust the centering magnets on the CRT neck to hide the raster edges, and to correctly display the text lines.
6. Repeat this procedure for the right monitor.

NOTE: Adjust the TV monitor size controls before any other size adjustments are performed.

Figure 9-10 - *TEST 23 - VIDEO TEST PATTERN is used for video alignment, sizing and centering.*



9.10.3 Camera Sizing and Optical Adjustments

9.10.3.1 Camera Rotation Axis Offset (mirror axis alignment)

Test Spec:
Less than 1/4" axis shift on the monitor as the camera is rotated through its 360 degree range.

1. Place the alignment tool on the image intensifier input surface.
2. Loosen the camera drive belt and disengage it from the drive gear. This will prevent damage to the rotation drive motor.
3. Continue using the VIDEO TEST PATTERN - Test 23, described in the previous procedure.

4. Rotate the camera to one extreme, make a fluoro exposure and with a felt-tip pen, place a mark on the monitor screen at the center of the alignment tool image.

5. Rotate the camera 90 degrees and mark the center again. Repeat this every 90 degrees throughout the 360 degree range.

6. Make a cross by connecting the diagonally opposite marks, and measure the length of the longest diagonal.

7. If this dimension is less than 1/4 inch, no further adjustment will be necessary.

8. Adjustment is made while making an exposure by varying the jackscrew settings supporting the mirror and aligning the center of the tool image with the center of the marked cross. When complete, re-check allignment.

9. Center the alignment tool crosshair in the center of the video test pattern by adjusting the horizontal and vertical centering on the camera Deflection PCB. Camera centering controls are further described in a following procedure.

NOTE: Be careful not to over-tighten the compression washers.

10. Replace the camera drive belt over the drive gear.

9.10.3.2 Camera Lens Aperture Setting

Set the camera lens aperture to f/2.0.

9.10.3.3 Active Image Size and Centering

Adjust the camera image size and centering according to the Video Test Pattern Instructions.

Spec: Diameter = 8.25 inches +/- .125

Camera Size and Centering Controls (Deflection PCB):

R-40	Hor. Size - normal
R-38	Hor. Centering - normal
R-39	Hor. Centering - reversed
R-19	Vert. Size
R-37	Vert. Centering

9.10.4 Image Circular Masking

Spec: Less than 2% of SID (.72 inch for 9-inch system, .76 inch for 6-inch system).

1. With the BYPASS switch in the "NORMAL" position, the image edges will be hidden by the circular blanking window. The blanking should cover the image edge at all points throughout a complete rotation of the camera.

2. In no case should there be more that 2% of the SID (referred to the input of the image tube) masked. This refers to areas radiated, but not imaged as a result of circular blanking or other masking.

3. Set the circular blanking on the monitor cart AD/DA PCB with the potentiometers listed below.

R45	Vertical Offset
R47	Vertical Size
R48	Horizontal Size
R50	Horizontal Offset

4. Press the *HELP* button to *exit Test 23*. Then select *Option 99 - Return to System*.

9.10.5 Camera Electrical Adjustments

Test Conditions:

1. Contrast Grid installed
2. No other filters in beam except aluminum collimator filter
3. Shading jumper out (disabled)
4. Auto gain jumper out (disabled)
5. Black level control disabled (jumper TP2 to TP7)
6. Camera input power = 24 +/- 1.0 VDC

9.10.5.1 +500 Volt Supply Adjustment.

1. Adjust R-13 to the maximum voltage extreme.

2. Reduce the "BEAM" (R-14) setting to minimum (blanked).

3. Measure the voltage at TP-6.

4. Adjust R-13 for 25 volts below the voltage measured above at TP6 or +500 VDC, whichever is less.

Figure 9-11 - *This view of the camera shows the location of the a) Video Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.*

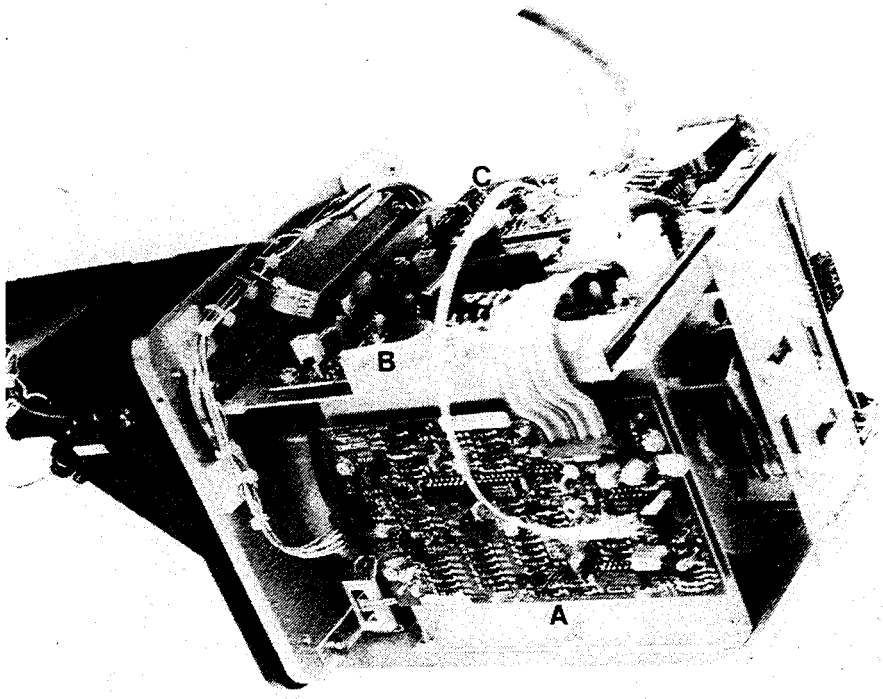
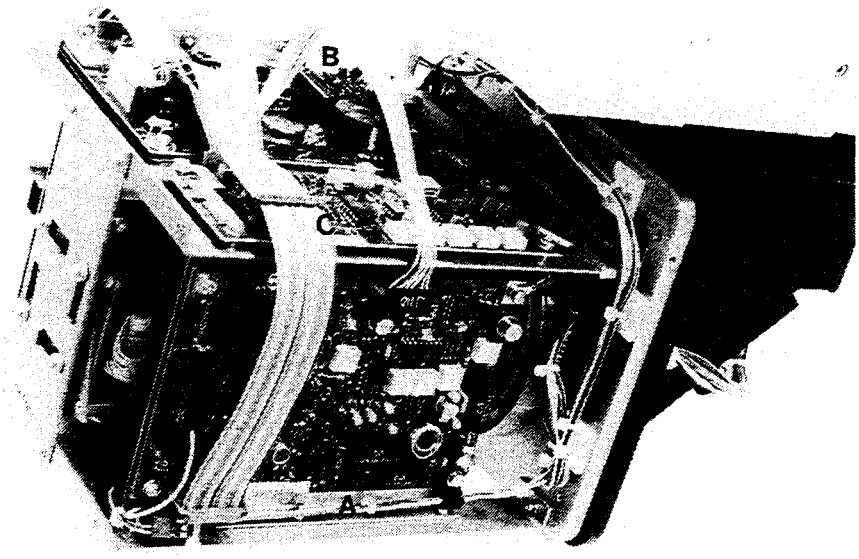


Figure 9-12 - *This view of the camera shows the a) Deflection Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.*



9.10.5.2 Beam Discharge

1. Adjust beam discharge current with the beam discharge pot R14 on the Camera Supply PCB.

2. Be sure there is sufficient beam current to discharge video amplitudes of 500 mv p-p as measured at TP-3.

3. While making an exposure and observing TP1, adjust R14 until the beam is fully discharged, then 1/8th turn beyond that point. The video level at TP3 will be observed to peak near this point.

9.10.5.3 Target Adjustment

Spec: 350 +/- 20 mv. at TP-3 on Video Processor PCB.

On the Video Processor PCB adjust the target voltage with R-43 while making an exposure to produce 350 mv p-p at TP-3.

9.10.5.4 Black Level

Spec: 75 +/- 10 mv at TP-1.

Adjust the Black Level Control (R-44) for 75mv black level as seen at TP-1 on the camera Video Processor PCB.

9.10.5.5 Camera Video Output

Spec: 850 +/- 40 mv peak video measured at J-8 of the AD/DA.

Adjust the Video Gain with R-9 on the Video Processor PCB to produce the video output measured at J8 on the AD/DA PCB.

9.10.5.6 Verify Dark Current Compensation

1. Monitor J8 on the AD/DA PCB.

2. While observing the composite video waveform during an exposure, temporarily remove the jumper between TP7 and TP2 on the camera Video PCB.

3. The black level should change, correcting to 50-150 mV above the video blanking level.

9.10.5.7 Video Output with Auto-brightness Enabled

Test conditions:
Auto-Gain enabled
Black level control enabled
Shading enabled.

Under the test conditions listed above, measure the video amplitude at J8 on the AD/DA PCB. The output video amplitude, with auto brightness enabled, should be 820 +/- 60 mv. peak.

9.10.6 Shading (Image Brightness Uniformity)

Test Conditions:
1. Contrast Grid installed
2. No other filters in beam except the aluminum collimator filter
3. * Shading jumper in (enabled)
4. Auto gain jumper out (disabled)
5. Black level control disabled (jumper TP2 to TP7)

* Shading controls adjusted for minimal shading error.

Spec:

Vertical shading component:	less than 100 mv p-p
Horizontal shading component:	Less than 100 mv p-p
Video amplitude:	850 +/- 40 mv peak (J-8 of the AD/DA)

Adjustment procedure:

1. With the horizontal sweep orientation "normal" and the scope sweep rate set to view horizontal (20 us/div) and triggered, adjust R-40 (Horiz. sawtooth) and R-42 (Horiz. parabola) for uniform amplitude across the video waveform.

Refer to Figure 9-13.

2. Restore the video amplitude with R-57 (BIAS).

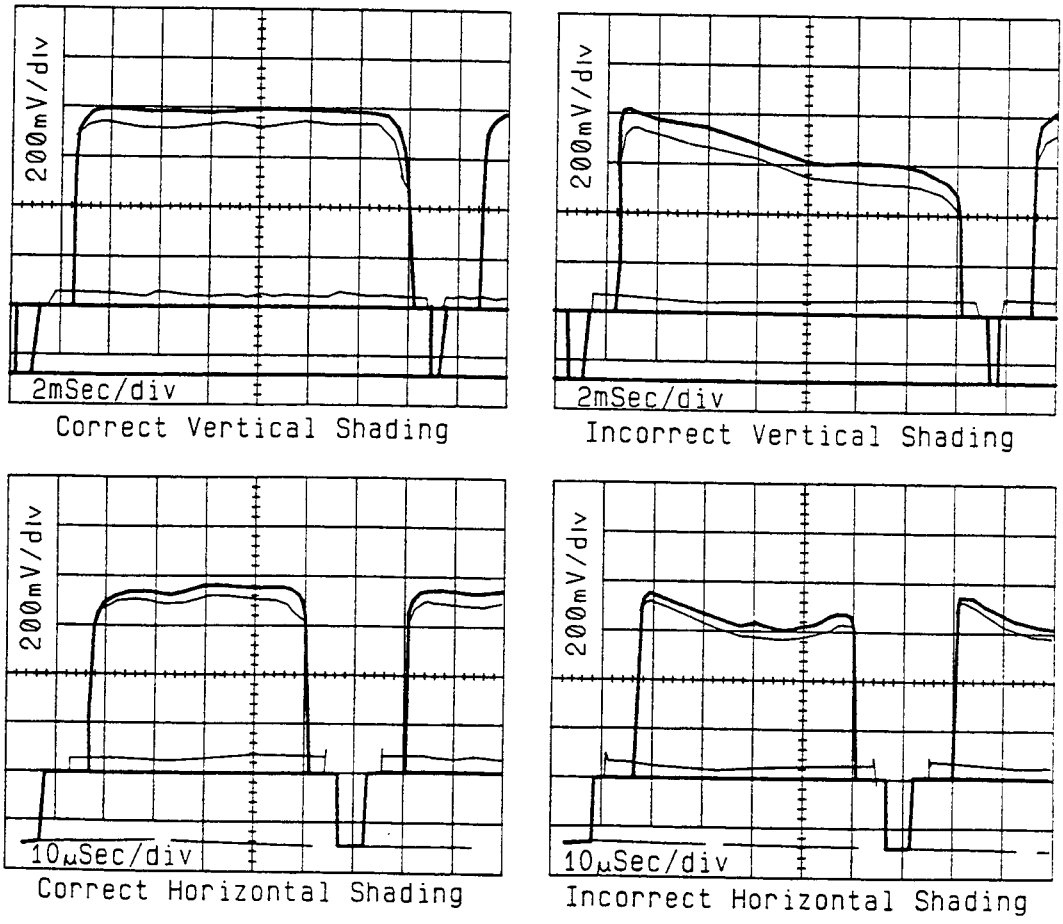
3. Change the scope sweep rate to view the vertical rate. (5 ms./div.) and adjust R-10 (Vert sawtooth) and R-15 (Vert parabola) for uniform amplitude across the video waveform.

4. Restore the video amplitude with R-57 (BIAS).

5. Repeat steps 1 and 2 with the horizontal orientation "reversed" using R-41 (horiz. sawtooth) and R-57 (BIAS) respectively.

NOTE: The shading specifications refers to the central 70% of the illuminated area in each axis. Some rounding at the edges is acceptable. It is generally helpful to "dip" the center just a little (approx. 50 mv.) to meet this specification.

Figure 9-13 - *Correct and incorrect shading waveforms are illustrated here.*



9.10.7 Resolution

Test Conditions:

1. Shading jumper in (enabled).
2. Video selector switch in the "BYPASS" position.
3. NO Contrast Grid.
4. Wisconsin Resolution Tool installed.
5. Adjust technique for 50 kVp @ 200 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 the technique for 200 +/- 10 mr./min. at 50 kVp. in "MANUAL" mode.

9.10.7.1 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.

3. Adjust C-3 (peaking capacitor) on the Preamp and Yoke assembly until the black image edges, viewed on the monitor, bleed white. Back off the adjustment of C-3 until the smearing just disappears. This will provide optimum preamp bandwidth without oscillation occurring.

Note: Use a nonmetallic adjustment tool on C-3.

9.10.7.2 Image Intensifier Focus

If this adjustment is necessary refer to the *Mainframe Service Section.*

Rotate the C-arm assembly to place the X-ray tube/image intensifier axis parallel to the floor with the X-ray tube port pointing away from the control panel.

9.10.7.3 Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

Test Specs:

(6" machine) -	40 linepairs/inch
(6/9" machine) -	40 linepairs/inch in 6" mode 35 linepairs/inch in 9" mode

9.10.8 Contrast Sensitivity Test

Test Conditions:
1. Technique factors adjusted to produce 80 kVp @ 1R/min.
2. 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 with the cart in the "NORMAL" mode and examine the stored image. Adjust the brightness and contrast controls on the monitor as necessary to optimize the image.

9.10.9 Image Noise, Correlated

Test Conditions:
1. Black level control enabled.
2. Shading jumper in (enabled).
3. Auto-gain enabled
4. Monitor Cart in BYPASS mode.

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.

9.10.10 Video Sampling Window Size and Centering

1. Connect a 2.2 Kohm resistor between TP-11 and TP-13 to see the video sampling window.

2. Put the monitor cart in "NORMAL" mode.

3. The window should now be visible when exposures are made. Adjust R-38 "H-CAL" and R-39 "V-CAL" to center this rectangular window within the viewed area.

4. 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.

9.10.11 Video Level Control and Auto Technique Tests

Test Conditions:

1. Auto-technique mode
2. Auto-gain enabled
3. Black level control enabled
4. Shading enabled
5. Contrast Grid installed.

1. Make an exposure with no filter in the beam and record the resulting kVp.

2. Make an exposure with the Aluminum filter (6" x 6" x .125") in the beam and record the resulting kVp.

3. Make an exposure with one (1) copper filter (6" x 6" x .093") in the beam and record the resulting kVp.

4. Make an exposure with two (2) copper filters (6" x 6" x .093") in the beam and record the resultant kVp.

5. The peak output video amplitude at (J8 on the AD/DA PCB) shall be 820 mv +/- 60 mv for each of the four conditions.

6. The resultant kVp readings for each of the four conditions shall be:

No filter	43+/-3 kVp
Aluminum	47+/-3 kVp
1 Copper filter	66+/-3 kVp
2 Copper filters	79+/-4 kVp

9.10.12 Camera Drive Chain Tension

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. Rotate the camera through 360 degrees and verify that the rotation motor is switched off at each limit. Verify that the chain tension allows free rotation in all positions. *Damage to the rotation motor and gear can result if the camera is rotated by hand.*

9.11 Image Processing and Monitor Cart Tests

9.11.1 AD/DA PCB Calibration

1. Place the PCB on an extender card and replace the regular daisy chain cable with the test ribbon cable (which is longer to accommodate the extender card).

2. Measure the following voltages on the AD/DA PCB:

TP-21	digital to analog reference	-1.0 VDC
TP-23	analog to digital reference	-2.0 VDC

3. Adjust R-1 (video offset adjust) so that the video baseline at P-6 (right video output) is at ground.

4. Adjust **R-2** (video offset adjust) so that the video base line at P-5 (left video output) is at ground.

5. While making a fluoro exposure observe the live video waveform, in-line, at P6 and P5 of the AD/DA PCB.

6. Verify a video amplitude of 850 mVpp +/- 50 mV and the sync portion, 400 mVpp +/- 50 mV. Observe a baseline at 0 volts.

9.11.2 Verify External Video

1. Check for the presence of an EIA RS170 composite video signal at the video output jacks on the rear of the monitor cart.

2. Verify a video amplitude of 850 mVpp +/- 50 mV and the sync portion, 400 mVpp +/- 50 mV. Observe a baseline at 0 volts.

NOTE: The video signal must be terminated with 75 ohms to correctly measure the amplitude.

9.11.3 Image Processor PCB

1. Place a scope probe on TP27 and TP5 (ground). Verify that the following TV signals are present:

TP-9	Composite sync
TP-10	Composite blanking
TP-7	Horizontal drive
TP-6	Vertical drive

2. Adjust C-6 for +2.5 VDC measured on TP27. Verify that the video is stable and displayed in the center of circular blanking.

9.11.4 Front Panel Diagnostics

1. Access the Software Diagnostic Tests from the front panel of the monitor cart by pressing the HELP key and then selecting the "Front Panel Diagnostics" from the menus. These tests can also be selected from the Terminal Controlled Diagnostics.

2. The Front Panel Diagnostics contain tests of the image/memory transfers which occur in normal operation.

   These tests are fully described in the Monitor Cart Service Section. Read the descriptions and follow the instructions for these tests.

3. There are also tests from this menu of the switches and LEDs on the Front Panel:

   Run the Front Panel LED Test to verify that all LEDs operate.

4. Generate a gray scale image from the test menu.

5. Swap the image from one monitor to the other (using the M1-M2 swap test) and examine the image for any signs of tear or jitter.

9.11.5 Monitor Cart Imaging Function Checks

A variety of image processing functions may be available on a given system. Refer to the Operator's Manual for instructions on using the available functions.

1. Enable each function on the front panel and using a suitable test image (such as the Wisconsin Copper Mesh Test Grid), evaluate the operation of the function. Camera rotation may be used to simulate motion when evaluating some functions.

2. Verify that the LIVE FLUORO (left) Footswitch generates a live fluoro image on the left monitor regardless of the status of the image processing controls.

3. Depress the PROCESS (right) Footswitch to initiate the selected image processing.

4. Enable the WINDOW and LEVEL functions and take another image. The WINDOW and LEVEL arrow buttons should change the dynamic range and brightness level of the image presented on the left-hand monitor.

5. Verify that the Negative Image (NEG) function reverses the lights and darks in the image.

6. Verify operation of both the INTEGRATE and the AVERAGE functions for all levels of averaging (number of frames).

7. Verify operation of the SHARPEN function.

9.11.6 Image Storage on Hard Disk

If the system is equipped with the option to store images on the hard disk, check its operation as follows:

1. Verify that the Manual SAVE function stores the image on the hard disc.
2. RECALL the image stored in the previous step.
3. Verify that the image counter increments and decrements, and that additional images can be recalled. "d0" error message displayed on the LED's indicates that no image was found in the specified location.
4. Enable the AUTO save function. Generate a picture on the left monitor, and press the L->R function switch. Verify that the image is auto-saved and that the LED image counter is incremented by one.
5. Time the transfer while saving an image to disk. The transfer should take less than 10 seconds, thus verifying disk transfer DMA.

9.12 Image Storage Options

Refer to Section 11, System Options.

9.12.1 AngioStor

Check out the operation of the AngioStor videodisk recorder described in the Options Section.

9.12.2 VTR

1. Verify VTR control operation as described in the operator's manual.
2. Check that the playback level is correct.

   Level adjustment instructions are found in the Options Section of the Service Manual.

CALIBRATION WORKSHEETS

Series 9000 - Serial Number _____

Calibration Performed By: _____

Location _____ *Date:* _____

Introduction

These worksheets accompany the Series 9000 system calibration procedures found in Section 9 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.

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 9000 System.

9.3 Preparation and Setup

9.3.1 Record the Test Equipment Used

Dynalyzer Model _____ S/N _____

Dynalyzer Display Model _____ S/N _____

Autocal Interface Box S/N _____

DVM/DMM Model _____ S/N _____

Oscilloscope Model _____ S/N _____

Dosimeter Model _____ S/N _____

Ion Chamber Model _____ S/N _____

9.3.2 Preparation and Inspection

___ *Steps 1 thru 9 completed.*

9.4 Electrical Tests

9.4.1 Leakage Current Testing

Leakage Current _____ Pass/Fail _____

9.4.2 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 = _____

9.4.3 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

9.4.4 Monitor Cart Power Supplies

___ *Steps 1 thru 3 completed.*

AC voltage at the AUX outlets _____ VAC

Measure the following voltages relative to DC Common (PS-1 pin 7):

PS-1 pin 12	red wire	_____ VDC
PS-1 pin 6	gray wire	_____ VDC
PS-1 pin 5	violet wire	_____ VDC
PS-1 pin 4	yellow wire	_____ VDC
PS-1 pin 3	blue wire	_____ VDC
TV monitor power supply		_____ VDC

9.4.5 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.

9.5 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

9.6 Functional Checks

9.6.1 Self-tests

___ Self-tests during powerup successfully completed.

9.6.2 Emergency Off and Processor Reset Test

___ Left Emergency Off breaks interlock circuit
___ Processor resets and runs.
___ Right Emergency Off breaks interlock circuit

9.6.3 Status Mode Tests

Refer to the Mainframe Service Section for instructions on using the Status Mode.

___ LED Test
___ Panel key test
___ Panel knob test

Date and initials listed for last calibration _____

Total RAM _____ Total disk space _____

9.6.4 Film Cassette Test (6-inch systems only)

___ *Steps 1 thru 6 completed.*

9.6.5 Verify Operation of Mainframe Controls

___ *Steps 1 thru 7 completed.*

9.6.6 Field Solenoid Position Test

___ *Steps 1 thru 7 completed.*

9.6.7 Verify Controls in MANUAL FLUORO

___ *Steps 1 thru 2 completed.*

9.6.8 AUTO FLUORO Tests

___ *Steps 1 thru 9 completed.*

9.6.9 Fluoro Boost Option

___ *Steps 1 thru 4 completed.*

9.6.10 Pulsed Operation

___ *Steps 1 thru 2 completed.*

9.6.11 Verify Fluoro Timer and Timer Reset

___ *Steps 1 thru 3 completed.*

9.7 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

9.7.1 Preparation

___ *Steps 1 thru 2 completed.*

9.7.2 Radiographic Beam Alignment

___ *Steps 1 thru 19 completed.*

Measure the dimensions of each field:

Minimum field - less than 1.97" square * _____
4-inch field - 4" +/- 0.50" square _____
6-inch field - 6" +/- 0.50" square _____
8-inch field - 8" +/- 0.50" square _____

* 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.

Note: The corners of the 8" field will be clipped by the 10" collimating ring on 6" image intensifiers.

9.7.3 Fluoroscopic Beam Alignment

___ *Steps 1 thru 6 completed.*

9.8 X-ray Calibration

9.8.2 Connections

___ The Dynalyzer, digital display, and autocal interface box are connected according to the instructions in this section.

9.8.3 Setup

___ General Setup

___ Autocal Interface Box

___ Dynalyzer High Voltage Unit

___ Dynalyzer DRO (Digital Display Unit)

9.8.4 Getting Started

___ *Steps 1 thru 7 completed.*

9.8.5 Duty Cycle Calibration

___ (9.8.5.1) Take Duty Cycle Data

___ (9.8.5.2) Calculate Duty Cycle Coefficients

___ (9.8.5.3) Write Duty Cycle Coefficients to EEPROM

9.8.6 Calibration Data

___ (9.8.6.1) Acquire Calibration Data

___ (9.8.6.2) Calculate Calibration Coefficients

___ (9.8.6.3) Update Coefficients to EEPROM

9.8.7 Verify Calibration

The following tests for kVp, mA and mAs accuracy require installation of a dynalyzer; the Autocal Interface Box is not required. *Refer to the Dynalyzer Instructions in the Appendix.*

Perform the tests indicated and record the results on the calibration worksheet. Verify that the system meets the specifications given with the tables below.

9.8.7.2 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 @ 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

9.8.7.3 MAS Accuracy Tests

mAs Accuracy @ 50 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp
200 mA	_____ mA (+/-10.0 mAs)	_____ kVp

---

mAs Accuracy @ 90 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp
200 mA	_____ mA (+/-10.0 mAs)	_____ kVp

---

mAs Accuracy @ 120 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp

9.8.7.4 Fluoro mA Accuracy Test

Fluoro mA Accuracy @ 50 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

Fluoro mA Accuracy @ 90 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

Fluoro mA Accuracy @ 120 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

9.9 Entrance Exposure Calibration

Fill in the worksheet table by determining the mA needed to produce 4.69 R/minute at increments of every five kVp. Do this across the range from 40 to 120 kVp.

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.

9.10 Imaging System Calibration

9.10.1 General Test conditions:

___ Conditions 1 thru 8 are being observed for the tests in this section.

9.10.2 Monitor Raster Size Adjustment

___ *Steps 1 thru 6 completed.*

9.10.3 Camera Sizing and Optical Adjustments

9.10.3.1 Camera Rotation Axis Offset (mirror axis alignment)

___ *Steps 1 thru 10 completed.*

9.10.3.2 Camera Lens Aperture Setting

___ Camera lens aperture set to f/2.0.

9.10.3.3 Active Image Size (camera size adjustments)

___ Adjust the camera image size according to the Video Test Pattern Instructions.

9.10.4 Image Circular Masking

___ *Steps 1 thru 4 completed.*

9.10.5 Camera Electrical Adjustments

___ Conditions 1 thru 6 are being observed for the tests in this section.

9.10.5.1 500 Volt Supply Adjustment

___ *Steps 1 thru 4 completed.*

9.10.5.2 Beam Discharge

___ *Steps 1 thru 3 completed.*

9.10.5.3 Target adjustment

___ Target voltage adjusted.

9.10.5.4 Black Level

___ Black Level Control adjusted.

9.10.5.5 Camera Video Output

Video output measured at J8 = _____ mVp

9.10.5.6 Verify Dark Current Compensation

___ *Steps 1 thru 3 completed.*

9.10.5.7 Video Output with Auto-brightness Enabled

Video output measured at J8 with Auto brightness enabled = _____ mVp.

9.10.6 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.

9.10.7 Resolution

___ Conditions 1 thru 5 are being observed for the tests in this section.

9.10.7.1 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.

9.10.7.2 Image Intensifier Focus

Adjustment **was/was not** neccessary (circle one).

9.10.7.3 Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

(6-inch machine) - _____ linepairs/inch

(6/9-inch machine) - _____ linepairs/inch in 6" mode
_____ linepairs/inch in 9" mode

9.10.8 Contrast Sensitivity Test

___ Conditions 1 thru 2 are being observed for the tests in this section.

# of penetrometer spots discernible = _____

9.10.9 Image Noise, Correlated

___ Conditions 1 thru 4 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.

9.10.10 Auto Brightness

9.10.10.1 Video Sampling Window Size and Centering

___ *Steps 1 thru 4 completed.*

9.10.11 Video Level Control and Auto Technique Tests

___ Conditions 1 thru 5 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
Aluminum	_____ kVp	_____ mVp
1 Copper filter	_____ kVp	_____ mVp
2 Copper filter	_____ kVp	_____ mVp

9.10.12 Camera Drive Chain Tension

___ *Steps 1 thru 3 completed.*

9.11 Image Processing and Monitor Cart Tests

9.11.1 AD/DA PCB Calibration

___ *Steps 1 thru 6 completed.*

9.11.2 Verify External Video

___ *Steps 1 thru 2 completed.*

9.11.3 Image Processor PCB

___ *Steps 1 thru 2 completed.*

9.11.4 Front Panel Diagnostics

___ *Steps 1 thru 5 completed.*

9.11.5 Monitor Cart Imaging Function Checks

___ *Steps 1 thru 7 completed.*

9.11.6 Image Storage on Hard Disk

___ *Steps 1 thru 5 completed.*

9.12 Image Storage Options

Refer to Section 11, System Options.

9.12.1 AngioStor

Check out the operation of the AngioStor videodisk recorder described in the Options Section.

9.12.2 VTR

___ *Steps 1 thru 2 completed.*

SECTION 10
UNPACKING AND INSTALLATION

This section describes the installation of the OEC-Diasonics mobile C-arm system. Included are instructions for unloading and unpacking, startup after long term storage, and guidelines for moving the system.

Site requirements and the Installation Checkout Procedure are found at the end of this section.

10.1 Responsibility

The customer must provide the labor and equipment necessary to unload the system from the transport vehicle and move it to the final location. The customer is responsible for obtaining all permits and for meeting all other requirements of state and local codes, regulations, and ordinances with respect to the installation and operation of the system.

The Installation Checkout Procedure should be performed only by a qualified service technician.

10.2 Unloading and Inspecting the Shipment

Before unpacking, the customer should inspect the shipping containers and exposed system components for any apparent damage. Any shipping container that appears damaged should be unpacked with the carrier's agent present. The customer should also ensure that all equipment specified in the purchase order has been delivered.

If any part of the shipment is damaged or missing, immediately notify the carrier and the nearest OEC-Diasonics regional service office or representative. Retain the shipping container and packing material for the carrier's inspection.

10.3 Domestic Unpacking Instructions

10.3.1 Unpacking the Mainframe Assembly

1. Remove the plywood ramp and place it at the rear of the palette base. *(Refer to Figure 10-1).*

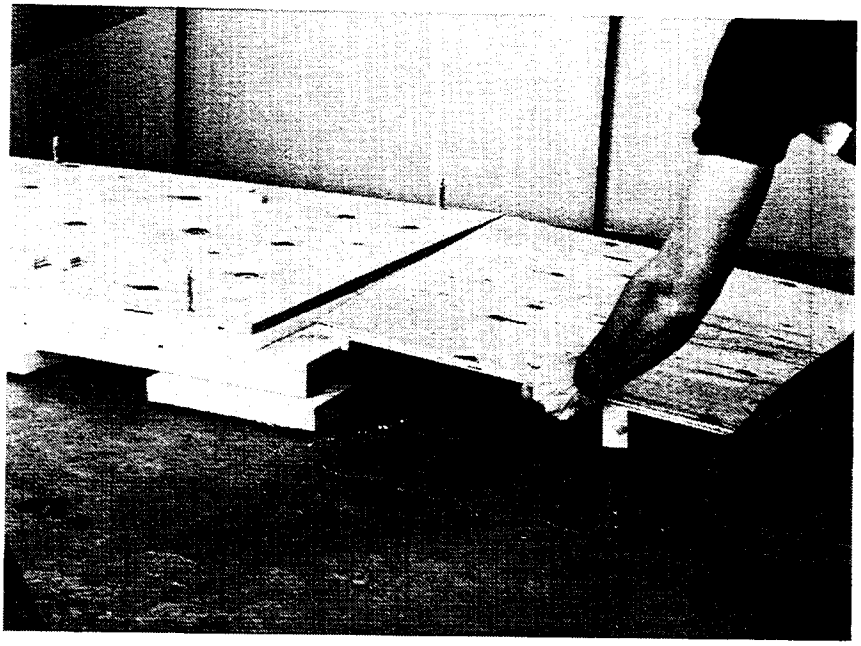


Figure 10-1 - *Place the plywood ramp at the rear of the palette base.*

2. Remove the image intensifier assembly from the palette and place it out of the way for now.

3. Remove the bolts and strap holding down the X-ray tube assembly.

4. Remove the metal straps holding the front and rear wheels in place. *(Refer to Figures 10-2 and 10-3).*

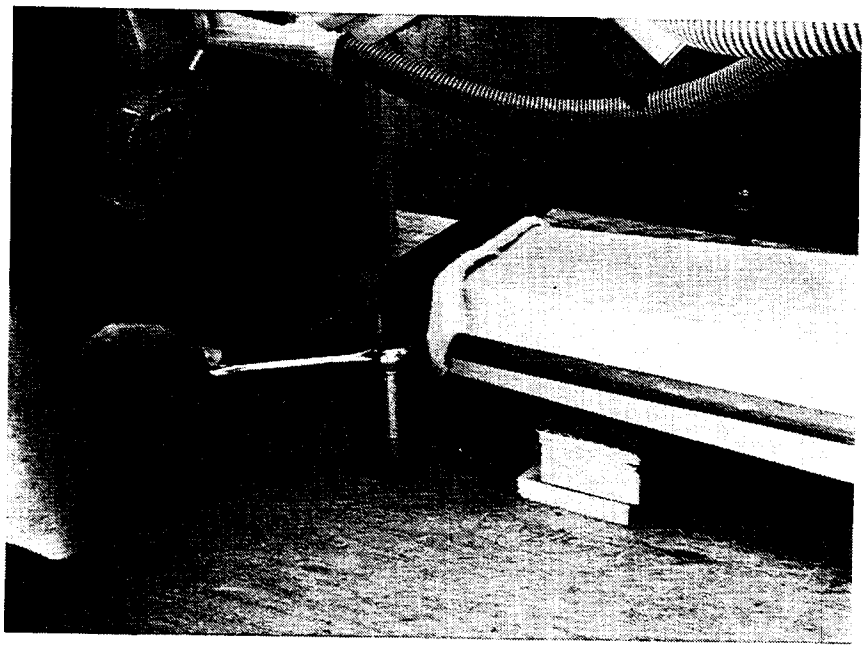


Figure 10-2 - *Remove the metal strap holding the front wheel in place.*

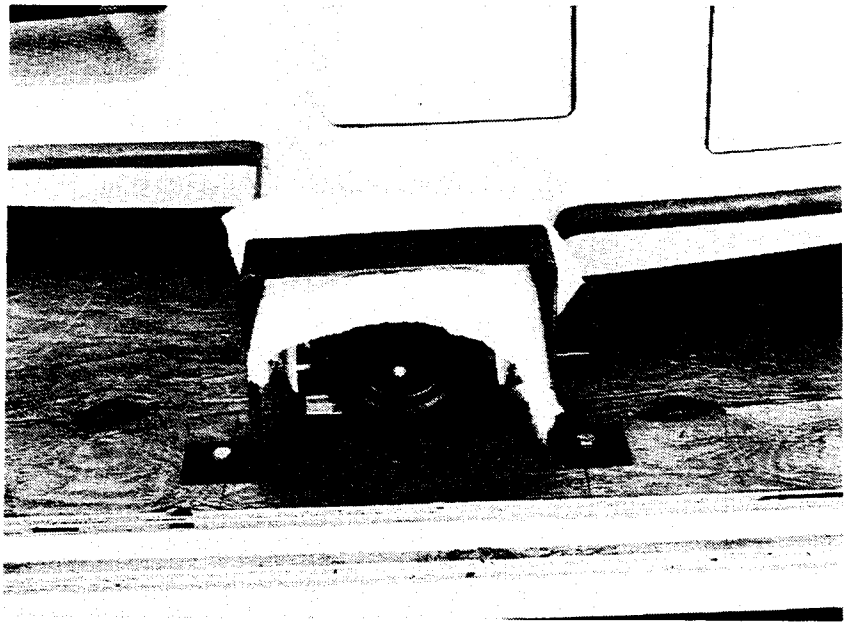


Figure 10-3 - *Remove the metal straps holding the rear wheels in place.*

5. Using the 3-ft. length of 2x4 as a lever, carefully lift up the front wheel and remove the support blocks. *(Refer to Figure 10-4)*.

6. Again using the 2X4 as a lever, lift up each rear wheel and remove the support blocks on both sides. *(Refer to Figure 10-5)*.

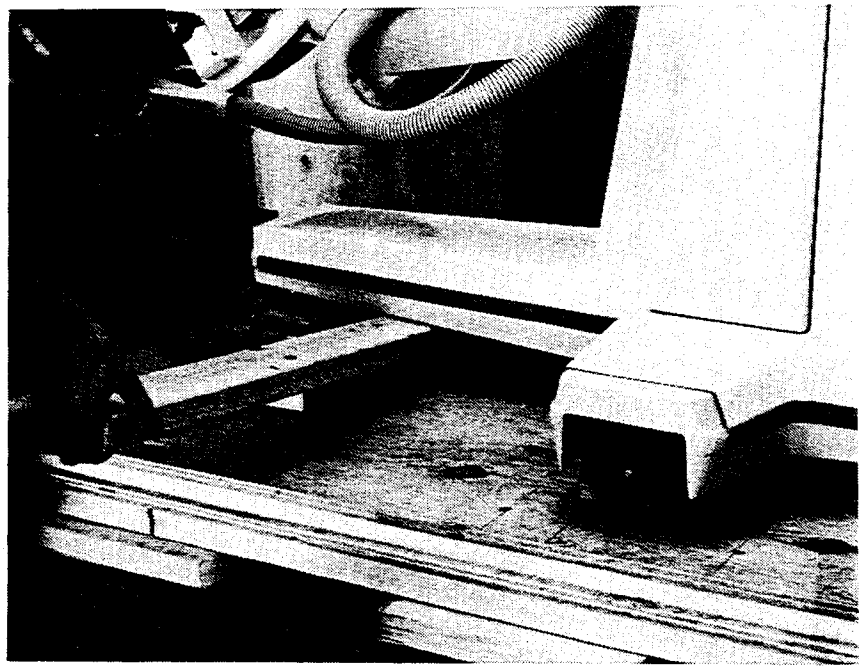


Figure 10-4 - *Use the length of 2x4 as a lever.*

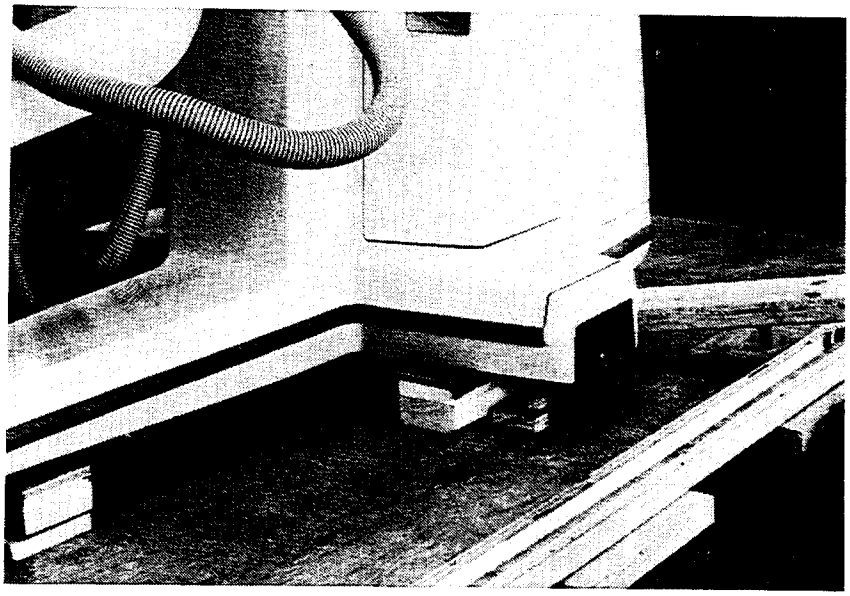


Figure 10-5 - *Use the length of 2x4 as a lever under each rear wheel to remove the blocks.*

7. Position the front and rear wheels in a straight line using the foot lever and the steering handle.

8. Pull the mainframe gently down the ramp. *(Refer to Figure 10-6).*

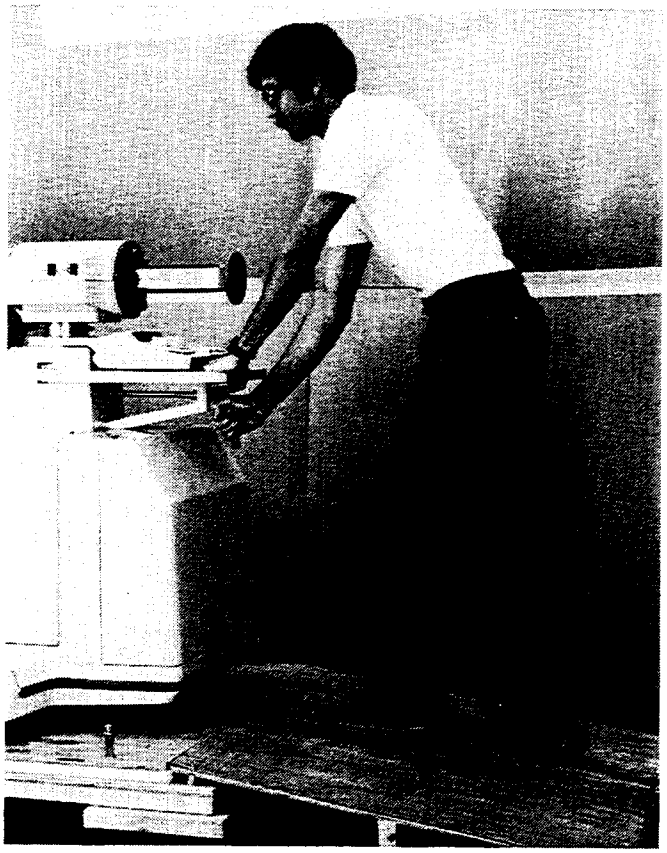


Figure 10-6 - *Carefully back the mainframe down the ramp.*

CAUTION: *Don't let the C-arm roll down the ramp too fast. Keep it in a straight line aimed straight back to avoid rolling off the side of the ramp.*

CAUTION: *Keep the base of the ramp clear of obstacles.*

9. After leaving the ramp, lock the C-arm wheels at right angles to each other to prevent the C-arm rolling.

10. Rotate the C-arm to place the imaging axis vertically with the image tube mount on the bottom.

CAUTION: *When the C-arm brakes are loosened the C-arm may pivot out of balance. Be sure the brakes are tight before attaching the weight of the image tube assembly to the C-arm.*

11. Locate the four Nylock screws in the shipping kit. Place the image intensifier assembly on the C-arm mount and insert and tighten the four Nylock screws.

12. Remove the protective bubble pack from the high voltage cable assembly, extension arm, and control panel. *(Refer to Figure 10-7).*

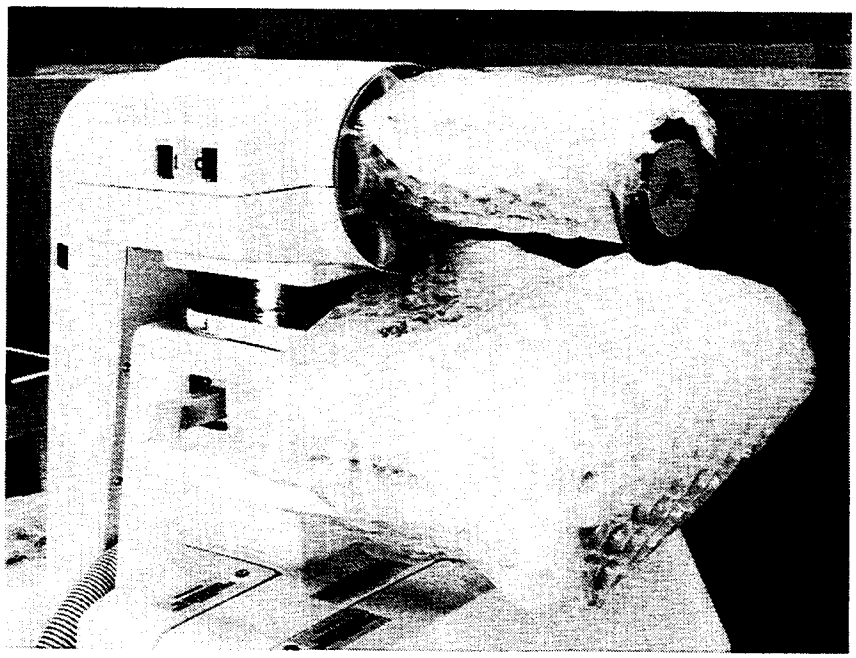


Figure 10-7 - *Remove the bubble packing.*

13. Remove the wood brace from the extension arm. *(Refer to Figure 10-8).*

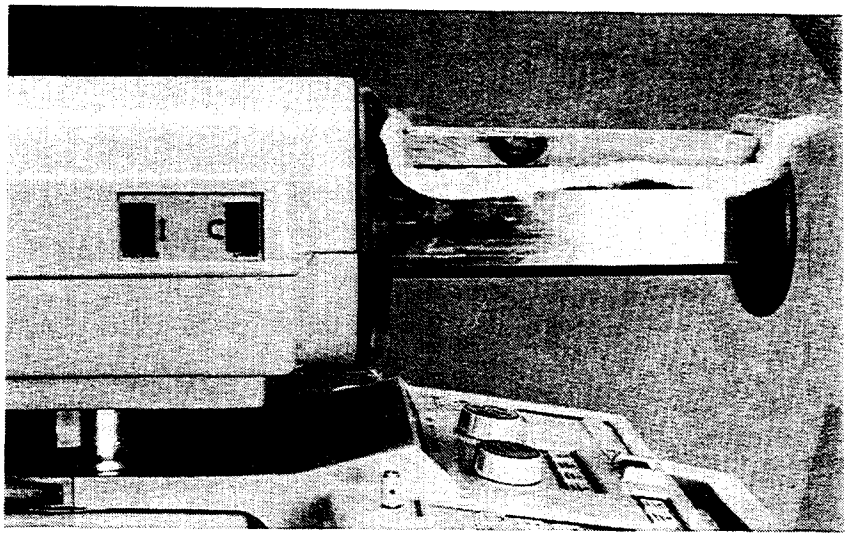


Figure 10-8 - *Remove the wooden brace.*

10.3.2 Repacking the Mainframe

Reverse the order of the above steps.

NOTE: *When placing the wood blocks under the three wheel assemblies, note that the front wheel block is higher than the two rear wheel blocks.*

WARNING: When removing the image intensifier, do not let the C-arm pivot unbalanced - make sure the C-arm brakes are tight.

10.3.3 Unpacking the Monitor Cart Assembly

1. Carefully cut away the shrink wrap covering the monitor cart. *(Refer to Figure 10-9).*

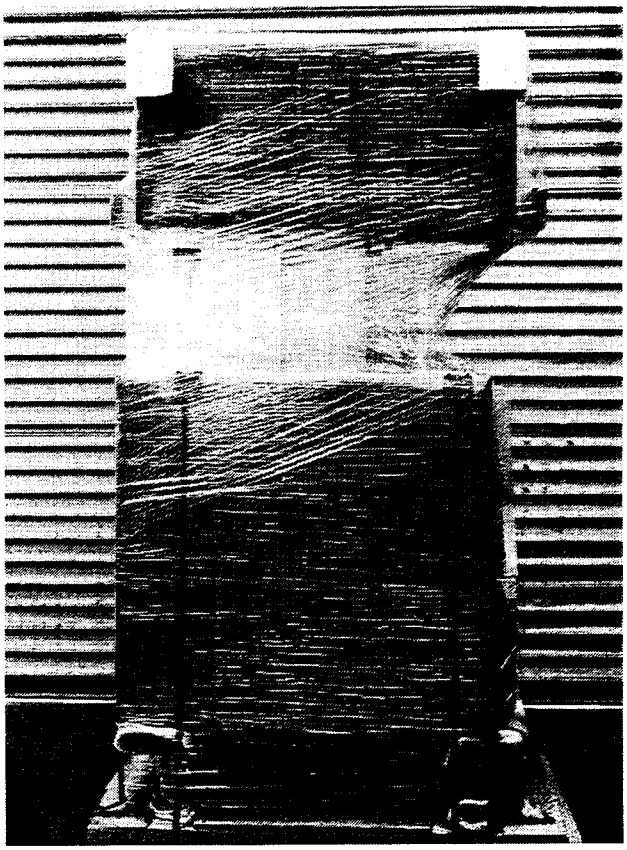
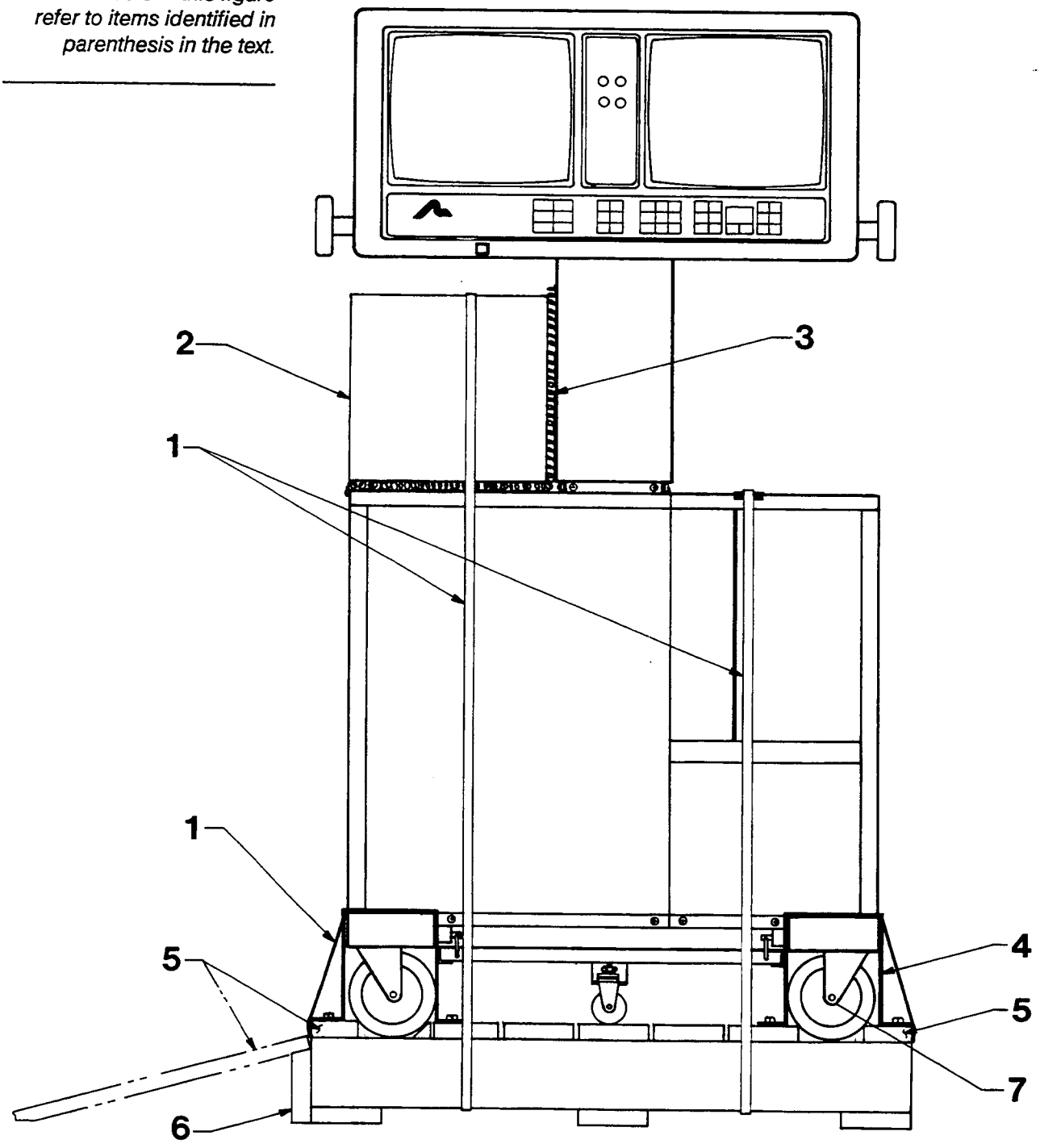


Figure 10-9 - *Remove the shrink wrap plastic covering the monitor cart.*

2. Cut the plastic straps secured around the monitor cart and the cardboard shipping box.

   If the cart has been shipped on a palette, follow steps 3 thru 7. *(Refer to Figure 10-10).*

Figure 10-10 - *Remove the monitor cart from the palette. The numbers in this figure refer to items identified in parenthesis in the text.*



3. Remove the shipping (accessory) kit (2) from the shelf top. Cut the nylon reinforced tape and remove the protective covering (3) from the shelf top.

4. Remove the two lag screws, metal strap and felt pad from each of the front wheels (4). *(Refer to Figure 10-11).*

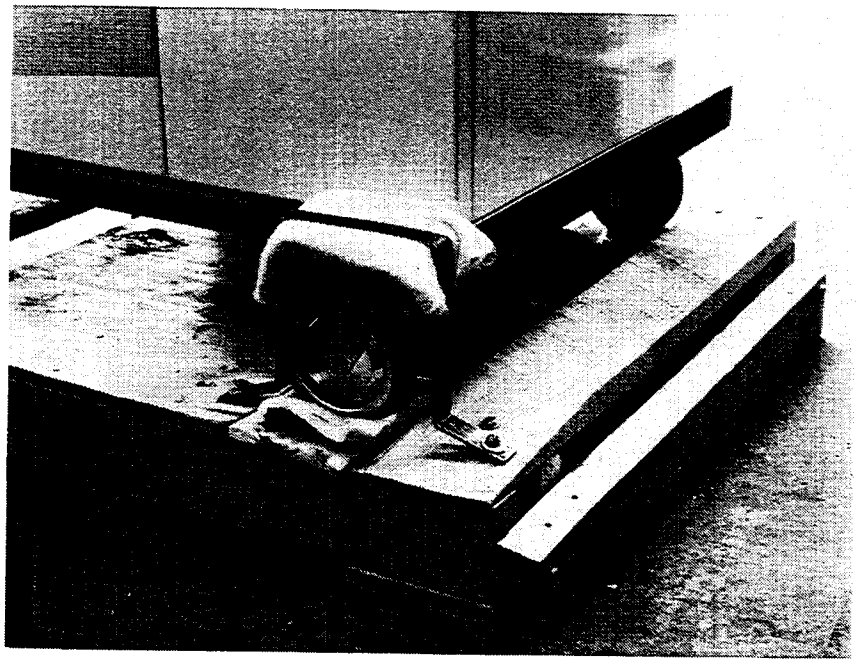


Figure 10-11 - *Remove the metal straps from each of the front wheels.*

5. Remove the lag screws and ramp planks (5), reposition the ramps on the ramp support (6), and secure in place using the 4 lag screws obtained during plank removal.

6. Unlock the rear wheel brakes. Unlock the caster swivel lock on the front wheel furthest from the ramp (7). Turn the caster 180 degrees and relock its swivel.

CAUTION: *The following steps require two strong people capable of controlling the cart as it is rolled out of its retension groove and down the ramp (the monitor cart weighs approximately 360 lbs.). Care must be taken to prevent the cart from rolling off the pallet and ramps.*

7. Roll the monitor cart up and over the center pallet planking and down the ramps to the floor.

8. Check for any unremoved packing materials on the cabinet. Unpack the accessory kit and the optional accessories.

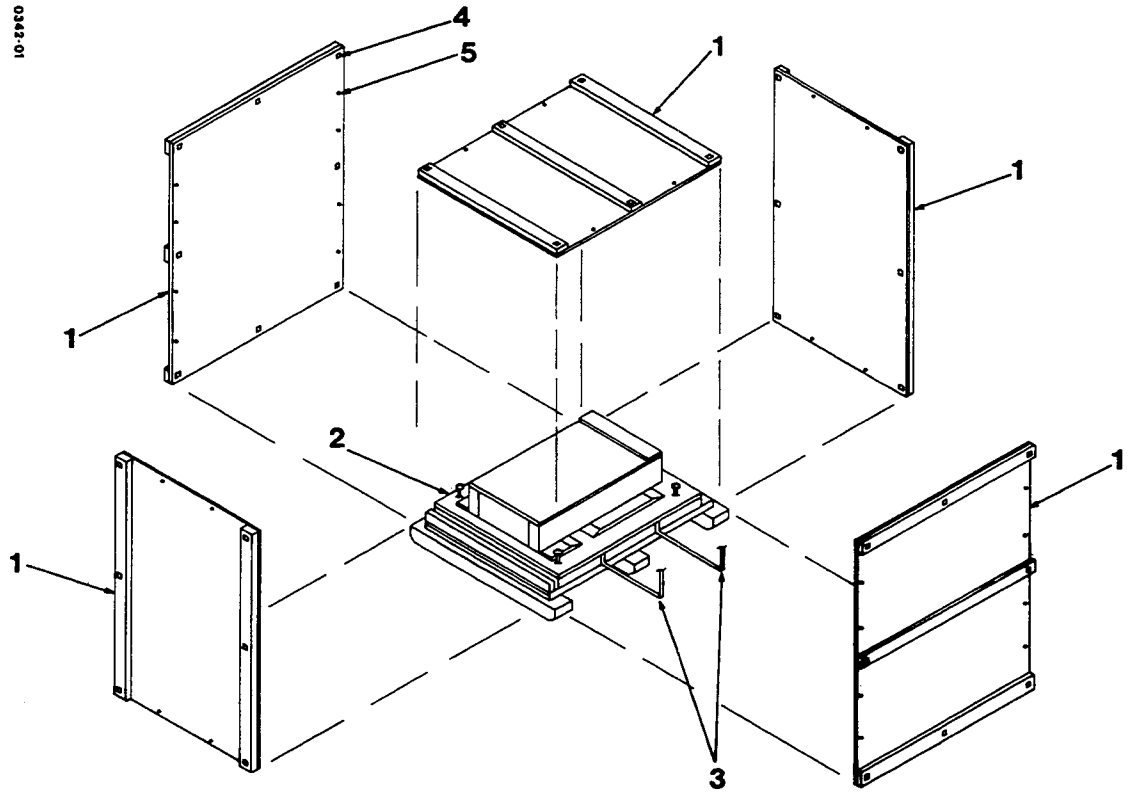
9. Install the top covers. Refer to the Assembly/Disassembly section in the Service Manual for instructions.

10. The monitor cart can now be moved to the installation site.

10.4 Foreign Export Unpacking Instructions, Mainframe and Monitor Cart Assemblies

The shipping containers consist of side and top pieces secured to the shipping palette with lag screws. *(Refer to Figure 10-12).*

Figure 10-12 - *Foreign export packing.*



1. Remove the lag screws which secure each panel to the wooden shipping palette.

2. As each panel is freed by removing the lag screws, lift the panel out of the way.

3. Follow the instructions previously given in this section for removing the equipment from the palettes and removing protective wrapping materials.

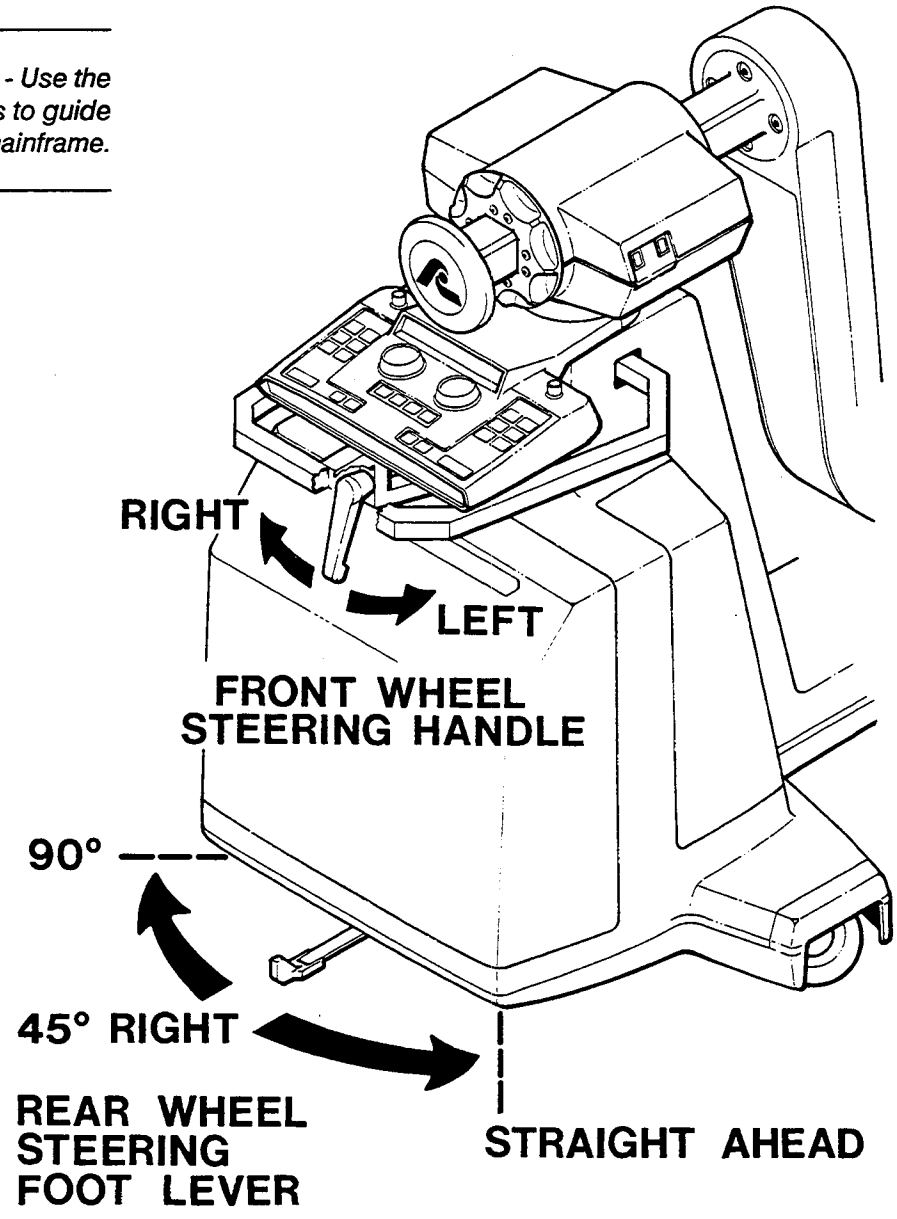
10.5 Moving the System

1. Place the C-arm and L-arm in their most compact positions. If the system has just been unpacked it is already in this configuration.

2. Lock all movable mechanical assemblies, such as the extension arm, in place. Tighten all locking handles.

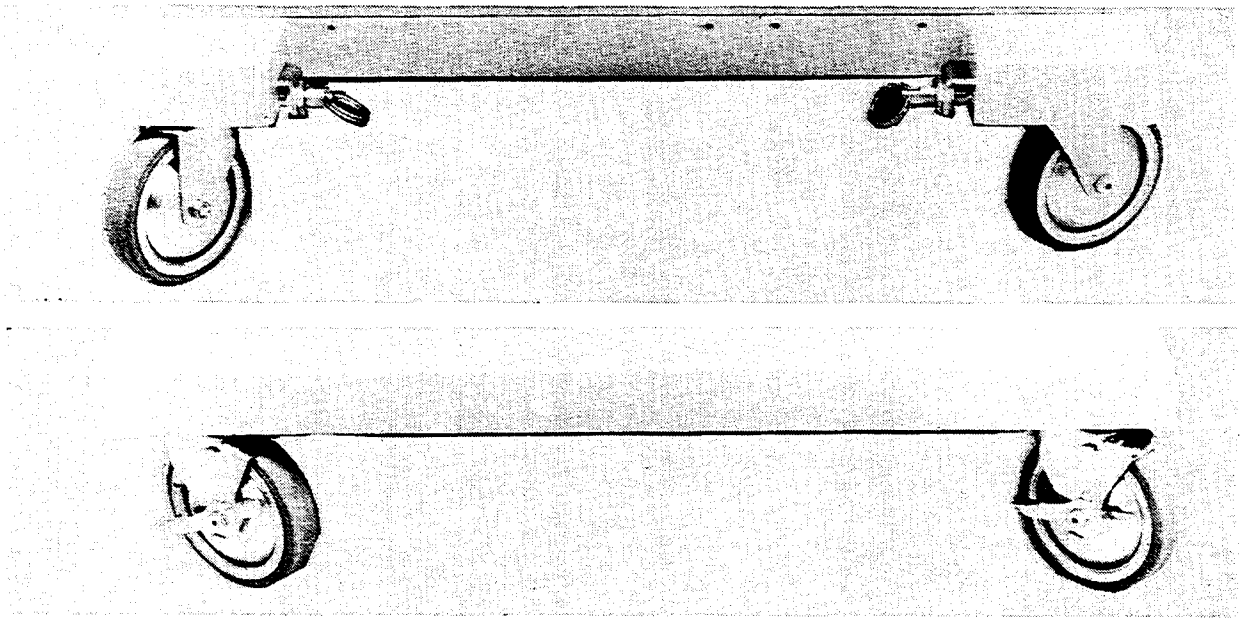
3. Steer the mainframe with the controls. The operation of the steering controls is demonstrated in Figure 10-13.

Figure 10-13 - *Use the steering controls to guide the mainframe.*



4. Unlock the monitor cart wheels and guide it carefully as you push. *(Refer to Figure 10-14).*

Figure 10-14 - *The front and rear wheel locks.*



5. When the system is finally in place, apply the friction wheel locks on the monitor cart and lock the mainframe front and rear wheels at right angles to each other.

Take These Precautions When Moving the System

- Two people should guide the mainframe and then return to guide the monitor cart when moving up or down an incline.

- Never move the system by pushing the mainframe ahead of you while pulling the monitor cart behind.

- Clear all hazards (this may mean both people and equipment) from the base of a ramp before moving the system along the incline.

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

- Never lock the mainframe or cart in place on an incline. It may roll out of control.

- Always apply the friction locks on the monitor cart and lock the front and rear wheels on the mainframe at right angles to each other when the system is in its final location.

10.6 Startup After Long Term Storage

Follow these steps if the system has been in storage for more than 60 days:

1. Plug in the system.
2. Follow the normal setup procedure.
3. Leave the system powered up in the FLUORO mode for at least four hours. (This allows for proper ion removal from the image intensifier tube).

If the system has been in storage for more than six months, condition the batteries and ensure their full charge before use:

1. Connect the interconnect cable between the mainframe and the monitor cart.
2. Plug in the monitor cart power cord. (The battery charger circuit will apply the charging current to the batteries in the mainframe).
3. Allow the batteries to charge in this manner for 24 hours.
4. Follow the normal setup procedure.
5. Leave the system in the FLUORO mode for at least four hours. (This allows for proper ion removal from the image intensifier tube).

10.7 Site Requirements

The major considerations for installation of the system are:

1) electrical power requirements,
2) environmental conditions, and
3) safety precautions.

The system power and operating environment requirements are listed in the *System Specifications*.

To satisfy its electrical requirements the system requires an input power source capable of providing:

115 VAC, 20 Amps or
230 VAC, 10 Amps.

Line voltage regulation requirements must be met as described in the Installation Checkout Procedure.

The customer is responsible for preparing the building, equipment environment and services required to install and operate the system.

10.8 Installation Checkout Procedure

As the steps in this procedure are performed, check them off on the Installation Checklist at the end of this section. You should make a photocopy of this checklist for use and save the original for reference.

10.8.1 Verify the Contents of the Accessory Kit

Verify that the following materials have been included in the System Accessory Kit (part # 870729). Note any shortages on the Checklist.

Two Operator's Manuals
Two Service Manuals
Two schematic Packages
Two mainframe keys
Footswitch assembly
Cassette holder (OEC-Diasonics metric or standard)
30 cm. skin spacer assembly
Eight socket-head Nylock screws
Copy of Configuration Sheet

Field Service Documentation Package:

- FDA form 2579
- Installation report (QAI 1003)
- Film identification stickers
- Various envelopes
- X-ray installation documentation instructions
- Instructions for Installation (QAI 1006)

10.8.2 Inspection and Setup

1. Install the skin spacer on the collimator assembly.

   Verify the presence of an aluminum filter at the bottom surface of the collimator and another aluminum filter located between the X-ray tube and the X-ray tube mounting bracket. The second filter can be seen after removing the aluminum filter from the bottom surface of the collimator. Look into the collimator and up toward the X-ray tube window.

2. Check the conductive casters on both the mainframe and the monitor cart for proper pressure and freedom of movement.

3. Inspect the interconnect cable; make sure the interconnect cable is permanently attached by its bracket to the monitor cart.

4. Remove the front, rear, and left side panels from the monitor cart and the left, right and rear covers from the mainframe. Inspect for loose hardware and shipping damage.

5. Inspect both the monitor cart card rack and the mainframe card rack. Verify that the extender board is present and that the retaining bars are screwed in place.

6. Replace all covers on the mainframe.

7. 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.*

10.8.3 Line Voltage Compatibility Check

The line voltage must be checked in each room where the equipment is to be used. Do not assume the line voltage will be constant throughout the hospital.

Verify voltage compatibility in all rooms where this machine will be used in the hospital. If a particular room is unavailable, write "NOT KNOWN" in the line voltage blank and put "NK" in the voltage and plug compatibility blanks on the checklist. A room is not plug compatible if it requires an adapter to be used. If any rooms are not voltage compatible, the hospital must be made aware of it.

10.8.4 Wiring the Isolation Transformer

1. The secondary voltage, measured on each leg referenced to neutral, should fall within the range 110-120 VAC. Wire the transformer to obtain a voltage as close to 115 VAC as possible.

   If the AC voltage range is:

94-102 VAC	wire T1 for 98 VAC
100-108 VAC	wire T1 for 104 VAC
105-115 VAC	wire T1 for 110 VAC
115-125 VAC	wire T1 for 120 VAC
122-134 VAC	wire T1 for 128 VAC

   If the AC voltage range is:

186-206 VAC	wire T1 for 196 VAC
200-218 VAC	wire T1 for 208 VAC
209-232 VAC	wire T1 for 220 VAC
228-252 VAC	wire T1 for 240 VAC
243-269 VAC	wire T1 for 256 VAC

2. Connect the interconnect cable to the mainframe and plug the power cord into the wall outlet. Check and record the voltages at the primary and secondary of the isolation transformer (T1).

3. Replace the covers on the monitor cart.

10.8.5 Basic Setup Checks

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 front panel. Refer to what these codes mean in the Service Section of this manual.

   Observe the Boot Codes on the mainframe LED panel and the Progress Codes on the monitor cart LED display as the operating software is loaded and the system is initialized.

   If any of these codes remains on the LEDs and the system fails to complete its booting and initialization, refer to the listing of boot codes in the Mainframe Service section or the listing of progress codes in the Monitor Cart Service section.

3. Check for correct AC voltage at the rear monitor cart AUX outlets.

10.8.6 Mechanical Checks

In the steps below, check for ease of movement without excessive play.

1. Check the **foot lever and steering handle** for proper movement. Then lock the C-arm in place by setting the wheels at right angles to each other.

2. Check **Wig Wag** - horizontal swing of the C-arm from side to side.

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 proper action of the pivot lock.

5. Check radial movement of the C-arm on the **cradle bearings** with proper holding action of the brakes.

6. Raise and lower the **L-arm.** The switch is located on either side of the extension arm assembly.

7. Rotate the **L-arm** 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

10.8.7 Verify Operation of Mainframe Controls

Warning: This procedure produces X-rays. Take the 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 an LED or beep response), indicating that the microprocessor is responding to the input.

3. Verify that the LARGE field switch removes the 6-inch collimator by listening for the "thunk" sound produced.

4. Select FILM mode and enter a low power technique.

5. Verify that the X-RAY ON lamps on the X-ray tube assembly, control panel and monitor cart light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

6. Verify operation of the footswitch.

7. 6-inch Machine only - Verify that in FILM mode, X-ray operation only occurs when the film cassette is in place.

8. Verify that the EMERGENCY OFF buttons on the control panel break the interlock circuit and prevent X-ray operation. (The message *INTLCKS BROKEN* will be displayed on the LED panel).

10.8.8 Verify Controls in MANUAL FLUORO

1. Select MANUAL FLUORO mode.

2. Verify that kVp and mA can be controlled with the control panel knobs.

10.8.9 AUTO FLUORO Tests

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Select AUTO FLUORO mode.

2. Using different thicknesses of copper filters, verify that the kV tracks up and down during X-rays as material thickness is increased and decreased.

3. Remove the copper filters.

4. Switch to live video using the VIDEO BYPASS switch (on the monitor cart rear) and verify that true live video appears on the left monitor and that the system does not lose synchronization.

5. Place the Wisconsin Copper Mesh Test Tool on the image intensifier assembly. Check image resolution during live imaging (video bypass mode). Minimum acceptable resolution is 35 line pairs per inch in the live mode.

6. Switch the VIDEO BYPASS switch to NORMAL. Check for proper operation of these mainframe controls:

   a. Left to right sweep reversal
   b. L -> R memory swap
   c. SHARPEN (if provided)

7. Verify operation of the motorized collimator and camera controls with the control panel switches.

8. Verify operation of the left monitor's remote contrast and brightness controls on the control panel. (Set the control on the monitor cart to REMOTE).

10.8.10 Verify Image Processing and Storage Features.

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Switch the VIDEO BYPASS switch to NORMAL.

2. Make a fluoro exposure and transfer the image to the right-hand monitor.

3. Make another exposure. The image will appear on the left monitor.

4. Enable the WINDOW and LEVEL functions and take another image. The WINDOW and LEVEL arrow buttons should change the dynamic range and brightness level of the image presented on the left-hand monitor.

5. Verify that the Negative Image (NEG) function reverses the lights and darks in the image.

6. Verify operation of both the Integration and the Averaging functions for all levels of averaging (number of frames).

7. Verify operation of the SHARPEN function.

8. 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.

9. *On systems equipped with hard disk image storage*, verify that the Manual SAVE function stores the image on the hard disc.

10. RECALL the image stored in the previous step.

11. *On systems equipped with hard disk image storage*, verify that the image counter increments and decrements, and that additional images can be recalled. "d0" error message displayed on the LED's indicates that no image was found in the specified location.

12. *On systems equipped with hard disk image storage*, enable the AUTO save function. Generate a picture on the left monitor, and press the L->R function switch. Verify that the image is auto-saved and that the LED image counter is incremented by one.

13. Time the transfer while saving an image to disk. The transfer should take less than 10 seconds, thus verifying disk transfer DMA.

14. Verify that the LEFT Fluoro footswitch generates a live fluoro image on the left monitor regardless of the status of the image processing controls.

15. Select an image processing mode (such as integrate). Press the RIGHT footswitch and verify that the selected image processing occurs.

16. Verify that the circular blanking is set as close as possible to the actual image edges throughout a full rotation in both normal and reversed image modes.

