EUREKA

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LINEAR™ IV

Automatic Collimation System

Installation
Operation
and Maintenance

00-02-1517 Rev. L

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

SECTION 1.0

INTRODUCTION

This product has been tested by Underwriter's Laboratories in conformance with standards set forth by UL 2601-1, CAN/CSA-C22.2 No. 601.1-M-90, and IEC 601-2-32. It has been found to comply with these standards and, therefore, bears the above "Recognized Component" symbol for UL and UL-C.

UL File No. E181750

Progeny, Inc. is registered to ISO9001, EN46001, and the Medical Device Directive 93/42/EEC Annex II by SGS Yarsley, Ltd.

1.0 INTRODUCTION

This manual contains information for the assembly, installation, adjustment, testing and maintenance of the LINEAR IV radiographic/fluoroscopic collimator manufactured by Progeny, Inc.

1.1 YOU HAVE LEGAL OBLIGATIONS

The manufacturers of beam limiting devices are required to provide instructions for the assembly, installation, adjustment and testing adequate to assure compliance with applicable provisions of DHHS Performance Standards 21 CFR Sub-Chapter J, Part 1020.

Those who assemble or service beam limiting devices must follow the instructions of the original manufacturer and process the FD-2579 Assemblers Report where applicable.

You assume responsibility for compliance of this product if you fail to follow the original manufacturer's instructions or modify any component which affects radiation safety.

The FDA (BRH) requires that manufacturers must include a specific requirement that the assembler perform all applicable tests at the time of installation. A thorough explanation of the equipment required and step-by-step instructions must be provided by the manufacturer. The instructions include a requirement to record key data to demonstrate at a later time that all tests were performed and that the equipment was left in full compliance with the standards.

As an assembler, you must perform these tests for the applicable requirements at the time of installation and following any repairs which could alter the performance.

A Compliance Data Log is provided in this manual to record the results of the tests.

1.2 BACKGROUND

An X-ray collimator functions as an apparatus for regulating the cross-sectional size and shape of a beam of radiation which emerges from an X-ray tube.

The source of radiation is virtually a point-source and, due to the tube housing design, emerges from the port as a solid diverging cone of radiation. The finite angle of the anode surface limits the X-ray beam on the anode side (heel-effect) forming a 'D" shaped X-ray field, limiting the useful coverage.

In "collimating" a beam to a given size and shape, a geared pair of lead shutters are moved symmetrically into the beam to absorb the unwanted portion of the emerging beam. A second geared pair of shutters are positioned at right angles to the first pair, and again are moved symmetrically into the beam. In this manner, a continuously variable square/rectangular beam is formed.

The landing area of the beam will contain a radiographic image receptor located in a plane perpendicular to the beam at pre-determined distances from the radiation source (focal spot).

The size and shape of the image receptor will determine the maximum useful cross-sectional size and shape of the beam in the plane of the image receptor. The source-to-image receptor distance (SID) determines the actual shutter opening required to regulate the beam size and shape in the plane of the image receptor.

"Positive" beam-limiting (PBL) devices incorporate means to prevent X-ray production until the beam limitation meets the applicable provisions of the Performance Standards.

Automatic PBL devices incorporate motors that regulate the shutter opening as required. Manual PBL devices require the operator to adjust the shutters by the use of knobs, levers, etc.

The primary objective of the electronic logic circuitry is to limit the beam to the size of the image receptor and to provide other standardized operations consistent with the DHHS Performance Standards 21 CFR Sub-Chapter J. This is accomplished by electrically measuring the size of the SID involved. The resultant signal is then compared to a signal which represents the collimator shutter opening to form a means of limiting the beam.

The second objective is to provide convenience features, such as a status indicator light to aid and guide the operator in the use of the collimator, particularly with a manual PBL device.

1.3 LINEAR IV STANDARD FEATURES

The Linear IV collimation system from Progeny includes all features required for diagnostic excellence, as well as to minimize installation and diagnostic down times:

- Full manual operation for table-top radiography.
- Automatic PBL operation upon insertion of a cassette into the bucky tray.
- Manual field size reduction after automatic PBL cycle.
- Optional remote shutter control capability for fluoroscopic or radiographic operation. Allows selection of up to three image intensifier sizes and all other features accessible at the front panel.
- Spotfilm capability for fluoro/spotfilm operation.
- Square or rectangular pattern continuously variable from 17" x 17" at 36" SID (or 43 cm x 43 cm at 90 cm SID) to fully closed.
- Size sensing capability for all metric and inch size cassettes.
- Compatible with urological tables that are equipped with image intensifier systems.
- Optional cone track available for accessories.
- Swivel mount for angulated positioning.

- Tape measure provided for accurate SID positioning.
- SID monitor provided for continuous SID vertical operation. Second SID monitor can be incorporated for differential SID operation.
- Bright bucky centering light-line.
- Digital display of SID and field size in English or metric units, selectable during calibration.
- Alpha numeric display of operational modes; to indicate ready, manual, and exposure hold conditions and the cause of the condition; to indicate RAD, FLUORO or SPOTFILM modes; and to display diagnostic, calibration, and error messages.
- Power assisted manual drive of the shutters or manually controlled knobs for size adjustment.
- **AUTOCAL**, built in smart software allows collimator calibration to be done solely at the front panel. No access to the logic board is necessary to complete calibration, no potentiometers to adjust, and interface to accessories such as SID monitors and Bucky trays are very adaptable allowing for almost any to be used in conjunction with the collimator.[1]
- Calibration information is stored in non-volatile memory with write protection. Thus power failures and most all electrical noise will not affect unit operation or calibration parameters.

1 Maximum interface voltage not to exceed 2.5 Vdc.

1.4 SPECIFICATIONS - LINEAR IV

Operation:	Fully automatic (PBL) within 2 seconds, and manual.
SID's for Automatic Operation:	Continuously variable from 36" (90 cm) through 72" (180 cm) vertical, and 36", 40", 48" and 72" (90cm, 100 cm, 120 cm, and 180 cm) horizontal.
SID Indicators:	Digital display of SID, selectable in Metric or English. Display is blank if valid SID is not confirmed.
Field Size Indicators:	Digital display of X-ray field size at image receptor for the particular SID. Display is blanked when a valid field size cannot be determined.
Radiation Shielding:	Rated at 150 kV. Less than 50 mR/Hr at one meter.
Film Coverage:	Continuously variable from 17" x 17" (43 cm x 43 cm) to 5" x 5" (13 cm x 13 cm) in automatic mode at all listed distances. Manual range from 17" x 17" (43 cm x 43 cm) to fully closed. 28° coverage - 14° from central ray.
Light Field:	More than 160 LUX (15 footcandles) with a minimum edge contrast ratio of 4:1 at one meter. Controlled by internal timer with quick turn-off capability. Timer turns off lamp after 25 $\pm$ 10 seconds.
Accuracy:	2% of SID in use.
X-Ray Field Accuracy:	Within 2% of SID in use in length and width (sum less than 4%).
SID Digital Display Accuracy :	Within 1% of measured SID.
Field Size Display Accuracy:	Corresponds to X-ray field size within 1% of the SID in use.
Bucky Light Line:	Bright center line extending from center of field to withdrawn tray.
Stereographic/ Tomographic PBL By-Pass:	Available at power supply. Accepts voltages of 5, 15, and 24 VAC switched ground.
MirrorAdjustment:	Allows for coarse or fine (thumbscrew) adjustment of mirror position.

Inherent Filtration:	2.0 mm (min.), aluminum equivalent at 70 kV and above. Low filtration mirror/bracket available from Progeny (1.0 mm min AL).			
Power Requirement:	115-230 VAC, 50/60 Hz, 3 AMP, 3 Wire, 1 Phase			
Light Field Lamp:	Type DZE, 25 VAC, 150 WATT (GE).			
Radiographic Mode Selector Input:	Switched ground.			
Image Intensified Mode Control:	Isolated from "C" contacts rated at 2 Amps at 120 VAC resistive load.			
Exposure Interlock:	Isolated from "C" contacts rated at 2 Amps at 120 VAC resistive load.			
Fuse	-	Input Supply	(1)	3 Amp MDL
	-	Lamp Power	(1)	8 Amp MDL
	-	Motor Supply	(1)	3 Amp MDL
Weight	-	Collimator	19.3 lbs (8.8 kg)	
	-	Power Supply	27.5 lbs (12.5 kg)	

1.5 REMOTE CONTROL UNIT INTERFACE

The Linear IV collimator system has the capability of remote control operation by using the built-in remote interface at the collimator head. The remote functions capable are the same as those availableat the front panel of the collimator and include: light field control, manual shutter control, automatic size preset, and image intensifier selection control.

A full function hand-held remote with the above functionality is available from Progeny.

Other remote units can be used if they can be interfaced to the built-in remote port. **CONTACT PROGENY, INC.FOR INFORMATION REGARDING THE REMOTE CONTROL INTERFACE.**

1.6 RADIATION AND MECHANICAL/ELECTRICAL WARNING (from NEMA Standards Publication/No. XR8-1979)

Radiation Warning for Diagnostic X-Ray Systems

X-rays are dangerous to both operator and others in the vicinity unless established, safe, exposure procedures are strictly observed.

The useful and scattered beams can produce serious, genetic or potentially fatal bodily injuries to any persons in the surrounding area if used by an unskilled operator. Adequate precautions must always be taken to avoid exposure to the useful beam, as well as to leakage radiation from within the source housing or to scattered radiation resulting from the passage of radiation through matter.

Those authorized to operate, test, participate in or supervise the operation of the equipment must be thoroughly familiar, and comply completely with the currently established safe exposure factors and procedures described in publications such as Sub-Chapter J of Title 21 of the Code of Federal Regulations, *"Diagnostic X-Ray Systems and their Major Components,"* and the National Council on Radiation Protection (NCRP) No. 33, *"Medical X-Ray and Gamma-Ray Protection for Energies up to 10 MeV-Equipment Design and Use,"* as revised or replaced in the future.

Failure to observe these warnings may cause serious, genetic or potentially fatal bodily injuries to the operator or those in the area.

Mechanical-Electrical Warning for Diagnostic X-Ray Systems

All of the moveable assemblies and parts of X-ray equipment should be operated with care.

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

Do not remove the flexible high tension cables from the X-ray tube housing, or high tension generator, or the access covers from the generator until the main and auxiliary power supplies have been disconnected.

When disconnecting high voltage cables, they must be grounded immediately in order to dissipate any electrical charge that may remain on the cables or the tube.

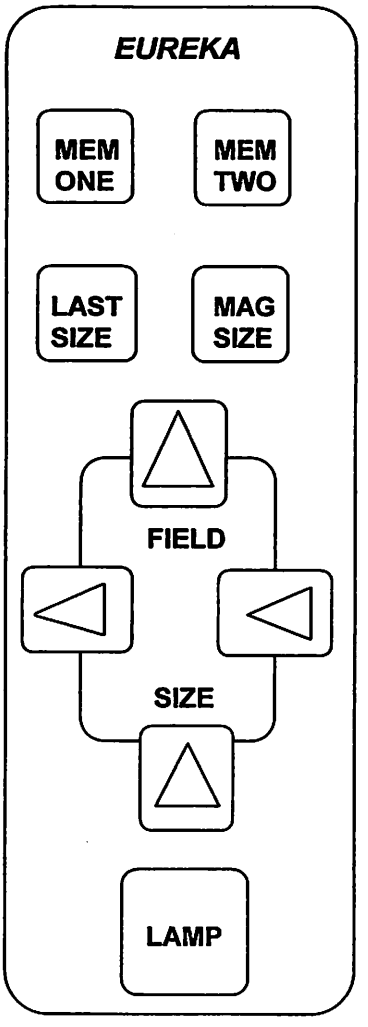
Failure to comply with the foregoing may result in serious or potentially fatal bodily injuries to the operator or those in the area.

1.7 REMOTE CONTROL UNIT

The Linear IV collimator system is available with a factory installed remote control unit. The remote functions available are to allow the user to implement field size changes using the hand held unit. The unit provides functions which are the same as those available at the front panel of the collimator. These functions include: light field control, manual shutter control, automatic size pretest, and image intensifier selection control.

If required to route the remote cable through small openings or system conduit hosing, it is possible to remove the cable from the hand held unit and reconnect it after the cable is routed. To implement this, first ensure system power is off, then remove the 4 screws from the bottom of the hand held unit and separate it into two pieces. Carefully remove the cable with its connector from the mating header on the printed circuit board inside. The cable may now be routed, with caution to protect the connector. The connector can be reinstalled and the unit reassembled.

A diagram of the remote control panel is provided:



1.8 COMPATIBILITY

The Linear IV collimator is compatible and can be adapted for use with X-ray tube/housing assemblies that meet all of the following factors:

1. Focal Distance of X-Ray Tube:

   The focal spot to collimator mounting flange distance must be 2.44 inches, +/- 0.031 inches (1/32"). Four (4) spacers are supplies for adaptation:

   1 - 1/4 inch (6.35 mm) spacer

   3 - 1/16 inch (4.23 mm) spacer

   Use any of the above combination to achieve the requirements.

2. Leakage Radiation:

   Maximum leakage radiation from the X-ray tube/housing assembly must not exceed 50 mR/hr at 100 cm (40 inches) at specified leakage technical factors. This collimator is compatible with all x-ray tube housing assemblies having leakage technique factors of 150 kV and 4 mA.

3. Inherent Filtration and Half-Value Layer:

   The Eureka Linear™ IV collimator has a minimum value of 2.0 mm aluminum equivalence at 70 kV. This value plus any tube inherent filtration plus any added filtration must meet the minimum requirements of 21 CFR Sub-Chapter J, Part 1020.30 (m)(1) Table 1 on beam quality (e.g. minimum HVL at 100 kV must be 2.7 mm Al.

   A low filtration mirror bracket (1.0 mm AL equivalent) is available from Progeny for use with X-ray tubes with high inherent filtration.

4. Application:

   The intended application is for general purpose radiographic, fluoroscopic, tomographic, and chest applications. Maximum tube rating must be 150 kV or less.

5. Installation:

   Must be made with supplied hardware, including mounting flange, spacers (as required), and four (4) 1/4" x 20 or four M6 x16 bolts equally spaced on a 3.625" (9.2 cm) diameter bolt center.

1.9 MAINTENANCE

The Collimator system must be properly maintained to assure both compliance with FDA regulations and useful life.

Preventive maintenance is to be performed once every twelve months. This includes inspection and lubrication of the collimator mechanism. The collimator mounting ring and locking screw (70-10036 and 26-00752) should be examined to ensure secure mounting of the collimator. **ONLY PROGENY P/N 26-00752 COLLAR LOCKING SCREW SHOULD BE USED.**

If collimator does not spin freely and smoothly, remove it from tube. Clean all surfaces of collar and mounting flanges. Apply lubriplate or similar grease. Mount collimator onto tube. If shutters seem too loose or too tight when turning knobs, remove the front bezel cover and adjust the knob tension bar as required. This can be done using an allen key to turn screws in bar.

Checkout should also occur if any of the following conditions occur:

- Lamp replacement
- Electronic component failure
- When collimator is removed from tube/housing assembly
- When collimator has been subjected to external damage

Refer to Section 5.0 for collimator CHECK-OUT procedure.

1.10 EUROPEAN REPRESENTATIVE

Progeny, Inc. has contracted with the following company to act as a European Authorized Representative relative to the requirements of EN46001 and the Medical Device Directive:

CE Partner 4U
Nijverheidsstraat 5
2624 BA Delft
Netherlands

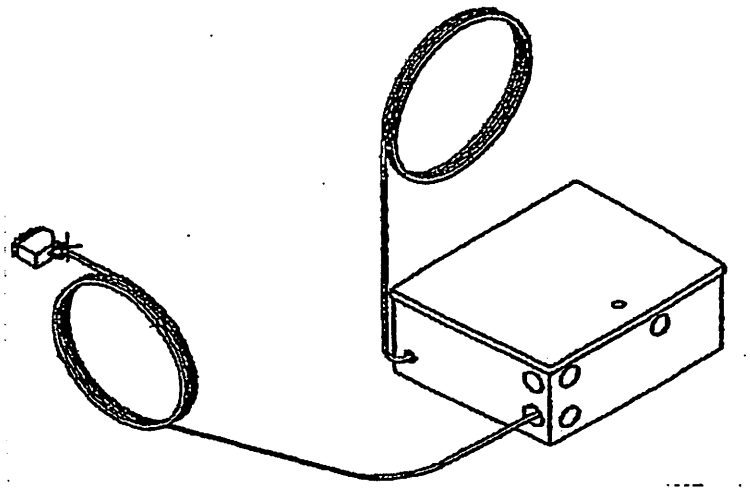
Phone: +31-15.2576682

European customers should direct any customer complaints or requests for product technical files to CE Partner 4U.

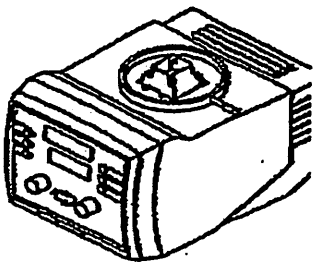
NO TEXT

SECTION 2.0

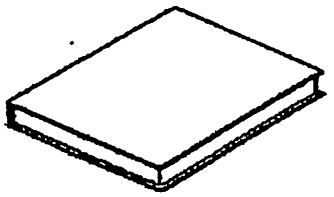
INSTALLATION



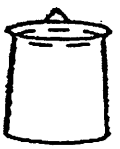
INTERCONNECT AND
POWER SUPPLY UNIT



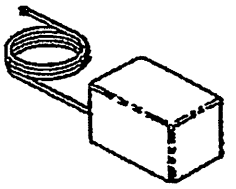
COLLIMATOR



MANUAL



MOUNTING HARDWARE
AND SPACERS



OPTIONAL
CONTINUOUS
SID MONITOR

FIGURE 2.1 - COMPONENT IDENTIFICATION

2.0 INSTALLATION

2.1 UNPACKING

Carefully unpack the equipment and check for damage incurred during shipment. Any damage should be referred to the agency that delivered the product.

2.2 EQUIPMENT SUPPLIED

Refer to Figure 2-1 for component identification

- Linear IV Collimator
- Spacers and mounting hardware
- Interconnect and power supply unit
- Packet containing Instruction Manual
- Continuous SID Monitor

2.3 COLLIMATOR MOUNTING

1. Determine the collimator mounting surface to focal spot distance from the data supplied with the X-ray tube (do not rely on an inscribed mark on the tube housing).

Note: The collimator will not perform properly unless the focal spot to upper swivel ring distance is 2-7/16" (2.44 inches, 62 mm) +/- 1/32" (.031 inches, 1 mm). Be sure to include any permanent mounting plates in the focal spot to port boss distance stated in the tube manufacturer's data.

Note: The Linear IV is designed to be used <u>with</u> a lead diaphragm or cone in the plastic port of the X-Ray tube. If it is found that lead diaphragms or cones require removal or modification, consult the factory.

2. Determine the total thickness of the supplied spacer(s) that must be added to the collimator mounting surface to obtain a focal spot to collimator mounting flange distance of 2-7/16" (2.44 inches, 62 mm) +/- 1/32" (.031 inches, 1 mm). Refer to Figure 2.2. Table 1 in the Appendix provides spacer information for some X-ray tube housings.

3. Remove the upper swivel ring from the collimator by removing the 6-32 socket head cap screw and opening the clamp ring.

NOTE: Two different lengths of screws are provided in the cloth bag containing the spacers. Determine the correct length of screw to use, taking into account the collimator spacing requirements and/or peculiarities of the tube housing port boss.

DIMENSIONS

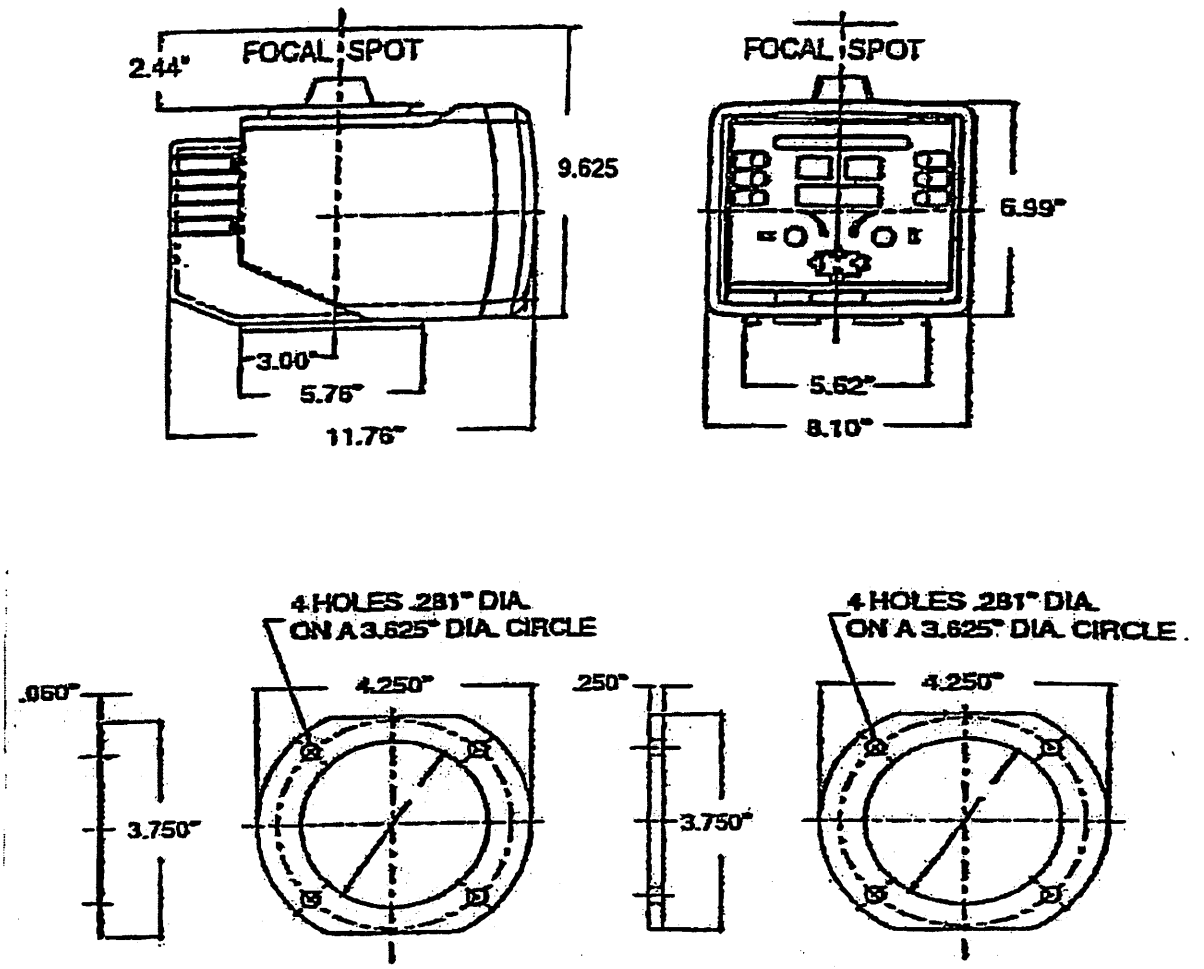


FIGURE 2.2

4. Clean the screws and housing port boss with alcohol and if necessary, remove any debris which may be present in the tube housing mounting holes.

5. **SECURELY** fasten the upper mounting flange and spacers to the collimator mounting surface. As a precaution, a medium strength thread locking compound, such as Loctite #242, should be applied to the screws before fastening the collimator mounting ring to the tube housing. The use of NYLOK or other vibration resistant screws is also recommended.

   Verify that the collimator mounting screws engage the housing by at least five (5) threads when used with any required collimator spacer plate(s).

6. Carefully support the collimator in place and re-attach the clamping ring. The hinge of the clamping ring must line up with the pin in the lower mounting ring. Apply Loctite to the 6-32 socket head screw holding the clamping ring and securely fasten together.

7. Inspect the fit of the collimator and tube housing. Grasp and attempt to move the collimator and then the tube housing assembly while inspecting for loose joints or gaps between the tube/collimator assembly as well as other tube mounting areas.

WARNING! FAILURE TO ADHERE TO THE ABOVE GUIDELINES MAY RESULT IN LOOSENING, DAMAGED SCREWS, OR MOUNT FAILURE WHICH CAN RESULT IN HEAVY COMPONENTS FALLING DURING USE. INCIDENTS OF LOOSE SYSTEM COMPONENTS SHOULD BE REPORTED IMMEDIATELY TO X-RAY SERVICE FOR REPAIR.

2.4 POWER SUPPLY CHASSIS MOUNTING

The power supply chassis is a NEMA enclosure intended to be mounted on a wall or in an equipment cabinet. There are knock-outs on the sides and bottom of the enclosure for cable entry. Follow all local wiring codes and locate the enclosure in an area that will permit.

- proper cable bend radii
- sufficient space for convection cooling
- clearance for enclosure door opening

The external connections to the system at the power supply chassis include:

- AC power input
- tube select input
- spotfilm alignment switch
- table image receptor input
- wall image receptor input
- horizontal SID input
- vertical SID input (discrete, continuous, or differential-continuous)
- table tilt monitor
- generator exposure interlock
- TOMO/STEREO by-pass input
- image intensifier select outputs

Refer to Figure 2.3 for power supply chassis dimensions.

NOTE: See the instruction manual that came with the optional Eureka remote control for installation instructions if your system has the optional Eureka remote control.