17. Check for presence of an EIA RS170 composite video signal at the video output jacks on the rear of the monitor cart.

NOTE: The video signal must be terminated with 75 ohms to correctly measure the amplitude.

10.8.11 Additional Image Processing Tests

An extensive set of tests are available through the Front Panel HELP function. These tests are described under Calibration and Diagnostic Software in the Monitor Cart Service section of this manual.

10.8.12 Fluoro Boost Option

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Enable boost on the control panel. Press down into the second position on the right footswitch.

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 image doesn't "burn out" or appear too dark.

10.8.13 Radiographic Beam Alignment Check

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Attach the beam alignment fixture to the face of the image intensifier assembly. Rotate the C-arm until the beam axis is perpendicular to the floor.

   On 6-inch models only: Verify that the cassette interlock switch is activated .

2. Make an exposure with the collimators fully open and the LARGE FIELD switch activated. Use 50 kV and 5 mAs. (The technique may vary depending on the type of film used.)

3. Close the collimators to their minimum field. Align the collimator assembly parallel to the cassette holder and repeat the exposure.

4. Develop the film.

5. Verify that the minimum field is contained within the target square (this must be less than 4.7 cm in each dimension measured on the film), that all of the innermost ring can be seen in the large field and none of the outer ring is visible.

6. Press the SMALL FIELD switch.

7. Install a new film cassette and repeat steps 2 thru 5 using the same technique.

8. Develop the film.

9. Verify that all the inner 6-inch ring is visible, and that none of the outer 6-inch ring is visible.

   The films are to be returned to the OEC-Diasonics Compliance Department per the instructions provided in the Field Service Documentation Package.

10.8.14 Fluoroscopic Beam Alignment Check

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. With the beam alignment fixture in place, select MANUAL FLUORO and set the technique at 45 kVp and 1 mA.

2. Bring up the Video Test Pattern on the monitor using the Monitor Cart Diagnostics described in the Monitor Cart Service section.

3. Make a fluoroscopic exposure and examine the test pattern image on the monitor. There should be no distortion of the image field and the inner circle of the beam alignment fixture reticle should be visible throughout its circumference.

10.8.15 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 check list:

   100 (Vn - V1)/ (V1)

   where: Vn = No load voltage
   V1 = 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.

10.8.16 Install and Verify System Options

Options provided may include:

Video Tape Recorder
AngioStor Video Disk
Hard Disk Image Storage (installed at the factory)
Patient Annotation (installed at the factory)

The installation of these options is described in Section 12 - Options.

10.8.17 Reporting

1. Return the assembler's copy of the Report of Assembly of Diagnostic X-ray (FDA form 2579), the Beam Alignment Radiographs (films), the completed Installation Report, and the Installation Checklist to OEC/Diasonics, Attention: Compliance Department, in the stamped, manila envelope provided in the Field Service Documentation Package.

2. Distribute the various remaining copies of the Report of Assembly of Diagnostic X-ray (FDA form 2579), per the documentation instructions included in the Field Service Documentation Package.

3. Verify the serial and model numbers listed and the control numbers on the Main Frame and Collimator. These should agree with those listed on FDA form 2579.

4. Record the installation in the service log.

   The OEC Representative MUST sign the last page of the Installation and Checkout Checklist, verifying acceptance of the unit. If, for any reason, installation can not be completed, the OEC Representative MUST be notified that unit is not yet ready for use. (A copy of the Installation and Checkout Procedure Checklist is found at the end of this section).

INSTALLATION CHECKLIST

Check off these steps as you perform the Installation Checkout Procedure in the service manual. Paragraph numbers are provided to make it easier to correlate the checklist to the procedure. Fill in specific data where requested.

Date - _____ S/N - _____

10.8.1 Verify the Contents of the Accessory Kit

Verify that the following materials have been included in the System Accessory Kit (part # 870729). Note any shortages below.

___ Two Operator's Manuals
___ Two Service Manuals
___ Two schematic packages
___ Two C-arm keys (inside ring binders)
___ Footswitch assembly
___ Cassette holder
___ 30 cm. skin spacer assembly
___ Eight Nylock socket-head screws
___ Copy of Configuration Sheet

___ Field Service Documentation Package:
___ FDA form 2579
___ Installation report (QAI 1003)
___ Film identification stickers
___ Various envelopes
___ X-ray Installation documentation instructions
___ Instructions for Installation (QAI 1006)

10.8.2 Inspection

___ 1. Check skin spacer, primary and secondary filters.
___ 2. Check conductive casters on cart and mainframe.
___ 3. Check interconnect cable attached to monitor cart with bracket.
___ 4. Remove panels and covers; inspect the interior of mainframe and cart.
___ 5. Inspect the card racks in monitor cart and mainframe.
___ 6. Replace all covers.
___ 7. Inspect AC power cable and the high voltage cable.

10.8.3 Line Voltage Compatibility Check

Verify voltage compatibility in all individual rooms where this machine is intended to be used in the hospital. If a particular room is unavailable, write "NOT KNOWN" in the line voltage blank and put "NK " in the voltage and plug compatibility blanks. A room is not plug compatible if it requires an adapter to be used. If any rooms are found not voltage compatible, the hospital must be made aware of it.

Location	Compatible ?	
	Voltage	Plug
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___

10.8.4 Wiring the Isolation Transformer

Primary _____ VAC

Secondary _____ VAC

___ 1. The secondary voltage measured on each leg should fall within the range of 110-120 VAC referenced to neutral.
___ 2. Replace the monitor cart covers.

10.8.5 Basic Setup

___ 1. Power up the system as usual.
___ 2. Monitor cart and mainframe complete their software boot and initialization with no self-test errors reported on the displays.
___ 3. Check for AC voltage at the rear monitor cart AUX outlets (110-120 VAC).

10.8.6 Mainframe Mechanical Checks

___ 1. Footlever and steering handle.
___ 2. Inspect the wig-wag.
___ 3. Inspect the extension arm
___ 4. Inspect the flip-flop and C-arm pivot point.
___ 5. Check C-arm movement in the cradle.
___ 6. Check L-arm lift movement.
___ 7. Check L-arm rotation.

10.8.7 Verify Operation of Mainframe Controls

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

___ 1. Verify that the anode is rotating.
___ 2. Check all control switches.
___ 3. Verify that the LARGE field switch removes the 6-inch collimator - listen for the "thunk" sound produced.
___ 4. Select FILM mode.
___ 5. Verify that the X-RAY ON lights on the X-ray Head, Control Panel and Monitor Cart light when the X-RAY ON button is pressed. The audible beep should also be heard.
___ 6. Verify operation of the footswitch.
___ 7. 6-inch Machine only - Verify that FILM Mode operation only occurs when the film cassette is in place.
___ 8. Verify that the EMERGENCY OFF buttons break the interlock circuit.

10.8.8 Verify Controls in MANUAL FLUORO

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

___ 1. Select MANUAL FLUORO mode.
___ 2. Verify control with the control panel knobs.
___ 3. Observe fluoro image on the left monitor.

10.8.9 Auto Fluoro Tests

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

___ 1. Select AUTO FLUORO mode.
___ 2. Verify that the kV tracks up and down as material thickness is increased and decreased.
___ 3. Remove copper filters.
___ 4. Verify operation of VIDEO BYPASS switch.
5. Check resolution during video bypass.

_____ line pairs per inch.

6. Check operation of mainframe video controls.

___ a. Left to right reversal
___ b. L->R Swap
___ c. SHARPEN (if provided)

___ 7. Check operation of the motorized collimator and camera controls.
___ 8. Check remote contrast and brightness controls.

10.8.10 Verify Image Processing and Storage Features

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

___ 1. Set video bypass switch to normal.

___ 2. Make an exposure and transfer image to right monitor.
___ 3. Make another exposure.
___ 4. Check operation of WINDOW and LEVEL.
___ 5. Check NEG function.
___ 6. Verify operation of INTEGRATION and AVERAGING.
___ 7. Check operation of SHARPEN.
___ 8. Check operation of L->R function from the monitor cart front panel.
___ 9. *On systems equipped with hard disk image storage*, verify operation of SAVE.
___ 10. *On systems equipped with hard disk image storage*, verify operation of RECALL.
___ 11. *On systems equipped with hard disk image storage*, verify operation that the image counter increments and decrements.
___ 12. *On systems equipped with hard disk image storage*, verify operation of AUTO.
___ 13. *On systems equipped with hard disk image storage*, verify operation of DMA.
___ 14. Verify operation of the FLUORO ONLY footswitch.
___ 15. Verify operation of the PROCESS footswitch.
___ 16. Check circular blanking.
___ 17. Verify proper video signal on the video output jacks (when terminated with 75 ohms).

10.8.11 Additional Image Processing Tests

___ As required.

10.8.12 Fluoro Boost Option

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

___ 1. Enable BOOST on the control panel.
___ 2. Alarm beeps at twice the normal rate.
___ 3. Verify that boost works in both auto and manual X-ray modes.
___ 4. Image doesn't "burn out" or appear to dark.

10.8.13 Radiographic Beam Alignment Checks

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

___ 1. On the first film - Verify that the minimum field is contained within the target square (this must be less than 4.7 cm in each dimension measured on the film), that all of the innermost ring can be seen in the large field and none of the outer ring is visible.

___ 2. On the second film - Verify that all the inner 6-inch ring is visible, and that none of the outer 6-inch ring is visible.

The films are to be returned to the OEC-Diasonics Compliance Department per the instructions provided in the Field Service Documentation Package.

10.8.14 Fluoroscopic Beam Alignment Check

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

___ 1. Bring up the Video Test Pattern, make a fluoroscopic exposure, and examine the image within the video test pattern.
___ 2. Circular blanking is correct.
___ 3. Image size is correct.

10.8.15 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. Calculate the percentage line voltage regulation and record the results below.

   100 (Vn - V1)/ (V1)

   where: Vn = No load voltage
   V1 = Max load voltage

   Vn=_____
   V1=_____

   Regulation = _____%

   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.

2. Measure the voltage on the isolation transformer secondary under maximum radiographic load. It must not fall below 100 VAC.

   Secondary voltage under max. load = _____ VAC

10.8.16 Install and Verify System Options

___ Install and verify options. The installation of options is described in Section 12, Options.

10.8.17 Reporting

___ 1. Return the assembler's copy of the Report of Assembly of Diagnostic X-ray (FDA form 2579), the Beam Alignment Radiographs (films), the completed Installation Report, and the Installation Checklist to OEC-Diasonics, attention: Compliance Department, in the stamped, manila envelope provided in the Field Service Documentation Package.

___ 2. Distribute the various remaining copies of the Report of Assembly of Diagnostic X-ray (FDA form 2579), per the documentation instructions included in the Field Service Documentation Package.

___ 3. Verify the serial and model numbers listed and the control numbers on the Main Frame and Collimator. These should agree with those listed on FDA form 2579.

___ 4. Record the installation in the service log.

___ 5. OEC Representative and hospital representative MUST sign last page of Installation Checklist, verifying acceptance of unit. If, for any reason, installation could not be completed, both OEC Representative and hospital representatives MUST be notified that unit is not yet ready for use.

This system is now installed and is operating in a satisfactory manner. The hospital representative acknowledges any limitations due to voltage incompatibilities between different areas of projected use.

OEC-DIASONICS Field Service Representative

_____

OEC Applications Representative

_____

Hospital Representative

_____

APPENDIX A

Recommended Tools and Test Equipment

Installation and Use of Special Equipment

Dosimeter

Printer Installation

Terminal Installation and Use

Service Log

This appendix describes recommended test equipment and the installation and use of special equipment needed to calibrate the system:

DOSIMETER
DYNALYZER
FLOPPY DISK DRIVE (INCLUDED IN DXR KIT)

This appendix also contains special instructions for connecting a terminal and printer to the system, and using the terminal menus to access special software.

NOTE: *Calibration must be current on the Dynalyzer, Dynalyzer Digital Display and the Dosimeter.*

A.1 Recommended Tools and Test Equipment

In addition to common hand tools normally in any service technicians tool kit, Table A-1 lists additional tools and equipment necessary for calibration and maintenance.

TABLE A-1

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 General 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 +/- .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.

    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 30 cm (12 inches) 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 30 cm (12 inches) 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 hence open to the atmosphere, the mass of air inside will depend upon the temperature and absolute pressure of the ambient air.

Table A-2 Temperature and Pressure Correction Factors for a vented ion chamber such as the Keithley Model 96030A.

Pressure in mm Hg	Temperature (in degrees Celcius)																					
mm	20	21	22	23	23.5	24	24.5	25	25.5	26	26.5	27	27.5	28	28.5	29	29.5	30
630	1.202	1.206	1.211	1.215	1.217	1.219	1.222	1.224	1.226	1.228	1.230	1.232	1.234	1.237	1.239	1.241	1.243	1.245
631	1.200	1.205	1.209	1.213	1.215	1.217	1.220	1.222	1.224	1.226	1.228	1.230	1.232	1.235	1.237	1.239	1.241	1.243
632	1.198	1.203	1.207	1.211	1.213	1.216	1.218	1.220	1.222	1.224	1.226	1.228	1.231	1.233	1.235	1.237	1.239	1.241
633	1.196	1.201	1.205	1.209	1.211	1.214	1.216	1.218	1.220	1.222	1.224	1.226	1.229	1.231	1.233	1.235	1.237	1.239
634	1.195	1.199	1.203	1.207	1.210	1.212	1.214	1.216	1.218	1.220	1.222	1.224	1.227	1.229	1.231	1.233	1.235	1.237
635	1.193	1.197	1.201	1.205	1.208	1.210	1.212	1.214	1.216	1.218	1.220	1.223	1.225	1.227	1.229	1.231	1.233	1.235
636	1.191	1.195	1.199	1.204	1.206	1.208	1.210	1.212	1.214	1.216	1.219	1.221	1.223	1.225	1.227	1.229	1.231	1.233
637	1.189	1.193	1.197	1.202	1.204	1.206	1.208	1.210	1.212	1.214	1.217	1.219	1.221	1.223	1.225	1.227	1.229	1.232
638	1.187	1.191	1.196	1.200	1.202	1.204	1.206	1.208	1.210	1.213	1.215	1.217	1.219	1.221	1.223	1.225	1.227	1.230
639	1.185	1.189	1.194	1.198	1.200	1.202	1.204	1.206	1.209	1.211	1.213	1.215	1.217	1.219	1.221	1.223	1.226	1.228
640	1.183	1.188	1.192	1.196	1.198	1.200	1.202	1.205	1.207	1.209	1.211	1.213	1.215	1.217	1.219	1.221	1.224	1.226
641	1.182	1.186	1.190	1.194	1.196	1.198	1.201	1.203	1.205	1.207	1.209	1.211	1.213	1.215	1.217	1.220	1.222	1.224
642	1.180	1.184	1.188	1.192	1.194	1.197	1.199	1.201	1.203	1.205	1.207	1.209	1.211	1.213	1.216	1.218	1.220	1.222
643	1.178	1.182	1.186	1.190	1.193	1.195	1.197	1.199	1.201	1.203	1.205	1.207	1.209	1.212	1.214	1.216	1.218	1.220
644	1.176	1.180	1.184	1.189	1.191	1.193	1.195	1.197	1.199	1.201	1.203	1.205	1.208	1.210	1.212	1.214	1.216	1.218
645	1.174	1.178	1.183	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.202	1.204	1.206	1.208	1.210	1.212	1.214	1.216
646	1.172	1.177	1.181	1.185	1.187	1.189	1.191	1.193	1.195	1.198	1.200	1.202	1.204	1.206	1.208	1.210	1.212	1.214
647	1.171	1.175	1.179	1.183	1.185	1.187	1.189	1.192	1.194	1.196	1.198	1.200	1.202	1.204	1.206	1.208	1.210	1.212
648	1.169	1.173	1.177	1.181	1.183	1.185	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.202	1.204	1.206	1.209	1.211
649	1.167	1.171	1.175	1.179	1.182	1.184	1.186	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.202	1.205	1.207	1.209
650	1.165	1.169	1.174	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.201	1.205	1.207
651	1.163	1.168	1.172	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.193	1.195	1.197	1.199	1.201	1.203	1.205
652	1.162	1.166	1.170	1.174	1.176	1.178	1.180	1.182	1.184	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.201	1.203
653	1.160	1.164	1.168	1.172	1.174	1.176	1.178	1.181	1.183	1.185	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.201
654	1.158	1.162	1.166	1.170	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.187	1.189	1.191	1.193	1.195	1.197	1.199
655	1.156	1.160	1.165	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.187	1.189	1.191	1.194	1.196	1.198
656	1.155	1.159	1.163	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.188	1.190	1.192	1.194	1.196
657	1.153	1.157	1.161	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.180	1.182	1.184	1.186	1.188	1.190	1.192	1.194
658	1.151	1.155	1.159	1.163	1.165	1.167	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.192
659	1.149	1.153	1.157	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190
660	1.148	1.152	1.156	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.187	1.189
661	1.146	1.150	1.154	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.177	1.179	1.181	1.183	1.185	1.187
662	1.144	1.148	1.152	1.156	1.158	1.160	1.162	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185
663	1.142	1.146	1.150	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183
664	1.141	1.145	1.149	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181
665	1.139	1.143	1.147	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179
666	1.137	1.141	1.145	1.149	1.151	1.153	1.155	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178
667	1.135	1.140	1.144	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176
668	1.134	1.138	1.142	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174
669	1.132	1.136	1.140	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172
670	1.130	1.134	1.138	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171
671	1.129	1.133	1.137	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169
672	1.127	1.131	1.135	1.139	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167
673	1.125	1.129	1.133	1.137	1.139	1.141	1.143	1.145	1.147	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166
674	1.124	1.128	1.132	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164
675	1.122	1.126	1.130	1.134	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162
676	1.120	1.124	1.128	1.132	1.134	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160
677	1.119	1.123	1.127	1.131	1.133	1.135	1.137	1.139	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159

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 degrees 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 A-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 that gravity and altitude are minor corrections compared with temperature and pressure.*

A.4 Connecting A Printer to the Monitor Cart

The Report Generator Software, and also Shot Logging, can produce printed reports using any of a number of compatible printers. Contact your field service representative for more information on specific printers which can be used. The printer interface cable (OEC-Diasonics P/N 870596) will work with some of them.

The printer should have a standard parallel interface. The corresponding cable connector on the monitor cart is a 25 pin D-type which is labeled AUX.

The AUX connector on the rear of the monitor cart does not provide a standard interface. The signals provided at the pins on this connector are listed below in table A-3.

Aux Connector Printer Interface **Table A-3**

SIGNAL	CONNECTOR PIN
Strobe/	1
D0	2
D1	3
D2	4
D3	5
D4	6
D5	7
D6	8
D7	9
Ack	14
Fault/	15
Init	16
Busy	17
Ground	19,20,21,22,23,24,25
Not used	10-13 and 18

A.5 Floppy Disk Drive Installation

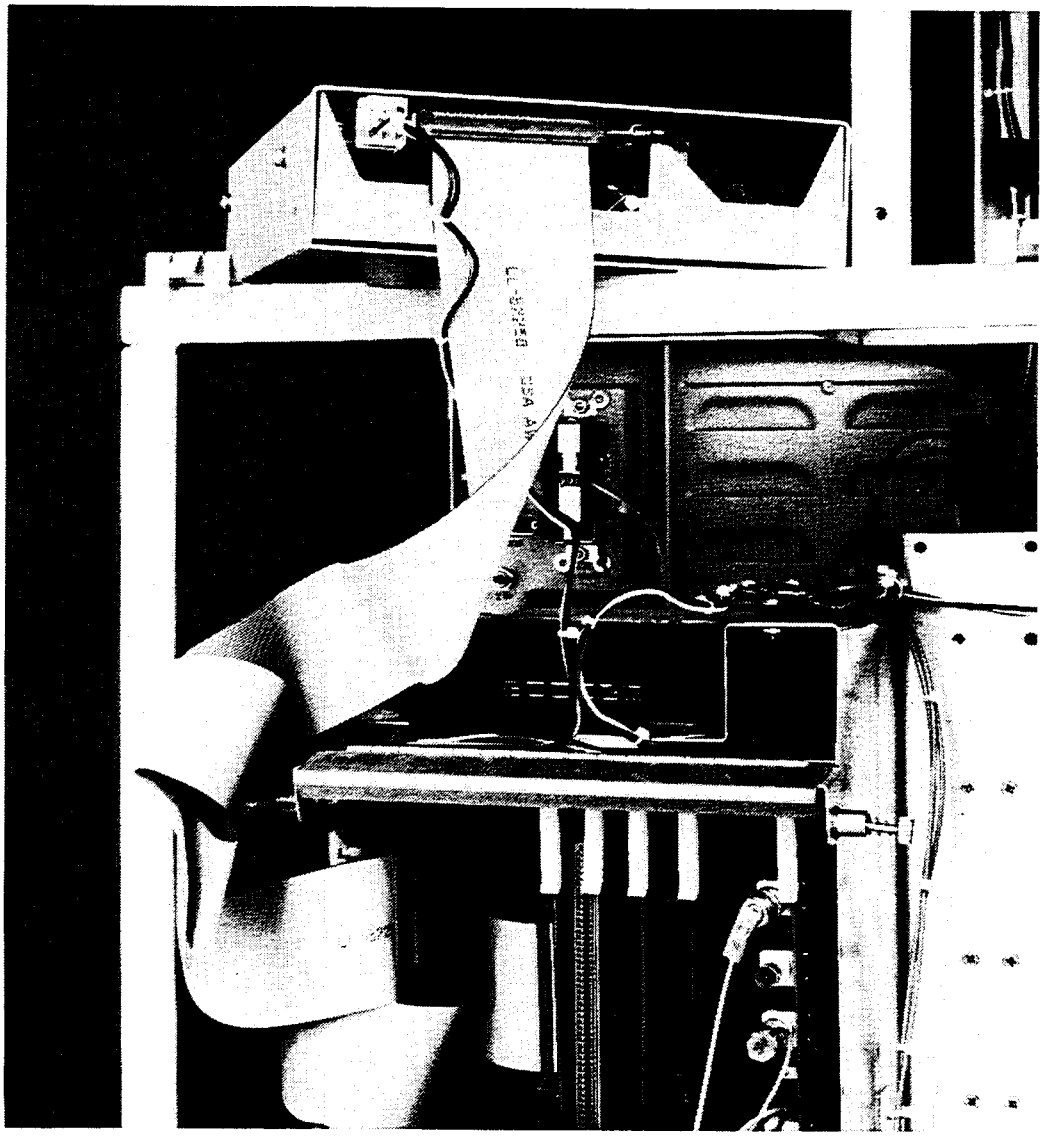
Refer to Figure 1. An 8-inch portable floppy disk drive is included in the DXR Field Kit.

The floppy drive must be installed to use diagnostic software not resident in the system, to install new versions of disk software or to add additional programs to the hard disk. The floppy drive requires an interface to the system through the Disk Controller PCB and is supplied with operating power by a molex connector.

Follow this installation procedure:

1. Unplug the monitor cart from the wall outlet.
2. Remove the left side and front panels.
3. Place the floppy drive conveniently on the left shelf top.
4. Locate the square molex connector with three wires: red, yellow, and black. This will be tied down just in front of the hard disk drive. Connect this to the mating connector on the floppy drive.
5. Connect the 50 pin ribbon cable between the floppy drive and the 50 pin connection on the OMT Adapter Board. This is a 1.5" x 3" board attached just inside the card cage on the upper left.
6. The floppy disk should be inserted into the drive with the label side facing the drive closing lever (facing up).
7. If the drive lever is closed with a floppy disk in place, the monitor cart will attempt to boot from the floppy disk when the cart power circuit breaker is turned on.

Figure 1 - *The floppy disk drive is shown connected to the monitor cart in this photo.*



A.6 External Terminal Installation and Use

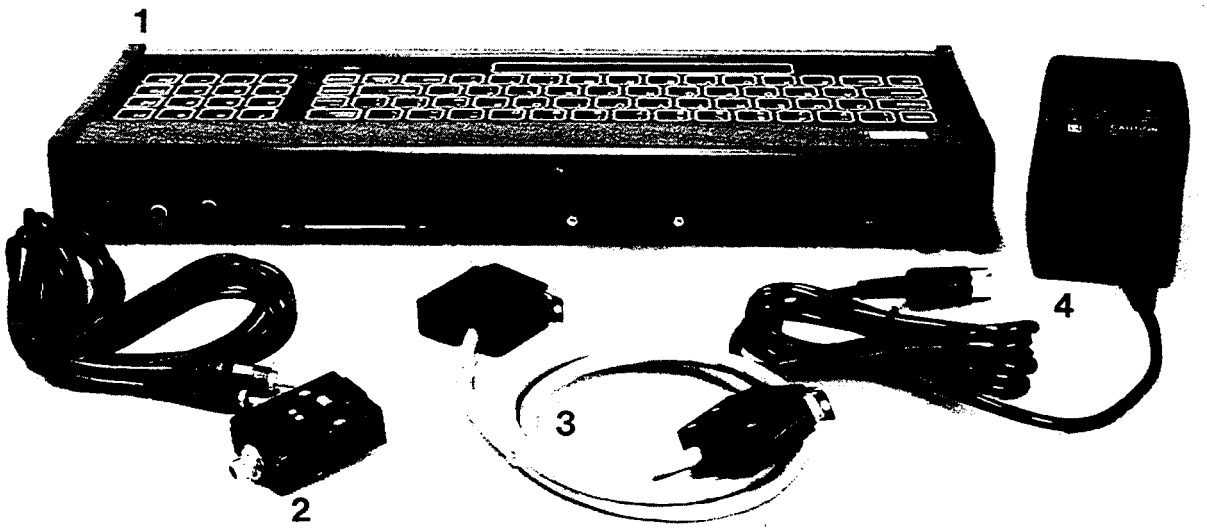
Several of the diagnostic software procedures and some of the specialized application software requires the use of an external computer terminal. If one is available on site it may be used with the proper communications protocol. This is discussed later in this section under "Installing Other Terminals".

Because of the variations in available terminals, for most field service applications it is strongly recommended that the DXR Field Service Kit is used.

The DXR Kit contains a keyboard terminal, power supply, modified RS-232 cable, and a video cable. The video jack adapter (P/N 870964), available separately, is also required. These parts are connected to the monitor cart to provide a computer terminal which uses the left monitor cart screen for the terminal monitor.

Figure 2 - *Components of the keyboard terminal are shown in this photo.*

1) Terminal/keyboard unit; 2) Video Out to VTR plug adaptor; 3) Interface cable to RS232 connector; 4) Power module.



A.6.1 Interfacing the Keyboard Terminal

1. Connect the keyboard or "RCA" labeled end of the interface cable (P/N 870257) to the keyboard terminal and the DXR labeled end to the monitor cart connector labeled "RS-232 Interface".

2. Clip the video jack adapter (P/N 870964) into the VTR connector on the rear of the monitor cart. Connect the video coax cable between the RCA-type connector on the adapter and the video out jack on the keyboard terminal.

3. Plug the power module into a 110 VAC power source and connect it to the keyboard unit.

4. Turn on the cart power and service breakers.

5. Press VTR Review to display keyboard terminal video on the left monitor.

A.6.2 Configuring the Keyboard Terminal

The keyboard will remember the communications setup for several weeks before it must be reinstalled. *Note: if the keyboard has been used within the last two weeks, skip ahead to "Activating Communications".* In the following instructions, type the keys indicated in the [ ] brackets.

1. Turn on the keyboard switch.

2. Type [2].

3. Type [3].

4. Follow the on-screen instructions to produce the following display on the monitor screen:

0 - Previous Menu	
1 - Screen Format	80
2 - TV Channel	3
3 - Cursor	Blink
4 - Line Wrap	On
5 - Auto Line End	Off
6 - Auto Screen Blank	On
7 - Status Line	On
A - Key Beep	On
B - Alpha Lock	On
C - User 1 Key	Select
D - User 2 Key	Menu

5. Once these options are correct as indicated above, type [0].

6. Type [3].

7. Another display will appear. Set it up as shown:

0 - Previous Menu	
1 - Communications Type	Direct
2 - Baud Rate	9600
3 - Data Bits	8
4 - Parity	None
5 - Stop Bits	2
6 - Duplex	Full
7 - Handshaking	Off

8. Once these options are correct type [0].

9. Type [0] again.

A.6.3 Activating communications

1. Type [3], then type [H].

2. The line at the bottom of the monitor should now read:

LINE SELECT MENU

3. After booting the system with the keyboard terminal installed, the monitor will display the line:

Press ESC to return to menu.

A.7 Service Log

The service log is found on the next pages. Enter the appropriate information when service or maintenance is performed.

OEC-DIASONICS, INC.

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

OEC-DIASONICS, INC.

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

9000 SERVICE MANUAL

UPDATE
00-876628-01
REV. A

INSTRUCTIONS:

1. Insert this -01 Update tab and text at the back of the manual, after the last page.

Date of Issue: November 1993

OEC MEDICAL SYSTEMS, INC.

384 Wright Brothers Drive
Salt Lake City
Utah
84116

(801) 328-9300

UPDATE CONTENTS

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Revision History

Update PN & Rev.	Manual PN	Manual Revision
00-876628-01, Rev. A	00-870820-01	C

UPDATE

1. BATTERY REPLACEMENT, TECHNIQUE PROCESSOR BOARD

The real time clock battery, B1, on the technique processor board should be replaced every two years. The age of the battery can be derived from either the delivery date, for a recently purchased unit, or from the dated label that is applied during battery service. Under normal operating conditions, the expected life of the battery is well in excess of two years. However, replacement every two years insures that the battery will not deplete during usage.

9000/URO1000 BATTERY REPLACEMENT KIT, 00-876434-03:

Quantity	Part Number	Description
1	74-122902-00	3V Lithium Battery
1	32-301420-00	2KΩ, 1/4W Resistor
1	88-359989-00	Self Adhesive Label
2	00-876488-01	Operator's Mnl. Replacement Pages
2	00-876801-01	Operator's Mnl. Replacement Pages

BATTERY REPLACEMENT KIT, 00-876434-02*:

Quantity	Part Number	Description
1	74-122902-00	3V Lithium Battery
1	88-359989-00	Self Adhesive Label

*See NOTE on the following page which explains when the -02 Kit is needed.

PARTS/TOOLS REQUIRED:

Indelible Marker

Soldering Iron

Solder

1.1 PROCEDURE

NOTE:

The following procedure is for first-time installation of a new battery on the PCB. It assumes that the 2KW resistor has *not* yet been installed near IC U79 and that you are using Battery Replacement Kit PN 00-876434-03. If this resistor has already been installed and you are only replacing the battery, you need to use Battery Replacement Kit PN 00-876434-02 which includes the new battery and label. Be sure to write the date of installation on the new label and place the label on U79 after replacing the battery.

1) Turn off all power to the system.

2) Remove the Technique Processor PCB from the generator card rack (see Figure 1, page 7).

3) Carefully remove U79 from the socket on the Technique Processor PCB and set aside (see Figure 2, page 8).

4) Locate the battery (B1) on the Technique Processor PCB (see Figure 2, page 8) and carefully remove the battery from the Technique Processor PCB by cutting the battery leads. After you remove the battery, carefully remove the leads of the battery from the Technique Processor PCB with your soldering iron and clean the solder holes so that the new battery can be installed.

5) While looking at the component side of the Technique Processor PCB locate the socket for U79. Near pin 12 of the socket for U79 is a short solder trace with a solder pad at both ends of the trace. Electrically this trace goes from U79 pin 14 to the battery B1. Refer to Figure 3, page 9, for the location of this trace.

6) Carefully cut the middle of the solder trace from step 5. Refer to Figure 3, page 9. Use your soldering iron to carefully remove the solder from the solder pads at the ends of the trace you cut.

7) Install the 2KΩ resistor (32-301420-00) provided with the Battery Replacement Kit on the component side of the Technique Processor PCB by inserting the leads of the resistor through the holes of the solder pads of the trace you cut in step 6. Carefully solder the resistor into place. Electrically this resistor is now in series between U79 pin 14 and the battery B1.

8) Install the new 3V battery (74-122902-00) provided with the Battery Replacement Kit on the Technique Processor PCB into the same location as the old battery. Carefully solder the battery onto the Technique Processor PCB.

9) Install U79 back into the socket on the Technique Processor PCB.

10) Using an indelible marker write the current date on the self adhesive label (88-359989-00) provided with the Battery Replacement Kit. Affix the self adhesive label to the top of U79 on the Technique Processor PCB.

11) Carefully install the Technique Processor PCB back into the system.

12) Turn the system on and allow it to boot completely. You may get a message on the control panel that says the system needs 24 hours to recharge. You may ignore this message and get past it by pressing any key on the control panel.

13) Enter the STATUS mode of the system through the control panel and set the time and date. Instructions on entering the STATUS mode for your particular system may be found in the Maintenance section of the Operator's Manual.

14) Reboot the system and make sure it boots up completely. Make sure the system operates correctly by verifying fluoro operation, film operation, image storage, etc.

15) After upgrading the 9000, leave the Operator's Manual Replacement Pages (00-876488-01) and (00-876801-01) that were sent as part of the upgrade kit with the customer.

Figure 1 - Technique Processor PCB location in 9000 Electronics Cabinet

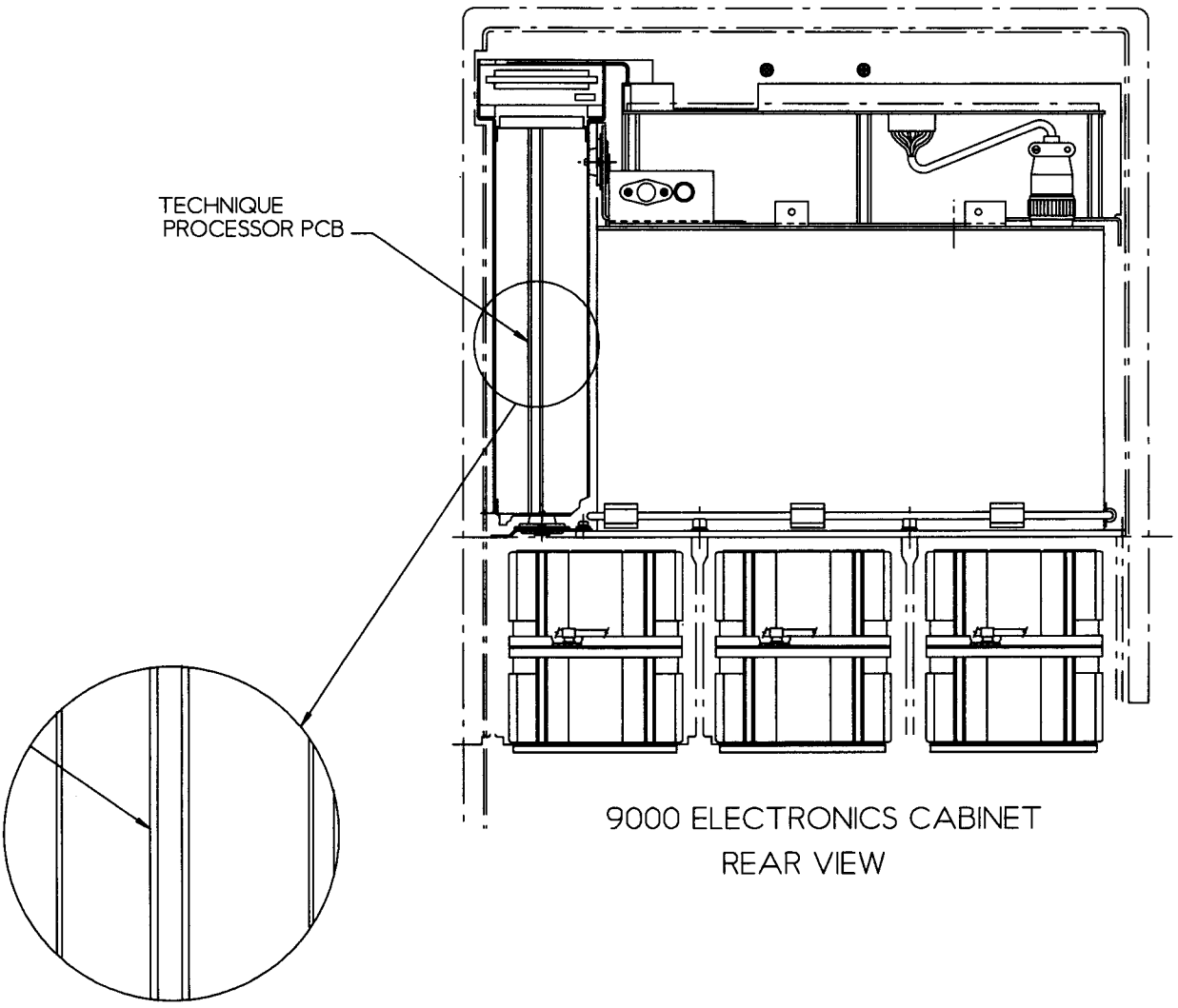


Figure 2 - Battery and Real Time Clock IC locations on Technique Processor Board

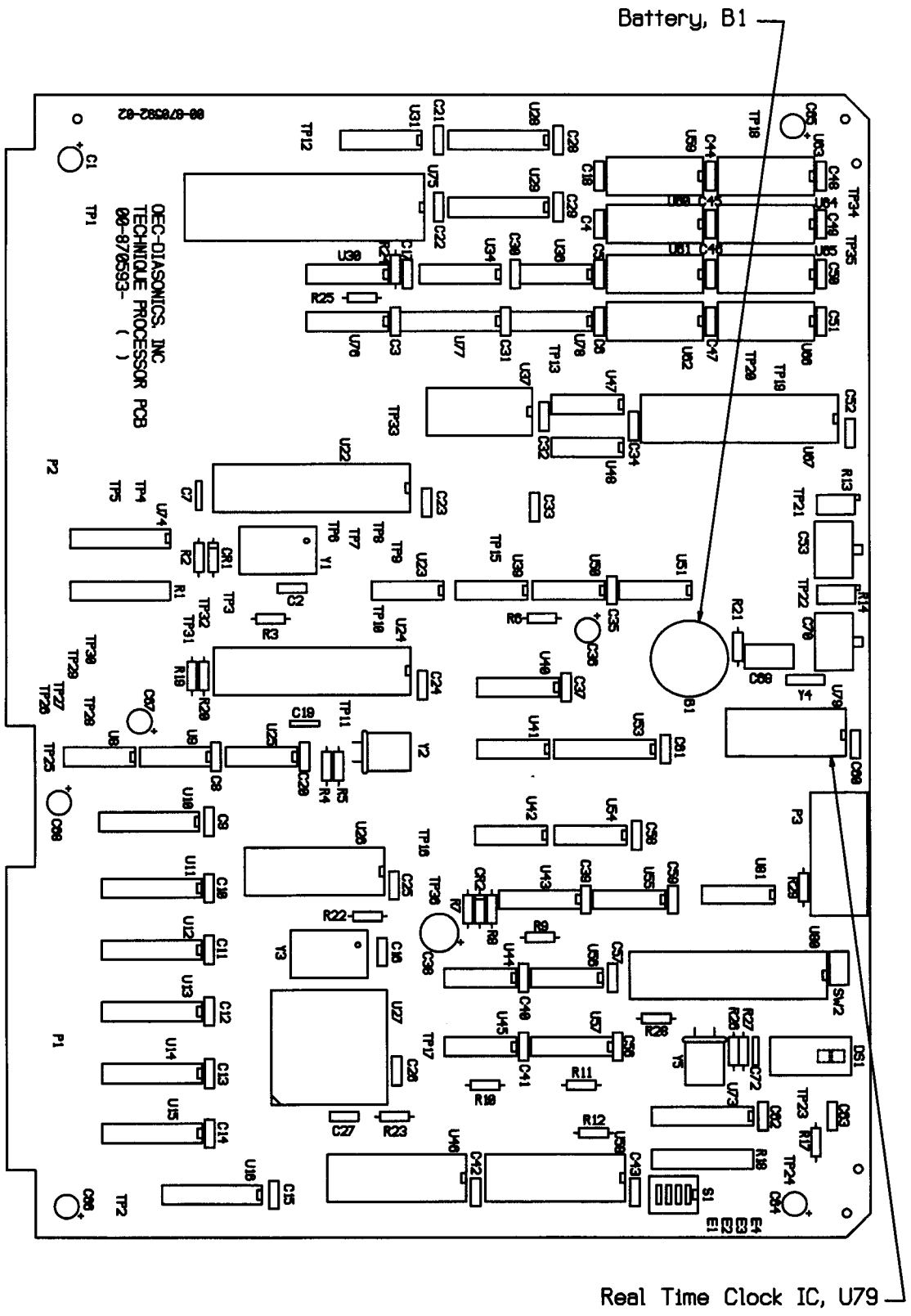
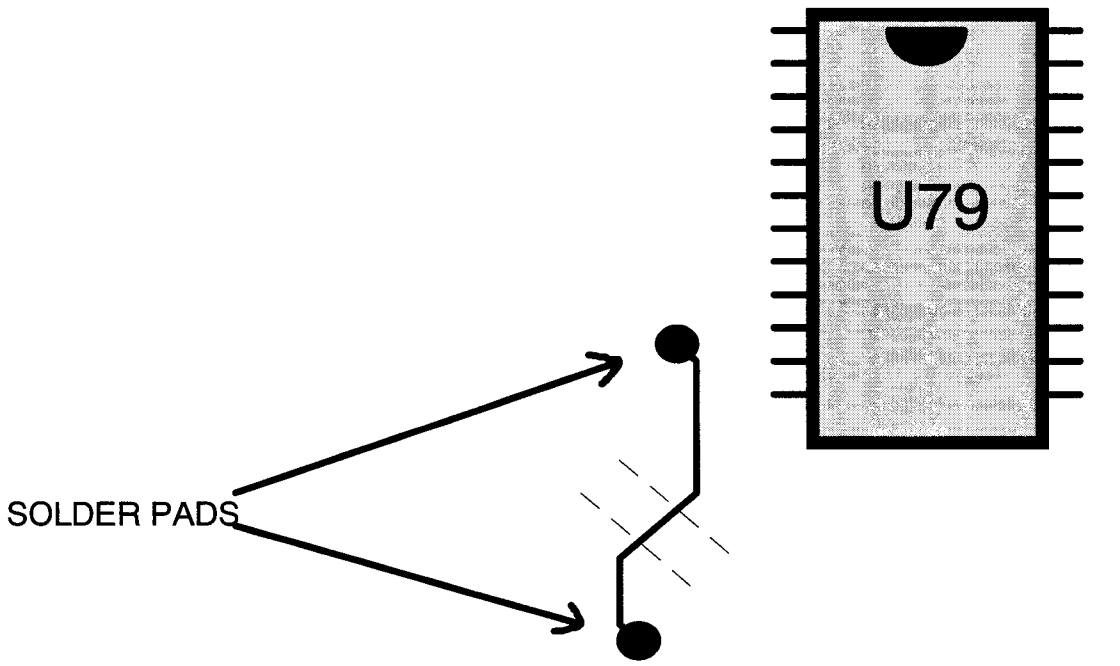


Figure 3 - Location of 2KΩ Resistor installation on the Technique Processor PCB



CUT TRACE BETWEEN DASHED LINES

INSTALL RESISTOR BETWEEN SOLDER PADS

APPENDIX A

Recommended Tools and Test Equipment

Installation and Use of Special Equipment

Dosimeter

Printer Installation

Terminal Installation and Use

Service Log

This appendix describes recommended test equipment and the installation and use of special equipment needed to calibrate the system:

DOSIMETER
DYNALYZER
FLOPPY DISK DRIVE (INCLUDED IN DXR KIT)

This appendix also contains special instructions for connecting a terminal and printer to the system, and using the terminal menus to access special software.

NOTE: *Calibration must be current on the Dynalyzer, Dynalyzer Digital Display and the Dosimeter.*

A.1 Recommended Tools and Test Equipment

In addition to common hand tools normally in any service technicians tool kit, Table A-1 lists additional tools and equipment necessary for calibration and maintenance.

TABLE A-1

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 General 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 +/- .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.

    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 30 cm (12 inches) 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 30 cm (12 inches) 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 hence open to the atmosphere, the mass of air inside will depend upon the temperature and absolute pressure of the ambient air.

Table A-2 Temperature and Pressure Correction Factors for a vented ion chamber such as the Keithley Model 96030A.

Pressure in mm Hg	Temperature (in degrees Celcius)																					
mm	20	21	22	23	23.5	24	24.5	25	25.5	26	26.5	27	27.5	28	28.5	29	29.5	30
630	1.202	1.206	1.211	1.215	1.217	1.219	1.222	1.224	1.226	1.228	1.230	1.232	1.234	1.237	1.239	1.241	1.243	1.245
631	1.200	1.205	1.209	1.213	1.215	1.217	1.220	1.222	1.224	1.226	1.228	1.230	1.232	1.235	1.237	1.239	1.241	1.243
632	1.198	1.203	1.207	1.211	1.213	1.216	1.218	1.220	1.222	1.224	1.226	1.228	1.231	1.233	1.235	1.237	1.239	1.241
633	1.196	1.201	1.205	1.209	1.211	1.214	1.216	1.218	1.220	1.222	1.224	1.226	1.229	1.231	1.233	1.235	1.237	1.239
634	1.195	1.199	1.203	1.207	1.210	1.212	1.214	1.216	1.218	1.220	1.222	1.224	1.227	1.229	1.231	1.233	1.235	1.237
635	1.193	1.197	1.201	1.205	1.208	1.210	1.212	1.214	1.216	1.218	1.220	1.223	1.225	1.227	1.229	1.231	1.233	1.235
636	1.191	1.195	1.199	1.204	1.206	1.208	1.210	1.212	1.214	1.216	1.219	1.221	1.223	1.225	1.227	1.229	1.231	1.233
637	1.189	1.193	1.197	1.202	1.204	1.206	1.208	1.210	1.212	1.214	1.217	1.219	1.221	1.223	1.225	1.227	1.229	1.232
638	1.187	1.191	1.196	1.200	1.202	1.204	1.206	1.208	1.210	1.213	1.215	1.217	1.219	1.221	1.223	1.225	1.227	1.230
639	1.185	1.189	1.194	1.198	1.200	1.202	1.204	1.206	1.209	1.211	1.213	1.215	1.217	1.219	1.221	1.223	1.226	1.228
640	1.183	1.188	1.192	1.196	1.198	1.200	1.202	1.205	1.207	1.209	1.211	1.213	1.215	1.217	1.219	1.221	1.224	1.226
641	1.182	1.186	1.190	1.194	1.196	1.198	1.201	1.203	1.205	1.207	1.209	1.211	1.213	1.215	1.217	1.220	1.222	1.224
642	1.180	1.184	1.188	1.192	1.194	1.197	1.199	1.201	1.203	1.205	1.207	1.209	1.211	1.213	1.216	1.218	1.220	1.222
643	1.178	1.182	1.186	1.190	1.193	1.195	1.197	1.199	1.201	1.203	1.205	1.207	1.209	1.212	1.214	1.216	1.218	1.220
644	1.176	1.180	1.184	1.189	1.191	1.193	1.195	1.197	1.199	1.201	1.203	1.205	1.208	1.210	1.212	1.214	1.216	1.218
645	1.174	1.178	1.183	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.202	1.204	1.206	1.208	1.210	1.212	1.214	1.216
646	1.172	1.177	1.181	1.185	1.187	1.189	1.191	1.193	1.195	1.198	1.200	1.202	1.204	1.206	1.208	1.210	1.212	1.214
647	1.171	1.175	1.179	1.183	1.185	1.187	1.189	1.192	1.194	1.196	1.198	1.200	1.202	1.204	1.206	1.208	1.210	1.212
648	1.169	1.173	1.177	1.181	1.183	1.185	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.202	1.204	1.206	1.209	1.211
649	1.167	1.171	1.175	1.179	1.182	1.184	1.186	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.202	1.205	1.207	1.209
650	1.165	1.169	1.174	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.192	1.194	1.196	1.198	1.200	1.201	1.205	1.207
651	1.163	1.168	1.172	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.193	1.195	1.197	1.199	1.201	1.203	1.205
652	1.162	1.166	1.170	1.174	1.176	1.178	1.180	1.182	1.184	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.201	1.203
653	1.160	1.164	1.168	1.172	1.174	1.176	1.178	1.181	1.183	1.185	1.187	1.189	1.191	1.193	1.195	1.197	1.199	1.201
654	1.158	1.162	1.166	1.170	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.187	1.189	1.191	1.193	1.195	1.197	1.199
655	1.156	1.160	1.165	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.187	1.189	1.191	1.194	1.196	1.198
656	1.155	1.159	1.163	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185	1.188	1.190	1.192	1.194	1.196
657	1.153	1.157	1.161	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.180	1.182	1.184	1.186	1.188	1.190	1.192	1.194
658	1.151	1.155	1.159	1.163	1.165	1.167	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190	1.192
659	1.149	1.153	1.157	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.186	1.188	1.190
660	1.148	1.152	1.156	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178	1.180	1.182	1.184	1.187	1.189
661	1.146	1.150	1.154	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.177	1.179	1.181	1.183	1.185	1.187
662	1.144	1.148	1.152	1.156	1.158	1.160	1.162	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183	1.185
663	1.142	1.146	1.150	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181	1.183
664	1.141	1.145	1.149	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179	1.181
665	1.139	1.143	1.147	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171	1.173	1.175	1.177	1.179
666	1.137	1.141	1.145	1.149	1.151	1.153	1.155	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176	1.178
667	1.135	1.140	1.144	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174	1.176
668	1.134	1.138	1.142	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172	1.174
669	1.132	1.136	1.140	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166	1.168	1.170	1.172
670	1.130	1.134	1.138	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169	1.171
671	1.129	1.133	1.137	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167	1.169
672	1.127	1.131	1.135	1.139	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159	1.161	1.163	1.165	1.167
673	1.125	1.129	1.133	1.137	1.139	1.141	1.143	1.145	1.147	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164	1.166
674	1.124	1.128	1.132	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162	1.164
675	1.122	1.126	1.130	1.134	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160	1.162
676	1.120	1.124	1.128	1.132	1.134	1.136	1.138	1.140	1.142	1.144	1.146	1.148	1.150	1.152	1.154	1.156	1.158	1.160
677	1.119	1.123	1.127	1.131	1.133	1.135	1.137	1.139	1.141	1.143	1.145	1.147	1.149	1.151	1.153	1.155	1.157	1.159

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 degrees 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 A-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 that gravity and altitude are minor corrections compared with temperature and pressure.*

A.4 Connecting A Printer to the Monitor Cart

The Report Generator Software, and also Shot Logging, can produce printed reports using any of a number of compatible printers. Contact your field service representative for more information on specific printers which can be used. The printer interface cable (OEC-Diasonics P/N 870596) will work with some of them.

The printer should have a standard parallel interface. The corresponding cable connector on the monitor cart is a 25 pin D-type which is labeled AUX.

The AUX connector on the rear of the monitor cart does not provide a standard interface. The signals provided at the pins on this connector are listed below in table A-3.

Aux Connector Printer Interface **Table A-3**

SIGNAL	CONNECTOR PIN
Strobe/	1
D0	2
D1	3
D2	4
D3	5
D4	6
D5	7
D6	8
D7	9
Ack	14
Fault/	15
Init	16
Busy	17
Ground	19,20,21,22,23,24,25
Not used	10-13 and 18

A.5 Floppy Disk Drive Installation

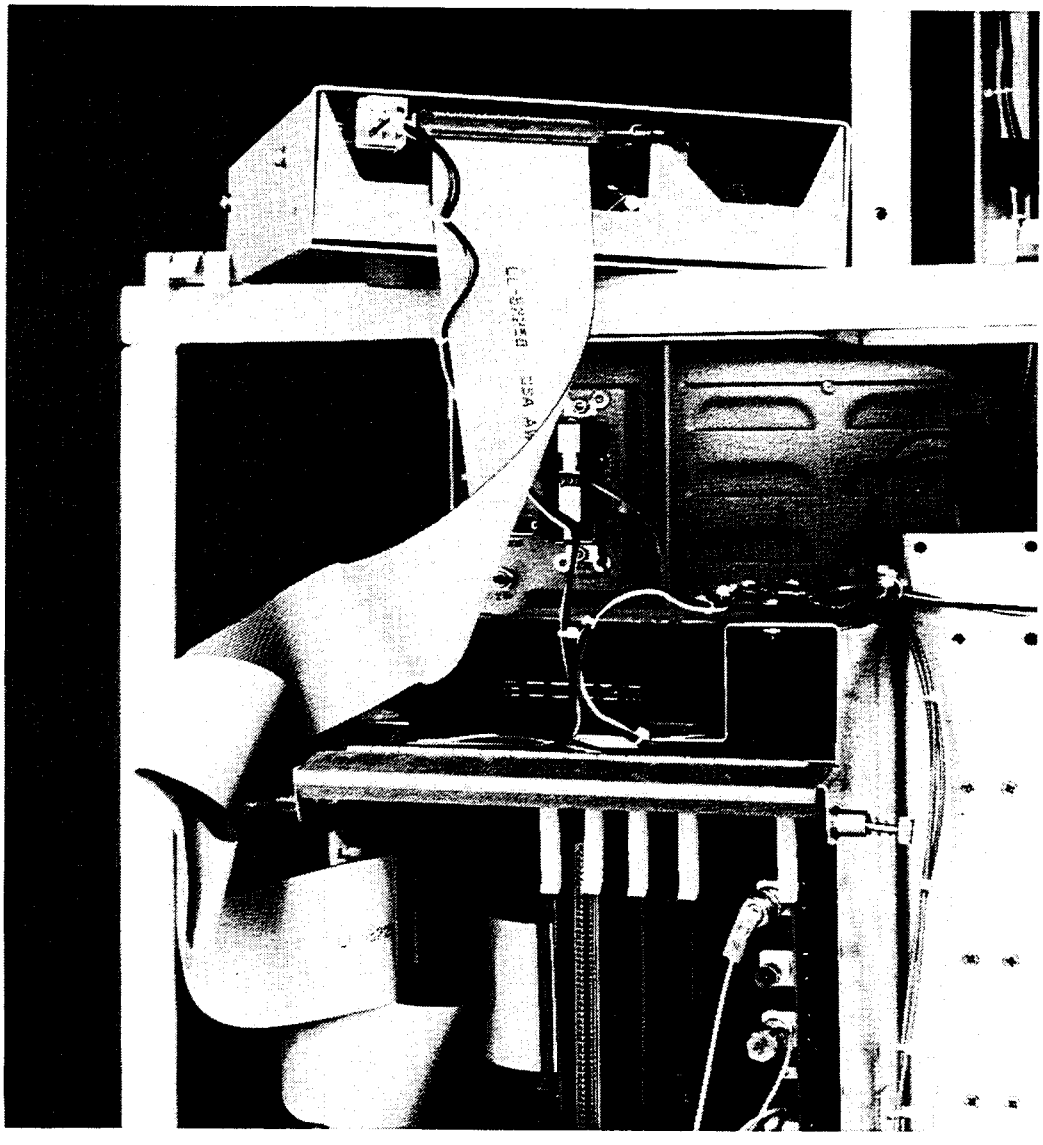
Refer to Figure 1. An 8-inch portable floppy disk drive is included in the DXR Field Kit.

The floppy drive must be installed to use diagnostic software not resident in the system, to install new versions of disk software or to add additional programs to the hard disk. The floppy drive requires an interface to the system through the Disk Controller PCB and is supplied with operating power by a molex connector.

Follow this installation procedure:

1. Unplug the monitor cart from the wall outlet.
2. Remove the left side and front panels.
3. Place the floppy drive conveniently on the left shelf top.
4. Locate the square molex connector with three wires: red, yellow, and black. This will be tied down just in front of the hard disk drive. Connect this to the mating connector on the floppy drive.
5. Connect the 50 pin ribbon cable between the floppy drive and the 50 pin connection on the OMT Adapter Board. This is a 1.5" x 3" board attached just inside the card cage on the upper left.
6. The floppy disk should be inserted into the drive with the label side facing the drive closing lever (facing up).
7. If the drive lever is closed with a floppy disk in place, the monitor cart will attempt to boot from the floppy disk when the cart power circuit breaker is turned on.

Figure 1 - *The floppy disk drive is shown connected to the monitor cart in this photo.*



A.6 External Terminal Installation and Use

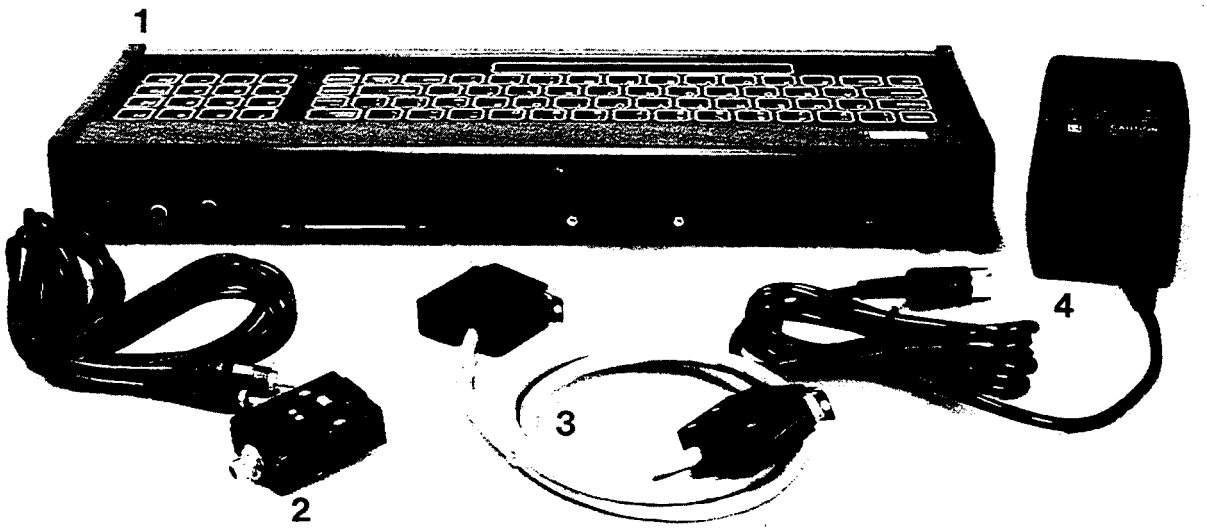
Several of the diagnostic software procedures and some of the specialized application software requires the use of an external computer terminal. If one is available on site it may be used with the proper communications protocol. This is discussed later in this section under "Installing Other Terminals".

Because of the variations in available terminals, for most field service applications it is strongly recommended that the DXR Field Service Kit is used.

The DXR Kit contains a keyboard terminal, power supply, modified RS-232 cable, and a video cable. The video jack adapter (P/N 870964), available separately, is also required. These parts are connected to the monitor cart to provide a computer terminal which uses the left monitor cart screen for the terminal monitor.

Figure 2 - *Components of the keyboard terminal are shown in this photo.*

1) Terminal/keyboard unit; 2) Video Out to VTR plug adaptor; 3) Interface cable to RS232 connector; 4) Power module.



A.6.1 Interfacing the Keyboard Terminal

1. Connect the keyboard or "RCA" labeled end of the interface cable (P/N 870257) to the keyboard terminal and the DXR labeled end to the monitor cart connector labeled "RS-232 Interface".

2. Clip the video jack adapter (P/N 870964) into the VTR connector on the rear of the monitor cart. Connect the video coax cable between the RCA-type connector on the adapter and the video out jack on the keyboard terminal.

3. Plug the power module into a 110 VAC power source and connect it to the keyboard unit.

4. Turn on the cart power and service breakers.

5. Press VTR Review to display keyboard terminal video on the left monitor.

A.6.2 Configuring the Keyboard Terminal

The keyboard will remember the communications setup for several weeks before it must be reinstalled. *Note: if the keyboard has been used within the last two weeks, skip ahead to "Activating Communications".* In the following instructions, type the keys indicated in the [ ] brackets.

1. Turn on the keyboard switch.

2. Type [2].

3. Type [3].

4. Follow the on-screen instructions to produce the following display on the monitor screen:

0 - Previous Menu	
1 - Screen Format	80
2 - TV Channel	3
3 - Cursor	Blink
4 - Line Wrap	On
5 - Auto Line End	Off
6 - Auto Screen Blank	On
7 - Status Line	On
A - Key Beep	On
B - Alpha Lock	On
C - User 1 Key	Select
D - User 2 Key	Menu

5. Once these options are correct as indicated above, type [0].

6. Type [3].

7. Another display will appear. Set it up as shown:

0 - Previous Menu	
1 - Communications Type	Direct
2 - Baud Rate	9600
3 - Data Bits	8
4 - Parity	None
5 - Stop Bits	2
6 - Duplex	Full
7 - Handshaking	Off

8. Once these options are correct type [0].

9. Type [0] again.

A.6.3 Activating communications

1. Type [3], then type [H].

2. The line at the bottom of the monitor should now read:

LINE SELECT MENU

3. After booting the system with the keyboard terminal installed, the monitor will display the line:

Press ESC to return to menu.

A.7 Service Log

The service log is found on the next pages. Enter the appropriate information when service or maintenance is performed.

OEC-DIASONICS, INC.

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

OEC-DIASONICS, INC.

OPERATOR/FIELD SERVICE SYSTEM LOG

Location	Model Number	Serial Number	Page Number

Date	Activity Performed	Explanation/Comments	Operator Initials	Serv Eng Initials

SECTION 9
CALIBRATION

9.1 Introduction

This section contains procedures used to test and calibrate the OEC-Diasonics Series 9000 System.

The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9000 System.

9.1.1 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 have been properly installed and correctly wired. It is further assumed that all subassemblies are without defect and 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 for use before beginning the calibration.

9.1.2 Test and Calibration Outline

The calibration procedures are presented in the following order:

i. Preparation
ii. Electrical Checks
iii. Mechanical Checks
iv. Functional Checks
v. Beam alignment
vi. X-ray Calibration
vii. Dose Calibration
viii. Imaging Chain
ix. Accuracy Verification
x. Special Image Processing and Monitor Cart Tests

9.2 Safety Precautions

WARNING: **The procedures in this section should only be performed by service engineers specifically trained by OEC-Diasonics to calibrate the Series 9000 System.**

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.

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.

9.3 Preparation and Setup

9.3.1 Record the Test Equipment Used

Record the information requested on the Worksheet.

9.3.2 Preparation and Inspection

1. To prevent the mainframe from rolling, position the front and rear wheels at right angles to each other . To keep the monitor cart from rolling, engage the monitor cart wheel locks.
2. Turn the keyswitch to OFF.
3. Unplug the power cord on the monitor cart.
4. Inspect the interconnect cable; make sure the interconnect cable is permanently attached by its bracket to the monitor cart.
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 conductive casters on both the mainframe and the monitor cart for proper pressure and freedom of movement.
8. Remove the front, rear, and left side panels from the monitor cart and the left, right and rear covers from the mainframe.
9. Connect the terminal to the mainframe as instructed in the Appendix.

9.4 Electrical Tests

9.4.1 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 100 uA (or other value specified by the user) in any of certain standard test configurations. *Leakage currents in excess of 100 uA may be recognized as unsafe in equipment of this type.*

1. Unplug the line cord.

2. Complete the measurement according to the instructions applicable to the available test device.

3. If leakage currents exceed the user's specifications during any of the preceding tests, the system under test has failed this test section. Document the fault and corrective action taken on the worksheet.

9.4.2 Ground Continuity

1. Disconnect the power cord and connect the interconnect cable between the monitor cart and the mainframe.

2. Check the continuity of the system ground between the mainframe and the monitor cart. Resistance shall be less than 0.5 ohms.

3. Measure the continuity of each power plug ground pin to its corresponding chassis. Resistance shall be less than 0.5 ohms.

9.4.3 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:

$$100\ (Vn - V1)/\ (V1)$$

where: Vn = No load voltage
V1 = 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.

9.4.4 Monitor Cart Power Supplies

1. Unplug the system power cord from the wall outlet.

2. Inspect the following power supply connections to the monitor cart electronics:

Disk Controller PCB supply	P-10
Hard disk power supply	P-3
I/O Dist.-Video Switching PCB	P-2 & P-3
Front Panel Processor PCB	J-21
Black and yellow wires	TV monitors

3. Plug the power cord into the wall. Turn on the CART POWER circuit breaker. Verify that the three cooling fans in the base of the cart are running.

4. Measure the output of the TV monitor power supply. It should measure +24 volts DC.

5. Measure the following voltages relative to DC Common (PS-1 pin 7):

PS-1 pin 12	+5 volts DC	red wire
PS-1 pin 6	+15 volts DC	gray wire
PS-1 pin 5	-15 volts DC	violet wire
PS-1 pin 4	+24 volts DC	yellow wire
PS-1 pin 3	-5 volts DC	blue wire

6. Check for the correct AC line voltage at the rear monitor cart AUX outlets.

9.4.5 Mainframe Power Supplies

1. Turn on the mainframe keyswitch.

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

WARNING: * F2 and F3 carry line voltage whenever the power cord is plugged in.

9.5 Mechanical Checks

In the steps below, check for ease of movement without excessive play.

1. Check the **foot lever and steering handle** for proper movement. Then lock the C-arm in place by setting the wheels at right angles to each other.

2. Check **Wig Wag** - horizontal swing of the C-arm from side to side.

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 proper action of 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. 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. Rotate the **L-arm** 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

9.6 Functional Checks

9.6.1 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 front panel. Refer to what these codes mean in the service sections of this manual.

3. Observe the Boot Codes on the mainframe LED panel and the Progress Codes on the monitor cart LED display as the operating software is loaded and the system is initialized.

4. If any of these codes remains on the LEDs and the system fails to complete its booting and initialization, refer to the listing of boot codes in the Mainframe Service Section or the listing of progress codes in the Monitor Cart Service Section.

9.6.2 Emergency Off and Processor Reset Test

1. With the system powered up, depress the **left** EMERGENCY OFF switch and make sure that the interlock circuit breaks and the LED display reads *INTERLKS BROKEN*.

2. Press any key, and then press the START switch to resume operation.

3. Again, with the system powered up, repeat step one using the **right** EMERGENCY OFF switch.

9.6.3 Status Mode Tests

Refer to the Mainframe 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 *LED 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).

9.6.4 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 make sure that the *NO CASSETTE* message does not appear.
5. Remove the cassette and observe that the *NO CASSETTE* does appear.
6. Rotate the C-arm to return the image intensifier below the X-ray tube.

9.6.5 Verify Operation of Mainframe Controls

WARNING: These tests produces X-rays. Take the 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 an LED 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 LARGE FIELD switch removes the 6-inch collimator by listening for the "thunk" sound produced when you press the switch.

5. Verify that the X-RAY ON lamps on the X-ray tube assembly, control panel and monitor cart light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

6. Verify operation of the footswitch.

7. Verify that early footswitch release will terminate the FILM exposure. The message *FOOT RELEASED* should appear on the control panel display.

9.6.6 Field Solenoid Position Test

This test verifies that the system can sense the position of the SMALL FIELD collimator.

1. Remove the bottom filtration plate on the collimator.

2. Place the system in the FLUORO mode and select the SMALL FIELD. Verify that the flipper returns to the 6-inch position.

3. Reach into the collimator and move the flipper (small field) collimator out of the center.

   Verify that the control panel displays the message *FLIPPER STUCK.*

4. Release the collimator and allow it to return to center.

5. Place the system in the FILM mode and select the LARGE FIELD.

   Verify that the flipper (small field) collimator moves out of the center.

6. Reach into the collimator and hold the flipper in the LARGE FIELD position. While holding the flipper in this position, select the SMALL FIELD from the front panel. The control panel should display the message *FLIPPER STUCK.*

7. Replace the filtration plate on the collimator.

9.6.7 Verify Controls in MANUAL FLUORO

1. Select MANUAL FLUORO mode.

2. Verify that kVp and mA can be controlled using the control panel knobs.

9.6.8 AUTO FLUORO Tests

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

1. Select AUTO FLUORO mode.
2. Switch to live video using the VIDEO BYPASS switch (on the monitor cart rear) and verify that true live video appears on the left monitor and that the TV monitors do not lose video sync.
3. Switch the VIDEO BYPASS switch to NORMAL.
4. Make a fluoro exposure and transfer the image to the right-hand monitor.
5. Make another exposure. The image will appear on the left monitor.
6. 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. 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 one set 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.

9. Verify operation of the left monitor's remote contrast and brightness controls on the mainframe control panel. (Set the left contrast control near the monitor screen to REMOTE).

9.6.9 Fluoro Boost Option

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

1. Enable BOOST on the control panel (if provided). Then to make the exposure, press down into the second position on the right footswitch.
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 image doesn't "burn out" or appear too dark.

9.6.10 Pulsed Operation

1. Enter the PULSE FLUORO mode.
2. Press X-ray On and verify pulsed operation when the button is pressed.

9.6.11 Verify Fluoro Timer and Timer Reset

1. In fluoro mode the accumulated exposure time is displayed in the center of the LED 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 should stop but the accumulated exposure display should not reset.
3. Press and hold the ALARM RESET for three full seconds. The accumulated timer display should reset to 0.

9.7 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

9.7.1 Preparation

1. Position the X-ray tube/image tube axis at a 45-degree angle to the floor. *Refer to Figure 9-1.*

2. Attach the beam alignment fixture and a loaded film cassette to the image intensifier assembly.

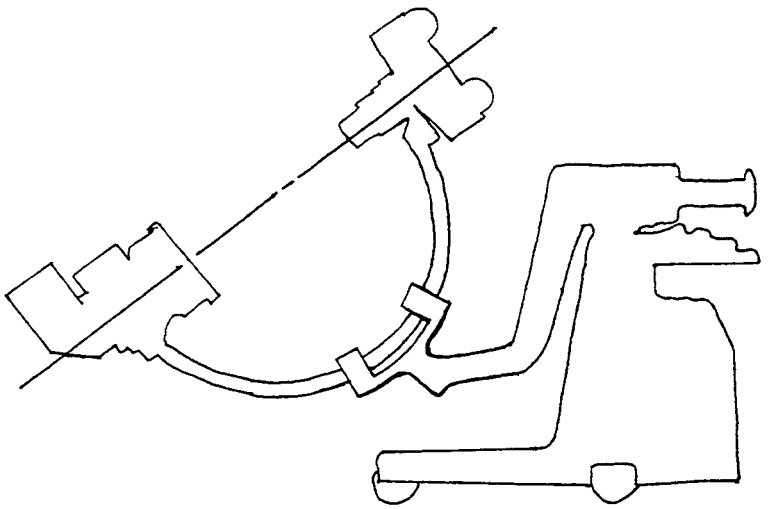


Figure 9-1 - *Position the imaging axis at a 45-degree angle to the floor.*

9.7.2 Radiographic Beam Alignment

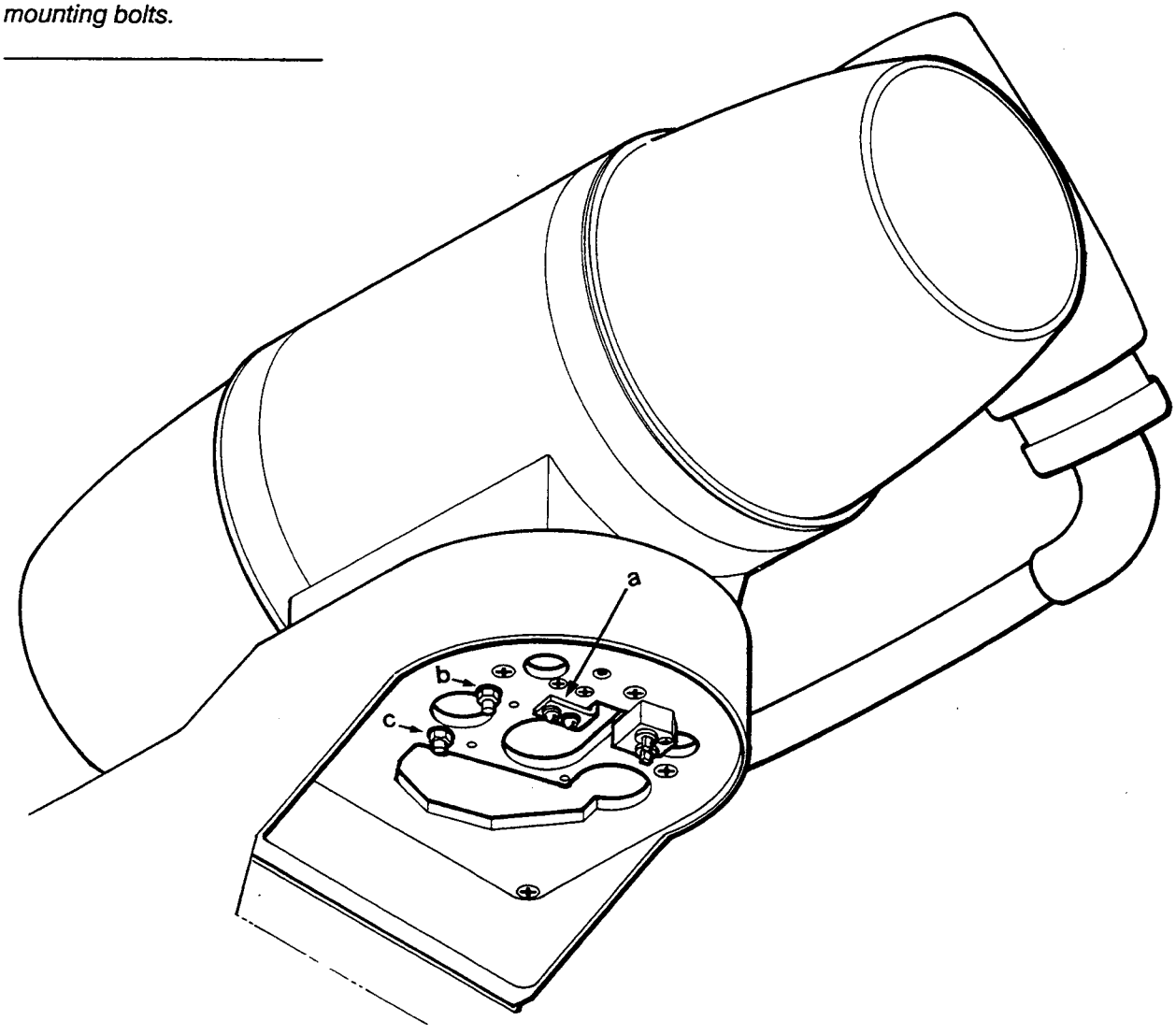
WARNING: This procedure produces X-rays. Take the appropriate precautions.

1. Set a radiographic technique of 50 kV 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 9-2 - *Adjust the shutter stop and the solenoid mounting bolts.*



4. Verify that the exposed area covers the entire large field.

5. If the beam is occluded 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:

   1. Remove the screws and cover plate from the X-ray head mounting assembly.

   2. 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.

   3. Make exposures as needed to verify the beam position.

   4. When the large field is properly centered, carefully retighten the locking screws avoiding any movement of the X-ray head as you tighten. Fine readustments may be needed as the eccentrics are tightened into place.