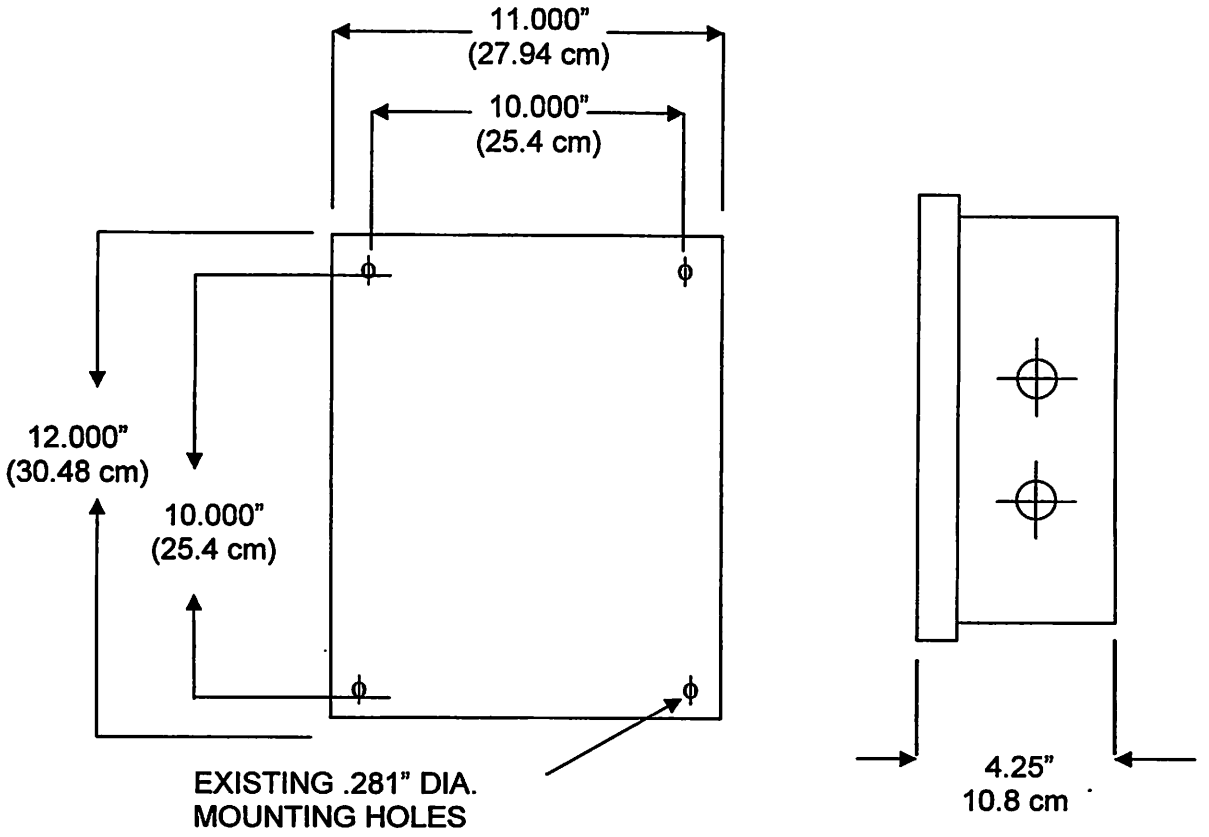


FIGURE 2.3

2.5 INTERCONNECT WIRING

CAUTION: YOU WILL BE WIRING 120 VAC OR 220 VAC INTO THE POWER SUPPLY CHASSIS. BE SURE THAT THE X-RAY GENERATOR IS OFF BEFORE PROCEEDING.

1. 120 VAC INPUT or 220 VAC INPUT

   Connect the three wire cable supplied to the VAC source as follows:

Black	-	Hot
Wire	-	Neutral
Green	-	Ground

   The power supply has a power line matching transformer capable of accepting 120 VAC or 220 VAC depending on power source available.

   Remove the protective sheet metal cover.

   Measure all AC power source with a RMS type voltmeter and record reading.

Connect the power source to the transformer tap closest to the power source voltage read. The taps are numbered as follows for:

115 VOLT OPERATION:

----- Parallel -----

125-V L1 = 4-8, L2 = 1-5
115-V L1 = 3-7, L2 = 1-5
105-V L1 = 2-6, L2 = 1-5

230 VOLT OPERATION:

----- Series -----

250-V L1 = 8, L2 = 1, Connect 4-5
230-V L1 = 7, L2 = 1, Connect 3-5
210-V L1 = 6, L2 = 1, Connect 2-5

The voltage selection switch inside the power supply chasis must be set to match the incoming line voltage.

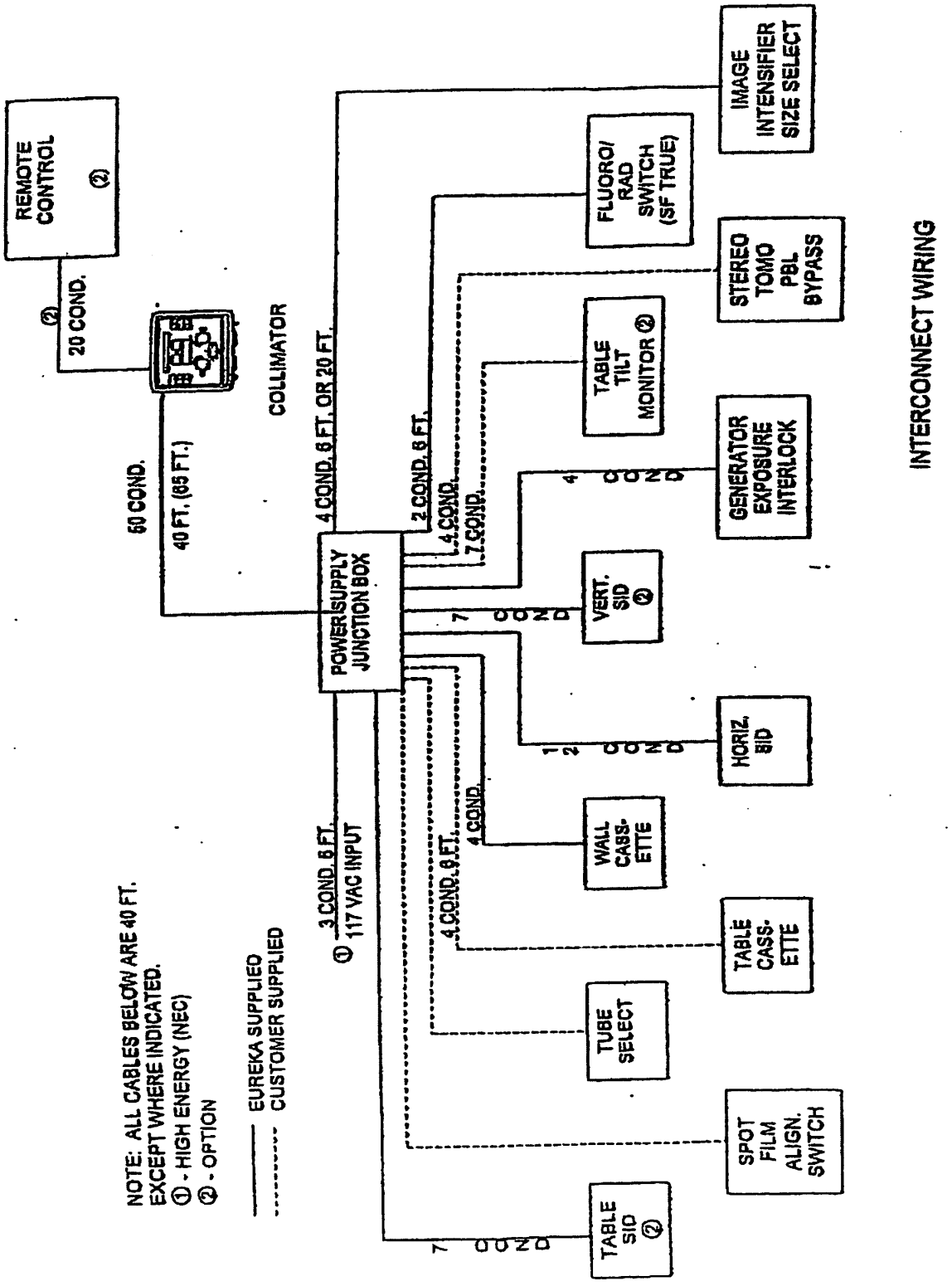


FIGURE 2.4 - Wiring Block Diagram

2. EXPOSURE INTERLOCK

Connect the supplied cable indicated on figure 2.5 and to the exposure interlock circuit of the generator. The collimator EXPOSURE HOLD is a set of normally open contacts that remain open in the HOLD condition. The contacts are FORM C with normally closed contacts available.

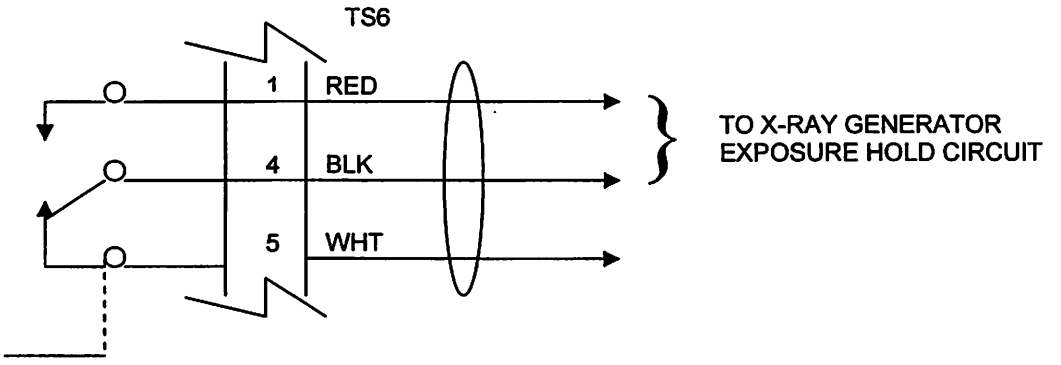


FIGURE 2.5

3. TOMO/STEREO INPUT

If the X-Ray system is equipped with either TOMO or STEREO shift capability, it is necessary to connect a signal to the collimator TOMO/STEREO by-pass input. This circuit accommodates a variety of signals. Determine the signal level available from the generator installation manual. Connect as indicated in figure 2.6.

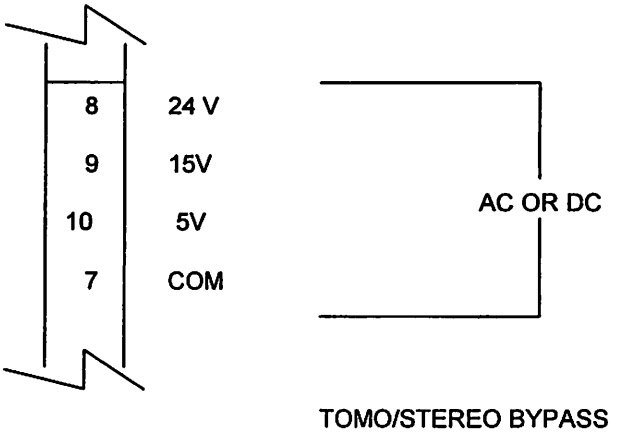


FIGURE 2.6

4. TABLE IMAGE RECEPTOR INPUT*

The Linear collimator systems are designed to operate with input characteristics as listed below.

Refer to the Cassette Tray Installation Manual and the appropriate Bucky Manual to assure proper operation of these devices.

Connect the table Image receptor input as indicated in Figure 2.7.

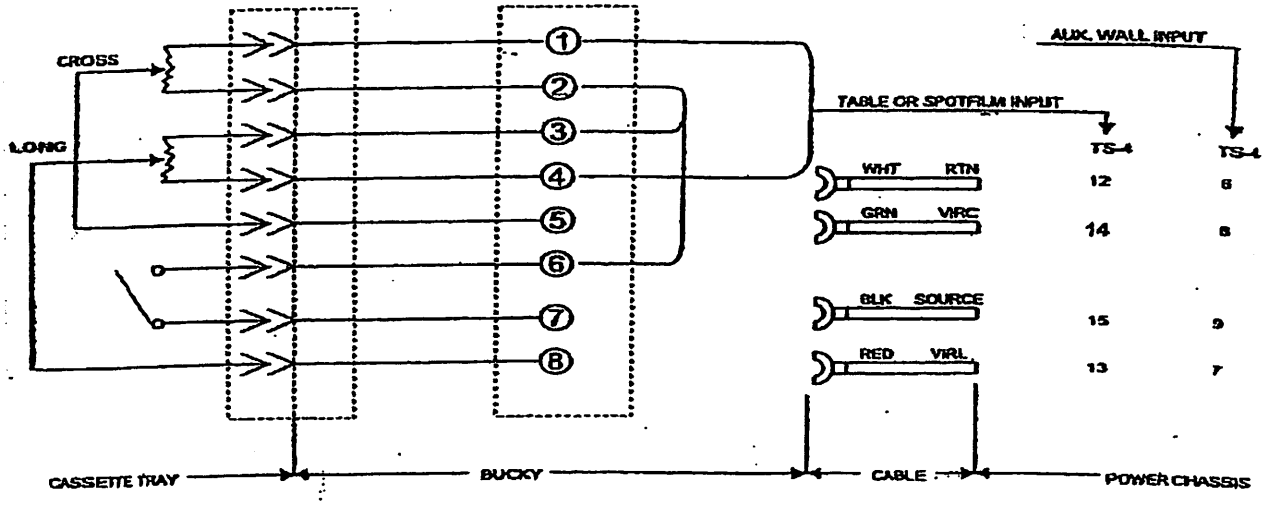


FIGURE 2.7

ELECTRICAL SPECIFICATIONS

- Impedance - 1000 OHMS, ± 5% total resistance
- Resistance Linearity - within 1.5%
- Output Voltage vs. Cassette Size with +2.5 volts applied between SUPPLY and COMMON Terminals is shown in the center column on the following page.

*Spotfilm input on systems equipped with this capability.

The following table is for reference only since absolute calibration is not necessary for correct collimator operation. The response **need only be linear** over the operation range of the bucky. **AUTOCAL** software recognizes and compensates for absolute error.

CASSETTE/FILM SIZE		DC OUTPUT VOLTAGE (2.5V INPUT)	
INCH	CM (metric)		
5		0.15	
6		0.32	
7		0.52	
	18		0.54
8		0.70	
9		0.88	
	24		0.96
10		1.08	
11		1.25	
	30		1.38
12		1.45	
	35		1.76
14		1.80	
	43		2.34
17		2.35	

5. AUXILIARY WALL CASSETTE TRAY INSTALLATION

Connect the inputs to the power supply chassis as indicated in figure 2.7 when an auxiliary wall cassette or size-sensing wall cassette holder is installed in the system.

6. CONTINUOUS VERTICAL SID MONITOR INSTALLATION

The Linear IV collimator is designed to operate with a continuous SID input as defined in figure 2.8. If the monitor is built into the equipment, refer to the manufacturer's equipment installation manual. Refer to Section 7.0 of this manual for more information or if the Progeny Continuous SID monitor is to be installed.

Any SID monitor that meets the following criteria is compatible to the Linear IV collimator.

Input Impedance $\leq 1\ k\Omega$

Response is linear over the range of operation of the SID monitor.

For accurate sizing, the following conditions must be met: A 10 turn potentiometer at a 1:1 ratio of movement must measure 14.4 ohms/inch; and a 4:1 ratio must measure 3.6 ohms/inch of movement. A ratio greater than 4:1 is not recommended.

Remove jumper between TS4-2 and TS4-3. Also remove jumper between TS5-15 and TS5-16. Make electrical connections as shown in Figure 2.8. Adjust potentiometer to read 450-500 ohms with the tube at 40" SID. At typical voltage would be 2.5 VDC.

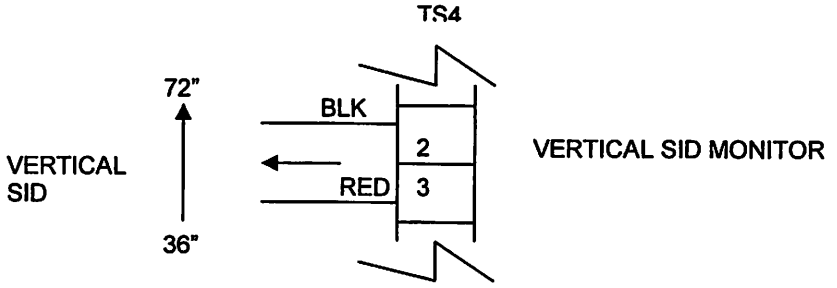


Figure 2.8

7. DIFFERENTIAL-CONTINUOUS SID MONITOR INSTALLATION (OPTION)

The Linear IV collimator can accommodate a second SID monitor as described in Section 7.0. This SID monitor is installed in an adjustable height table to allow continuous SID operation regardless of table top position. Remove jumper between TS4-4 and TS4-5. Also remove jumper between TS5-15 and TS5-16. See Figure 2.9 for electrical connection. A typical 1:1 ratio would be 0.5 VDC when table is in fully raised position.

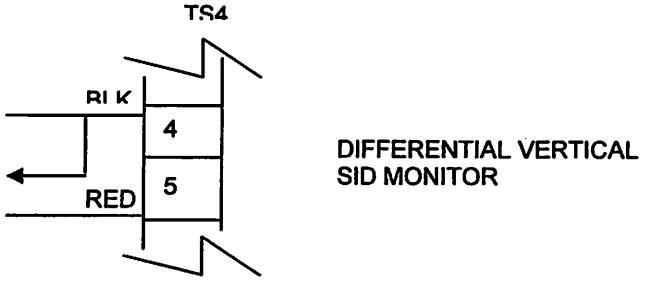


Figure 2.9

8. If the system does not use continuous vertical SID monitoring, it is necessary to install a switch to be activated at the 40" vertical SID position. The switch must be installed to activate within ± 0.2 inches of the 40 inch SID position. Connect the normally open contacts to TS5-15 and TS5-16.

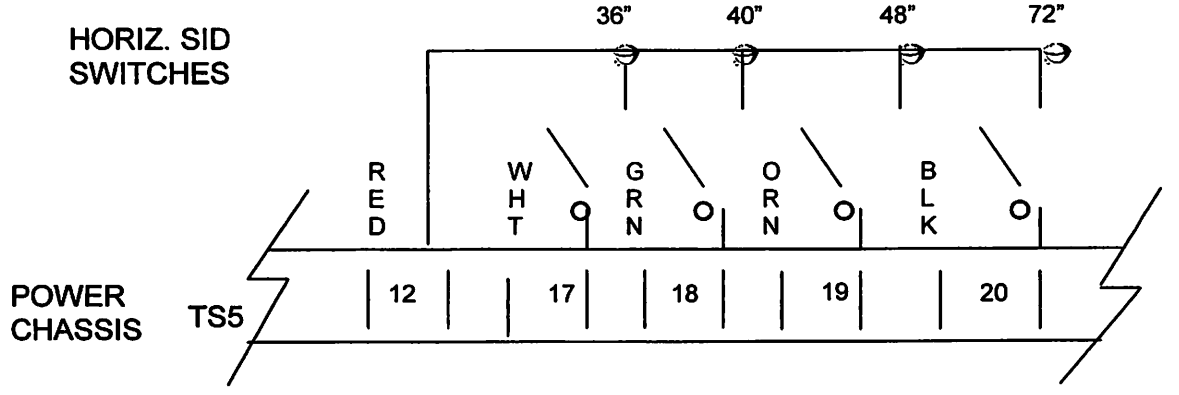
If the collimator is permanently mounted in the 40" vertical position, a jumper may be installed between TS5-15 and TS5-16.

NOTE: If NO continuous SID monitor is installed, place a jumper between TS4-2 and TS4-3 and also between TS4-4 and TS4-5.

9. HORIZONTAL SID INSTALLATION

A switched signal is required at the horizontal SID positions to be used. Only one switch signal is to be present at any one time. Position each of the switches to close within ± 0.2 inches of their respective SID's.

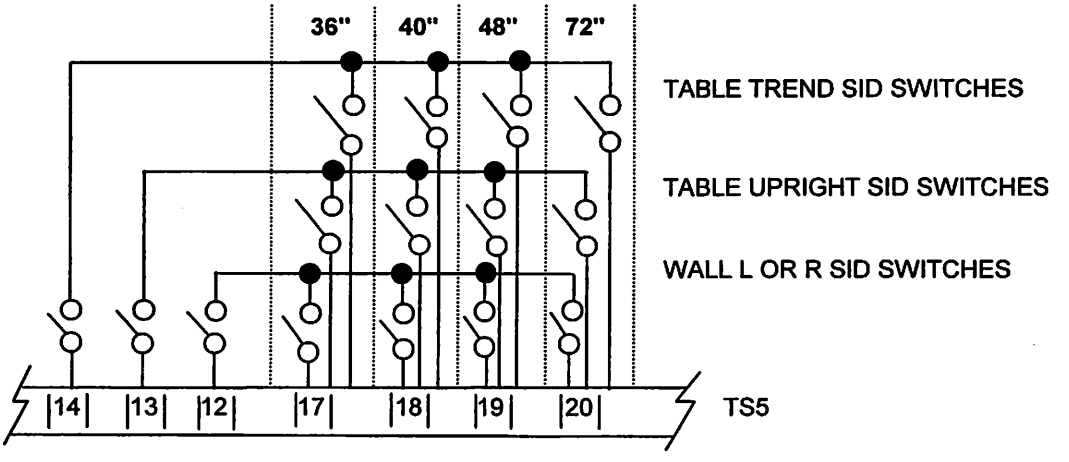
Connect the switches to the power supply chassis as indicated in Figure 2.10a for Non-Tilting tables or Figure 2.10b for Tilting tables.



FOR:
NON-TILT TABLE SYSTEMS

HORIZONTAL SID SWITCH CKT.

Figure 2.10 (a)



FOR:
TILT TABLE SYSTEMS

HORIZONTAL SID SWITCH CKT.

Figure 2.10 (b)

10. TABLE TILT MONITOR

It is necessary to mount the table tilt monitor to transfer angular position information to the collimator if a tilting table is installed as part of the X-Ray system. Proper orientation of the monitor is shown in figure 2.11.

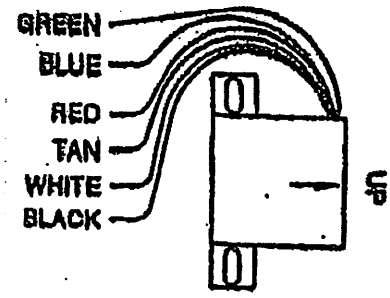
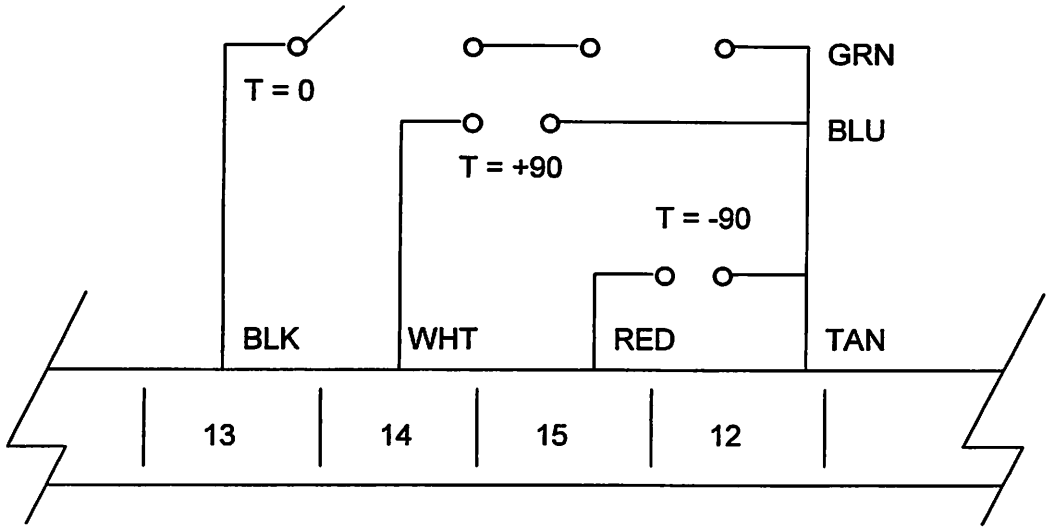


Figure 2.11

Remove the jumper between TS6-13 and TS6-12. Connect the table tilt monitor as indicated in Figure 2.12.



NOTE: FOR NON-TILT TABLE SYSTEMS, JUMPER TS6-13 TO TS6-12

Figure 2.12

Systems that can tilt and still have the image receptor aligned with the X-ray source usually have a signal that indicates whether they are aligned or not. If aligned, exposure should be allowed and SID should be valid. Correct operation can be achieved by paralleling the table tilt circuitry for the collimator with such a signal. See Figure 2.13 for connection.

POWER SUPPLY CHASSIS

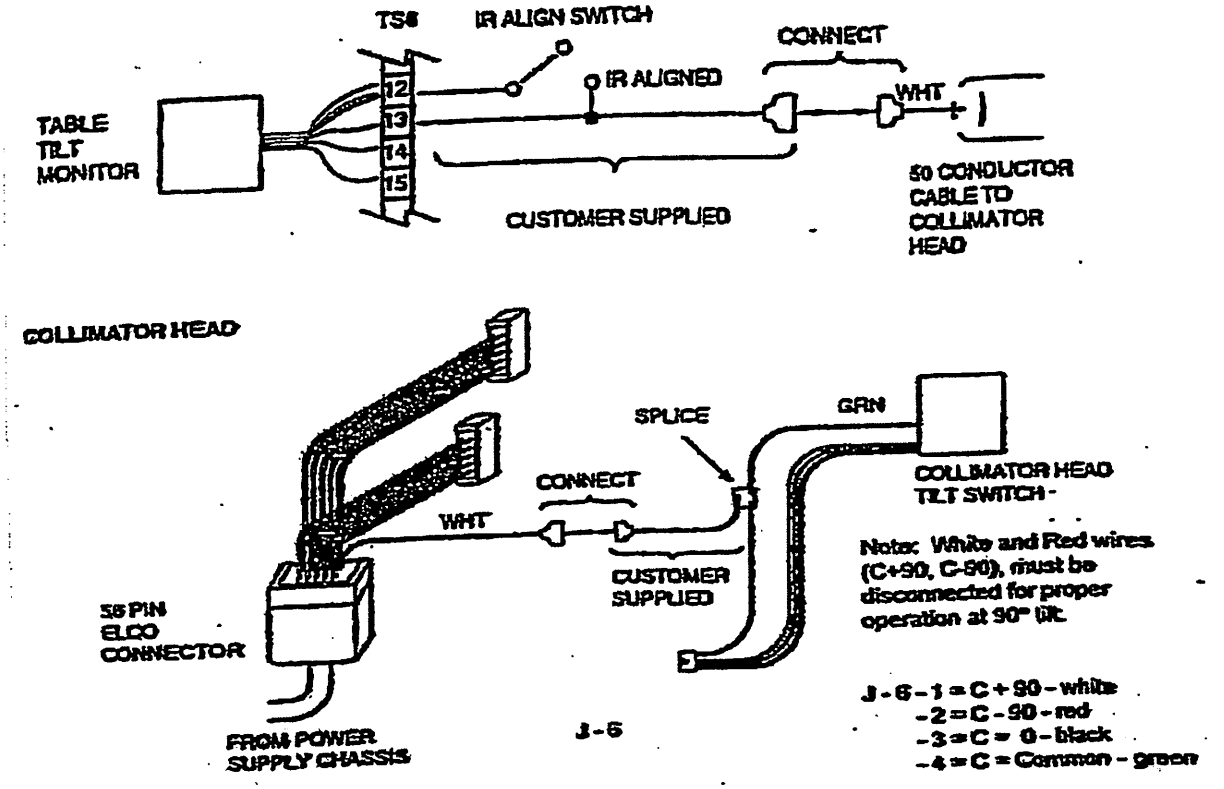
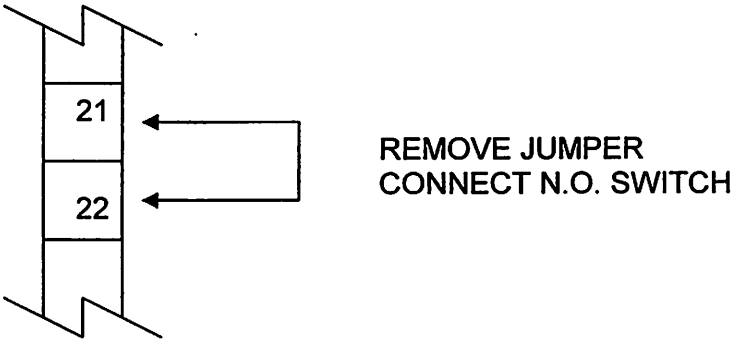


Figure 2.13

11. SPOTFILM ALIGNMENT SWITCH INPUT

Systems that utilize a spotfilm device can use this input to indicate an invalid condition (e.g. spotfilm misalignment). Remove the factory installed jumper between TS5-21 and TS5-22 and connect a normally open switch to TS5-21 and TS5-22 as shown in Figure 2.14. This switch should open whenever an invalid condition occurs.



SPOT FILM ALIGNMENT SWITCH

Figure 2.14

12. RADIOGRAPHIC/FLUOROSCOPIC MODE SWITCH

This input is used to indicate to the collimator that a radiographic (PBL) or a fluoroscopic mode of operation is requested. Refer to Figure 2.15. A customer supplied single-pole single throw switch should be installed between TS5-10 and TS5-11 for combination operation. This switch should be closed when the system is in radiographic mode, otherwise it should be open.

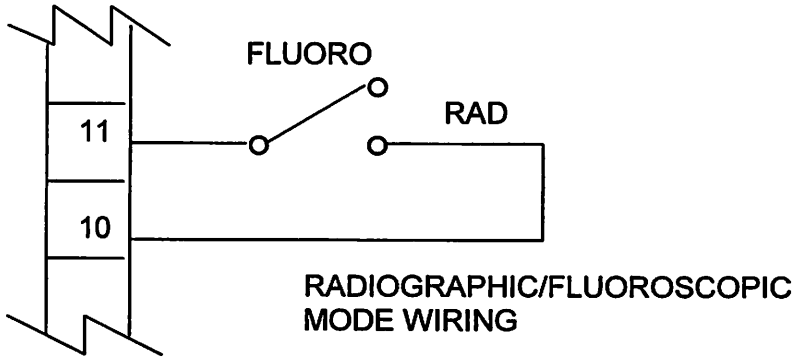


Figure 2.15

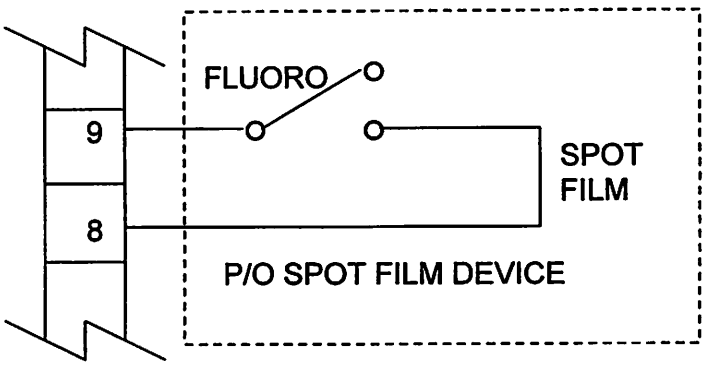
NOTE: THE RADIOGRAPHIC MODE MAY ONLY BE ESTABLISHED WHEN THE X-RAY GENERATOR IS CONFIGURED TO POSITIVELY PREVENT FLUOROSCOPIC PROCEDURES WHILE ALLOWING CONVENTIONAL RADIOGRAPHIC TECHNIQUES.

Fluoroscopic/spotfilm only systems must have the factory installed jumper between TS5-10 and TS5-11 removed.

Radiographic (PBL) systems must have the factory installed jumper between TS5-10 and TS5-11 connected.

13. FLUORO/SPOTFILM SELECT SWITCH

Special procedure fluoroscopic systems which employ a spotfilm device can use a set of isolated contacts connected to TS5-8 and TS5-9 as shown in Figure 2.16. This switch indicates to the collimator that spotfilm mode has been selected. The switch should be configured to be open during fluoroscopic procedures and closed when a spotfilm is requested. This function is normally provided by the spotfilm device.



FLUORO/SPOT FILM SWITCH WIRING

Figure 2.16

14. IMAGE INTENSIFIER MODE CONTROL WIRING

This system can be used with any single mode (NORM-II 1), dual mode (MAG 1-II 2), or tri-mode (Mag2-II 3) image tube.

When using an image intensifier with selectable modes the image intensifier image diameter must be controlled by the collimator.

NOTE: When using an image intensifier with selectable modes, all other mode selection controls elsewhere in the system must be disabled or otherwise prevented from being used by the operator.

A customer supplied 3 conductor cable of appropriate gauge should be connected to TS5 as shown in Figure 2.17.

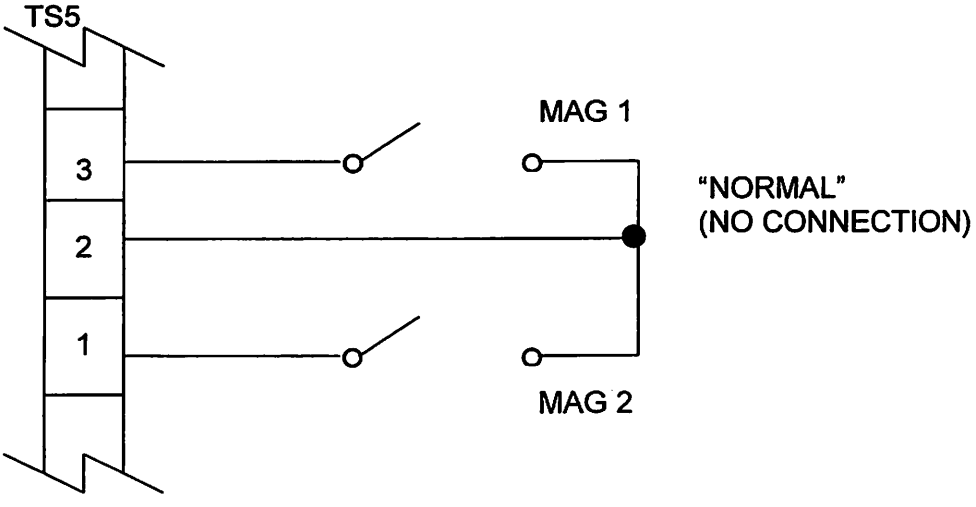


IMAGE INTENSIFIER MODE CONTROL WIRING

Figure 2.17

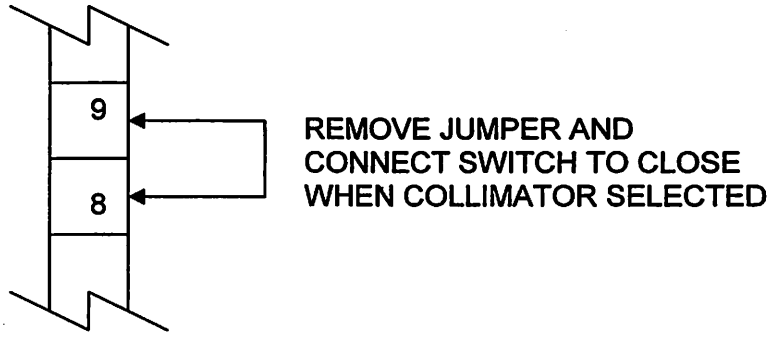
15. TUBE SELECT INPUT

An indicator must be provided to indicate which tube is in use when the same X-ray generator can control more than one tube. A PBL OVER-RIDE condition will be displayed on the collimator with the de-selected tube.

Remove the factory installed jumper between TS1-8 and TS1-9 and connect an isolated set of contacts to TS1-8 and TS1-9 as shown in figure 2.18. The contacts should close when the X-ray tube for this particular collimator has been selected at the generator control.

NOTE: Opening the TUBE SELECT switch will create a PBL OVER-RIDE condition. Exposure hold from the collimator will <u>not</u> be invoked for that particular tube circuit.

WARNING! HAZARDOUS AC VOLTAGES MAY STILL BE PRESENT IN THE POWER SUPPLY CHASSIS WHEN THE TUBE SELECT INPUT HAS BEEN OPENED.



"TUBE SELECT"
INDICATOR WIRING

Figure 2.18

16. Some models of the Linear IV Collimator have the capability of accommodating a remote Field Lamp Switch. The Field Lamp Switch can be remotely activated by connecting a switch to the power supply as follows. Connect one wire of the switch to DGND, TS4-4. Connect the other wire of the switch to the white wire with the red faston tab in the power supply. Refer to Figure 2.19. The switch will close a 5 volt logic sense input to ground, sinking no more than 50 mA DC.

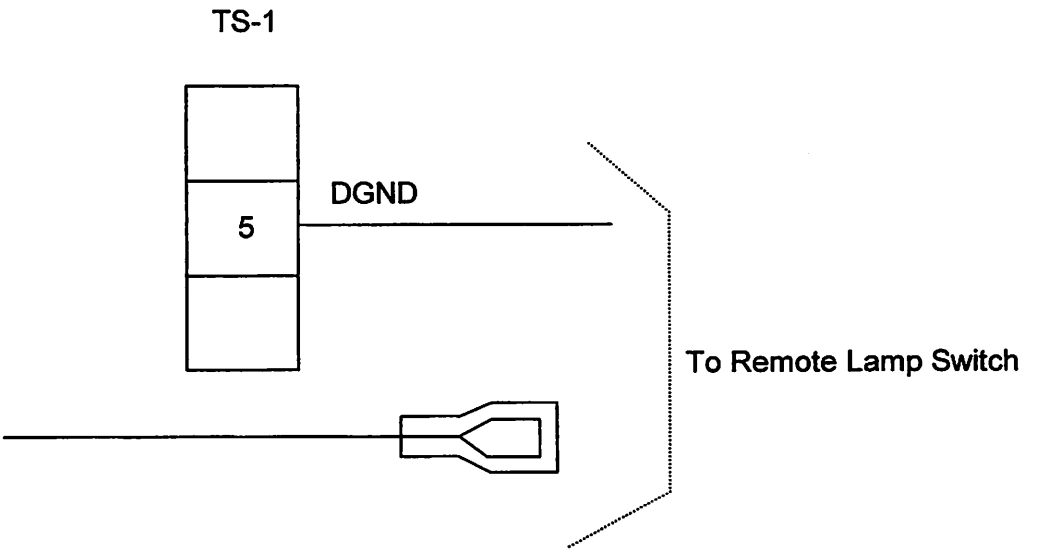


Figure 2.19
Remote Lamp Switch Connection

NO TEXT

SECTION 3

ALIGNMENT PROCEDURES

3.0 ALIGNMENT PROCEDURES

It is necessary to confirm that the light field accurately represents the X-ray field. The X-ray field (image) can be compared to the light field by establishing a defined light field and exposing a film to produce a density of 1.0.

The X-ray field should be determined by exposing a film to a density of 1.0 on the developed image and observing the points at which the density is just visibly increased above the base fog background of the film.

In a similar manner, the light field edges should be determined by observing the light field on a white background. Comparisons may be made by observing the points at which the light field is just visibly increased over the background illumination and comparing this with the X-ray field (and to the tolerance marks on the pattern).

The Performance Standards 1020.30 (b) (22) and (45) define the edges of the light field as the locus of points at which the illumination is one-fourth of the maximum and the edges of the X-ray field as the locus of points at which the exposure rate is one-fourth of the maximum.

PLEASE NOTE: Eureka collimators are 100% tested and calibrated at the factory. Our intention is that you will only have to confirm operation.

3.1 LIGHT FIELD / X-RAY CONGRUENCE TEST

1. Place the X-ray source-to-table distance at 40" (100 cm) SID and lock in place.

2. Turn collimator power on and place into PBL OVERRIDE by jumpering TS5-4 and TS5-5 together.

3. Locate a cassette on the tabletop and accurately center the cassette to the light field. Mark the position of the cassette on the tabletop.

4. Manually reduce the size of the light/X-ray field to the next smaller film size.

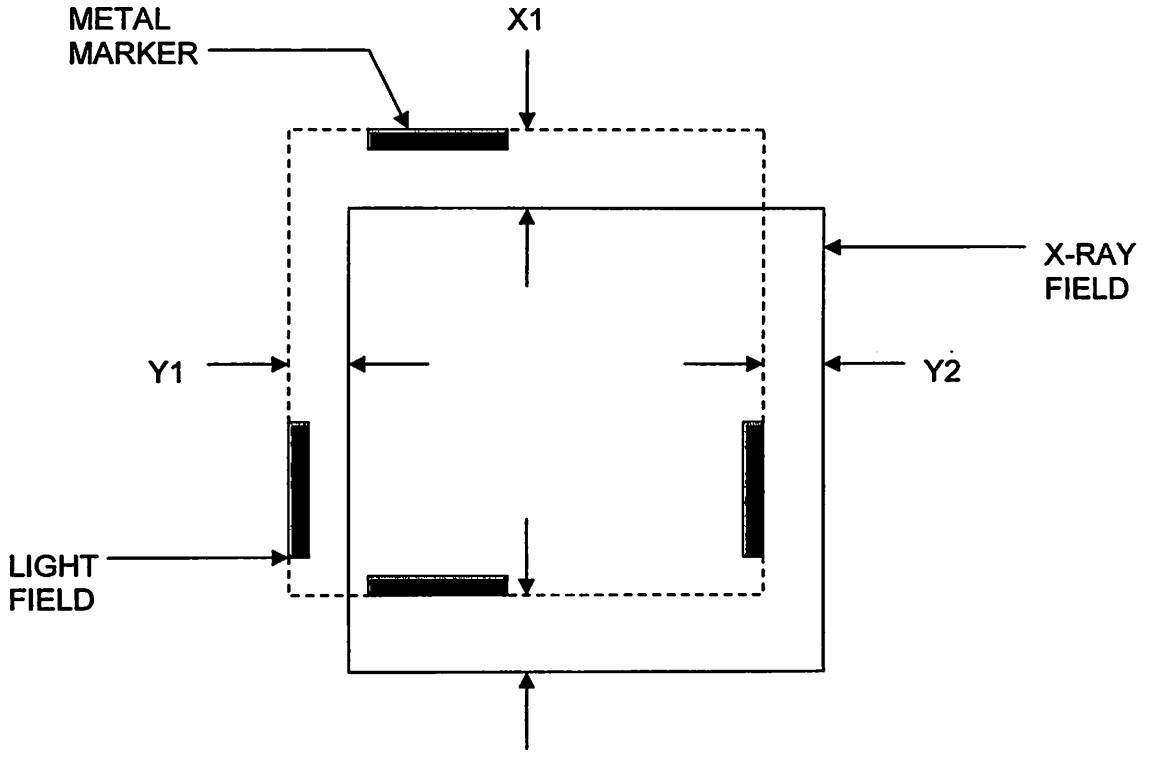
5. Identify the light field edges and carefully mark the edges by placing metal markers as illustrated below in Figure 3.1.

6. Expose the film to a density of 1.0 and develop.

7. Carefully identify the X-ray field edges and measure the difference between the X-ray field and edges and the light field edges.

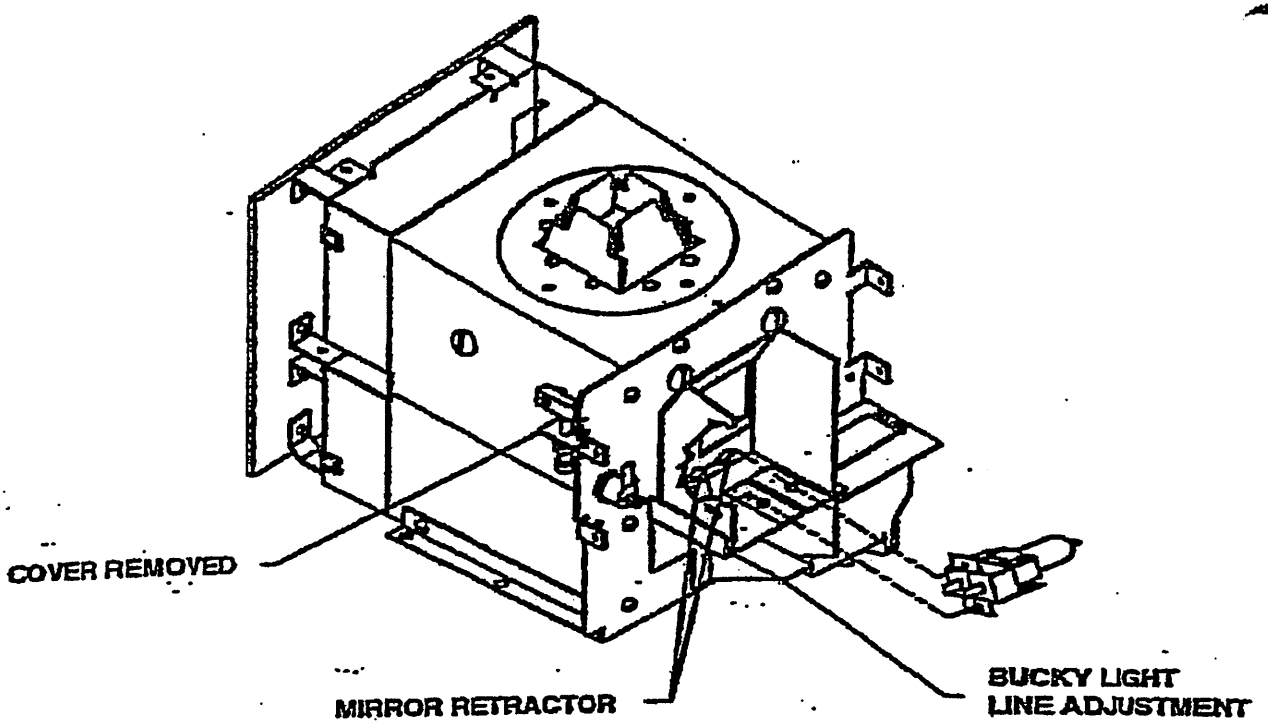
8. The sum of the long axis difference (X1 + X2) shall not exceed 2 percent of the SID, and the sum of the cross axis difference shall not exceed 2 percent of the SID.

9. If adjustment is necessary, continue with Section 3.2. If no adjustment is necessary skip to section 3.3.



X1 + X2 MUST BE LESS THAN 2% OF THE SID
Y1 + Y2 MUST BE LESS THAN 2% OF THE SID

Figure 3.1 - Light Field Congruence



CROSS ALIGNMENT

1. Adjust knurled screw for light field alignment.
2. (Option) Add Loctite to set in position.

LONGITUDINAL ALIGNMENT

1. Slightly loosen the two #6-32 screws.
2. Position lamp bracket laterally for field alignment, left to right.
3. Tighten the two #6-32 screws.

Figure 3.2 - Light Field Adjustment

WARNING! **THE LAMP AND HEAT DEFLECTORS MAY BE HOT ENOUGH TO CAUSE SEVERE BURNS. DO NOT TOUCH ANY OBJECT IN THE LAMP AREA WITH BARE SKIN.**

WARNING! **THE INTENSITY OF LIGHT OUTPUT IS SUFFICIENT TO TEMPORARILY IMPAIR YOUR VISION IF ALLOWED TO ENTER THE EYES DIRECTLY . MAINTAIN A POSITION IN WHICH YOU CAN SEE NEITHER THE FILAMENT WHEN IT IS OFF, NOR ALLOW LIGHT TO DIRECTLY ENTER YOUR FIELD OF VISION WHEN IT IS ON.**

3.2 FIELD PROJECTION LAMP AND MIRROR ADJUSTMENT

This procedure must be performed when the field projection lamp is altered from it's original position or replaced.

This procedure must also be performed if the original mirror angle has been altered and if any edge of the developed X-ray image is outside of the tolerance marks as defined in Section 3.1.

Steps 1 through 9 should be carefully reviewed or repeated prior to a lamp or mirror adjustment attempt. This is particularly important if only a single testing indicates a failure to meet the requirements defined in Step 9.

The collimator position and the developed X-ray film must remain undisturbed from the position defined in Steps 1 through 9 of Section 3.1.

Remove the rear cover and the lamp housing heat shield. See Figure 3.2.

WARNING! THE LAMP AND HEAT DEFLECTORS MAY BE HOT ENOUGH TO CAUSE SEVERE BURNS. DO NOT TOUCH ANY OBJECT IN THE LAMP AREA WITH BARE SKIN.

WARNING! THE INTENSITY OF THE LIGHT OUTPUT IS SUFFICIENT TO TEMPORARILY IMPAIR YOUR VISION IF ALLOWED TO ENTER THE EYES DIRECTLY. MAINTAIN A POSITION IN WHICH YOU CAN SEE NEITHER THE FILAMENT WHEN IT IS OFF, NOR ALLOW LIGHT TO DIRECTLY ENTER YOUR FIELD OF VISION WHEN IT IS ON.

1. If the developed X-ray image (steps 1 through 9 in section 3.1) is off-center in the longitudinal direction, loosen the two screws securing the lamp bracket. See Figure 3.2.

2. Use a pair of long nose pliers to move the bracket slightly until ***the light field has shifted*** to a position that is centered to the developed X-ray image in the longitudinal direction. Tighten the two screws securing the lamp bracket.

3. If the developed X-ray image (steps 1 through 9 in section 3.1) is in error in the cross-table direction, adjust the angle of the mirror (using the adjustment screw) until ***the light field has shifted*** to a position that is centered to the developed X-ray image.

4. If the X-ray image is smaller than the light field, loosen the screws securing the lamp socket and use a pair of long nose pliers to move the socket further away from the center of the collimator until light field/X-ray field congruency has been achieved.

5. If the X-ray image is larger than the light field, loosen the screws securing the lamp socket and use a pair of long nose pliers to move the socket closer to the center of the collimator until light field/X-ray field congruency has been achieved.

6. Repeat steps 1 through 9 in section 3.1 to confirm the results of the above adjustment.

7. Tighten the lamp bracket screws and replace the rear cover.

3.3 CROSS HAIR WINDOW ADJUSTMENT

This procedure is to be performed if the cross hair shadows are not centered to the light field (Reference Figure 4.1).

1. Remove the spacer and the entire collimator enclosure.

2. Loosen the screws securing the plastic window.

3. Move the plastic window to align and center the cross hair pattern to the light field (center lines on the test pattern).

4. Tighten the screws and reassemble the collimator covers.

3.4 BUCKY CENTERING LIGHT-LINE ADJUSTMENT

If the collimator is equipped with a Bucky Light-Line Prism:
This procedure is to be performed if the centering light-line is not centered to the ***correctly adjusted light-field.*** If it is centered replace the collimator enclosure and skip to section 4.0.

WARNING: THE LAMP AND HEAT DETECTORS MAY BE HOT ENOUGH TO CAUSE SEVERE BURNS. DO NOT TOUCH ANY OBJECT IN THE LAMP AREA WITH BARE SKIN.

WARNING: THE INTENSITY OF THE LIGHT OUTPUT IS SUFFICIENT TO TEMPORARILY IMPAIR YOUR VISION IF ALLOWED TO ENTER THE EYES DIRECTLY. MAINTAIN A POSITION IN WHICH YOU CAN SEE NEITHER THE FILAMENT WHEN IT IS OFF, NOR ALLOW LIGHT TO DIRECTLY ENTER YOUR FIELD OF VISION WHEN IT IS ON.

1. If the centering light-line is off-center to the correctly centered light-field or exhibits a rainbow of colors along one edge, loosen the two screws securing the prism/slit bracket See Figure 3.2.