6. Remove the collimator assembly from the X-ray head, and select the small field.

7. Making exposures as required, adjust the 6-inch flipper stop (a) and the shutter solenoid mounting bolts (b & c) to center the 6-inch beam on the beam alignment fixture. *Refer to Figure 9-2.*

8. Check that the microswitch still functions properly.

9. Reinstall the collimator. Select the 6" field and make a radiographic exposure. Select the Large field and make another exposure on the same film.

   Check that the alignment of both fields is correct.

10. Complete the information on the film label and attach it to the upper right hand corner of the developed film.

11. Select the LARGE FIELD. Adjust the leaf collimator shutters to 6 x 6 inches and make an exposure.

12. Measure the actual size of the exposed area on the film. If necessary, loosen the set screws on the shutter adjustment knobs and adjust the collimator knobs to correspond to that size.

13. Tighten all set screws.

14. Set the radiographic technique to 50 kV and 1 mAs.

15. Make multiple exposures on a film with the shutters set to minimum, 4", 6" and 8". Label one shutter direction X and the other Y.

16. Measure the actual dimensions of the exposed areas. *The measured and actual dimensions should coincide within +/- 0.5 inch.*

    The dimensions of each field shall be as follows:

Minimum field -	less than 1.97", square *
4-inch field -	4" +/- 0.50", square
6-inch field -	6" +/- 0.50", square
8-inch field -	8" +/- 0.50", square

    * 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.

    Note: The corners of the 8" field will be clipped by the 10" collimating ring on 6" image intensifiers.

17. Record the measured values on the supplied label. Attach the label to the film.

18. On the exposed film obtained in step 15, mark each corner of the 6" area with a pen. Using a straight edge, connect the dots diagonally. *The intersection of the diagonal lines should fall within the center circle on the beam alignment fixture.*

19. Install the 0.5 mm aluminum filter on the collimator.

9.7.3 Fluoroscopic Beam Alignment

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

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. Set the video selector switch on the rear of the monitor cart to BYPASS.

5. 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 fluoroscopic test reticle should be visible around the entire input area of the image intensifier tube.

6. Return the video selector switch to NORMAL.

9.8 X-ray Calibration

9.8.1 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 is removed, disabling mA servo.
2. A series of exposures is 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.

Overview: mA/kVp Technique Calibration

1. mA servos are enabled (the mA jumper is replaced).
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.

9.8.2 Connections

Refer to Figures 9-3 and 9-4.

Connect the Dynalyzer III High Voltage Unit, Digital Display (DRO) III, Autocal Interface Box, and DVM to the mainframe electronics as shown in Figure 9-3.

NOTE: Refer to the general instructions for the Dynalyzer in the Appendix.

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.

Dynalyzer II

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.

Autocal Interface

Connect the autocal interface box to connectors J1 and J2 on the Analog Support PCB (cable part number 00-871432).

Figure 9-3 - *Connections between the Analog PCB and the calibration equipment.*

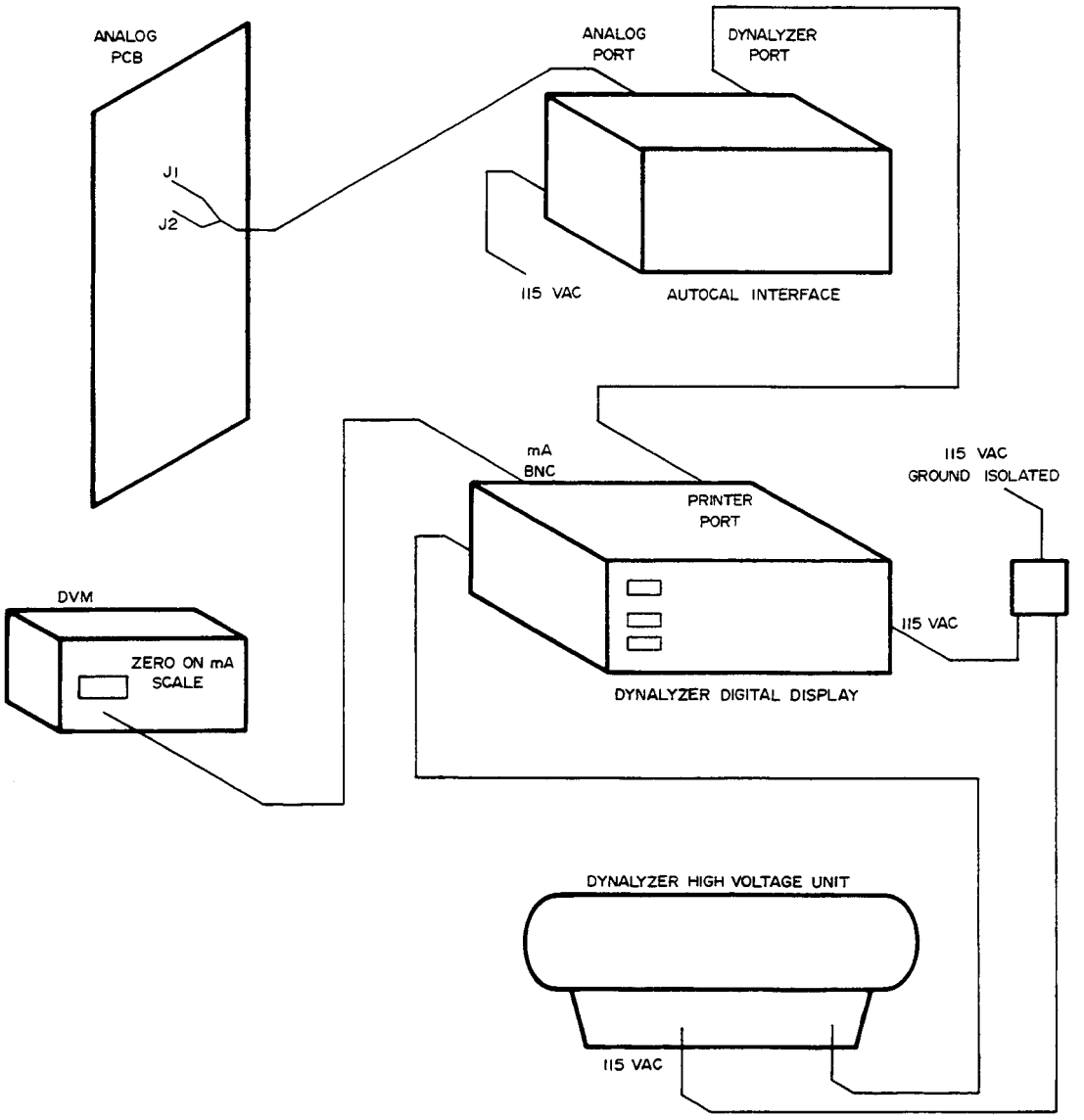


Figure 9-4 - *Connections are made between the back of the Analog PCB and the AutoCal Interface Box.*

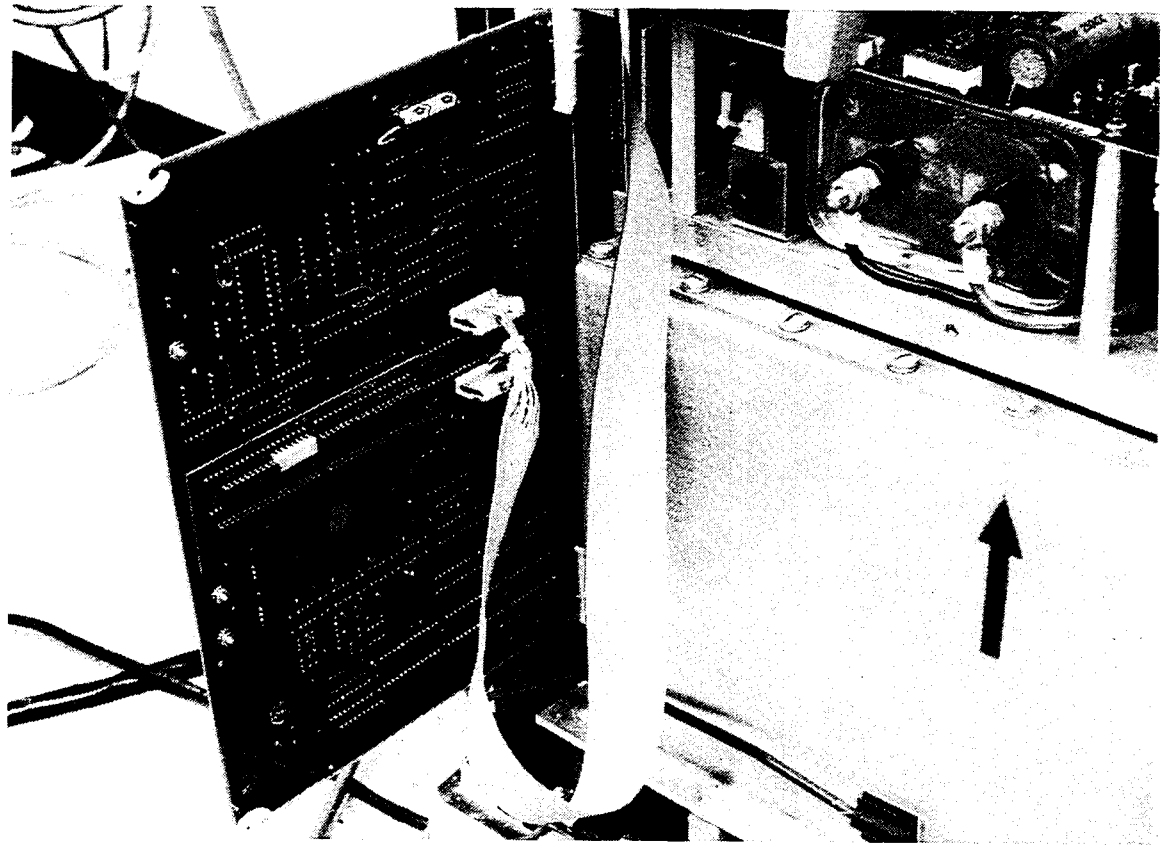
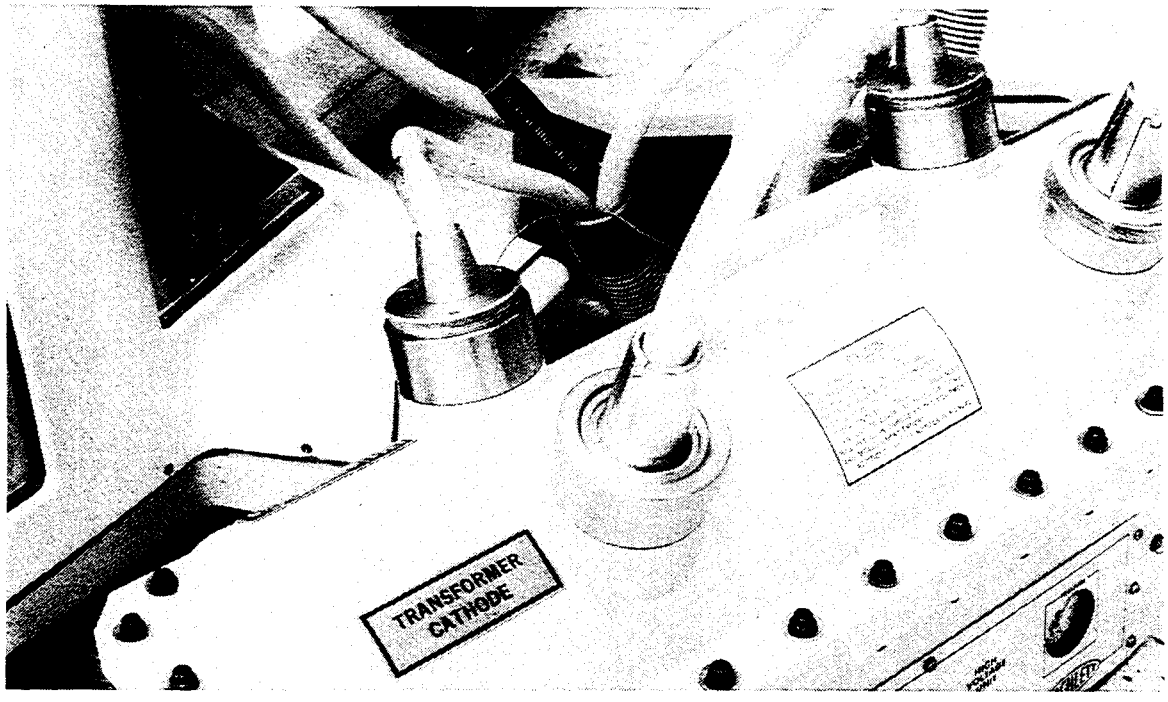


Figure 9-5 - *Refer to the Appendix for instructions on making the high voltage connections to the Dynalyzer High Voltage Unit.*



9.8.3 Setup

NOTE: Refer also to the general instructions for Dynalyzer use in the Appendix.

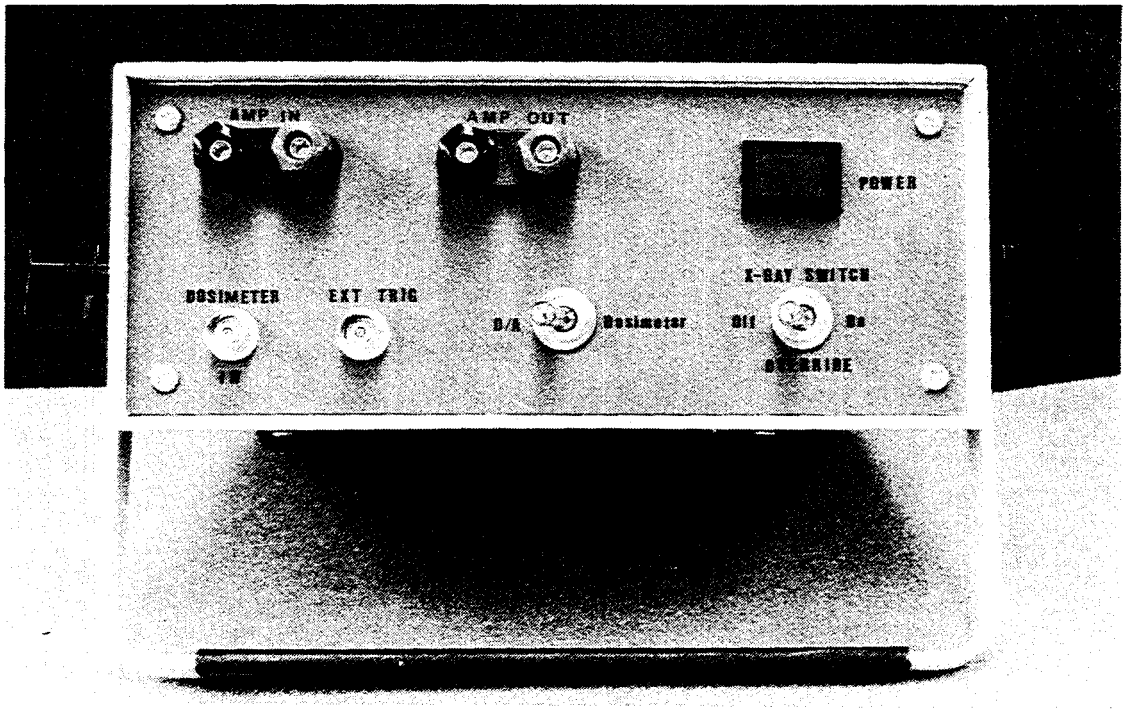
General Setup

1. Jumper across E3 on the Generator Controller PCB with a shorting plug to disable mA servo.
2. Turn on the power to all calibration equipment.

Autocal Interface Box

Refer to Figure 9-6. Turn X-ray Switch Override **ON**.

Figure 9-6 - *The AutoCal Box. Refer to the text for proper switch settings.*



Dynalyzer III High Voltage Unit

Refer to Figure 9-7. 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 9-7 - *The Dynalyzer III High Voltage Unit. Set the FLUORO/RAD switch as described in the text.*

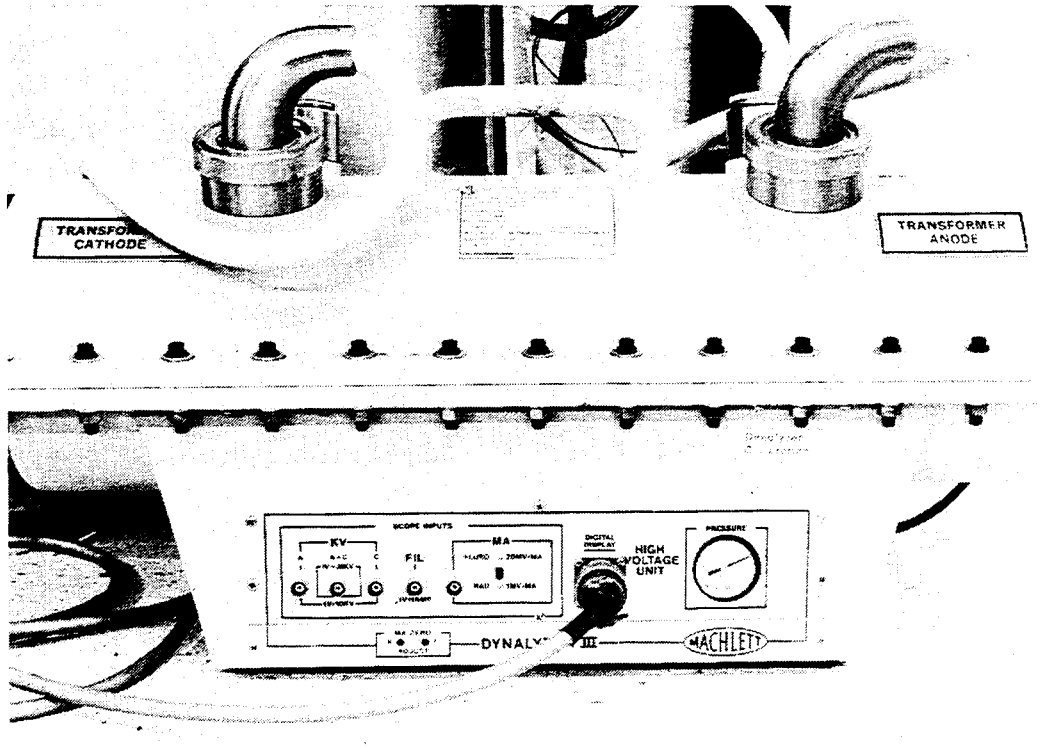
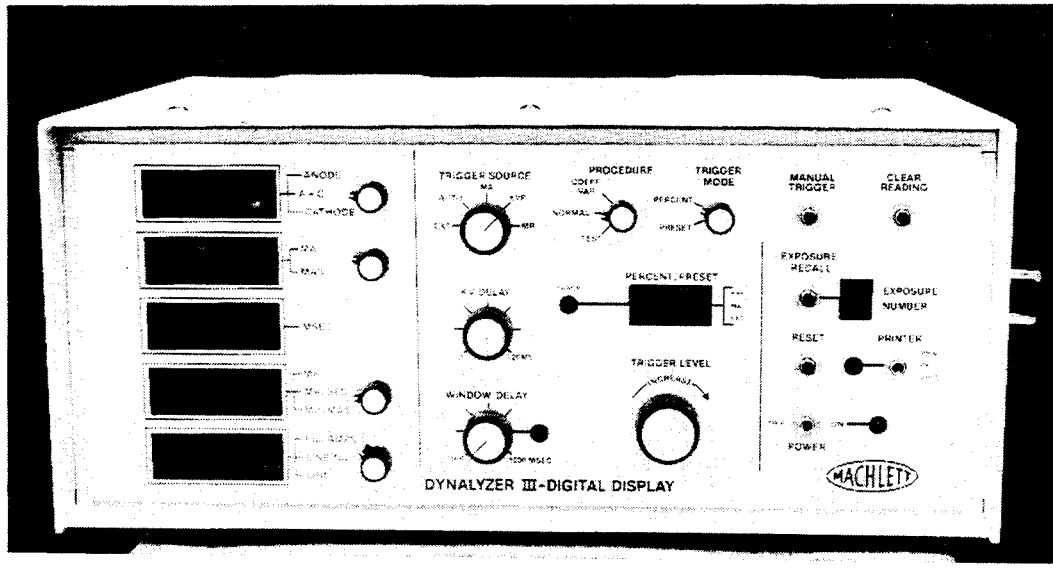


Figure 9-8 - *Dynalyzer III Digital Display*. Set the controls as described in the text.



Dynalyzer III DRO (Digital Display Unit)

Refer to Figure 9-8.

Set the controls as follows:

Displays:	**A+C,**	**mA**
Trigger Source:	**kVp**	
Procedure:	**NORMAL**	
Trigger Mode:	**PERCENT**	
kV Delay:	**20 ms**	
Window Delay:	**OFF**	
Trigger Level:	**50**	
Printer	**AUTO**	

Dynalyzer II High Voltage Unit

No special settings are required.

Dynalyzer II DRO (Digital Display Unit)

Refer to Figure 9-9.

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)		

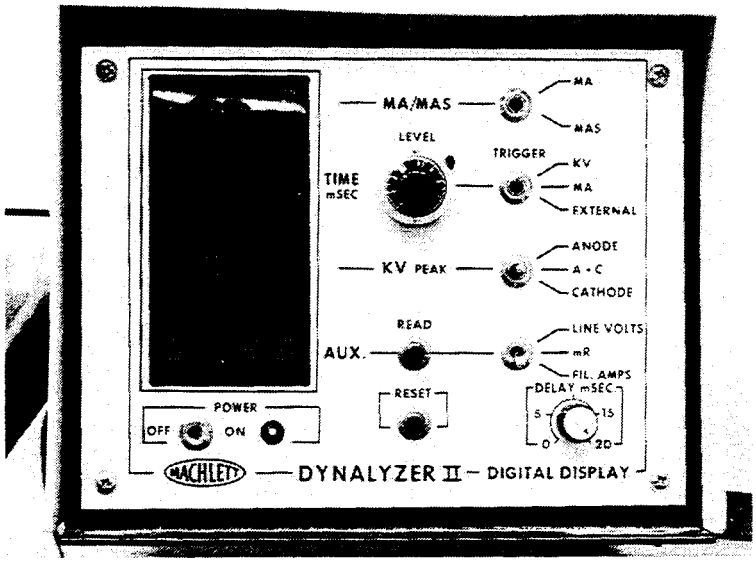
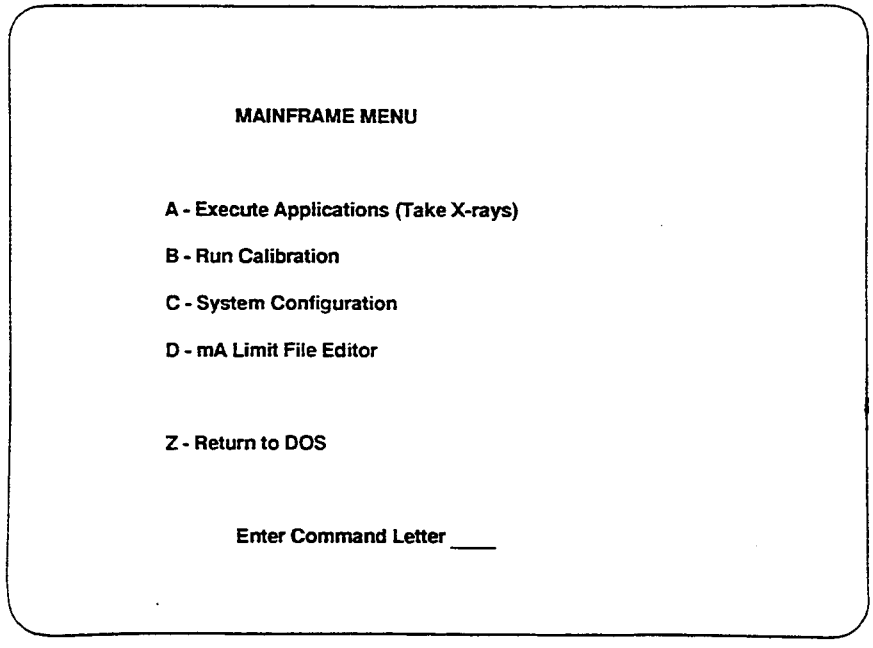


Figure 9-9 - *Dynalyzer II Digital Display. Refer to the text for the proper switch settings.*

9.8.4 Getting Started

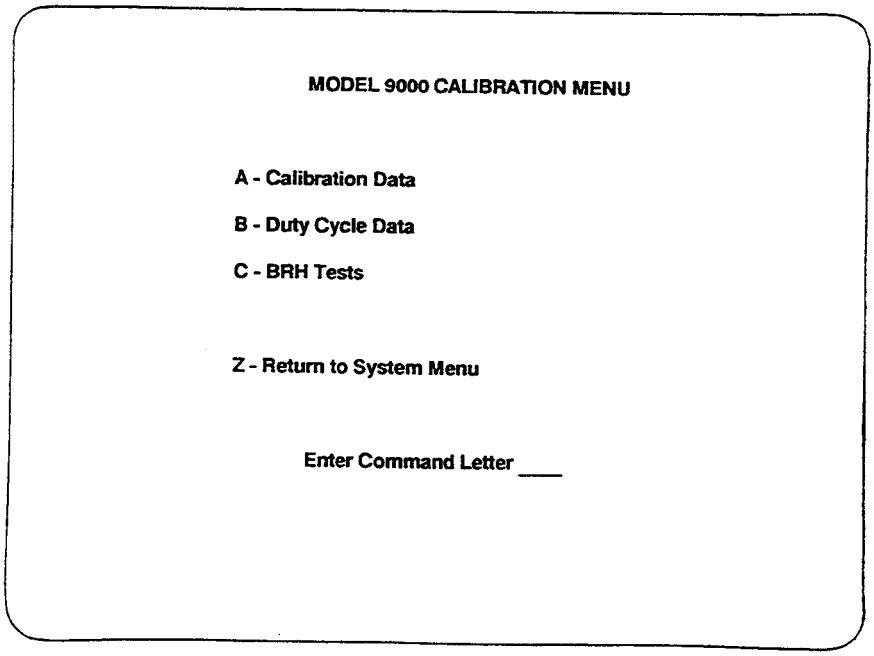
1. Connect the computer terminal to the monitor cart. Instructions for connecting and using the external computer terminal are found in the Appendix.
2. Press *[ESC]*.
3. Select: *Z - Return to main menu.*
4. Select: *Y - Access Mainframe Menu.*

   The Mainframe Menu will appear:



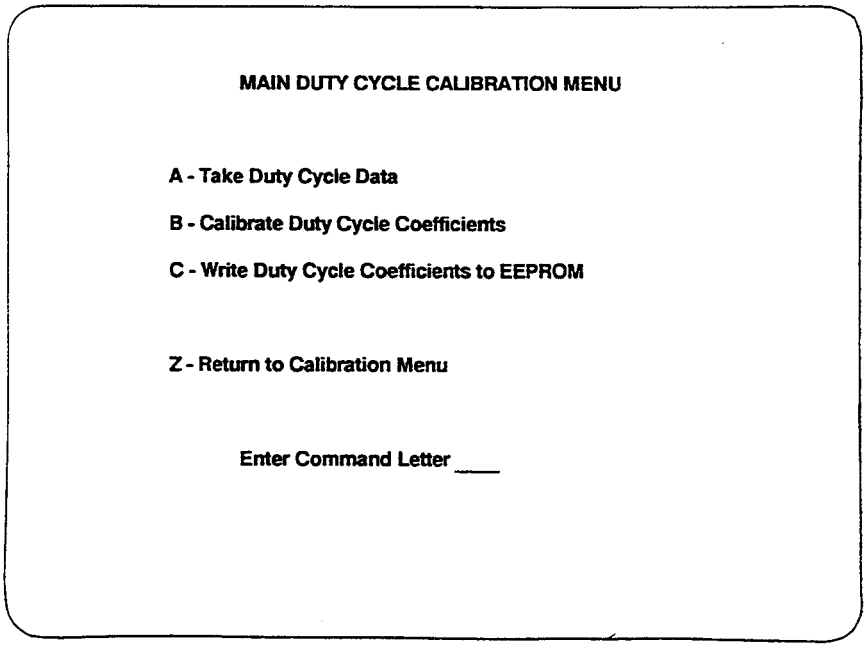
5. From the Mainframe Menu select: *B - Run Calibration.*
6. Enter your initials when prompted: *Enter initials please.*

7. From the *CALIBRATION MENU* select: *B- DUTY CYCLE DATA.*



9.8.5 Duty Cycle Calibration

The Duty Cycle Menu will next appear on the terminal screen:



9.8.5.1 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).

2. Zero the Dynalyzer high voltage unit.

Note: Zero *both* the FLUORO and RADIOGRAPHIC settings on the Model III.

3. Depress the footswitch (or X-ray On button) when ready.

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].

6. The Dynalyzer II tank must be switched between FLUORO and RAD to accommodate filament size changes during calibration. When this is required, The following prompt will appear on the terminal screen:

   *** SWITCHING FILAMENTS ***
   Change tank setting to ___ (FLUORO or RAD) for ___ (small or large) spot calibration. Press [ENTER] when ready to continue.

   When beginning the calibration procedure using a Dynalyzer III, the on-screen instructions will indicate the switch setting (FLUORO or RAD) with which to start.

9.8.5.2 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.

9.8.5.3 Write Duty Cycle Coefficients to EEPROM

1. When the calculations are complete, you will be returned to the Duty Cycle Calibration Menu.

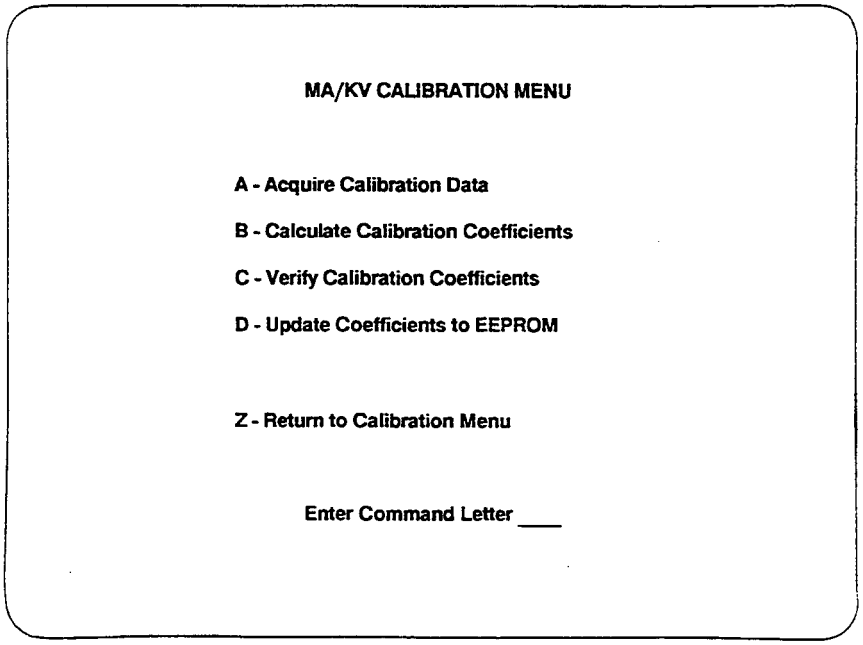
2. Select: *C - Write Duty Cycle Coefficients to EEPROM.*

3. This takes only a blink of the eye.

4. Select: *Z - Return to Calibration Menu.*

9.8.6 mA/kV Calibration

Technique calibration uses the mA/kV Calibration Menu:



9.8.6.1 Acquire Calibration Data

1. From the Main Calibration Menu select: *A - Calibration Data.*
2. From the mA/kV Calibration Menu select: *A - Acquire Calibration Data.*
3. Remove the mA servo-disable jumper E3.
4. Zero the Dynalyzer (both settings on the Model III).
5. Depress the footswitch when ready.
6. The system automatically takes 38 predefined exposures.

   The calibration software will prompt you to change the Dynalyzer setting (FLUORO/RADIOGRAPHIC) as needed.
7. Observe the results reported on the screen. The technique values should be similar to those read on the control panel and the Dynalyzer readout.
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].

9.8.6.2 Calculate Calibration Coefficients

1. Select: *B - Calculate Calibration Coefficients.*
2. The coefficients will be displayed briefly on the monitor.

9.8.6.3 Update Coefficients to EEPROM

1. Select: *D - update coefficients to EEPROM.*
2. This step is performed before the verification data is acquired.

Note: Menu item *C - Verify Calibration Coefficients* is not implemented for field use. Proceed with the manual verification procedure given below.

9.8.7 Verify Calibration

9.8.7.1 General Information

Calibration must be verified following regular calibration procedures or when any of the following components are replaced:

- X-ray Tube
- Generator Controller PCB
- High Voltage Regulator Components
- High Voltage Tank

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.*

9.8.7.2 KVP Accuracy Tests

The tests in this section are designed to measure the kVp accuracy of the system. Perform the tests indicated and 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. Slew the mA to maximum at each kVp.
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 @ 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.

9.8.7.3 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. Select the small field.
2. Take exposures at 5 mAs 50 mAs, and at 200 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. Select the SMALL field.
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.

9.8.7.4 Fluoro MA Accuracy Test

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.

9.9 Entrance Exposure Calibration

Entrance Exposure Limitation Tests

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.

Entrance Exposure Calibration

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.

Measurement Position The entrance exposure for the system is measured 30 cm (12 inches) from the input surface of the imaging assembly.

NOTE: Remove the dynalyzer prior to execution of this procedure.

Equipment Required The following equipment is required to perform the entrance exposure tests:

* Keithley Model 35050 dosimeter with Model 96030 ion chamber or equivalent (Calibration must be current).

* Metric Scale or Ruler

* Lead Apron or lead plate

* 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 such 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 4.69 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: *D - mA Limit File Editor.*

11. For each value listed by the mA Limit File Editor, select the kVp index number and enter the mA found in the steps above.

12. Enter the data obtained every five kVp (recorded in the worksheet table) and interpolate the remaining values.

13. When the table on the screen is complete, press [ENTER].

14. Follow the instructions on the screen to save the editing changes.

9.10 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.

9.10.1 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:

   1. Place the dosimeter 30 cm. (12 inches) from the input surface of the image intensifier.
   2. Adjust the technique factors to produce the required radiation level.
   3. Then LOCK the technique and remove the dosimeter for the tests.

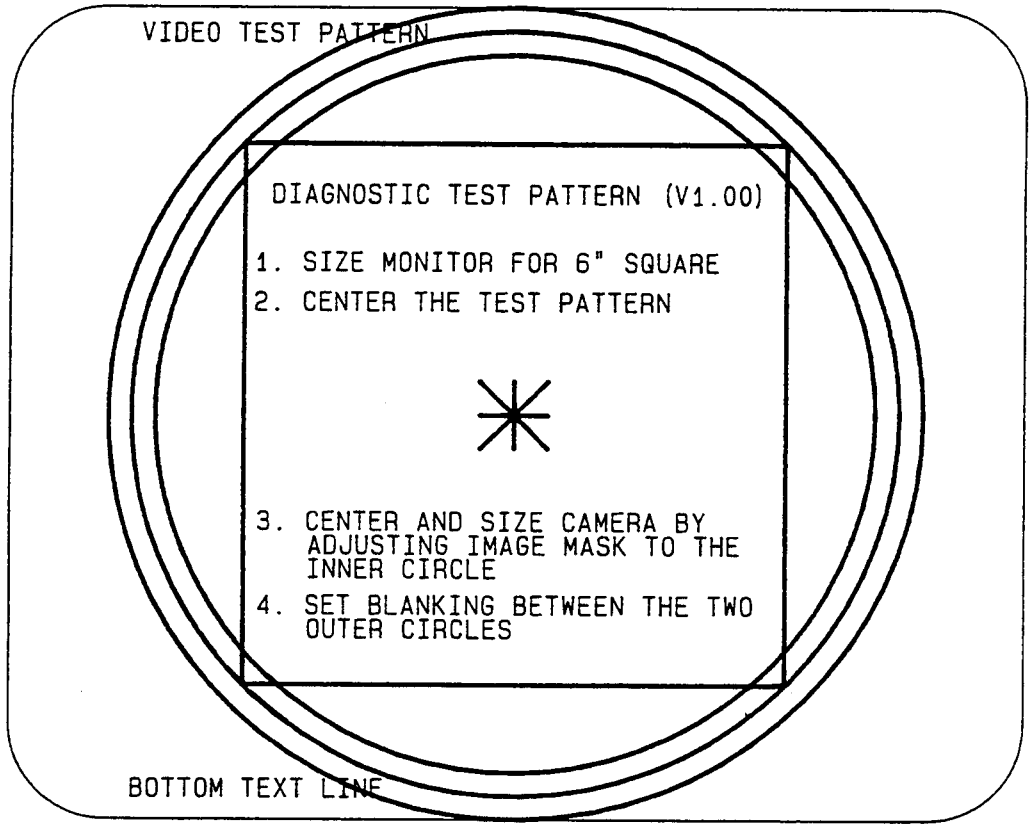
3. Unless otherwise noted, all radiation measurements are made 30 cm. (12 inches) above the input surface of the image intensifier.
4. The camera lens aperture is set to f/2.0.
5. X-ray beam alignment has been performed with satisfactory results.
6. On 6/9-inch fluoroscopy systems, all camera tests and 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.

9.10.2 Monitor Raster Size Adjustment

1. Place the video selector switch on the rear of the monitor cart in the "NORMAL" position.
2. Put the monitor cart into the diagnostics mode. Follow the instructions in the Monitor Cart Service Section for using either the **Front Panel** or **Terminal Diagnostics**.
3. Select test *23 - VIDEO TEST PATTERN.*
4. While viewing the test pattern, adjust the *VERT SIZE* and the *WIDTH* controls on the left monitor to produce a 6-inch square in the center of the screen.
5. It may be necessary to adjust the centering magnets on the CRT neck to hide the raster edges, and to correctly display the text lines.
6. Repeat this procedure for the right monitor.

NOTE: Adjust the TV monitor size controls before any other size adjustments are performed.

Figure 9-10 - *TEST 23 - VIDEO TEST PATTERN is used for video alignment, sizing and centering.*



9.10.3 Camera Sizing and Optical Adjustments

9.10.3.1 Camera Rotation Axis Offset (mirror axis alignment)

Test Spec:
Less than 1/4" axis shift on the monitor as the camera is rotated through its 360 degree range.

1. Place the alignment tool on the image intensifier input surface.
2. Loosen the camera drive belt and disengage it from the drive gear. This will prevent damage to the rotation drive motor.
3. Continue using the VIDEO TEST PATTERN - Test 23, described in the previous procedure.

4. Rotate the camera to one extreme, make a fluoro exposure and with a felt-tip pen, place a mark on the monitor screen at the center of the alignment tool image.

5. Rotate the camera 90 degrees and mark the center again. Repeat this every 90 degrees throughout the 360 degree range.

6. Make a cross by connecting the diagonally opposite marks, and measure the length of the longest diagonal.

7. If this dimension is less than 1/4 inch, no further adjustment will be necessary.

8. Adjustment is made while making an exposure by varying the jackscrew settings supporting the mirror and aligning the center of the tool image with the center of the marked cross. When complete, re-check allignment.

9. Center the alignment tool crosshair in the center of the video test pattern by adjusting the horizontal and vertical centering on the camera Deflection PCB. Camera centering controls are further described in a following procedure.

NOTE: Be careful not to over-tighten the compression washers.

10. Replace the camera drive belt over the drive gear.

9.10.3.2 Camera Lens Aperture Setting

Set the camera lens aperture to f/2.0.

9.10.3.3 Active Image Size and Centering

Adjust the camera image size and centering according to the Video Test Pattern Instructions.

Spec: Diameter = 8.25 inches +/- .125

Camera Size and Centering Controls (Deflection PCB):

R-40	Hor. Size - normal
R-38	Hor. Centering - normal
R-39	Hor. Centering - reversed
R-19	Vert. Size
R-37	Vert. Centering

9.10.4 Image Circular Masking

Spec: Less than 2% of SID (.72 inch for 9-inch system, .76 inch for 6-inch system).

1. With the BYPASS switch in the "NORMAL" position, the image edges will be hidden by the circular blanking window. The blanking should cover the image edge at all points throughout a complete rotation of the camera.

2. In no case should there be more that 2% of the SID (referred to the input of the image tube) masked. This refers to areas radiated, but not imaged as a result of circular blanking or other masking.

3. Set the circular blanking on the monitor cart AD/DA PCB with the potentiometers listed below.

R45	Vertical Offset
R47	Vertical Size
R48	Horizontal Size
R50	Horizontal Offset

4. Press the *HELP* button to *exit Test 23*. Then select *Option 99 - Return to System*.

9.10.5 Camera Electrical Adjustments

Test Conditions:

1. Contrast Grid installed
2. No other filters in beam except aluminum collimator filter
3. Shading jumper out (disabled)
4. Auto gain jumper out (disabled)
5. Black level control disabled (jumper TP2 to TP7)
6. Camera input power = 24 +/- 1.0 VDC

9.10.5.1 +500 Volt Supply Adjustment.

1. Adjust R-13 to the maximum voltage extreme.

2. Reduce the "BEAM" (R-14) setting to minimum (blanked).

3. Measure the voltage at TP-6.

4. Adjust R-13 for 25 volts below the voltage measured above at TP6 or +500 VDC, whichever is less.

Figure 9-11 - *This view of the camera shows the location of the a) Video Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.*

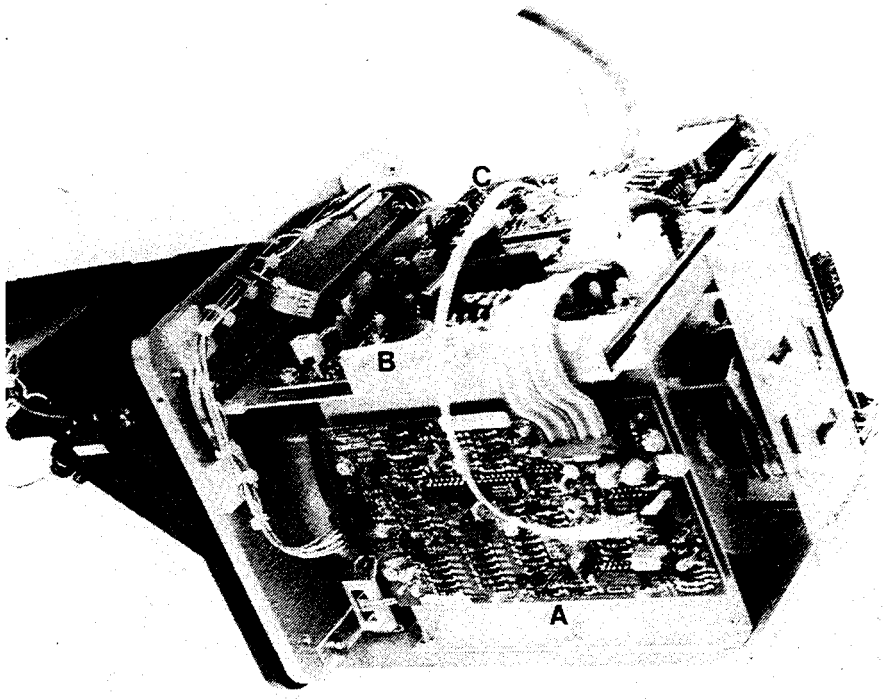
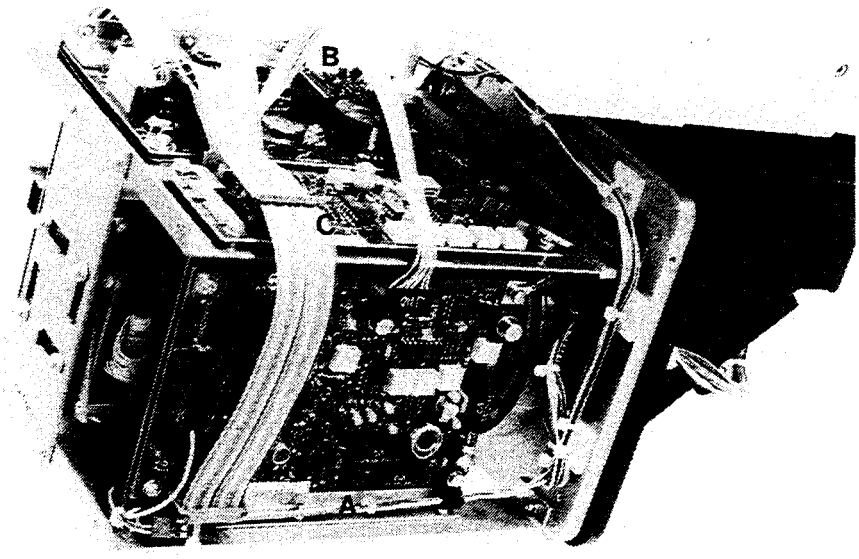


Figure 9-12 - *This view of the camera shows the a) Deflection Board, b) Camera Power Supply Board, and the c) Window/Shading Generator Board.*



9.10.5.2 Beam Discharge

1. Adjust beam discharge current with the beam discharge pot R14 on the Camera Supply PCB.

2. Be sure there is sufficient beam current to discharge video amplitudes of 500 mv p-p as measured at TP-3.

3. While making an exposure and observing TP1, adjust R14 until the beam is fully discharged, then 1/8th turn beyond that point. The video level at TP3 will be observed to peak near this point.

9.10.5.3 Target Adjustment

Spec: 350 +/- 20 mv. at TP-3 on Video Processor PCB.

On the Video Processor PCB adjust the target voltage with R-43 while making an exposure to produce 350 mv p-p at TP-3.

9.10.5.4 Black Level

Spec: 75 +/- 10 mv at TP-1.

Adjust the Black Level Control (R-44) for 75mv black level as seen at TP-1 on the camera Video Processor PCB.

9.10.5.5 Camera Video Output

Spec: 850 +/- 40 mv peak video measured at J-8 of the AD/DA.

Adjust the Video Gain with R-9 on the Video Processor PCB to produce the video output measured at J8 on the AD/DA PCB.

9.10.5.6 Verify Dark Current Compensation

1. Monitor J8 on the AD/DA PCB.

2. While observing the composite video waveform during an exposure, temporarily remove the jumper between TP7 and TP2 on the camera Video PCB.

3. The black level should change, correcting to 50-150 mV above the video blanking level.

9.10.5.7 Video Output with Auto-brightness Enabled

Test conditions:
Auto-Gain enabled
Black level control enabled
Shading enabled.

Under the test conditions listed above, measure the video amplitude at J8 on the AD/DA PCB. The output video amplitude, with auto brightness enabled, should be 820 +/- 60 mv. peak.

9.10.6 Shading (Image Brightness Uniformity)

Test Conditions:
1. Contrast Grid installed
2. No other filters in beam except the aluminum collimator filter
3. * Shading jumper in (enabled)
4. Auto gain jumper out (disabled)
5. Black level control disabled (jumper TP2 to TP7)

* Shading controls adjusted for minimal shading error.

Spec:

Vertical shading component:	less than 100 mv p-p
Horizontal shading component:	Less than 100 mv p-p
Video amplitude:	850 +/- 40 mv peak (J-8 of the AD/DA)

Adjustment procedure:

1. With the horizontal sweep orientation "normal" and the scope sweep rate set to view horizontal (20 us/div) and triggered, adjust R-40 (Horiz. sawtooth) and R-42 (Horiz. parabola) for uniform amplitude across the video waveform.

Refer to Figure 9-13.

2. Restore the video amplitude with R-57 (BIAS).

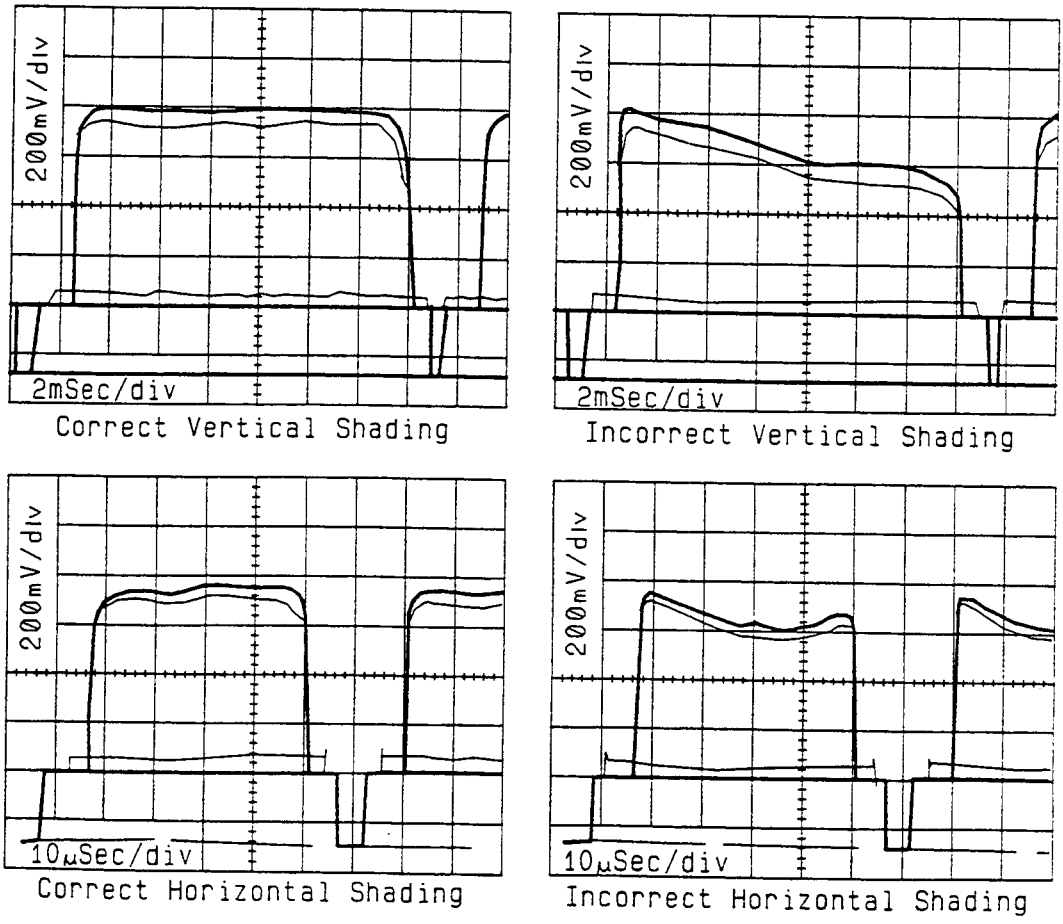
3. Change the scope sweep rate to view the vertical rate. (5 ms./div.) and adjust R-10 (Vert sawtooth) and R-15 (Vert parabola) for uniform amplitude across the video waveform.

4. Restore the video amplitude with R-57 (BIAS).

5. Repeat steps 1 and 2 with the horizontal orientation "reversed" using R-41 (horiz. sawtooth) and R-57 (BIAS) respectively.

NOTE: The shading specifications refers to the central 70% of the illuminated area in each axis. Some rounding at the edges is acceptable. It is generally helpful to "dip" the center just a little (approx. 50 mv.) to meet this specification.

Figure 9-13 - *Correct and incorrect shading waveforms are illustrated here.*



9.10.7 Resolution

Test Conditions:

1. Shading jumper in (enabled).
2. Video selector switch in the "BYPASS" position.
3. NO Contrast Grid.
4. Wisconsin Resolution Tool installed.
5. Adjust technique for 50 kVp @ 200 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 the technique for 200 +/- 10 mr./min. at 50 kVp. in "MANUAL" mode.

9.10.7.1 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.

3. Adjust C-3 (peaking capacitor) on the Preamp and Yoke assembly until the black image edges, viewed on the monitor, bleed white. Back off the adjustment of C-3 until the smearing just disappears. This will provide optimum preamp bandwidth without oscillation occurring.

Note: Use a nonmetallic adjustment tool on C-3.

9.10.7.2 Image Intensifier Focus

If this adjustment is necessary refer to the *Mainframe Service Section.*

Rotate the C-arm assembly to place the X-ray tube/image intensifier axis parallel to the floor with the X-ray tube port pointing away from the control panel.

9.10.7.3 Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

Test Specs:

(6" machine) -	40 linepairs/inch
(6/9" machine) -	40 linepairs/inch in 6" mode 35 linepairs/inch in 9" mode

9.10.8 Contrast Sensitivity Test

Test Conditions:
1. Technique factors adjusted to produce 80 kVp @ 1R/min.
2. 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 with the cart in the "NORMAL" mode and examine the stored image. Adjust the brightness and contrast controls on the monitor as necessary to optimize the image.

9.10.9 Image Noise, Correlated

Test Conditions:
1. Black level control enabled.
2. Shading jumper in (enabled).
3. Auto-gain enabled
4. Monitor Cart in BYPASS mode.

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.

9.10.10 Video Sampling Window Size and Centering

1. Connect a 2.2 Kohm resistor between TP-11 and TP-13 to see the video sampling window.

2. Put the monitor cart in "NORMAL" mode.

3. The window should now be visible when exposures are made. Adjust R-38 "H-CAL" and R-39 "V-CAL" to center this rectangular window within the viewed area.

4. 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.

9.10.11 Video Level Control and Auto Technique Tests

Test Conditions:

1. Auto-technique mode
2. Auto-gain enabled
3. Black level control enabled
4. Shading enabled
5. Contrast Grid installed.

1. Make an exposure with no filter in the beam and record the resulting kVp.

2. Make an exposure with the Aluminum filter (6" x 6" x .125") in the beam and record the resulting kVp.

3. Make an exposure with one (1) copper filter (6" x 6" x .093") in the beam and record the resulting kVp.

4. Make an exposure with two (2) copper filters (6" x 6" x .093") in the beam and record the resultant kVp.

5. The peak output video amplitude at (J8 on the AD/DA PCB) shall be 820 mv +/- 60 mv for each of the four conditions.

6. The resultant kVp readings for each of the four conditions shall be:

No filter	43+/-3 kVp
Aluminum	47+/-3 kVp
1 Copper filter	66+/-3 kVp
2 Copper filters	79+/-4 kVp

9.10.12 Camera Drive Chain Tension

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. Rotate the camera through 360 degrees and verify that the rotation motor is switched off at each limit. Verify that the chain tension allows free rotation in all positions. *Damage to the rotation motor and gear can result if the camera is rotated by hand.*

9.11 Image Processing and Monitor Cart Tests

9.11.1 AD/DA PCB Calibration

1. Place the PCB on an extender card and replace the regular daisy chain cable with the test ribbon cable (which is longer to accommodate the extender card).

2. Measure the following voltages on the AD/DA PCB:

TP-21	digital to analog reference	-1.0 VDC
TP-23	analog to digital reference	-2.0 VDC

3. Adjust R-1 (video offset adjust) so that the video baseline at P-6 (right video output) is at ground.

4. Adjust **R-2** (video offset adjust) so that the video base line at P-5 (left video output) is at ground.

5. While making a fluoro exposure observe the live video waveform, in-line, at P6 and P5 of the AD/DA PCB.

6. Verify a video amplitude of 850 mVpp +/- 50 mV and the sync portion, 400 mVpp +/- 50 mV. Observe a baseline at 0 volts.

9.11.2 Verify External Video

1. Check for the presence of an EIA RS170 composite video signal at the video output jacks on the rear of the monitor cart.

2. Verify a video amplitude of 850 mVpp +/- 50 mV and the sync portion, 400 mVpp +/- 50 mV. Observe a baseline at 0 volts.

NOTE: The video signal must be terminated with 75 ohms to correctly measure the amplitude.

9.11.3 Image Processor PCB

1. Place a scope probe on TP27 and TP5 (ground). Verify that the following TV signals are present:

TP-9	Composite sync
TP-10	Composite blanking
TP-7	Horizontal drive
TP-6	Vertical drive

2. Adjust C-6 for +2.5 VDC measured on TP27. Verify that the video is stable and displayed in the center of circular blanking.

9.11.4 Front Panel Diagnostics

1. Access the Software Diagnostic Tests from the front panel of the monitor cart by pressing the HELP key and then selecting the "Front Panel Diagnostics" from the menus. These tests can also be selected from the Terminal Controlled Diagnostics.

2. The Front Panel Diagnostics contain tests of the image/memory transfers which occur in normal operation.

   These tests are fully described in the Monitor Cart Service Section. Read the descriptions and follow the instructions for these tests.

3. There are also tests from this menu of the switches and LEDs on the Front Panel:

   Run the Front Panel LED Test to verify that all LEDs operate.

4. Generate a gray scale image from the test menu.

5. Swap the image from one monitor to the other (using the M1-M2 swap test) and examine the image for any signs of tear or jitter.

9.11.5 Monitor Cart Imaging Function Checks

A variety of image processing functions may be available on a given system. Refer to the Operator's Manual for instructions on using the available functions.

1. Enable each function on the front panel and using a suitable test image (such as the Wisconsin Copper Mesh Test Grid), evaluate the operation of the function. Camera rotation may be used to simulate motion when evaluating some functions.

2. Verify that the LIVE FLUORO (left) Footswitch generates a live fluoro image on the left monitor regardless of the status of the image processing controls.

3. Depress the PROCESS (right) Footswitch to initiate the selected image processing.

4. Enable the WINDOW and LEVEL functions and take another image. The WINDOW and LEVEL arrow buttons should change the dynamic range and brightness level of the image presented on the left-hand monitor.

5. Verify that the Negative Image (NEG) function reverses the lights and darks in the image.

6. Verify operation of both the INTEGRATE and the AVERAGE functions for all levels of averaging (number of frames).

7. Verify operation of the SHARPEN function.

9.11.6 Image Storage on Hard Disk

If the system is equipped with the option to store images on the hard disk, check its operation as follows:

1. Verify that the Manual SAVE function stores the image on the hard disc.
2. RECALL the image stored in the previous step.
3. Verify that the image counter increments and decrements, and that additional images can be recalled. "d0" error message displayed on the LED's indicates that no image was found in the specified location.
4. Enable the AUTO save function. Generate a picture on the left monitor, and press the L->R function switch. Verify that the image is auto-saved and that the LED image counter is incremented by one.
5. Time the transfer while saving an image to disk. The transfer should take less than 10 seconds, thus verifying disk transfer DMA.

9.12 Image Storage Options

Refer to Section 11, System Options.

9.12.1 AngioStor

Check out the operation of the AngioStor videodisk recorder described in the Options Section.

9.12.2 VTR

1. Verify VTR control operation as described in the operator's manual.
2. Check that the playback level is correct.

   Level adjustment instructions are found in the Options Section of the Service Manual.

CALIBRATION WORKSHEETS

Series 9000 - Serial Number _____

Calibration Performed By: _____

Location _____ *Date:* _____

Introduction

These worksheets accompany the Series 9000 system calibration procedures found in Section 9 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.

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 9000 System.

9.3 Preparation and Setup

9.3.1 Record the Test Equipment Used

Dynalyzer Model _____ S/N _____

Dynalyzer Display Model _____ S/N _____

Autocal Interface Box S/N _____

DVM/DMM Model _____ S/N _____

Oscilloscope Model _____ S/N _____

Dosimeter Model _____ S/N _____

Ion Chamber Model _____ S/N _____

9.3.2 Preparation and Inspection

___ *Steps 1 thru 9 completed.*

9.4 Electrical Tests

9.4.1 Leakage Current Testing

Leakage Current _____ Pass/Fail _____

9.4.2 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 = _____

9.4.3 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

9.4.4 Monitor Cart Power Supplies

___ *Steps 1 thru 3 completed.*

AC voltage at the AUX outlets _____ VAC

Measure the following voltages relative to DC Common (PS-1 pin 7):

PS-1 pin 12	red wire	_____ VDC
PS-1 pin 6	gray wire	_____ VDC
PS-1 pin 5	violet wire	_____ VDC
PS-1 pin 4	yellow wire	_____ VDC
PS-1 pin 3	blue wire	_____ VDC
TV monitor power supply		_____ VDC

9.4.5 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.

9.5 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

9.6 Functional Checks

9.6.1 Self-tests

___ Self-tests during powerup successfully completed.

9.6.2 Emergency Off and Processor Reset Test

___ Left Emergency Off breaks interlock circuit
___ Processor resets and runs.
___ Right Emergency Off breaks interlock circuit

9.6.3 Status Mode Tests

Refer to the Mainframe Service Section for instructions on using the Status Mode.

___ LED Test
___ Panel key test
___ Panel knob test

Date and initials listed for last calibration _____

Total RAM _____ Total disk space _____

9.6.4 Film Cassette Test (6-inch systems only)

___ *Steps 1 thru 6 completed.*

9.6.5 Verify Operation of Mainframe Controls

___ *Steps 1 thru 7 completed.*

9.6.6 Field Solenoid Position Test

___ *Steps 1 thru 7 completed.*

9.6.7 Verify Controls in MANUAL FLUORO

___ *Steps 1 thru 2 completed.*

9.6.8 AUTO FLUORO Tests

___ *Steps 1 thru 9 completed.*

9.6.9 Fluoro Boost Option

___ *Steps 1 thru 4 completed.*

9.6.10 Pulsed Operation

___ *Steps 1 thru 2 completed.*

9.6.11 Verify Fluoro Timer and Timer Reset

___ *Steps 1 thru 3 completed.*

9.7 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

9.7.1 Preparation

___ *Steps 1 thru 2 completed.*

9.7.2 Radiographic Beam Alignment

___ *Steps 1 thru 19 completed.*

Measure the dimensions of each field:

Minimum field - less than 1.97" square * _____
4-inch field - 4" +/- 0.50" square _____
6-inch field - 6" +/- 0.50" square _____
8-inch field - 8" +/- 0.50" square _____

* 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.

Note: The corners of the 8" field will be clipped by the 10" collimating ring on 6" image intensifiers.

9.7.3 Fluoroscopic Beam Alignment

___ *Steps 1 thru 6 completed.*

9.8 X-ray Calibration

9.8.2 Connections

___ The Dynalyzer, digital display, and autocal interface box are connected according to the instructions in this section.

9.8.3 Setup

___ General Setup

___ Autocal Interface Box

___ Dynalyzer High Voltage Unit

___ Dynalyzer DRO (Digital Display Unit)

9.8.4 Getting Started

___ *Steps 1 thru 7 completed.*

9.8.5 Duty Cycle Calibration

___ (9.8.5.1) Take Duty Cycle Data

___ (9.8.5.2) Calculate Duty Cycle Coefficients

___ (9.8.5.3) Write Duty Cycle Coefficients to EEPROM

9.8.6 Calibration Data

___ (9.8.6.1) Acquire Calibration Data

___ (9.8.6.2) Calculate Calibration Coefficients

___ (9.8.6.3) Update Coefficients to EEPROM

9.8.7 Verify Calibration

The following tests for kVp, mA and mAs accuracy require installation of a dynalyzer; the Autocal Interface Box is not required. *Refer to the Dynalyzer Instructions in the Appendix.*

Perform the tests indicated and record the results on the calibration worksheet. Verify that the system meets the specifications given with the tables below.

9.8.7.2 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 @ 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

9.8.7.3 MAS Accuracy Tests

mAs Accuracy @ 50 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp
200 mA	_____ mA (+/-10.0 mAs)	_____ kVp

---

mAs Accuracy @ 90 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp
200 mA	_____ mA (+/-10.0 mAs)	_____ kVp

---

mAs Accuracy @ 120 kVp

Test Spec: +/- 5 % or +/- 2 mAs, whichever is greater.

mAs Required	mAs Measured	kVp Measured
5 mA	_____ mA (+/-2.0 mAs)	_____ kVp
50 mA	_____ mA (+/-2.5 mAs)	_____ kVp

9.8.7.4 Fluoro mA Accuracy Test

Fluoro mA Accuracy @ 50 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

Fluoro mA Accuracy @ 90 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

Fluoro mA Accuracy @ 120 kVp

Test Spec: +/- 15 % or +/- 0.9 mA, whichever is greater.

mA Required	mA Measured	kVp Measured
1 mA	_____ mA (+/-0.9 mA)	_____ kVp
max mA = _____ mA	_____ mA (+/-0.9 mA)	_____ kVp

9.9 Entrance Exposure Calibration

Fill in the worksheet table by determining the mA needed to produce 4.69 R/minute at increments of every five kVp. Do this across the range from 40 to 120 kVp.

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.

9.10 Imaging System Calibration

9.10.1 General Test conditions:

___ Conditions 1 thru 8 are being observed for the tests in this section.

9.10.2 Monitor Raster Size Adjustment

___ *Steps 1 thru 6 completed.*

9.10.3 Camera Sizing and Optical Adjustments

9.10.3.1 Camera Rotation Axis Offset (mirror axis alignment)

___ *Steps 1 thru 10 completed.*

9.10.3.2 Camera Lens Aperture Setting

___ Camera lens aperture set to f/2.0.

9.10.3.3 Active Image Size (camera size adjustments)

___ Adjust the camera image size according to the Video Test Pattern Instructions.

9.10.4 Image Circular Masking

___ *Steps 1 thru 4 completed.*

9.10.5 Camera Electrical Adjustments

___ Conditions 1 thru 6 are being observed for the tests in this section.

9.10.5.1 500 Volt Supply Adjustment

___ *Steps 1 thru 4 completed.*

9.10.5.2 Beam Discharge

___ *Steps 1 thru 3 completed.*

9.10.5.3 Target adjustment

___ Target voltage adjusted.

9.10.5.4 Black Level

___ Black Level Control adjusted.

9.10.5.5 Camera Video Output

Video output measured at J8 = _____ mVp

9.10.5.6 Verify Dark Current Compensation

___ *Steps 1 thru 3 completed.*

9.10.5.7 Video Output with Auto-brightness Enabled

Video output measured at J8 with Auto brightness enabled = _____ mVp.

9.10.6 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.

9.10.7 Resolution

___ Conditions 1 thru 5 are being observed for the tests in this section.

9.10.7.1 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.

9.10.7.2 Image Intensifier Focus

Adjustment **was/was not** neccessary (circle one).

9.10.7.3 Measure Imaging Resolution

Measure resolution using the Wisconsin Resolution Test Tool.

(6-inch machine) - _____ linepairs/inch

(6/9-inch machine) - _____ linepairs/inch in 6" mode
_____ linepairs/inch in 9" mode

9.10.8 Contrast Sensitivity Test

___ Conditions 1 thru 2 are being observed for the tests in this section.

# of penetrometer spots discernible = _____

9.10.9 Image Noise, Correlated

___ Conditions 1 thru 4 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.

9.10.10 Auto Brightness

9.10.10.1 Video Sampling Window Size and Centering

___ *Steps 1 thru 4 completed.*

9.10.11 Video Level Control and Auto Technique Tests

___ Conditions 1 thru 5 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
Aluminum	_____ kVp	_____ mVp
1 Copper filter	_____ kVp	_____ mVp
2 Copper filter	_____ kVp	_____ mVp

9.10.12 Camera Drive Chain Tension

___ *Steps 1 thru 3 completed.*

9.11 Image Processing and Monitor Cart Tests

9.11.1 AD/DA PCB Calibration

___ *Steps 1 thru 6 completed.*

9.11.2 Verify External Video

___ *Steps 1 thru 2 completed.*

9.11.3 Image Processor PCB

___ *Steps 1 thru 2 completed.*

9.11.4 Front Panel Diagnostics

___ *Steps 1 thru 5 completed.*

9.11.5 Monitor Cart Imaging Function Checks

___ *Steps 1 thru 7 completed.*

9.11.6 Image Storage on Hard Disk

___ *Steps 1 thru 5 completed.*

9.12 Image Storage Options

Refer to Section 11, System Options.

9.12.1 AngioStor

Check out the operation of the AngioStor videodisk recorder described in the Options Section.

9.12.2 VTR

___ *Steps 1 thru 2 completed.*

SERVICE MANUAL

00-870820-01

SERIES 9000

X-RAY IMAGING SYSTEM

Effectivity:

This manual contains descriptions, instructions and procedures which apply only to Series 9000 systems with serial numbers in the 96-000 and 99-000 series.

Date of Issue: September 1987

OEC-DIASONICS

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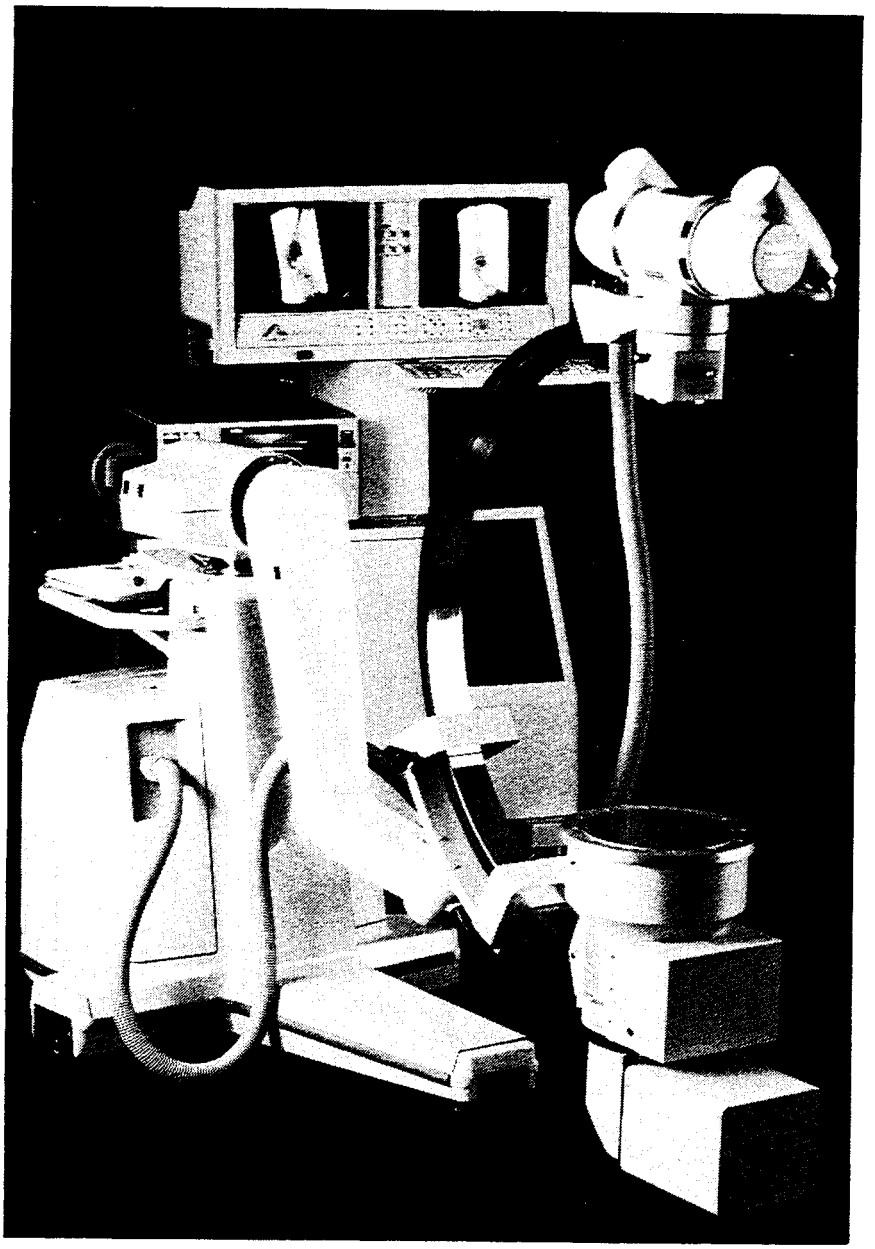
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SERIES 9000 X-RAY IMAGING SYSTEM (Details of this photograph may vary depending on options).

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 the properly trained service engineer who 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 Series 9000 system.

This manual is intended to compliment the training offered by OEC-Diasonics. You should not attempt any of the procedures in this manual unless you have received this training on the Series 9000 System. Reading this manual does not alone 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.

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SECTION 10
UNPACKING AND INSTALLATION

This section describes the installation of the OEC-Diasonics mobile C-arm system. Included are instructions for unloading and unpacking, startup after long term storage, and guidelines for moving the system.

Site requirements and the Installation Checkout Procedure are found at the end of this section.

10.1 Responsibility

The customer must provide the labor and equipment necessary to unload the system from the transport vehicle and move it to the final location. The customer is responsible for obtaining all permits and for meeting all other requirements of state and local codes, regulations, and ordinances with respect to the installation and operation of the system.

The Installation Checkout Procedure should be performed only by a qualified service technician.

10.2 Unloading and Inspecting the Shipment

Before unpacking, the customer should inspect the shipping containers and exposed system components for any apparent damage. Any shipping container that appears damaged should be unpacked with the carrier's agent present. The customer should also ensure that all equipment specified in the purchase order has been delivered.

If any part of the shipment is damaged or missing, immediately notify the carrier and the nearest OEC-Diasonics regional service office or representative. Retain the shipping container and packing material for the carrier's inspection.

10.3 Domestic Unpacking Instructions

10.3.1 Unpacking the Mainframe Assembly

1. Remove the plywood ramp and place it at the rear of the palette base. *(Refer to Figure 10-1).*

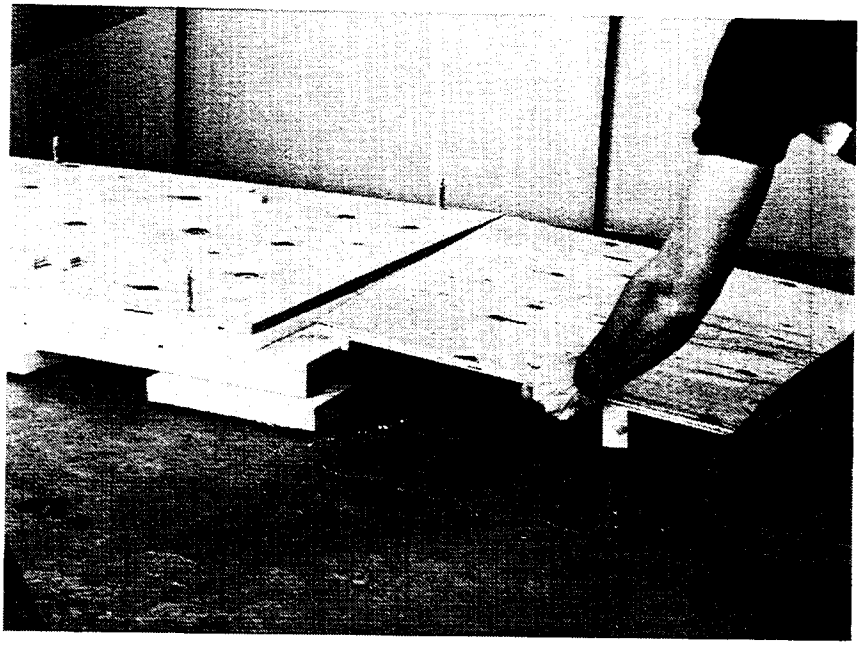


Figure 10-1 - *Place the plywood ramp at the rear of the palette base.*

2. Remove the image intensifier assembly from the palette and place it out of the way for now.

3. Remove the bolts and strap holding down the X-ray tube assembly.

4. Remove the metal straps holding the front and rear wheels in place. *(Refer to Figures 10-2 and 10-3).*

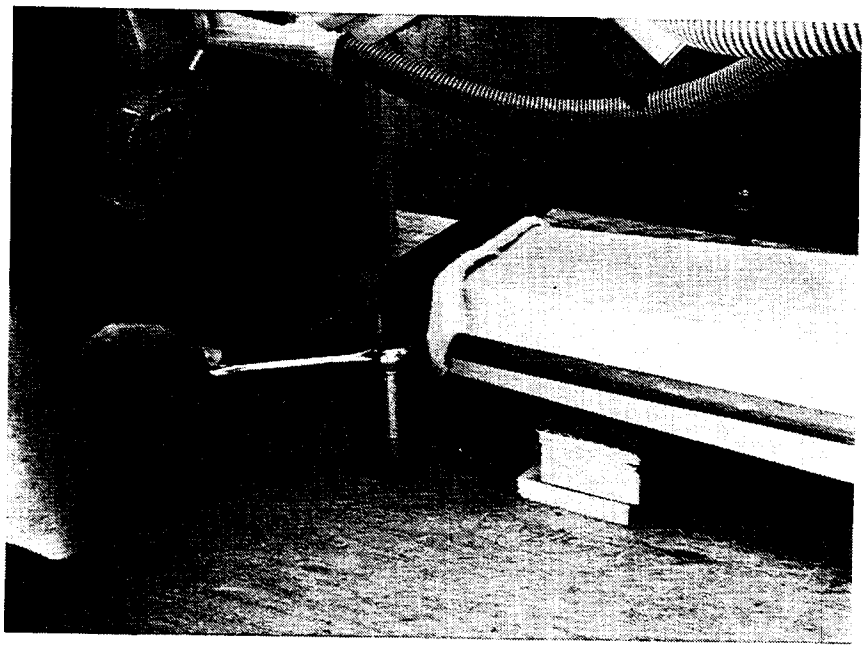


Figure 10-2 - *Remove the metal strap holding the front wheel in place.*

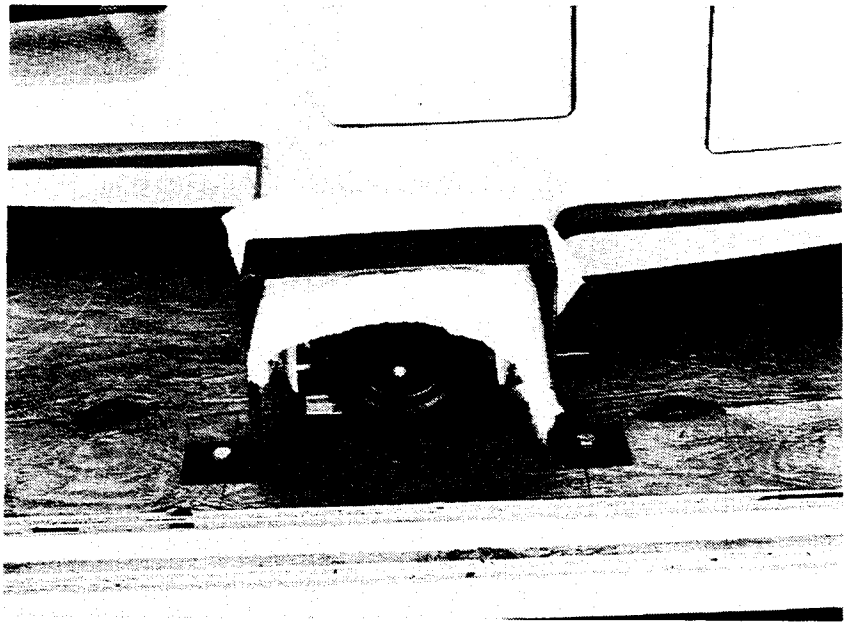


Figure 10-3 - *Remove the metal straps holding the rear wheels in place.*

5. Using the 3-ft. length of 2x4 as a lever, carefully lift up the front wheel and remove the support blocks. *(Refer to Figure 10-4)*.

6. Again using the 2X4 as a lever, lift up each rear wheel and remove the support blocks on both sides. *(Refer to Figure 10-5)*.

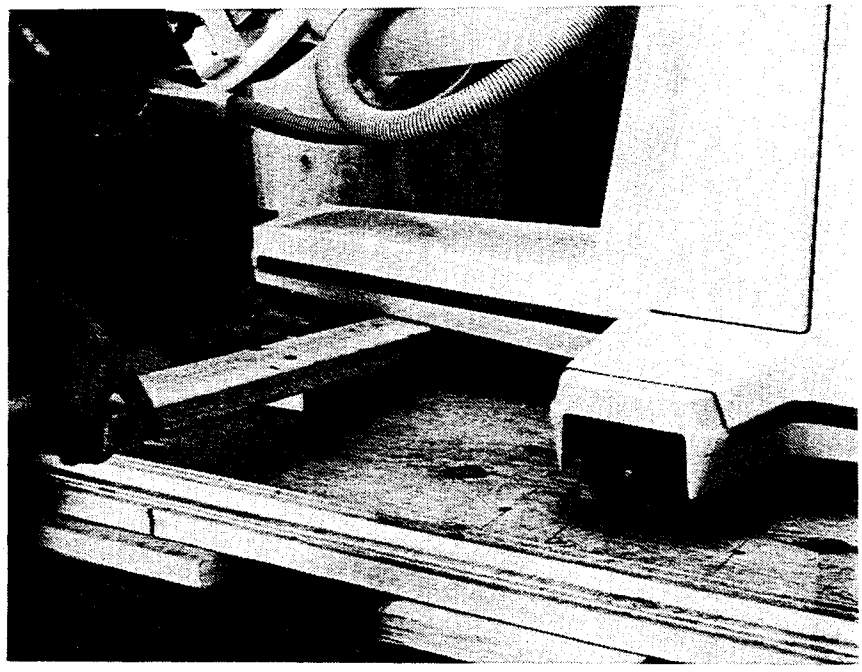


Figure 10-4 - *Use the length of 2x4 as a lever.*

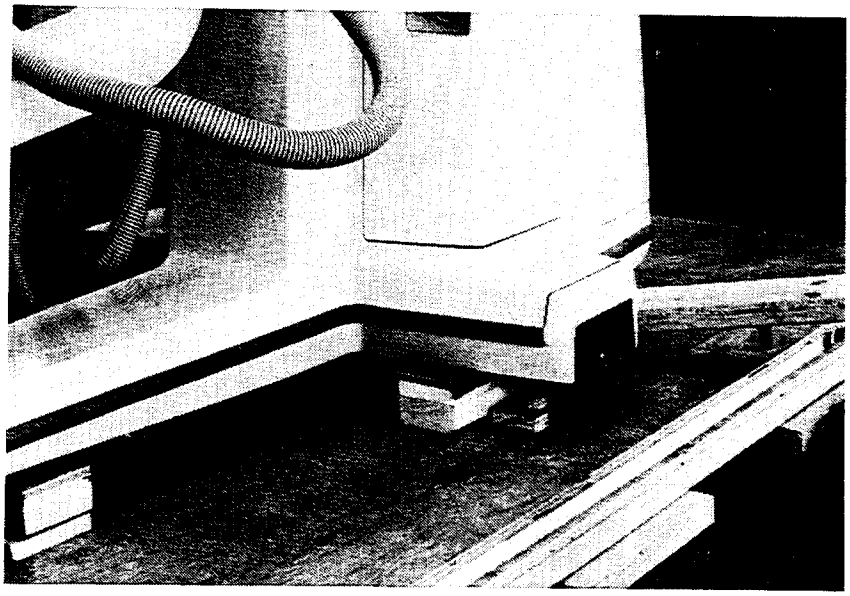


Figure 10-5 - *Use the length of 2x4 as a lever under each rear wheel to remove the blocks.*

7. Position the front and rear wheels in a straight line using the foot lever and the steering handle.

8. Pull the mainframe gently down the ramp. *(Refer to Figure 10-6).*

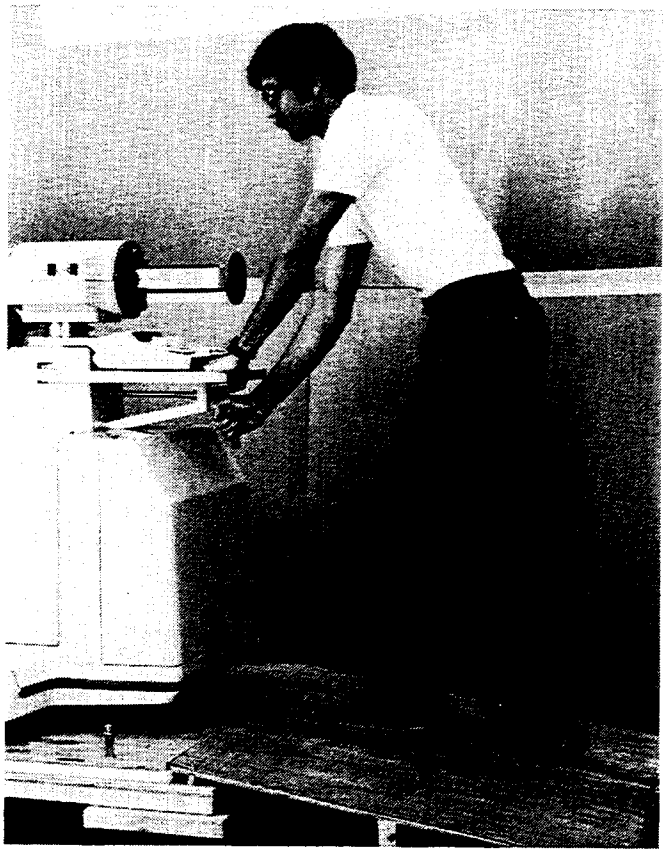


Figure 10-6 - *Carefully back the mainframe down the ramp.*

CAUTION: *Don't let the C-arm roll down the ramp too fast. Keep it in a straight line aimed straight back to avoid rolling off the side of the ramp.*

CAUTION: *Keep the base of the ramp clear of obstacles.*

9. After leaving the ramp, lock the C-arm wheels at right angles to each other to prevent the C-arm rolling.

10. Rotate the C-arm to place the imaging axis vertically with the image tube mount on the bottom.

CAUTION: *When the C-arm brakes are loosened the C-arm may pivot out of balance. Be sure the brakes are tight before attaching the weight of the image tube assembly to the C-arm.*

11. Locate the four Nylock screws in the shipping kit. Place the image intensifier assembly on the C-arm mount and insert and tighten the four Nylock screws.

12. Remove the protective bubble pack from the high voltage cable assembly, extension arm, and control panel. *(Refer to Figure 10-7).*

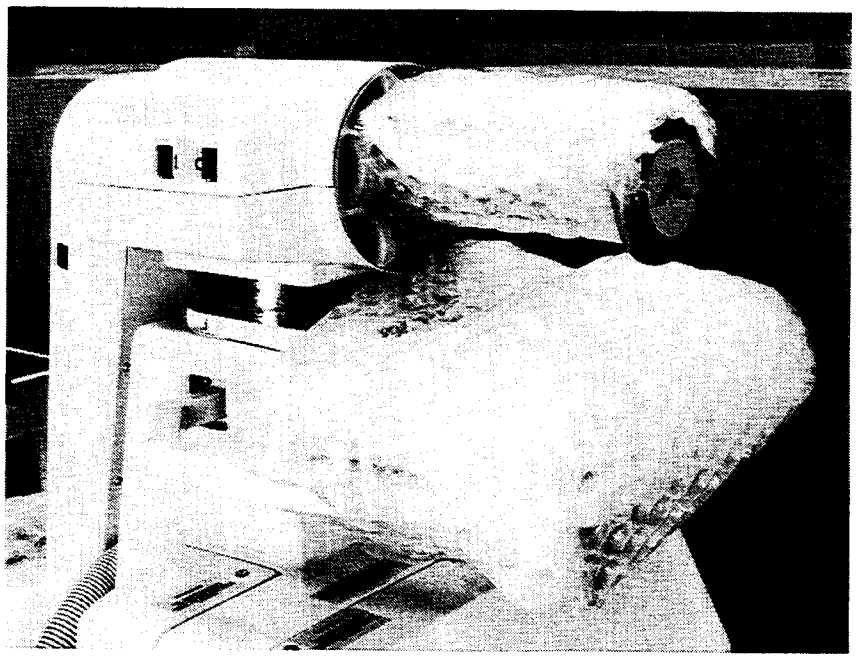


Figure 10-7 - *Remove the bubble packing.*

13. Remove the wood brace from the extension arm. *(Refer to Figure 10-8).*

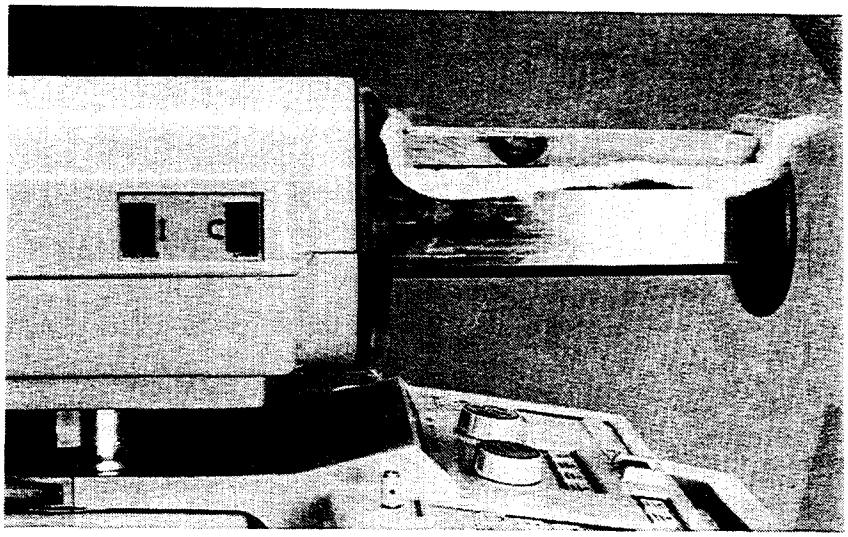


Figure 10-8 - *Remove the wooden brace.*

10.3.2 Repacking the Mainframe

Reverse the order of the above steps.

NOTE: *When placing the wood blocks under the three wheel assemblies, note that the front wheel block is higher than the two rear wheel blocks.*

WARNING: When removing the image intensifier, do not let the C-arm pivot unbalanced - make sure the C-arm brakes are tight.

10.3.3 Unpacking the Monitor Cart Assembly

1. Carefully cut away the shrink wrap covering the monitor cart. *(Refer to Figure 10-9).*

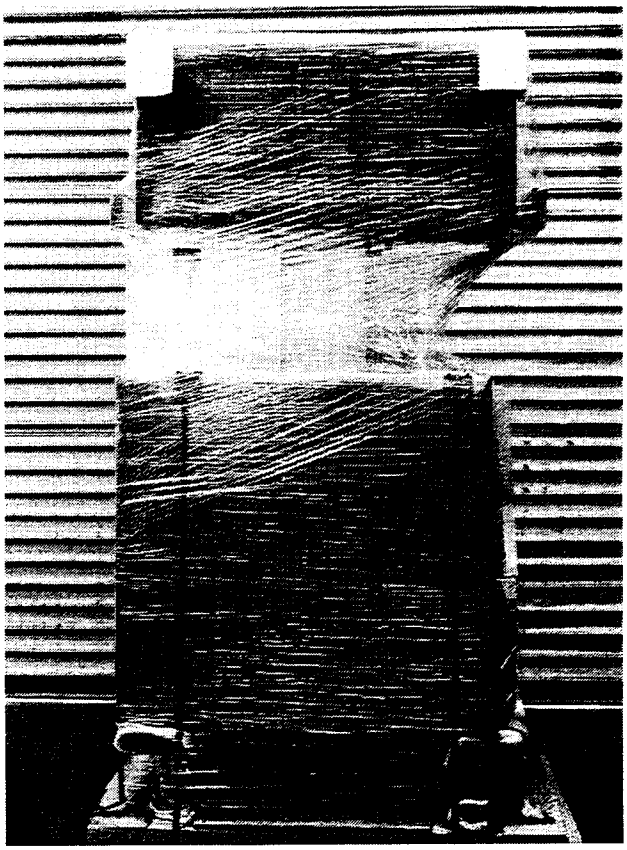
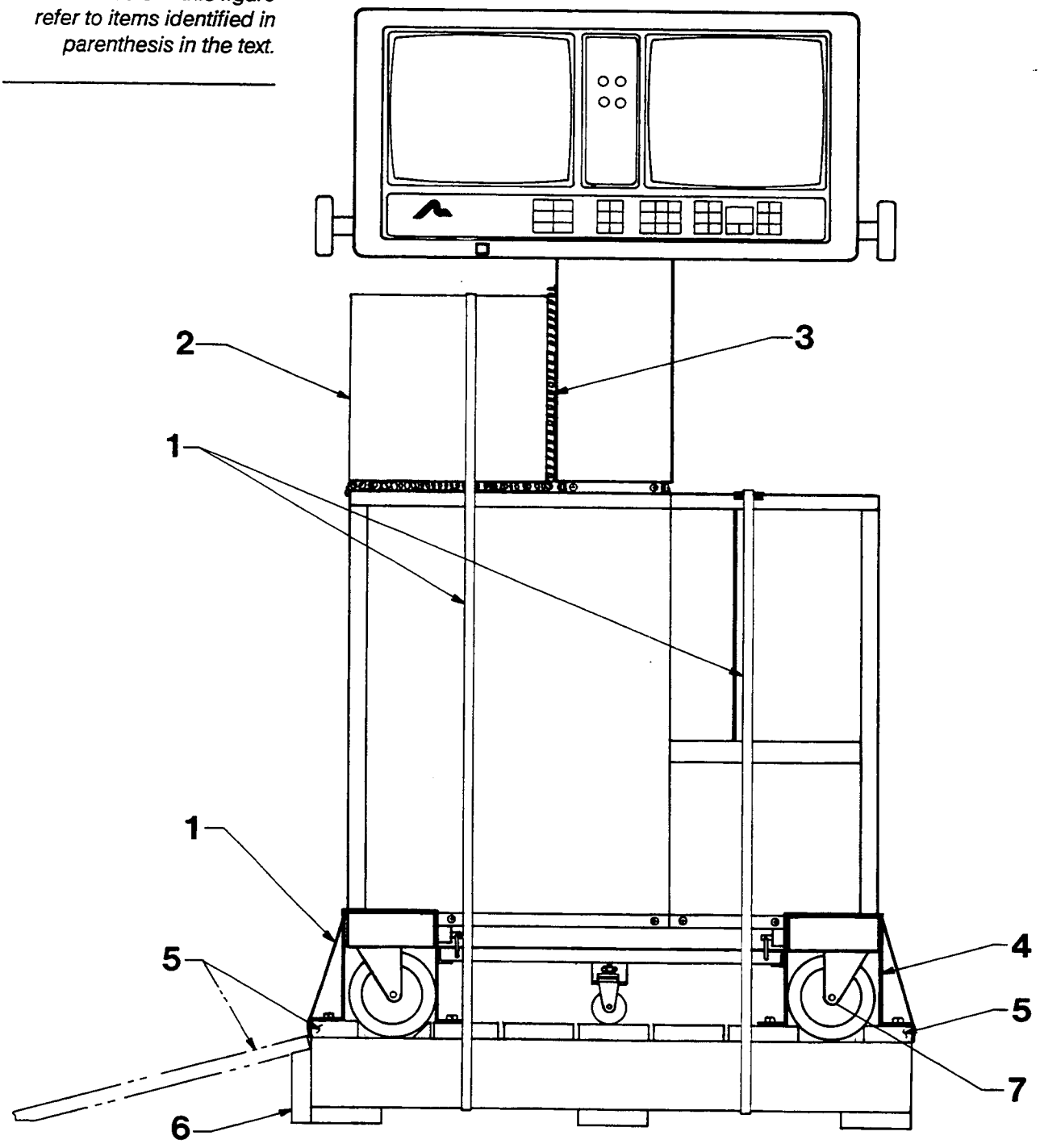


Figure 10-9 - *Remove the shrink wrap plastic covering the monitor cart.*

2. Cut the plastic straps secured around the monitor cart and the cardboard shipping box.

   If the cart has been shipped on a palette, follow steps 3 thru 7. *(Refer to Figure 10-10).*

Figure 10-10 - *Remove the monitor cart from the palette. The numbers in this figure refer to items identified in parenthesis in the text.*



3. Remove the shipping (accessory) kit (2) from the shelf top. Cut the nylon reinforced tape and remove the protective covering (3) from the shelf top.

4. Remove the two lag screws, metal strap and felt pad from each of the front wheels (4). *(Refer to Figure 10-11).*

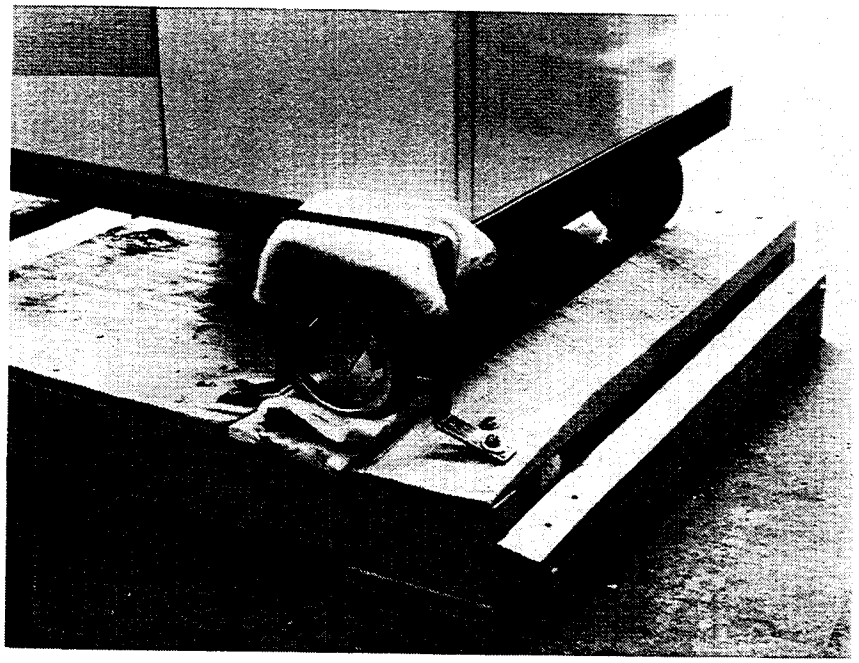


Figure 10-11 - *Remove the metal straps from each of the front wheels.*

5. Remove the lag screws and ramp planks (5), reposition the ramps on the ramp support (6), and secure in place using the 4 lag screws obtained during plank removal.

6. Unlock the rear wheel brakes. Unlock the caster swivel lock on the front wheel furthest from the ramp (7). Turn the caster 180 degrees and relock its swivel.

CAUTION: *The following steps require two strong people capable of controlling the cart as it is rolled out of its retension groove and down the ramp (the monitor cart weighs approximately 360 lbs.). Care must be taken to prevent the cart from rolling off the pallet and ramps.*

7. Roll the monitor cart up and over the center pallet planking and down the ramps to the floor.

8. Check for any unremoved packing materials on the cabinet. Unpack the accessory kit and the optional accessories.

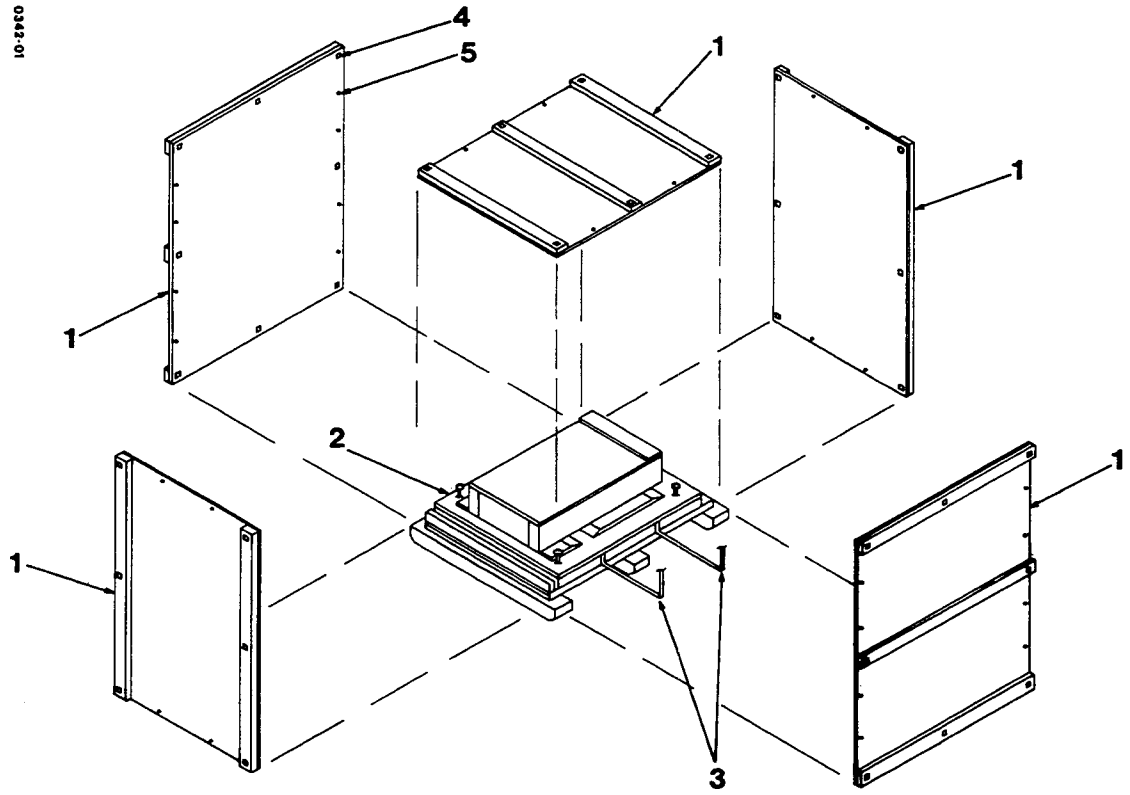
9. Install the top covers. Refer to the Assembly/Disassembly section in the Service Manual for instructions.

10. The monitor cart can now be moved to the installation site.

10.4 Foreign Export Unpacking Instructions, Mainframe and Monitor Cart Assemblies

The shipping containers consist of side and top pieces secured to the shipping palette with lag screws. *(Refer to Figure 10-12).*

Figure 10-12 - *Foreign export packing.*



1. Remove the lag screws which secure each panel to the wooden shipping palette.

2. As each panel is freed by removing the lag screws, lift the panel out of the way.

3. Follow the instructions previously given in this section for removing the equipment from the palettes and removing protective wrapping materials.

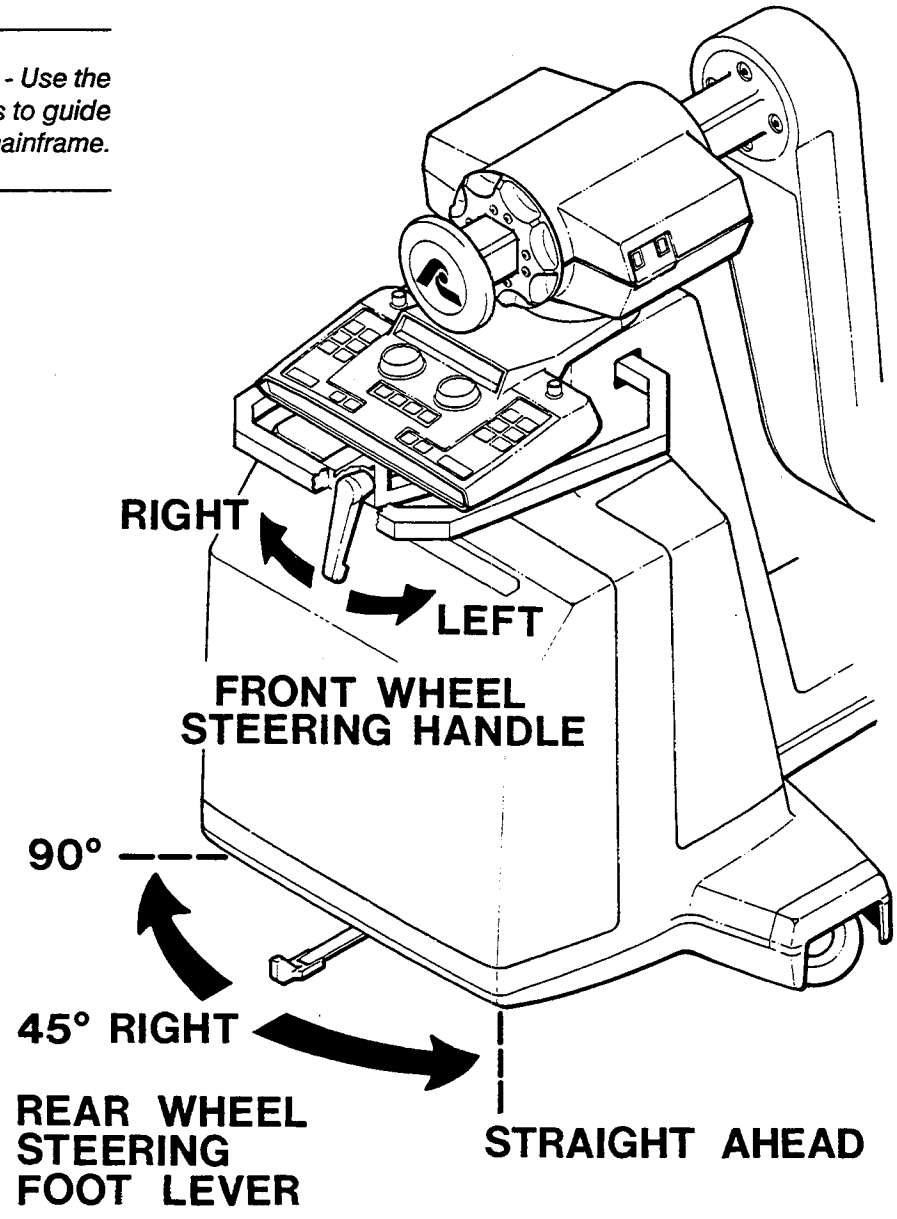
10.5 Moving the System

1. Place the C-arm and L-arm in their most compact positions. If the system has just been unpacked it is already in this configuration.

2. Lock all movable mechanical assemblies, such as the extension arm, in place. Tighten all locking handles.

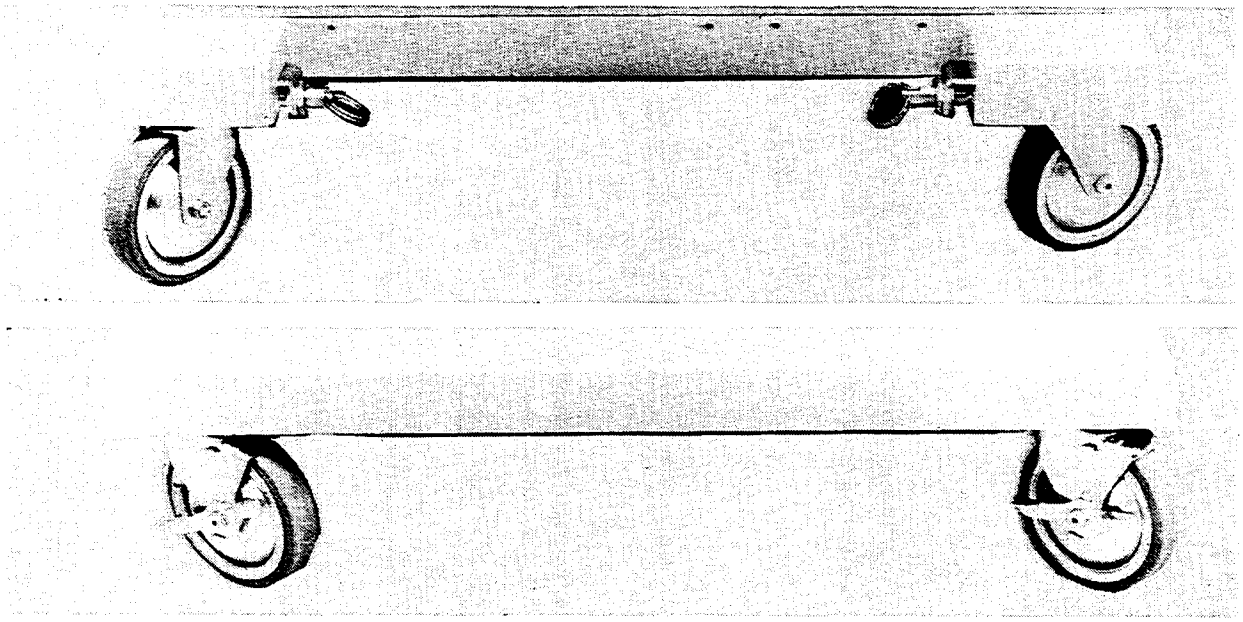
3. Steer the mainframe with the controls. The operation of the steering controls is demonstrated in Figure 10-13.

Figure 10-13 - *Use the steering controls to guide the mainframe.*



4. Unlock the monitor cart wheels and guide it carefully as you push. *(Refer to Figure 10-14).*

Figure 10-14 - *The front and rear wheel locks.*



5. When the system is finally in place, apply the friction wheel locks on the monitor cart and lock the mainframe front and rear wheels at right angles to each other.

Take These Precautions When Moving the System

- Two people should guide the mainframe and then return to guide the monitor cart when moving up or down an incline.

- Never move the system by pushing the mainframe ahead of you while pulling the monitor cart behind.

- Clear all hazards (this may mean both people and equipment) from the base of a ramp before moving the system along the incline.

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

- Never lock the mainframe or cart in place on an incline. It may roll out of control.

- Always apply the friction locks on the monitor cart and lock the front and rear wheels on the mainframe at right angles to each other when the system is in its final location.

10.6 Startup After Long Term Storage

Follow these steps if the system has been in storage for more than 60 days:

1. Plug in the system.
2. Follow the normal setup procedure.
3. Leave the system powered up in the FLUORO mode for at least four hours. (This allows for proper ion removal from the image intensifier tube).

If the system has been in storage for more than six months, condition the batteries and ensure their full charge before use:

1. Connect the interconnect cable between the mainframe and the monitor cart.
2. Plug in the monitor cart power cord. (The battery charger circuit will apply the charging current to the batteries in the mainframe).
3. Allow the batteries to charge in this manner for 24 hours.
4. Follow the normal setup procedure.
5. Leave the system in the FLUORO mode for at least four hours. (This allows for proper ion removal from the image intensifier tube).

10.7 Site Requirements

The major considerations for installation of the system are:

1) electrical power requirements,
2) environmental conditions, and
3) safety precautions.

The system power and operating environment requirements are listed in the *System Specifications*.

To satisfy its electrical requirements the system requires an input power source capable of providing:

115 VAC, 20 Amps or
230 VAC, 10 Amps.

Line voltage regulation requirements must be met as described in the Installation Checkout Procedure.

The customer is responsible for preparing the building, equipment environment and services required to install and operate the system.

10.8 Installation Checkout Procedure

As the steps in this procedure are performed, check them off on the Installation Checklist at the end of this section. You should make a photocopy of this checklist for use and save the original for reference.

10.8.1 Verify the Contents of the Accessory Kit

Verify that the following materials have been included in the System Accessory Kit (part # 870729). Note any shortages on the Checklist.

Two Operator's Manuals
Two Service Manuals
Two schematic Packages
Two mainframe keys
Footswitch assembly
Cassette holder (OEC-Diasonics metric or standard)
30 cm. skin spacer assembly
Eight socket-head Nylock screws
Copy of Configuration Sheet

Field Service Documentation Package:

- FDA form 2579
- Installation report (QAI 1003)
- Film identification stickers
- Various envelopes
- X-ray installation documentation instructions
- Instructions for Installation (QAI 1006)

10.8.2 Inspection and Setup

1. Install the skin spacer on the collimator assembly.

   Verify the presence of an aluminum filter at the bottom surface of the collimator and another aluminum filter located between the X-ray tube and the X-ray tube mounting bracket. The second filter can be seen after removing the aluminum filter from the bottom surface of the collimator. Look into the collimator and up toward the X-ray tube window.

2. Check the conductive casters on both the mainframe and the monitor cart for proper pressure and freedom of movement.

3. Inspect the interconnect cable; make sure the interconnect cable is permanently attached by its bracket to the monitor cart.

4. Remove the front, rear, and left side panels from the monitor cart and the left, right and rear covers from the mainframe. Inspect for loose hardware and shipping damage.

5. Inspect both the monitor cart card rack and the mainframe card rack. Verify that the extender board is present and that the retaining bars are screwed in place.

6. Replace all covers on the mainframe.

7. 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.*

10.8.3 Line Voltage Compatibility Check

The line voltage must be checked in each room where the equipment is to be used. Do not assume the line voltage will be constant throughout the hospital.

Verify voltage compatibility in all rooms where this machine will be used in the hospital. If a particular room is unavailable, write "NOT KNOWN" in the line voltage blank and put "NK" in the voltage and plug compatibility blanks on the checklist. A room is not plug compatible if it requires an adapter to be used. If any rooms are not voltage compatible, the hospital must be made aware of it.

10.8.4 Wiring the Isolation Transformer

1. The secondary voltage, measured on each leg referenced to neutral, should fall within the range 110-120 VAC. Wire the transformer to obtain a voltage as close to 115 VAC as possible.

   If the AC voltage range is:

94-102 VAC	wire T1 for 98 VAC
100-108 VAC	wire T1 for 104 VAC
105-115 VAC	wire T1 for 110 VAC
115-125 VAC	wire T1 for 120 VAC
122-134 VAC	wire T1 for 128 VAC

   If the AC voltage range is:

186-206 VAC	wire T1 for 196 VAC
200-218 VAC	wire T1 for 208 VAC
209-232 VAC	wire T1 for 220 VAC
228-252 VAC	wire T1 for 240 VAC
243-269 VAC	wire T1 for 256 VAC

2. Connect the interconnect cable to the mainframe and plug the power cord into the wall outlet. Check and record the voltages at the primary and secondary of the isolation transformer (T1).

3. Replace the covers on the monitor cart.

10.8.5 Basic Setup Checks

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 front panel. Refer to what these codes mean in the Service Section of this manual.

   Observe the Boot Codes on the mainframe LED panel and the Progress Codes on the monitor cart LED display as the operating software is loaded and the system is initialized.

   If any of these codes remains on the LEDs and the system fails to complete its booting and initialization, refer to the listing of boot codes in the Mainframe Service section or the listing of progress codes in the Monitor Cart Service section.

3. Check for correct AC voltage at the rear monitor cart AUX outlets.

10.8.6 Mechanical Checks

In the steps below, check for ease of movement without excessive play.

1. Check the **foot lever and steering handle** for proper movement. Then lock the C-arm in place by setting the wheels at right angles to each other.

2. Check **Wig Wag** - horizontal swing of the C-arm from side to side.

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 proper action of the pivot lock.

5. Check radial movement of the C-arm on the **cradle bearings** with proper holding action of the brakes.

6. Raise and lower the **L-arm.** The switch is located on either side of the extension arm assembly.

7. Rotate the **L-arm** 90 degrees in each direction. The switch is located on either side of the extension arm assembly.

10.8.7 Verify Operation of Mainframe Controls

Warning: This procedure produces X-rays. Take the 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 an LED or beep response), indicating that the microprocessor is responding to the input.

3. Verify that the LARGE field switch removes the 6-inch collimator by listening for the "thunk" sound produced.

4. Select FILM mode and enter a low power technique.

5. Verify that the X-RAY ON lamps on the X-ray tube assembly, control panel and monitor cart light when the X-RAY ON button is pressed. The X-RAY ON audible beep should also be heard.

6. Verify operation of the footswitch.

7. 6-inch Machine only - Verify that in FILM mode, X-ray operation only occurs when the film cassette is in place.

8. Verify that the EMERGENCY OFF buttons on the control panel break the interlock circuit and prevent X-ray operation. (The message *INTLCKS BROKEN* will be displayed on the LED panel).

10.8.8 Verify Controls in MANUAL FLUORO

1. Select MANUAL FLUORO mode.

2. Verify that kVp and mA can be controlled with the control panel knobs.

10.8.9 AUTO FLUORO Tests

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Select AUTO FLUORO mode.

2. Using different thicknesses of copper filters, verify that the kV tracks up and down during X-rays as material thickness is increased and decreased.

3. Remove the copper filters.

4. Switch to live video using the VIDEO BYPASS switch (on the monitor cart rear) and verify that true live video appears on the left monitor and that the system does not lose synchronization.

5. Place the Wisconsin Copper Mesh Test Tool on the image intensifier assembly. Check image resolution during live imaging (video bypass mode). Minimum acceptable resolution is 35 line pairs per inch in the live mode.

6. Switch the VIDEO BYPASS switch to NORMAL. Check for proper operation of these mainframe controls:

   a. Left to right sweep reversal
   b. L -> R memory swap
   c. SHARPEN (if provided)

7. Verify operation of the motorized collimator and camera controls with the control panel switches.

8. Verify operation of the left monitor's remote contrast and brightness controls on the control panel. (Set the control on the monitor cart to REMOTE).

10.8.10 Verify Image Processing and Storage Features.

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Switch the VIDEO BYPASS switch to NORMAL.

2. Make a fluoro exposure and transfer the image to the right-hand monitor.

3. Make another exposure. The image will appear on the left monitor.

4. Enable the WINDOW and LEVEL functions and take another image. The WINDOW and LEVEL arrow buttons should change the dynamic range and brightness level of the image presented on the left-hand monitor.

5. Verify that the Negative Image (NEG) function reverses the lights and darks in the image.

6. Verify operation of both the Integration and the Averaging functions for all levels of averaging (number of frames).

7. Verify operation of the SHARPEN function.

8. 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.

9. *On systems equipped with hard disk image storage*, verify that the Manual SAVE function stores the image on the hard disc.

10. RECALL the image stored in the previous step.

11. *On systems equipped with hard disk image storage*, verify that the image counter increments and decrements, and that additional images can be recalled. "d0" error message displayed on the LED's indicates that no image was found in the specified location.

12. *On systems equipped with hard disk image storage*, enable the AUTO save function. Generate a picture on the left monitor, and press the L->R function switch. Verify that the image is auto-saved and that the LED image counter is incremented by one.

13. Time the transfer while saving an image to disk. The transfer should take less than 10 seconds, thus verifying disk transfer DMA.

14. Verify that the LEFT Fluoro footswitch generates a live fluoro image on the left monitor regardless of the status of the image processing controls.

15. Select an image processing mode (such as integrate). Press the RIGHT footswitch and verify that the selected image processing occurs.

16. Verify that the circular blanking is set as close as possible to the actual image edges throughout a full rotation in both normal and reversed image modes.

17. Check for presence of an EIA RS170 composite video signal at the video output jacks on the rear of the monitor cart.

NOTE: The video signal must be terminated with 75 ohms to correctly measure the amplitude.

10.8.11 Additional Image Processing Tests

An extensive set of tests are available through the Front Panel HELP function. These tests are described under Calibration and Diagnostic Software in the Monitor Cart Service section of this manual.

10.8.12 Fluoro Boost Option

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Enable boost on the control panel. Press down into the second position on the right footswitch.

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 image doesn't "burn out" or appear too dark.

10.8.13 Radiographic Beam Alignment Check

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. Attach the beam alignment fixture to the face of the image intensifier assembly. Rotate the C-arm until the beam axis is perpendicular to the floor.

   On 6-inch models only: Verify that the cassette interlock switch is activated .

2. Make an exposure with the collimators fully open and the LARGE FIELD switch activated. Use 50 kV and 5 mAs. (The technique may vary depending on the type of film used.)

3. Close the collimators to their minimum field. Align the collimator assembly parallel to the cassette holder and repeat the exposure.

4. Develop the film.

5. Verify that the minimum field is contained within the target square (this must be less than 4.7 cm in each dimension measured on the film), that all of the innermost ring can be seen in the large field and none of the outer ring is visible.

6. Press the SMALL FIELD switch.

7. Install a new film cassette and repeat steps 2 thru 5 using the same technique.

8. Develop the film.

9. Verify that all the inner 6-inch ring is visible, and that none of the outer 6-inch ring is visible.

   The films are to be returned to the OEC-Diasonics Compliance Department per the instructions provided in the Field Service Documentation Package.

10.8.14 Fluoroscopic Beam Alignment Check

Warning: This procedure produces X-rays. Take the appropriate precautions.

1. With the beam alignment fixture in place, select MANUAL FLUORO and set the technique at 45 kVp and 1 mA.

2. Bring up the Video Test Pattern on the monitor using the Monitor Cart Diagnostics described in the Monitor Cart Service section.

3. Make a fluoroscopic exposure and examine the test pattern image on the monitor. There should be no distortion of the image field and the inner circle of the beam alignment fixture reticle should be visible throughout its circumference.

10.8.15 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 check list:

   100 (Vn - V1)/ (V1)

   where: Vn = No load voltage
   V1 = 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.

10.8.16 Install and Verify System Options

Options provided may include:

Video Tape Recorder
AngioStor Video Disk
Hard Disk Image Storage (installed at the factory)
Patient Annotation (installed at the factory)

The installation of these options is described in Section 12 - Options.

10.8.17 Reporting

1. Return the assembler's copy of the Report of Assembly of Diagnostic X-ray (FDA form 2579), the Beam Alignment Radiographs (films), the completed Installation Report, and the Installation Checklist to OEC/Diasonics, Attention: Compliance Department, in the stamped, manila envelope provided in the Field Service Documentation Package.

2. Distribute the various remaining copies of the Report of Assembly of Diagnostic X-ray (FDA form 2579), per the documentation instructions included in the Field Service Documentation Package.

3. Verify the serial and model numbers listed and the control numbers on the Main Frame and Collimator. These should agree with those listed on FDA form 2579.

4. Record the installation in the service log.

   The OEC Representative MUST sign the last page of the Installation and Checkout Checklist, verifying acceptance of the unit. If, for any reason, installation can not be completed, the OEC Representative MUST be notified that unit is not yet ready for use. (A copy of the Installation and Checkout Procedure Checklist is found at the end of this section).

INSTALLATION CHECKLIST

Check off these steps as you perform the Installation Checkout Procedure in the service manual. Paragraph numbers are provided to make it easier to correlate the checklist to the procedure. Fill in specific data where requested.

Date - _____ S/N - _____

10.8.1 Verify the Contents of the Accessory Kit

Verify that the following materials have been included in the System Accessory Kit (part # 870729). Note any shortages below.

___ Two Operator's Manuals
___ Two Service Manuals
___ Two schematic packages
___ Two C-arm keys (inside ring binders)
___ Footswitch assembly
___ Cassette holder
___ 30 cm. skin spacer assembly
___ Eight Nylock socket-head screws
___ Copy of Configuration Sheet

___ Field Service Documentation Package:
___ FDA form 2579
___ Installation report (QAI 1003)
___ Film identification stickers
___ Various envelopes
___ X-ray Installation documentation instructions
___ Instructions for Installation (QAI 1006)

10.8.2 Inspection

___ 1. Check skin spacer, primary and secondary filters.
___ 2. Check conductive casters on cart and mainframe.
___ 3. Check interconnect cable attached to monitor cart with bracket.
___ 4. Remove panels and covers; inspect the interior of mainframe and cart.
___ 5. Inspect the card racks in monitor cart and mainframe.
___ 6. Replace all covers.
___ 7. Inspect AC power cable and the high voltage cable.

10.8.3 Line Voltage Compatibility Check

Verify voltage compatibility in all individual rooms where this machine is intended to be used in the hospital. If a particular room is unavailable, write "NOT KNOWN" in the line voltage blank and put "NK " in the voltage and plug compatibility blanks. A room is not plug compatible if it requires an adapter to be used. If any rooms are found not voltage compatible, the hospital must be made aware of it.

Location	Compatible ?	
	Voltage	Plug
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___
Room _____	___	___

10.8.4 Wiring the Isolation Transformer

Primary _____ VAC

Secondary _____ VAC

___ 1. The secondary voltage measured on each leg should fall within the range of 110-120 VAC referenced to neutral.
___ 2. Replace the monitor cart covers.

10.8.5 Basic Setup

___ 1. Power up the system as usual.
___ 2. Monitor cart and mainframe complete their software boot and initialization with no self-test errors reported on the displays.
___ 3. Check for AC voltage at the rear monitor cart AUX outlets (110-120 VAC).

10.8.6 Mainframe Mechanical Checks

___ 1. Footlever and steering handle.
___ 2. Inspect the wig-wag.
___ 3. Inspect the extension arm
___ 4. Inspect the flip-flop and C-arm pivot point.
___ 5. Check C-arm movement in the cradle.
___ 6. Check L-arm lift movement.
___ 7. Check L-arm rotation.

10.8.7 Verify Operation of Mainframe Controls

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

___ 1. Verify that the anode is rotating.
___ 2. Check all control switches.
___ 3. Verify that the LARGE field switch removes the 6-inch collimator - listen for the "thunk" sound produced.
___ 4. Select FILM mode.
___ 5. Verify that the X-RAY ON lights on the X-ray Head, Control Panel and Monitor Cart light when the X-RAY ON button is pressed. The audible beep should also be heard.
___ 6. Verify operation of the footswitch.
___ 7. 6-inch Machine only - Verify that FILM Mode operation only occurs when the film cassette is in place.
___ 8. Verify that the EMERGENCY OFF buttons break the interlock circuit.

10.8.8 Verify Controls in MANUAL FLUORO

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

___ 1. Select MANUAL FLUORO mode.
___ 2. Verify control with the control panel knobs.
___ 3. Observe fluoro image on the left monitor.

10.8.9 Auto Fluoro Tests

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

___ 1. Select AUTO FLUORO mode.
___ 2. Verify that the kV tracks up and down as material thickness is increased and decreased.
___ 3. Remove copper filters.
___ 4. Verify operation of VIDEO BYPASS switch.
5. Check resolution during video bypass.

_____ line pairs per inch.

6. Check operation of mainframe video controls.

___ a. Left to right reversal
___ b. L->R Swap
___ c. SHARPEN (if provided)

___ 7. Check operation of the motorized collimator and camera controls.
___ 8. Check remote contrast and brightness controls.

10.8.10 Verify Image Processing and Storage Features

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

___ 1. Set video bypass switch to normal.

___ 2. Make an exposure and transfer image to right monitor.
___ 3. Make another exposure.
___ 4. Check operation of WINDOW and LEVEL.
___ 5. Check NEG function.
___ 6. Verify operation of INTEGRATION and AVERAGING.
___ 7. Check operation of SHARPEN.
___ 8. Check operation of L->R function from the monitor cart front panel.
___ 9. *On systems equipped with hard disk image storage*, verify operation of SAVE.
___ 10. *On systems equipped with hard disk image storage*, verify operation of RECALL.
___ 11. *On systems equipped with hard disk image storage*, verify operation that the image counter increments and decrements.
___ 12. *On systems equipped with hard disk image storage*, verify operation of AUTO.
___ 13. *On systems equipped with hard disk image storage*, verify operation of DMA.
___ 14. Verify operation of the FLUORO ONLY footswitch.
___ 15. Verify operation of the PROCESS footswitch.
___ 16. Check circular blanking.
___ 17. Verify proper video signal on the video output jacks (when terminated with 75 ohms).

10.8.11 Additional Image Processing Tests

___ As required.

10.8.12 Fluoro Boost Option

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

___ 1. Enable BOOST on the control panel.
___ 2. Alarm beeps at twice the normal rate.
___ 3. Verify that boost works in both auto and manual X-ray modes.
___ 4. Image doesn't "burn out" or appear to dark.

10.8.13 Radiographic Beam Alignment Checks

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

___ 1. On the first film - Verify that the minimum field is contained within the target square (this must be less than 4.7 cm in each dimension measured on the film), that all of the innermost ring can be seen in the large field and none of the outer ring is visible.

___ 2. On the second film - Verify that all the inner 6-inch ring is visible, and that none of the outer 6-inch ring is visible.

The films are to be returned to the OEC-Diasonics Compliance Department per the instructions provided in the Field Service Documentation Package.

10.8.14 Fluoroscopic Beam Alignment Check

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

___ 1. Bring up the Video Test Pattern, make a fluoroscopic exposure, and examine the image within the video test pattern.
___ 2. Circular blanking is correct.
___ 3. Image size is correct.

10.8.15 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. Calculate the percentage line voltage regulation and record the results below.

   100 (Vn - V1)/ (V1)

   where: Vn = No load voltage
   V1 = Max load voltage

   Vn=_____
   V1=_____

   Regulation = _____%

   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.

2. Measure the voltage on the isolation transformer secondary under maximum radiographic load. It must not fall below 100 VAC.

   Secondary voltage under max. load = _____ VAC

10.8.16 Install and Verify System Options

___ Install and verify options. The installation of options is described in Section 12, Options.

10.8.17 Reporting

___ 1. Return the assembler's copy of the Report of Assembly of Diagnostic X-ray (FDA form 2579), the Beam Alignment Radiographs (films), the completed Installation Report, and the Installation Checklist to OEC-Diasonics, attention: Compliance Department, in the stamped, manila envelope provided in the Field Service Documentation Package.

___ 2. Distribute the various remaining copies of the Report of Assembly of Diagnostic X-ray (FDA form 2579), per the documentation instructions included in the Field Service Documentation Package.

___ 3. Verify the serial and model numbers listed and the control numbers on the Main Frame and Collimator. These should agree with those listed on FDA form 2579.

___ 4. Record the installation in the service log.

___ 5. OEC Representative and hospital representative MUST sign last page of Installation Checklist, verifying acceptance of unit. If, for any reason, installation could not be completed, both OEC Representative and hospital representatives MUST be notified that unit is not yet ready for use.

This system is now installed and is operating in a satisfactory manner. The hospital representative acknowledges any limitations due to voltage incompatibilities between different areas of projected use.

OEC-DIASONICS Field Service Representative

_____

OEC Applications Representative

_____

Hospital Representative

_____

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 the properly trained service engineer who 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 Series 9000 System.

This manual is intended to compliment the training offered by OEC-Diasonics. Reading this manual does not alone 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.

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 certain hazards, emergency procedures and instructions for accident reporting.

Section 3
Mainframe 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.

Section 4
Monitor Cart Theory of Operation
A description of the hardware and software is provided to facilitate an understanding of the maintenance, calibration and repair of the monitor cart. Optional patient annotation and hard disk image storage are covered.

Section 5
Mainframe Parts, Disassembly and Replacement
Step by step instructions for removing and replacing field serviceable parts.

The major field replaceable parts are pictured and identified with their OEC-Diasonics part numbers.

Section 6
Monitor Cart Parts, Disassembly and Replacement
Step by step instructions for removing and replacing field serviceable parts.

The major field replaceable parts are pictured and identified with their OEC-Diasonics part numbers.

Section 7
Mainframe Service and Diagnostics
Mainframe boot and error codes, event codes and warning messages. Using the control panel Status Mode. Tables of adjustments, switches and jumpers.

Section 8
Monitor Cart Service and Diagnostics
How to change the monitor cart option configuration. Front Panel error messages. Built-in test and diagnostic software. Shot logging.

Section 9
Mainframe Calibration
Calibration procedures for the system are provided. A calibration worksheet is included.

Section 10
Installation
Unpacking, repacking, installation and on-site checkout instructions are provided.

Section 11
Options
Installation of options, interfaces, special troubleshooting and maintenance notes. Options include: VTR, AngioStor, multiformat camera.

Appendix
Recommended tools and test equipment. Installation and Use of Special Equipment. Printer Installation. Terminal installation and use. Test Log.

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 00-870820-01). Operating instructions for the system are contained in the Operator's Manuals for each member of the Series 9000 family:

9000 basic model - 00-871352
9000 with E.S.P. Option - 00-871353
9000 with E.S.P. and Vascular or Neuro-Vascular Option - 00-871354

Schematic diagrams for the system are contained in the schematic package, part number 00-870822.

The system contains some equipment and assemblies manufactured by original equipment manufacturers (OEM's) and not OEC-Diasonics. 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 maintenance 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 (21CFR 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, Generator Controller 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

Figures 1, 2, and 3 illustrate the major assemblies of the OEC-Diasonics Mobile C-arm X-ray System. The two major assemblies, the mainframe and the monitor cart, are connected by an 18 foot interconnect cable which carries power, video and communications signals.

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 to provide static grounding in an operating room environment.

1.5 Standard Equipment

Table 2 Standard Equipment

ITEM	*PART NUMBER*
C-arm Assembly	00-870724
Monitor Cart Assembly	00-870727
Collimator and Plate Assembly	
(6-inch)	00-870472
(6/9-inch)	00-870472
Image Intensifier Asm w/ Vidicon	
(6-inch)	00-870725
(6/9-inch)	00-870817
Cassette Holder	
(6-inch standard)	00-861095
(6-inch metric)	00-871096
(9-inch standard)	00-871138
(9-inch metric)	00-871139
Accessory Parts Kit	00-870729
Conductive Caster Asm	00-860092
Foot Switch Assembly (Dual Stage)	00-900012
30 cm Extension Spacer	00-837201

Figure 1 - *The mainframe is shown in this drawing.*

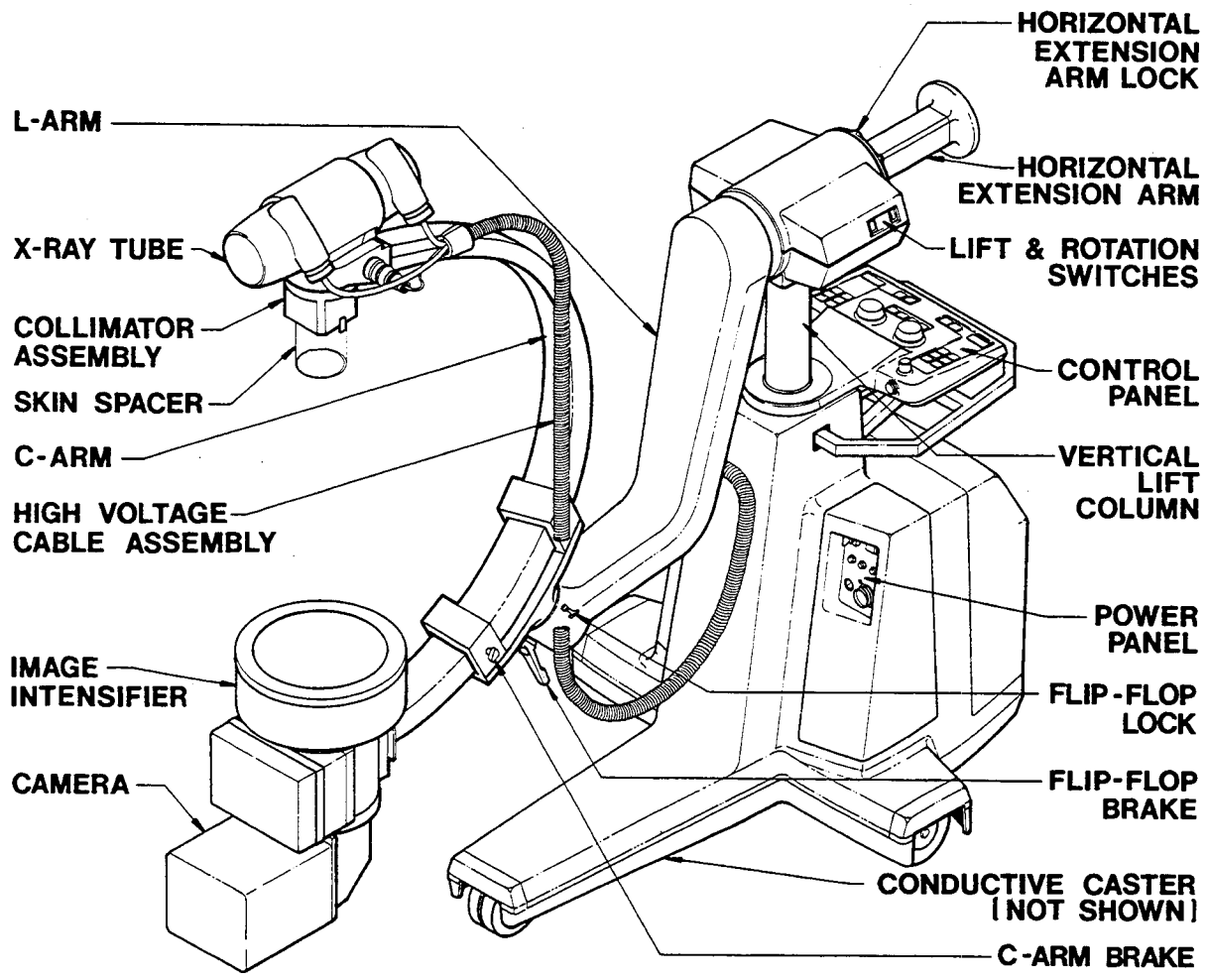


Figure 2 - *Front view of the monitor cart.*

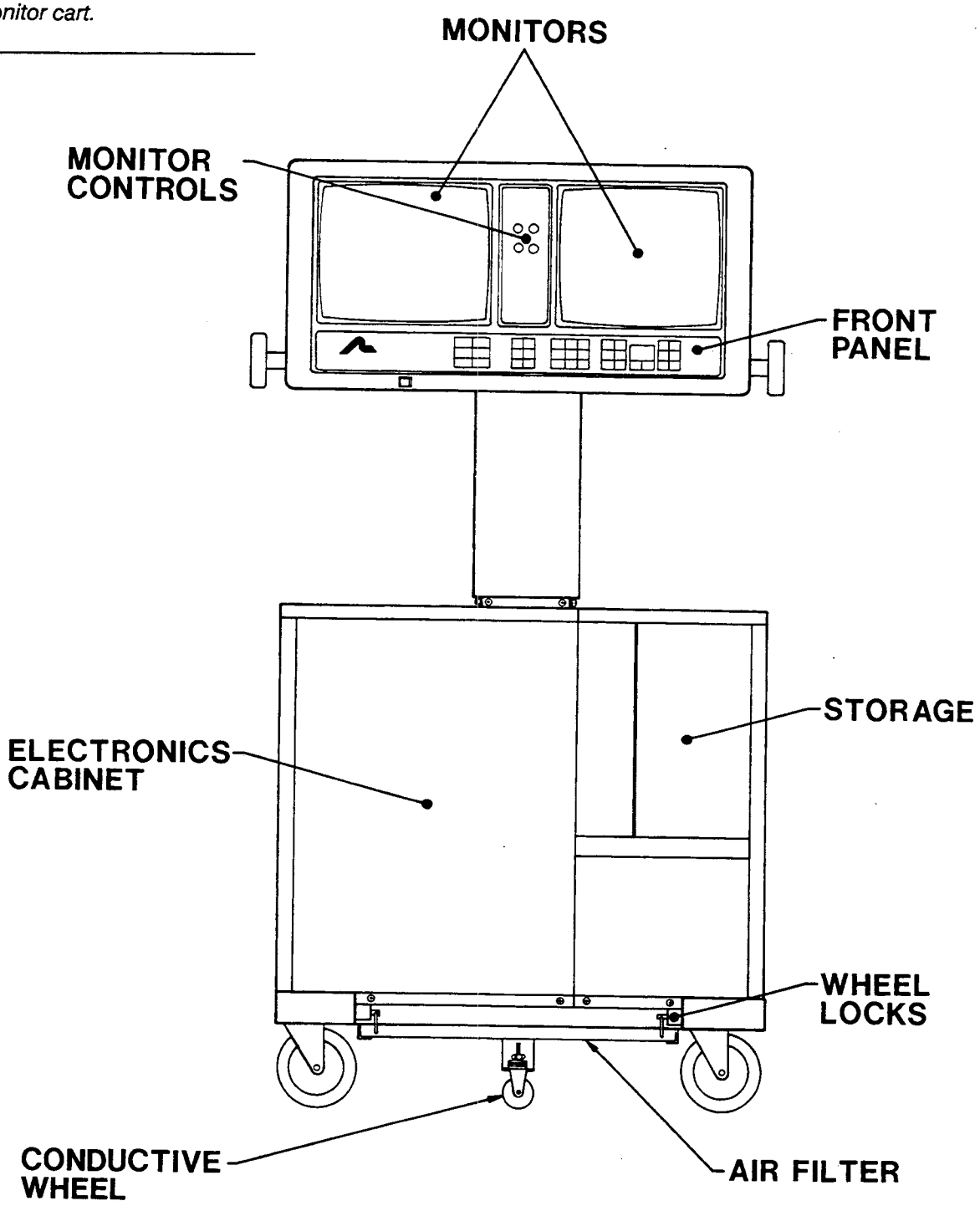
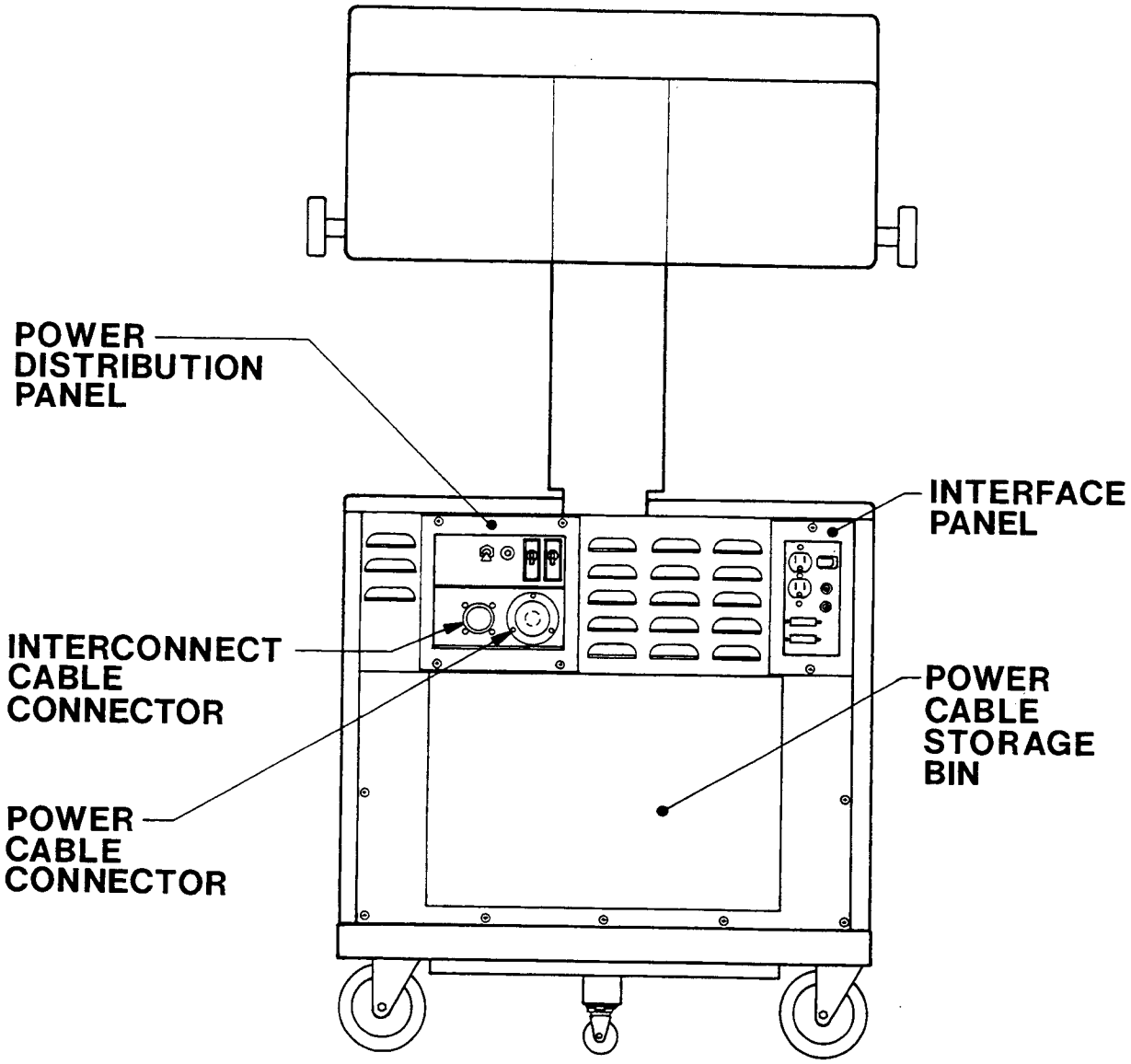


Figure 3 - *Rear view of the monitor cart.*



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 connecting an external terminal. The option files are described in the sections of this manual: "Mainframe Service" and "Monitor Cart Service."

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 dual mode 6/9-inch image intensifier. Serial numbers in the 63-000 range identify systems equipped with 6-inch image tubes. Serial numbers in the 93-000 range identify those equipped with 6/9-inch image tubes.

1.9 Monitor Cart Options

Image Storage

Images may be stored by several means, in analog or digital format, depending upon the system configuration.

Internal Hard Disk Image Storage - a hard disk memory system capable of storing sixty 512 x 512 x 8 bit matrix images. The digitized image can be saved on the hard disk and later recalled.

Video Tape Recorder - The undigitized image is available for storage on a video tape recorder or AngioStor.

AngioStor - Up to 20 seconds of high resolution video can be stored and reviewed. Playback can be continuous or stepped a single frame at a time.

Multi-format Camera - Several models are available to make hard copy films of fluoro images.

Patient Annotation - Images can be annotated with identifying information on the screen or on hard disc. A swing out keyboard is used with special software.

Image Processing

The circuits and software in the monitor cart perform image processing on the video signal. The specific operations, which may include frame integration, frame averaging, image subtractions, and "window" and "level" control of the gray scale, are selected from the monitor cart front panel.

Most image processing options can be identified by examining the monitor cart front panel.

SECTION 7
MAINFRAME
SERVICE AND DIAGNOSTICS

7.1 Safety Procedures During Service

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 adjustments 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 can result if such metal articles are placed across the battery terminals.

7.2 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 however, 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.

7.2.1 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

7.2.2 Technique Processor Boot Codes

These codes are 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

7.2.3 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

7.2.4 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

7.2.5 Misc 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.

7.3 Event Codes and Warning Messages

7.3.1 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 7.4.

Event Code Table

Refer to Table 1; 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 a * in the table.

Table 1 Event Code Listing

01	not used	
02	not used	
03	not used	
04*	X-RAY JUMPER ON	jumper left in after calibration
05	SWITCH STUCK	x-ray switch is sensed as on improperly
06*	PRECHARGE FAIL	precharge cycle has failed
07*	HV INVERTER ON	high voltage generator is on
08	not used	
09	MAIN PGM LOAD	main program is loaded to RAM
0A	INIT COMPLETE	hardware initialization is complete
0B	not used	
0C	D CURRENT FAIL	dark current cannot be calculated
0D	not used	
0E	FLUORO-PREP	indicates software state
0F	FLUORO-INIT	indicates software state
10	FLUORO-READY	indicates software state
11	FLUORO-XRAY	indicates software state
12	not used	
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	not used	
18	not used	
19	FLUOROS FILM	indicates transition: standby to film
1A	not used	
1B	not used	
1C	not used	
1D	BOOST FOOT UP	boost switch released
1E	BOOST OVERTIME	boost terminated at 30 seconds
1F	HOUSING 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 OVERHEAT	heat integrator warning
24	HOUSE OVERHEAT	heat integrator warning
25	WILL OVERHEAT	film mode warning
26	CP DEAD	control panel dead
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 was terminated from front panel
2A	not used	
2B	X-RAY ARMED	instant on is prearmed
2C	FILM - PREP	indicates software state
2D	FILM - INIT	indicates software state
2E	FILMX - FLUORO	indicates software state

Table 1 (continued) Event Code Listing

2F	FILM - READY	indicates software state
30	not used	
31	FILM - WARMUP	indicates software state
32	FILMS - FLUORO	indicates software state
33	FILM - XRAY	indicates software state
34	FILM - INST ON	indicates software state
35	FILM XOFF	indicates software state
36	XRAY COMPLETE	exposure has ended
37	FOOT RELEASED	x-ray switch released early in film mode
38	XRAY OVERTIME	film mAs integration error has occurred
39	not used	
3A	not used	
3B	not used	
3C	not used	
3D	EXCESS FILM KVP	a calibration error has occurred
3E	LOW FILM KVP	a calibration error has occurred
3F	EXCESS FILM MA	a calibration error has occurred
40	LOW FILM MA	a calibration error has occurred
41	not used	
42*	FLIPPER STUCK	the flipper collimator is stuck
43	MA ON IN ERROR	improper generator operation
44	not used	
45	KV ON IN ERROR	improper generator operation
46*	STATOR NOT ON	rotating target stator is not running
47*	OVERLOAD FAULT	generator fault detected
48*	SATURATION FLT	generator saturation fault detected
49*	FILAMENT FAULT	generator fault detected
4A*	INTRLKS BROKEN	interlock circuit was interrupted
4B*	HV INVERTER OFF	high voltage generator is on
4C	not used	
4D*	OVERVOLTGE FLT	generator overvoltage fault
4E*	NO SERVO TABLE	disk software failure
4F*	NO MUXRAM DATA	disk software failure
50	NO OPTIONS FILE	no default parameters
51	USER END	normal operation has been interrupted
52	EXIT PROGRAM	exit program from terminal
53	NO CASSETTE	
54	LOADING STATUS	control panel is entering the status mode
55	NO SYSTEM FILE	disk software failure
56	NO MA LIMITS	disk software failure

* Fatal Errors

7.3.2 Warning Messages During Operation

Follow the recommendations below for remedying 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.

7.3.3 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. These conditions can be remedied by allowing time for the X-ray tube to cool. These messages alternate with the normal information displayed on the LED panel.

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.

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.

7.3.4 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 provide additional recharging time, leave the system plugged in with the interconnect cable in place overnight.

7.3.5 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 Generator Controller PCB has been left in place, disabling regulation. Results in automatic shutdown.

SWITCH 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.

BPLUS FAULT
The battery voltage is low; the batteries may be weak. Results in automatic shutdown.

SHOT TOO LONG
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.

LG FIELD STUCK
The collimator is stuck in the large field position. 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 FLT
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.

INTRLKS 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.

7.4 Control Panel Status Mode

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.

If the mainframe fails at the "Press Start" prompt during startup, the Status Mode can still be entered in the manner described below.

7.4.1 To Enter the Status Mode:

1. PRESS and HOLD the unlabeled button below the image reversal button for five seconds.
2. The message *STATUS V n.n* indicates that you have entered the status mode. Once in this mode, turn either the right or left knob 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 knob.
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, scroll the menu item *EXIT THIS MENU* onto the display 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*.

7.4.2 Status Menus

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

7.4.2.1 Battery Status

When this menu is entered, you are instructed to press START. This completes the interlock circuit and allows battery measurement. If no action is taken within ten seconds, the message PRESS START is replaced by INTERLOCK TIMEOUT, and you are returned to the the status menu level.