2. Use a pair of long-nose pliers to move the bracket as required to center the light-line to the correctly adjusted light-field.

NOTE: IN ORDER TO AVOID THE RAINBOW OF COLORS ALONG THE EDGES, MAINTAIN THE PRISM IN A POSITION THAT IS CENTERED TO THE BRIGHT LIGHT-LINE THAT IS OBSERVED ON THE BRACKET AT THE BASE OF THE PRISM.

3. Tighten the screws and replace the collimator covers.

If the collimator is equipped with a Bucky Light-Line Laser:

WARNING! THE LAMP AND HEAT DEFLECTORS MAY BE HOT ENOUGH TO CAUSE SEVERE BURNS. DO NOT TOUCH ANY OBJECT IN THE LAMP AREA WITH BARE SKIN.

WARNING! THE INTENSITY OF LIGHT OUTPUT IS SUFFICIENT TO TEMPORARILY IMPAIR YOUR VISION IF ALLOWED TO ENTER THE EYES DIRECTLY. MAINTAIN A POSITION IN WHICH YOU CAN SEE NEITHER THE FILAMENT WHEN IT IS OFF, NOR ALLOW LIGHT TO DIRECTLY ENTER YOUR FIELD OF VISION WHEN IT IS ON.

CAUTION! This unit utilizes a low power (2.5 x 10^{-3} W 650 nm) Class II laser to produce an alignment beam. DO NOT STARE DIRECTLY INTO BEAM OR VIEW WITH OPTICAL INSTRUMENTS.

Laser Adjustment

1.) Verify alignment of the field light to the X-ray beam.

2.) Remove the covers from the collimator.

3.) Open the long shutters to the maximum setting.

4.) Close the long shutter to project a .25 to .50 wide beam onto the work surface.

5.) Use a "rigid projection board" (piece of cardboard ~ 12" x 18") to sweep the activated laser/field light beam from the work surface up to the bottom of the collimator.

6.) Note the laser line to field light position and alignment at the extremes of the projection board movement.

7.) Axial angular adjustment: Indicated by an angular mis-alignment of the laser line to the field light projection. Loosen the 4-40 rotation stop screw and rotate the laser module until the laser line is parallel and in alignment with the field light projection.

8.) Lateral (side to side) adjustment: Loosen the bracket laser mounting screws and adjust the laser side to side in the slots provided. Tighten the mounting screws.

9.) Longitudinal angular adjustment: Indicated by the laser line projection moving from one side to the other of the field light projection. Loosen the module mount screws. Move laser module to appropriate direction.

10.) Reinstall the covers on the collimator.

Figure 3.3
Laser Bucky line Projections

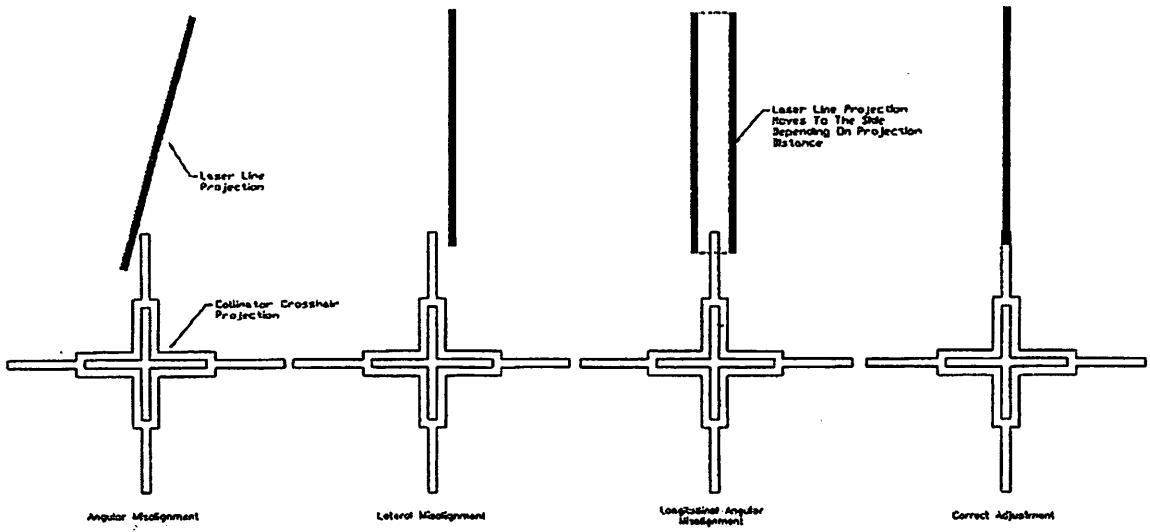
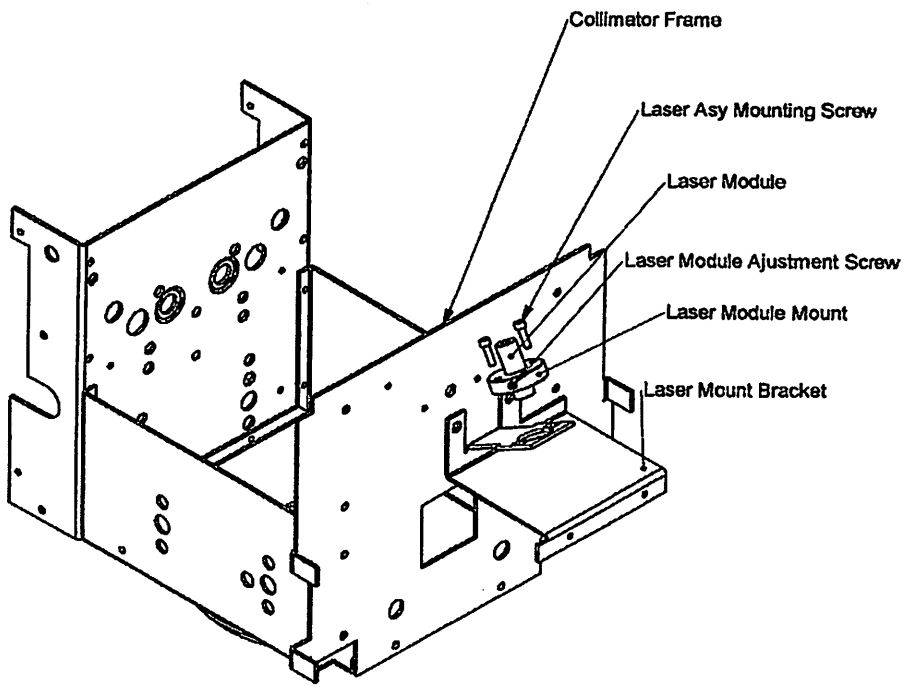


Figure 3.4
Reference View of Laser Parts



(NO TEXT)

SECTION 4

CALIBRATION

4.0 CALIBRATION

Your new Linear IV collimator is 100% tested and calibrated at the factory. Re-calibration on-site is necessary to maximize the collimator's response to your existing peripheral equipment and provide for the correct operation of the system installed. Calibration time has been significantly shortened with the introduction of AUTOCAL. Calibration is done solely at the front panel and does not require any access to printed circuit boards during the process.

The LINEAR IV can be calibrated to operate with either English or metric cassettes and SID's in the radiographic mode. At this time, fluoroscopic operation is only in English units. Contact the factory if you desire metric units in fluoroscopic operation.

The LINEAR IV is also equipped with write-protected non volatile memory to save calibration and memory preset information without risk of loss due to power interruptions and/or electrical interference.

The calibration default is a fixed SID system, with wall bucky and table bucky, and fluoroscopic/spotfilm capability with a 9" image intensifier. Re-calibration enabled (W1 on).

NOTE: EXPOSURE HOLD IS ENABLED DURING CALIBRATION. IF IT IS REQUIRED THAT EXPOSURES BE MADE (OPTIONAL STEPS) THEN THE EXPOSURE HOLD CIRCUIT MUST BE DISCONNECTED FROM THE X-RAY GENERATOR.

The calibration procedure assumes that installation of all equipment utilized with the collimator is complete and correct. Section 5.0 will contain checkout procedures that can be used to verify the collimator is working correctly and provide troubleshooting information in the event it is not.

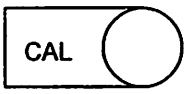
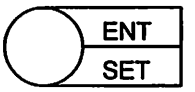
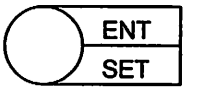
NOTE: THE LINEAR IV HAS A HARDWARE CALIBRATION INTERLOCK FEATURE WHICH DISABLES THE CALIBRATION FUNCTION BUTTON ON THE FRONT PANEL TO PREVENT UNAUTHORIZED OR ACCIDENTAL CALIBRATION. IF THIS FEATURE IS ENGAGED THE CAL BUTTON WILL NOT CREATE ANY RESPONSE. TO BYPASS THE INTERLOCK, THE COLLIMATOR ENCLOSURE MUST BE REMOVED AND JUMPER W1 ON THE CPU BOARD BE INSTALLED.

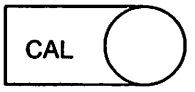
NOTE: THE LINEAR IV ALSO HAS A SOFTWARE CALIBRATION INTERLOCK FEATURE TO PREVENT ACCIDENTAL CALIBRATION. A SECURITY CODE MUST BE ENTERED TO ACCESS CALIBRATION FEATURES.

Equipment required

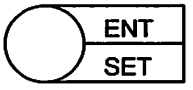
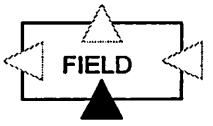
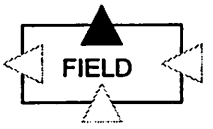
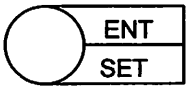
1. 14" X 17" (35 cm x 43 cm) FILM Cassette
2. 8" X 10" (18cm x 24 cm) FILM Cassette

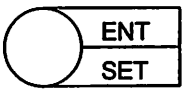
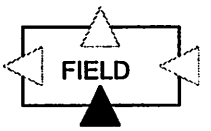
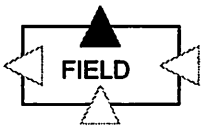
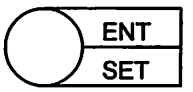
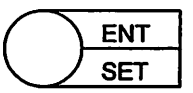
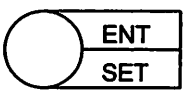
4.1 CALIBRATION PROCEDURE

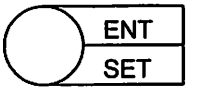
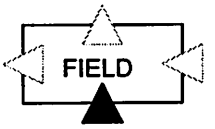
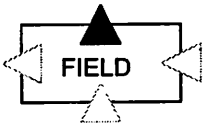
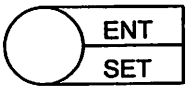
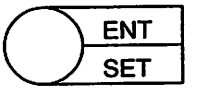
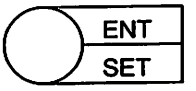
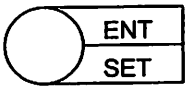
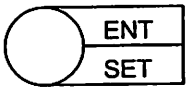
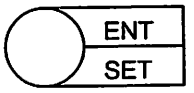
INSTRUCTION	BUTTONS	DISPLAY
1. Press the CAL button on the front panel. The message "Service Mode?" should appear on the display. If not see section 4.2		SERVICE MODE?
2. Press the ENT/SET key within 4 seconds to confirm the request, or else you will be returned to the previous state of operation. Upon confirmation the message "ENTER CODE _____" will be displayed.		ENTER CODE _____
3. Enter the security code needed to access the calibration function. This must be done within 10 seconds or else you will be returned to your previous state of operation. As you enter the code, * will replace the _ on the display for each code entry. The security code is the following: LAST SIZE, MAG SIZE, ENT/SET, CAL followed by ENT/SET to enter the code.	    	ENTER CODE _____* ENTER CODE _____** ENTER CODE _____*** ENTER CODE _____****

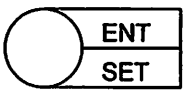
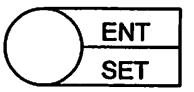
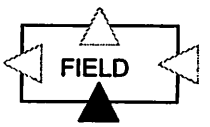
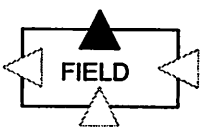
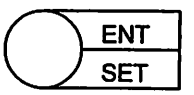
INSTRUCTION	BUTTONS	DISPLAY
If the incorrect code is entered the display will show "INVALID CODE", "ACCESS DENIED" and you will be returned to the previous state of operation.		INVALID CODE ACCESS DENIED
If the correct code is entered the display will show "CALIBRATE?". If it does not continue to press CAL until it does.		CALIBRATE?
If you do not wish to continue at this point, press CAL until "EXIT TO SYSTEM?" is displayed and press ENT/SET. You will be returned to previous state of operation.		EXIT TO SYSTEM?

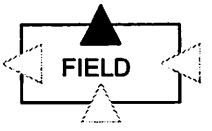
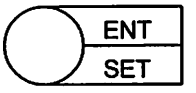
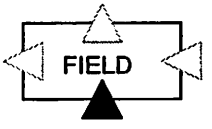
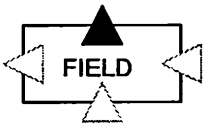
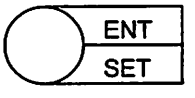
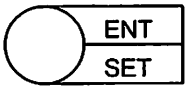
NOTE: IF YOU ENTER CALIBRATION IN STEP 4, YOU ARE REQUIRED TO COMPLETE ALL FOLLOWING STEPS. YOU WILL NOT BE ALLOWED TO EXIT PREMATURELY.

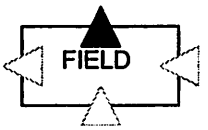
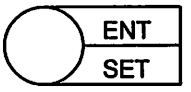
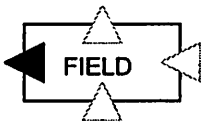
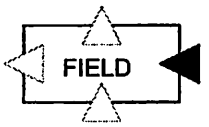
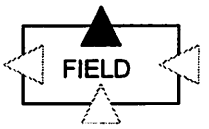
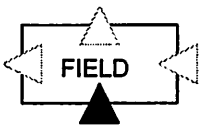
4. Press ENT/SET to enter calibration. The display will show "AUTO-CALIBRATION" for 4 seconds and then it will display "MODE ENGLISH?"		AUTO-CALIBRATION MODE: ENGLISH?
5. Press Cross Close to display "MODE METRIC?"		MODE: METRIC?
Press Cross Open to display "MODE: ENGLISH?"		MODE: ENGLISH?
Press ENT/SET to execute the displayed response.		OK
6. The LIMITS CAL sets the mechanical limits of the collimator shutters into memory to prevent the collimator from sizing to an unachievable size and protect the drive motors.		DO LIMITS CAL?

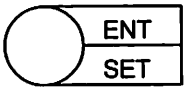
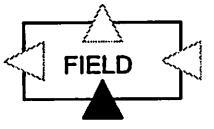
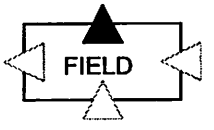
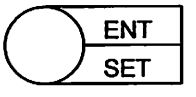
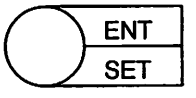
INSTRUCTION	BUTTONS	DISPLAY
Press ENT/SET to start the LIMITS CAL.		OK
Press Cross Close to display "SKIP LIMITS CAL?".		SKIP THIS STEP?
Press Cross Open to display "DO LIMITS CAL?"		DO LIMITS CAL?
Press ENT/SET to execute the displayed response.		OK
If you decide to skip the LIMITS CAL proceed to step 9.		
7. LIMITS CAL STEP 1		
The display will instruct you to "Open shutters", "to maximum field", "and press ENT". Follow the instructions to continue.		Open shutters to maximum field and press ENT. OK
8. LIMITS CAL STEP 2		
The display will instruct you to "Close shutters", "to minimum field", "and press ENT". Follow the instructions to continue.		Close shutters to minimum field and press ENT OK
9. LIMITS CAL is now complete, the display now shows "DO VERTICAL CAL?"		DO VERTICAL CAL?
10. VERTICAL CAL calibrates the collimator for vertical operation, fixed or continuous SID and table bucky. This step is required for correct vertical operation.		

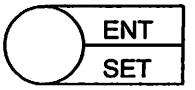
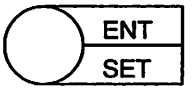
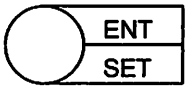
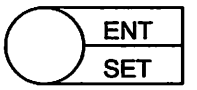
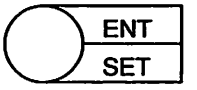
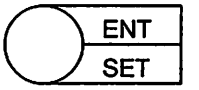
INSTRUCTION	BUTTONS	DISPLAY
Press ENT/SET to start VERTICAL CAL.		OK
Press Cross Close to display "SKIP VERT CAL?"		SKIP THIS STEP?
Press Cross Open to display "DO VERTICAL CAL?"		DO VERTICAL CAL?
Press ENT/SET to execute the displayed response.		OK
If you decide to skip VERTICAL CAL, skip to step 19.		
11. VERTICAL CAL STEP 1		
Set vertical SID to 40" (100 cm) and press ENT/SET.		Set SID to 40" (100 cm) Vert OK
Set pattern on the x-ray.		
Set field size to 14" X 14" (35 cm x 35 cm) square using the light field and press ENT/SET.		Set field to 14" x 14" (35 cm x 35 cm) OK
Insert a 14" X 17" (35 cm x 43 cm) film cassette into the table bucky tray, close the tray, and press ENT/SET. Either orientation is permitted.		Insert Cassette 14" x 17" (35 cm x 43 cm) OK
Set field size to 5" X 5" (13 cm x 13 cm) square using the light field and press ENT/SET.		Set Field to 5" x 5" (13 cm x 13 cm) OK
Insert an 8" X 10" film cassette into the table bucky tray, close the tray, and press ENT/SET. Either orientation is permitted.		Insert Cassette 8" x 10" (18cm x 24cm) OK

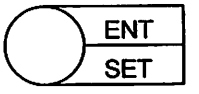
INSTRUCTION	BUTTONS	DISPLAY
12. VERTICAL CAL STEP 2		
Use the provided template to size to the markings of 14" X 14" @ 72" SID with actual SID set at 40" (35 cm x 35 cm @ 180 cm with actual SID at 100 cm)		DO NOT MOVE SID. SET FIELD TO 14" x 14" (35 cm x 35 cm) @ 72" (180 cm) PER TEMPLATE.
Press ENT/SET to continue.		OK
Use the provided template to size to the markings of 5" x 5" @ 72" SID with actual SID set at 40" (13 cm x 13 cm @180 cm SID with actual SID set at 100 cm).		DO NOT MOVE SID. SET FIELD TO 5" x 5" (13 cm x 13 cm) @ 72" (180 cm) PER TEMPLATE
Press ENT/SET to continue.		OK
13. VERTICAL CAL STEP 3		
You will now choose whether you have a fixed SID system or a continuous SID system to the table.		FIXED SID SYS?
Press Cross Close to choose a continuous SID system.		CONT. SID SYS?
Press Cross Open to choose a fixed SID system.		FIXED SID SYS?
Press ENT/SET to confirm the displayed response.		OK
If you have a fixed SID system skip to step 18.		

INSTRUCTION	BUTTONS	DISPLAY
14. VERTICAL CAL STEP 4		
The following steps will calibrate the collimator for use with continuous SID monitors.		SET SID TO 72" (180 cm) or SET SID TO 56" (140 cm) or SET SID TO 48" (120 cm) or SET SID TO 36" (92 cm)
Press the Cross Open to toggle through selections of target SID's for calibration - choose the SID furthest away from 40" (100 cm) allowable by the tube support system, move to that SID, and press ENT/SET.	 	OK
15. VERTICAL CAL STEP 5		
You will now choose whether your system is equipped for continuous SID (tube moveable vertically) or differential (tube and table moveable vertically).		SYS-SINGLE SID?
If your system has installed a second SID monitor for an adjustable height table-top, Press Cross Close.		SYS-DIFF SID?
If your system is equipped only with a single SID monitor, press Cross Open.		SYS-SINGLE SID?
Press ENT/SET to confirm the selection. If you have selected a single SID system skip to step 18.		OK
16. VERTICAL CAL STEP 6		
Set the adjustable table to the full up position and press ENT/SET.		SET TBL FULL UP OK

INSTRUCTION	BUTTONS	DISPLAY
17. VERTICAL CAL STEP 7		
Press Cross Open to toggle through selections of target table heights for calibration - choose the lowest height from the selections, move to that setting, and press ENT/SET.	 	SET TBL DOWN TO: 8" (20 cm) or 6" (15 cm) or 4" (10 cm) or 2" (5 cm) OK END CONT SID CAL
18. VERTICAL CAL STEP 8		
You will now be asked to input the distance in inches from the image receptor (bucky tray) to the table top. This value is used to provide an estimate size and SID for table top operations.		TBL SID OFFSET?
Press LONG OPEN to increment offset by 1" (2.54 cm).		(Offset distance is displayed on SID display).
Press LONG CLOSE to decrement Offset by 1" (2.54 cm).		
Press CROSS OPEN to increment offset by 0.1" (.25 cm).		
Press CROSS CLOSE to decrement Offset by 0.1" (.25 cm).		

INSTRUCTION	BUTTONS	DISPLAY
The size is indicated on the SID display.		
Press ENT/SET to store distance offset.		OK
The collimator is now calculating the vertical compensation and calibration parameters for your system. The process should take less than 5 seconds.		WORKING...
19. HORIZONTAL CAL STEP 1		
Next you will be asked if you want to perform HORIZONTAL Calibration. HORIZONTAL Calibration is Necessary if your system will operate with a wall bucky or if the collimator can tilt +90 degrees or –90 degrees.		HORIZONTAL CAL?
Press Cross Close to skip HORIZONTAL CAL.		SKIP THIS STEP?
Press Cross Open to perform HORIZONTAL CAL.		HORIZONTAL CAL?
Press ENT/SET to confirm selection.		OK HORIZONTAL CAL
If you choose to skip HORIZONTAL CAL proceed to step 22, else continue.		
Tilt the collimator to the appropriate wall where the wall bucky is located and press ENT/SET.		SET COLL TO WALL OK

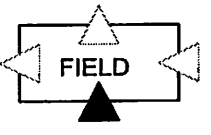
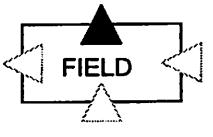
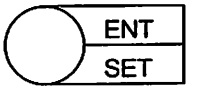
INSTRUCTION	BUTTONS	DISPLAY
If the tilt is identified incorrectly, a message indicating incorrect tilt will be displayed. Correct the tilt and press ENT/SET.		INCORRECT TILT SET COLL TO WALL OK
Set horizontal SID to 40" (100 cm) and press ENT/SET.		SET SID TO 40" (100 cm)
Set field size to 14" X 14" (35 cm x 35 cm) square using the light field and press ENT/SET.		SET FIELD TO 14" x 14" (35 cm x 35 cm) OK
Insert a 14" x 17" (35 cm x 43 cm) film cassette into the wall bucky, close the tray, and press ENT/SET.		Insert Cassette 14" x 17" (35 cm x 43 cm) OK
Set field size to 5" x 5" (13 cm x 13 cm) square using the light field and press ENT/SET.		Set Field to 5" x 5" (13 cm x 13 cm) OK
Insert an 8" x 10" (18 cm x 24 cm) film cassette into the wall bucky, close the tray, and press ENT/SET.		Insert Cassette 8" x 10" (18 cm x 24 cm) OK
20. HORIZONTAL CAL STEP 2		
Use the template provided to size the markings 14" x 14" @ 72" with SID actually set at 40" (35 cm x 35 cm with SID actually set to 100 cm).		DO NOT MOVE SID SET FIELD TO 14" x 14" (35 cm x 35 cm) @ 72" (180 cm) PER TEMPLATE.
Press ENT/SET to continue.		OK

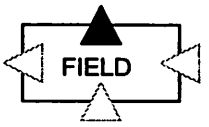
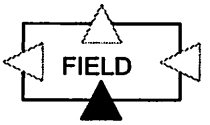
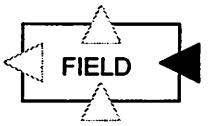
INSTRUCTION	BUTTONS	DISPLAY
Use the template provided to size to the markings 5" x 5" @ 72" with SID actually set at 40" (13 cm x 13 cm @180 cm with SID actually set to 100 cm).		DO NOT MOVE SID. SET FIELD TO 5" X 5" (13 cm X 13 cm) @ 72" (180 cm) PER TEMPLATE.
Press ENT/Set to continue.		OK

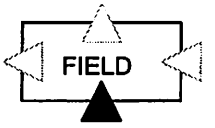
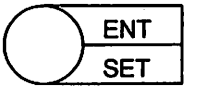
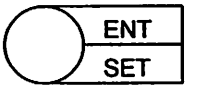
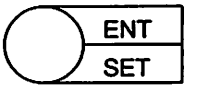
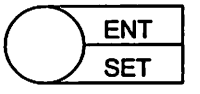
21. HORIZONTAL CAL STEP 3

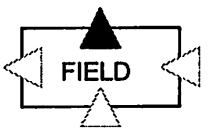
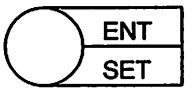
The collimator is now calculating the horizontal compensation and calibration parameters for your system. This process should take less than 5 seconds.		WORKING...

22. VERTICAL CAL STEP 9

Next you will be asked if you want to Perform fluoroscopic calibration. FLUORO CAL is necessary if your System has fluoroscopic capability or you intend to use fluoroscopic functions.		DO FLUORO CAL?
Press Cross Close to skip FLUORO CAL.		SKIP THIS STEP
Press Cross Open to perform FLUORO CAL.		DO FLUORO CAL?
Press ENT/SET to confirm your selection.		OK
If you choose to skip FLUORO CAL Proceed to step 29.		