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

7.4.2.2 Camera Status

VIDEO LEVEL
DARK CURRENT
CAMERA GAIN
EXIT THIS MENU

7.4.2.3 Heat Status

HOUSING HEAT
ANODE HEAT
THERMISTOR
EXIT THIS MENU

7.4.2.4 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 NUMBER	
0	*MEASURED KVP*
1	*MEASURED MA*
2	*FILAMENT B+*
3	*VIDEO LEVEL*
4	*HOUSING TEMPERATURE*
5	*DOSIMETER*
6	*SPARE*
7	*SPARE*
8	*TAP VOLTAGE*
9	*LINE VOLTS*
10	*CHARGE CURRENT*
11	*CHARGE VOLT*
12	*FIL CURRENT*
13	*SPARE*
14	*SPARE*
15	*SPARE*

EXIT THIS MENU

7.4.2.5 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 and 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

7.4.2.6 Control Panel Diagnostics

PANEL LED TEST
PANEL KEY TEST
PANEL KNOB TEST
PANEL CLOCK TEST
SPEAKER TEST
CLOCK TEST
REMOTE BAUD CHECK
EXIT THIS MENU

7.4.2.7 Date/Time Set

SET TIME
SET DATE
EXIT THIS MENU

7.4.2.8 System Options

(XXXX below indicates the current option setting).

ABS TABLE XXXX
ABS BOOT XXXX
CAM GAIN XXXX
LENGTH OF PULSED MODE PULSE
EXIT THIS MENU

7.4.2.9 Examine Calibration Parameters

TABLE A	*TABLE B*
TABLE C	*TABLE D*
TABLE E	*TABLE F*
TABLE G	*TABLE H*
TABLE I	*TABLE J*
TABLE K	*TABLE L*

LAST CAL DATE and TECHNICIAN
NUMBER OF CALIBRATIONS

7.4.2.10 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 - (last 128, beginning with most recent stored in EEPROM. This table is only updated when a fatal system error occurs.)

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

NUMBER OF FATAL EVENTS (accumulated number of fatal event occurances).

DATE AND TIME OF LAST FATAL ERROR

7.4.2.11 Miscellaneous

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

MODEL NUMBER
SERIAL NUMBER
TOTAL RAM
FREE RAM SPACE
TOTAL DISK SPACE
FREE DISK SPACE
INSTALLATION DATE AND TECH
NUMBER OF FILM EXPOSURES
EXIT THIS MENU

7.5 Internal LED indicators

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

The Technique Processor LED digit - This LED echos 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 interlock circuit is complete. 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 Generator Controller PCB.

7.6 Video Camera - Jumpers and Adjustments

7.6.1 Video PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1	IN	Shading
E2	IN	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

7.6.2 Preamp and Yoke ASM

FUNCTION	*ADJUSTMENT*
Peaking	C3

7.6.3 Power Supply PCB

FUNCTION	*ADJUSTMENT*
Beam Discharge	R14
+500 VDC	R13
Focus	R11
H-drive Sync	R25

Adjustment **H-Drive Sync Frequency**

1. Disconnect the H-drive.
2. Adjust R25 to obtain 14.5 kHz at TP14.

7.6.4 Shading/Window PCB

FUNCTION	*ADJUSTMENT*
H- Sawtooth #1	R40
H- Sawtooth #2	R41
H- Parabola	R42
H- Window Cal.	R38
V- Sawtooth	R10
V- Parabola	R16
V- Window Cal.	R39

7.6.5 Deflection PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1	AFC	line Lock/Auto Freq Cntl
E2	525 (60 Hz)	line rate select
	625 (50 Hz)	line rate select
E3		unused
E4		unused
E5-E6	OUT	U2 clock source
E7-E8-E9	E7-E8	50 HZ
	E8-E9	60 HZ
E10-E11-E12	E11-E12	Clock
E16-E17-E18	E16-E17	Horiz reversal

FUNCTION	*ADJUSTMENT*
H- Size	R40
H- Normal Centering	R38
H- Reverse Centering	R39
V- Size	R19
V- Centering	R37
AFC Tuning	L1

7.7 Image Intensifier Adjustments

7.7.1 6-inch Image Intensifier

ELECTROSTATIC FOCUS ADJUSTMENT

Refer to figure 7-1 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.

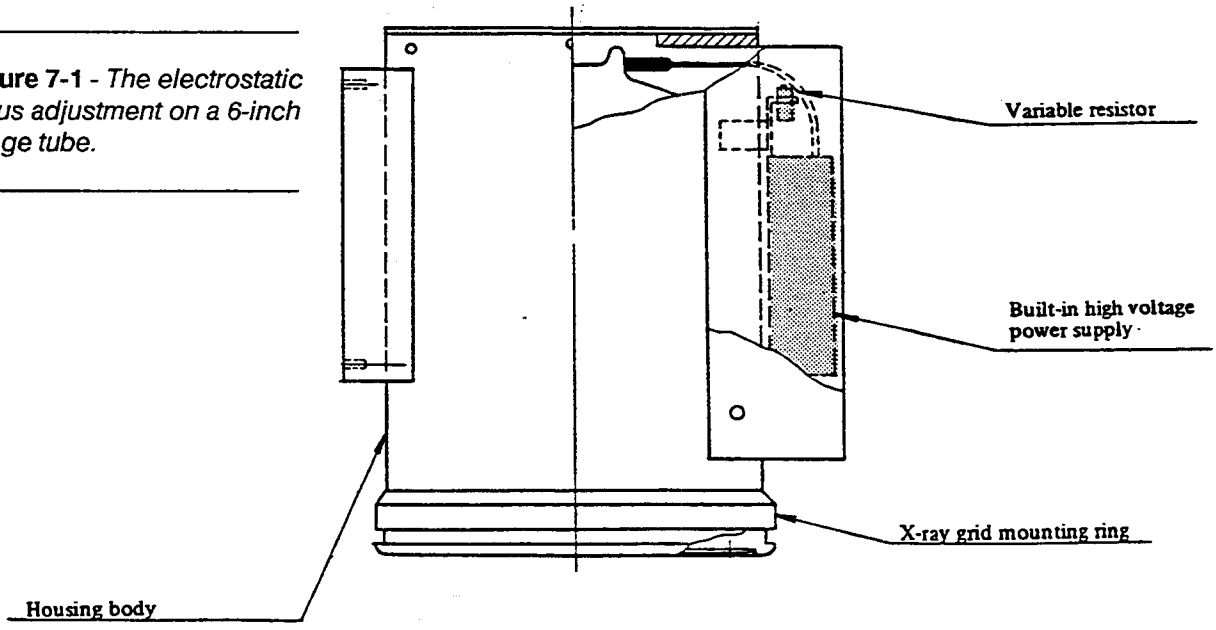


Figure 7-1 - *The electrostatic focus adjustment on a 6-inch image tube.*

7.7.2 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. Refer to Table 2.

Table 2 6/9-inch Image Tube Adjustments

The 6-inch mode adjustments are made to the pots labeled M1; 9-inch mode adjustments are made to the pots labeled N. The M2 adjustments are not applicable.

MODE	*OVERALL SIZE*	*OVERALL FOCUS*	*EDGE FOCUS*
6-INCH	G3	G2	G1
9-INCH	G3	G2	G1

Note: G3 (overall size) may only need adjustment in the 9-inch mode to make the image slightly smaller.

7.8 High Voltage Generator and Generator Controller PCB

These procedures are recommended if the Generator Controller PCB or any High Voltage Generator major component is replaced. Follow these procedures in order.

WARNING: This equipment contains very high power electrical components and should be serviced only by personnel intimately familiar with the circuitry and its operation. The voltages and power levels attainable are capable of causing serious injury, burns, and electrocution. At certain locations, these voltages are present EVEN WITH POWER CORD DISCONNECTED.

WARNING: Due to the high power delivery capability of the battery, and the hazardous voltages present, the mainframe high voltage circuitry should be approached in a cautious and orderly manner.

When energizing a system for the first time following a major repair of the high power or control circuitry, it is important that power limiting techniques be applied until proper functioning can be determined.

7.8.1 Checkout Preparation:

CAUTION: **These checkout tests are to be conducted with the battery and the battery charger disconnected. Do not reconnect the battery or power the charger until directed to do so in these procedures.**

1. Unplug the system from the wall outlet.
2. Disconnect the red connector to the positive lead of the battery, and remove the fuses F2 and F3 in the A.C. power path of the battery charger circuit (these fuses are located on the front of the power panel).

7.8.2 High Power Driver Stage Tests

1. With the high voltage supplies disconnected (as described above) boot the system by running "MAIN 0 " from the external terminal according to the instructions in Section 7.12. The "0 " argument allows the software to operate with no high voltage present.

2. Press START to engage the interlock circuit when prompted on the control panel.

3. Press the "X-RAY ON" switch; with an oscilloscope, the drive pulses at R139 and R156 (ungrounded end) should measure 2.6 +/- .3 volts peak.

4. Measure the turn-off pulse at the trailing edge of the drive pulses seen at R139 and R156. This should be a negative going spike, greater than -1.0 volt in amplitude, and greater than 5 usec. in duration.

5. Disable kV servo by installing jumper E5 on the Generator Controller PCB.

6. Measure the duration of the on-pulses. The duration should be approximately 20 usec.

7. Check that the on-pulse duration can be varied by turning the kVp Knob on the control panel.

8. Remove the jumper from E5.

7.8.3 Power Limited Functional Test

1. Disable the kVp servo by installing a jumper at E5 on the Generator Controller PCB.

2. Set the fluoro technique to: 50 kVp and 0.5 mA.

3. Connect one battery (60 VDC) into the circuit with a 12 ohm 100 watt resistor wired in series with the positive battery lead. (Bypass the other two battery packs).

4. Boot the system by running "MAIN 40 " from the external terminal according to the instructions in Section 7.12. The "40 " argument allows the software to operate with a lower battery voltage present.

5. Make an exposure while observing the following:

   There should be no fault messages on the control panel display and a sinewave should appear at P1-4 and P1-5 of the Generator Controller PCB.

6. Make a fluoro exposure and observe the waveform at TP-13 on the Generator PCB for the following:

kVp Sensor Functional Test A sinewave equal to 42 to 48 percent of the amplitude seen in step 5 should be present during the exposure.

7. Remove the jumper at E5.

8. Make an exposure and observe the following:

kVp Regulation Test The amplitude of the waveform at TP-13 should be 5.0 +/- .20 Vpp, and its amplitude should be adjustable by varying the "KV" knob on the control panel.

NOTE: *It will not be possible to obtain more than about 6 volts p-p with only one battery connected.*

9. Verify the waveform at P1-12 (small filament output) without making an exposure.

Filament Drivers

There should be no signal at P1-11 (large filament) in this mode.

10. Put the system in "FILM" mode and arm for "instant on". This is done by pressing the X-RAY ON switch and releasing it before the exposure actually occurs.

11. Verify the waveform at P1-11 without making an exposure.

Filament Drivers There should not be a signal at P1-12 (small filament) in this mode.

7.8.4 High Voltage Application

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

1. Open the interlock circuit by pressing EMERGENCY OFF. Wait one minute to discharge the filter capacitance. Reconnect all batteries but leave the 12 ohm 100 watt resistor in series.

2. Jumper E5 should be removed and Jumper E3 installed. Set the technique for FLUORO and 50 kVp, 0.5 mA.

3. Reboot the system by typing MAIN at the terminal. (Refer to the instructions in Section 7.12).

CAUTION: *Do not use the "0 NOCAL" argument this time, as this will close the large contactor prematurely, resulting in very large inrush currents.*

4. Make a fluoro exposure and observe that no fault messages appear on the control panel display.

5. Turn off the keyswitch. Disconnect the power cord from the wall outlet. Wait one minute to discharge the filter capacitance. Remove the series 12 ohm resistor, reconnecting the batteries in their normal configuration.

6. Remove both jumpers E3 and E5 from the Generator Controller PCB.

7.8.5 Adjusting Charger Output Voltage

1. The batteries are connected in their normal configuration prior to this procedure (see step 5 of the previous procedure).
2. Unplug the power cord. Install F-2 and F-3 to provide A.C. power to the charger circuit.
3. Remove the panel mount fuse below the Generator Controller PCB.
4. Plug in the power cord. Leave the interlocks disengaged - DO NOT PRESS START.
5. Adjust R-108 for 211 +/- 3 VDC at C-63(+).

7.8.6 Adjusting Charger Voltage Readout (Bargraph)

1. Adjust R109 clockwise until the bargraph reads below 210 volts.
2. Then turn R109 counter-clockwise until the 210 volt LED just turns on.

7.8.7 Generator Controller PCB Jumpers

JUMPER	*SHOULD BE*	*FUNCTION*
E3	IN only for calibration	disables mA servo
E5	IN only for test	disables kV servo

7.9 Analog Support PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Counter Timer Clock-Input
E4-E11	TBA	Board Rev

7.10 Technique Processor PCB

Switch Settings

SWITCH	*SHOULD BE*	*FUNCTION*
S1		reserved
S2		reserved
S3	OFF	real time clock disable
S4	ON	autoboot switch, if off mainframe will boot in monitor program
E0-E3		Board Rev
E9, E10	IN, IN	Real Time Clock Oscillator

Adjustment

Disk Drive Interface - Read/Write Pulses

Use this procedure to adjust the read/write data pulse widths. Measure frequency and pulse widths at the test points indicated using an oscilloscope. To obtain proper accuracy in this measurement, set the horizontal scale as indicated in [brackets] below.

1. Connect the 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 [set scope on 100 ns/div].

7.11 Control Panel Processor PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E3	IN	Dual UART Oscillator Circuit

Switch Settings

SW8	*SW7*	*BAUD RATE*
off	off	9600 baud (normal)
off	on	4800 baud
on	off	2400 baud
on	on	1200 baud

SW5	SW4	COMMUNICATION DIAGNOSTICS
off	off	disabled (normal)
off	on	echo key request to terminal
on	off	echo T.P. commands to terminal
on	on	undefined

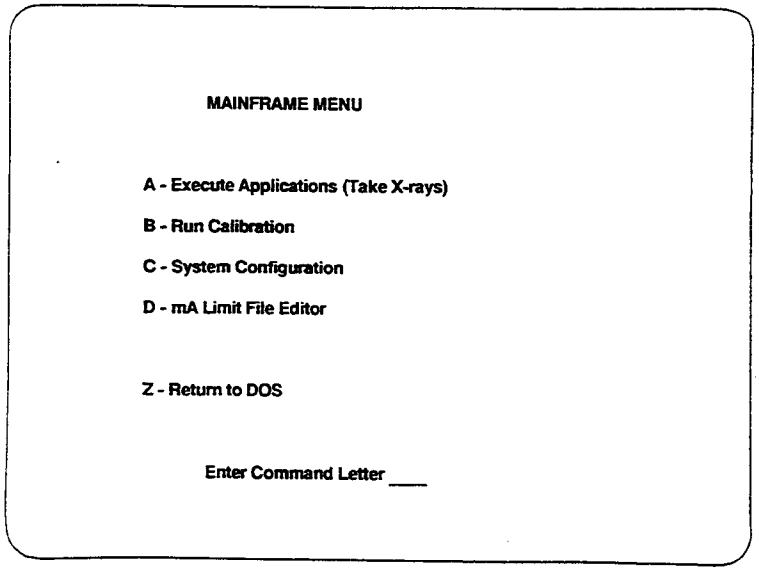
SW3	SW2	SW1	DIAGNOSTIC MODES
off	off	off	normal operation
off	off	on	segment & LED check
off	on	off	keyboard diagnostics
off	on	on	clock & speaker checks
on	off	off	UART loop test
on	off	on	memory test
on	on	off	undefined
on	on	on	undefined

7.12 Accessing the Mainframe with the External Terminal

7.12.1 Mainframe Terminal Menus

Mainframe software menus are accessed from the monitor cart MAIN MENU by selecting "Access Mainframe Menu".

This Mainframe Menu will appear.



Refer also to Section 8.6.3 in *Monitor Cart Service* for a summary of the selections available from the monitor cart Main Menu.

7.12.2 To Access Mainframe DOS (MSDOS$_{TM}$)

1. Connect the external terminal by following the instructions given in the Appendix: *External Terminal Use*.
2. Press [ESC] to view the Program Access Menu.
3. From the Program Access Menu select: *Z-Return to Main Menu.*
4. From the Main Menu select: *Y-Access Mainframe Menu.*
5. From the Mainframe Main Menu select: *Z-Exit to DOS.*

7.12.3 Booting From the External Terminal

1. The system can be booted from the external terminal for certain test procedures. Do this only when specifically told to do so in the test procedure.
2. Enter the command line desired after performing step 5 in Section 7.12.2 above:

   Type *MAIN* to invoke the Main Program.

   Type *MAIN 0* when required by certain test procedures.

7.12.4 Exit Applications Software

If the mainframe fails at the "Press Start" prompt during startup, the Main Menu can be accessed by pressing [ESC] and typing END.

7.13 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 Generator Controller PCB.
3. The bargraph may indicate 160 or 170 volts during the exposure. If the voltage drops to 150 volts, there could be a problem with the batteries.

7.14 Evaluating the Battery Charger

The battery charger circuit on the Generator Controller 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 measured at E1 should be about 210 VDC.
2. Above 625 mA the voltage measured at E1 should rise to approximately 230 VDC.
3. Above about 2 amps charger current, the charger current limits and the charger voltage at E1 will decrease.
4. Overvoltage shutdown should occur above approximately 240 VDC, indicated by a sudden drop in output voltage at E1.
5. During mainframe boot, the charger output is shutdown momentarily; the output voltage should briefly drop to about 150 VDC.

7.15 Resetting the Battery Circuit Breaker

The 50 Amp battery circuit breaker will trip in the event of a major overload in the battery circuit. Determine the cause before resetting. *Refer to Figure 7-2.*

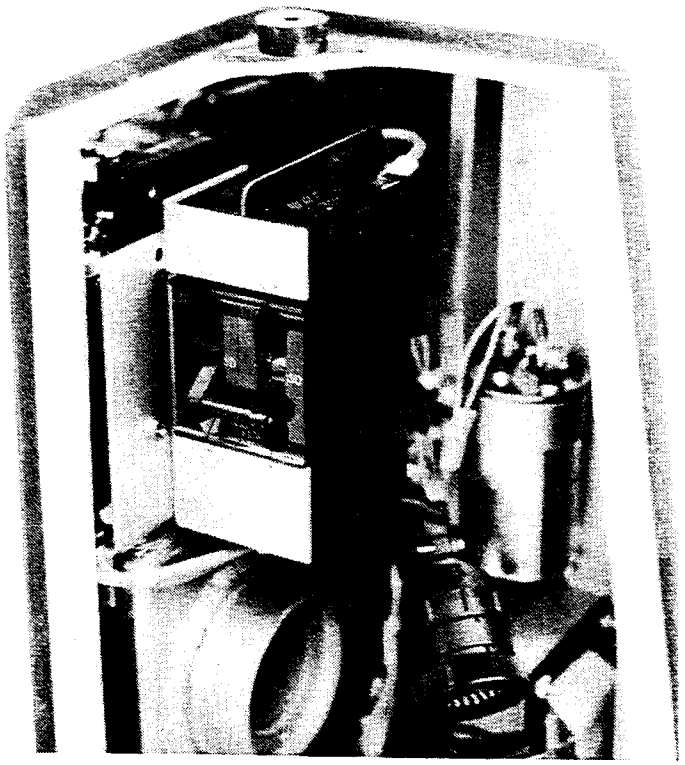


Figure 7-2 - *The battery circuit breaker is shown in this photo.*

7.16 Mainframe Mechanical Adjustments

7.16.1 Loosening a Stuck Lift Shaft

If either of the limit switches on the lift column are badly misadjusted, the column may bind at the top or bottom of its travel.

1. Directly above the top of the shaft, there is an access hole through which to insert a hex wrench.
2. Reach the wrench into the hole and onto the hex head at the top of the shaft. Turn the shaft in the direction opposite to the bind.

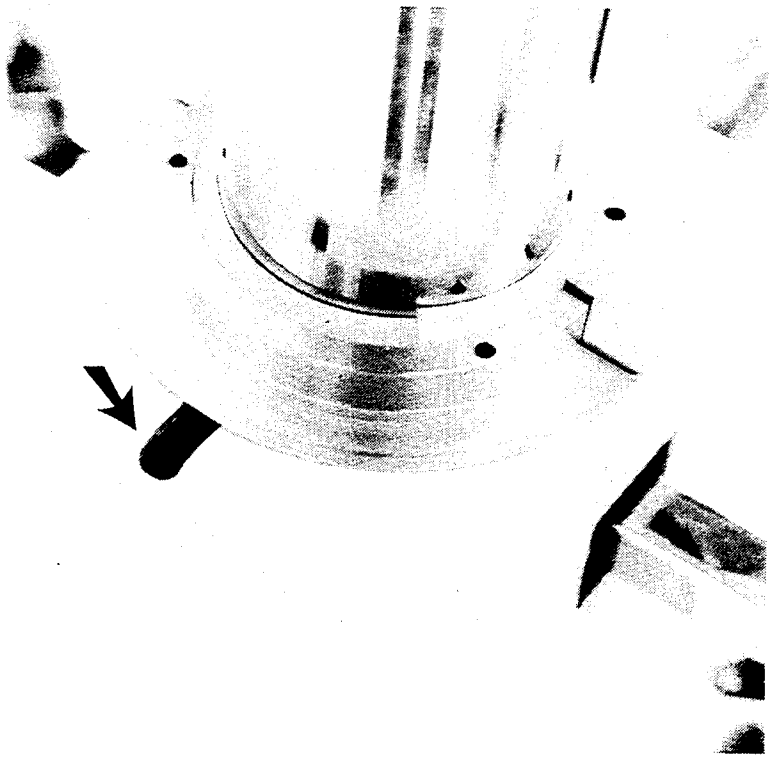


Figure 7-3 - *The lift shaft can be turned with a hex wrench inserted through this hole.*

7.16.2 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 blade screwdriver rotate each bearing to minimize sloppy, loose or irregular movement of the the C-arm within the cradle. Do not adjust these to cause overtight bearing contact.
3. Test the bearing contact through the full range of movement.
4. Tighten the set screws.

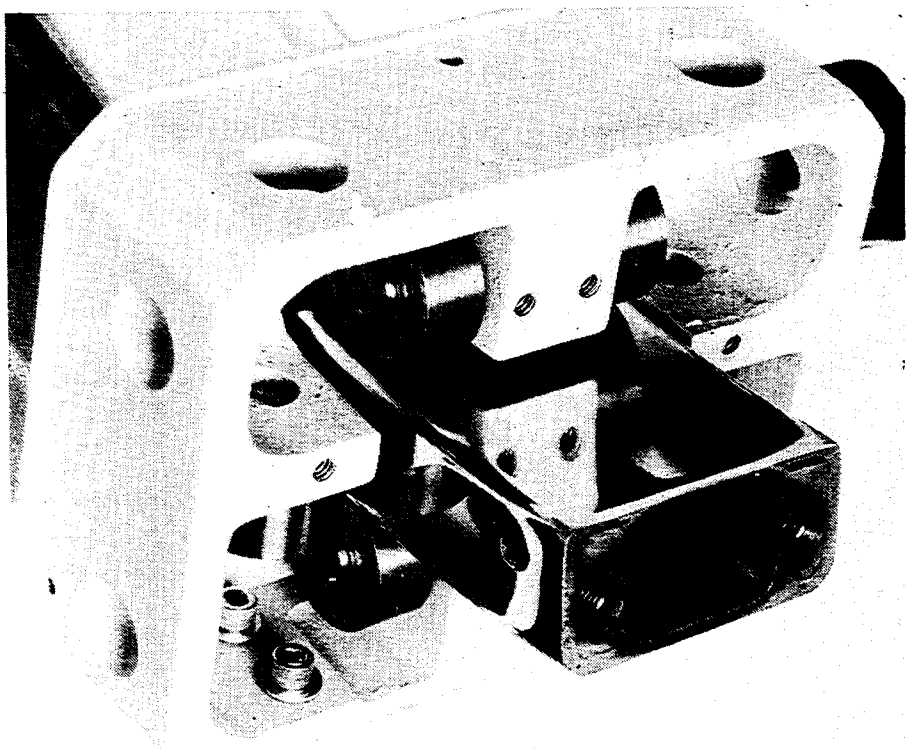


Figure 7-4 - *The cradle bearings can be exposed in the bearing blocks.*

SECTION 6
MONITOR CART PARTS, DISASSEMBLY AND REPLACEMENT

The information in this section will help you identify, disassemble and replace parts on the monitor cart. Section 6.2 contains assembly and disassembly instructions. Section 6.3 provides an illustrated parts list.

6.1 Safety

It is very important that you read and understand the emergency and safety procedures described in the Safety Section of the service manual.

WARNING: **Circuits inside the equipment use voltages which are capable of causing serious injury or death from electrical shock. To avoid this hazard always unplug the AC power cable before opening, removing, or replacing equipment covers or doors.**

There are no procedures in this section of the manual which should be attempted by anyone other than a properly trained service technician.

6.2 Monitor Cart Assembly/Disassembly

6.2.1 Removing the Access Panels

Refer to Figures 6-1 through 6-3.

The electronics of the monitor cart are accessed by removing sectional panels and covers.

Generally, all these panels attach in the same manner: interlocking tabs are attached to the frame along one edge, and the panel is secured with screws along the opposite edge.

6.2.1.1. Front Panel Removal for Access to Card Rack

Refer to Figure 6-1.

1. Remove two screws from the bottom of the panel and tilt the bottom edge of the panel out slightly.
2. Lift up on the panel to clear the tabs along the top edge and remove the panel.

6.2.1.2 Right Front Panel Removal for Access to Monitor Power Supply

Refer to Figure 6-1.

1. Remove two screws from the bottom of the panel.
2. Lift the panel up slightly, and then off.

6.2.1.3 Rear Panel Removal

Refer to Figure 6-2.

Removing the rear panel allows access to the Isolation Transformer T1 and the rear of the card cage.

1. Remove the seven screws along the bottom and sides of the rear panel.
2. There are no locking tabs, the panel can be simply lifted off.

6.2.1.4 Left Side Panel Removal for Access to Disk Interface and Video Switching PCB'S

Refer to Figure 6-3.

1. Remove the front panel.
2. Remove the two screws inside the left front cart frame.
3. Slide the panel toward the rear of the cart about 1 inch to clear the tabs.
4. Lift off the side panel.

6.2.2 Replacing the Air Filter

1. Face the front of the monitor cart and locate the air filter underneath the cart cooling fans.
2. Pull the air filter straight out.
3. Replace the air filter when it has become dirty enough to impair the flow of air through the fans.

Figure 6-1 - *Monitor cart covers, front view.*

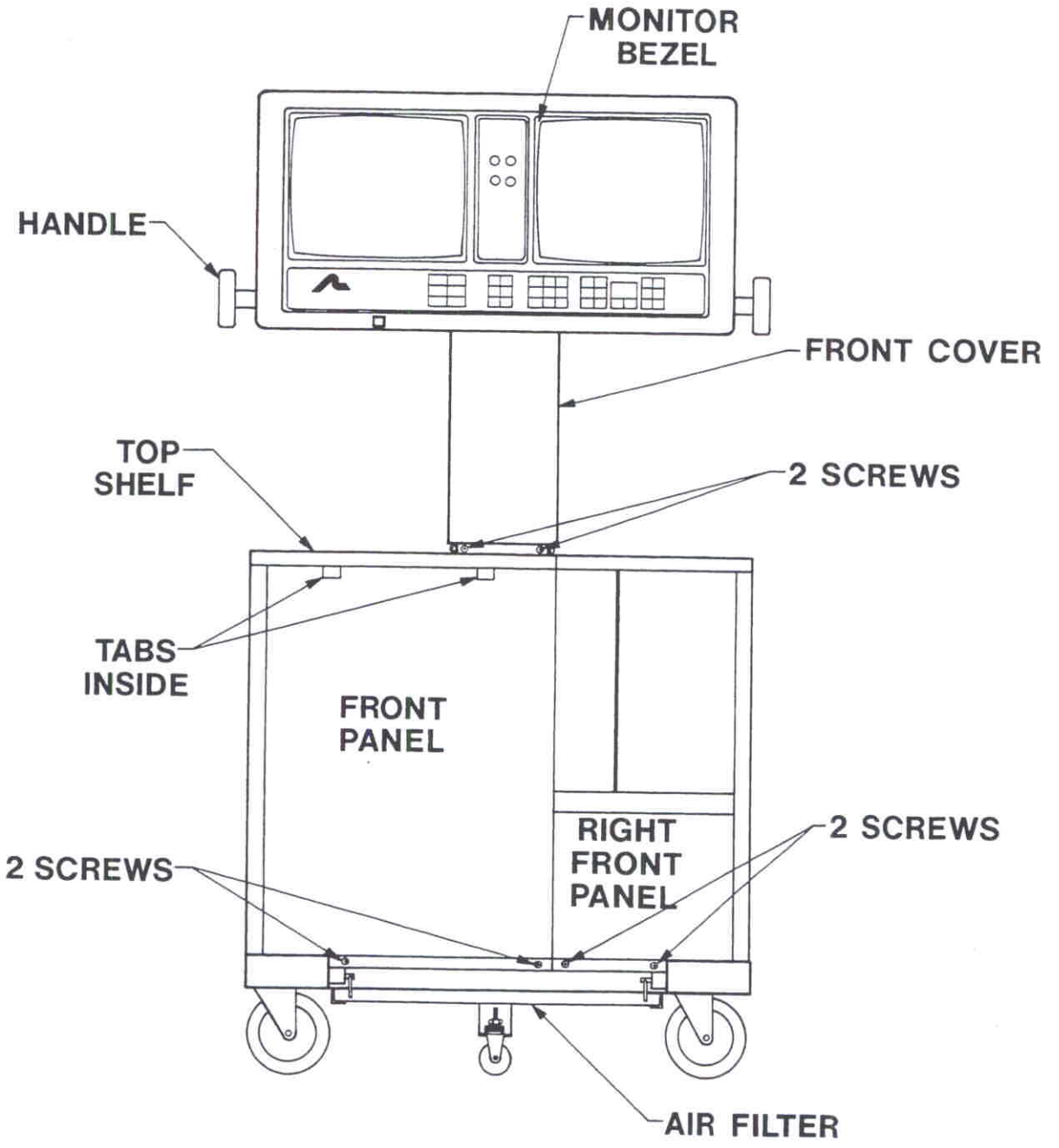


Figure 6-2 - *Monitor cart covers, rear view.*

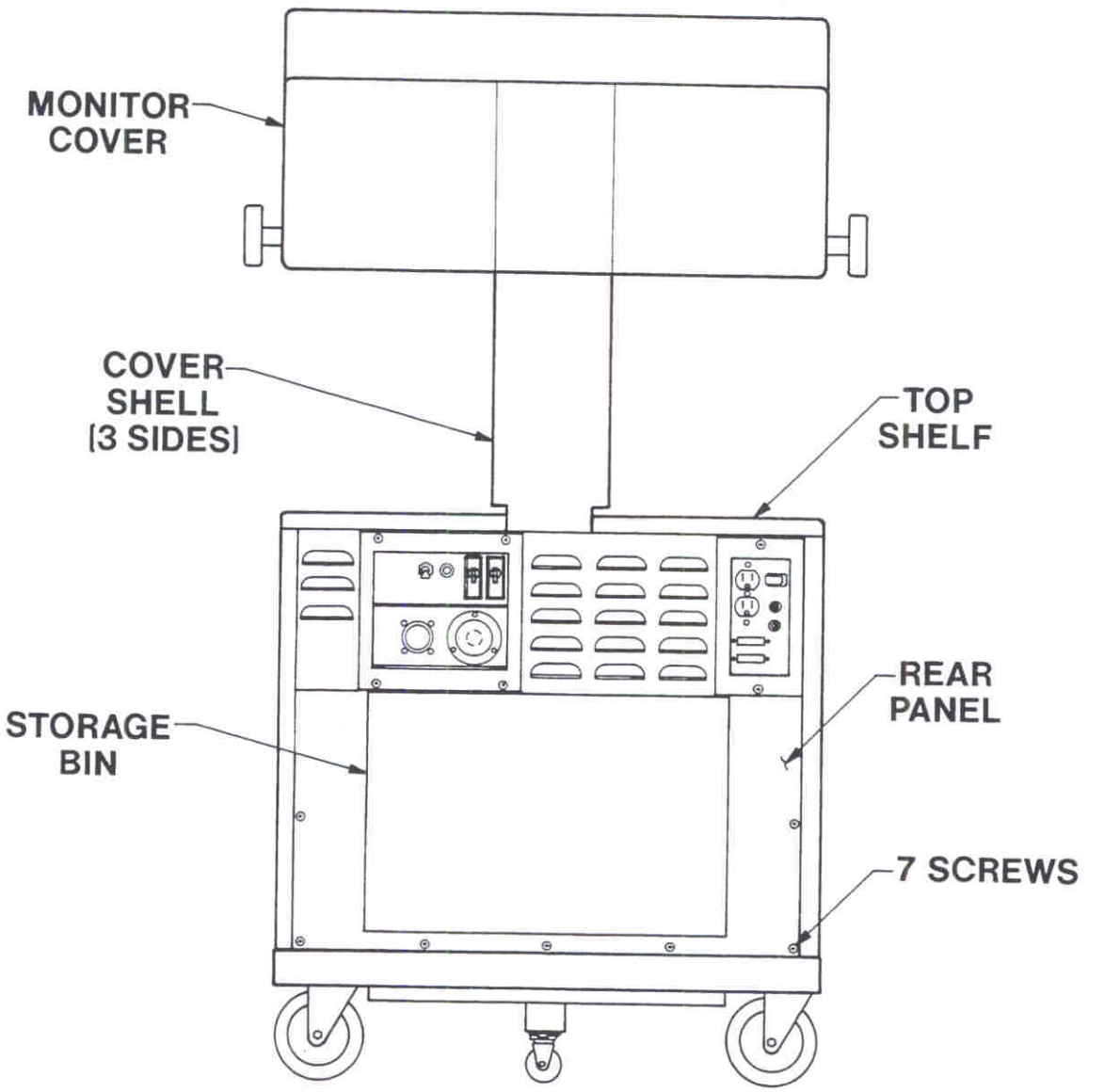
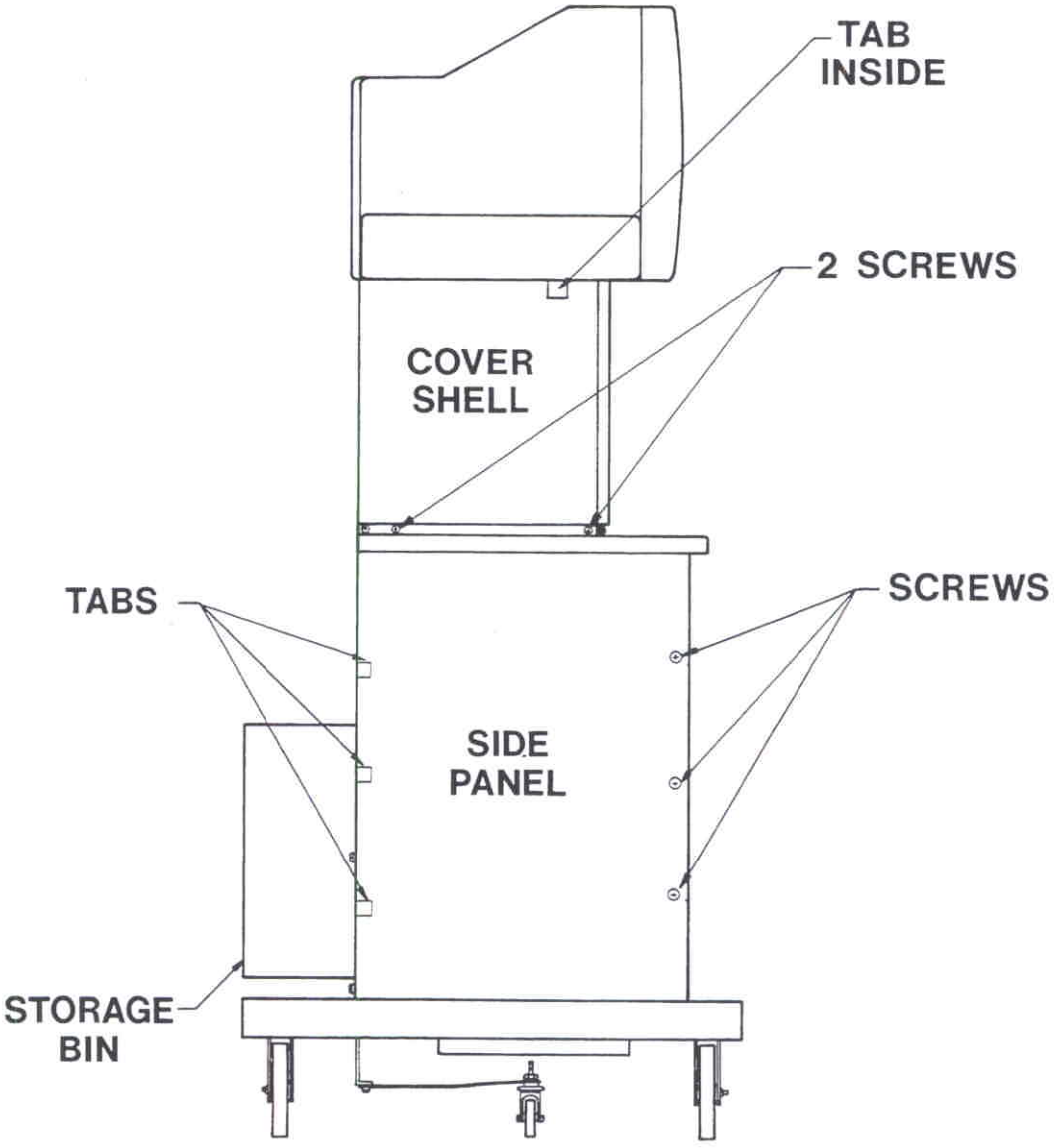


Figure 6-3 - *Monitor cart covers, side view.*



6.2.3 Removing the Monitor Covers

Refer to Figure 6-4.

1. Remove the four screws and grillwork from the bottom of each monitor.
2. Remove the two screws from the rear inside corners of the monitor cover.
3. Remove the two screws from the front inside corners of the monitor cover.
4. Lift the front edge of the cover up about 1/16 inch, to avoid trapping the cover tab on the monitor base.
5. Slide the cover back from the monitors and lift it away.

6.2.4 Removing the Monitors

Refer to Figures 6-5 and 6-6.

1. Remove the monitor cover as described in procedure 6.2.2 above.

WARNING: Observe the high voltage and implosion hazard warnings for handling CRTs.

2. Disconnect the brightness and contrast control connectors and the 2-pin Molex video connector going to the circuit board mounted on the monitor.
3. Disconnect the 3-pin Molex power connector.
4. Remove the nylon tie wraps as needed to free the disconnected wiring from the monitor frame.
5. Remove 3 screws on each side of the monitor base (6 screws total).
6. Carefully remove the monitor.
7. When replacing a monitor make sure that the front of the tube is firmly seated forward against the bezel. The monitor can be positioned with the screws on the monitor base brackets.

Figure 6-4 - *The attachment points for the monitor cover and grillwork are shown in this photo. With the grillwork removed, the Front Panel Processor PCB and the Remote Contrast/Brightness PCB are visible on their mounting plates.*

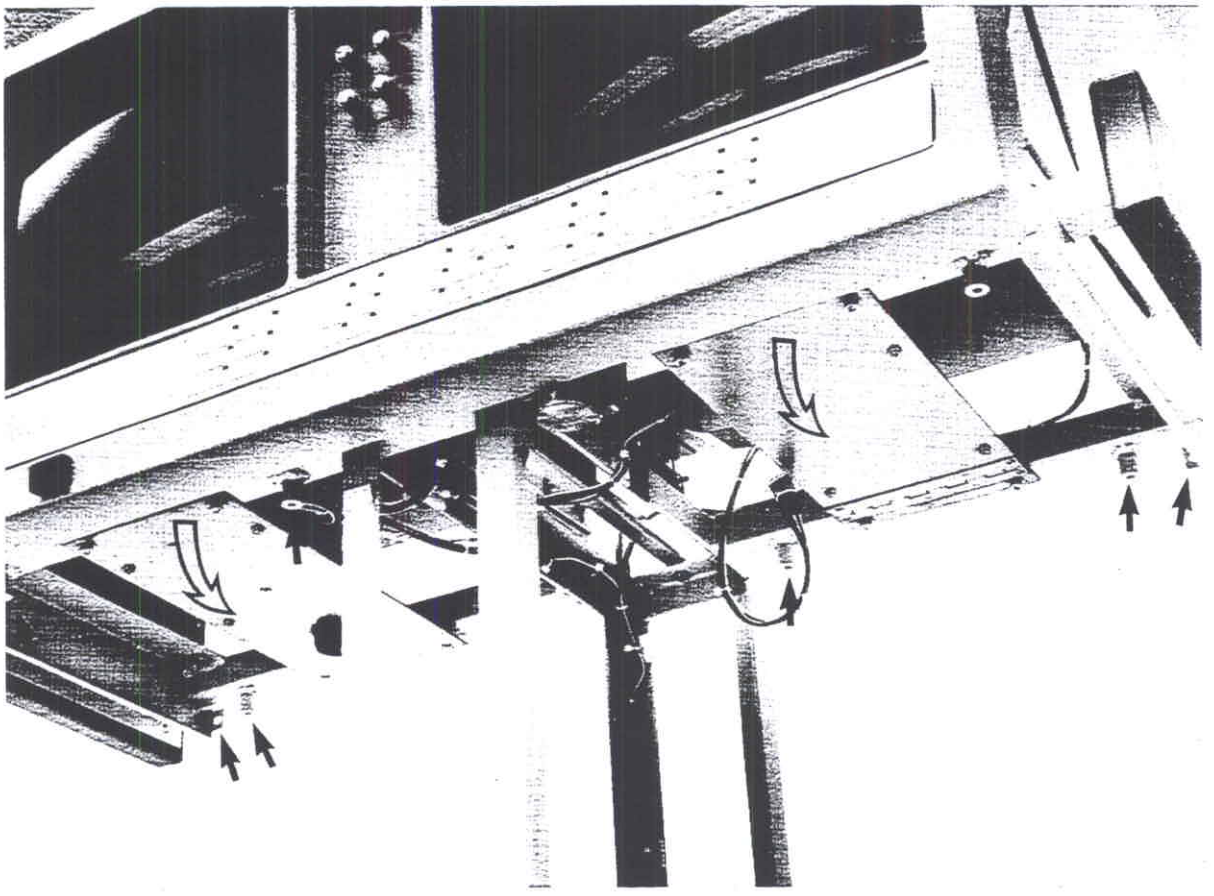


Figure 6-5 - *Remove the six screws holding each monitor as indicated in these photos.*

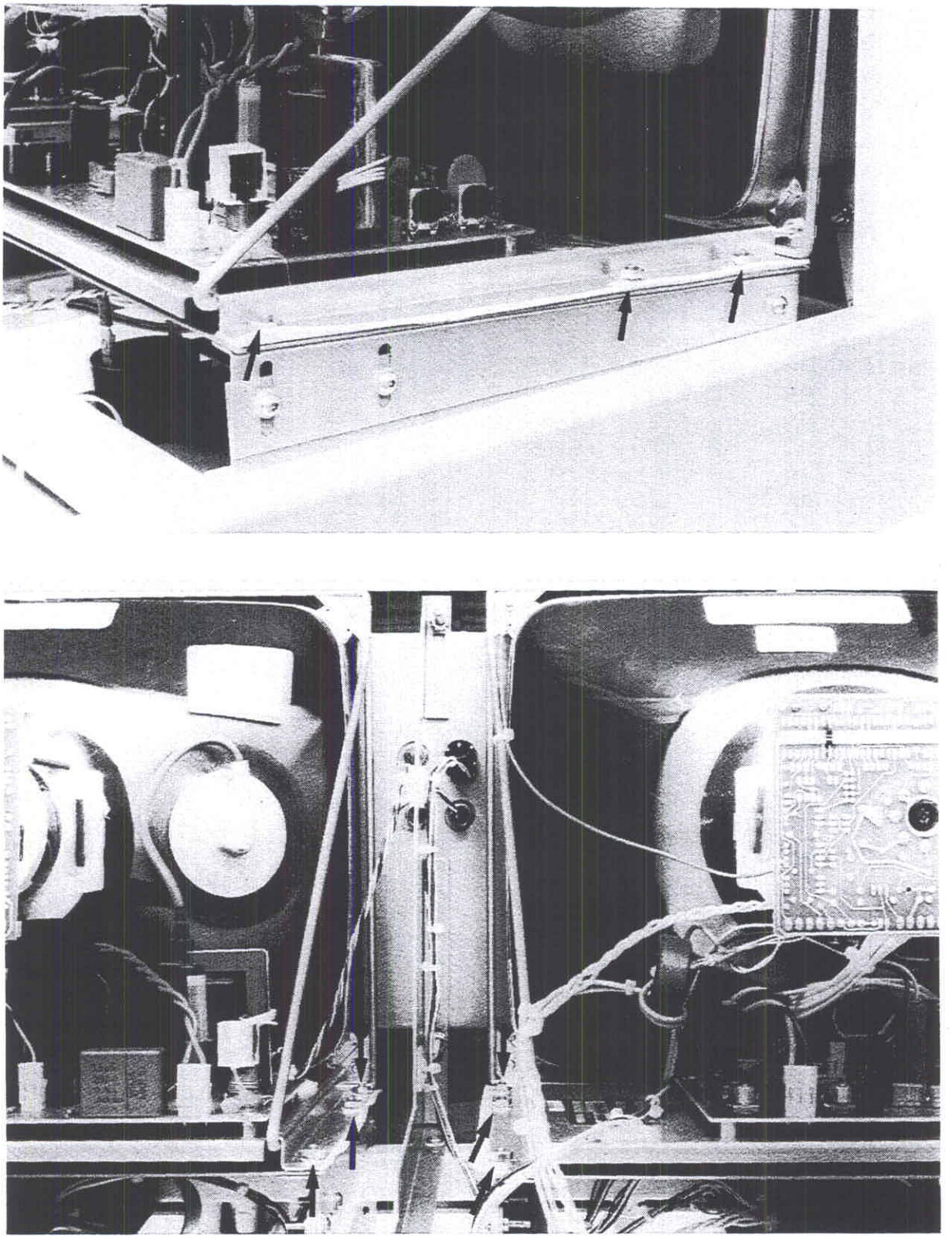
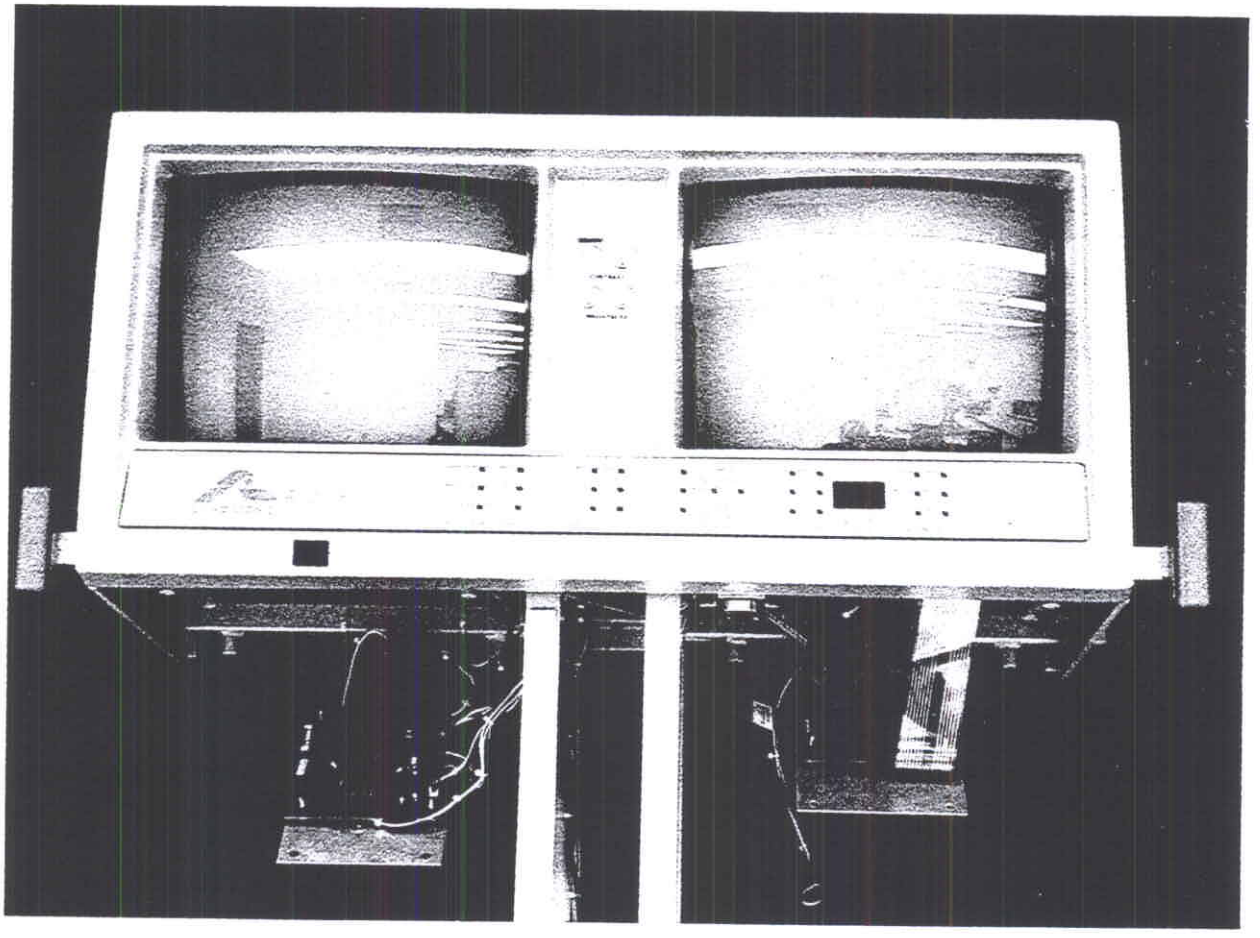


Figure 6-6 - *The panels below each monitor drop down to expose the Front Panel Processor PCB and the Remote Contrast/Brightness Control PCB.*

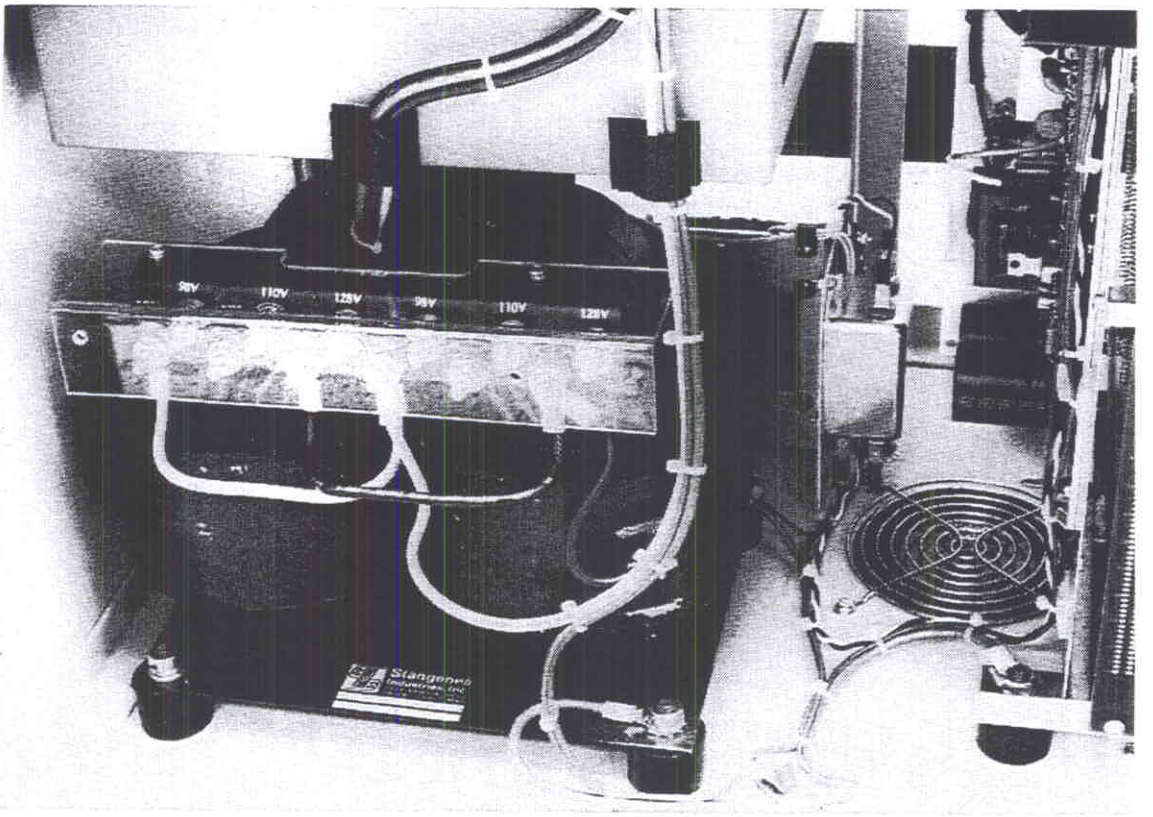


6.2.5 Removing the Isolation Transformer

Refer to Figure 6-7.

1. Unplug the main power cable from the wall outlet.
2. Remove the rear access panel.
3. Label all wires before removing them from the transformer. Disconnect the wires from the isolation transformer terminals.
4. Remove the four nuts securing the transformer to the shock mounts in the base of the cart.
5. Lift the transformer off the shock mounts and out of the cart. The transformer is heavy - lift it carefully.

Figure 6-7 - *Removing the isolation transformer.*



6.2.6 Access to the Front Panel Processor PCB

Refer to Figure 6-6.

1. Remove the grillwork below the right monitor.
2. Locate the Front Panel Processor PCB on the hinged panel under the monitor. Remove the 2 screws and swing the panel and PCB assembly down on its hinge.
3. Use care not to strain the cables and their connectors which are plugged into the PCB.

6.2.7 Access to the Remote Contrast/Brightness PCB

Refer to Figure 6-6.

1. Remove the grillwork below the left monitor.
2. Locate the PCB on the hinged panel below the monitor. Remove the two screws and swing the panel down on its hinge.
3. Use care not to strain the cables and their connectors which are plugged into the PCB.

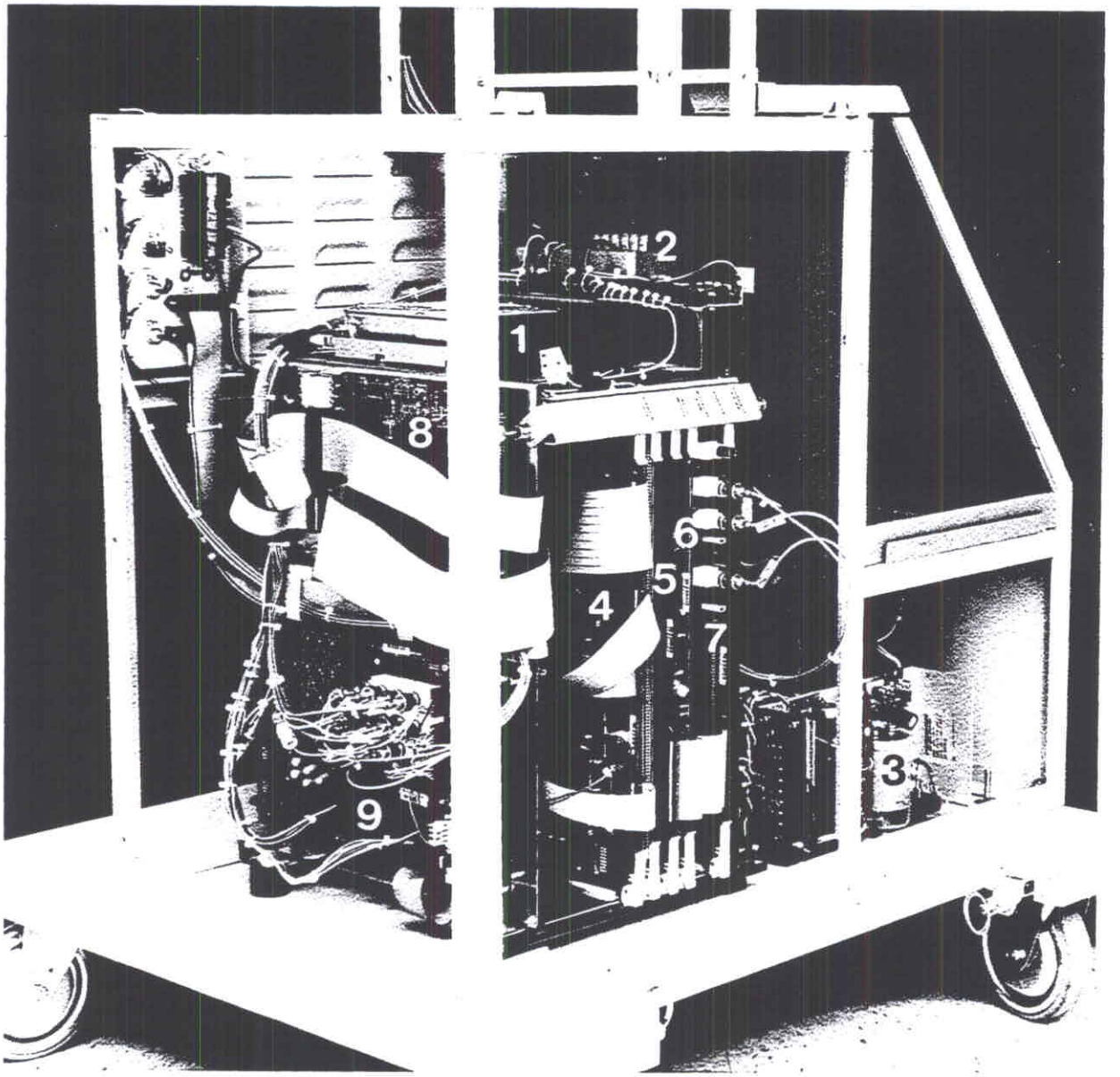
6.2.8 Removing the Card Rack Power Supply

Refer to Figure 6-8.

1. Remove all wiring from their push on connections at the terminal strip on the bottom of the power supply.
2. Remove the circuit boards from the card rack.
3. Reach inside the card rack and remove the 2 screws securing the lower end of the power supply.
4. Remove the screws securing the hard disk drive on the top of the card rack and shift it to the side to access the two screws holding the top of the power supply. It is not necessary to disconnect the cables to the disk drive.

Figure 6-8 - *The components in the base of the monitor cart are identified in this photo.*

1- Hard disk, 2- card rack power supply, 3- monitor power supply, 4- Disk Interface PCB, 5- Pipeline Filter PCB, 6-Image Processor PCB, 7- AD/DA PCB, 8- Disk Controller PCB, 9- IO Distribution/ Video Switch PCB



6.2.9 Removing the Hard Disk Drive

Refer to Figure 6-8.

1. Disconnect the two ribbon cables and the power cable connection to the hard disk drive.

   (Note that different drives may be mounted with the connectors to the front or the rear). *If the connectors are inaccessible, then perform the following removal steps 2 and 3 and then turn the drive to access the connectors.*

2. Remove the circuit boards from the card rack.

3. Reach up from inside the card rack and remove the four screws securing the Hard Disk Drive to the top of the rack.

4. Remove the drive.

6.2.10 Removing PCBs From the Card Rack

Refer to Figure 6-8.

1. Remove the front access panel.

2. Loosen the knurled screws at each end of the retaining bar, and swing it up on its hinge.

3. Remove the ribbon cables from their their front edge connections. Be sure they are adequately labeled for later reconnection.

4. Pull out on the card ejectors to disengage the PCBs from their rear edge connectors on the motherboard.

6.2.11 Installing PCBs in the Card Rack

Refer to Figure 6-8.

The PCBs which slide into the card rack slots are from left to right:

Disk Controller PCB
Extender Board
Pipeline Filter PCB
Image Processor PCB
AD/DA PCB

1. Make sure that the rear edge connectors are clean and bright. Clean with a soft eraser and a cloth with solvent.

2. Line up each PCB with the top and bottom card edge guides and slide the cards into the rack until the rear edge connectors engage the motherboard.

3. Press firmly on the card ejectors until the PCB is fully seated in both rear edge connectors on the motherboard.

4. Reconnect all ribbon cables. Be sure that pin 1 of each ribbon cable connector matches up with pin 1 of each PCB connector.

   Connect the short, multiconnector daisy-chain cable to the P-3 connectors of the Image Processor, Pipeline Filter, and AD/DA PCBs.

   Attach the ribbon cables to P-9, P-10, P-11 and P-12 on the Disk Interface PCB.

   Attach the coaxial cables to J-5, J-6 and J-8 on the AD/DA PCB.

5. Swing down the PCB retaining bar and lock it in place by tightening the knurled screws.

6.2.12 Removal of the I/O Distribution-Video Switching PCB

Refer to Figure 6-8 and Figure 6-9.

The I/O Distribution-Video Switching PCB is mounted on standoffs attached to the left side of the card rack.

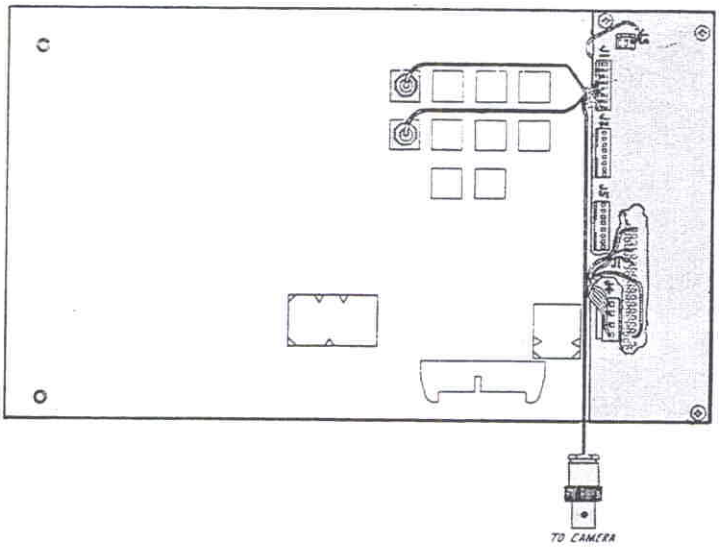
1. Remove the front and the left side access panels.

2. Remove the PCBs from the card rack as required to reach the screws which secure the I/O Distribution-Video Switching PCB standoffs.

3. Disconnect all BNC, ribbon, and power cables from the PCB. *Refer to Figure 6-9 for connector replacement.*

4. Remove the screws securing the PCB standoffs to the card rack and remove the PCB.

Figure 6-9 - *I/O Distribution Video Switch PCB connections are shown below; detail on right shows connections to the Sync Separator PCB*



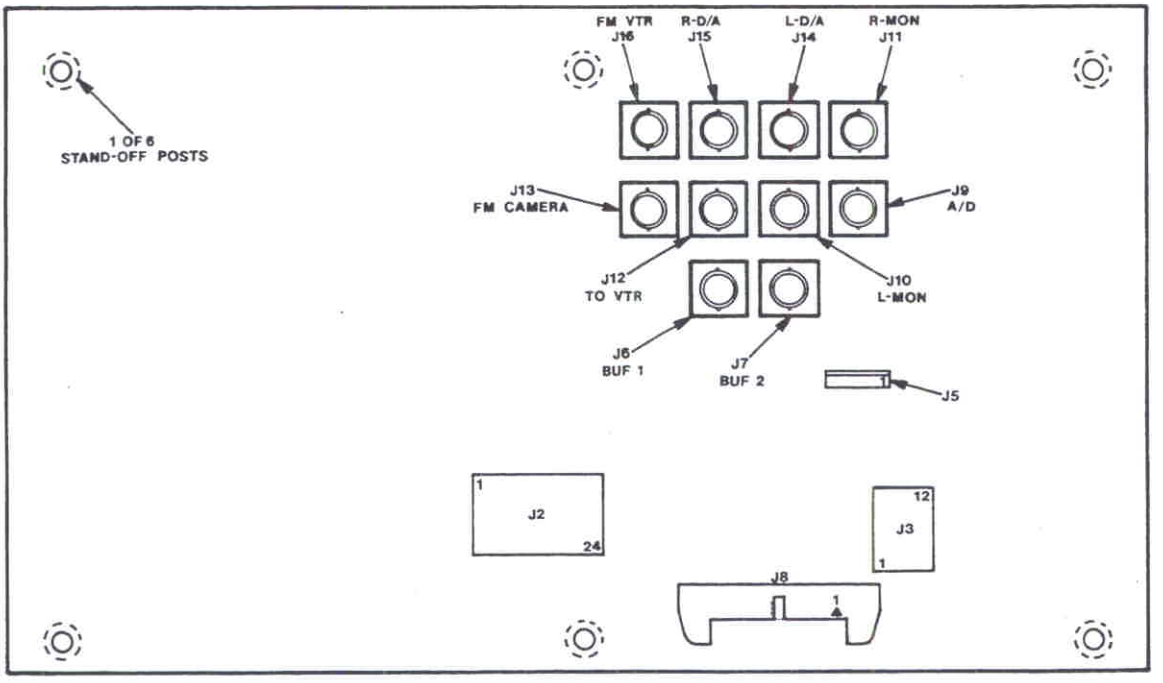
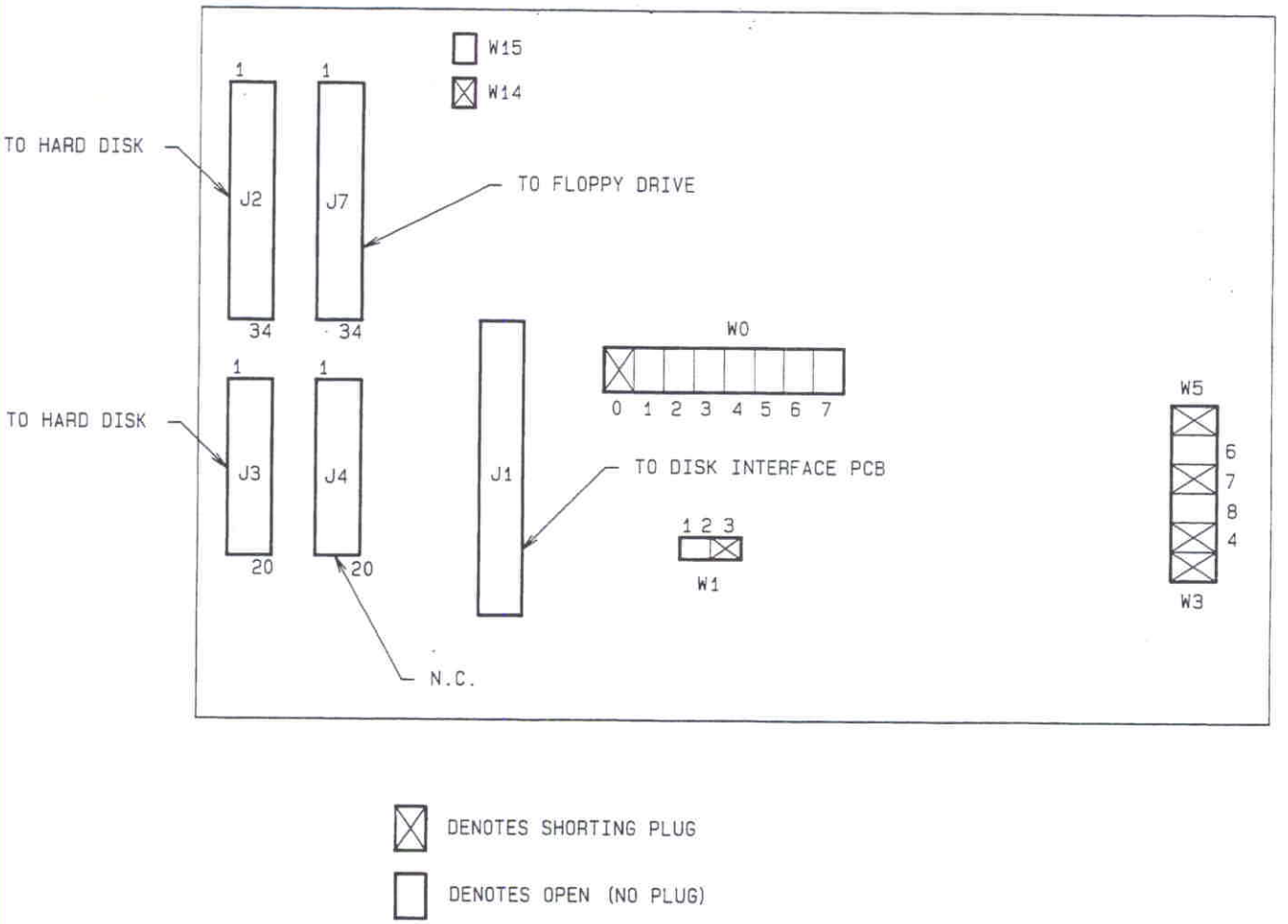


Figure 6-10 - *The connector placement on the Disk Controller PCB is shown in this drawing.*



6.2.13 Sync Separator (AngioStor Interface) PCB

Refer to Schematic 00-870543, and Figures 6-8 and 6-9.

On systems equiped with the AngioStor Disk Recorder, an interface PCB is mounted piggyback on the I/O Distribution PCB. The connections between the Interface PCB and the I/O Video Switch PCB are as follows:

I/O Dist Video Switch PCB	AngioStor Interface PCB
J1-19	J3-1
J1-21	J4-1
J1-34	J4-2
J1-32	J4-3
J1-37	J4-4
J16	J1-3, J1-4
J-13	J1-5, J1-6

6.2.14 Removal of the Disk Controller PCB

Refer to Figure 6-10.

1. Remove the left side panel to access the PCB.
2. Disconnect all connections to the PCB. *Refer to Figure 6-10 for connector placement.*
3. Remove the 4 sets of screws and insulating washers. Each screw is insulated from the PCB with nylon washers on both sides of the board. *When the board is reinstalled be sure that these insulating washers are in place.*

6.3 Illustrated Parts List

The major replacable assemblies are illustrated on the following pages.

Part numbers are subject to change. Contact Technical Support for assistance with part interchangeability.

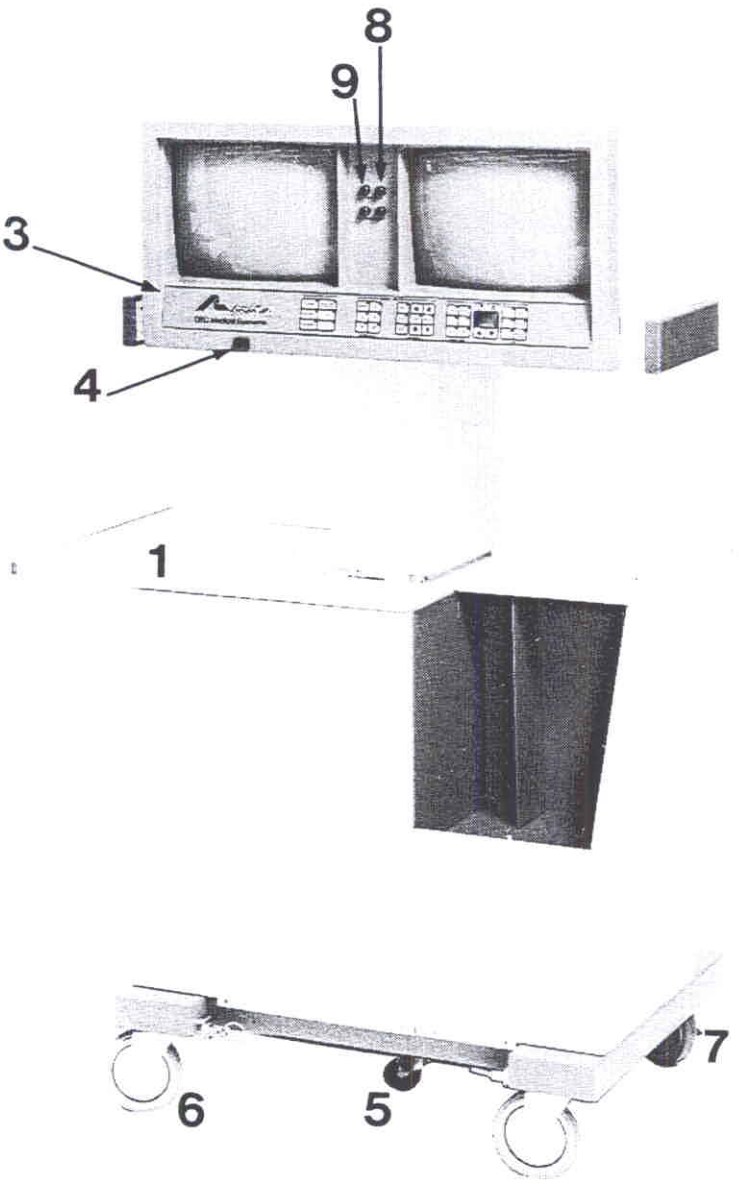
Fig. 1 Monitor Cart

1.	shelf, accessory, monitor cart	00-870523
2. *	shelf, accessory, RH, monitor cart	00-870541
3.	front panel assembly	00-870398
	membrane switch panel sub-asm	00-870397
	LED PCB display	00-870394
	display, 7-segment LED	67-480626
	lamp, red LED, MV5753	67-499845
4.	indicator, rectangular	71-229509
	cap, lens, red	00-870739
	lamp, 6.3VDC	71-229506
5.	conductive caster asm	00-860092
6.	casters, front	10-08-390
7.	casters, rear w/ brakes	10-08-391
8.	knobs 1/8-inch shaft	23-519934
9.	knobs 1/4-inch shaft (remote)	23-519931

Overall View

* Item 2 is not shown in this photo.

Monitor Cart



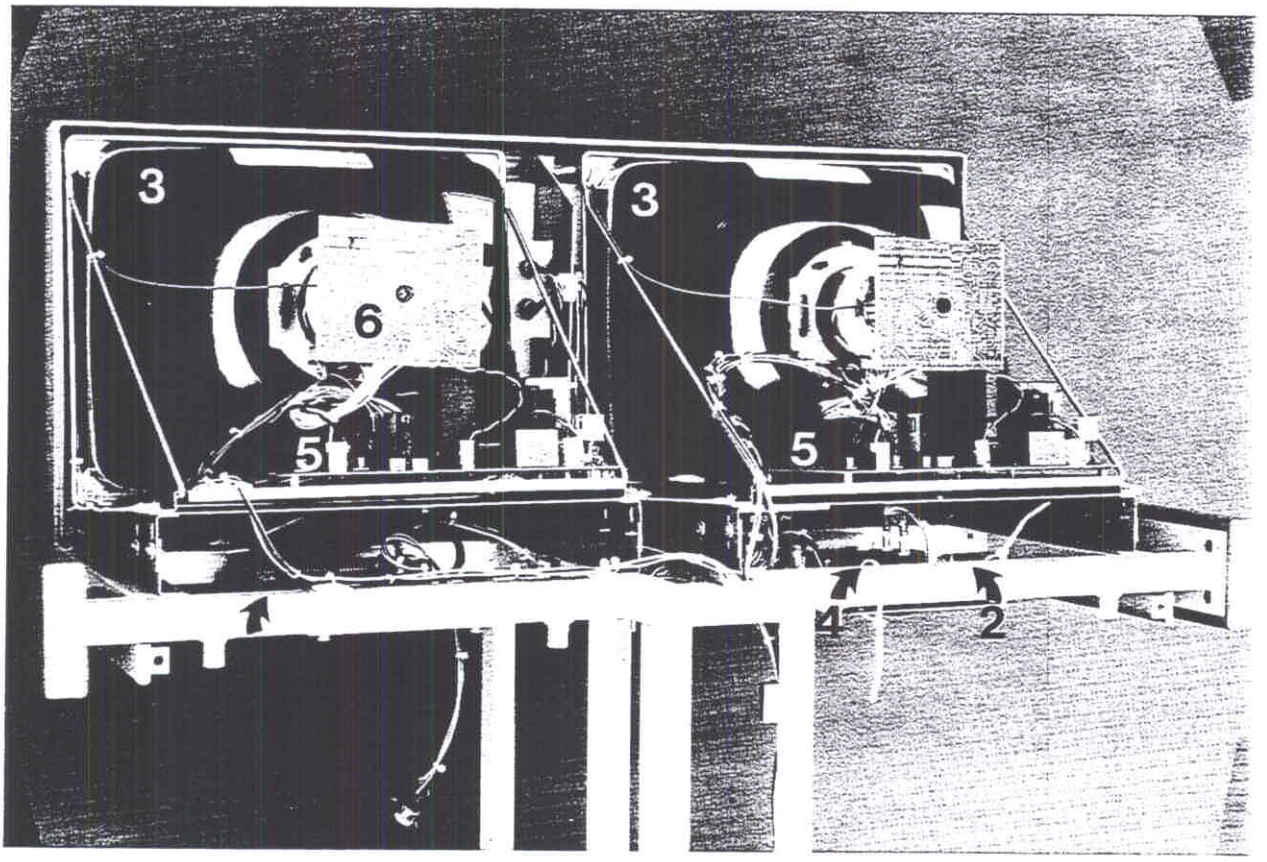
Overall View **Fig. 1**

Fig. 2 Monitor Cart

1.	Front Panel Processor PCB	00-870509
2.	Remote Contrast Brightness Control PCB	00-870930
3.	TV monitor	00-860364
4.	audio alarm	76-829967
5.	Dataray Video Procesor PCB	00-900036
6.	Dataray Deflection PCB	00-900035

Rear Exposed Monitor View

Monitor Cart



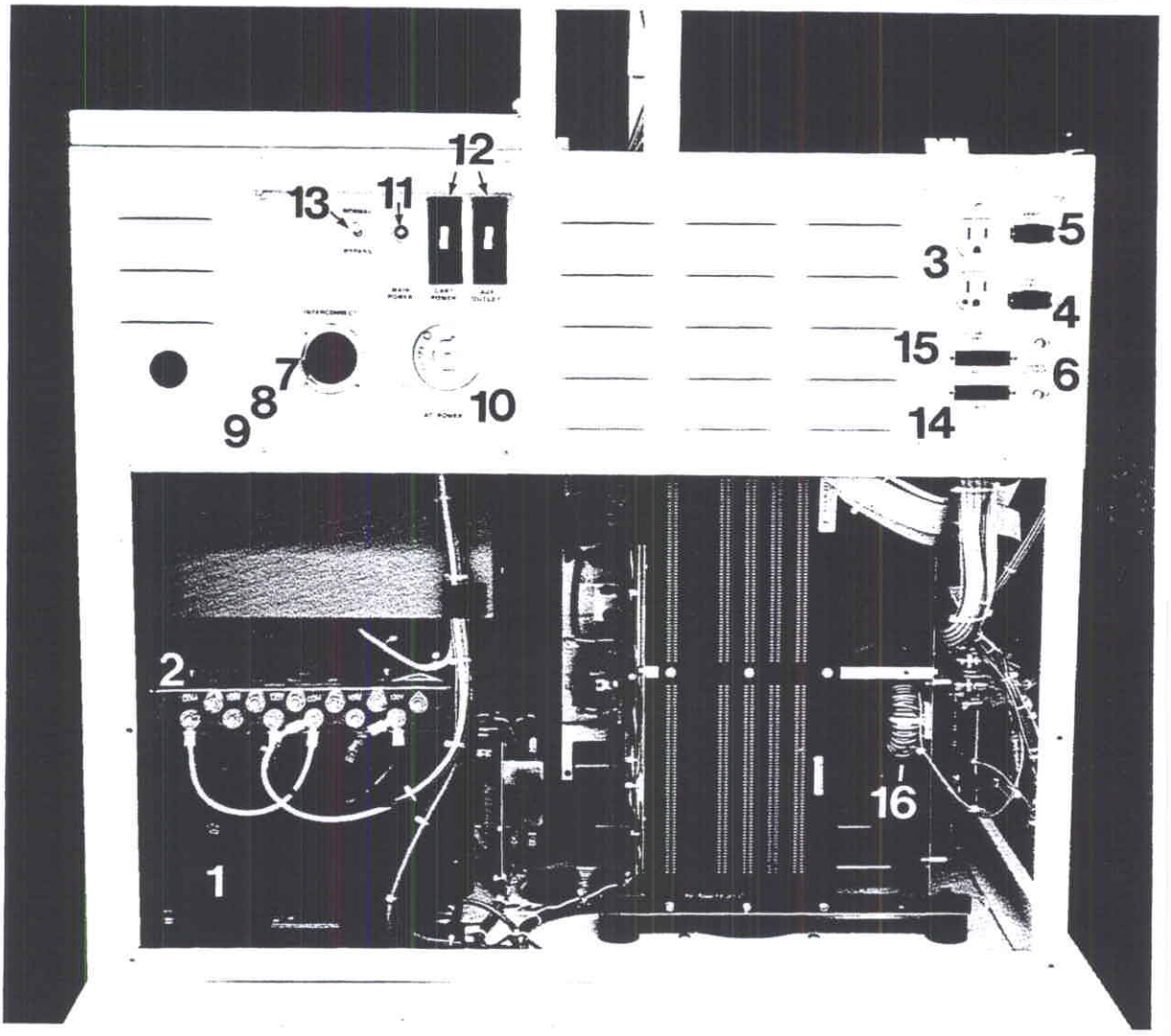
Rear Exposed Monitor View **Fig. 2**

Fig. 3 Monitor Cart

1.	isolation transformer	00-860736
2.	transformer terminal cover	00-870136
3.	duplex outlet, 3-wire	51-433989
4.	connector jack, 8-pin VTR	00-900047
5.	connector jack, 8-pin AngioStor	00-900047
6.	connector jack, BNC	58-018941
7.	connector, receptacle, circ	52-998346
8.	contact pin	52-998300
9.	bracket, retainer, interconnect cable	00-871331
10.	connector, inlet, 3-pin M	51-332981
11.	ckt breaker, 10 A	55-700448
12.	ckt breaker, 5A	55-700032
13.	toggle switch, DPDT	71-149970
14.	cable asm, AUX	00-870117
15.	cable asm, RS232	00-870118
16.	video balun	00-870370

Rear Lower View

Monitor Cart



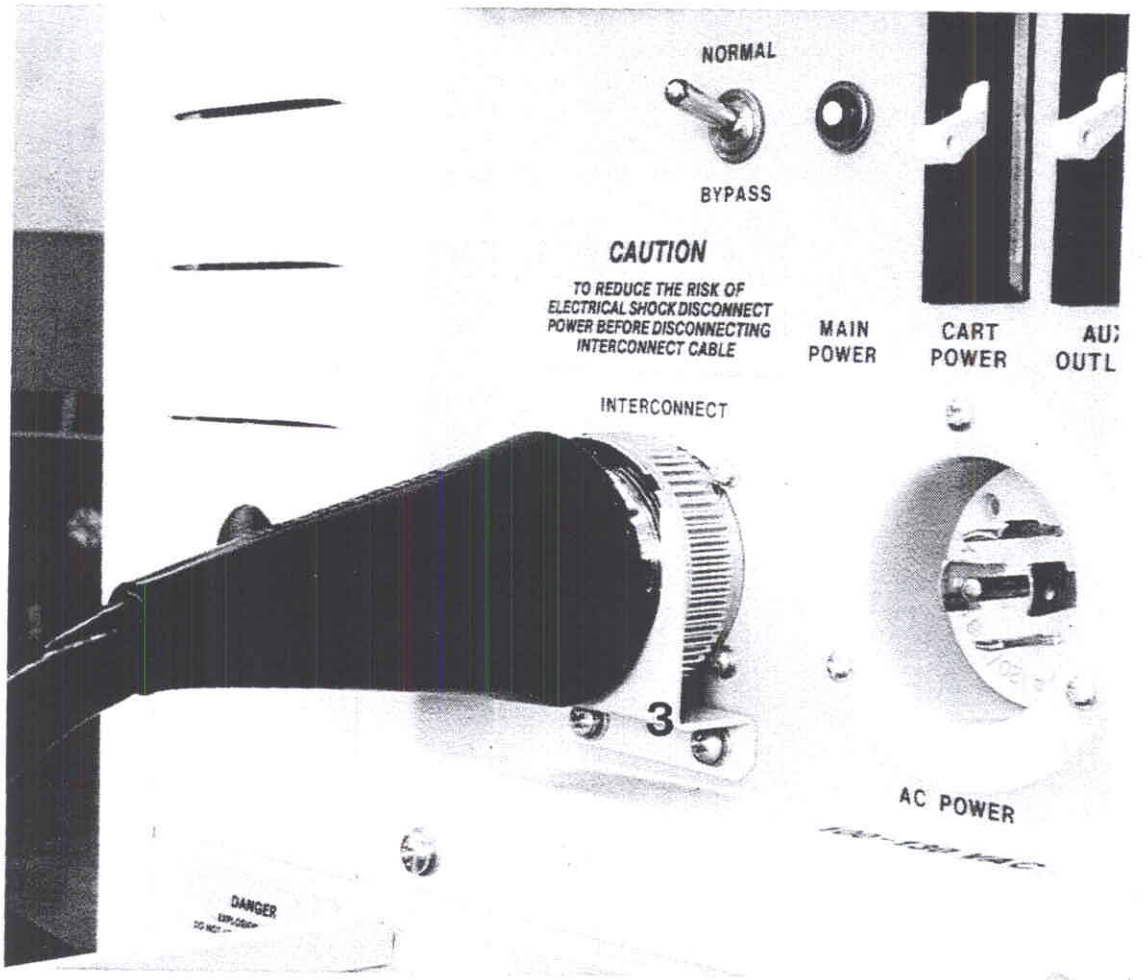
Rear Lower View

Fig. 3

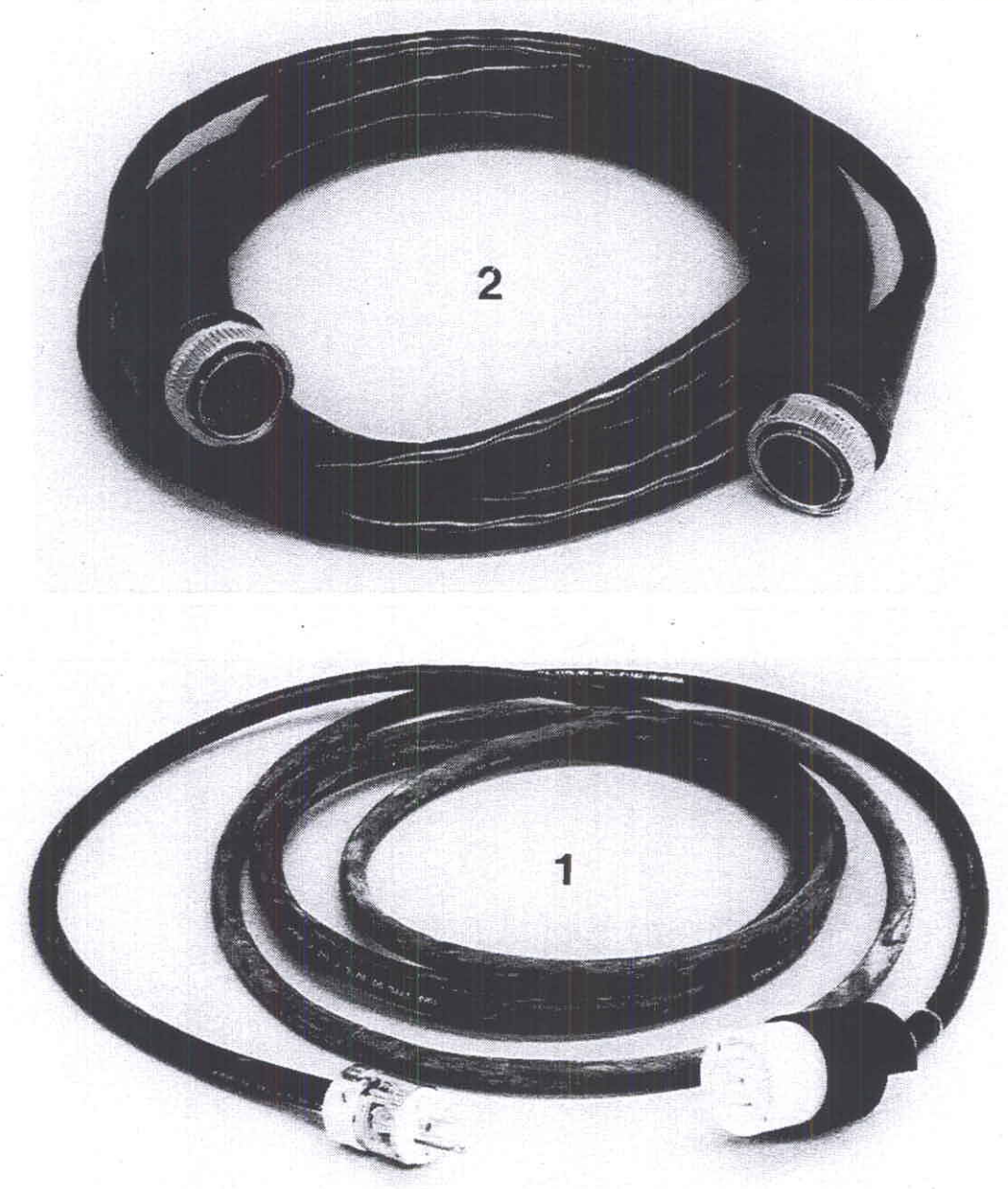
Fig. 4 a, b, c Power and Interconnect Cables

1.	asm, power cable	00-871369
2.	asm, interconnect cable	00-900101
3.	bracket, retainer, interconnect cable	00-871331

Fig. 4a



Monitor Cart



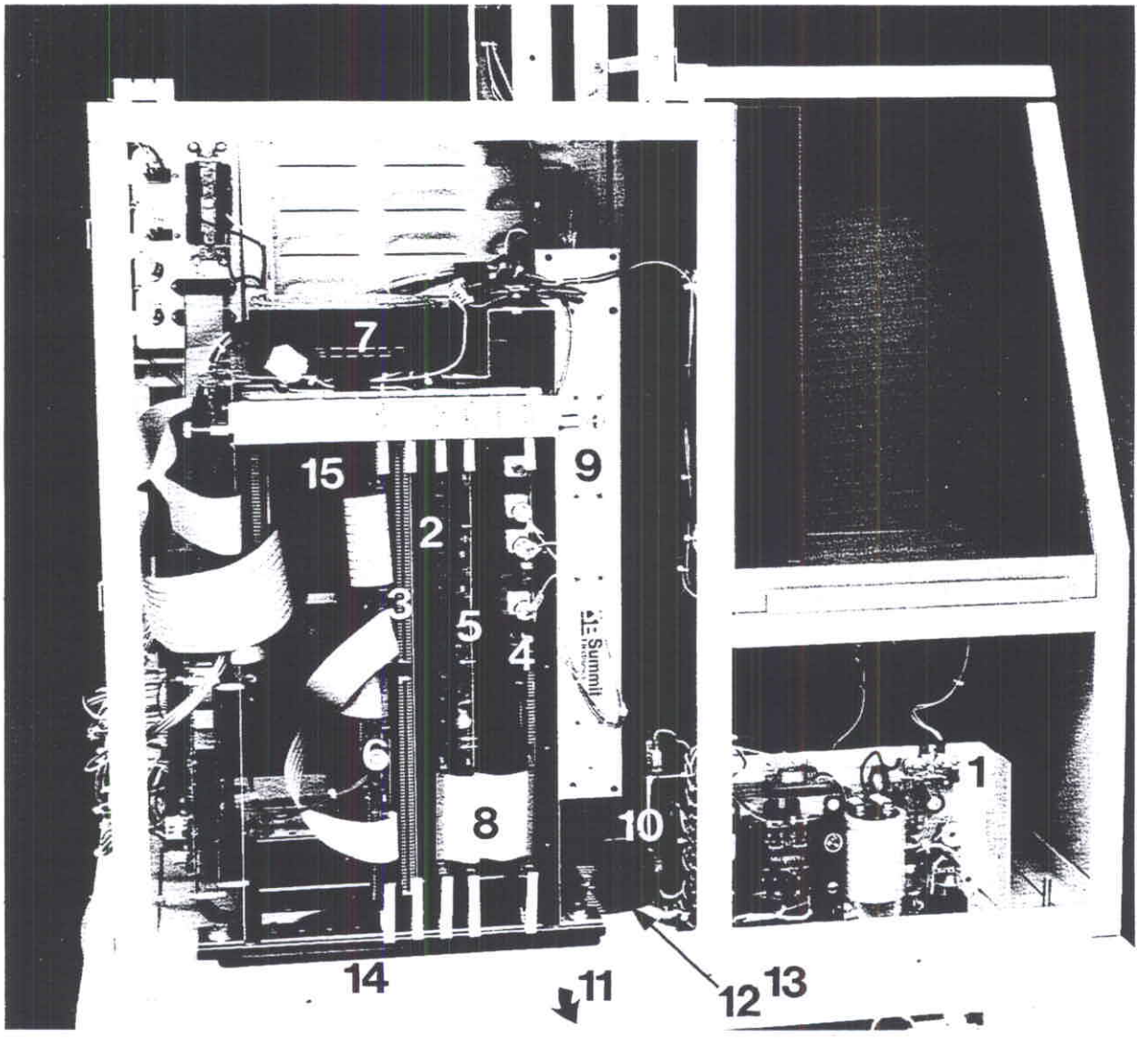
Power and Interconnect Cables **Fig. 4b, c**

Fig. 5 Monitor Cart

1.	24 Volt power supply	00-870285
2.	pipeline filter PCB	00-870503
3.	extender pcb	00-860893
4.	AD/DA converter pcb	00-860898
5.	image processor PCB	00-870390
6.	disk interface PCB	00-870015
7.	disk drive, winchester, 1/2 height	00-900077
8.	daisy chain cable	00-870556
9.	power supply, 5 VDC	00-870065
10.	filter, pwr line, 10 A	43-399887
11.	air filter asm	00-870386
12.	finger guard	20-839926
13.	fan, 4" axial	20-839955
14.	card guides	22-319805
15.	disk controller adapter PCA	00-900075

Lower Electronics, Front View

Monitor Cart



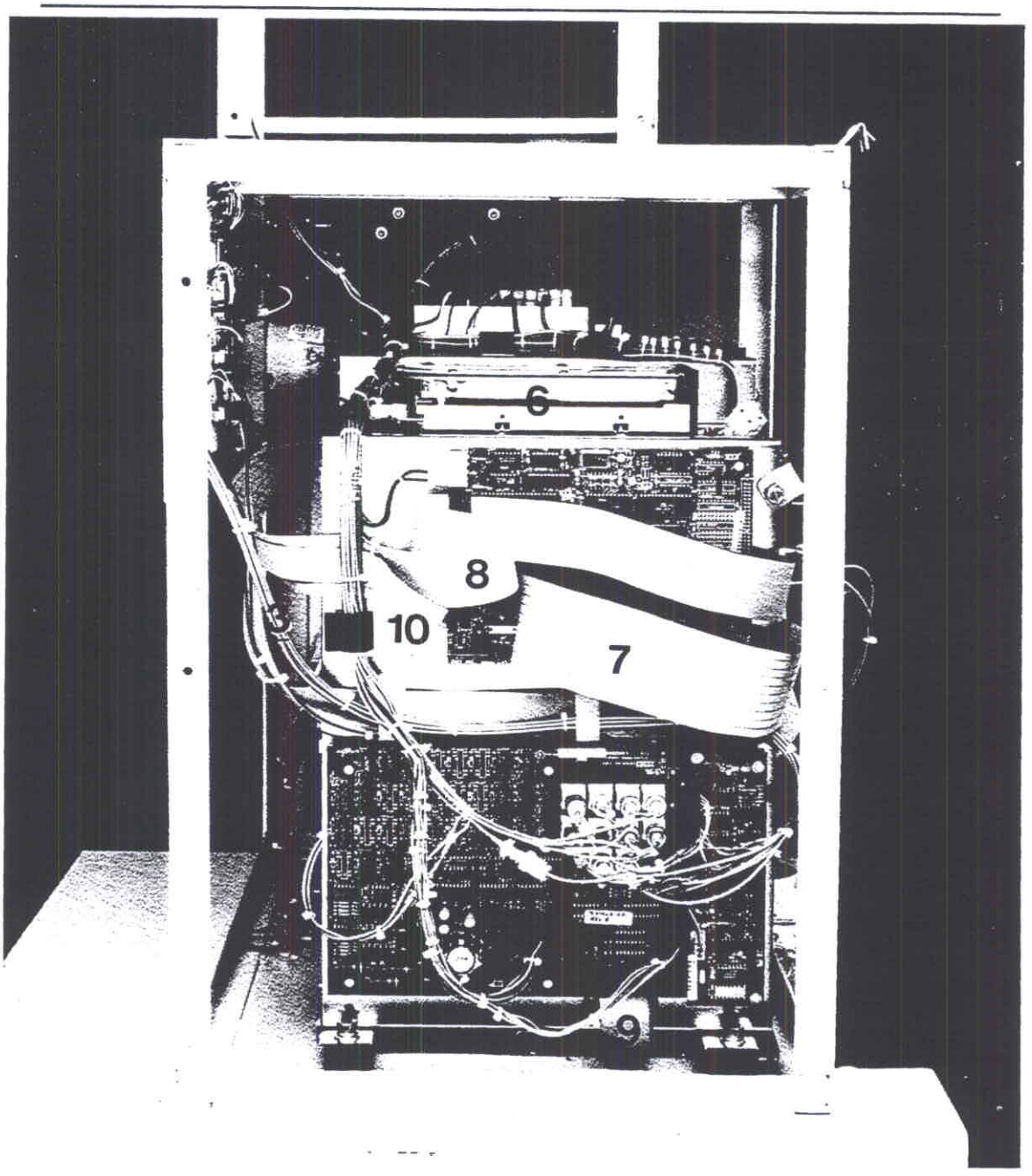
Lower Electronics, Front View **Fig. 5**

Fig. 6 Monitor Cart

1.	OMTI disk controller PCA	00-900079
2.	cable asm, AUX	00-870117
3.	cable asm, RS232	00-870118
4.	asm, PCB, I/O DIST/VIDEO SW	00-870187
5.	sync-separator PBC	00-870545
6.	disk drive, winchester, 1/2 height	00-900077
7.	cable asm, 50 pin ribbon	00-870024
8.	cable asm, disk control	00-870121
9.	cable asm, image processor interface	00-870119
10.	cable asm, disk data	00-870120

Lower Electronics, Side View

Monitor Cart



Lower Electronics, Side View **Fig. 6**

SECTION 8
MONITOR CART
SERVICE AND DIAGNOSTICS

8.1 Safety Precautions During Service

Read the Safety section of this manual before attempting any service procedures which require removal of the electronics covers.

WARNING **Use extreme care if you must perform adjustments or tests on the electronics when power is applied.**

8.2 Monitor Cart Progress and Error Codes

The alphanumeric display on the monitor cart front panel will display error codes when faults occur with the monitor cart electronics. These are listed and described below.

8.2.1 Boot Progress Codes

During the software loading or boot process, the alphanumeric LEDs on the front panel will display "b" codes, indicating where in the boot sequence, code is being executed. Since these codes do not normally indicate an error, they are referred to as *progress codes*. Typically, these codes will be erased once normal program operation has begun. If the program does not complete the boot process, a "b" code will remain on the LED display, indicating the point where an error occurred. The meaning of each "b" code is described below.

b0 - Initial start from address 0000H.
b1 - Attempting to load from floppy disc drive
(may be connected during service or software installation).
b2 - Attempting load from hard drive.
b3 - Boot load failed.
b4 - Cold boot program loaded, attempting to load DOS.
b5 - DOS loaded.
b6 - SEARCH.COM has been loaded and is searching for the number of the last image saved to the hard disk.
b7 - SEARCH.COM has successfully completed the search.

8.2.2 Initialization Progress Codes

Once the main program has been loaded, a series of "A" progress codes will be displayed. When initialization is completed, the "A" code will be erased and the next available image location will be displayed. Each "A" code which occurs during the initialization process is defined below.

A1 - Overlay manager is loaded.
A2 - Memory is being initialized.
A3 - Video relays are being initialized.
A4 - Image Processor PCB is being initialized.
A5 - Initializing X-Ray system communications.
A6 - Initializing internal software error handler.
A7 - Initialize gray scales and log RAMS.
A8 - Initialize VTR.
A9 - Initialize HELP function.

8.2.3 Hard Disk Drive Error Codes

During initialization or program execution, unrecoverable hard disk errors may occur. An error will be reported on the monitor cart front panel LED display. "d" codes that might appear during initialization or operation of the system are described below.

d0 - No image was found at the location specified during a hard disk image recall. This is a user error which does not indicate a malfunction.
d2 - Cannot find the requested data block.
d3 - A bad data block was encountered.
d4 - A formatting error occurred.
d5 - The drive cannot find its alternate track.
d6 - A Disk Controller PCB time out error occurred.
d7 - An internal software error was detected.
d9 - The hard disk is not ready.
dA - A drive error occurred.
dB - A Disk Controller PCB error occurred.
dC - Attempting to recall an invalid image.
dD-dF - Reserved for future use.

8.2.4 Program Errors

Operator and program errors are displayed on the front panel. The following error codes all occur during execution of the main program:

ERROR: **E1**
CAUSE: The front panel has not responded to the host processor over the serial communication link.
CHECKS: Observe the serial data lines between the host and the front panel. Verify that the front panel software is correct and that the processor is running.

ERROR: **E2**
CAUSE: Repeated NAK response from the front panel to the host processor.
CHECKS: Same as error E1.

ERROR: **E3**
CAUSE: Repeated invalid response from the front panel to the host processor.
CHECKS: Same as error E1.

ERROR: **E4**
CAUSE: Image processor has not responded to the host processor over the serial communication link.
CHECKS: Check the serial data lines between the host and IP. Verify that the IP software is correct and processor is running.

ERROR: **E5**
CAUSE: Repeated NAK response from IP to the host processor.
CHECKS: Same as error E4.

ERROR: **E6**
CAUSE: Repeated invalid response from the IP .
CHECKS: Same as error E4.

ERROR: **E7**
CAUSE: X-ray System communications error.

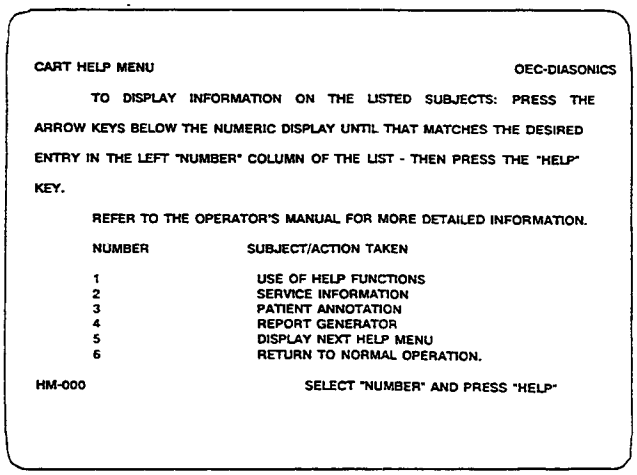
8.3 Monitor Cart Diagnostics Menus

The Diagnostics Menus provide access to:

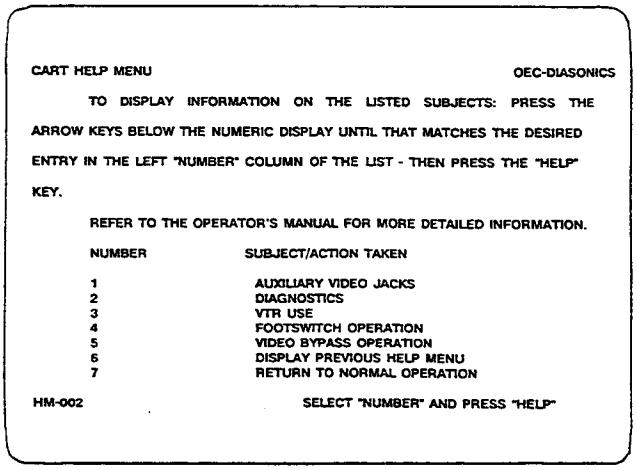
Front Panel Controlled Diagnostics
Terminal controlled Diagnostics

These are discussed in the following pages. The steps below describe how to select and use the Diagnostics Menus:

1. Press HELP HELP (HELP twice) to view the first menu, shown here. From this menu select entry NUMBER 5.

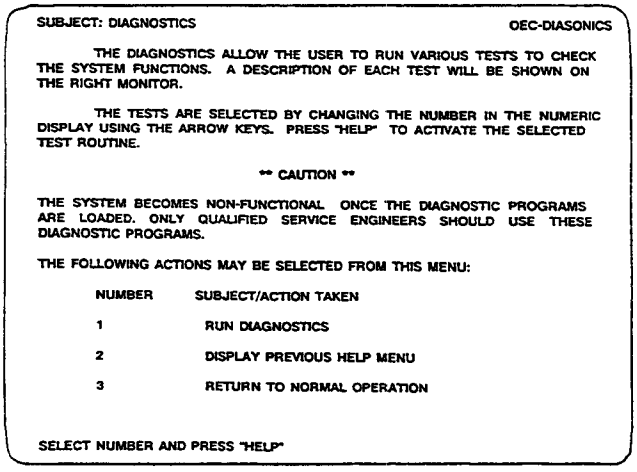


2. Select NUMBER 2 - DIAGNOSTICS and press HELP.



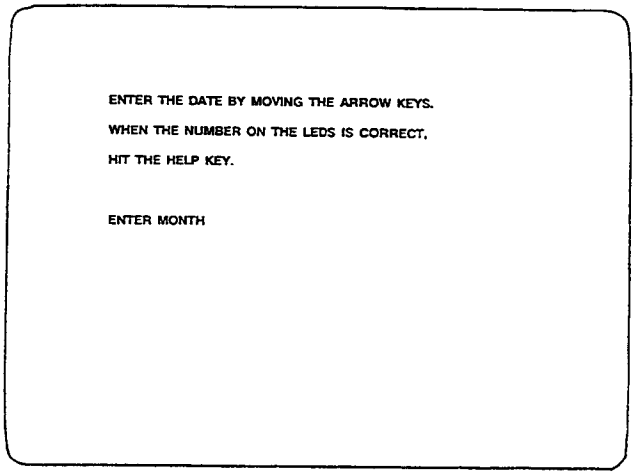
3. Select NUMBER 1 - RUN DIAGNOSTICS.

   The system cannot be operated for normal use when the diagnostic software is loaded. Only qualified service engineers should use these programs.

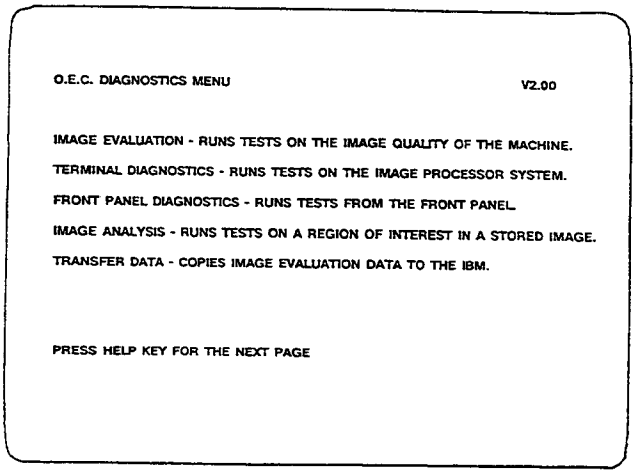


4. You are first asked to enter the date. Press the arrow keys, up or down, until the correct number is displayed on the LED readout. Then press HELP to complete the entry.

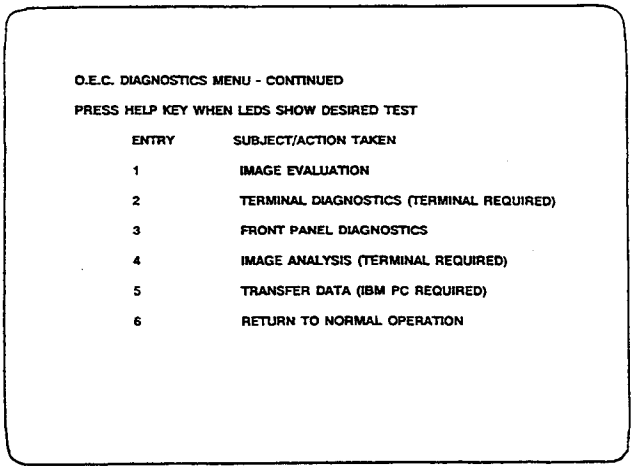
Enter the month.
Enter the day
Enter the year.



5. This help screen will appear with a brief description of the functions available in the next menu. Press HELP for the next screen.



6. Select the desired diagnostics from this menu. Each of the diagnostics is described in the following sections. Enter the number and press HELP. Entry NUMBER 6 will return you to normal operation.

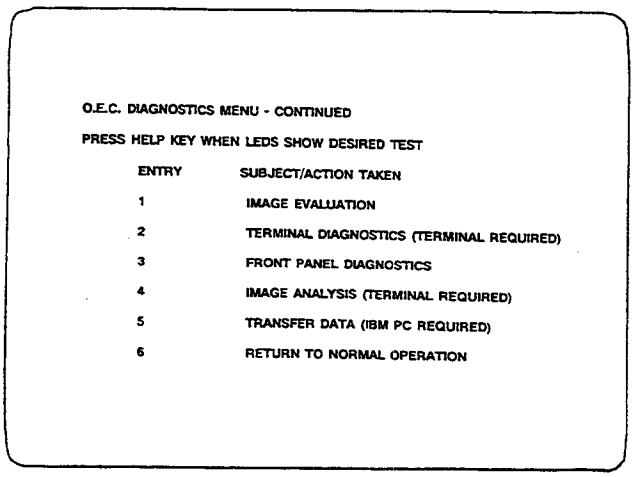


8.4 Front Panel Diagnostics

The Front Panel Diagnostics test the monitor cart electronics and are selected from the Front Panel Diagnostic Menu.

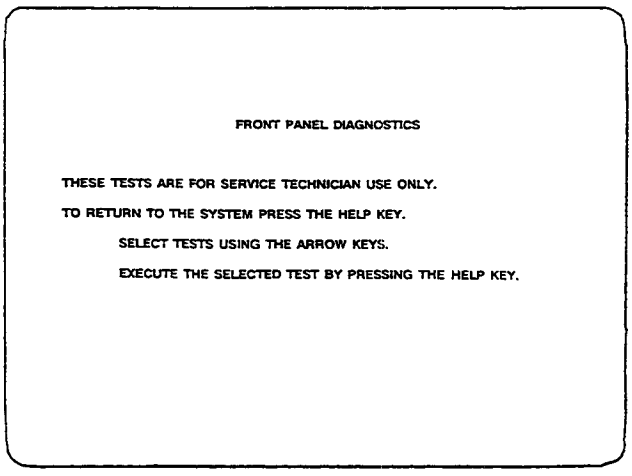
---

1. Select ENTRY 3 - FRONT PANEL DIAGNOSTICS from the Diagnostics Menu. (See above: *Entering the Diagnostics Menus*).



2. Refer to the list of Terminal Diagnostics given in the next section. These tests are identical, except where noted. (The cycle memory test #11, for example, is not available from the front panel).

3. Select the desired test number on the LED readout by using the arrow keys. Begin the test by pressing HELP.



8.5 Terminal Controlled Diagnostics

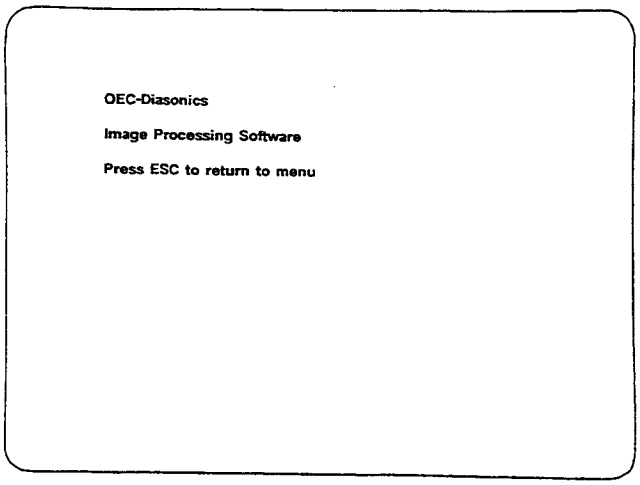
The Terminal Controlled Diagnostics test the monitor cart electronics. These same tests may be accessed from the front panel.

8.5.1 Using the Terminal Controlled Diagnostics

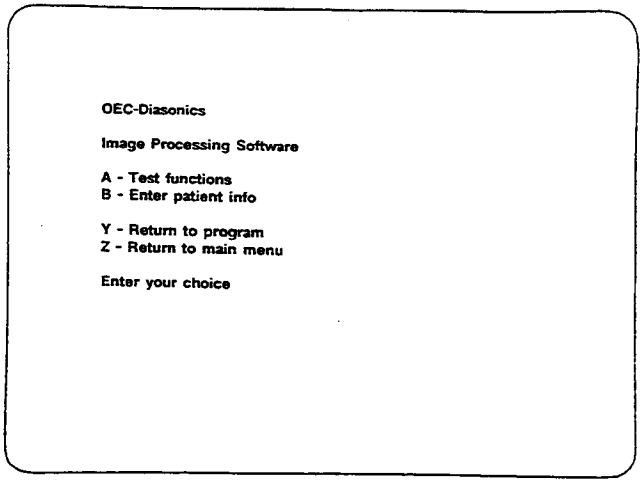
The Terminal Diagnostics require the use of an externally connected computer terminal. (Refer to the Appendix: *Terminal Installation and Use*).

---

1. Connect a terminal (such as the DXR keyboard terminal described in the Appendix), to the RS-232 connector on the rear of the monitor cart. The screen shown here will appear when the cart is booted. Press [ESC].

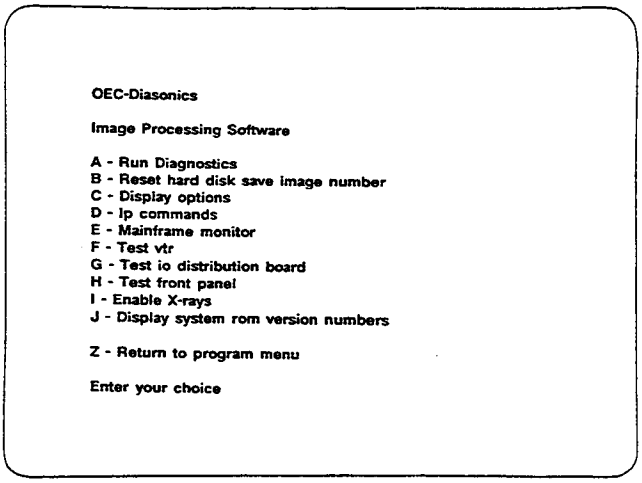


2. Select ENTRY A - TEST FUNCTIONS from the program access menu.



3. A list of choices will appear on the terminal screen (or the monitor screen if it is being used as the terminal).

Enter: A - RUN DIAGNOSTICS.



4. The following tests may be selected from the terminal screen. Type in the number and press [RETURN].

1 - Segment Ram Test	15 - Exchange M1 Data
2 - Memory Segment Read Test	16 - Exchange M2 Data
3 - Memory Segment Write Test	17 - Swap M1/m2 Data
4 - M1 Clear Test	18 - Left Monitor Live
5 - M1 Memory Test	19 - Left Monitor Digital
6 - M1 Exchange Test	20 - Select Gray Scale Val.
7 - M1/M2 Swap Test	21 - CRT Character Test
8 - M2 Clear Test	22 - Front Panel Test
9 - M2 Memory Test	23 - Video Test Pattern
10 - M2 Exchange Test	24 - Front Panel LED Test
11 - Cycle Memory Tests	
12 - Write Vertical Gray Scale	99 - return to system
13 - Write Horiz. Gray Scale	
14 - Invert M1 Data	

8.5.2 Explanations of the Terminal Diagnostics

This section briefly describes each diagnostic test. Note that options 1 thru 10 are memory tests that can be repeatedly cycled by selecting option 11. However, the cycle capability exists only when the external terminal is used. The front panel diagnostics will automatically jump over option number 11 (and option 20 which is also limited) while scrolling through the options.

Most tests listed below may be performed in any order required. The Video Test Pattern is one of the tests included in this group.

The order in which the memory tests are listed is the order in which they should be run. Their order must be followed since an error in a prior test will make the next test useless.

Error Messages - The errors that are detected during these tests are displayed in different ways depending on how the tests were originated. When using the terminal oriented diagnostics it is possible to relay more information about the error condition to the terminal than it is using the front panel diagnostics. The front panel diagnostics assume that there is not a terminal interfaced to the system, so all error messages are displayed on the front panel LED display. The first character of the display will be an "E" and the second digit will be a hex value between 0 and F that corresponds to the error found. If the error condition is a number greater than 15 (or F hex) then an F will be displayed. The cycle test mode also restricts the amount of error information displayed.

1- SEGMENT RAM TEST

This test first writes AA hex to every address in the segment ram. Each line is then read into a 512 byte buffer that was previously cleared to 0's. If each byte of the buffer now contains AA hex, then the same test is performed using 55 hex.

Error messages- In the terminal diagnostic mode text messages indicate the number of errors encountered for each bit mask. The cycle test returns 1 error for each bit mask test that failed, for a possible total of 2 errors per pass. The front panel diagnostics will return an error code of "E1" if any error occurred, or an error code of "E0" if no errors were detected.

2- MEMORY SEGMENT READ TEST

The function of this test is to verify that a segment can be read from the memory M1. This is accomplished by filling a 16k byte block of dram with the value FF hex (this sets all bits to 1), then clearing the memory, reading segment #0 of M1 into the DRAM block that previously contained all 1's, and then checking to see that all memory bits were cleared to 0.

Error messages- The error value returned by this test indicates the number of bytes in the segment that remained uncleared. In the front panel diagnostic mode, an error value greater than 15 will be displayed as

an "F". In the cycle mode, any number of errors found will be counted as a single error per pass.

3- MEMORY SEGMENT WRITE TEST

This test is to verify that a segment of data can be written to the memory M1. First M1 is cleared, then a 16k byte section of DRAM is filled with the alternating bit pattern of 55 hex. The entire segment is written to memory M1 segment #0, then read back into dram and checked to see if every byte was properly written. The test is then repeated using the bit pattern AA hex.

Error messages - The error value returned by this test indicates the number of bytes in the segment that was found to contain a value other than that which was written to it.In the front panel diagnostic mode an error value greater than 15 will be displayed as an "F". In the cycle mode, any errors found will be counted as a single error per pass.

4- M1 CLEAR TEST

This test checks to see that a "clear frame" operation can be performed on memory M1. The hex value FF is written to an address in segment #0 of memory M1, and then a clear frame operation clears the entire 128k block. The address previously written to is then checked for a value of 0.

Error messages - This test returns an error of 1 if it failed, and 0 if it passed.

5- M1 MEMORY TEST (takes approximately 3.5 min)

This test alternates every bit of the frame and checks the result. First the value 55 hex is written to each byte of the frame, and then read back and verified. The same is done using the hex value AA.

Error messages- Using the terminal diagnostics, an error message statement is returned for each segment declaring that either an error was found in that segment, or that the segment memory checked out OK. In the front panel test mode an error code of "E1" indicates that the failure occurred during the first pass when the hex value 55 was written, and an error code of "E2" means that the error was discovered when expecting to read back AA hex. In cycle mode the error value accumulated during a single pass indicates how many segment errors were found for both bit masks. For example, if the error total was incrementing by 32 for each cycle, that would indicate that all 16 segments had at least 1 error during both the AA and 55 bit tests.

6- M1 EXCHANGE TEST

This test verifies that the "exchange frame" function is working properly. When an exchange frame is performed on either M1, or M2, the address lines are changed so that the background frame becomes the foreground frame, and vice versa. First the hex value AA is stored in a single memory address in segment #0of M1. The foreground frame is then exchanged to the background, and the hex value 55 is stored in the new foreground frame. Another exchange frame is called which, if everything happened according to plan, should leave the AA back in the foreground memory.

After checking the AA, an exchange frame is called one more time, and the new foreground is checked for the 55 value that was stored there earlier. The same test is then repeated for the other 15 segments.

Error messages - In the terminal diagnostic mode, a message is displayed after checking each of the sixteen segments.The error message will either indicate that the segment checked out OK, or it will say that when it was expecting to read a hex value of ??, it in fact found a hex value of ??. In front panel mode, the error value represents the number of segments in which an error was encountered. In cycle mode, any errors are counted as 1 error per pass.

7- M1/M2 SWAP TEST

Because the only memory that can be read from, and written to directly is the foreground frame of M1, the M2 memories can only be accessed by swapping the information in M2 to M1. The result of a swap leaves the foreground of M2 in M1, and vice versa. The swap test first clears both M1 and M2 foreground memories, and then the value 55 hex is stored to a single address of segment #0, and written to M1. The entire frame is then swapped to M2, and a hex AA is stored in the same address of the cleared frame that is now in M1. A swap is performed again and a check is made to verify that the 55 was swapped back to M1. Once more a swap is performed and this time an AA is expected in M1.

Error messages- During the terminal diagnostic test an error message will be displayed indicating the result of the test. In front panel mode an error code "E1" means that an error was detected while trying to read the 55 hex, an "E2" means that the failure occurred when the AA was expected, and an "E3" indicates that both failed. Cycle mode returns a single error per pass if any errors occurred.

8- M2 CLEAR TEST

This test checks to see that a "clear frame" operation can be performed on memory M2. The hex value FF is written to an address in segment #0 of memory M1, then swapped to M2. M2 is then cleared using a clear frame operation, and swapped back to M1 to be checked for any bits that were not cleared.

Error messages- This test returns an error of 1 if it failed, and 0 if it passed.

9- M2 MEMORY TEST (takes approximately 3.5 min)

This test alternates every bit of the frame and checks the result. First the value 55 hex is written to each byte of the M1 frame, swapped to M2, swapped back to M1, read back and verified. The same is done using the hex value AA.

Error messages-Using the terminal diagnostics, an error message statement is returned for each segment declaring that either an error was found in that segment, or that the segment memory checked out OK. In the front panel test mode the an error code of "E1" indicates that the failure occurred during the first pass when the hex value 55 was written, and an error code of "E2" means that the error was discovered while expecting to read back AA hex. In cycle mode, the error value

accumulated during a single pass indicates in how many segments errors were found, for both bit masks. For example, if the error total was incrementing by 32 for each cycle, that would indicate that all 16 segments had at least 1 error during both the AA and 55 bit tests.

10- M2 EXCHANGE TEST

This test verifies that the "exchange frame" function is working for the M2 frames. First the hex value AA is stored in a single memory address in segment #0 of M1, and then M1 is swapped to M2. The foreground frame of M2 is then exchanged to the background. The hex value 55 is then stored in M1 and then swapped to M2. Another exchange frame is called, which should leave the AA back in the foreground memory of M2, with 55 in the background frame. After checking the AA, an exchange frame is called for M2, and the new foreground is checked for the 55 value that was stored there earlier. The test is repeated for the other 15 segments.

Error messages - In the terminal diagnostic mode, a message is displayed after checking each of the sixteen segments. The error message will either indicate that the segment checked out OK, or it will say that when it expected to read a hex value of xx, it instead read a hex value of yy. In front panel mode, the error value represents the number of segments in which an error was encountered. In cycle mode, errors are counted as 1 error per pass.

11- CYCLE MEMORY TESTS

The cycle mode repeats the memory tests, keeps track of the number of cycles performed, and accumulates the number of errors. This type of test is especially useful in tracking down system failures that are intermittent, or of a thermal nature. One useful feature of this mode is the ability to select the tests to be included in the cycle, while ignoring the others.

NOTE: Most of the following tests write data to the foreground of memory M1. Although it is not possible to write data directly to M2, a "SWAP M1/M2" (option 16) allows any data in M1 to be swapped into M2.

12- WRITE VERTICAL GRAY SCALE

A vertical gray scale is written to M1.

13- WRITE HORIZONTAL GRAY SCALE

A horizontal gray scale is written to M2.

14- INVERT M1 DATA

Inverts the data in the foreground of M1 byte by byte.

15- EXCHANGE M1 DATA

Exchanges the foreground memory of M1 for the background memory by switching address lines.

16- EXCHANGE M2 DATA

Exchanges the foreground memory of M2 for the background by switching address lines.

17- SWAP M1/M2 DATA
A processing function of the Image Processor swaps the data in the foreground memory of M1 with the data currently in the foreground memory of M2.

18- DISPLAY LEFT MONITOR LIVE
The left monitor displays a live non-digitized picture, and the system allows X-rays. X-rays are disabled upon exiting this option.

19- DISPLAY LEFT MONITOR DIGITAL
The left monitor displays a digitized picture, and the system allow X-rays. X-rays are disabled upon exiting this option.

20- SELECT GRAY SCALE VALUE
This option allows the technician to choose what gray scale value to write write to M1. The system allows a value between 0 (black) and 200 (white).

21- CRT CHARACTER TEST
A block of text characters is written to M1 which can be used to verify that the monitors have been set up properly, allowing all text lines to be clearly visible.

22- FRONT PANEL TEST
Using the terminal diagnostics, the scan codes for each front panel key is displayed on the terminal when each key is pressed. With the front panel diagnostics the scan codes are displayed as hex values on the LED display.

23- VIDEO TEST PATTERN
This test draws a special video test pattern to M1, and uses that pattern on M1 as a mask to do a digitized subtraction on M2. X-rays are allowed during this option so that the camera can be properly centered. The instructions to the technician for aligning both the monitors and the camera are written to the monitors along with the pattern. X-rays are disabled upon exiting this mode.

24- FRONT PANEL LED TEST
The front panel LED test turns on all of the front panel LED's. The LED`s are all turned off again when the test is exited. When this test is initiated using the front panel diagnostics, the "HELP" key LED will flash to remind the technician how to exit this mode.

99- RETURN TO SYSTEM
Places the system at the diagnostics menu, where Return to System can be selected, returning normal operation with the same defaults and parameters used to begin with at power-up.

8.6 Monitor Cart Terminal Mode

The Terminal Mode requires the use of an externally connected computer terminal. (Refer to this in the Appendix under *Terminal Installation and Use*).

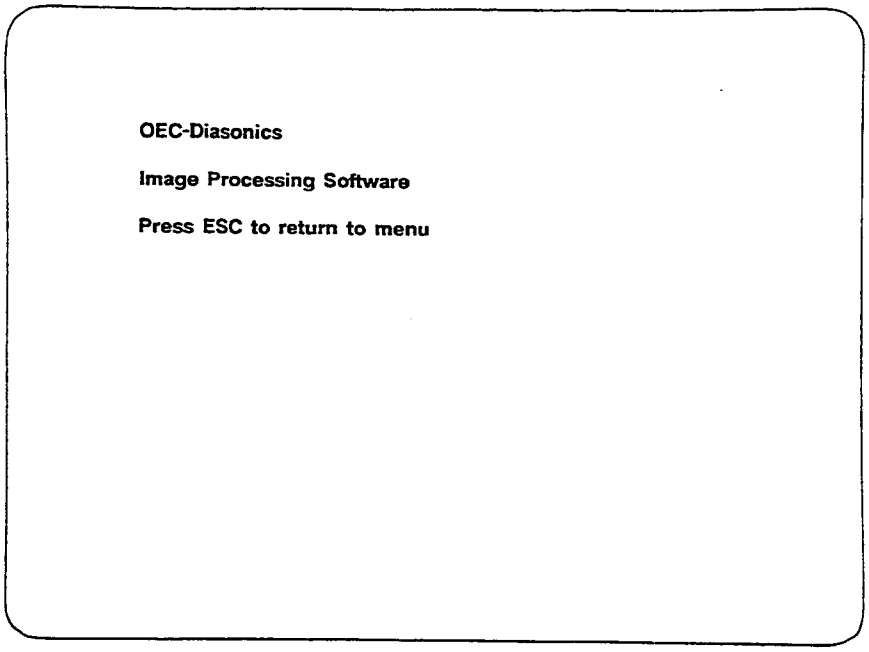
Some menu entries are passcode protected. Each attempt to select one of these protected entries generates an access code. A passcode is then required to unlock each access code. A new access code is generated with each access.

The major screen menus which can be accessed with a terminal are shown below.

8.6.1 Initial Menus

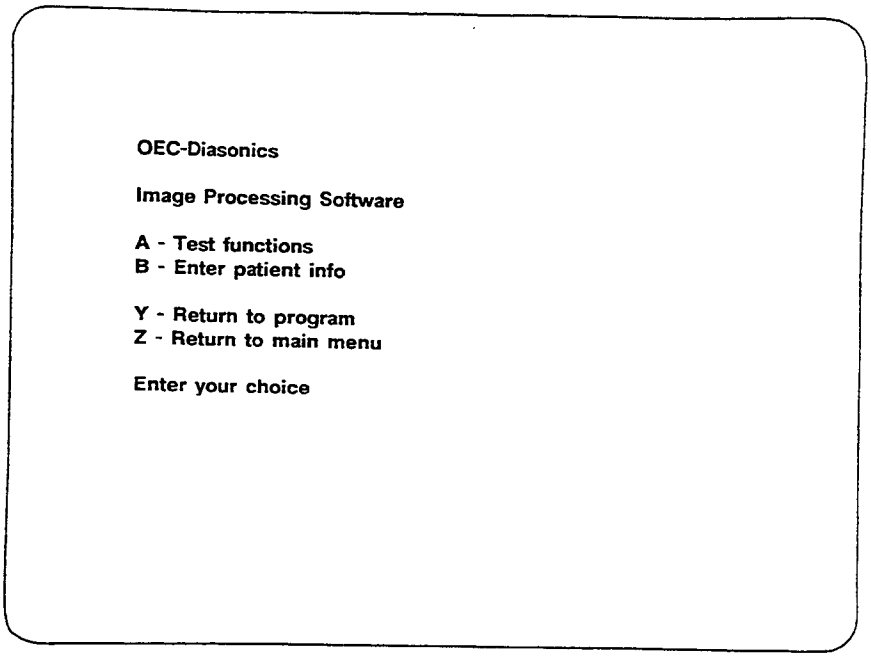
8.6.1.1 Powerup Screen Message

The powerup screen first appears when the terminal is turned on.



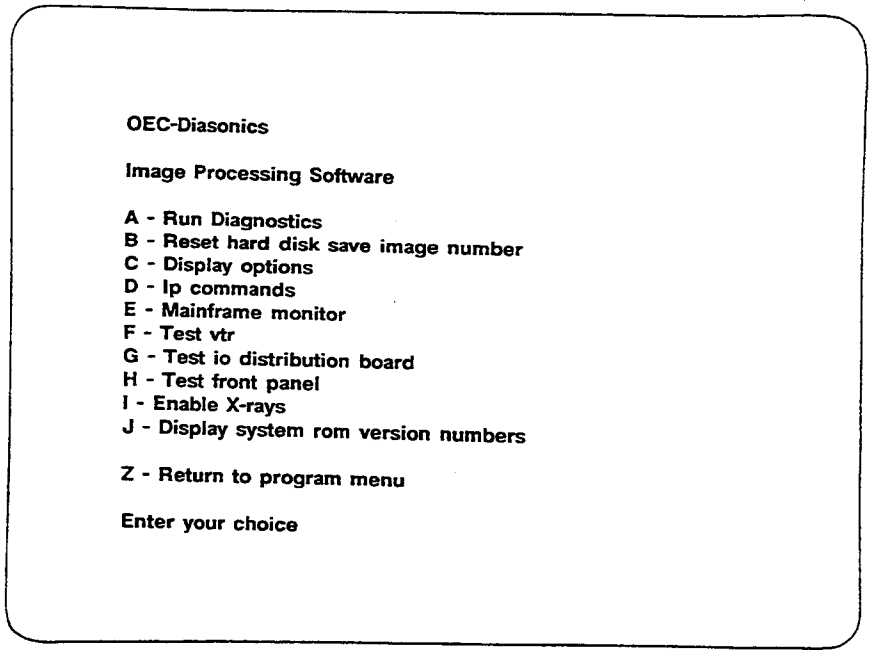
8.6.1.2 Program Access Menu

Press [ESC] for the Program Access Menu.

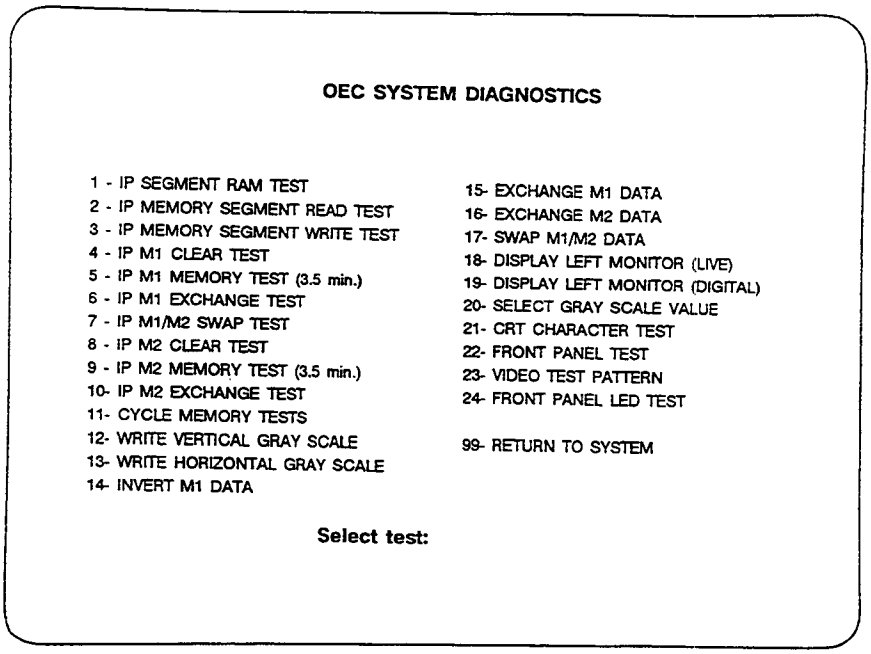


8.6.2 Test Function Menu

This menu lists test functions.

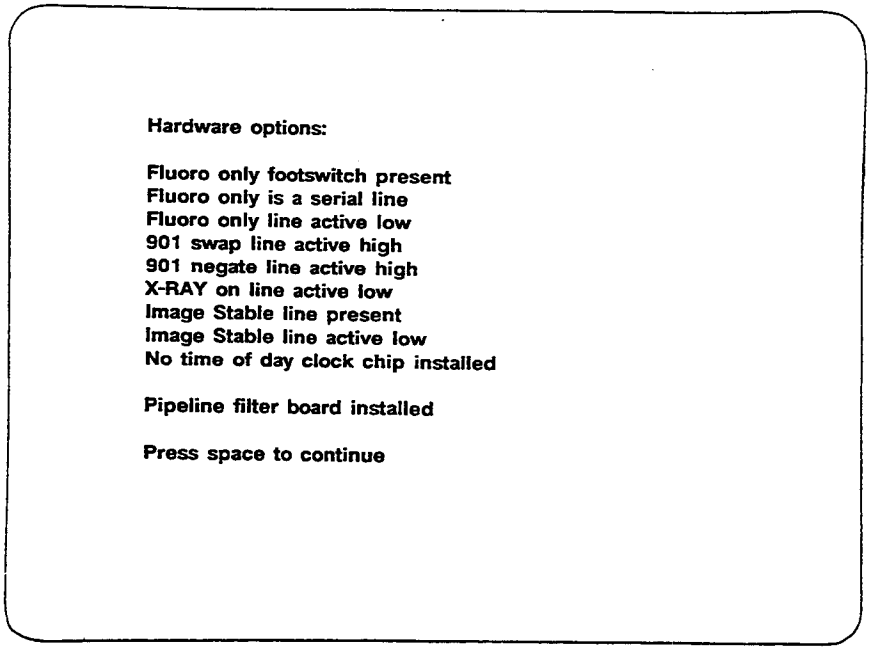


8.6.2.1 Run Diagnostics

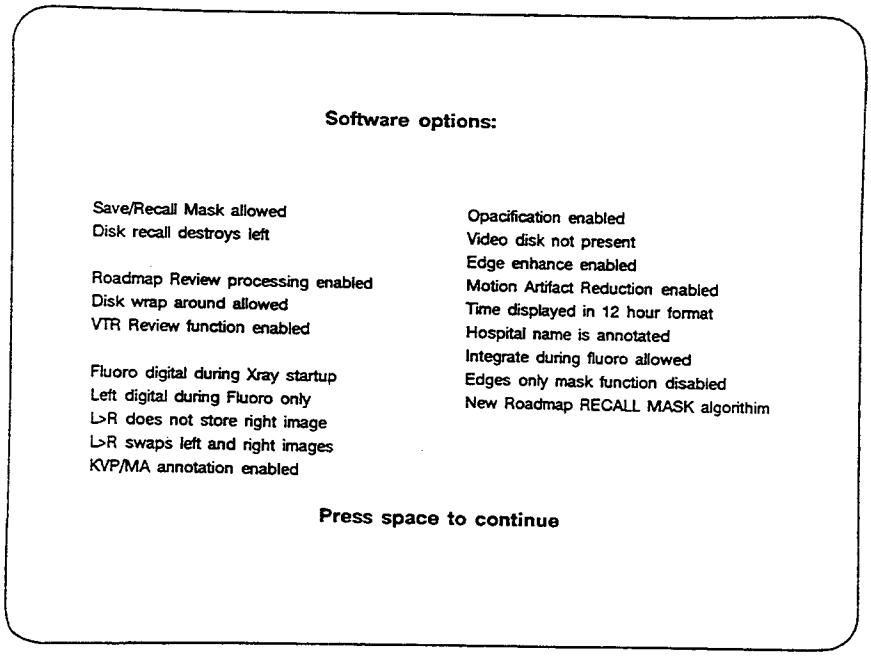


8.6.2.2 Display Options

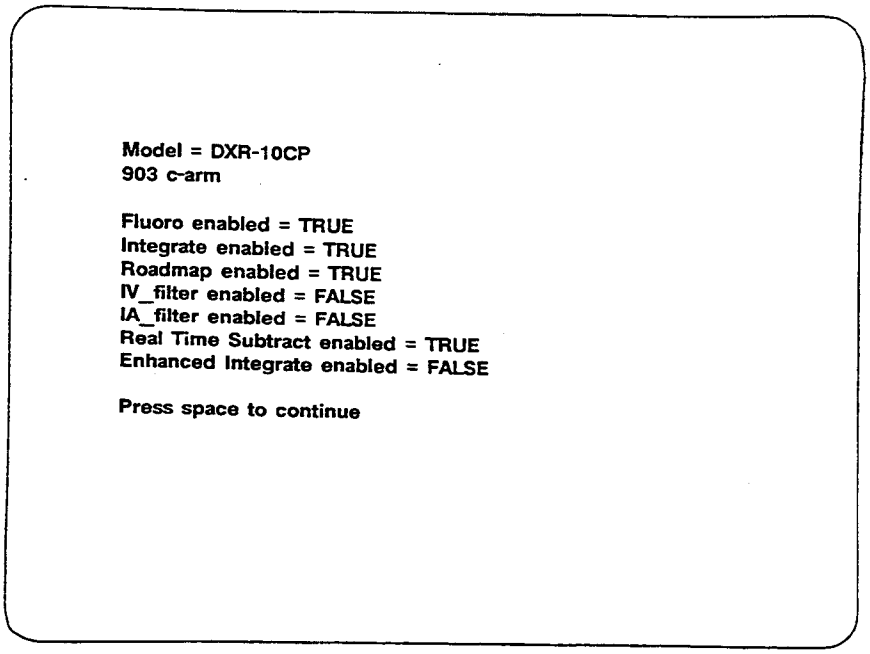
Hardware Options



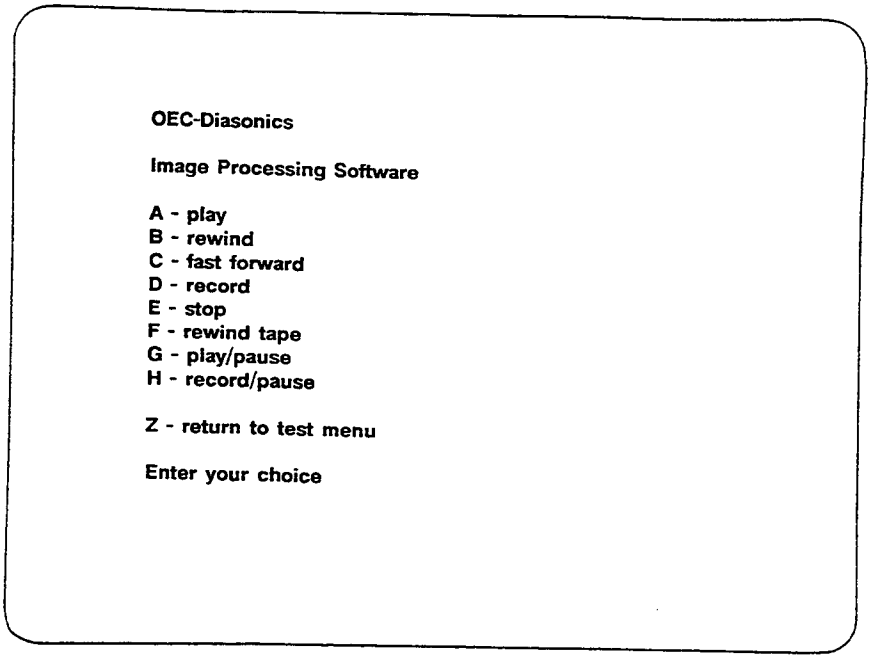
Software Options



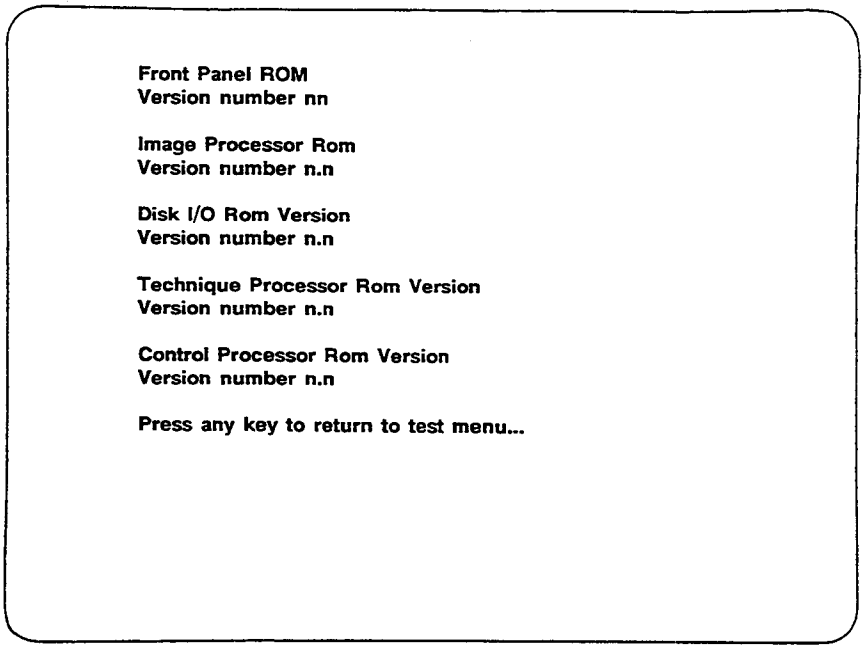
More Software Options



8.6.2.3 Test VTR



8.6.2.4 Display ROM Version Numbers



8.6.3 Main Menu

This menu can be accessed directly from the Program Access Menu.

```
OEC-Diasonics
System Software Manager
System ID Code:

A - Run Applications
B - Change system options
C - Run Diagnostics
D - Reboot to floppy disk
E - Load system software
F - Modify Terminal installation
G - Run Image Analysis
H - Examine shot log file
I - Erase shot log file
J - Transfer image files

Y - Access mainframe menu (903 only)
Z - Exit to DOS

Please make a selection:
```

8.6.3.1 Change System Options

```
OEC-Diasonics
Option change and display program
System Part No:

A - Hardware options
B - Software options
C - Mode options
D - Set power up default mode
E - Screen storage definitions
F - System relay definitions
G - Other byte options
H - Model number
I - Serial number

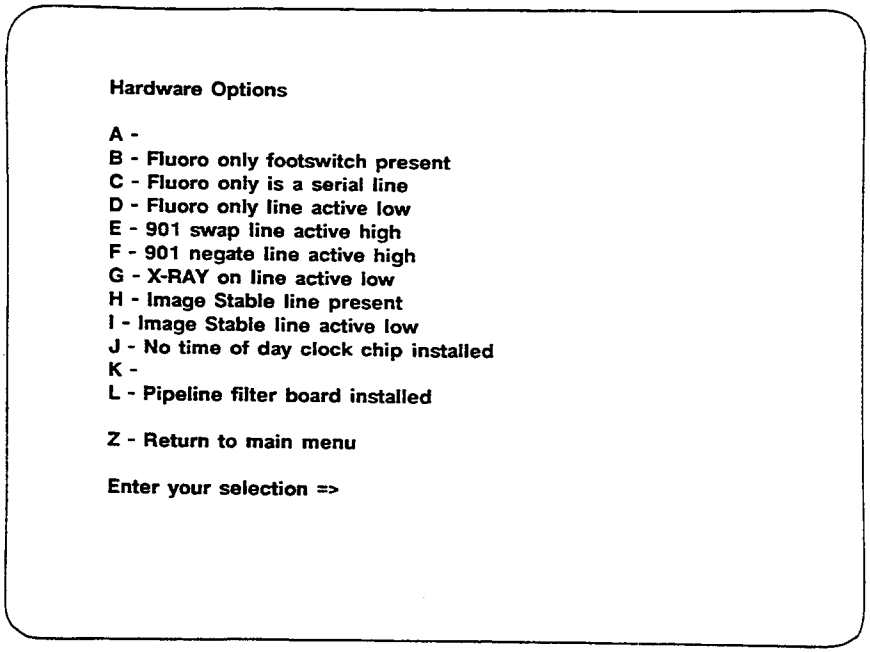
J - Hospital name

L - C-arm model number

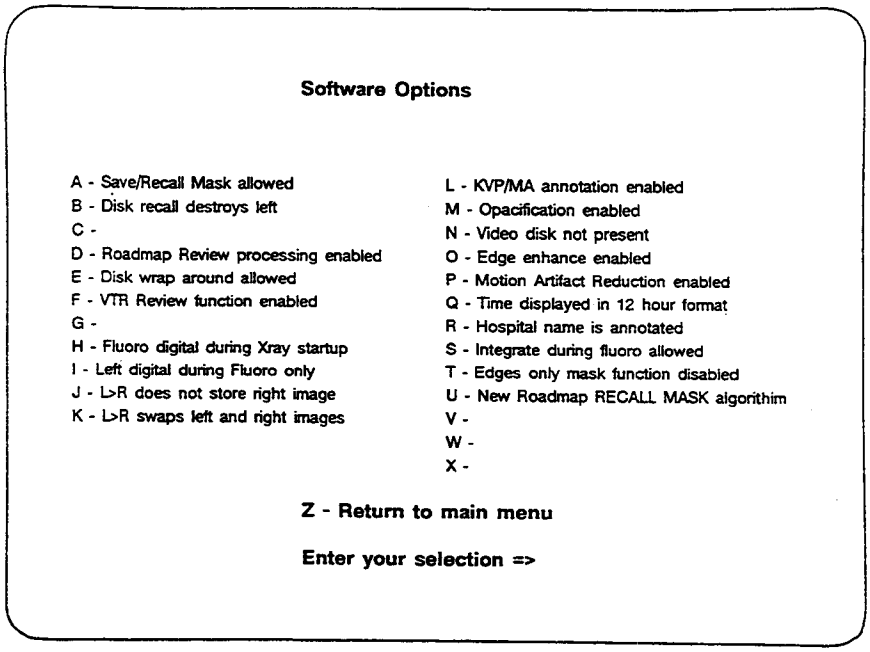
Y - Abort program, make no changes
Z - Exit program and update changes

Enter your selection =>
```

Hardware Options



Software Options



Mode Options (example)

```
Fluoro ENABLED

A - Enable Fluoro
B - Disable Fluoro
C - Change Fluoro default parameters

Z - Next processing mode

Enter your selection =>
```

Mode Options (example)

```
Integrate ENABLED

A - Enable Integrate
B - Disable Integrate
C - Change Integrate default parameters

Z - Next processing mode

Enter your selection =>
```

Set Powerup Default Mode

```
Current Power Up Mode = Fluoro

A - Fluoro
B - Integrate
C - Roadmap
D -
E -
F - Real Time Subtract
G -
H -

Z - No change

Enter your selection =>
```

Screen Storage Definitions

```
A - Pixels per scan line = 512
B - Scan lines per field = 240
C - Save and Recall start even field line number = 2
D - Save and Recall start odd field line number = 2
E - Display is    Interlaced

Z - Return to main menu

Enter your selection =>
```

System Relay Definitions

```
A - Normal closed relay setting
  = [K24,K22,K15,K7]
B - Normal video relay setting
  = [OUT,K30,K25,K22,K15,K8,K1,]
C - Xrays on relay setting
  = [OUT,K30,K24,K22,K15,K8,K1,]
D - Process video tape relay setting
  = [OUT,K30,K25,K15,K8,K4]
E - Review video tape relay setting
  = [OUT,K30,K25,K15,K10]
F - Process video disk relay setting
  = [K30,K25,K15,K8,K4]
G - Review video disk relay setting
  = [K30,K25,K15,K10]
Z - Exit

Enter your selection =>
```

Other Byte Options

This list is several screens in length and scrolls up as you progress down the list.

```
Log scale factor = 128
Change it? (Y or N) N

Fluoro window scale factor = 255
Change it? (Y or N) N

Fluoro level scale factor = 255
Change it (Y or N) N

Subtract window scale factor = 255
Change it? (Y or N) N

Subtract level scale factor = 160
Change it? (Y or N) N

Max hard disk value = 60
Change it? (Y or N) N

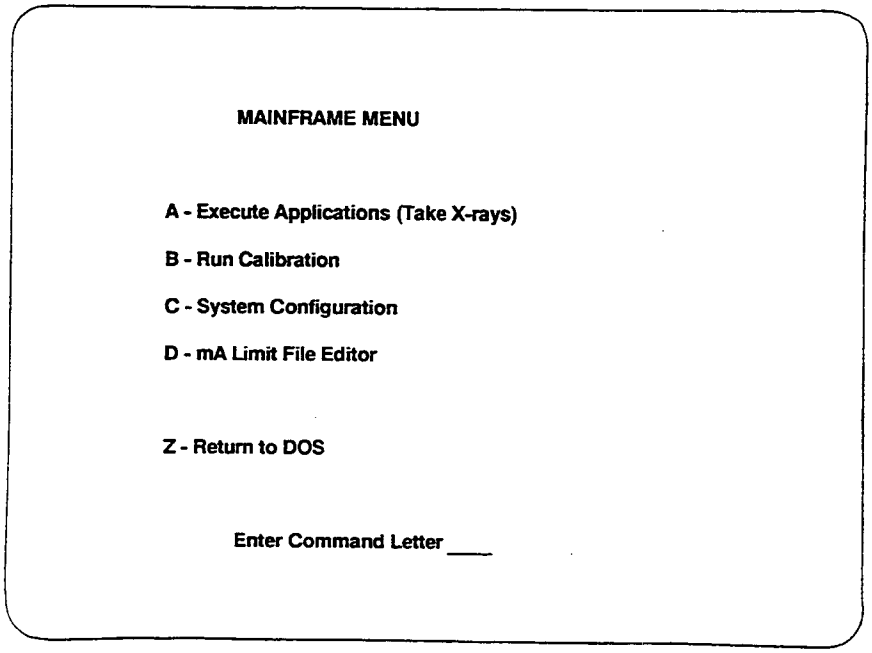
Subtract stable delay = 240
Change it? (Y or N)
```

8.6.3.2 Mainframe Access Menu

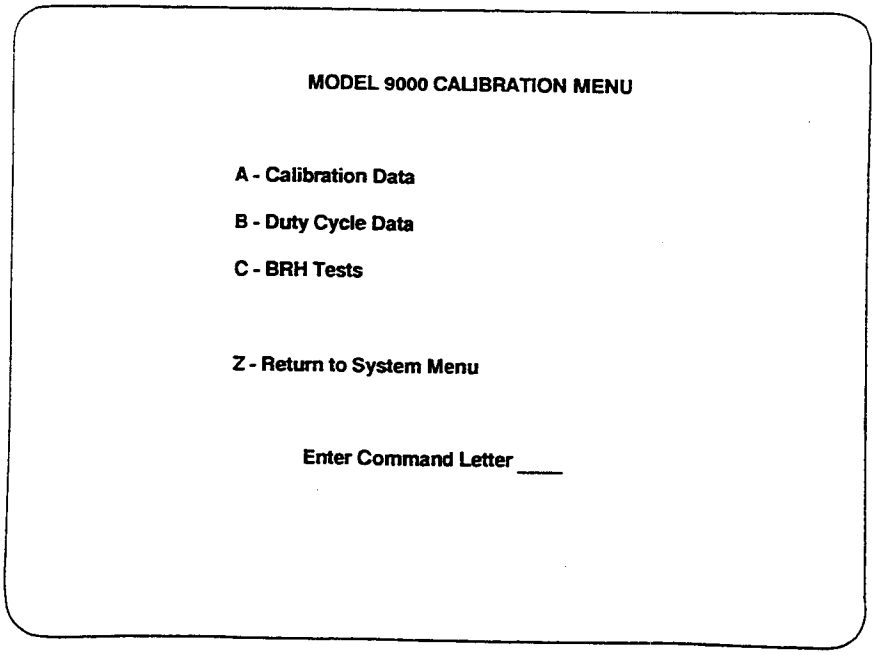
Select this menu from the monitor cart MAIN MENU.