INSTRUCTION	BUTTONS	DISPLAY
23. FLUORO CAL STEP 1		FLUORO CAL
FLUORO CAL allows you to set-up three II magnification sizes automatically or manually. The automatic sizing allows you to choose from a variety of preset II sizes based on your current calibration parameters. Manual sizing allows three independent sizes to be set for your II sizes.		FLUORO CAL
First you will be asked to input the distance in inches from the image receptor (image intensifier) to the film plane of the table bucky. This value is used to provide field size information with respect to the image intensifier when it is the selected image receptor.		II FILM OFFSET?
Press CROSS OPEN to increment offset by 0.1".		(Offset distance is displayed on SID display)
Press CROSS CLOSE to decrement offset by 0.1".		
Press LONG OPEN to increment offset by 1".		
Press LONG CLOSE to decrement offset by 1".		
This size is indicated on the SID display.		
Press ENT/SET to confirm your selection.		MANUAL FLUORO CAL

INSTRUCTION	BUTTONS	DISPLAY
Press Cross Close to choose automatic FLUORO CAL.		AUTO FLUORO CAL
Press Cross Open to choose manual FLUORO CAL.		MANUAL FLUORO CAL
Press ENT/SET to confirm your selection.		OK
If you choose automatic FLUORO CAL skip to step 27.		
24. FLUORO CAL STEP 2		
Set field size using the light field to the desired NORMal II size and press ENT/SET.		SET FLD TO NORM OK
25. FLUORO CAL STEP 3		
Set field size using the light field to the desired MAG1 size and press ENT/SET.		Set Fld to MAG1 OK
26. FLUORO CAL STEP 4		
Set field size using the light field to the desired MAG2 size and press ENT/SET.		Set Fld to MAG2 OK
27. FLUORO CAL STEP 5		
For automatic FLUORO CAL you will be asked to select the largest II size available. The sizes for MAG1 and MAG2 will automatically be determined.		II MAX SIZE = 9"

INSTRUCTION	BUTTONS	DISPLAY
Press Cross Open to toggle through choices and then press ENT/SET.		
		

MAX II	MAG1	MAG2	
6	6	6	II MAX SIZE = 6" or
9	6	4.5	II MAX SIZE = 9" or
12	9	6	II MAX SIZE = 12" or
14	12	9	II MAX SIZE = 14" or
16	14	12	II MAX SIZE = 16" or

OK

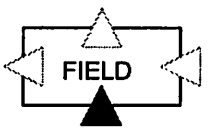
28. FLUORO CAL STEP 6

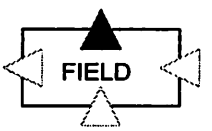
FLUORO CAL is complete. — END FLUORO CAL

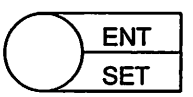
29. Next you will be asked to select whether you would like to display the continuous SID on the front panel or if you would like to blank it. — SHOW CONT. SID?

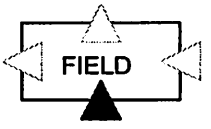
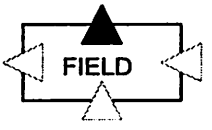
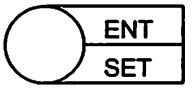
Some X-ray systems have built in SID indication and it may be preferable to blank one of the displays to avoid confusion.

Hiding the display **does not** affect the calculation of SID not automatic operation.

Press Cross Close to blank the continuous SID display. —  — HIDE CONT. SID?

Press Cross Open to activate the continuous SID display. —  — SHOW CONT. SID?

Press ENT/SET to confirm selection. —  — OK

INSTRUCTION	BUTTONS	DISPLAY
30. Next you will be asked to select whether you would like to display the horizontal SID on the front panel or if you would like to blank it. Some X-ray systems have built in SID indication and it may be preferable to blank one of the displays to avoid confusion. Hiding the display **does not** affect the calculation of SID not automatic operation.		SHOW HORIZ. SID?
Press Cross Close to blank the horizontal SID display.		HIDE HORIZ. SID?
Press Cross Open to activate the horizontal SID display.		SHOW HORIZ. SID?
Press ENT/SET to confirm selection.		OK
31. Next the collimator will save and store in permanent memory all of your configuration items, including any memory preset field sizes. This should take less than 15 seconds.		STORING DATA
END OF CALIBRATION		END OF CALIBRATION

There will be a three second delay and then you will be put back into a runtime mode in which normal collimator operation will resume.

4.2 DISABLING HARDWARE CALIBRATION INTERLOCK

If you were not required to come to this section from section 4.1, please skip to the next section.

The following procedure defines the process of removing the hardware calibration interlock feature of the Linear IV.

1. Remove the entire collimator enclosure.

2. Locate W1 on the CPU board and verify the jumper is installed. If W1 is installed and calibration is still not accessible, return for service. Otherwise install jumper W1.

3. Re-assemble collimator enclosure.

4.3 ENABLING HARDWARE CALIBRATION INTERLOCK

If desired, a hardware calibration interlock can be employed to prevent unauthorized or accidental calibrations. This will prevent calibration to be performed unless entry to the collimator head is established. This is an additional safeguard to the software code interlock feature.

This section is optional.

1. Remove the entire collimator enclosure.

2. Locate W1 on the CPU board and remove the jumper on W1.

3. Test interlock by pressing the CAL button. If no action occurs the interlock is established.

4. Re-assemble collimator enclosure.

(NO TEXT)

SECTION 5

COLLIMATOR FUNCTION CHECK

5.0 COLLIMATOR FUNCTION CHECK

This section describes a number of tests which can be performed to verify operation of the collimator and attached peripheral components.

The first part of the test is semi-automated and does not require knowledge of SID and or cassette size. Its' purpose is to identify if the drive and feedback mechanisms and circuits are functioning properly. The test consists of the collimator sizing through a number of preset field sizes for different SID's for confirmation by the installer. Data can also be recorded on an attached table to verify linearity and accuracy of the collimator.

The rest of the tests will confirm operation of some of the peripheral components that are attached to the collimator system.

Since not all sections of this procedure may apply to a particular situation, it is important that the assembler thoroughly review this section along with Sections 2.0, 3.0, and 4.0 before starting. Also, different systems require different compliance requirements. Section 6.0, "COMPLIANCE VERIFICATION" has been written to provide the assembler with the information needed to assure compliance with the types of systems into which this collimator may be installed. It is the responsibility of the assembler to determine which compliance requirements are applicable.

YOU HAVE LEGAL OBLIGATIONS:
PRIOR TO RELEASE OF THE SYSTEM TO THE USER, THE RESULTS OF EACH STEP MUST BE DEFINED.

ENTER THE APPROPRIATE DATA IN THE SPACES PROVIDED IN THE COMPLIANCE DATA LOG AND RETAIN FOR YOUR RECORDS AS PROOF THAT THESE TESTS WERE SUCCESSFULLY PERFORMED.

EQUIPMENT REQUIRED:

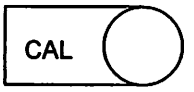
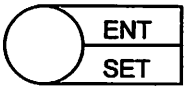
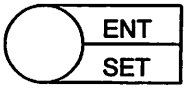
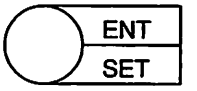
A. The X-ray tube support and the table must include angulation indicators in order to comply with part 1020.31 (d)(2)(i) and 1020.21 (e)(1)(ii). These indicators are to be used for the following tests.

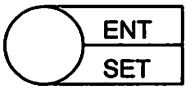
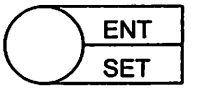
B. The X-ray tube support device also must include SID indicating means in order to comply with 1020.31 (e)(1)(i). This indicator will be used in these tests.

C. Measuring Tape (ruler). This is to be used as a backup for the SID indicating means and as an operational range measurement.

D. Linear IV test patterns 70-09021 and 70-09022 supplied with this manual.

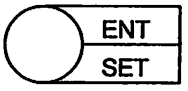
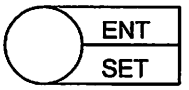
5.1 COLLIMATOR FUNCTION CHECK PROCEDURES

INSTRUCTION	BUTTONS	DISPLAY
1. Press the CAL button on the front panel.		
The message "Service Mode?" should appear on the display. If not see section 4.2.		SERVICE MODE?
2. Press the ENT/SET key within 4 seconds to confirm the request, else you will be returned to the previous state of operation.		
Upon confirmation the message "ENTER CODE _____" will be displayed.		ENTER CODE _____
3. Enter the security code needed to access the calibration function. This must be done within 10 seconds or else you will be returned to your previous state of operation.		
As you enter the code, * will replace the _ on the display for each code entry.		ENTER CODE ___* ENTER CODE __** ENTER CODE _*** ENTER CODE ****
This security code is the following: LAST SIZE, MAG SIZE, ENT/SET, CAL followed by ENT/SET to enter the code.		
		
If the incorrect code is entered the display will show "INVALID CODE", "ACCESS DENIED" and you will be returned to the previous state of operation.		INVALID CODE ACCESS DENIED
		
		

INSTRUCTION	BUTTONS	DISPLAY
If the correct code is entered the display will show "CALIBRATE?". Press the CAL button until "VERIFICATION?" appears.		CALIBRATE? VERIFICATION?
If you do not wish to continue at this point, press CAL until "EXIT TO SYSTEM?" is displayed and press ENT/SET. You will be returned to the previous state of operation.		EXIT TO SYSTEM?
Press ENT/SET to enter the verification mode "COLLIMATOR CHECK" will appear for three seconds and then 14" FS @ 40" (35 cm FS @ 100 cm) will size to the parameters displayed.		COLLIMATOR CHECK 14" FS @ 40" SID or 35 cm FS @ 100 cm
4. Verify the size to be 14" X 14" at 40" SID (35 cm x 35 cm at 100 SID). Using the supplied template verify that the illuminated size falls within the tolerance marks. Measure the illuminated field size and record into table 5.1 or make an exposure and record the size of the exposed area of the film in table 5.1.		
5. Press ENT/SET when finished. The display will indicate 5" FS @ 40" SID (12 cm FS @ 100 cm SID)and the collimator will size to the parameters displayed.		5" FS @ 40" SID or 13 cm FS @ 100 cm SID
6. Verify the size to be 5" X 5" @ 40" SID (12 cm x 12 cm @ 100 cm SID). Using the template verify that the illuminated size falls within the tolerance marks.		

INSTRUCTION	BUTTONS	DISPLAY
Measure the illuminated field size and record into table 5.1 or make an exposure and record the size of the exposed area of film in table 5.1.		
7. Calculate the error and percent error in table 5.1. Complete the rest of the table and verify that the collimator is operating in a linear fashion as prescribed by the limits noted on the table.		

NOTE: IF THE COLLIMATOR FAILS THE LINEARITY TEST, YOU SHOULD FIRST RE-CALIBRATE THE SYSTEM AS DESCRIBED IN SECTION 4. IF AFTER RE-CALIBRATION THE COLLIMATOR CONSISTENTLY FAILS THE LINEARITY TEST, RETURN THE COLLIMATOR HEAD FOR SERVICE.

8. Press ENT/SET when finished. The display will now indicate 14" FS @ 72" SID (35 cm FS @ 180 cm SID) and the collimator will size to the parameters displayed.		14" FS @ 72" SID 35 cm FS @ 180 cm
9. Verify the size to be what is indicated on the front panel display . Using the template verify that the illuminated size falls within the tolerance marks or make an exposure and verify the exposure size is within the allowable error of 2% SID.		5" FS @ 72" SID or 13 cm FS @ 180 cm SID 14" FS @ 36" SID or 35 cm FS @ 92 cm SID 5" FS @ 36" SID or 13 cm FS @ 92 cm SID 14" FS @ 48" SID or 35 cm FS @ 120 cm SID 5" FS @ 48" SID or 13 cm FS @ 120 cm
10. Press ENT/SET when finished to proceed to the next test size.		

INSTRUCTION	BUTTONS	DISPLAY
11. Repeat steps 8 - 10 for the remaining test sizes until the message "EXIT TO SYSTEM?" is displayed.		EXIT TO SYSTEM?
Press ENT/SET to return to run-time operation. The collimator function check is complete.		

5.2 HORIZONTAL COLLIMATOR FUNCTION CHECK

Repeat section 5.1 with the collimator in the horizontal position to verify collimator operation in the horizontal position.

5.3 PREPARATION FOR FUNCTION CHECK PROCEDURES

Access to the power chassis PCB (Master PCB) may be necessary for the following procedures. Make sure the collimator is in a run-time condition with a cassette installed in the table cassette holder. The collimator should not be in calibration, verification, nor cycle modes during these procedures.

5.4 COLLIMATOR TILT SWITCH CHECKOUT

Position the collimator at 0° horizontal. Angulate the collimator to a 0° beam-down position. Slowly angulate the collimator +20° toward a beam left position and back to a -20° beam-right position.

Observe the message MANUAL-TILT on the collimator front panel, observe the field size indicators "___ ____", and observe the SID display blanks. This should occur whenever the collimator is tilted more than 11° in either direction from vertical. If this does not occur, the tilt switch assembly is probably defective. It must be replaced as a unit. Refer to the Replaceable Parts List in Section 8.

5.5 TABLE TILT SWITCH CHECKOUT (TILTING TABLES ONLY)

With a cassette installed in the table cassette holder, angulate the collimator to 0° beam-down. Angulate the table to 0° horizontal and slowly tilt to +20° and then to -20°. A READY-RAD message must be displayed with the table at 0° and remain on for +11° and -11° from horizontal.

Position the table at +90° upright (usually actual of +85°) and angulate the collimator to a +90° beam-left position. Slowly tilt the table 20° down from the maximum upright position (+70°). The MANUAL-TILT message must be displayed at a position 11° from +90° (+79° and remain on for tilt to 70°.

5.6 CONTINUOUS SID MONITOR CHECKOUT

Make sure the collimator is in run-time operation, in radiographic mode, with READY-RAD displayed on the front panel.

Adjust the position of the head to 40" (100 cm) SID and verify that the SID display on the front panel indicates 40" (100 cm) SID within the prescribed tolerances in the specifications section in the beginning of the book.

Adjust the position of the head to numerous other SID's and verify the display indicates the correct SID within the prescribed limits each time.

(OPTION) If the system is equipped with an adjustable height table top and a second SID monitor is installed. Verify SID and display by also moving the table top to numerous table heights.

Above 72.0" (180 cm) SID and below 36.0" (92 cm) SID a message of EXP HLD - SID LIM will be displayed to indicate that SID has passed the working limits of the collimator. The SID display should blank.

5.7 EXTERNAL SID SIGNAL TEST (HORIZONTAL)

Angulate the collimator to 90 degrees at the wall mounted cassette holder. Insert a cassette into the tray and verify that the collimator is in run-time operation with READY-RAD displayed on the front panel.

Move the collimator horizontally until the distance from the source (focal spot) to the image receptor (film in cassette) is at 72" (180 cm) SID. Slowly move the collimator to a greater and then to a lesser SID while measuring the actual SID.

72.0 (180.0) will be displayed on the collimator front panel SID display at a measured 72" (180 cm) SID and must switch off at a maximum of 72.75" (182 cm) and at a minimum of 71.25" (178 cm) SID.

Move the collimator horizontally to a 48" (120) SID, and slowly move the collimator to a greater and then to a lesser SID.

48.0 (120.0) will be displayed on the collimator front panel SID display at a measured 48" (120 cm) SID and must switch off at a maximum of 48.48" (50 cm) and at a minimum of 47.52" (46 cm) SID.

Move the collimator horizontally to a 40" (120 cm) SID, and slowly move the collimator to a greater and then to a lesser SID.

40.0 (100.0) will be displayed on the collimator front panel SID display at a measured 40" (100 cm) SID and must switch off at a maximum of 40.40" (102 cm) and at a minimum of 39.60" (98 cm) SID.

Move the collimator horizontally to a 36" (92 cm) SID, and slowly move the collimator to a greater and then to a lesser SID.

36.0 (92.0) will be displayed on the collimator front panel SID display at a measured 36" (92 cm) SID and must switch off at a maximum of 36.36" (94 cm) and at a minimum of 35.64" (90) SID.

5.8 TILTING TABLE RECEPTOR SID SIGNAL CHECKOUT (FOR TILTING TABLES ONLY)

Angulate the table to a full upright position. Angulate the collimator beam-left to aim the X-Ray beam at the upright table cassette tray. Place a cassette in the cassette tray and verify that the collimator is in a run-time mode with READY-RAD displayed on the collimator front panel.

Move the collimator horizontally to a 48" (120 cm) SID, and slowly move the collimator to a greater and then to a lesser SID.

48.0 (120.0) will be displayed on the collimator front panel SID display at a measured 48" (120 cm) SID and must switch off at a maximum of 48.48" (122 cm) and at a minimum of 47.52" (124 cm) SID.

Move the collimator horizontally to a 40" (100 cm) SID, and slowly move the collimator to a greater and then to a lesser SID.

40.0 (100.0) will be displayed on the collimator front panel SID display at a measured 40" (100 cm) SID and must switch off at a maximum of 40.40" (102 cm) and at a minimum of 39.60" (98) SID.

Move the collimator horizontally to a 36" (92 cm) SID, and slowly move the collimator to a greater and then to a lesser SID.

36.0 (92.0) will be displayed on the collimator front panel SID display at a measured 36" (92 cm) SID and must switch off at a maximum of 36.36" (94 cm) and at a minimum of 35.64" (90 cm) SID.

5.9 EXTERNAL RADIOGRAPHIC IR SIGNALS CHECKOUT (TILTING OR NON-TILTING TABLES)

Angulate the collimator to a 0° beam-down direction with a measured SID of 40" (100 cm) measured to the bucky. For tilting tables, angulate the table to a 0° horizontal. The MANUAL-NO CASS message should be displayed on the collimator front panel.

1. Locate a cassette in the table cassette tray.

   A. EXPOSURE HOLD should be displayed while the collimator rapidly adjusts to the desired size and stops.

B. READY-RAD should then display, the current SID and the current field size will be indicated on the front panel.

C. The displayed field size should be the same as the cassette size inserted.

2. Do not remove the cassette at this time. Angulate the collimator to properly aim at the wall cassette holder with horizontal SID at about 50" (127 cm).

NOTE: Although the cassette was left in the table cassette tray, it should not produce an IR TRUE signal, thus MANUAL - SID FIX? should be displayed indicating that the horizontal SID is not at a fixed position.

3. Fully insert a cassette into the wall cassette holder and move the collimator horizontally to each of the available SID's (i.e. 36", 40", 48", and 72" or 92cm, 100cm, 120 cm, and 180 cm).

A. The correct SID value should be indicated.

B. The collimator should rapidly adjust to the desired size and stop. The EXPOSURE HOLD message will change to a READY -RAD message when the collimator stops.

C. The field size indicated on the display should be the same as the cassette size inserted in the wall cassette holder.

4. Remove the cassette from the table cassette tray. The removal of this cassette should not produce a response.

5.10 EXTERNAL FLUOROSCOPIC IR SIGNALS CHECKOUT (TILTING OR NON-TILTING TABLES)

1. Angulate the collimator to a 0° beam-down direction with a measured SID OF 40" measured to the input screen of the image intensifier. Select FLUORO/SPOTFILM mode. For tilting tables, angulate the table to 0° horizontal. The collimator should adjust to the previously selected image intensifier magnification size and READY-FLUORO should be displayed on the collimator front panel.

2. Press the MAG SIZE button on the front panel or optional remote control.

A. The collimator should rapidly adjust and stop.

B. The light field size at the plane of the image receptor should be approximately the same size as preset for NORM during calibration.

B. READY-FLUOR NORM should be displayed on the collimator front panel.

3. Press the MAG SIZE button on the front panel or optional remote control again.

   A. The collimator should rapidly adjust and stop.

   B. The light field size at the plane of the image receptor should be approximately the same size as preset for MAG1 during calibration.

   C. READY-FLUOR MAG1 should be displayed on the collimator front panel.

4. Press the MAG SIZE button on the front panel or optional remote control again.

   A. The collimator should rapidly adjust and stop.

   B. The light field size at the plane of the image receptor should be approximately the same size as preset for MAG2 during calibration.

   C. READY-FLUOR MAG2 should be displayed on the collimator front panel.

5. Increase the size of the light field by means of the front panel or optional remote control power assist shutter control button.

   The light field size should not enlarge beyond the currently selected image intensifier magnification size.

5.11 TILTING TABLE EXTERNAL RADIOGRAPHIC IR SIGNAL CHECKOUT

1. Select RAD mode. Tilt the table to it's full upright position. Up to +79° and without a cassette in the table bucky, the message MANUAL-TILT should be displayed on the collimator front panel.

2. Angulate the collimator to the +90° beam-left position. The message MANUAL-NO CASS should be displayed on the collimator front panel.

3. Insert a cassette into the cassette tray and fully insert the tray into the table. Adjust the SID to a position near 46" (117 cm). The message EXP HLD-LOCK SID will be displayed on the collimator front panel.

4. Move the collimator horizontally to each of the available SID's (i.e. 36", 40", and 48" or 92 cm, 100 cm or 120 cm).

   A. The corresponding SID should be displayed on the SID display of the collimator front panel.

   B. The collimator should rapidly adjust and stop while the message EXPOSURE HOLD changes to READY-RAD on the collimator front panel.

   C. The field size indicated should be approximately the same size as the inserted cassette.

D. Repeat steps 1-4 of this section with the table and collimator tilted to -90° beam-right position.

5.12 SPOTFILM IR SIGNALS CHECKOUT

1. Locate a cassette in the table cassette tray and fully insert the tray into the table. Select FLUORO/SPOTFILM mode.

   A. The collimator shutters adjust to the film size.

   B. The message READY-SPOTFILM should be displayed on the collimator front panel.

NOTE: Pressing the LAST SIZE button on the collimator front panel or the optional remote control will cause the collimator to size to the last fluoroscopic size that was in use.

5.13 STEREO/TOMO BYPASS SIGNAL CHECKOUT

1. Angulate the collimator to 0° beam-down direction with a measured SID of 40" measured to the bucky. For tilting tables, adjust the table to 0° horizontal. The message MANUAL-NO CASS should be displayed on the collimator front panel.

2. Locate a cassette in the table cassette tray and fully insert the tray into the table.

   A. The message EXPOSURE HOLD will be displayed while the collimator rapidly adjusts and stops. Then READY-RAD will be displayed.

   B. The indicated size should be approximately the same size as the inserted cassette size.

3. Create a STEREO/TOMO condition by placing jumpers between TS6-7 to ground, and between TS6-10 and +5VDC. The message STEREO/TOMO should be displayed on the collimator front panel and the collimator should be in MANUAL mode.

4. Remove the jumpers. The collimator should return to the state described in 2.

5.14 NOTES ON CASSETTE TRAY ADJUSTMENT

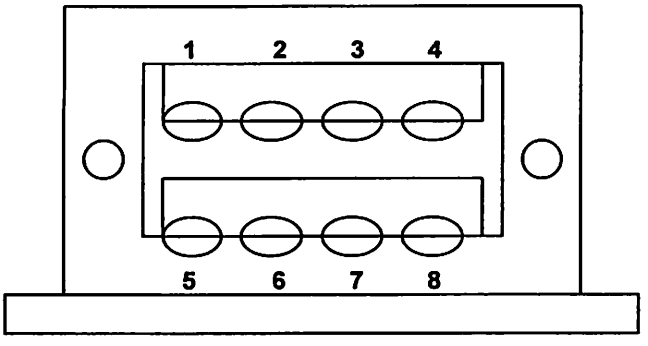
The table cassette tray and the wall cassette holder **do not** need to be adjusted to be synchronous with each other. The collimator retains separate calibration parameters for both image receptors.

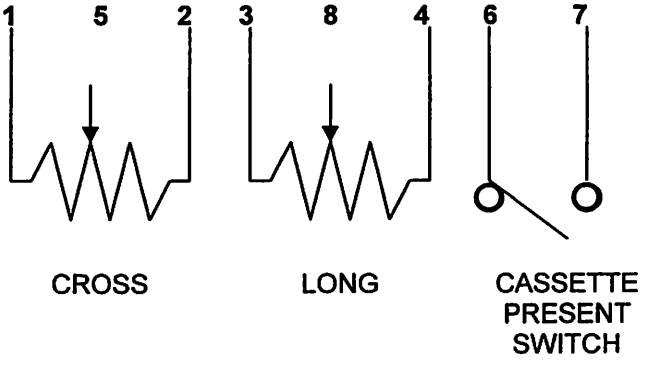
The collimator knows which tray it is shooting at when installed properly, therefore it is unnecessary for the table and wall cassette tray potentiometers to be set exactly the same.

The collimator has been calibrated at the factory around a cassette tray that is calibrated for an 11" (12-1/8" outside) or 28 cm (31 cm outside) cassette. The 11" (28 cm) dimension represents exactly one half of the 1 kilo-ohm cassette tray potentiometer. Consult the tray manufacturer's manual if adjustment is necessary.

NOTE: THE LINEAR IV'S AUTOCAL FEATURE "LEARNS" THE SETTINGS OF YOUR TRAY, THEREFORE MINOR DEVIATIONS FROM THE CHART BELOW ARE ACCEPTABLE AND ADJUSTMENT OF THE TRAY UNNECESSARY. THE ONLY REQUIRED CONDITION IS THAT THERE IS A LINEAR RELATIONSHIP BETWEEN CASSETTE SIZE AND OHMIC OUTPUT.