When this menu is selected, the mainframe interlocks open to prevent X-rays.

To resume normal mainframe operation select "Execute Applications" from this menu.

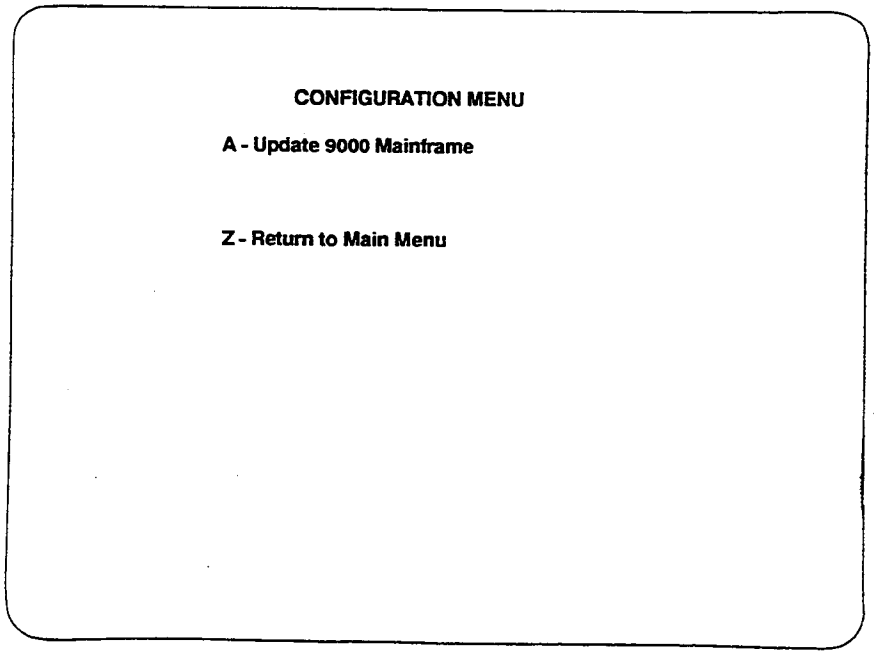


Model 9000 Calibration Menu



Configuration Menu

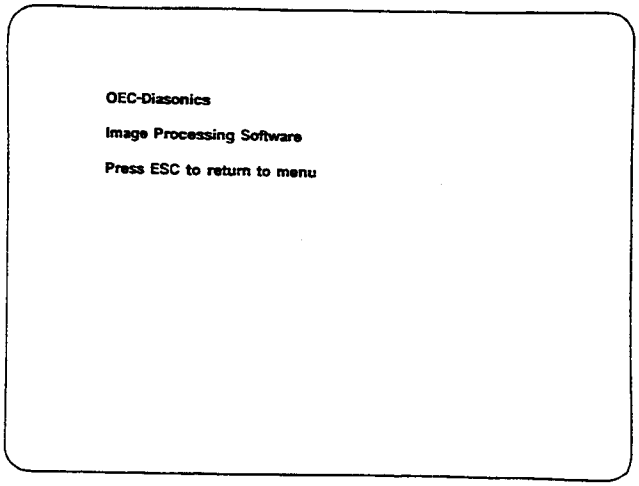
The Configuration Menu allows changes of boost operation and image tube size.



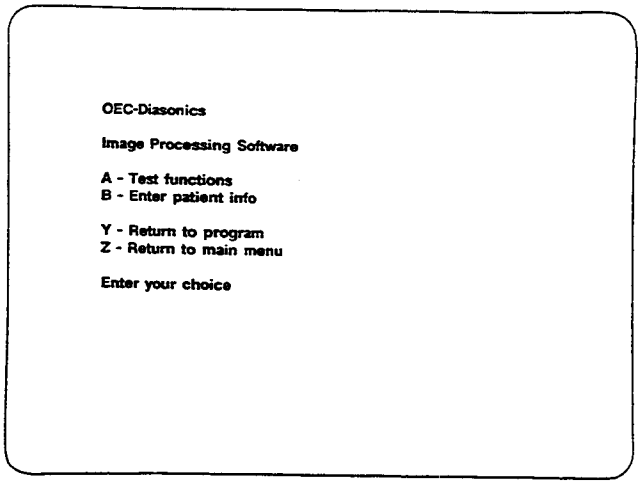
8.7 Examine Shot Log File

Shot Logging provides the field engineer with a record of the last 500 X-ray shots. This can be of value in evaluating X-ray tube history and performance.

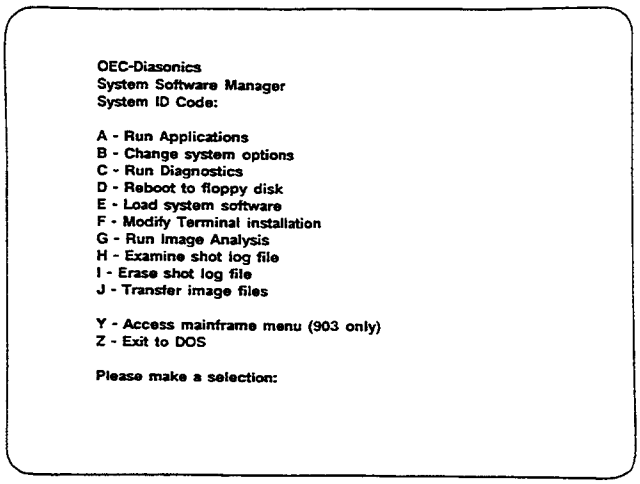
1. An external terminal must be connected to examine the shot log file. Press [ESC].



2. Enter [Z] and press [RETURN].

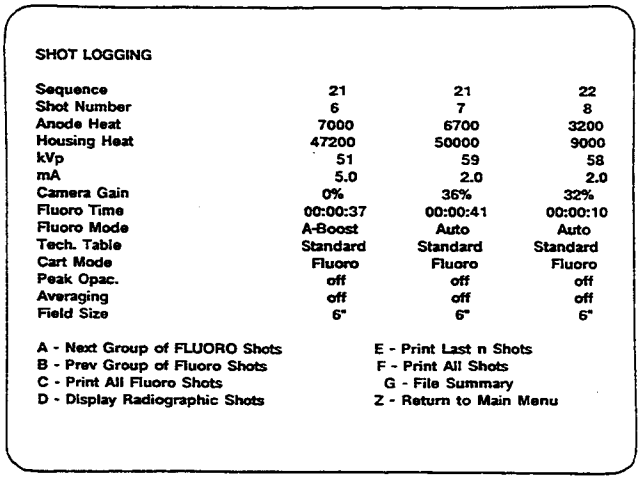


3. From the MAIN MENU, select entry [H] - EXAMINE THE SHOT LOG FILE.



4. A portion of the shot log file will appear on the screen with a command menu below.

From this menu enter:
C - Print all fluoro shots
E - Print last n shots
F - Print all shots
G - View overall shot summary
G, then P - Print shot summary



5. If a printout is desired, connect a printer using a printer cable such as P/N 870596 to the monitor cart AUX connector. Follow the instructions given in the Appendix for printer installation.

Figure 8-1 - *Here is a sample of a printout obtained by entering C - Print all Fluoro shots:*

10CPXXXX Cottonwood Hospital Page 1

Fluoro SEQ	Mode NUM	ANODE	HOUSING	KVP	MA	GAIN	ON-TIME	MD	CART-MODE	OPAC	AVG	FD
1	1	800	6500	61	2.2	36%	0:00:09	A	Fluoro	Off	Off	6"
2	1	400	19300	63	2.4	36%	0:00:05	A	Fluoro	Off	Off	6"
2	2	1400	21600	63	2.4	36%	0:00:13	A	Fluoro	Off	Off	6"
2	3	1300	27500	40	0.5	0%	0:00:13	A	Fluoro	Off	Off	6"
2	4	2000	29600	63	2.4	36%	0:00:19	A	Fluoro	Off	Off	6"
2	5	1400	45800	61	2.2	36%	0:00:22	A	Fluoro	Off	Off	6"
2	6	3000	50900	120	3.2	100%	0:00:29	A	Fluoro	Off	Off	6"
2	7	800	57800	40	0.5	0%	0:00:29	A	Fluoro	Off	Off	6"
2	8	3000	61300	40	15.0	0%	0:00:34	AB	Fluoro	Off	Off	6"
2	9	2900	61000	40	0.5	0%	0:00:47	A	Fluoro	Off	Off	6"
2	10	5500	66300	47	20.0	73%	0:00:51	AB	Fluoro	Off	Off	6"
2	11	13500	75800	47	20.0	44%	0:00:59	AB	Fluoro	Off	Off	6"
2	12	12900	79900	40	20.0	49%	0:01:01	AB	Fluoro	Off	Off	6"
2	13	23400	92500	40	20.0	73%	0:01:16	AB	Fluoro	Off	Off	6"
2	14	22300	95200	61	2.2	36%	0:01:24	A	Fluoro	Off	Off	6"
2	15	24100	98700	61	20.0	97%	0:01:26	AB	Fluoro	Off	Off	6"
2	16	32300	109300	61	20.0	88%	0:01:38	AB	Fluoro	Off	Off	6"
2	17	36000	119700	50	5.6	0%	0:01:49	AB	Fluoro	Off	Off	6"
2	18	37500	123600	42	20.0	58%	0:01:54	AB	Fluoro	Off	Off	6"
2	19	33700	130700	45	20.0	74%	0:02:00	AB	Fluoro	Off	Off	6"
2	20	29900	137300	120	3.2	100%	0:02:10	A	Fluoro	Off	Off	6"
2	21	29700	139100	62	2.3	36%	0:02:23	A	Fluoro	Off	Off	6"
2	22	28900	142600	64	2.5	36%	0:02:41	A	Fluoro	Off	Off	6"
2	23	17600	146600	62	2.3	36%	0:03:08	A	Fluoro	Off	Off	6"
3	1	0	11700	50	2.0	10%	0:00:00	P	Fluoro	Off	Off	6"
3	2	0	11700	50	2.0	43%	0:00:00	P	Fluoro	Off	Off	6"
3	3	0	11700	50	2.0	99%	0:00:01	P	Fluoro	Off	Off	6"
3	4	0	11600	50	2.0	99%	0:00:01	P	Fluoro	Off	Off	6"
3	5	0	11600	50	2.0	99%	0:00:02	P	Fluoro	Off	Off	6"
3	6	0	11600	50	2.0	99%	0:00:02	P	Fluoro	Off	Off	6"
3	7	0	11600	50	2.0	99%	0:00:03	P	Fluoro	Off	Off	6"
3	8	0	11600	50	2.0	99%	0:00:03	P	Fluoro	Off	Off	6"
3	9	0	11600	50	2.0	99%	0:00:04	P	Fluoro	Off	Off	6"
3	10	0	11600	50	2.0	99%	0:00:04	P	Fluoro	Off	Off	6"
3	11	0	11600	50	2.0	99%	0:00:05	P	Fluoro	Off	Off	6"
3	12	0	11600	50	2.0	99%	0:00:05	P	Fluoro	Off	Off	6"
3	13	0	11500	50	2.0	99%	0:00:06	P	Fluoro	Off	Off	6"
3	14	0	11500	50	2.0	99%	0:00:06	P	Fluoro	Off	Off	6"
3	15	0	11500	50	2.0	99%	0:00:07	P	Fluoro	Off	Off	6"
3	16	0	11500	50	2.0	99%	0:00:07	P	Fluoro	Off	Off	6"
3	17	0	13000	50	2.0	99%	0:00:08	P	Fluoro	Off	Off	6"
3	18	0	13000	50	2.0	99%	0:00:08	P	Fluoro	Off	Off	6"
3	19	0	13000	50	2.0	99%	0:00:09	P	Fluoro	Off	Off	6"
3	20	0	13000	50	1.5	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	0	13000	50	1.1	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	13000	50	0.7	99%	0:00:09	P	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	36%	0:00:08	A	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0:00:10	A	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Fluoro	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Off	Off	6"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6"

Figure 8-2 - *Here is a sample printout obtained by entering G - File Summary, then P - Print Summary.*

10CPXXXX Cottonwood Hospital Summary

Total shots..... 190
Total sequences..... 25

Highest Anode Heat.... 37500
Sequence.... 2
Number.... 18
Average Anode Heat.... 4301

Highest Housing Heat.. 146600
Sequence.... 2
Number.... 23
Average Housing Heat.. 34455

Total Radiographic Shots....9
Neo-Natal Shots....0

	0.3mm	1.0mm
Number of shots	9	0
Average KVP used	57	0
Average MAS used	43	0

Total Fluoro Shots.....181

	Auto	Manual	A-Boost	M-Boost	Pulsed	One-Shot
Number of shots	128	12	19	0	0	22
Average KVP used	66	80	52	0	0	50
Average MA used	2	4	15	0	0	2
Average GAIN used	39%	74%	29%	0%	0%	92%

Technique Table	Standard	Modified	Custom
Number of shots...	181	0	0

	Fluoro	Integrate	Roadmap	IV-filter	IA-Filter	Subtract
Number of shots	134	8	17	0	0	22
Opacified shots	0	0	1	0	0	0
Averaging Off	126	0	12	0	0	21
Averaging of 2	0	0	0	0	0	0
Averaging of 4	1	2	4	0	0	1
Averaging of 8	2	0	1	0	0	0
Averaging of 16	0	0	0	0	0	0
Averaging of 32	5	6	0	0	0	0
Averaging of 64	0	0	0	0	0	0
Averaging of 128	0	0	0	0	0	0

8.8 Monitor Cart Adjustments, Switches and Jumpers

8.8.1 I/O Distribution/Video Switch PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	OUT	Bit PA7
E4-E5-E6	OUT	Bit PA6
E7-E8-E9	E8-E9	Bit PA5 X-ray On
E10-E11-E12	E11-E12	Bit PA4 Video Stable
E13-E14-E15	E14-E15	Bit PA3 Store

Adjustment **Floppy Disk Voltage Adjustment**

Adjust R24 on this PCB for +12 VDC between TP19 and TP20.

8.8.2 AD/DA Converter PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Video buffer and sync separator
E4-E5-E6	E5-E6	Buffered Video select
E7-E8-E9	E8-E9	Video Sync Select

Adjustment **Circular blanking**

Vertical	R47, R45
Horizontal	R48, R50

Adjustment **Offset Adjustment**

(Adjust blanking level to 0 VDC)

Left video (P5) offset	R2
Right video (P6) offset	R1

8.8.3 Sync Separator PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Video Source Select

8.8.4 Image Processor PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2	IN	U8 Vertical Reset
E3-E4	IN	Timing Clock Output
E5-E6	IN	U8 Horizontal Reset
E7-E8	IN	A12
E9-E10	IN	A13
E11-E12	IN	A14
E13	OPEN	Ground
E14-E15-E16	E15-E16	No CPU Wait States

Adjustment **Gen-lock Adjustment**

1. Place scope probe on TP27 and TP5 (ground) and adjust C-6 for + 2.5 VDC.

2. Verify that the video is stable and displayed in the center of the circular blanking window.

8.8.5 Disk Interface PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E58-E59	IN	Reset Circuit
E53-E54	OUT	Reset Circuit
E21-E29		
E28-E36	E25-E33	1200 Baud, Front Panel and Mainframe
E37-E45		
E44-E52	E41-E49	1200 Baud, External Ports
E17-E18-E19	E17-E18	DTR handshaking
E55-E56-E57	E56-E57	X-ray disable pullup
E62-E63-E64	E62-E63	DRAM Controller Reset

Disk Interface U8 DIP Switch Settings

(1=on 0=off)
8 7 6 5 4 3 2 1

1	autoboot
0	use DMA
1	50 Hz operation
0	60 Hz operation
0	1024 bytes/sector
x	reserved
0 0 0	Miniscribe HD
0 0 1	Fujitsu
0 1 0	Tandon, IMI, Seagate

8.8.6 Pipeline Filter PCB

JUMPER	*SHOULD BE*	*FUNCTION*
E1-E2-E3	E1-E2	Memory Out Disable

8.8.7 Remote Contrast/Brightness PCB

Set the following jumpers according to the type of monitor installed.

DATA-RAY MONITOR	*ELSTON MONITOR*
E2	E1
E7	E8
E5	E6
E3	E4

8.9 Formatting the Hard Disk

If the Hard Disk requires formatting (after replacement or because of a format problem) follow this procedure:

CAUTION **Formatting the hard disk will erase all data and programs. The monitor cart is then unusable until the software has been recopied from a source floppy disk.**

1. Connect an external computer terminal to the serial communications connector on the rear of the cart. Follow the instructions for using the external keyboard and monitor found in the Appendix.

2. Follow the instructions in the Appendix for installing the external floppy disk drive.

3. Insert the system floppy disk into the floppy drive.

4. Format the hard disk using the following menu sequence:

   (ESC) Select Program Menu
   (Z) Return to Main Menu
   (D) Create Hard Disk System

5. Enter the correct hard disk model, the correct line frequency, and hit the RETURN key. The hard disk will be formatted and system information will be copied to it. This takes about 20 minutes to complete.

6. After the format and copy sequence is complete, turn the video circuit breaker off. Disconnect and remove the floppy drive.

7. Turn the video circuit breaker on again and verify that the system will boot from the hard disk.

8. Enter the model number at the terminal using the following menu sequence:

   (ESC) Select Program menu
   (Z) Return to Main Menu
   (B) Change System Options
   (G) Model Number

9. After entering the correct access code, enter the model number. Access Codes are available by telephoning 800-453-8412.

10. Select (H) Serial Number. After entering the correct access code, enter the serial number of the machine.

11. Exit the main menu (Z) and update the changes made in the last two steps.

SECTION 4
MONITOR CART
THEORY OF OPERATION

This section provides technical descriptions of the hardware and software used in the OEC-Diasonics Mobile C-arm Imaging System. The purpose is to assist the service technician or field engineer in understanding the maintenance and calibration procedures in this manual.

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

The software plays a central role in the operation of the system. Therefore discussion of software is combined with the theory of operation of the hardware in this section.

4.1 Major Components and Options

4.1.1 Major Components

Figure 4-1 is a block diagram showing the major components and some options available on the monitor cart. The major control, data, and address busses within the system are illustrated. The bit width of these busses is indicated in parentheses. The serial links employ subsets of standard RS-232 serial interfaces.

The monitor cart contains the following major components:

Disk Interface PCB - coordinates image and data transfers between the system hard disk and memory; also programs image processing operations.

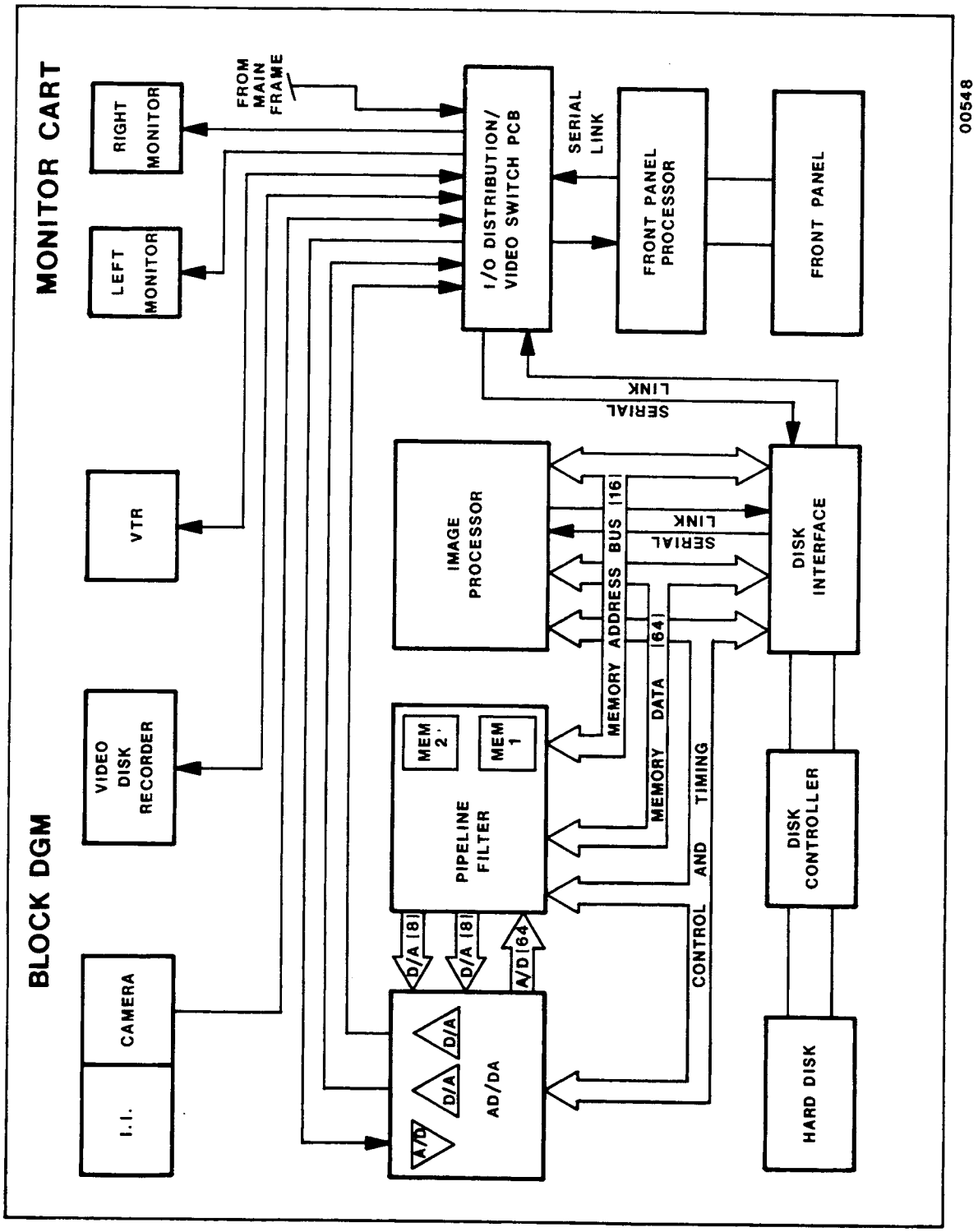
Front Panel Processor Assembly - consists of the control panel switches, LEDs, and the Front Panel Processor PCB.

Image Processor PCB - a board level microcomputer that controls the special functions of the digital processing circuits.

I\O Distribution\Video Switch PCB - controls the distribution of the video inputs and outputs of the image processing circuits.

AD\DA Converter PCB - digitizes the incoming composite video signal for processing and converts the digital image data into a composite video signal for display on the TV monitors.

Figure 4-1 - *Block diagram of the major components of the monitor cart.*



Pipeline Filter PCB - performs algorithms on the digital image data and also contains the image memories.

Disk Controller PCB - an OEM circuit board that controls the hard disk and also controls a floppy disk when connected.

OEM components - which include DC power supplies, the isolation transformer and the two TV monitors.

4.1.2 Image Storage Options

Various options may be installed depending on the system configuration:

Hard disk image storage for up to 60 digitized images.

Video tape recorder for real time storage of the composite video signal.

AngioStor video disk recorder for high resolution storage of video frames.

Multi-format camera to make hard copies of fluoro images.

Patient annotation for identifying and commenting stored images.

4.1.3 Image Processing Options

The major image processing and image storage options can be identified by referring to the front panels shown in Figure 4-2. Model upgrades can be performed by replacing these panels and their associated electronics and software.

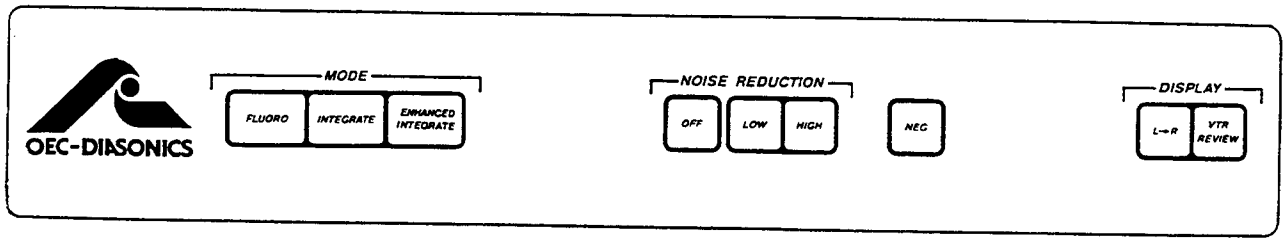
In Figure 4-2 the following panels are identified:

1 - Basic 9000 system

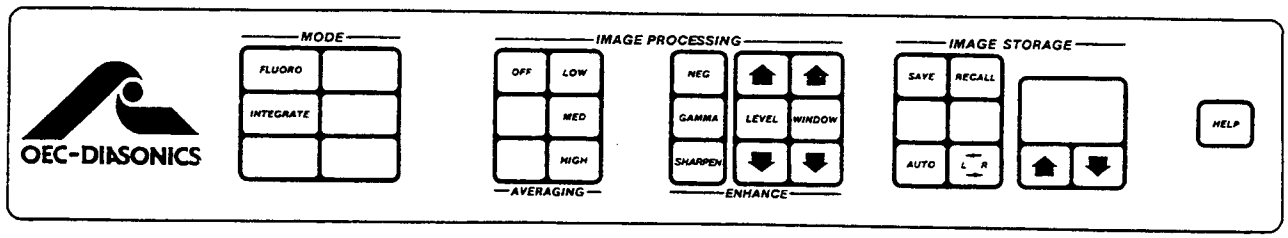
2 - Expanded Surgical Package

3 - Expanded Surgical Package with Vascular or Neurovascular Options

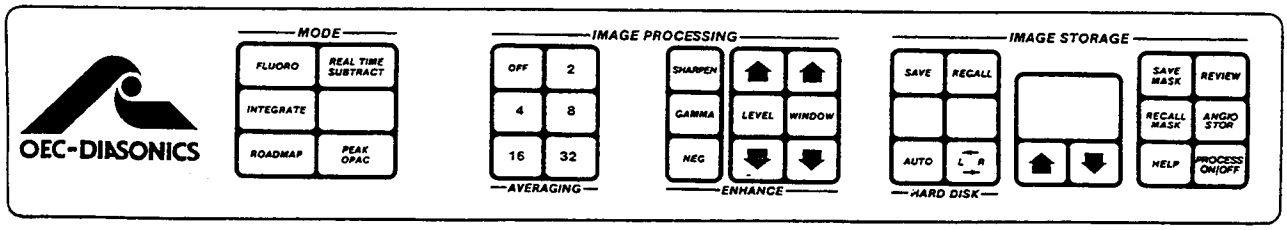
Figure 4-2 - *The major image processing options can be identified by their different front panels.*



1



2



3

4.1.4 Major Connections

Interconnect Cable

Refer to Drawing 00-870735.

The interconnect cable provides AC power to the mainframe, control communications between the mainframe and monitor cart and the video signal to the monitor cart. This is described further in the *Mainframe Theory of Operation.*

Other Connections

The following tables describe the connectors located on the interface panel on the rear of the monitor cart.

Table 1 RS232 Connector

PIN	*SIGNAL*
3	RXD
5	TXD
7	RTS
9	CTS
11	DSR
13	COM
14	DTR
15	DCD

Table 2 AUX Connector

PIN	*SIGNAL*
3	spare
5	stop
7	record
9	search
10	VTR clock
11	pause
12	ground
13	play
14	ground
15	f. forward
16	ground
17	reverse
18	ground
20	ground
22	ground
24	ground

Table 3 **VTR - J34**

PIN	*SIGNAL*
3	shield
4	video to VTR
2	video from VTR
6	shield

Table 4 **Video Out**

PIN	*SIGNAL*
J36	video out 1
J35	video out 2

Table 5 **Video Disk J37**

PIN	*SIGNAL*
1	record enable
5	ground
4	video to AngioStor
3	shield
2	video from AngioStor
6	shield
8	composite sync
7	shield

4.2 Power Distribution

AC Power Input power is supplied via the isolation transformer T1 located in the base of the monitor cart assembly. Taps on the primary and secondary windings of T1 allow system connection to various line source voltages.

DC Power DC voltages for circuit board operation (+5, -5, +/- 15 VDC) are obtained from the switching power supply located on the side of the card rack.

A 24 VDC supply in the base of the monitor cart supplies power to the tv monitors.

4.3 Monitor cart operation

4.3.1 Image Processing Functions

The image processing functions, selected from the front panel, may include the following, depending on system options and model:

Averaging Real-time video frame averaging is used to improve signal to noise ratio and reduce motion artifacts. A running average is calculated for each pixel to be displayed. The average can be obtained over a variable number of frames: 2, 4, 8, 16, 32. Noise and motions which are not correlated with structures in the image are averaged out. Since it is a real-time average, the pixel values used in the calculation are constantly changing and the average is recalculated each time a new frame is added.

Integration Frame integration is similar to frame averaging. The main difference is that integration stops after a specific number of frames have been averaged. The last image displayed when integrating results from averaging the previous frames.

Real-time Subtraction Real-time subtraction allows successive images to be subtracted from a mask image. Perfect subtraction results in a gray-scale value which is off-set to 80 Hex, a mid-range gray.

Roadmapping Roadmapping is similar to real time subtraction, but the mask image is negated and reused for successive subtractions until another mode of processing is selected.

Peak Opacification Peak Opacification can be performed on successive frames. The darkest value for each pixel in the image is saved and displayed.

Gamma The gamma function maps the gray scale range as an exponential function. This results in a compression of the dynamic range when dealing with an image where the brightness range is large. Linear gray scale mapping is used when gamma is not enabled.

Sharpen Image sharpening is achieved by an algorithm which emphasizes image edges. This process involves translations of horizontal and vertical pixel locations. The circuitry to perform these translational movements is divided between the Image Processor PCB and the Recursive Filter PCB. This requires executing an algorithm which shifts the image a certain number of pixels in the X axis and a number of lines in the Y axis. The Y shift is set by changing the beginning pixel address generated by the address counters on the Image Processor PCB.

Window and Level Window and Level controls are used to remap the gray scale to upper and lower portions of the gray range and to alter the slope of the video transfer function. These are analogous to contrast and brightness controls.

Subtraction With Averaging and Peak Opacification Averaging and peak opacification can be selected from the front panel for use during real time subtraction and roadmapping. These are applied selectively during the mask and subtraction phases as shown below:

	REAL TIME SUB		ROADMAPPING	
PHASE	*MASK*	*SUB*	*MASK*	*SUB*
AVG		X		X
		or		
PK OPAC		X	X	

4.3.2 Image Memories

The fluoro image is transferred between several memories during processing. These memories are described below:

Segment Ram Sixteen kbytes of static ram located on the Disk Interface PCB are used to read and write segments of data to the Pipeline Filter memory from the hard disk. The 16 kbytes translates to the monitor as an image segment 32 lines down x 512 pixels across. Only Pipeline Filter memory M1 can be written to or read from via the segment ram.

Pipeline Filter Memory 512 kbytes of ram is mapped into two pairs of memory (M1 and M2) for a total of four 128 kbytes image frames.

Image Frame Each 128 kbyte memory frame is large enough to store a 512 x 512 byte image. Whichever frame is currently mapped to the monitor is considered the foreground frame, while the other 128k block is the background frame. The Image Processor can switch the address lines so that these memory blocks exchange roles.

DRAM 64 kbytes of dynamic ram located on the Disk Interface PCB is not used for image storage but is where the system software resides after boot-up.

4.3.3 Serial Links Between Boards

Monitor Cart-Mainframe The serial communications port between the monitor cart and the mainframe uses hardware handshaking and operates at 9600 baud.

I.P. - Disk Interface Serial communications between the Disk Interface PCB and the Image Processor PCB operates at 1200 baud and supports XON/XOFF handshaking. The Image Processor also has a 128 byte buffer for this port.

Front Panel - Disk Interface PCB Serial communications between the Front Panel Processor and the Disk Interface PCB operates at 1200 baud and supports XON/XOFF handshaking.

4.4 Monitor Cart Software

The monitor cart software can be divided into three major functional areas:

1. Main program software
2. Image processing software
3. Front Panel software

4.4.1 Main Program Software

The main program consists of system operating software and application programs which are stored on the hard disk and loaded into the Disk Interface board DRAM for execution. The transfer occurs during the monitor cart booting process and is directed by a smaller program in EPROM on the Disk Interface PCB. When executed by the processor on the Disk Interface PCB, the application program issues commands to the other processors on the Image Processor and Front Panel Processor PCB's. The operation of the I/O Distribution - Video Switching PCB is also controlled by the main program.

4.4.2 Image Processing Software

This software resides in EPROM on the Image Processor PCB and controls the operation of the Pipeline Filter and Image Processor PCB's. For some processing applications it receives function calls from the application program running on the Disk Interface PCB.

4.4.3 Front Panel Software

The Front Panel Processor PCB executes a program which resides in EPROM. It scans the front panel keys and sends the scan codes to the application program for interpretation. The application program, in turn, issues commands to the Front Panel Processor PCB to update the LEDs and the alphanumeric display on the front panel. The Front Panel Processor PCB also sends commands to the Disk Interface PCB for image processing selection.

4.4.4 System Initialization

When power is first applied, each microprocessor starts an initialization or "boot" sequence by executing software code which resides in EPROM.

Disk Interface Initialization: Commands are issued to the Disk Controller PCB, via a parallel port on the Disk Interface PCB, to read the first sector from the hard disk into memory. If a floppy disk drive is installed during service procedures, the first sector of the floppy disk will be read instead.

If the disk read operation is unsuccessful, an error message is issued to the AUX port, which may be read on an external terminal during service procedures. The system then enters the monitor program, contained in EPROM on the Disk Interface PCB.

The code read from the first sector directs the transfer of the rest of the operating system into memory and transfers control to the Disk Operating System. The function of the Disk Operating System is to load various utilities, diagnostic, and application programs into RAM for execution. In normal operation, the Disk Operating System then executes the application program.

Image Processor Initialization: The monitors are cleared, gray scale and log table RAM's are loaded on the AD/DA and Pipeline Filter PCB's, and communication ports are initialized. The Image Processor PCB then waits for function calls from the Disk Interface PCB, and Front Panel commands.

Front Panel Processor Initialization: The Front Panel Processor initialization consists of clearing all I/O ports to turn off all LEDs. It then begins scanning the keyboard and multiplexing the LEDs. Commands are exchanged with the Disk Interface PCB through a serial data interface.

4.5 Monitor Cart Electronics

4.5.1 Disk Interface PCB

Refer to Figure 4-3 and Schematic 00-870013.

The Disk Interface PCB is a Z80-based board level computer. Its main tasks are to load and execute the disk operating system and applications software from the hard disk and to control image transfers between the hard disk and memory. Data transfers between the hard disk and memory are accomplished via the Disk Controller PCB. Handshaking occurs between the Disk Interface and Disk Controller PCBs to control the data transfer with the hard disk.

The Disk Interface PCB communicates with the Front Panel Processor PCB, with the Image Processor PCB, and with the main frame X-ray Processor PCB via RS 232 serial data links. The Front Panel Processor PCB reads the switch panel and passes the data to the Disk Interface PCB. The Disk Interface PCB then selects the appropriate image processing program segment and sends it to the Image Processor PCB.

CPU

The CPU, U60 is a Z80A. It uses an 8-bit data bus and 16-bit address bus.

The CPU is reset in either of three ways:

1. At power-up, by the charge time of C137 through R20.

2. On manual reset, during tests and adjustment of the system. Closing S1 discharges C137, and allows it to recharge through R20.

3. By the watchdog timer, U75, when its Q7 output goes active (high).

Watchdog Timer

In order to prevent the watchdog timer from resetting the CPU during normal operations, the CPU periodically resets counter U75 via I/O 4 (U77E).

DMA Controller

The direct memory access (DMA) controller, U59, emulates the Z-80 CPU during fast data transfers. Wait requests from the DRAM controller are applied to U80-10 when the controller forces an internal refresh. The DMA can perform memory to memory, and memory to I/O transfers at a rate of up to one megabyte per second.

Multiplexer U67 selects either the wait state or I/O 70 as the chip enable input to the DMA based upon the state of the BUSAK control signal. When the BUSAK output from the Z-80 is low, the output of the wait-state generator (U78C-8) is applied to the DMA controller U59. During DMA accesses, the interrupt line is pulsed periodically by the DMA controller (U59). These are gated through U79C to provide a reset to the watchdog timer, preventing it from timing out. Since the CPU is held in the wait state by the output from U78C, it does not sense the interrupt pulses from the DMA.

Programmable Counter and Baud Rate Generator

Counter timer circuit (CTC) U61 contains three independently programmable counters. The output of counter "0" provides a non-maskable interrupt to the CPU.

Counter "1" provides a software controllable baud rate clock to the auxiliary serial communications port U30. Counter "2" provides a standard baud rate clock (307.2 kHz) to counter U52.

Counter U52 is operated as an 8-bit binary counter. It provides output clock signals for baud rates of 9600, 4800, 2400, 1200, 600, 300, 150, and 75. (The actual clock signal is 16-times the Baud rate.) The outputs of U52 are configured with jumpers so that two separate baud rates can be selected, EE to serial communications port U31, and FF to serial communications port U30.

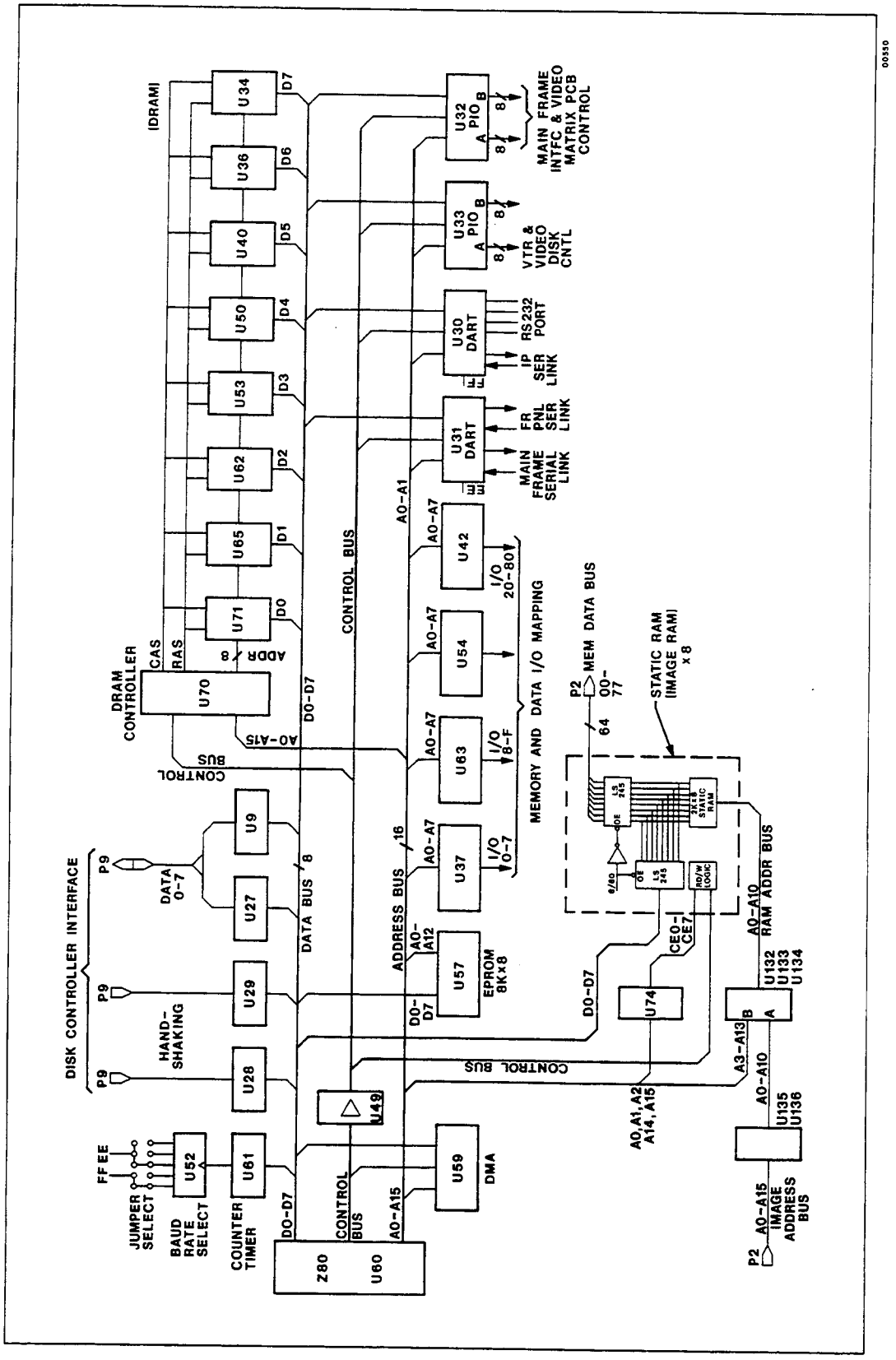
Disk Controller Interface

Communications between the Disk Interface PCB and the Disk Controller PCB is via bi-directional open-collector TTL lines. The open-collector lines are balanced with 220 ohm pull-up resistors to +5V, and 330 ohm pull-down resistors to ground. All control signals between the two devices are active low.

For DMA writes to the Disk Controller PCB, the D0-7 bits on the internal data bus are clocked into U27 by the negative true I/O 2. For DMA reads of data from the Disk Controller PCB, the input DATA 0-7 bits are enabled through buffer U9 by the negative true I/O 3.

The handshake function is provided by flip-flop U1A and gates U12A and U23C. This circuit provides an automatic acknowledge every time the DMA writes a data byte to, or reads a data byte from the Disk Controller PCB.

Figure 4-3 - *Block diagram of the Disk Interface PCB.*



Boot PROM

The boot PROM (U57) occupies memory space from "0" to "1FFF" (HEX), and is controlled by the memory map I/O circuit. The boot PROM contains the program necessary to load the disk operating system from the hard disk into RAM. Execution then jumps to the newly located code in the disk operating system program. The boot PROM is disabled until the next time the system is reset.

Parallel Interface

Parallel interface is provided by two Z80 PIO's, U32 and U33. U32 port A is assigned as the interface for data to and from the mainframe, U32 port B interfaces various functions such as X-RAY ON AND DISABLE/, SWITCH DATA, SWITCH CLOCK, SWITCH LATCH, IM- REQ/, TIMER and VERT INT. Bit 7, VERT INT, is dedicated to the vertical reset which provides a 60 Hz clock to allow the system to synchronize any necessary software functions to the vertical field rate of the imaging system. U33 port A is assigned as a VTR remote control interface. U33 port B is assigned to an auxiliary device output connector and serves as a printer port.

Memory Map

The memory map circuit consists of memory chip enable PROM U39, the flip-flops of U38 and gate U43C. There are three memory spaces on the Disk I/O Interface PCB. The three memory spaces are occupied by:

* 8k x 8 boot PROM
* 16k x 8 image memory, static RAM
* 64k x 8 DRAM

When I/O 6 is asserted true, U38B is set and U39 selects the DRAM for the entire 64k memory space. When I/O 7 is asserted, U38A is set, the 80/8 signal is high and U39 enables the lower 16K memory space as image memory in the 8-bit wide mode, and the remaining memory space is dedicated to the DRAM. In all configurations of the memory map, the DRAM occupies the block of memory address space above that used by either the boot PROM or the image memory.

When the image RAM is not selected, and thus not mapped into the addressable memory, the DRAM is configured in the 64-bit wide mode and is available for data transactions with the image memory data bus.

I/O Decoders

The data and memory mapping I/O signals for the Disk Controller PCB are decoded by PROMs U37, U42, U54, and U63. The I/O decoder PROMs are enabled when the IORQ/ signal is true and the inverted M1/ output of U45D is low; and they are addressed by the A0-7 address bus bits.

Image Memory

Depending on the state of the 80/8 signal, the image memory RAMs are either connected in parallel with the 64-bit wide image memory bus, or connected sequentially with the Z80 data bus.

Memory Control Logic

When the system is in the 80-wide mode, it is reading 64 bits at a time. When in the 8-bit wide mode, 8-bit pixels are read in sequential order. PROM U74 provides chip enable signals based on this system status. In the 80-wide mode CE0-7 are issued simultaneously. In the 8-bit mode, CE0-7 are issued sequentially when memory is being accessed by the Z-80 DMA. Addresses are selected by multiplexers U132/133/134 from the internal address bits A3-A13 and the system image address bits A0-A10.

Image transfer from buffer to system image memory is implemented in hardware. The Z80 determines and preloads a segment number of the image (there are 16 segments in an image). The segment number is held in latch U81 and compared with the image address bus A11-A14. When the two are equal, a high level is asserted at U97-6 (OUT). The OUT signal triggers the circuits for reading or writing an entire segment to the main image-memory.

The Image Processor PCB controls the main image-memory data by providing RAS, CAS, READ ENABLE, WRITE ENABLE, and address control.

DRAM

The 64k x 8 dynamic RAM section consists of the eight 64k x 1 RAMs U34-/36/40/50/53/62/65/71. U70 is a TMS4500A dynamic RAM controller. U70 generates all of the RAS and CAS signals, and multiplexes the A0-15 address bits. It also provides refresh and arbitration logic to the DRAM's.

U70 is enabled or disabled by the memory mapping circuit via U77D and U68B. U70 is clocked by the 8 MHz clock signal so it can generate RAS and CAS pulses with adequate system timing for the DRAMs to be accessed without wait states.

Serial Communications

Serial communications occur via two dual asynchronous receiver /transmitters (DARTs) U30 and U31.

Channel A of U31 is a buffered serial RS-232 port dedicated to two-way communications with the mainframe X-ray Processor PCB. Channel B of U31 is TTL open-collector buffered, serial RS-232 port, dedicated to two-way communications with the Front Panel Processor PCB.

Channel A of U30 is a buffered TTL serial RS-232 port, dedicated to two-way communications with the Image Processor PCB. Channel B of U30 is a buffered serial RS-232 port with selectable baud rate, for two-way communications with an external terminal.

4.5.2 Front Panel Processor Assembly

Refer to Schematic No. 870507 and Figure 4-4.

The Front Panel Processor Assembly consists of the following:

* Front Panel Processor PCB, No 00-870507
* Overlay, Front Panel, SCD No. 00-870481
* LED Display PCB, Schematic No 00-870392

The Front Panel Processor Assembly provides the interface between the touch-sensitive membrane switches of the monitor cart front panel and the Disk Interface PCB. It senses front panel switch closures and reports the results to the Disk Interface PCB, which in turn provides commands to the Front Panel Processor to drive the LED indicators, the two digit numeric display, and the beeper.

Front Panel Processor PCB

Refer to Figure 4-5.

The Front Panel Processor PCB is based on the Z8 microcomputer, U20, a Z8682. The Z8682 data bus is multiplexed with the lower A0-A7 address bits. Demultiplexing of the AD bus is achieved by latch U3.

Processor I/O Ports

Communications between the Front Panel Processor PCB and the Disk Interface PCB takes place over a serial RS-232 link. U20 can be programmed to function as a universal asynchronous receiver/transmitter (UART) for serial RS-232 data by using its built-in I/O ports P3-0 and P3-7. The internal UART baud rate clock is software controlled and is generated by one of two timers that are part of U20.

Clock Generator

The clock signal for U20 is derived from 8 MHz crystal Y1.

Program Storage

Program storage is provided by the 4K x 8 EPROM U13. U12 is an 8 2K RAM.

LEDs and Alphanumeric Display

The LED indicators and the two numeric displays are driven by a time-multiplexed refresh technique. Each LED is associated with a position in an 8 x 8 matrix. The position within the matrix is determined by a row number (R0 - R7) and a column number (C0 - C7). To light a particular LED, both of its associated row and column drivers must be on.

The row driver U10, consists if eight common emitter current sources. The contents of the row register U9 control the row drivers of U10. A high output from U9 turns its associated row driver on; a low output turns its driver off, placing the outputs of U9 in the high Z state. A high applied to U9-1 (OE) also disables the row drivers of U10.

The column drivers of U7 and U5 are open-collector inverting drivers. They are controlled by the outputs of column register U14. A high output from U14 turns its associated column driver on (low impedance to ground); a low outputs turns its driver off.

The outputs from the LED drivers are connected with the LED Display PCB via connectors P27 (column bits C0-C7) and P28 (row bits R0-R7).

If the LED refresh fails, the LEDs are protected by the watchdog timer U4A, which will turn off all of the row drivers, setting the outputs of U9 to the high Z state.

Figure 4-4 - *Block diagram of the Front Panel Assembly.*

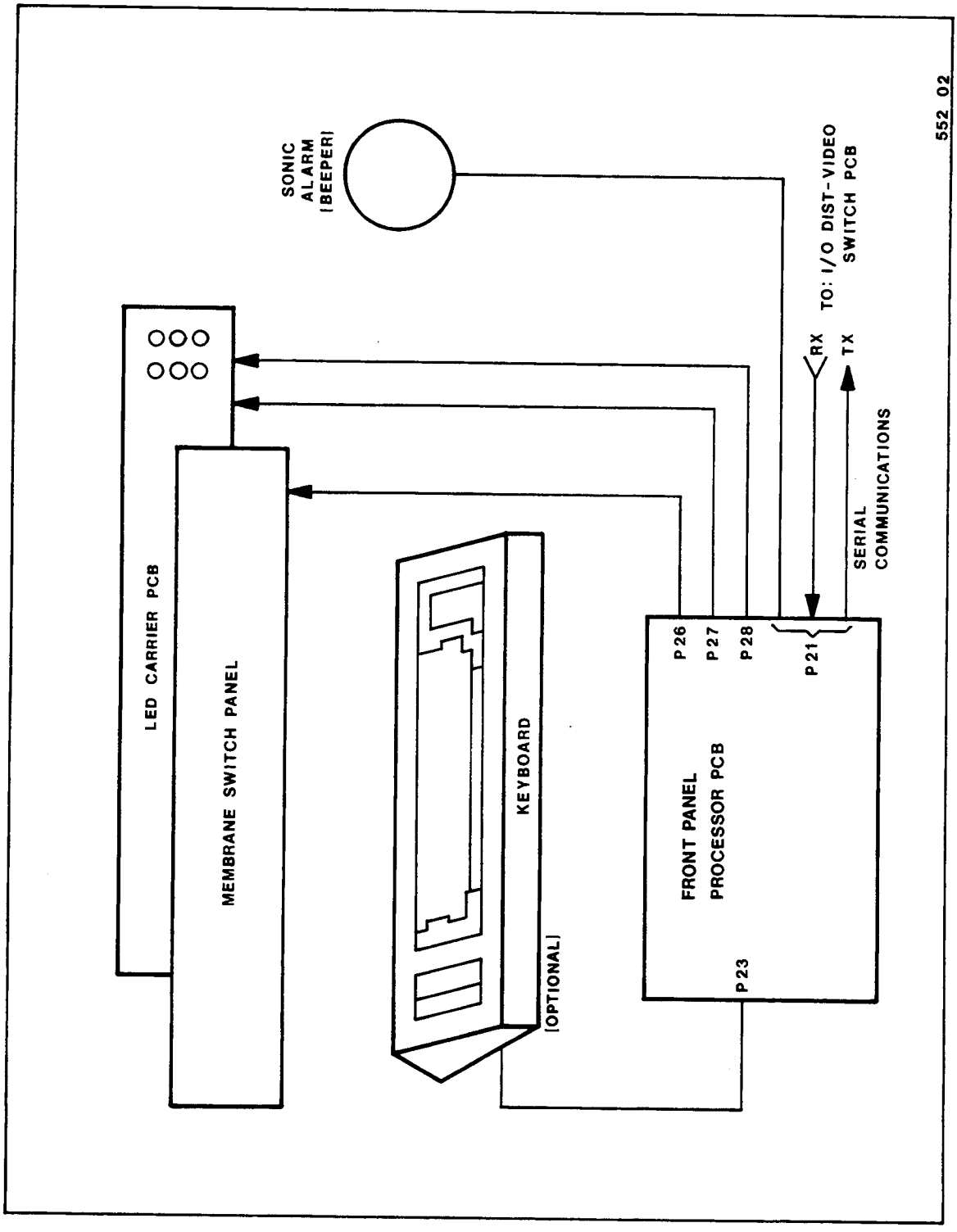
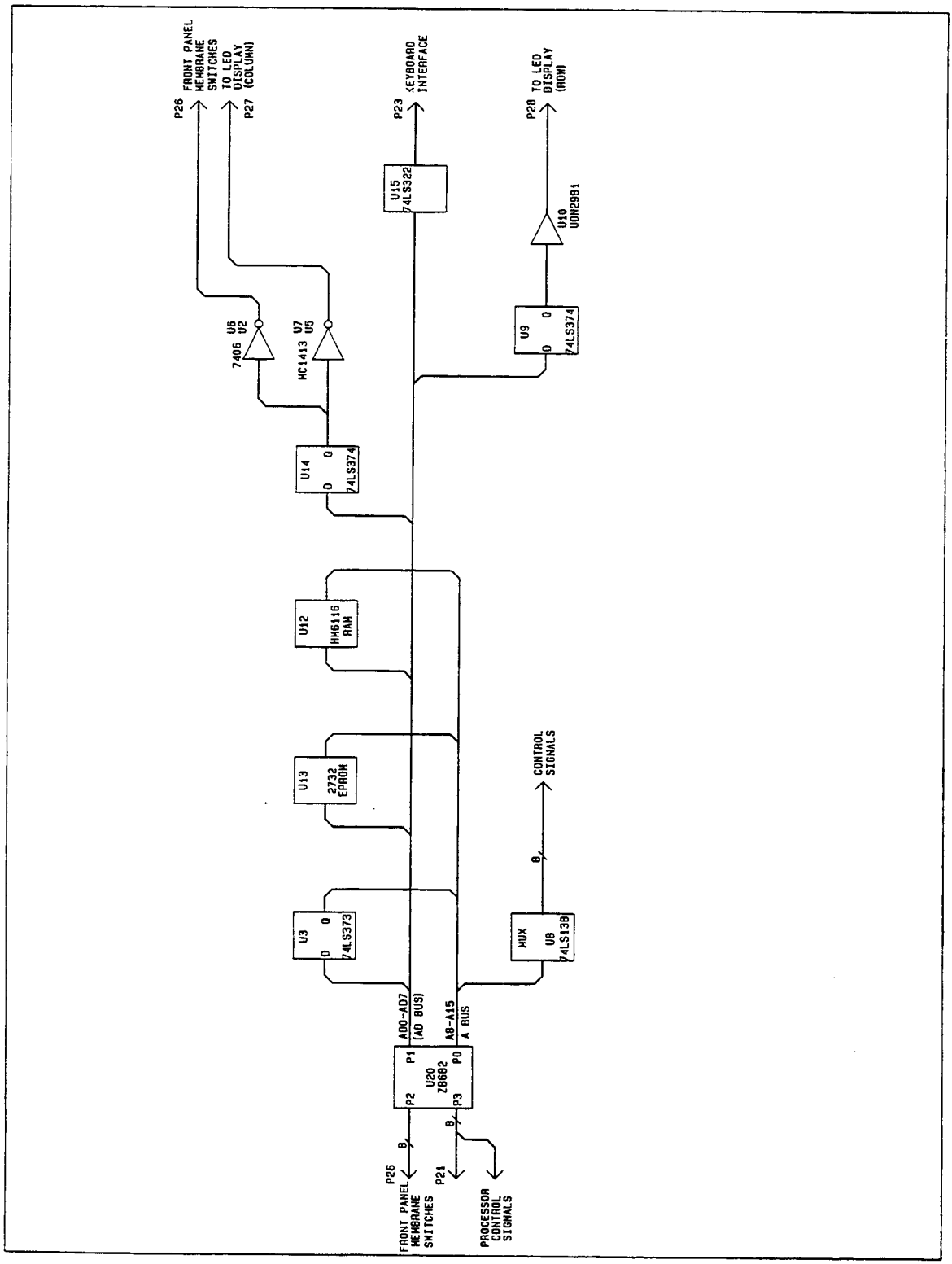


Figure 4-5 - *Block diagram of the Front Panel Processor PCB.*



Beeper (Sonic Alarm) Driver

The beeper is driven by the P3-5 output of U20-10. A high level output at U20-10 turns the driver U5G on, providing a return path to ground for the device.

Front Panel Switch Matrix

The switches on the front panel are arranged in a matrix similar to the LED matrix. Each switch is identified by a row and column number. The switch matrix is scanned using a time-multiplexed technique.

Optional Keyboard Interface

P23 provides a connection for the optional keyboard used for patient annotation. Three signals are required for keyboard operation: KBDATA, KBCLK, and RESET.

4.5.3 Image Processor PCB

Refer to Figures 4-6 and Schematic 00-870388.

The Image Processor PCB is a Z80 based board level computer which controls the operation of the I/O Distribution/Video Switch PCB, AD/DA Converter PCB and Pipeline Filter PCB, and executes data transfers with the 64-bit system memory bus. It communicates with the Disk Interface PCB via an RS-232 serial data link and the system control bus. The image processing program-segment is received from the Disk Interface PCB via the serial link.

Reset

The CPU can be reset by the EXT RESET/ signal. A low level is applied to the RESET input of the CPU, U80.

Data Bus

The Image Processor PCB has two internal data buses: a bidirectional data bus (to/from the CPU) identified by D0-D7 and a uni-directional bus (from the CPU) identified by DB0-DB7.

The D0-D7 internal bus interfaces data with the PROM, the Serial Timer and Interrupt Controller, and the RAMs. The 8-bit internal data bus is interfaced with the 64 bit memory data bus by latches U100 - U107 and U110 - U117.

The unidirectional internal data bus (BD0-BD7) is interfaced with the bidirectional data bus through 8-bit buffer U109. The data on the BD0-BD7 internal bus is applied directly to the system control bus through pins 1-8 of connector P3, the daisy-chained ribbon cable. The system control data bus is used to write log-RAM and processing control data to registers on the Pipeline Filter PCB. Grayscale-RAM data is also written to the AD/DA PCB from the Image Processor PCB.

Memory Data Bus

The 64-bit wide image-memory bus is read and written to by latches U110-U117 and U100-U107. The read and write data transfers between the latches and the memory data bus are controlled by the RMD (read memory data) and EMD (enable memory data) signals. The sequential transfer of data in 8-bit bytes between the latches and the internal data buses D0-D7 and DB0-DB7 is determined by the sequence of the OUT 00-07 and IN 00-07 signals from the I/O port decoders.

Memory Addressing

Latches U95 and U96 multiplex the 8-bit BD data bus onto the 16-bit memory address bus. U95 and U96 are also used to initialize the address counters U84, U85, U88, and U89.

Edge Enhancement Pixel Shift

Address counters may be initialized with an offset count which produces a line shift in the vertical image axis. This is used by the edge enhancement algorithm when combined with the horizontal axis shifting performed on the Pipeline Filter PCB.

PROMS

Programming on the Image Processor PCB resides in the PROM U50 (2764). This PROM based software directs much of the image processing on the Pipeline Filter PCB.

RAM

The Image Processor PCB has three 2K X 8 static RAMs, U31, U32, U51. These RAMs serve as a scratch pad memory for the CPU.

Serial Timer and Interrupt Controller

U73 provides a serial RS-232 data link with the Disk Interface PCB and the Front Panel Processor PCB. Data received over this link includes function calls from the Disk Interface PCB and scan codes from the Front Panel.

Memory Control Logic

The memory control logic is synchronized to the video rates by composite blanking (C BLANK, H-rate) and vertical drive (VR DRV, V-rate).

Video Sync Generator

Refer to Figure 4-7 and Schematic 00-870388.

The 82 MHz clock signal produced by VCO U5 is applied to a binary divider which provides three outputs: 10.25 MHz (PC1), 5.125 MHz (PC2), and 2.58 MHz. The 2.58 MHz signal is applied as the clock input to TV sync generator U8 which in turn provides five TV signal outputs: C SYNC, C BLANK, HR DRV, VR DRV, and an even field signal E FLD. These signals are synchronized with the incoming video signal through the phase comparator circuit U3, Q2 and U4. Adjustment of C6 changes the frequency of the VCO until the incoming video rate and the U8 video rate are in phase.

Figure 4-6 - *Block diagram of the Image Processor PCB.*

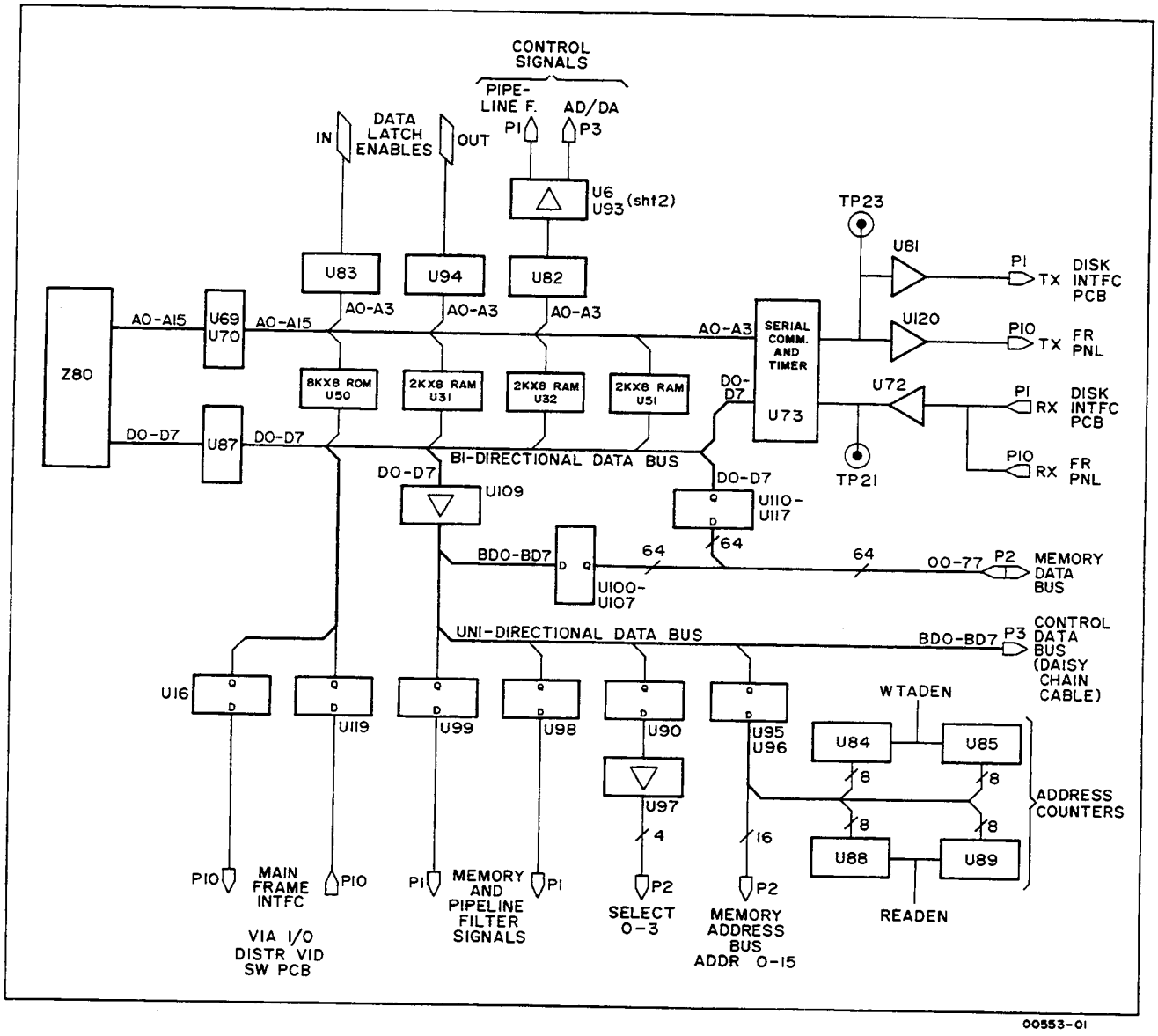
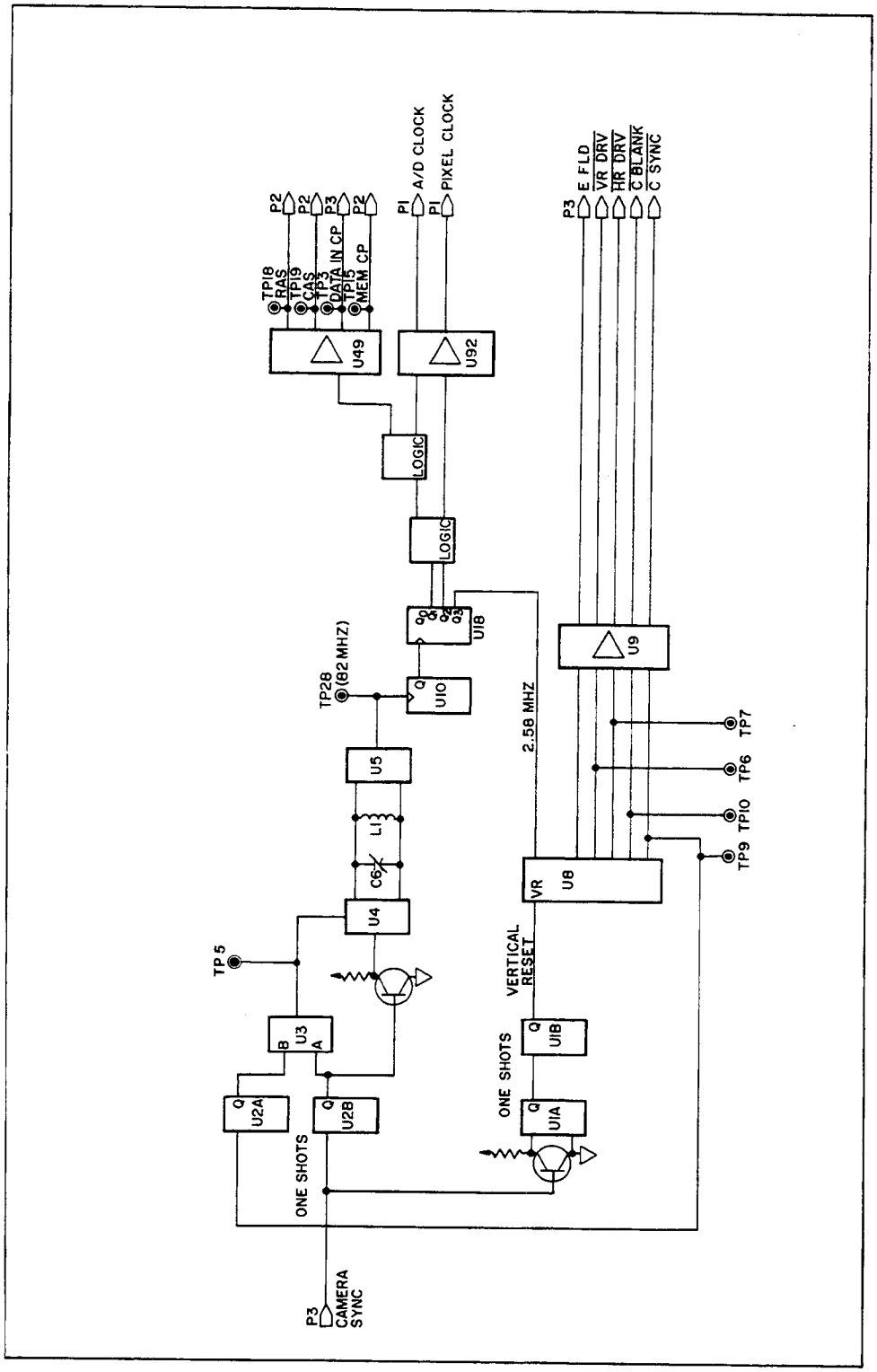


Figure 4-7 - *Block diagram of the Image Processor PCB, Video Sync Circuit.*



4.5.4 I/O Distribution/Video Switch PCB

Refer to Figure 4-8 and Schematic 00-870185.

The I/O Distribution/Video Switch PCB contains five primary circuits:

* Voltage Regulator Circuit
* Connector Interface Circuit
* Control Word Serial-to-Parallel Shift Register
* Video Switching Relay Matrix Circuit
* Video Buffer/Driver Circuit.

Voltage Regulator

Potentiometer R24 is adjusted so that the output of VR1 (TP19) provides +12 VDC at the input connector to the hard disk drive assembly.

Other DC inputs on the PCB are: +5 VDC, -5 VDC, -15 VDC, and the switched +5 VDC which is applied to the switching relays.

Connector Interface

The connector interface allows routing a number of mainframe control signals to the Disk Interface PCB where they are used to coordinate image processing with X-ray exposures.

Control Word Shift Register

U7 through U10 comprise a 16-bit serial-to-parallel shift register for the switching relay matrix control word. The word is latched at the outputs of U7 and U8 as a 16-bit wide parallel word and is applied to inverting buffers U1-U4. Each inverter output drives an associated video switching relay. Note that some of the relays are normally open and some are normally closed.

Switching Relay Matrix

Note: Only the following relays are installed:

K1, K4, K7, K8, K10, K15, K16, K18, K19, K20, K24, K25, K28, K30, K31.

There are five possible video sources in the imaging system:

* Camera (live video)
* Left D/A channel
* Right D/A channel
* VTR option
* AngioStor option

There are six possible video destinations:

* A/D converter (for digital processing)
* left monitor
* right monitor
* VTR
* AngioStor
* VIDEO OUT 1 and 2, BNC connectors on the monitor cart rear panel.