Cassette Tray		Ohms Between Ts-13 or 14
English	Metric	and TS4-12
5"	13 cm	60 Ohms
7"	18 cm	207
8"	20 cm	280
10"	24 cm	427
11"	27 cm	500
12"	30 cm	573
14"	35 cm	720
17"	43 cm	940





DESIRED SIZE		ACTUAL SIZE	ERROR=DESIRED SIZE-ACTUAL SIZE	%ERROR = ERROR X 100 / DESIRED SIZE
LONG	14" (35 cm)			ERROR1=
CROSS	14" (35 cm)			ERROR2=
LONG	5" (13 cm)			ERROR3=
CROSS	5" (13 cm)			ERROR4=

NOTE: Keep appropriate sign in all calculations

collimator operation is linear if

Error 1 - Error 3 $\leq$ 1%

AND

Error 2 - Error 4 $\leq$ 1%

ERROR 1-ERROR 3		$\leq$ 1%	PASS/FAIL
ERROR 2 - ERROR 4		$\leq$ 1%	PASS/FAIL

TABLE 5.1

DESIRED SIZE		ACTUAL SIZE	ERROR=DESIRED SIZE-ACTUAL SIZE	%ERROR = ERROR X 100 / DESIRED SIZE
LONG	14" (35 cm)			ERROR1=
CROSS	14" (35 cm)			ERROR2=
LONG	5" (13 cm)			ERROR3=
CROSS	5" (13 cm)			ERROR4=

NOTE: Keep appropriate sign in all calculations

collimator operation is linear if

Error 1 - Error 3 $\leq$ 1%

AND

Error 2 - Error 4 $\leq$ 1%

ERROR 1-ERROR 3		$\leq$ 1%	PASS/FAIL
ERROR 2 - ERROR 4		$\leq$ 1%	PASS/FAIL

TABLE 5.1

SECTION 6

COMPLIANCE VERIFICATION

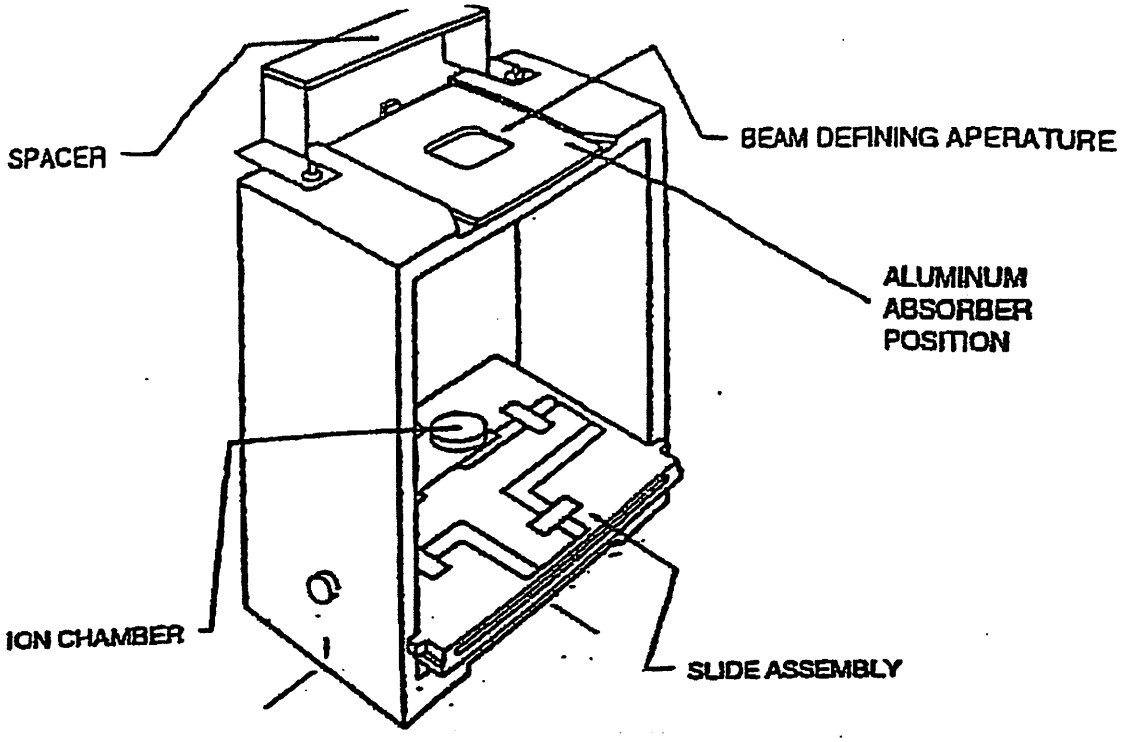
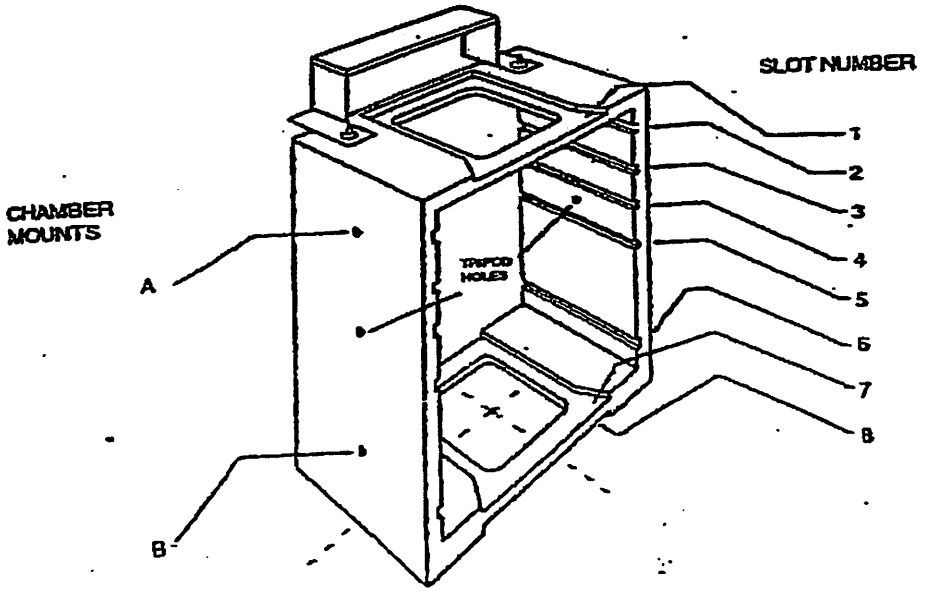


Figure 6.1



LEFT SIDE MOUNTING HOLES FOR COMPLIANCE TESTING

Figure 6.2

6.0 COMPLIANCE VERIFICATION

It is necessary for the assembler to verify compliance. A series of tests, when performed at the time of installation, will indicate compliance with 21 CFR, Sub-Chapter J, Part 1020, Performance Standards.

The following tests are from NEMA Standards Publication, No. XR-8-1979 (Test Methods for Diagnostic X-Ray Machines for Use During Initial Installation).

For each compliance item, there may be a variety of test methods described. Which method is used will depend on the tester's experience, availability of equipment, time, or special requirements of the Eureka Linear Collimator. Any reference to tolerances on compliance items are referenced directly from 21 CFR, Sub-Chapter J, Regulations. They do not take into account inaccuracies brought about by the test equipment, instrumentation, or the human element. These factors must be considered when these tests are performed and the compliance of the equipment is being determined.

6.1 VERIFICATION OF TESTS TO BE PERFORMED

	Test Procedure or Requirement	Applicable Paragraph
1.	Visual Definition of X-Ray Light Field	XR8/2.14
2.	Intensity of Light Field Illumination	XR8/2.15
3.	Minimum Field Size	XR8/2.16
4.	X-Ray Field/Receptor Center Alignment	XR8/2.17
5.	Indication of Field Size	XR8/2.18
6.	Positive Beam Limitation (PBL)	XR8/2.19
7.	X-Ray Field Limitation and Alignment	XR8/2.20
8.	Return to PBL with Image Receptor Change	XR8/2.21
9.	Beam Quality	XR8/2.09
10.	Fluoro X-Ray Field Limitation	XR8/2.24
11.	Fluoro Source to Skin Distance (SSD)	XR8/2.25
12.	Primary Barrier - X-Ray Lockout	XR8/2.27
13.	Alignment of X-Ray Edges (Spotfilm)	XR8/2.29
14.	X-Ray/IR Center Alignment (Spotfilm)	XR8/2.30

RECORD THE RESULTS ON THE *RECORD SHEET* SUPPLIED AT THE END OF THIS SECTION

Radiation Warning for Diagnostic X-Ray Systems

X-rays are dangerous for both the operator and others in the vicinity unless established safe exposure procedures are strictly observed.

The useful and scattered beams can produce serious, genetic or potentially fatal bodily injuries to any persons in the surrounding area if used by an unskilled operator. Adequate precautions must always be taken to avoid exposure to the useful beam, as well as leakage radiation from within the source housing or to scattered radiation resulting from the passage of radiation through matter.

Those authorized to operate, test, participate in or supervise the operation of the equipment must be thoroughly familiar and comply completely with the currently established safe exposure factors and procedures described in publications such as Sub-Chapter J of Title 21 of the Code of Federal Regulations, *"Diagnostic X-Ray Systems and their Major Components,"* and the National Council on Radiation Protection (NCRP) No. 33, *"Medical X-Ray and Gamma-Ray Protection for Energies up to 10 Me V-Equipment Design and Use,"* as revised or replaced in the future.

Failure to observe these warnings may cause serious, genetic or potentially fatal bodily injuries to the operator or those in the area.

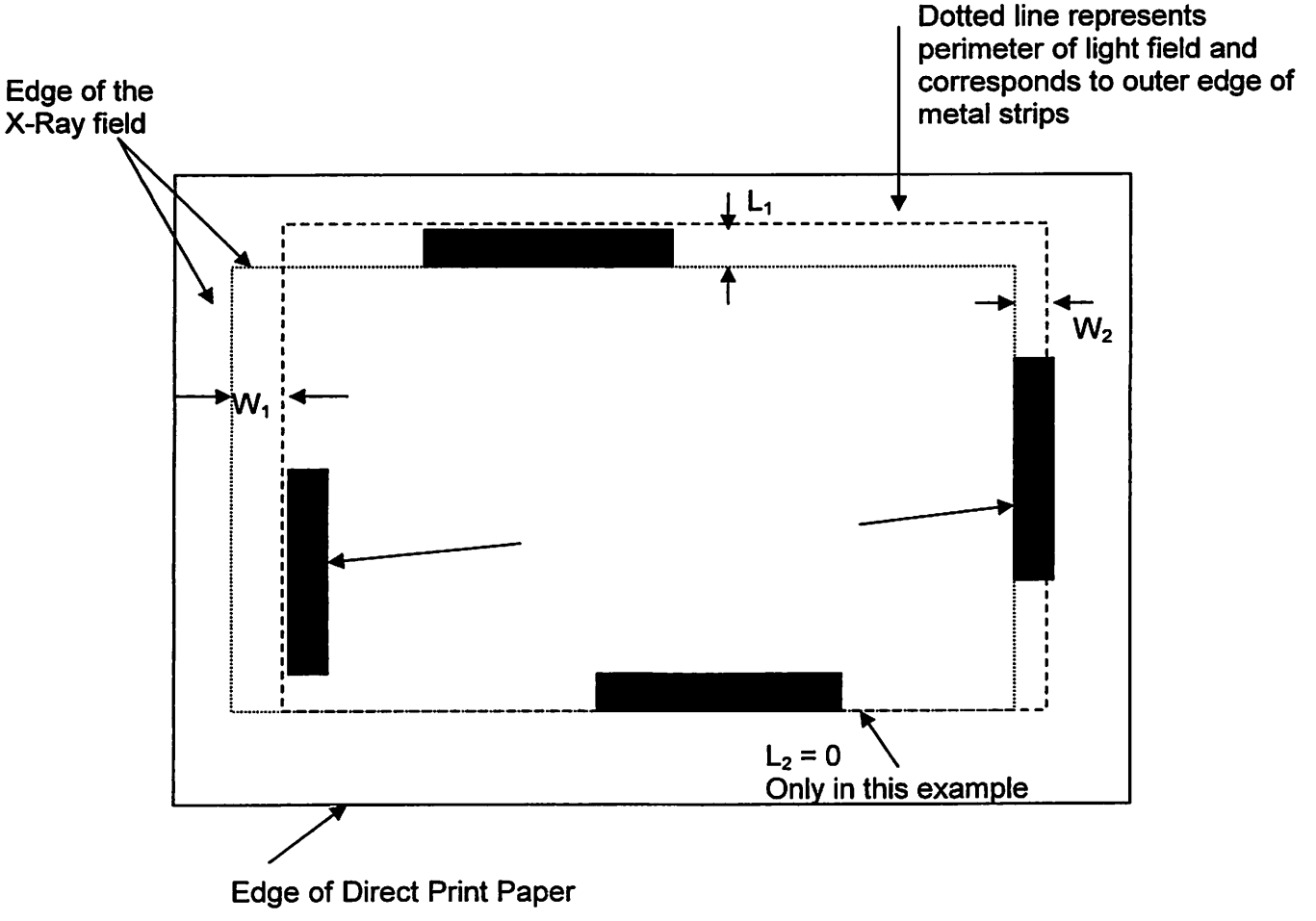


Figure 6.3

XR 8-2.14 VISUAL DEFINITION (RADIOGRAPHIC) OF X-RAY LIGHT FIELD

REQUIREMENT - Means shall be provided for visually defining the perimeter of the X-ray field. The total misalignment of the edges of the visually defined field with the respective edges of the X-ray field along either the length or width of the visually defined field shall not exceed 2 percent of the distance from the source to the center of the visually defined field when the surface upon which it appears is perpendicular to the axis of the X-ray beam (see 21 CFR 1020.31 (d) (2)).

.01 METHOD 1 - FDA COMPLIANCE TEST METHOD

A. EQUIPMENT REQUIRED

1. BRH/FDA compliance test stand (including slide assembly). See Figure 6.1.

2. Four metal marker strips.

3. Plastic cassette, loaded with direct-print paper or film.

B. PROCEDURE

1. Attach the spacer, positioned out of the primary beam to the test stand. Center the stand on the table. Center the source over the stand, assure by the means provided that the axis of the X-ray beam is perpendicular to the plane of the image receptor, and bring the beam-limiting device down into firm contact with the spacer. Select the MANUAL mode of operation (there must not be a cassette in the cassette holder).

2. Insert the slide assembly, grid side up, into slot 6 of the test stand and the focal spot assembly into slot 1 (Figure 6-2). Place a cassette loaded with direct print paper or film into the slide assembly.

3. Adjust the collimator so that no part of the light-field intersects any portion of the top of the test stand. (Further collimation to a light field of less than 15 by 20 centimeters (6 by 8 in) on the slide assembly grid may be desirable to assure that the X-ray field will be fully contained on the direct print paper for film in the slide assembly).

4. Position the outer edge of each metal strip to correspond with each side of the light-field. One end of the metal strip shall extend to the center line of the respective grid arm.

5. Select proper technique factors and make an exposure (may require several exposures to obtain 1 R to the direct print paper).

6. Develop the direct print paper or film.

C. VERIFICATION OF COMPLIANCE

For determination of misalignment, compare the edges of the X-ray field to the edges of the light-field as defined by the outer edges of the metal strips. On each side of the rectangular fields, measure the separation between the X-ray field and the outside edge on the image of the respective metal strip. Sum these measured separations for opposite sides of the X-ray field to yield a total misalignment in the length and width dimensions. Record the length misalignment and width misalignment, both without regard to sign (see Paragraph D on following page and Figure 6-3).

D. CALCULATIONS

Calculate the source to image distance (SID) per the following formula (to slot 6) as the indicated source-to-table top distance minus 4.7 centimeters (1.85 in) and record. Calculate 2 percent of this SID and record. Both the length and width misalignment must be less than 2 percent of SID (to slot 6).

$$\frac{2.5}{S} = \frac{X}{X + 13.95}$$

$$2.5X + (2.5)\ 13.95 = XS$$

$$(2.5)\ 13.95 = XS - 2.5X$$ See Fig. 6-4

$$34.875 = X\ (S - 2.5)$$

$$X = \frac{34.875}{S - 2.5}$$

The misalignments are calculated as follows:

Length misalignment = $L_1 + L_2 \leq 2\%$ SID
Width misalignment = $W_1 + W2 \leq 2\%$ SID

Calculate 2% of the measured SID. Each of the misalignments, length or width, must be less than or equal to 2% of the measured SID for compliance.

NEMA Standards 5-15-79

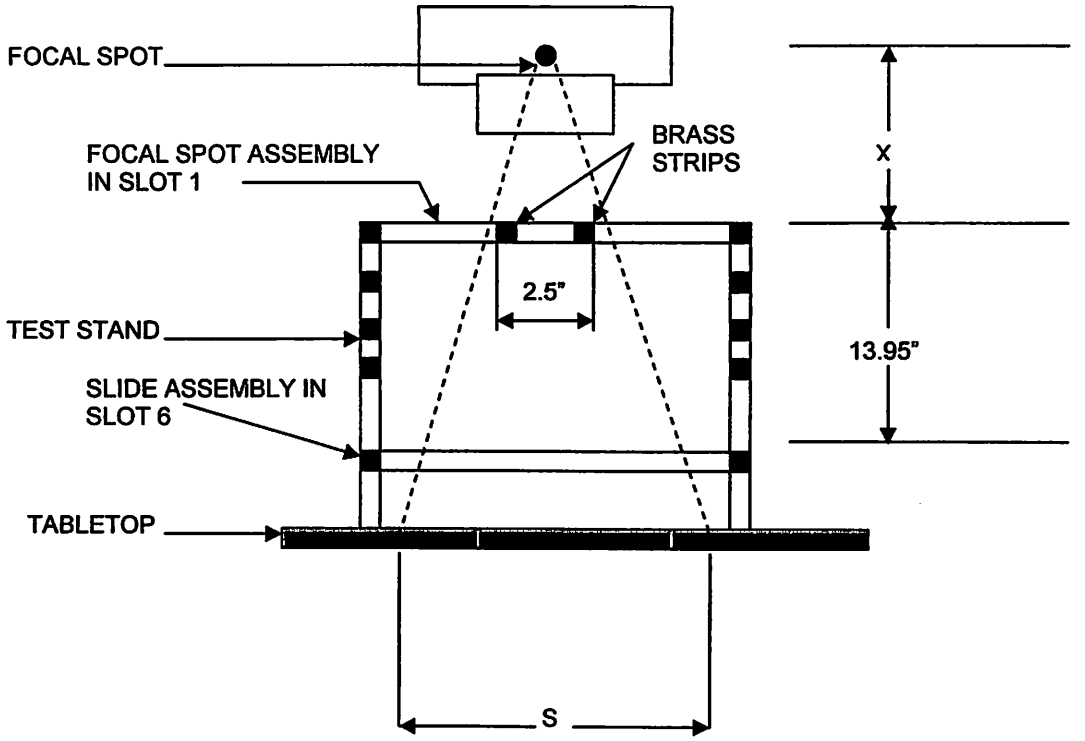


Figure 6.4

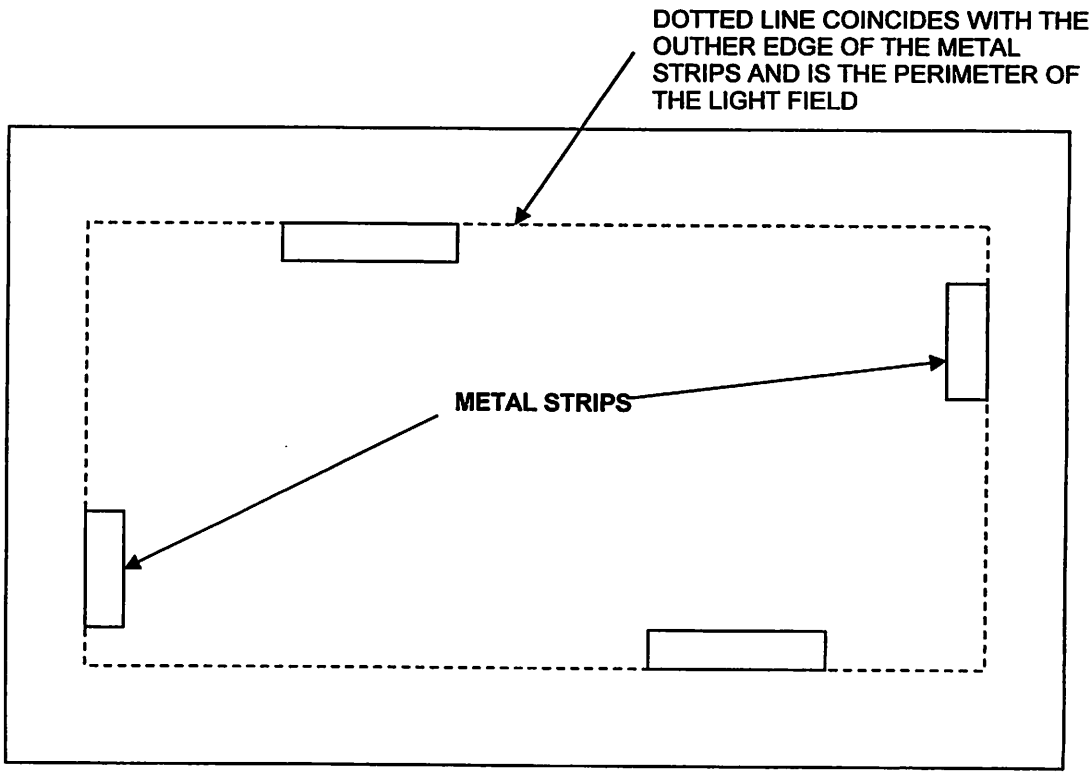


Figure 6.5

.02 METHOD II - METAL MARKER METHOD

A. GENERAL

The actual versus indicated source-to-image receptor distance (SID) test must be performed prior to attempting this test.

B. EQUIPMENT

1. Plastic cassette with direct-print paper or film.

2. Radio-opaque markers*.

   * Each marker is approximately 1/32 inch galvanized sheet metal having the dimensions of 1.5 by 1.5 inches.

C. PROCEDURE

1. Adjust the source assembly and the beam-limiting device so that they are approximately centered over the table and perpendicular to the table top. Then position the beam-limiting device to the SID previously determined and record the indicated value.

2. Insert the cassette and turn on the light-field.** Adjust the beam-limiting device to the next size smaller than the cassette size being used.

   ** Make a note to record the field size indicated on the dial of the beam-limiting device for the SID being used.

3. Position the outer edge of each metal marker on the table top to correspond with each side of the light-field (Fig. 6-5).

4. Select the appropriate technique factors and make an exposure.

5. Develop film or direct-print paper.

D. VERIFICATION OF COMPLIANCE

For determination of misalignment, compare the edges of the X-ray field to the edges of the light-field as defined by the outer edges of the metal strips. On each side of the rectangular fields, measure the separation between the X-ray field and the outside edge of the image of the respective metal strip. Sum these measured separations for opposite sides of the X-ray field to yield a total misalignment in the length and width dimensions. Record the length misalignment and width misalignment, both without regard to sign (see Par. E below and Fig. 6-3).

E. CALCULATIONS

Calculate the SID per the following formula (to slot 6) as the indicated source-to-tabletop distance minus 4.7 centimeters (1.85 in) and record. Calculate 2 percent of this SID and record. Both the length and width misalignment must be less than 2 percent of SID (to slot 6).

$$\frac{2.5}{S} = \frac{X}{X + 13.95}$$

$$2.5X + (2.5)\ 13.95 = XS$$

$$(2.5)\ 13.95 = XS - 2.5X$$ See Fig. 6-4

$$34.875 = X\ (S - 2.5)$$

$$\frac{X}{} = \frac{34.875}{S - 2.5}$$

The misalignments are calculated as follows:

Length misalignment = $L_1 + L_2 \leq 2\%$ SID
Width misalignment = $W_1 + W2 \leq 2\%$ SID

Calculate 2% of the measured SID. Each of the misalignments, length or width, must be less than or equal to 2% of the measured SID for compliance.

NEMA Standards 5-15-79

.03 METHOD III - ALTERNATE TEST STAND METHOD

A. GENERAL

1. The image of the radiation field on the film must be of uniform density with sharply defined edges.

2. The graduated template is utilized to minimize the amount of error introduced into the measurement of the X-ray field size.

3. The actual versus indicated SID must be determined prior to performing this test.

B. EQUIPMENT

1. Manufacturer's recommended test stand.

2. Cassettes and film.

3. Graduated template.

C. PROCEDURE

1. Align the tube unit and image receptor and set the SID with the normal operating aids (detents, scales, lights, etc.)

2. Load cassette and insert into image receptor.

3. Close shutters to a size smaller than that of the cassette placed into the image receptor.

4. Position the test stand in accordance with the manufacturer's instructions.

5. Energize the field light and record or define the position of the four light field edges as shown on the graduated template or position four metal markers so that the outer edge of each metal marker corresponds to an edge on each side of the light-field or both.

6. Select proper technique factors, make an exposure, and develop film.

D. VERIFICATION OF COMPLIANCE

1. Calculate 2 percent of the actual SID and record.

2. Compare the edges of the X-ray field to the edges of the light field as defined by the outer edges of the metal markers or by the graduated scale.

3. Measure the distance between the edges of the two fields for each side of the rectangular fields (see Fig. 6.3).

4. Arithmetically sum the misalignment of opposite sides, regardless of sign, of the rectangles, to yield misalignment in each of the two directions.

$$\text{Length misalignment} = L_1 + L_2 \leq 2\% \text{ SID}$$
$$\text{Width misalignment} = W_1 + W2 \leq 2\% \text{ SID}$$

Both the length and width misalignment must be less than 2 percent SID as calculated in Step 1.