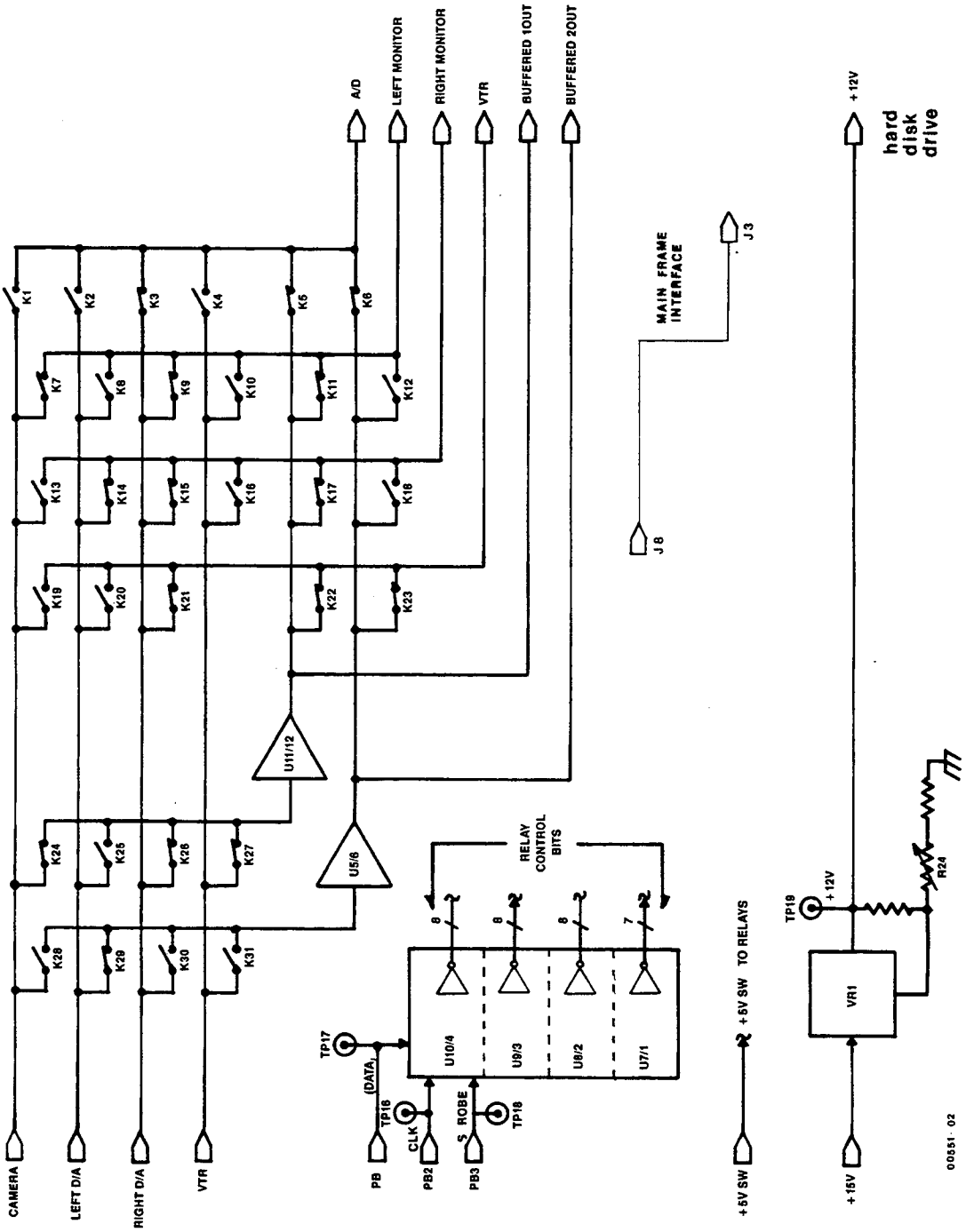
Note that the camera (live) video output is applied directly to the input of the AD/DA Converter PCB, but to the VTR through a buffer. This circuit configuration prevents double termination of the camera video output. The software control of the relays prevents undesirable double termination of any of the video sources. The video output of the VTR can be selected through K4 and applied to the analog input of the AD/DA Converter PCB and processed in the same manner as the camera video.

AngioStor Interface

Refer to Schematic 00-870543.

Additional video buffering and sync circuitry for the AngioStor disk recorder is provided by the piggy-back PCB installed on the right side of the I/O Distribution-Video Switching PCB. Refer to the *Options* section of this manual.

Figure 4-8 - *Block diagram of the I/O Distribution Video Switch PCB.*



4.5.5 AD/DA Converter PCB

Refer to Figures 4-9, 4-10 and Schematic 00-860896.

The AD/DA Converter PCB contains circuits that perform the following functions:

1. Conversion of the incoming composite video from the I/O Distribution/Video Switch PCB to digital data which is then available to the Pipeline Filter PCB on the 64 bit wide A/D bus.
2. Generation of a circular blanking window.
3. Subtraction of two separate images (D/A OUT 1 and D/A OUT 2, from the Pipeline Filter PCB) from each other.
4. Detection and removal of the sync pulses from incoming video signal.
5. Gray scale correction of the digital data output from the Pipeline Filter PCB.
6. Conversion of the digital image-data from the Pipeline Filter PCB into a composite analog video signal which is routed through the I/O Distribution/Video Switch PCB for display on the TV monitors.

A/D Conversion

The incoming video signal is AC coupled to buffer Q2. The Q2 output is applied to comparator U19 which is biased to strip the inverted sync signal. The video signal is amplified by U18, and a porch is added by clamping the output to ground before the C-SYNC pulse. The clamped video signal is buffered through U33 and applied to the analog input of A/D converter U32 and also to analog mux U24 for raw display.

The analog input to U32 is converted into 8 bit data words at the 10 mHz clock rate of the A/D CLOCK signal and is applied to 8-bit tri-state buffer U54. The outputs of U54 are enabled only during the video window of the circular blanking signal (CIRC BLANK/).

Circular Blanking

U28a and U29a produce a ramping voltage, reset at the CSYNC rate, which is applied through U73a to the input of multiplier U34. Similarly, U29b and U28b produce a ramp, reset at the vertical rate, which is applied through U73b to the input of multiplier U35.

The outputs of U34 and U35 are parabolas which are then applied to the summing node of U36. The result, at the output of U36, is the circular blanking signal (CIRC BLANK/) used to control the size of the video window.

A/D Clock and Data Latches

The AD PIXEL MR signal clears 8-bit flip flop U52. When U52 is enabled, it generates eight separate A/D clock signals. The sequential outputs from U52 convert the digital video data from U32, and the digital blanking data from U72, into the eight 8-bit parallel channels for transfer to the 64-bit video data bus.

Data Bus Interface

Data on the system data bus is buffered through U16 and applied to the internal data bus. Control and clock signals are buffered through U7. The gray scale data is clocked into latch U15 by the GRAY DATA LCH signal. The gray scale address data is clocked into latch U17 by the ADDA CONT LCH. The blanking level data (for the area outside of circular blanking) is clocked into latch U72 by the BLNK LEVEL SET clock signal.

Digital Image Subtraction

D/A DATA 1 processed digital image data is clocked into latches U50, U56 and U70 by the D/A clock signal. D/A DATA 2 is clocked into latches U49, U50, and U68. The two data channels may be subtracted by the ALU U51, U57. The output of the ALU is applied to the left monitor processing channel.

Gray Scale RAMS

Each monitor channel has a dedicated 256 x 8 gray scale RAM: U26, U30 for the left monitor, and U39, U46 for the right. The gray scale RAMs contain a 256-value gray scale table which performs the WINDOW, LEVEL, and NEGATE mapping functions on the digitized video. Gray scale data is addressed by the image data.

Left D/A Channel

The digital output from U26, U30 (gray scale data addressed by image data) is applied to the digital input of D/A converter U25 and clocked by the D/A CLK signal. Delayed composite blanking (DLY C BLNK) is applied to the disable input of U25 which sets the level of the analog output during blanking. The resultant video signal is buffered through U10 which provides a source terminated composite video output.

Right D/A Channel

The digital output from U39, U46 (gray scale data addressed by image data) is applied to the digital input of D/A converter U38 and clocked by the D/A CLK signal. Delayed composite blanking (DLY C BLNK) is applied to the disable input of U38 which sets the level of the analog output during blanking. The resultant video signal is buffered through U8 which provides a source terminated composite video output.

Figure 4-9 - *Block diagram of the AD/DA Converter PCB, A/D circuits.*

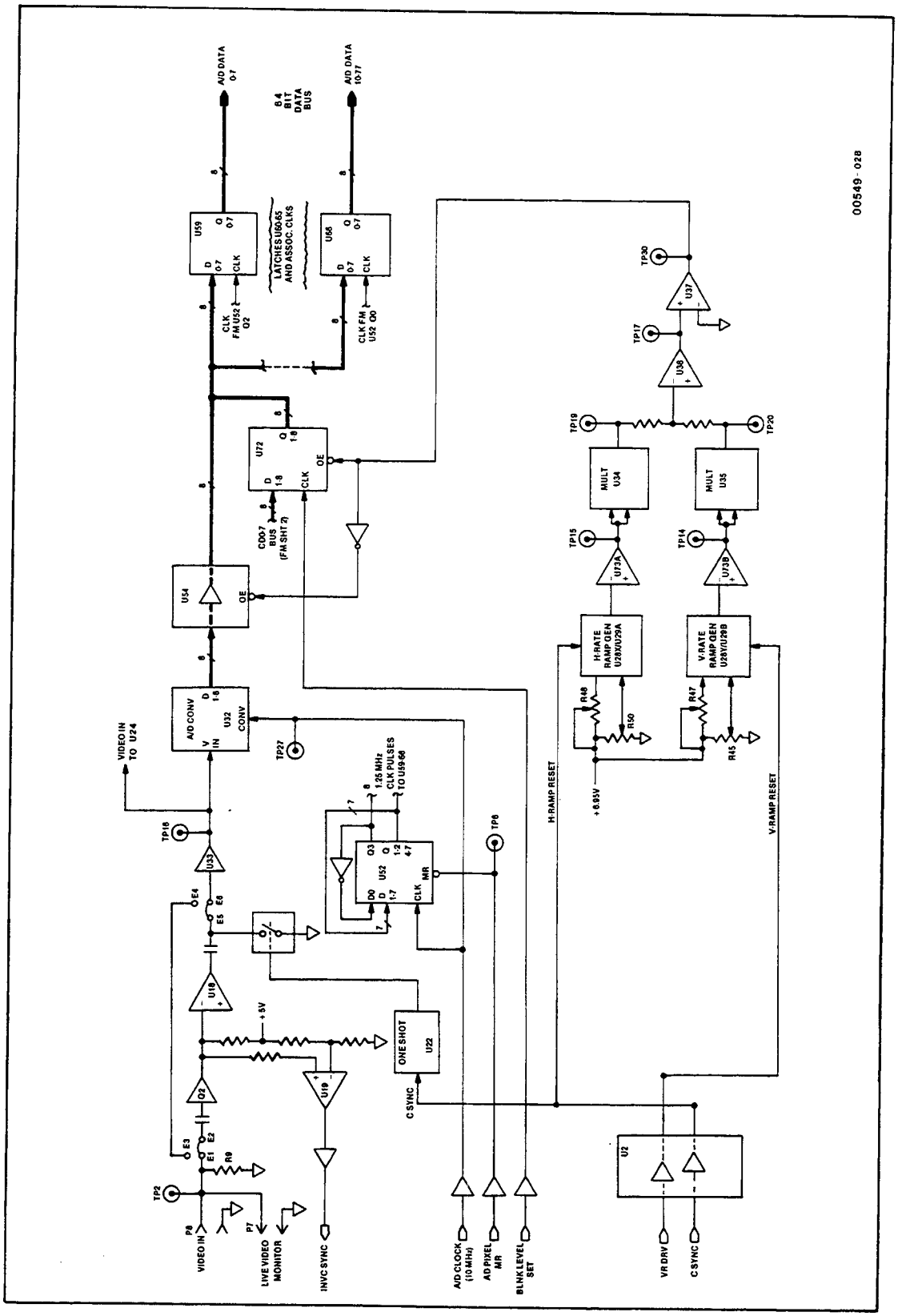
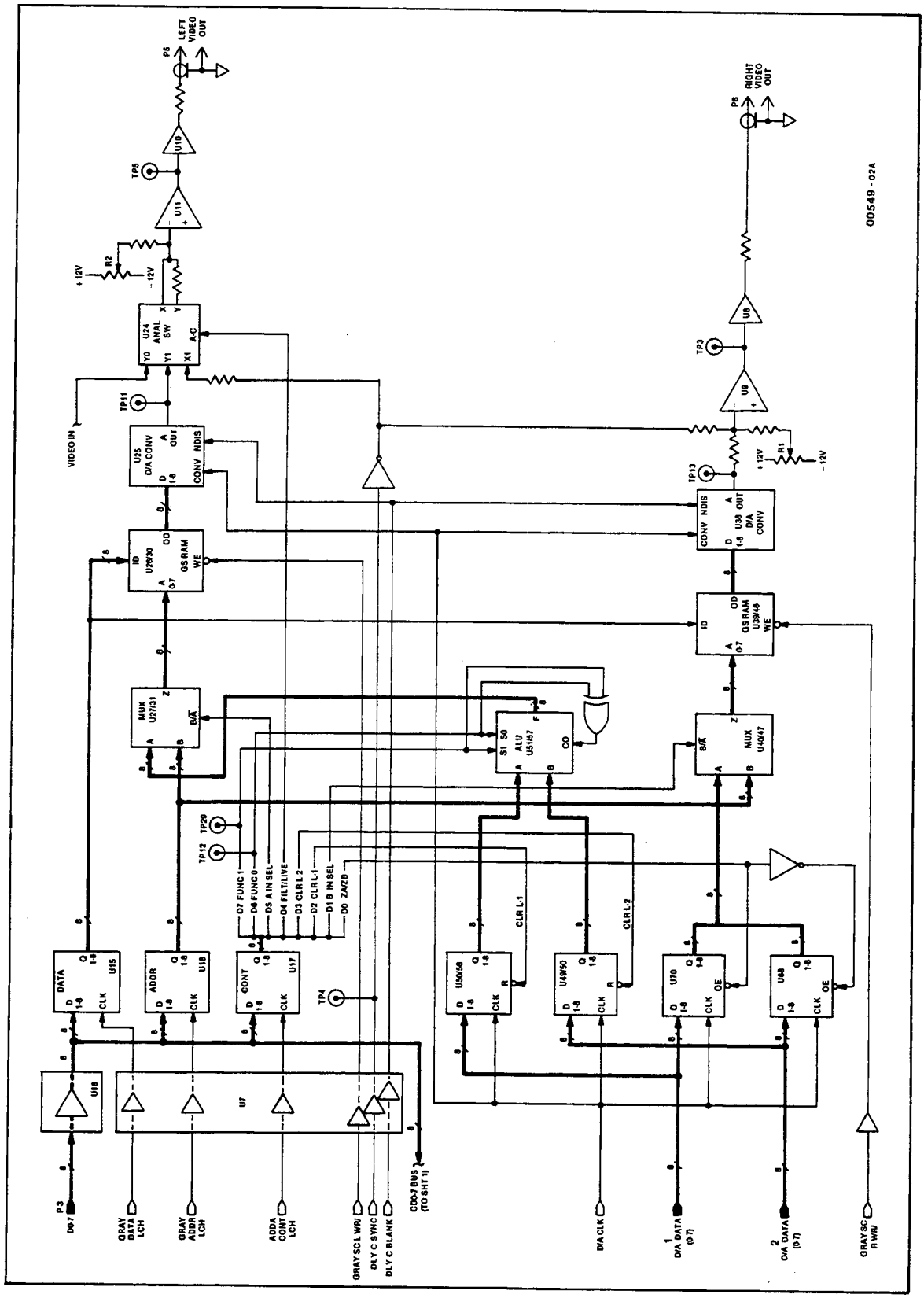


Figure 4-10 - *Block diagram of the AD/DA Converter PCB, D/A circuits.*



4.5.6 Pipeline Filter PCB

Circuit Functions

Refer to Figure 4-11 and Schematic 00-870501.

Referring to the block diagram, the hardware on the Pipeline Filter PCB may be divided into five functional areas:

The Filter Circuit - consists of the adder/subtractors, shifters, and assorted registers and selectors that control the data flow in the top half of the block diagram. The filter is used for averaging, opacification, edge sharpening, motion artifact reduction, and integration. The output of the filter is channeled through a log-table RAM, into either of the frame memories, and out to the AD/DA PCB to be displayed as an image. The log-RAMs are updated during the vertical interval.

The Buffer - consists of the selectors, adder/subtractors, shifters and latches that control the data flow on the lower half of the block diagram. Normally the Buffer simply passes a saved image to the AD/DA PCB to be displayed. However the Buffer can be used for live-digitizing, integration, and single frame subtraction processing.

Memory 1 - holds two frames of data. Incoming data can come from either the filter or the buffer. The memory bus connects with the Disk Interface and Image Processor PCB's. The memory output bus is also connected to the buffer inputs.

Memory 2 - Holds two frames of data. Incoming data can come from either the filter or the buffer. The memory 2 output bus is connected back to the filter circuit inputs.

Control Signals - Control timing and functions of the filter, buffer, and memories.

Pipeline Filter Buses

The following data busses can be identified in the block diagram.

R0 - R7: Filtered, integrated, shifted, or live data that is input to the log-RAMs.

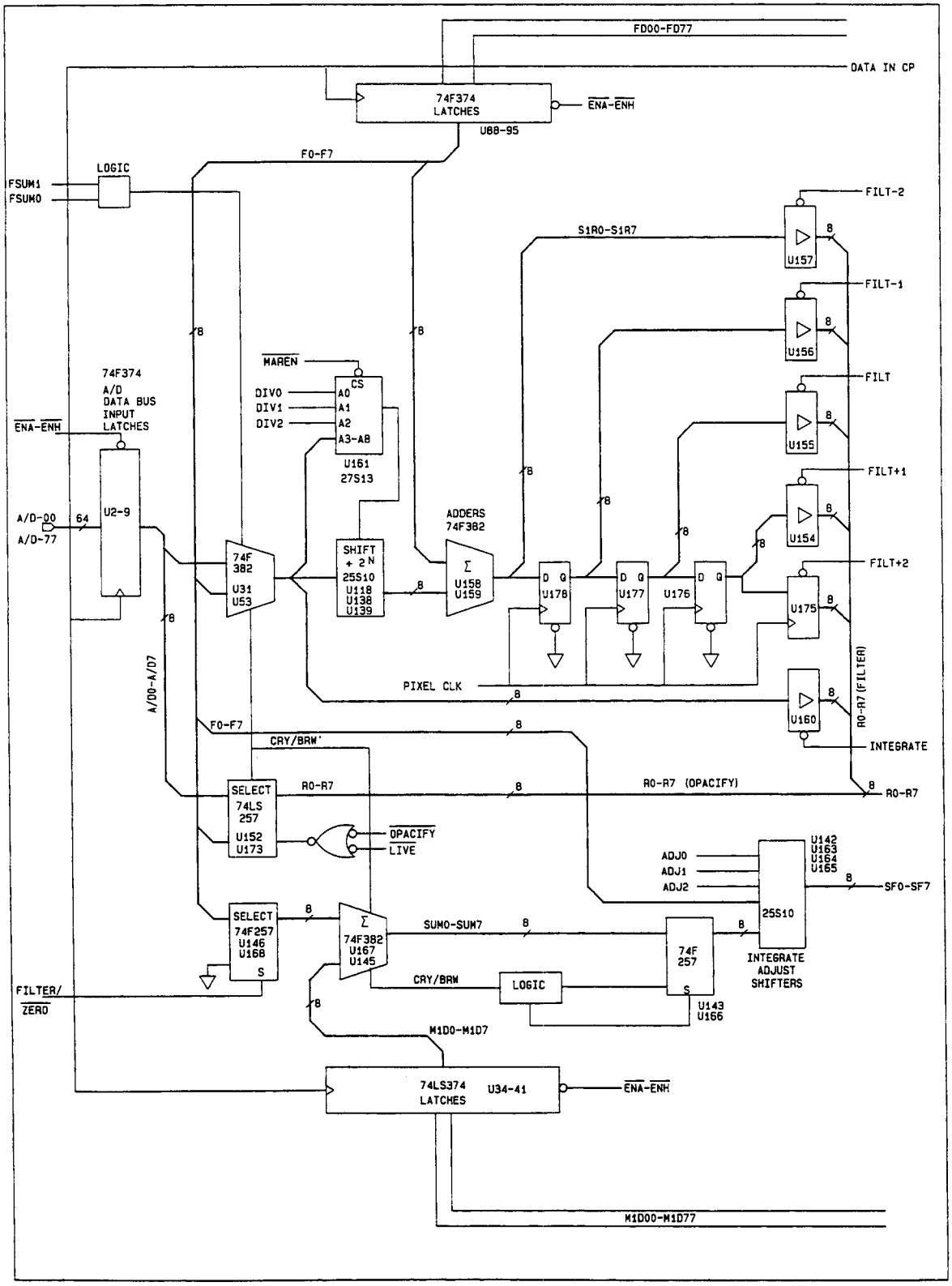
S1R0 - S1R7: The sum of M2 data (F0-F7) and shifted or subtracted A/D data. Used to implement normal averaging.

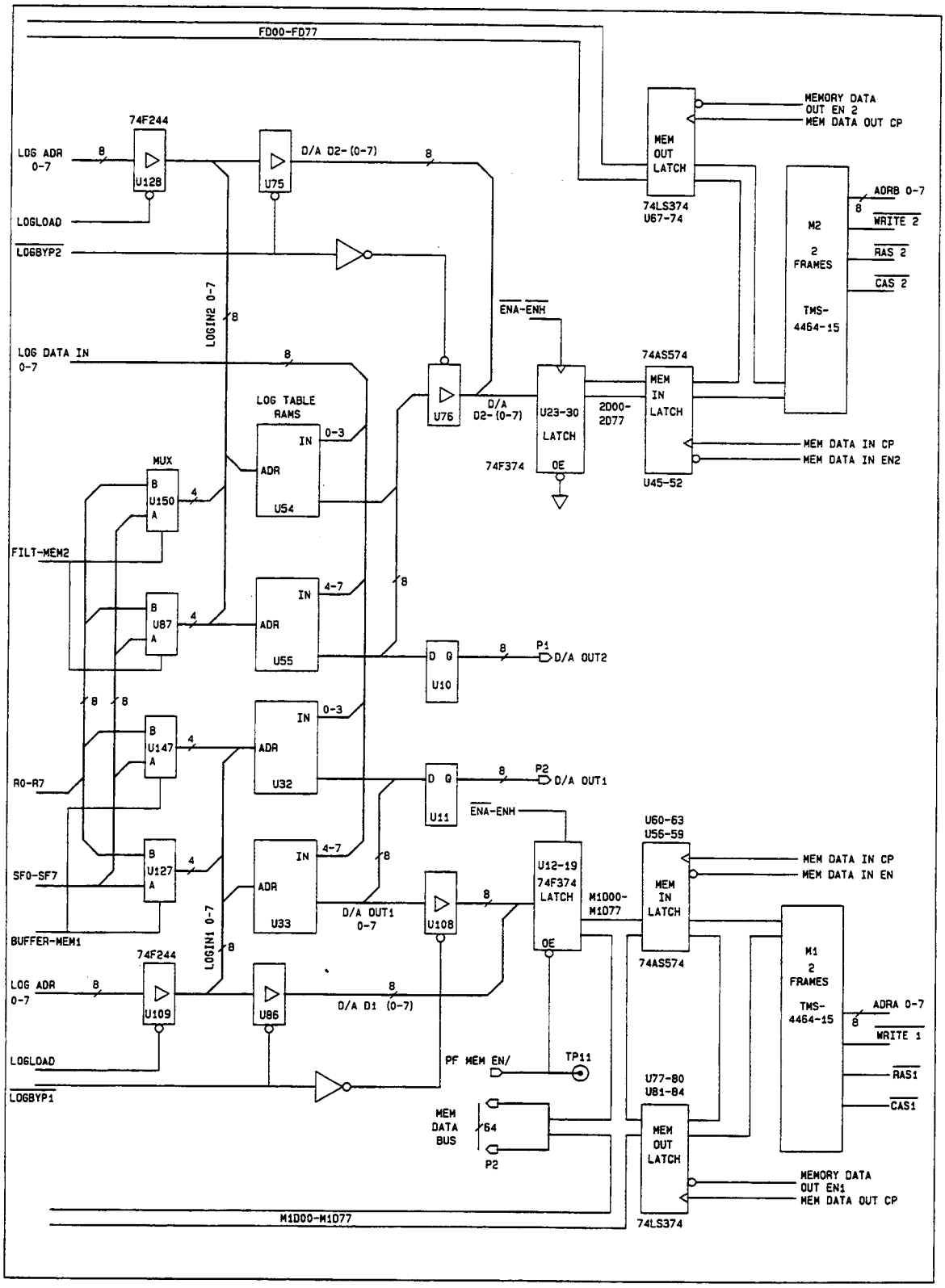
F0 - F7: Data bus from M2, demultiplexed to sequentially transmit the 64-bit bus as eight 8-bit bytes.

SF0 - SF7: Output from integration adjust shifters.

A/D0 - A/D7: Demultiplexed A/D data from AD/DA PCB.

Figure 4-11 - *Block diagram of the Pipeline Filter PCB (two pages).*




FD00-FD77
74F244
LOG ADR 0-7
8
U128
LOGLOAD
LOGBYP2
U75
D/A D2-(0-7)
8
MEM OUT LATCH
74LS374 U67-74
MEMORY DATA OUT EN 2
MEM DATA OUT CP
M2 2 FRAMES TMS-4464-15
ADRB 0-7
8
WRITE 2
RAS 2
CAS 2
LOGIN2 0-7
8
ENA-ENH
LOG DATA IN 0-7
8
LOG TABLE RAMS
U76
D/A D2-(0-7)
U23-30 LATCH
74F374
OE
2D00-2D77
74AS574
MEM IN LATCH
U45-52
MEM DATA IN CP
MEM DATA IN EN2
MUX
B
U150
A
4
IN
ADR
U54
0-3
FILT-MEM2
B
U87
A
4
IN
ADR
U55
4-7
8
D Q
U10
8
P1
D/A OUT2
8
8
B
U147
A
4
IN
ADR
U32
0-3
D Q
U11
8
P2
D/A OUT1
R0-R7
ENA-ENH
B
U127
A
4
IN
ADR
U33
4-7
8
D/A OUT1 0-7
U108
8
U12-19 74F374 LATCH
OE
M1D00-M1D77
U60-63
U56-59
MEM IN LATCH
74AS574
MEM DATA IN CP
MEM DATA IN EN
SF0-SF7
BUFFER-MEM1
LOGIN1 0-7
8
74F244
LOG ADR 0-7
8
U109
U86
8
D/A D1 (0-7)
M1 2 FRAMES TMS-4464-15
ADRA 0-7
8
WRITE 1
RAS1
CAS1
LOGLOAD
LOGBYP1
PF MEM EN/
TP11
U77-80
U81-84
MEM OUT LATCH
74LS374
MEM DATA BUS
64
P2
MEMORY DATA OUT EN1
MEM DATA OUT CP
M1D00-M1D77

M1D0 - M1D7: Data bus from M1. demultiplexed to sequentially transmit the 64-bit bus as eight 8-bit bytes.

D/A D1-0 - D/A D1-7: Output from log-RAMs or output obtained bypassing log-RAMS. Will be multiplexed onto 64-bit M1 data bus.

D/A D2-0 - D/A D2-7: Output from log-RAMs or output obtained bypassing log-RAMS. Will be multiplexed onto 64-bit M1 data bus.

Overall Operation

The Pipeline Filter latches a 64-bit wide data path (A/D00-A/D77) originating from the AD/DA PCB. This is read from the latches in 8-bit wide pixel bytes to be processed sequentially, as if on a pipeline. The 64-bit words are clocked into latches U2 through U9 by DATA IN CP. 8-bit pixel bytes are enabled onto the internal A/D0-A/D7 bus by ENA - ENH.

Data transfers between the 8-bit and 64- bit buses are controlled throughout the board by the DATA IN CP and the eight enable signals: ENA-ENH. ENA-ENH are derived from the pixel clock and the DATA IN CP by counter U153 and mux U1.

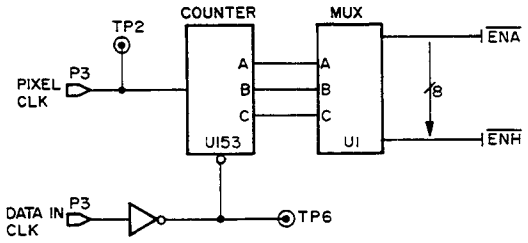
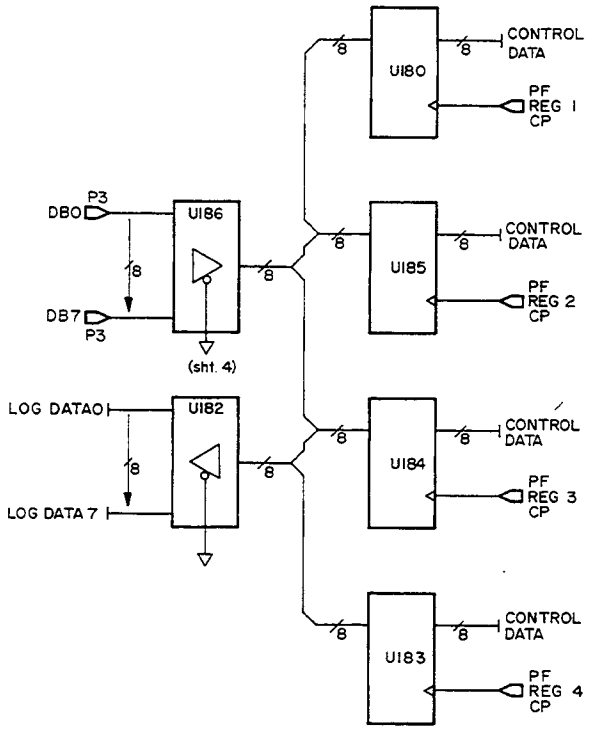


Figure 4-12 - *Decoding the eight enable signals, ENA-ENH.*

Processing command words are received from the Image Processor PCB via the daisy chained ribbon cable at P3. These are addressed to four control data registers PF REG 1-4. Log Data LOG DATA 0-7 (for the Gamma function) is also received from the Image Processor PCB and loaded into the log-RAMS.

Figure 4-13 - *The four control data registers, PF REG 1- PF REG 4.*



Memory control signals, the pixel clock, and DATA IN CP are generated on the Image Processor PCB. They are transmitted to the Filter PCB via P3, the daisy-chain ribbon cable connector.

After processing, the data is again clocked onto a 64 bit wide bus before being stored in memory or placed on the system image-data bus.

But the pixel data is passed in 8-bit bytes to the AD/DA via P1 (D/A OUT2) and P2 (D/A OUT1).

Memory consists of dynamic RAM TMS-4464 (4-bit x 64 k), in two separate banks of 16 each. ADRA0-ADRA7 is multiplexed with the RAS and CAS signals to address memory 1. ADRB0-ADRB7 is multiplexed with RAS and CAS to address memory 2.

Figure 4-14 - *Addressing memories 1 and 2.*

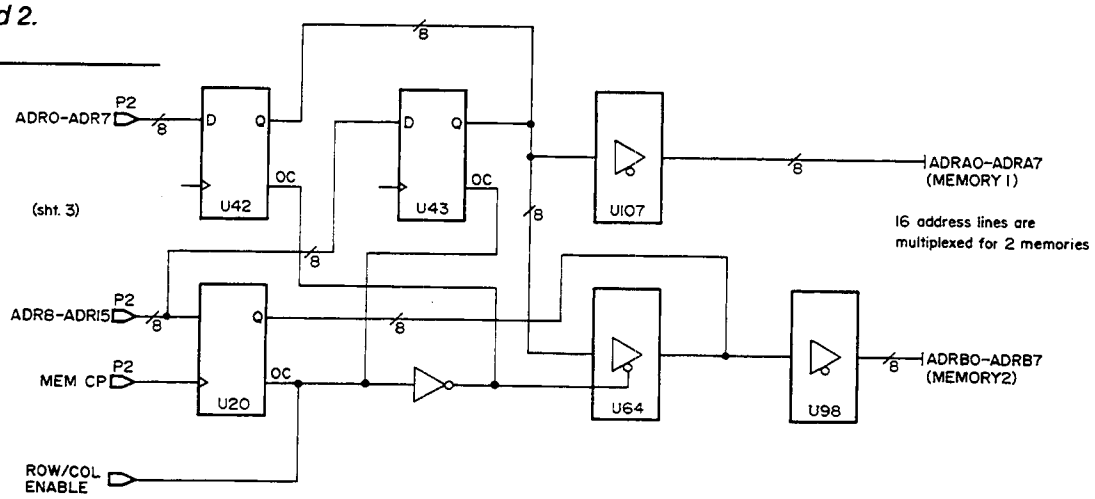


Image Processing Functions

Under software control the image data is routed through the circuits described above to provide the following:

Live Digitized Output — A/D0-A/D7 is selected by U152/U173. The pixel data is passed to the log RAMs for application of any selected gamma function, and then is output at P1, D/A OUT 2.

Stored Image Output from M1 and M2 — Memory contents are routed via the internal buses through the log RAMs. Memory 1 appears on D/A OUT1, Memory 2 appears on D/A OUT1.

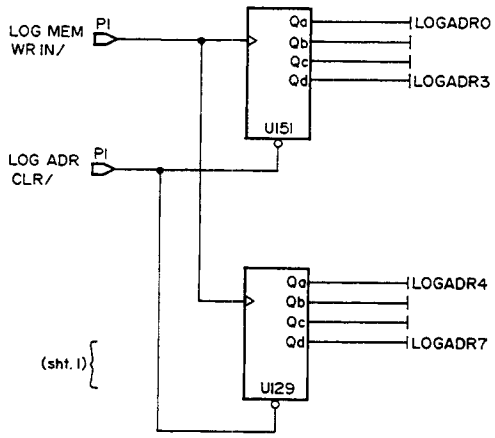
Frame Averaging — An algorithm is performed in which incoming pixel data is combined with the running average for that pixel. The subtraction algorithm D-M(t)/N + M(t) is performed as follows, where D= D/A data, M(t) = old memory value, M(t+1) is the new memory value, and N is the number of frames averaged.

Memory Swap — Image transfer between memories, M1 to M2 or M2 to M1, bypasses the log RAMs. The bypass control lines LOGBYP2 and LOGBYP1 are active. LOGBYP2 enables U75 to buffer the data onto the D/A D2 bus where it is latched onto the 64-bit bus 2D00-2D77 and into M2. LOGBYP1 enables U86 to buffer the data onto D/A D1 where it is latched onto the 64-bit bus M1D00-M1D77.

Gamma — The log RAMS on the Pipeline Filter PCB are loaded with a table from the Image Processor PCB according to which the image pixel values are mapped to an exponential gray scale.

LOG ADR 0-7 are generated by address counters U151 and U129.

Figure 4-15 - *Log RAM address counters.*



Motion Artifact Reduction

When the difference between the incoming and previous images is large, there is an adjustment of the averaging algorithm divisor. MARS is enabled by setting MAREN/ low.

Opacification

The incoming pixel value is compared against the previous value for that pixel in the image. The darker value of the two is kept. When (AD0-AD7) is greater than (F0-F7), summer U31,U53 generates a carry/borrow signal. This selects the source of the pixel placed on the R0-R7 bus by selector U152, U173.

Integration

Allows an average to be computed over a predetermined number of image frames. Result of addition step is a 16-bit word, overflow occurs into the upper eight bits. Last step is a division performed by right justifying into the upper byte.

Single Frame Subtraction

This subtraction is performed on the Pipeline Filter PCB alone. M2-M1 or M1-M2. Subtraction from both memories occurs a byte at a time by Adders U145 and U167. The result is placed on the SUM0-SUM7 bus and routed back into memory.

Edge Enhancement

This requires executing an algorithm which shifts the image a certain number of pixels in the X axis and a number of lines in the Y axis, and adds the original pixels with those at the shifted position. The Y shift is determined by changing the beginning storage address generated by the address counters on the Image Processor PCB. The X shift is produced with delay flip flops (U175-U178). which are selected by the FILT/ controls. FILT select lines are generated by 3 to 8 line decoder U179 which multiplexes control data latched from the Image Processor DB 0-7 control bus.

4.5.7 TV Monitors

The two TV monitors are designed especially for medical diagnostic applications. These provide:

* 75 ohm terminated input impedance
* RS170 standard negative sync
* Composite input video range of 0.3 to 2.5 volts p-p;
* Bandwidth in excess of 15 MHz at -3 dB
* Full genlock synchronization (vertical and horizontal).

4.5.8 Remote Contrast/Brightness Control PCB

Refer to Schematic 00-870928.

This PCB is located below the left monitor and allows the left monitor to be adjusted from either the mainframe or the monitor cart.

4.6 Image Storage

4.6.1 Hard Disk (Winchester Drive)

The hard disk unit contains space for storage of up to 60 images in digital format which can be recalled and displayed at a later time for further review. In addition, interfaces are provided for non-digital storage of images on video tape recorder or video disk.

The hard disk has a storage capacity of 20 megabytes, 15 megabytes of which are dedicated to image storage. The remaining 5 megabytes serve as program storage.

4.6.2 Video Tape Recorder (VTR)

The VTR may be used to store real time images on magnetic tape. The storage format is not digital. Successive video frames at a rate of 30 per second can be continuously recorded for up to one hour on a single cassette. Single frames cannot be randomly accessed. The tape counter offers an approximation of frame location and must be referenced against an external log of image contents.

4.6.3 AngioStor Video Disk Recorder

The AngioStor Video Disk Recorder may be used to store real-time images in a non-digital format. Up to 600 frames may be stored and later played back at rates of 30, 15, 6 and 4.5 frames per second.

4.6.4 Multi-Format Camera

The multi-format camera is provided with the same video signals which are displayed on the monitors. These signals are displayed on an internal monitor screen which is photographed. The format and number of images which are placed on the photographic film vary depending upon the camera model.

SECTION 11
OPTIONS

Various options which may be installed on the imaging system are covered in this section:

* Video tape recorder
* AngioStor video disk recorder
* Multiformat camera
* Patient annotation

Table 1 summarizes the signals provided for external image storage at the rear monitor cart connectors.

Table 1 Interfacing Signals

CONNECTOR & PIN	*SIGNAL*
MULTIFORMAT CAMERA INTERFACE	
J35	VIDEO OUT 2
J36	VIDEO OUT 1
VIDEO DISK INTERFACE	
J37-1	RECORD ENABLE
J37-5	GND
J37-4	TO VIDEO DISK
J37-3	SHIELD
J37-2	FROM VIDEO DISK
J37-6	SHIELD
J37-8	COMPOSITE SYNC
J37-7	SHIELD
VTR INTERFACE	
J38-4	TO VTR INPUT (LIVE VIDEO)
J38-3	SHIELD
J38-2	TO VTR OUTPUT
J38-6	SHIELD

11.1 Video Tape Recorder

11.1.1 VTR Installation

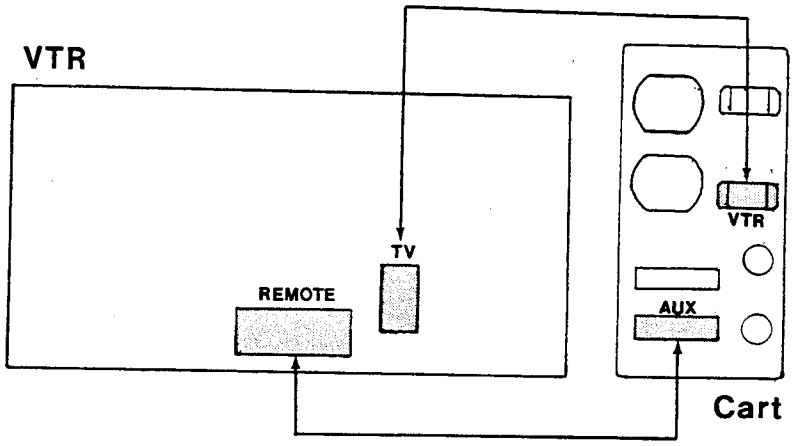


Figure 11-1 - *Connections are made between the VTR and the rear of the monitor cart.*

1. Connect the VTR VIDEO CABLE between the TV connector on the VTR and the VTR VIDEO connector on the rear of the monitor cart.
2. Connect the VTR CONTROL CABLE between the REMOTE connector on the rear of the VTR and and the AUX connector on the monitor cart rear panel.
3. Connect the VTR power cord to the service outlet.
4. Set up the VTR Controls as shown in Table 2.
5. Turn on the Service breaker and the VTR. Insert a blank video tape into the VTR.

   Note: a red button is provided with each video cassette. It must be installed in order to record. When it is removed, the tape can be played back, but not recorded.
6. Place the VTR in the RECORD mode by simultaneously depressing the PLAY, RECORD, and PAUSE buttons.

Figure 11-2 - *Power, Remote and TV input connections are made on the rear of the VTR.*

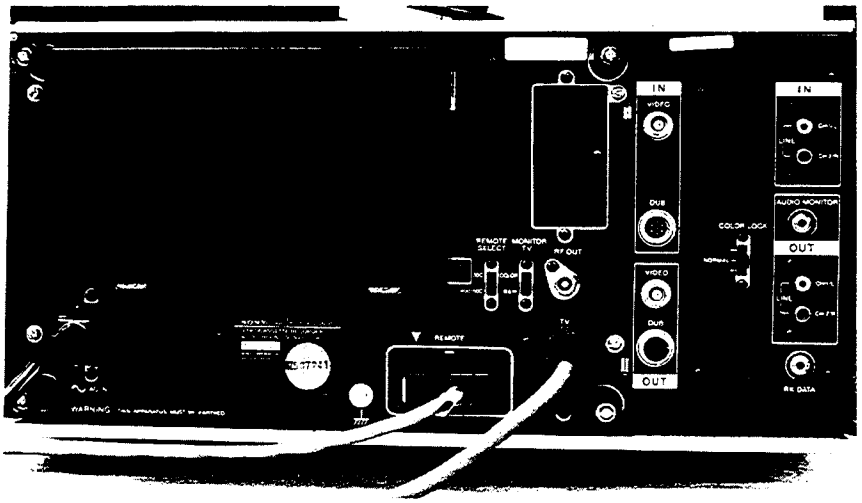


Table 2 **VTR Settings**

SWITCH/CONTROL	*SETTING*
AUDIO LEV	0
AUDIO LIMIT	OFF
AUDIO MON	MIX
DUB/CH 1	N.A.
EJECT	OFF
F-FWD	OFF
HEADPHONE	1
INPUT SEL	T.V.
PAUSE	OFF
PLAY	OFF
POWER	ON
PROGRAMED OPERATION	OFF
REC	OFF
REW	OFF
SEARCH	OFF
STOP	OFF
TIMER	OFF
TRACKING	FIXED

11.1.2 VTR Adjustment

Refer to Figure 11-3.

With an oscilloscope, verify the amplitude of the VTR video output as 1 volt composite video. Use the following procedure to adjust the VTR video output level.

1. Place the 60 kV shading tool on the image intensifier. Set the X-ray technique for MANUAL FLUORO at 60 kVp and 1.0 mA.
2. Connect an oscilloscope to J12 (To VTR) on the I/O Distribution Video Switch PCB using a coaxial "T" adaptor.
3. Tape several minutes of continuous fluoro imaging of the shading tool.
4. Verify that the video at J12, from baseline to white peaks, does not exceed 850 mVp and the sync portion of the signal is approximately 400 mVp.
5. Remove the top cover of the VTR and locate the 3 full depth PCBs. Locate the adjustment pot **RV6** on the inner-most board on the side facing the head assembly.
6. Connect the oscilloscope to J16 (From VTR) on the I/O Distribution Video Switch PCB using a coaxial "T" adaptor.
7. Rewind and review the recording you have made of the shading tool. Adjust **RV6** so the video signal meets the requirements of step 4.
8. Reinstall the VTR cover.



Figure 11-3 - *Adjust RV6 as shown in this photo.*

11.2 Angiostor Video Disk Recorder

The AngioStor is used primarily for recording raw video for post-processing. The video disk system is capable of storing 20 seconds of video at the rate of 30 frames per second.

The AngioStor must be supplied with a continuous source of composite video sync pulses, and the video being recorded must be composite video. Both the sync pulses and the composite video are provided by the Sync Separator PCB (P/N 00-870545, see schematic 00-870543).

The Sync Separator PCB supplies the AngioStor with a composite sync signal that is generated on the PCB when the AngioStor is not recording and with the sync that is stripped from the source video while the AngioStor is recording.

In addition, this PCB routes the source video from either the camera or from the VCR, and also routes the output video to either the VCR or the image processing system.

For more information refer to Service Technical Bulletin 86-011, 5 December 1986.

Additional maintenance and operating instructions are found in the OEM manual supplied with the AngioStor.

11.2.1 Installing the AngioStor Video Disk Recorder

1. Unpack the AngioStor. The Angiostor is shipped as the following components:

   * Mobile rack cabinet with installed electronics.
   * Remote control panel (optional)
   * Oktel operation and maintenance manual.
   * Storage disk (platter).

2. The Angiostor is shipped fully tested, but with the storage platter removed. Refer to the Oktel manual for instructions on installing the platter.

3. Place the AngioStor rack cabinet in a convenient location.

Note: The control panel may be located remotely on some installations.

4. Connect the cabinet electronics to a hospital grade receptacle capable of providing 117 VAC +/- 10% 60Hz. 950 VA (approx. 5 Amps). *Do not plug the AngioStor into the service outlet on the rear of the monitor cart.*

5. Connect the multiconductor-cable snap-on plug to the mating connector on the monitor cart rear panel. This is labeled: DISK VIDEO OUTPUT.

6. (OPTIONAL) If the control panel is not mounted in the rack cabinet - connect the coaxial cable to the rear of the remote control panel.

7. When installation is complete, proceed with the power up procedure.

11.2.2 Angiostor Power Up

NOTE: Do not plug the AngioStor into the cart service breaker.

1. Power up the monitor cart.

2. Turn on the **main power switch (1)** on the front of the AngioStor cabinet.

   Refer to Figure 11-5.

3. Turn on the **power switch (2)** located on the AngioStor control panel.

4. When the **servo lock LED (3)** on the AngioStor control panel turns on, the system is ready for use.

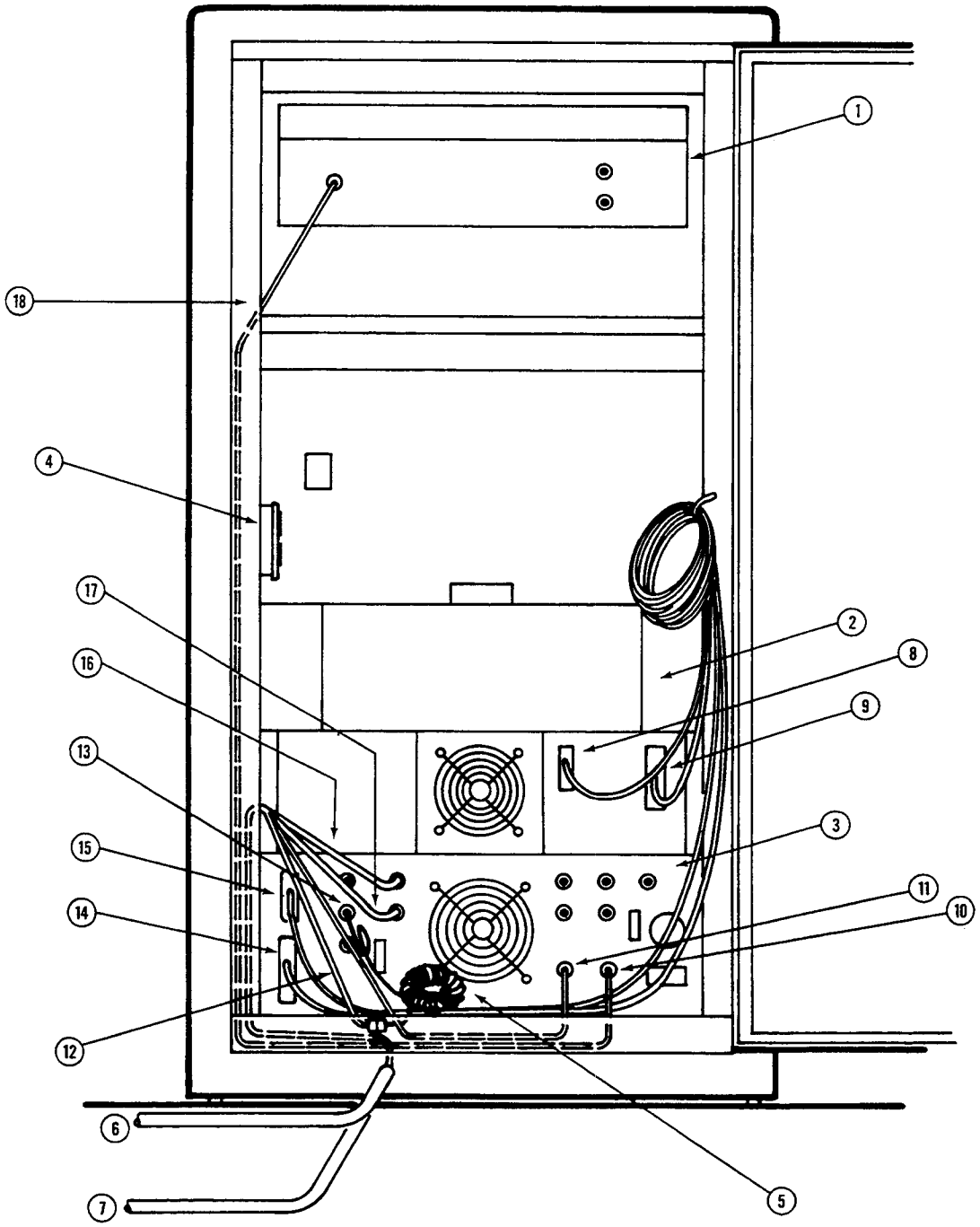
   Refer to the Operator's Manual for operating instructions.

11.2.3 AngioStor Connections

The following major components, cables and connections are found inside the rear of the AngioStor cabinet. Refer to Figure 11-4 for their locations.

1 - Control panel unit
2 - Video disk drive
3 - Signal processor/ servo drive
4 - Power outlet box
5 - Video filter balun
6 - Cable to monitor cart
7 - Power cord
8 - Connector: READ/WRITE 2
9 - Connector: SERVO
10 - Connector: REMOTE PANEL (to control panel unit)
11 - Connector: REMOTE RECORD
12 - Coax: Video-In (black)
13 - Connector: VIDEO-IN
14 - Connector: SERVO
15 - Connector: READ/WRITE
16 - Coax: Video-Out (white)
17 - Coax: Sync (gray)
18 - Coax cable to signal processor/servo drive.

Figure 11-4 - *Connections are made to the rear of the AngioStor components as shown in this drawing.*



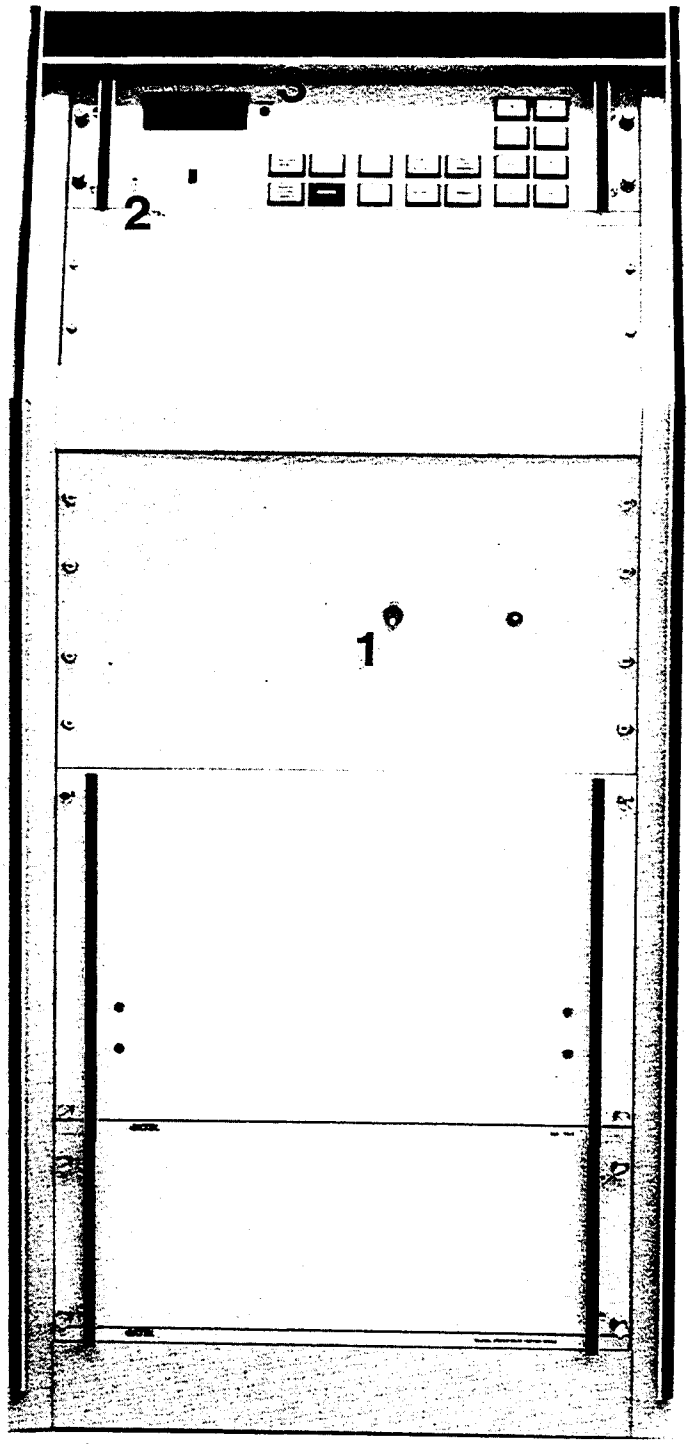


Figure 11-5 - *The AngioStor main switches are shown in this photo.*

11.2.4 AngioStor Troubleshooting Notes

Refer to the AngioStor Service Manual for detailed fault determination procedures. Before you do, however, check the following items:

1. Are all cables and connections in place? Are all BNC connectors solidly mated to their cables?
2. Have all switches been turned on in the correct order?
3. Are the disk and the disk heads clean?
4. Is the disk side with a light colored stripe under the hub lock positioned on top, so that the N-track is being read?
5. Are the motor SYNC LED on the control panel and the SERVO LOCK LED on the remote control unit on?
6. Does the numeric display on the AngioStor remote control unit contain the number 1 on powerup?
7. Do the lighted switches on the remote control unit respond by turning on and off when the switches are pressed?
8. Is the composite video sync signal from the monitor cart reaching the AngioStor?
9. Are all AngioStor printed circuit boards well seated in their connectors?

11.2.5 AngioStor Maintenance Notes

1. In normal operation the video disk rotates clockwise as viewed from the top. Always turn the disk in this direction, never counterclockwise.
2. Exercise extreme care when handling the video disk. Never touch it with bare hands, as this will leave oils and acids from the skin which will damage the media surface. Avoid contaminating the surface of the disk with dust or liquid spills.
3. The disk surface and the recording heads are delicate. To avoid damaging them during any major relocation of the AngioStor, remove the video disk and package it carefully. The best packaging is the original shipping container in which the disk was supplied. The head actuator arm locking screws should also be tightened before relocation to prevent damage to the heads. The dust cover should be secured over the head actuator assemblies during shipment to prevent contamination and damage.

4. The disk should be cleaned before it is installed. Clean the bottom side of the disk while it rests in the shipping container and then after mounting the disk onto the hub and tightening the diskhub retainer, clean the top of the disk. Only clean, dry, lint free wiping materials should be used for disk cleaning. Use only "zero residue" solvents to clean the disk surface. Some solvents which fit this description are: Tech Spray "Zero Residue Cleaner", T-P35 (available as OEC-Diasonics P/N 88-299318), and 95% isopropanol (reagent grade).

5. When bringing the heads into contact with the disk, always use a smooth-finished piece of plain white paper to ease the heads onto the disk. The paper should then be removed from between the disk and the head with a gentle pull tangent to the radius of the head and in a counter-clockwise direction.

6. The heads themselves need to be cleaned only infrequently, as determined by visual inspection of the heads with a magnifying lens. When head cleaning is required, it can be done without removing the heads from their actuator assemblies:

   a. Swing the actuator arm for the head to be cleaned off of the disk.

   b. Clean the head by dragging a piece of smooth-finished white paper, saturated with cleaning solvent, across the disk contact surface of the head.

   c. When the head has been cleaned, swing the arm back over the disk using the procedure described above to protect the head from damage.

   Use extreme care when working with the heads, and especially with the very fragile thick-film ribbon cables.

7. After installing the disk, the phase error signal should always be checked with an oscilloscope. The maximum allowed value of the phase error signal is 50 mV peak-to-peak. A new "N-track" signal should only be recorded on the disk if the phase error signal has an amplitude greater than this value.

11.3. Multiformat Camera

The video connections for the multiformat camera are located on the rear of the monitor cart.

Instructions for the camera are provided separately.

11.4 Patient Annotation

Patient annotation consists of a PC-compatible keyboard, a connector to the Front Panel Processor PCB, and special software.

The keyboard connector provides the following signals:

Table 3 Keyboard Interface

PIN	*SIGNAL*
PIN	*SIGNAL*
1	KBCLK
2	KBDATA
3	RESET
4	GROUND
5	+5 VDC

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 all safety requirements applicable to medical electronic equipment of this type.

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

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 who has been trained to troubleshoot and repair the Series 9000 System.

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

WARNING: **The procedures in this manual should not be attempted by anyone who is not specifically trained by OEC-Diasonics to work on the Series 9000 System.**

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; nor can it be responsible 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.
P.O.Box 25296
Salt Lake City, Utah
84125-0296
801-973-6800

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 who work with or are exposed to X-ray tubes must take precautions to protect themselves against serious injury. Do not be careless.

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.

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.

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: **This equipment contains very high power electrical components and should be serviced only by personnel intimately 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.**
- Video monitors (monitor cart) - **25,000 volts.**
- Transformers (especially the isolation transformer in the monitor cart) - **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.**

WARNING: **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.**

WARNING: **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.**

WARNING: **Do not remove the interconnect cable from its connector on the monitor cart. Hazardous voltage (120 VAC) is present on the pins of this connector when the monitor cart is plugged into a power outlet. These pins are exposed when the interconnect cable is not in place.**

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.

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

Federal DHHS guide lines specify that the minimum source-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-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 Emergency Power Off

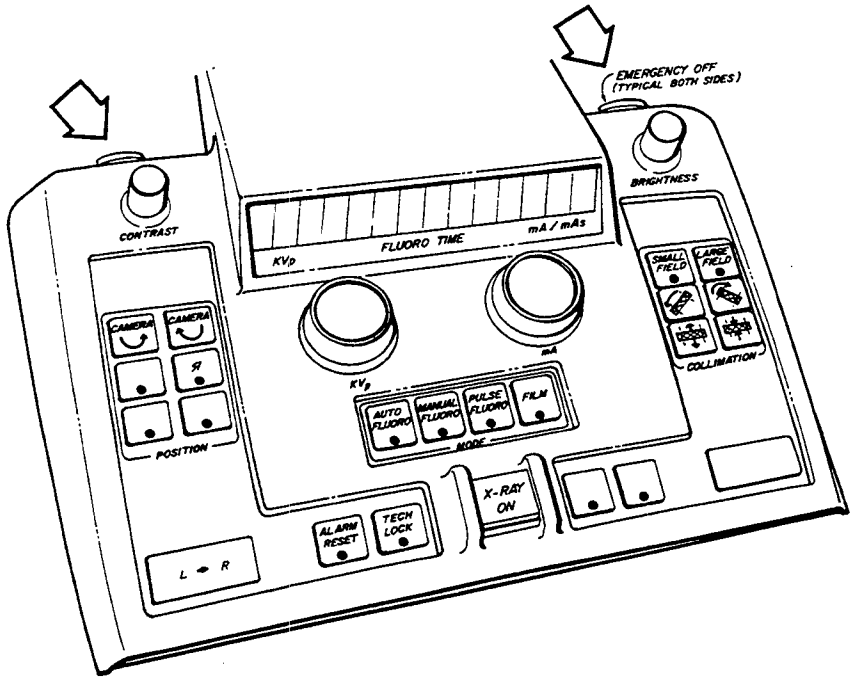
Refer to Figure 1.

The system has two EMERGENCY OFF buttons located on the C-arm control panel. When either button is pressed, operation of the system 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.

In the unlikely event that a malfunction in the motor control circuitry causes a motor to drive without an operator command, it is important to train all operators to respond by pressing the EMERGENCY OFF switch.

The monitor cart electronics are separately controlled by the cart power breaker on the cart power panel. To remove power only from the monitor cart electronics turn this breaker off.

Fig. 1 - The locations of the two emergency off buttons are shown here.



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 by a qualified service technician.

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 System Failure During Fluoroscopic Use

If the system image processing electronics fail during a critical operative procedure, set the toggle switch on the rear of the monitor cart to BYPASS. This will direct undigitized live fluoro images to the left monitor, bypassing the image processing electronics.

NOTE: Last-image-hold will not operate in BYPASS.

2.5.4 System Malfunction

If a fuse is blown repeatedly or a circuit breaker trips after being reset, it may indicate an equipment malfunction. Do not attempt to operate the system until it has been checked out by a qualified service technician.

If any of the system controls fail to respond as indicated in the Operator's Manual, the operator should, if the immediate circumstances allow:

1. Turn the power off.
2. Unplug the system from the wall outlet.
3. Notify a qualified service technician immediately.
4. Do not attempt to operate the system until the service technician has advised that it is operating properly.

The system should not used beyond the immediate situation if any system control failure occurs.

2.5.5 Electrical Fire

The owner should develop an emergency procedure for the area in which the system is installed that includes the following safety measures:

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 *The use of 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.*

2.5.6 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.

2.6 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:

- The potential for death or the type of serious injury that may result is specified in the labeling for the system.

- The malfunction and the routine service, repair, or maintenance instructions to correct the malfunction are described in the labeling for the system.

- The malfunction has occurred at or below its expected rate of frequency and severity.

- 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.

2.7 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.

9000 SERVICE MANUAL

UPDATE
00-876628-01
REV. A

INSTRUCTIONS:

1. Insert this -01 Update tab and text at the back of the manual, after the last page.

Date of Issue: November 1993

OEC MEDICAL SYSTEMS, INC.

384 Wright Brothers Drive
Salt Lake City
Utah
84116

(801) 328-9300

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Revision History

Update PN & Rev.	Manual PN	Manual Revision
00-876628-01, Rev. A	00-870820-01	C

UPDATE

1. BATTERY REPLACEMENT, TECHNIQUE PROCESSOR BOARD

The real time clock battery, B1, on the technique processor board should be replaced every two years. The age of the battery can be derived from either the delivery date, for a recently purchased unit, or from the dated label that is applied during battery service. Under normal operating conditions, the expected life of the battery is well in excess of two years. However, replacement every two years insures that the battery will not deplete during usage.

9000/URO1000 BATTERY REPLACEMENT KIT, 00-876434-03:

Quantity	Part Number	Description
1	74-122902-00	3V Lithium Battery
1	32-301420-00	2KΩ, 1/4W Resistor
1	88-359989-00	Self Adhesive Label
2	00-876488-01	Operator's Mnl. Replacement Pages
2	00-876801-01	Operator's Mnl. Replacement Pages

BATTERY REPLACEMENT KIT, 00-876434-02*:

Quantity	Part Number	Description
1	74-122902-00	3V Lithium Battery
1	88-359989-00	Self Adhesive Label

*See NOTE on the following page which explains when the -02 Kit is needed.

PARTS/TOOLS REQUIRED:

Indelible Marker

Soldering Iron

Solder

1.1 PROCEDURE

NOTE:

The following procedure is for first-time installation of a new battery on the PCB. It assumes that the 2KW resistor has *not* yet been installed near IC U79 and that you are using Battery Replacement Kit PN 00-876434-03. If this resistor has already been installed and you are only replacing the battery, you need to use Battery Replacement Kit PN 00-876434-02 which includes the new battery and label. Be sure to write the date of installation on the new label and place the label on U79 after replacing the battery.

1) Turn off all power to the system.

2) Remove the Technique Processor PCB from the generator card rack (see Figure 1, page 7).

3) Carefully remove U79 from the socket on the Technique Processor PCB and set aside (see Figure 2, page 8).

4) Locate the battery (B1) on the Technique Processor PCB (see Figure 2, page 8) and carefully remove the battery from the Technique Processor PCB by cutting the battery leads. After you remove the battery, carefully remove the leads of the battery from the Technique Processor PCB with your soldering iron and clean the solder holes so that the new battery can be installed.

5) While looking at the component side of the Technique Processor PCB locate the socket for U79. Near pin 12 of the socket for U79 is a short solder trace with a solder pad at both ends of the trace. Electrically this trace goes from U79 pin 14 to the battery B1. Refer to Figure 3, page 9, for the location of this trace.

6) Carefully cut the middle of the solder trace from step 5. Refer to Figure 3, page 9. Use your soldering iron to carefully remove the solder from the solder pads at the ends of the trace you cut.

7) Install the 2KΩ resistor (32-301420-00) provided with the Battery Replacement Kit on the component side of the Technique Processor PCB by inserting the leads of the resistor through the holes of the solder pads of the trace you cut in step 6. Carefully solder the resistor into place. Electrically this resistor is now in series between U79 pin 14 and the battery B1.

8) Install the new 3V battery (74-122902-00) provided with the Battery Replacement Kit on the Technique Processor PCB into the same location as the old battery. Carefully solder the battery onto the Technique Processor PCB.

9) Install U79 back into the socket on the Technique Processor PCB.

10) Using an indelible marker write the current date on the self adhesive label (88-359989-00) provided with the Battery Replacement Kit. Affix the self adhesive label to the top of U79 on the Technique Processor PCB.

11) Carefully install the Technique Processor PCB back into the system.

12) Turn the system on and allow it to boot completely. You may get a message on the control panel that says the system needs 24 hours to recharge. You may ignore this message and get past it by pressing any key on the control panel.

13) Enter the STATUS mode of the system through the control panel and set the time and date. Instructions on entering the STATUS mode for your particular system may be found in the Maintenance section of the Operator's Manual.

14) Reboot the system and make sure it boots up completely. Make sure the system operates correctly by verifying fluoro operation, film operation, image storage, etc.

15) After upgrading the 9000, leave the Operator's Manual Replacement Pages (00-876488-01) and (00-876801-01) that were sent as part of the upgrade kit with the customer.

Figure 1 - Technique Processor PCB location in 9000 Electronics Cabinet

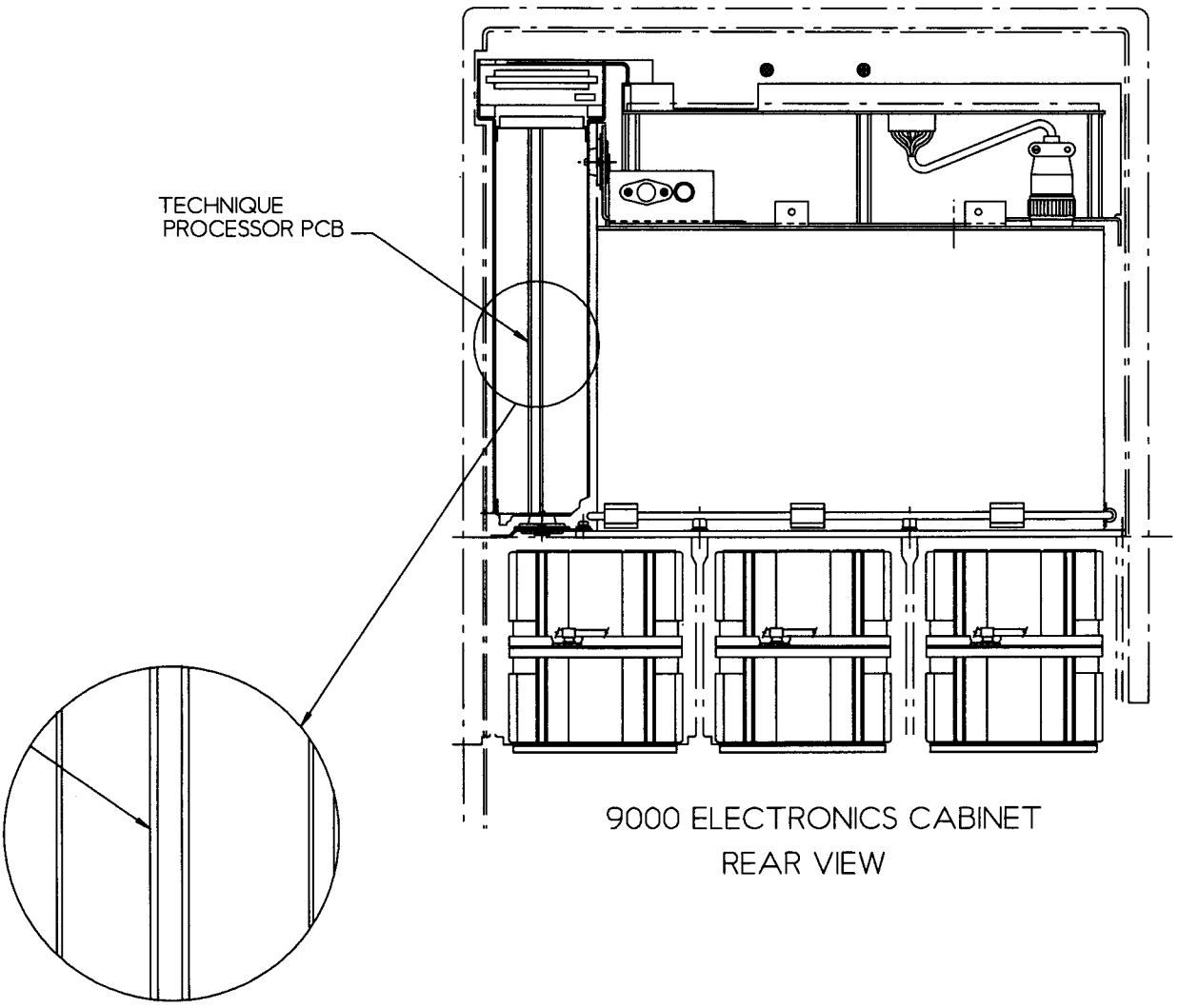


Figure 2 - Battery and Real Time Clock IC locations on Technique Processor Board

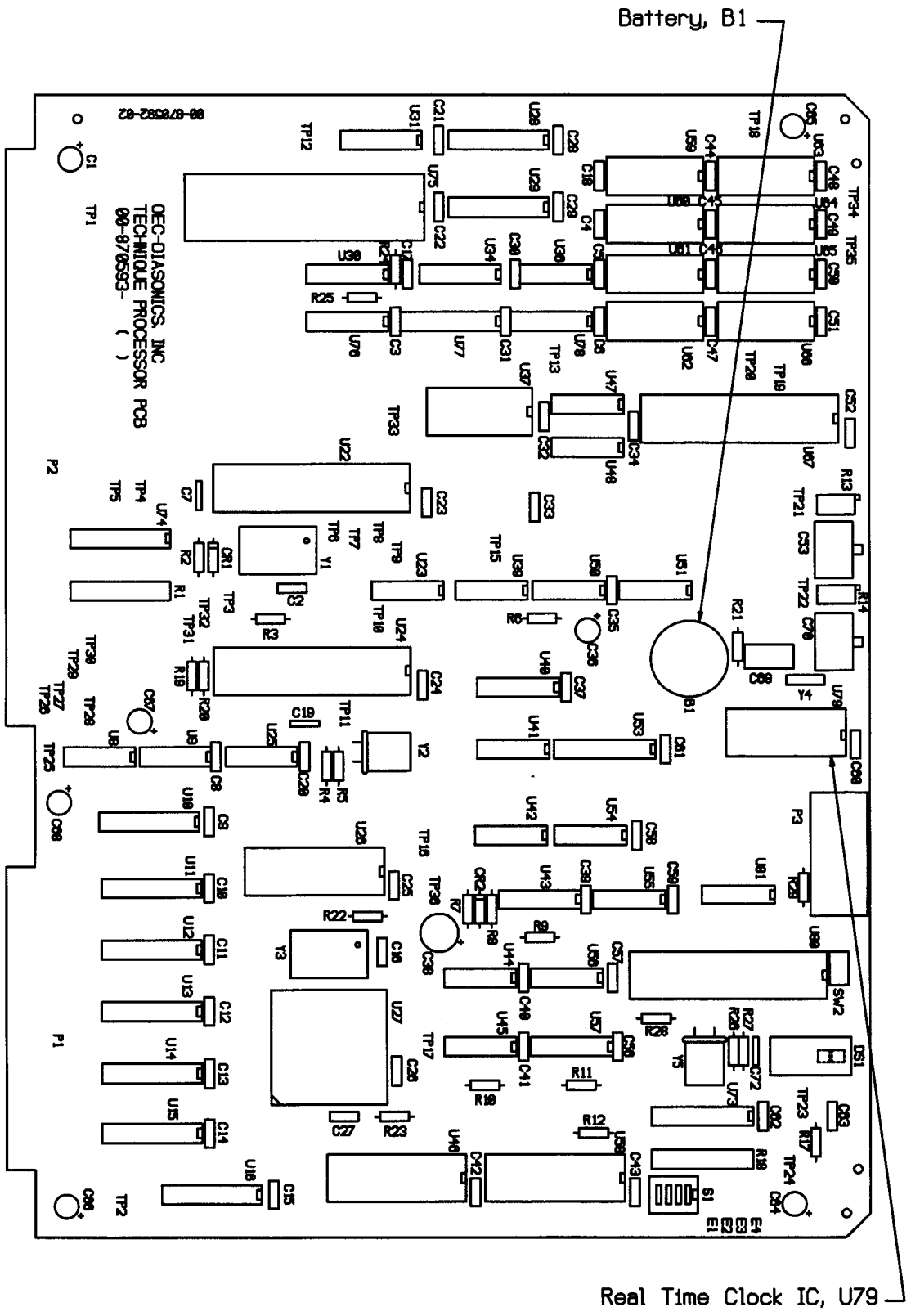
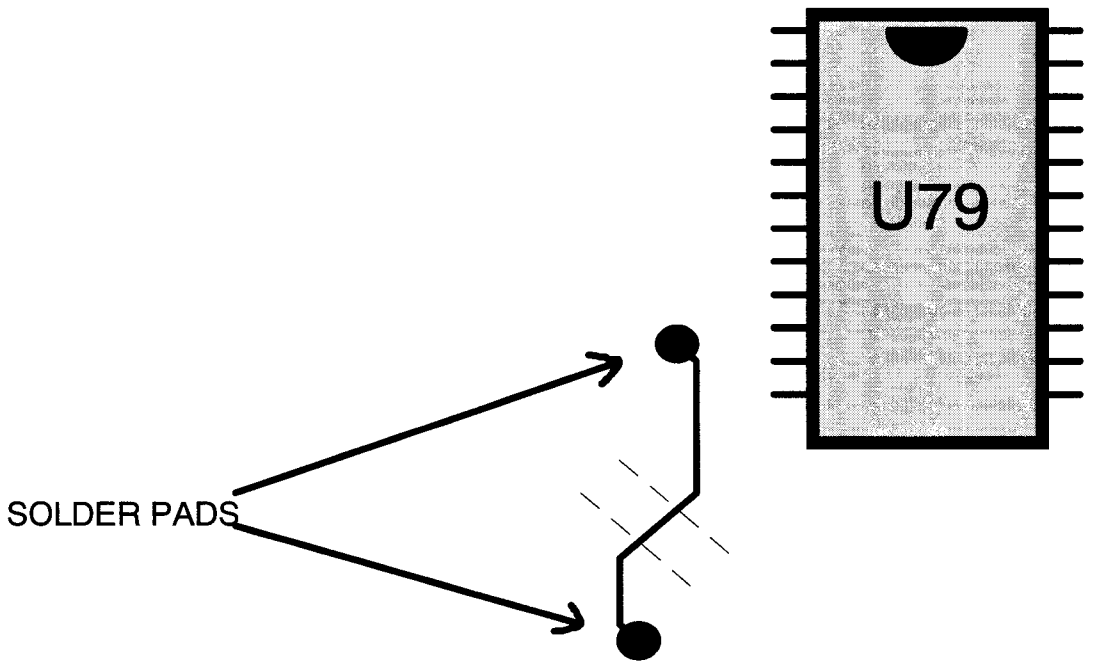


Figure 3 - Location of 2KΩ Resistor installation on the Technique Processor PCB



CUT TRACE BETWEEN DASHED LINES

INSTALL RESISTOR BETWEEN SOLDER PADS