NEMA Standards 5-15-79

XR 8-2.15 INTENSITY OF LIGHT FIELD ILLUMINATION

REQUIREMENT - When a light localizer is used to define the X-ray field, it shall provide an average illumination of not less than 160 lux (15 footcandles) at 100 centimeters or at the maximum SID, whichever is less. The average illumination shall be based on measurements in the approximate center of each quadrant of the light field (See 32 CFR 1020.31 (d) (2) (ii)).

.01 METHOD 1 - DIRECT TEST

A. GENERAL

1. Make certain that all surfaces in the light path are clean.

2. Reduce ambient light level as much as is feasible.

B. EQUIPMENT

Photometer capable of measuring 160 lux (15 footcandles).

C. PROCEDURE

1. Place the photometer on the tabletop and set the diagnostic source assembly so that the sensing area of the photometer is at 100 centimeters or the maximum SID, whichever is less.

2. Open the beam-limiting device to assure that each quadrant of the light field is larger than the sensing area of the photometer.

3. Refer to the manufacturer's instructions for proper use of the photometer.

4. Turn on the light localizer.

5. At or near the center of a light field quadrant, determine the illuminance by subtracting the ambient light level from the corresponding light level as measured when the light localizer is energized. Do not move the photometer between measurements.

6. Repeat the procedure for the remaining three quadrants.

7. Determine the average illuminance of the four light field quadrants.

8. Record the model number, serial number, and the date of calibration of test instrument.

D. VERIFICATION OF COMPLIANCE

Verify that the average illumination is not less than 160 lux (15 footcandles).

NEMA Standards 5-15-79

.02 METHOD II - INDIRECT TEST

A. GENERAL

1. This indirect test is feasible after the correlation between light output and voltage is made; the manufacturer then specifies a voltage to be measured or adjusted, or both.

2.

2. Make certain that all surfaces in the light path are clean and unobstructed.

B. EQUIPMENT

Digital voltmeter.

C. PROCEDURE

1. Remove trim covers to gain access to the lamp socket.

2. Verify that the specified lamp is in the socket.

3. With the light-field energized, measure the voltage across the lamp socket terminals.

4. Record the voltage measured.

5. Record the model number, serial number and calibration date of the digital voltmeter.

D. VERIFICATION OF COMPLIANCE

The voltage recorded shall be within the tolerances specified by the manufacturer.

NOTE: THE AC VOLTAGE AT THE LAMP SOCKET MUST NOT BE LESS THAN 19.5 VAC RMS

XR 8-2.16 MINIMUM FIELD SIZE

REQUIREMENT - Minimum field size at 100 centimeters (radiographic) or the maximum SID (fluoroscopic) shall be less than or equal to 5 by 5 centimeters (see 21 CFR 1020.31 (d) (1), 1020.31 (e) (2), and 1020.32 (b) (2)).

.01 METHOD 1 - FILM METHOD

A. GENERAL

1. The following test is to be used for radiographic, fluoroscopic, and spotfilm devices.

2. This procedure need not be performed if it is apparent by visual means that the beam-limiting device can be adjusted to a size less than 5 by 5 centimeters at the specified SID.

B. EQUIPMENT

1. Cassette.

2. X-ray film or direct-print paper.

C. PROCEDURE 1 - RADIOGRAPHIC AND SPOTFILM DEVICES

1. Adjust the maximum SID obtainable (spotfilm devices or 100 centimeter radiographic devices).

2. Adjust the beam-limiting device to the smallest field size obtainable.

3. Load cassette and set proper technique factors.

4. Make an exposure.

5. Process film.

D. PROCEDURE 2 - FLUOROSCOPIC

1. Set fluoroscopic system for maximum SID and lock into position.

2. Remove all compression cones from the beam.

3. With the X-ray beam off, attach beam attenuator to the input surface of the image receptor.

4. Attach cassette to the bottom of the attenuator.

5. Close shutters as far as possible.

6. Set technique factors to assure proper exposure of the film.

7. Make exposure.

8. Process film.

E. VERIFICATION OF COMPLIANCE

Measure the X-ray field produced on film and verify that the field size is less than or equal to 5 by 5 centimeters.

NEMA Standards 5-15-79

.02 METHOD II - VISUAL METHOD

A. GENERAL

1. The following test is to be used for radiographic, fluoroscopic, and spotfilm devices.

2. This procedure need not be performed if it is apparent by visual means that the beam-limiting device can be adjusted to a size less than 5 by 5 centimeters at the specified SID.

3. These tests attempt to minimize radiation exposures as well as film processing by utilizing light-field visual display, or image display, or visual mechanical movement.

B. EQUIPMENT

Beam attenuator

C. PROCEDURE 1 - RADIOGRAPHIC

1. Set the tube unit at a distance of 100 centimeters from the image receptor.

2. Pull out the bucky tray and place an unloaded cassette into the tray. Do not reinsert bucky tray.

3. Position source assembly over film cassette in the extended bucky tray.

4. Actuate the light field and close shutters to minimum size. If the light is completely blocked from the image receptor, no further test is required.

5. Measure the light field size on the cassette of the extended bucky tray.

D. VERIFICATION OF COMPLIANCE

Measured field size must be less than or equal to 5 by 5 centimeters.

E. PROCEDURE 2 - SPOTFILM/FLUOROSCOPIC

1. Set SID for maximum obtainable and lock in place.

2. Position beam attenuator to intercept entire X-ray beam.

3. Set appropriate technique factors (both spotfilm and fluoroscopic).

4. Close shutters to smallest size obtainable and make an exposure.

5. Verify on viewing device that there is no visual indication of radiation. If any radiation field is discernible, Method I must be utilized to determine minimum field size.

F VERIFICATION OF COMPLIANCE

Verify that no visual indication of the radiation field is discernible.

XR 8-2.17 X-RAY FIELD/RECEPTOR CENTER ALIGNMENT

REQUIREMENT - Means shall be provided to align the center of the X-ray field with respect to the image receptor to within 2 percent of the SID (See 21 CFR 1020.31 (e) (1)).

A. GENERAL

1. All exposures taken during this test must have a uniform film density of approximately 1.0.

2. Actual versus indicated SID must be determined prior to performing this test.

B. EQUIPMENT

Radiographic cassette loaded with film (8 by 10 inches).

C. PROCEDURE

1. Load cassette with film and place into the bucky tray.

2. Assure the X-ray beam is perpendicular to the image receptor and centered over the bucky tray.

3. Set the SID to the value determined in the actual versus indicated SID test.

4. Reduce the X-ray field to approximately 6 by 8 inches.

5. Make an exposure and develop the film.

To determine as accurately as possible the corners of the image recorded on the film, locate two points on each of the four sides of the image. Through the two points on each side draw a straight line. These four lines, when extended, intersect making a rectangle which is a close approximation of the actual X-ray field. Draw a diagonal across the image to determine the center of the X-ray image.

7. To determine the center of the X-ray film draw diagonals across the film (the point where these two lines cross is the center of the film), or fold the film into quarters (the point where the two folds cross is the center of the film).

8. The distance from the film center mark to the image center mark is measured and recorded as the linear displacement or misalignment of the centers of the X-ray field and the image receptor.

D. VERIFICATION OF COMPLIANCE

Verify that this distance is less than or equal to 2 percent of the SID.

NEMA Standards 5-15-79

XR 8-2.18 INDICATION OF X-RAY FIELD SIZE

REQUIREMENT - Means shall be provided on the beam-limiting device to indicate field size in the image receptor plane to within 2 percent of the SID (see 21 CFR 1020.31 (e) (1)).

A. GENERAL

The actual versus indicated SID test must be performed prior to beginning this test.

B. EQUIPMENT

A 24 by 30 centimeter or a 10 by 12 inch cassette with film.

C. PROCEDURE

1. Set the SID to the value determined in the actual versus indicated SID test.

2. Center the film cassette in the cassette tray and insert into position.

3. Adjust the field size to 15 by 15 centimeters or 8 by 8 inches by means of the numerical indicators on the beam-limiting device.

4. Make an exposure and develop film.

5. Measure and record the length and width dimensions of the image.

D. VERIFICATION OF COMPLIANCE

The deviation of any of the recorded dimensions must not exceed 2 percent of the SID in Step 1.

NEMA Standards 5-15-79

XR 8-2.19 POSITIVE BEAM LIMITATION (PBL)

REQUIREMENT

Means shall be provided for positive-beam limitation (PBL) which will, at the SID for which the device is designed, either cause automatic adjustment of the X-ray field in the plane of the image receptor to the image receptor size within five seconds after insertion of the image receptor or, if adjustment is accomplished automatically in a time interval greater than 5 seconds or is manual, will prevent production of X-rays until such adjustment is completed. At SID's at which the device is not intended to operate, the (e) (2)).

A. GENERAL

The PBL requirement must be met if both the beam axis and table angulation are within plus or minus 10 degrees of the horizontal or vertical and the film is used in the cassette tray.

B. EQUIPMENT

Large size cassette.

C. PROCEDURE

1. Set the source assembly to a SID where the PBL system is intended to operate.

2. Place the largest film cassette with which the system is intended to operate into the cassette tray; do not insert cassette tray at this time.

3. Turn on the light localizer and adjust the beam-limiting device to the smallest obtainable field size.

4. Insert the cassette tray and measure the time elapsed from the insertion of the cassette tray with the cassette inserted to the adjustment of the X-ray field to the image receptor size.

5. The adjustment must be accomplished within 5 seconds.

6. If the adjustment is not accomplished within 5 seconds or the beam-limiting device is of the manual type, select low-range values of the tube potential and tube current and attempt to make an exposure. The production of X-rays must be prevented until the PBL adjustment is completed.

7. Move the source assembly to a SID where the PBL system is not intended to operate (see manufacturer's specifications) and attempt to make an exposure. Exposures must not be possible.

NEMA Standards 5-15-79

XR 8-2.20 X-RAY FIELD LIMITATION AND ALIGNMENT

REQUIREMENT

The X-ray field size in the plane of the image receptor, whether automatically or manually adjusted, shall be such that neither the length nor the width of the X-ray field differs from that of the image receptor by greater than 3 percent of the SID and that the sum of the length and width differences without regard to sign be no greater than 4 percent of the SID, when the equipment indicates that the beam axis is perpendicular to the plane of the image receptor (see 21 CFR 1020.31 (e) (2) (ii)).

.01 METHOD 1 - FDA/CDRH TEST STAND METHOD .

A. EQUIPMENT

1. FDA/CDRH compliance test stand with accessories
2. Slide assembly.
3. Plastic cassette containing a sheet of direct-print paper or X-ray film.
4. Ruler.
5. Cassette (preferably 8 to 10 inches or smaller).

B. PROCEDURE

1. Using the means provided, align the source assembly so that the beam axis is perpendicular to the image receptor.
2. Place the test stand on the table.
3. Position the spacer so that it does not intersect the primary beam and secure with the pushbutton connectors.

4. Center the source assembly over the test stand using the means provided, e.g. the light-field used to define the X-ray field.

5. Bring the source assembly down into firm contact with the spacer.

6. Center the cassette tray with the source assembly using the means provided, e.g. bucky light.

7. Insert the plastic cassette into the slide assembly. Then insert the slide assembly into slot 5 (see Figure 6-2).

8. Center the film cassette in the cassette tray and insert into position. If the positive-beam limitation will not operate at this SID, raise the source assembly and lock in position at the first operable SID.

9. Make an exposure. Develop the image. Measure and record the length and width dimensions of the image.

10. Calculate the field size correction factor as the SID/A where:

    a. SID is the indicated source-to-image receptor distance, and

    b. A is the indicated source-to-tabletop distance less 7.7 inches. Multiply each of the measured dimensions by the correction factor.

    $$\text{X-ray field length at under-table image receptor} = \frac{SID}{A} \times (\text{X-Ray field length at slot 5})$$

    $$\text{X-ray field width at under-table image receptor} = \frac{SID}{A} \times (\text{X-Ray field width at slot 5})$$

    Determine the difference without regard to sign between the corrected length and width dimensions and the corresponding cassette film size dimensions (8 by 10, 5 by 7, etc.). Each of these differences must be less than 3 percent of the SID, and the sum of these differences must be less than 4 percent of the SID.

    NEMA Standards 5-15-79

.02 METHOD II - ALTERNATE TEST STAND METHOD

A. GENERAL

Prior to performing this test, the magnification factor must be determined in accordance with the X-ray/light field alignment test - Method III.

B. EQUIPMENT

1. Manufacturer's recommended test stand.

2. Cassette with film.

C. PROCEDURE

1. Align the tube unit and image receptor and set SID to the value determined in the actual versus indicated SID test.

2. Insert empty 8 by 10 inch cassette into bucky tray.

3. Position test stand in accordance with manufacturer's instructions.

4. Load a second cassette and place in the designated position.

5. Select the proper technique factors, make an exposure, and develop film.

6. Measure the length and width of the X-ray image on the film.

7. Multiply each measurement by the magnification factor previously determined.

D. VERIFICATION OF COMPLIANCE

Verify that the X-ray field size in the plane of the image receptor does not differ from that of the image receptor by greater than 3 percent of the SID and that the sum of the length and width differences without regard to sign is not greater than 4 percent of the SID.

NEMA Standards 5-15-79

.03 METHOD III - CASSETTE METHOD

A. GENERAL

This procedure can be used only when a capability is provided for overriding positive-beam limitation.

B. EQUIPMENT

1. Large cassette with film.

2. Small cassette, empty.

C. PROCEDURE

1. Insert empty smaller cassette into bucky tray.

2. Switch system to the override mode.

3. Remove the smaller cassette and insert the loaded large cassette.

4. Select the proper technique factors, make an exposure, and develop film.

5. Measure the length and width of the X-ray image on the film.

D. VERIFICATION OF COMPLIANCE

Verify that the X-ray field size in the plane of the image receptor does not differ from that of the image receptor (smaller cassette) by greater than 3 percent of the SID and that the sum of the length and width differences without regard to sign is not greater than 4 percent of the SID.

NEMA Standards 5-15-79

XR 8-2.21 RETURN TO POSITIVE-BEAM LIMITATION (PBL) WITH IMAGE RECEPTOR CHANGE

REQUIREMENT

Return to positive-beam limitation (PBL) shall occur with a change in image receptor size (see 21 CFR 1020.31 (e) (2) (iii)).

A. EQUIPMENT

Medium size cassette.

B. PROCEDURE

1. Select positive-beam limitation mode.

2. Insert the medium size cassette into the bucky tray and record the field size indication.

3. Collimate down to a field size smaller than the cassette.

4. Remove and reinsert the cassette.

C. VERIFICATION OF COMPLIANCE

Verify that the system has returned to positive-beam limitation. Record the field size indication and verify that it is equal to the previously recorded field size.

NEMA Standards 5-15-79

XR 8-2.09 BEAM QUALITY (HALF-VALUE LAYER (HVL))

REQUIREMENT

The minimum beam quality requirements listed in Table 6-1 shall be met (see 21 CFR 1020.30 (m)).

.01 METHOD I - VISUAL DETERMINATION OF HALF-VALUE LAYER (HVL)

A. GENERAL

The above HVL requirement will be considered to have been met if it can be demonstrated that the aluminum equivalent of the total filtration in the primary beam is not less than that shown in Table 6-2.

B. EQUIPMENT

None required

Table 6-1 MINIMUM BEAM QUALITY REQUIREMENTS

Kvp Range	Measured kVp	HVL (mmAl*)
Below 50.....	30	0.3
	40	0.4
	49	0.5
50 to 70.....	50	1.2
	60	1.3
	70	1.5
Above 70.....	71	2.1
	80	2.3
	90	2.5
	100	2.7
	110	3.0
	120	3.2
	130	3.5
	140	3.8
	150	4.1

* Type 1100 aluminum alloy as given in Aluminum Association Publication No. ASD-1, Aluminum Standards and Data

TABLE 6-2 ALUMINUM EQUIVALENT OF PRIMARY BEAM TOTAL FILTRATION

Operating Voltage (kVp)	Total Filtration (mm Al Equivalent)
Below 50.....	0.5
50 - 70	1.5
Above 70	2.5

C. PROCEDURE

Visually inspect the system and determine the aluminum equivalence of the total filtration in the primary beam. This includes the inherent filtration of the X-Ray tube, X-Ray tube housing, beam-limiting device, and any additional filtration that may have been added in the useful beam (in fluoroscopic systems the tabletop system is included as part of the added filtration).

D. VERIFICATION OF COMPLIANCE

The aluminum equivalence of the total filtration must be equal to or greater than the amount specified in Table 6-2.

NEMA Standards 5-15-79

.02 METHOD II - STANDARD ABSORBER METHOD

A. GENERAL

This test is to be used when the surveyor cannot remove or see the total filtration equivalence.

The HVL determinations obtained from the following procedures are to be compared with those illustrated in Table 6-1. The HVL in millimeters of aluminum of the system being tested must be greater than or equal to the values shown in Table 6-1.

B. EQUIPMENT

1. Radiation detector

2. Standard absorber with equivalent filtration of 2.5 millimeters of aluminum.

C. PROCEDURE

1. With the detection device positioned horizontally, an exposure is made at a preselected technique factor of 80 kV and appropriate mA and time. The reading of the radiation output is recorded.

2. Position a total of 2.5 ,millimeters of aluminum at the port of the beam-limiting device and repeat the exposure using the same technique factors. Record the radiation output.

   For X-ray units operating at low kVp (less than 50) and for mammography units, it will be necessary to use an aluminum absorber of 0.6 millimeters at 49 kVp.

D. VERIFICATION OF COMPLIANCE

Verify that the radiation output in Step 2 is greater than or equal to 50 percent of the radiation output in Step 1.

NEMA Standards 5-15-79

.03 METHOD III - FDA/CDRH COMPLIANCE TEST

A. GENERAL

The HVL determinations obtained from the following procedures are to be compared with those illustrated in Table 6-1. The HVL in millimeters of aluminum of the system being tested must be greater than or equal to the values shown in Table 6-1.

B. EQUIPMENT

1. BRH/FDA compliance test stand with accessories (Figure 6.1).

2. Survey meter adapted for use with stand and ion chamber.

3. Several sheets of aluminum, each having a thickness of 0.5 or 1.0 millimeter.

C. PROCEDURE

1. Attach the spacer, positioned out of the primary beam, to the test stand. Center the stand on the table. Center the source over the stand and bring the beam-limiting device down into firm contact with the spacer. Select the MANUAL mode of operation (there must not be a cassette in the cassette tray). Insert the beam-defining assembly in slot 1 of the stand with the leaded side up (see Figure 6.2). Adjust the beam-limiting device so that the X-ray field slightly exceeds the aperture of the beam-defining assembly. Mount the ion chamber at position B with the chamber facing upward. Connect the chamber and meter with the cable provided. Select a tube potential that is commonly used and is in the highest kV range of the X-ray system.

2. With no added filtration in the beam, make an exposure and record the reading. For all diagnostic X-ray equipment, use Table 6-3 to determine increments of filtration required to perform the half-value layer procedure. Make an exposure and record the reading for each total thickness.

TABLE 6-3 HIGHEST DESIGN OPERATING RANGE

TOTAL ADDED FILTRATION (mm Al)		
Below 50 kVp	50-70 kV	Above 70 kVp
0.5	1.0	1.5
1.0	1.5	2.5
1.5	2.5	3.5
2.0	3.5	4.5

The recorded data is plotted on semi-log graph paper (Examples A and B, Fig. 6.6) and the half-value layer is read directly from the graph.

D. VERIFICATION OF COMPLIANCE

Verify that the half-value layer of the useful beam for a given X-Ray tube potential is not less than the values shown in Table 6-1.

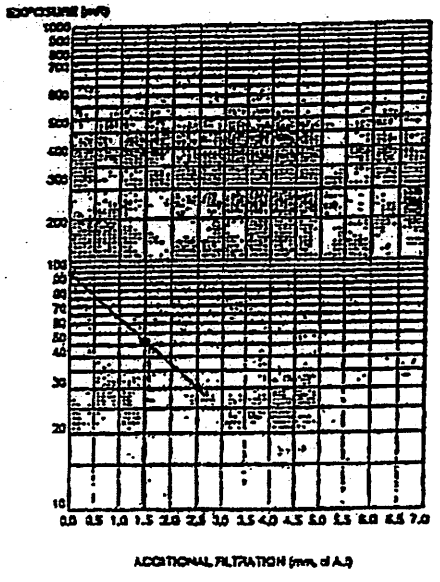
TABLE 6-4 HALF-VALUE LAYERS AS A FUNCTION OF FILTRATION AND TUBE POTENTIAL FOR DIAGNOSTIC UNITS*

Total Filtration mm Al	PEAK POTENTIAL (kV)									
	30	40	50	60	70	80	90	100	110	120
	Typical Half-Value Layers (mm Al)									
0.5	0.36[δ]	0.47[δ]	0.58	0.67	0.76	0.84	0.92	1.00	1.08	1.16
1.0	0.55	0.78	0.95	1.08	1.21	1.33	1.46	1.58	1.70	1.82
1.5	0.78	1.04	1.25[δ]	1.42[δ]	1.59[δ]	1.75	1.90	2.08	2.25	2.42
2.0	0.92	1.22	1.49	1.70	1.90	2.10	2.28	2.48	2.70	2.90
2.5	1.02	1.38	1.69	1.95	2.16	2.37[δ◆]	2.58[δ◆]	2.82[δ◆]	3.06[δ◆]	3.30[δ◆]
3.0	....	1.49	1.87	2.16	2.40	2.62	2.86	3.12	3.38	3.65
3.5	....	1.58	2.00	2.34	2.60	2.86	3.12	3.40	3.68	3.95

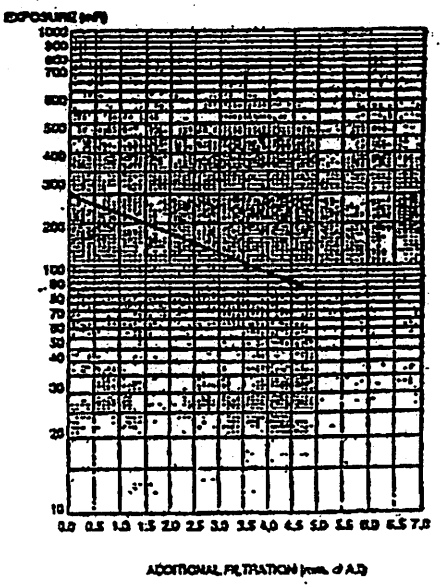
* For full-wave rectified potential

δ Recommended minimum HVL for radiographic units

◆ Recommended minimum HVL for fluoroscopes



EXAMPLE A



EXAMPLE B

Figure 6.6

XR 8-2.24 FLUOROSCOPIC X-RAY FIELD LIMITATION

REQUIREMENT

A. NONIMAGE-INTENSIFIED FLUOROSCOPY

The X-Ray field by non image-intensified fluoroscopic equipment shall not extend beyond the entire visible area of the image receptor. This requirement applies to field size during fluoroscopic procedures.

B. IMAGE-INTENSIFIED FLUOROSCOPY

1. During fluoroscopic procedures, neither the length nor the width of the X-Ray field in the plane of the image receptor shall exceed the visible area of the image receptor by more than 3 percent of the source-to-image distance (SID). The sum of the excess length and the excess width shall be no greater than 4 percent of the SID.

2. Compliance shall be determined with the beam axis perpendicular to the image receptor. For rectangular X-Ray fields used with circular image receptors, the error in alignment shall be determined along the length and width dimensions of the X-Ray field which pass through the center of the visible area of the image receptor. (See 21CFR 1020.32 (b).)

.01 METHOD I - FDA/CDRH TEST STAND METHOD

A. EQUIPMENT

1. FDA/CDRH compliance test stand and accessories.

2. Brass or copper attenuation block.

3. Plastic cassette and direct-print paper or redipack film cassette.

B. PROCEDURE

1. Position all movable grids and compression cones out of the path of the primary beam. If necessary, level the table and retract the spotfilm carriage. If the system utilizes a television monitor, turn it on and allow time for warm up.

2. Place the test stand in the approximate center of the table.

3. Insert the slide assembly, grid side down, into slot 5 (See Fig. 6.2.)

4. Place attenuator block on top of slide assembly.

5. Fully open the beam-limiting device.

6. Center the image receptor over the test stand by observing the image of the grid on the image receptor.

7. Bring the imaging assembly down into firm contact with the top of the stand.

8. If using a dual-field image intensifier, e.g., 6-and 9-inch capability, select the mode of largest image magnification, e.g., 6-inch mode in this case.

9. Adjust the controls to obtain the best quality image.

10. Insert a plastic cassette containing a sheet of direct-print paper or redipack film cassette into the slide assembly and make an exposure.

11. At the image output, count the units from the center of the grid to each edge of the image as shown by lines A, B, C and D of Fig. 6.7.

    Note that line A passes between grid numbers 1 and 4, B passes between numbers 1 and 2, etc. Record the measurements in order.

12. Develop the film and outline the perimeter of the image.

13. Count the units from the center of the grid to each edge as you did with A, B, C, and D above. Record these as A', B', C' and D'.

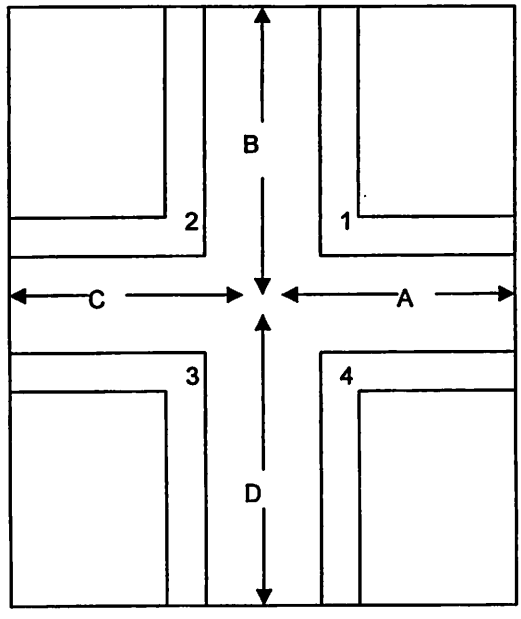


Figure 6.7
FLUOROSCOPIC X-RAY FIELD LIMITATION TEST STAND METHOD

C. VERIFICATION OF COMPLIANCE

For compliance of non image-intensified systems, A shall be less than or equal to A', B shall be less than or equal to B', C shall be less than or equal to C', and D shall be less than or equal to D'.

For image-intensified systems, determine the source-to-slot-5 distance by adding 18.5 centimeters (7.3 in) to the minimum source-to-skin distance (SSD) determined by the SSD test procedure using the FDA/CDRH test stand. Calculate and record 3 percent and 4 percent of this distance. Determine the difference, without regard to sign of A and A', B and B', C and C', and D and D'. Sum the differences. They must be less than or equal to 4 percent of the source-to-slot-5 distance. In addition, the sum of A and A' plus C and C' differences and the sum of the B and B' plus the D and D' differences must each be less than or equal to 3 percent of the source-to-slot-5 distance.

.02 METHOD II - DIRECT METHOD

A. EQUIPMENT

1. Lead foil phantom or copper attenuator.

2. Direct-print paper.

3. One by one-inch steel marker.

4. Four additional metal markers (each marker is approximately 1/32-inch galvanized sheet metal having the dimensions of 1.5 by 0.5 inches).

B. PROCEDURE - NON IMAGE-INTENSIFIED FLUOROSCOPE

1. Place the image receptor as close as possible to the tabletop.

2. Open the shutters to the maximum and activate the fluoroscopic tube.

3. Slowly increase the distance between the tabletop and the image receptor. The unit is in compliance if, at the greatest extension of the image receptor, there is an unilluminated border all round the visible area of the image receptor. No further tests need to be made.

4. If the illuminated area expands to the edges of the visible area of the image receptor, lower the image receptor until there is a small unilluminated border.

5. Close the shutters to produce approximately a 2-inch wide unilluminated border. Resume increasing image-receptor-to-tabletop distance. The unit is not in compliance if the illuminated area continues to expand.

6. If the illuminated area does not expand, then at the maximum SID, slowly open the shutters to the maximum. The unit is in compliance if the illuminated area does not expand.

C. PROCEDURE - IMAGE INTENSIFIED FLUOROSCOPE
(Over-the-table Tube, Variable Collimator)

This procedure can be used only if the distance from the input phosphor to the tabletop does not change with SID and if the SID is variable.

1. Raise the tube housing to its greatest SID and, if the beam-limiting device is not automatic, close the shutters to their fullest extent.

2. Activate the tube and slowly increase the field size while observing the monitor. If at the maximum field size it is obvious that the image of the beam-limiting device is apparent at the edge of the image receptor, no further test need be made. (See Fig. 6.8.)

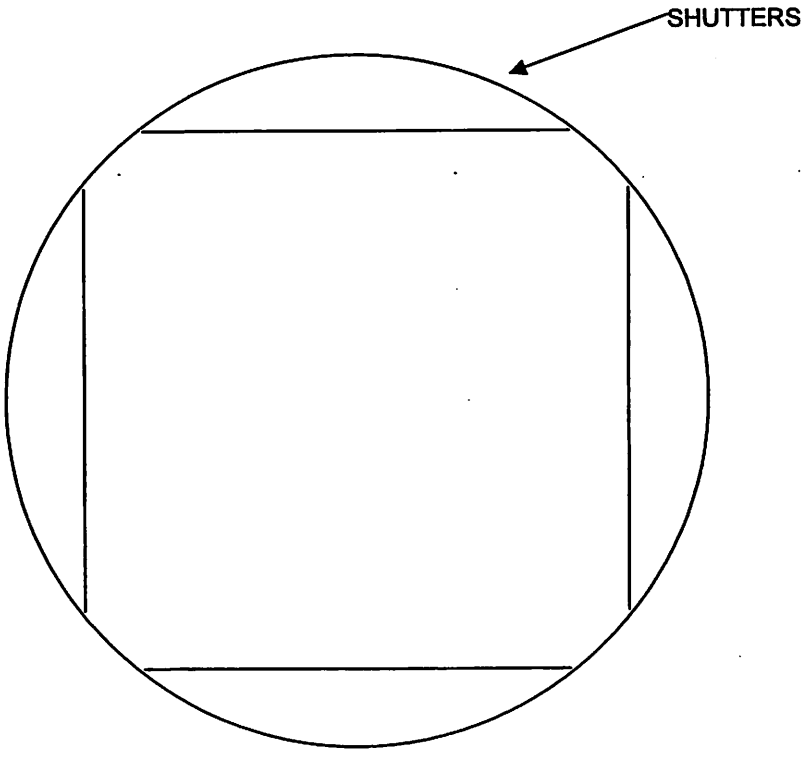


Figure 6.8

3. If there is no unilluminated area at any of the edges of the image receptor, lower the tube head until the bottom of the beam-limiting device is at its minimal distance from the tabletop (or 12 inches, whichever is greater). Record this distance.

4. Place a lead foil phantom or copper attenuator on the tabletop and center a loaded cassette in the light-field (Fig. 6.9)

5. Adjust the light-field to give a 5-by 7 inch field on the cassette and mark the edges with metal markers.

6. Attach a 1-by 1-inch steel marker to the center of the bottom of the beam-limiting device. (Exact centering is not necessary.)

7. Make an appropriate exposure.

8. Develop the direct-print paper or film and check light and X-ray beam alignment.

9. Measure length of marker image.

10. By similar triangles, determine the source-to-tabletop distance.

11. This procedure can continue only if the unit is aligned to radiographic requirements (plus or minus 2 percent SID). Raise the tube head to maximum SID.

12. Mark the edges of the visible area by placing two radiopaque markers within the light-field and parallel to each other and to the edges of the light-field.

13. While viewing the markers through the image intensifier, activate the tube on and off, adjusting the parallel markers between exposures until the outer edges of the markers are no longer visible (Fig. 6.10)

14. Again, turn on the light-field and measure the distance from the edges of the light-field to the parallel markers.

15. To determine the maximum source-to-tabletop distance, subtract the beam-limiting-device-to-tabletop distance previously determined from the source-to-tabletop distance as previously calculated and add this result to the measured distance from the bottom of the beam-limiting device to the tabletop. Calculate the percent of the SID of the X-ray field that is in excess of the visible area.

16. Place the markers at right angles to the original position and repeat the last three steps.

NEMA Standard 5-15-1979

D. PROCEDURE - IMAGE INTENSIFIED FLUOROSCOPE (Under-the-table Tube, Variable Collimator)

NOTE: This procedure is not included since it does not apply to the Linear IV Collimator System.

E. VERIFICATION OF COMPLIANCE

For non image-intensified fluoroscopy, verify that the X-Ray field does not extend beyond the visible area of the image receptor.

For image-intensified fluoroscopy, verify that neither the length or width misalignment exceeds the visible area of the image receptor by more than 3 percent of the SID. The sum of the excess length and the excess width shall be no greater than 4 percent of the SID.

NEMA Standard 5-15-1979

OVER-THE-TABLE TUBE

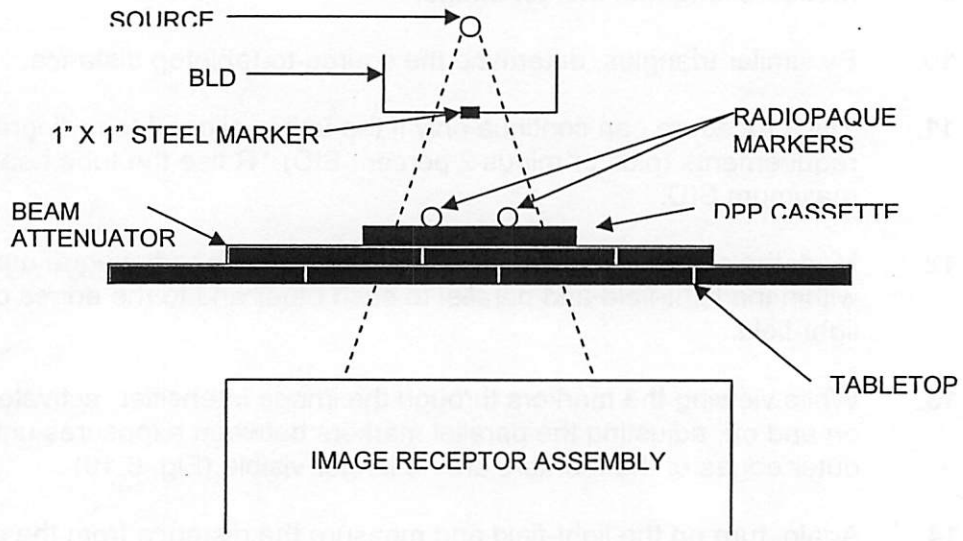


Figure 6.9

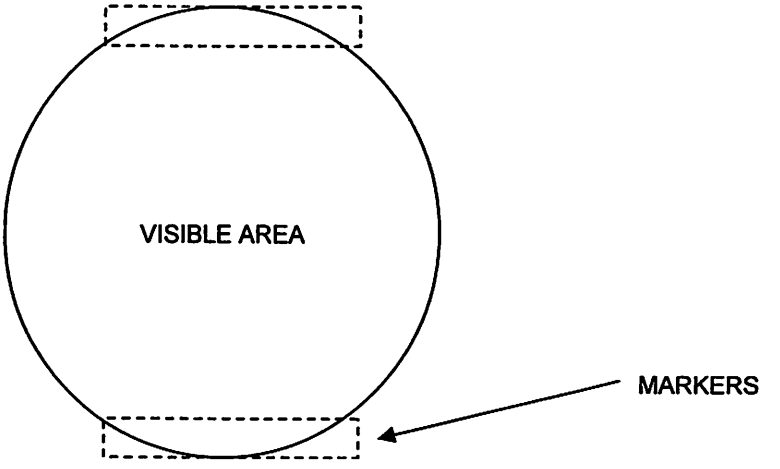


Figure 6.10

XR 8-2.25 FLUOROSCOPIC SOURCE-TO-SKIN DISTANCE (SSD)

REQUIREMENT - The source-to-skin distance (SSD) shall be not less than 38 centimeters (15 in) on stationary fluoroscopes. (See 21 CFR 1020.32 (f).)

A. GENERAL

If the SSD can be measured directly, no further testing is necessary.

B. EQUIPMENT

1. FDA/CDRH compliance test stand with accessories (Fig. 6.1).
2. Plastic cassette and direct-print paper or redipack film cassette.
3. Brass or copper attenuation block.

C. PROCEDURE

1. Position all movable grids and compression cones out of the primary beam. If necessary, return the table to the horizontal position and raise the spotfilm carriage. If the system utilizes a television monitor, turn it on and allow time for warm up.
2. Place the test stand in the approximate center of the table.
3. Insert the slide assembly, grid side down, at slot 3 (See Fig. 6.2.).
4. Place attenuation block on the top of slide assembly.

5. Fully open the beam-limiting device.

6. Center the image receptor over the test stand by observing the image of the grid on the image receptor.

7. Bring the image assembly down into firm contact with the spacer bar on the top of the stand.

8. Slide the focal spot assembly, brass side up, into slot 7.

9. Insert the plastic cassette or the redipack film cassette into the slide assembly.

10. Make an exposure assuring proper density on the film or paper.

11. Remove the cassette and develop the direct-print paper or film.

12. Measure the minimum separation of the outside edges of the focal spot strips (see Fig. 6.13).

D. CALCULATIONS

Calculate the minimum SSD.

Minimum SSD (in inches)=

$$\frac{28.25\ \text{in}^2}{(\text{Image size in inches} - 2.5)} - 0.4\ \text{in}$$

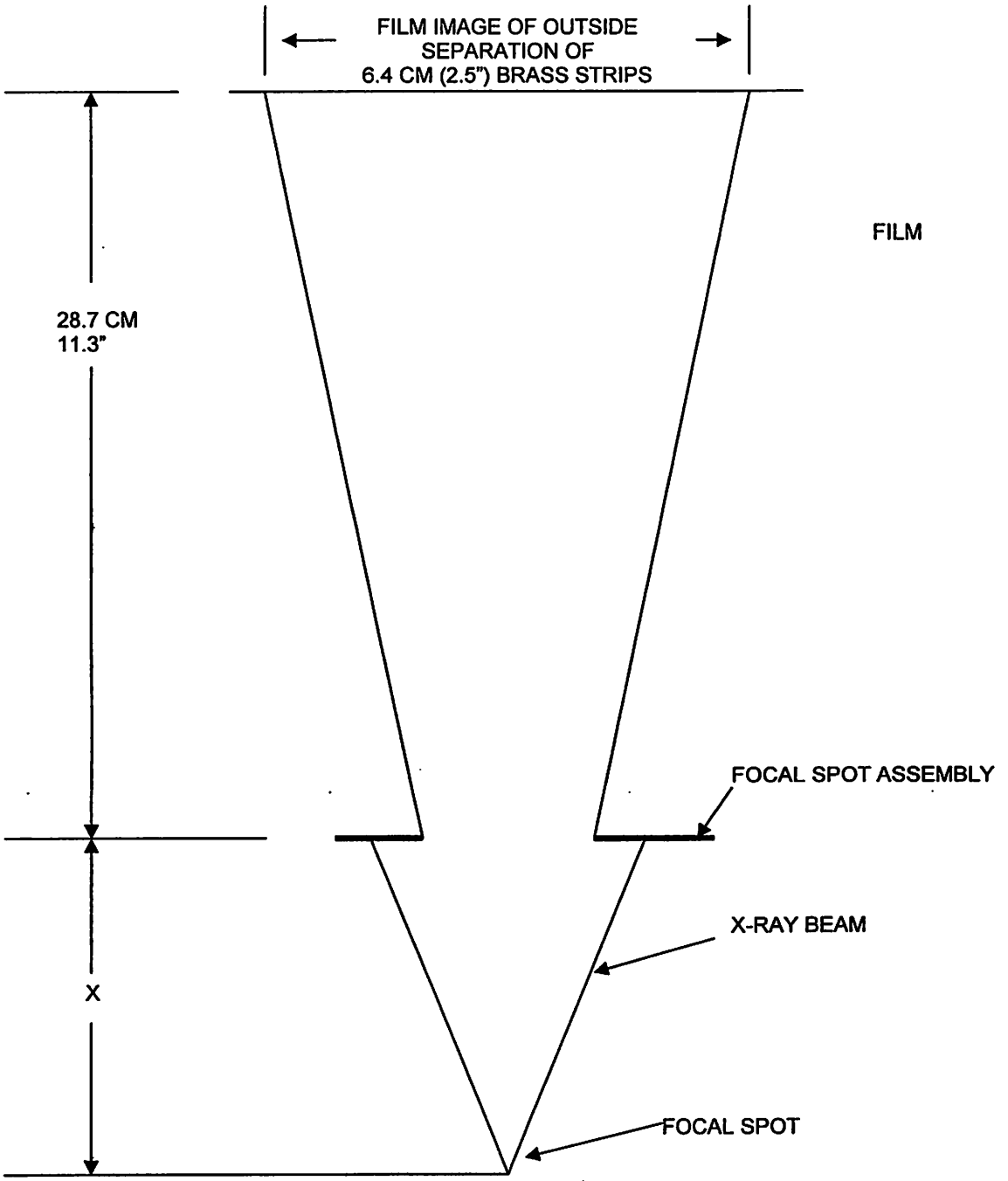
Minimum SSD (in centimeters) =

$$\frac{182.3\ \text{cm}^2}{(\text{Image size in cm} - 6.4)} - 1.0\ \text{cm}$$

E. VERIFICATION OF COMPLIANCE

Verify that the SSD is not less than 38 centimeters (15 in).

NEMA Standard 5-15-1979



EQUATION:

$$X = \frac{182.3\ cm^2}{(\text{IMAGE SIZE IN CENTIMETERS} - 6.4\ cm)}$$

EQUATION:

$$X = \frac{28.25"}{(\text{IMAGE SIZE IN INCHES} - 2.5")}$$

MINIMUM SSD IN (CENTIMETERS) = X – 1.0 cm
MINIMUM SSD (IN INCHES) = X – 0.4"

Figure 6.11 SPOT FILM GEOMETRY

XR 8-2.27 PRIMARY BARRIER - X-RAY LOCKOUT

REQUIREMENT - For equipment manufactured after February 25, 1978, when the angle between the image receptor and the beam axis is variable, means shall be provided to indicate when the axis of the X-ray beam is perpendicular to the plane of the image receptor.

The fluoroscopic tube shall not produce X-rays unless the barrier is in position to intercept the entire useful beam. (See 21 CFR 1020, 32 (a) and 1020.32 (b) (2) (iii).)

A. VERIFICATION OF COMPLIANCE

Move the primary barrier off the detents position and verify that X-rays cannot be produced by the fluoroscopic X-ray tube. Verify that, if the beam angulation is variable, a means is provided to indicate that the beam axis is perpendicular to the plane of the image receptor.

NEMA Standards 5-15-1979

SPOTFILM RADIOGRAPHIC TESTS

XR 8-2.29 ALIGNMENT OF X-RAY FIELD EDGES TO SELECTED PORTIONS OF THE IMAGE RECEPTOR

REQUIREMENT - The misalignment of the X-ray field with that portion of the image receptor selected on the spotfilm device, along either the length or the width dimension, shall not exceed 3 percent of the source-to-image-receptor distance (SID), and the total misalignment without regard to sign along both dimensions shall not exceed 4 percent of the SID. (See 21 CFR 1020.31 (g).)

A. GENERAL

Technique factors must be selected for a film density of approximately 1.0.

B. EQUIPMENT

1. Manufacturer's recommended test stand.
2. Graduated template.
3. Two cassettes.
4. Film.

C. PROCEDURE

1. Verify by the means provided that the axis of the X-ray beam is perpendicular to the plane of the image receptor (applicable only where variable beam angulation is provided.)

2. Load the cassette with film and place in the spotfilm device.

3. Position test stand in accordance with manufacturer's instructions.

4. Load a second cassette with film and place in the designated position on the test stand. *This film must be large enough to accept a one-on-one format.*

5. Place graduated template in a position between the X-ray source and the two cassettes.

6. Select proper techniques factors and a one-on-one spotfilm format.

7. Make an exposure and develop films.

8. Repeat steps 1 through 7 for each available spotfilm format.

D. CALCULATIONS

1. Calculate the magnification factor by measuring the distance between the same two points on the graduated template image on each of the two films. The two points chosen must be as far apart as possible. Divide the smaller measurement into the larger measurement to determine the magnification factor.

2. If the source-to-test stand film distance is known, calculate the actual SID by multiplying the magnification factor by the known source-to-test film distance.

3. If the source-to-test stand film distance is not known, measure the actual distance from the graduated template position to the test stand film plane (distance Z, see Fig. 6.14).

4. Calculate the source-to-template distance (distance X) using the following formula:

$$\frac{A}{B} = \frac{X}{X+Z} \quad \text{or } X = \frac{AZ}{B-A}$$

where:

A = two points on a graduated template.
B = magnification of the same two points on the graduated template used in A.

5. Calculate the source-to-test stand film distance by adding distance X and distance Z. Multiply the source-to-test stand film distance by the magnification factor determined in step 1 to determine the actual SID.

6. On the test stand film measure and record distances a, b, c, and d from the center of the graduated template to each respective edge of the radiographic image (see Fig. 6.15).

7. Multiply each distance a through d by the magnification factor and record the products as a', b', c', and d'. Note the a', b', c', and d' are the respective distances they would have been if they had been recorded at the spotfilm plane.

8. On the spotfilm image measure distances A, B, C, and D from the center of the graduated template image to each respective edge of the selected portion of the spotfilm (see Fig. 6.16). Record distances A, B, C, and D as measured.

9. Calculate the length differences and width differences without regard to sign as follows:

   Length difference = B -b' + D - d'

   Width difference = A-a' + C - c'

   Record the sum of the length and width differences.

E. VERIFICATION OF COMPLIANCE

1. Calculate 3 and 4 percent of the actual SID and record.

   The individual length and width misalignment, regardless of sign, must be less than or equal to 3 percent of the SID as calculated in step 1. The summation of the length and width misalignments, regardless of sign, must be less than or equal to 4 percent of the SID as calculated in step 1.

NEMA Standard 5-15-1979

XR 8-2.30 ALIGNMENT OF CENTER OF X-RAY FIELD TO CENTER OF SELECTED PORTION OF IMAGE RECEPTOR

REQUIREMENT - The center of the X-ray field in the plane of the film shall be aligned with the center of the selected portion of the film to within 2 percent of the source-to-image distance (SID). (See 21 CFR 1020.31 (g) (4).)

A. GENERAL

1. All exposures taken during this test should have a uniform film density of approximately 1.0.

2. The actual SID must be determined prior to performing this test.

B. EQUIPMENT

Radiographic cassette and film.

C. PROCEDURE

1. Load cassette with film and place in the spotfilm device.

2. Select a one-on-one spotfilm format.

3. Assure that the SID is set to the value previously determined in the actual SID determination test.

4. Reduce the X-ray field size to a size slightly smaller than the size of the film area to be exposed.

5. Make an exposure and develop film.

6. Repeat steps 1 through 5 for each available spotfilm format.

7. To determine the centers of the X-ray films draw diagonals across the film (the point where these two lines cross is the center of the film).

8. To determine the corners of the image recorded on the film , locate two points on each side of the four sides of the image. Through the two points on each side draw a straight line. These four lines when extended intersect making a rectangle which is a close approximation of the actual X-ray field. Draw diagonals across the rectangular figure determined. The point at which the two diagonals cross is assumed to be the center of the X-ray field.

9. The distance from the film center mark is measured and recorded as the linear displacement or misalignment of the centers of the image receptor and the X-ray field.

D. VERIFICATION OF COMPLIANCE

Verify that this distance is less than or equal to 2 percent of the SID.

NEMA Standard 5-15-1979

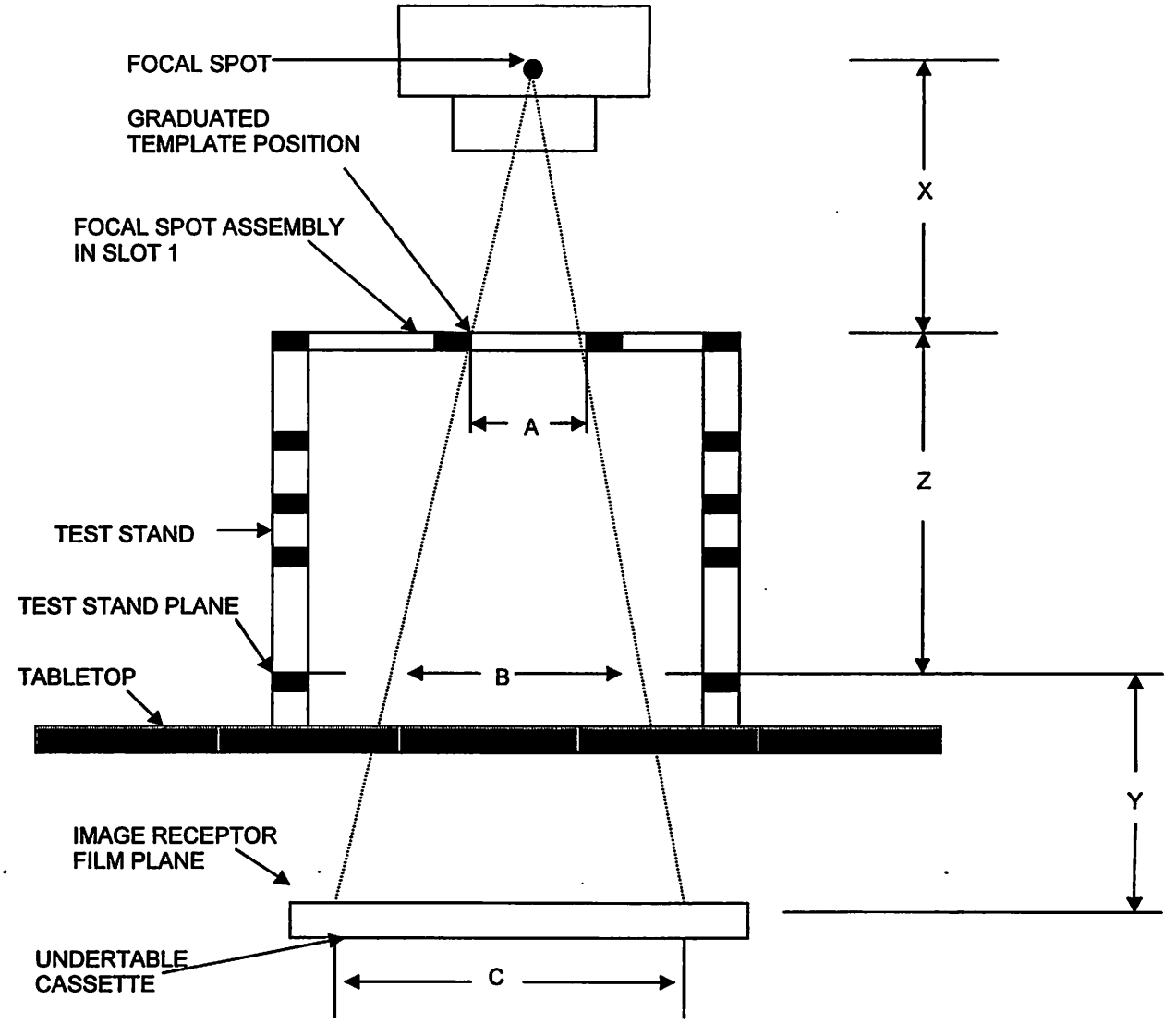


Figure 6.12
DETERMINATION OF SID

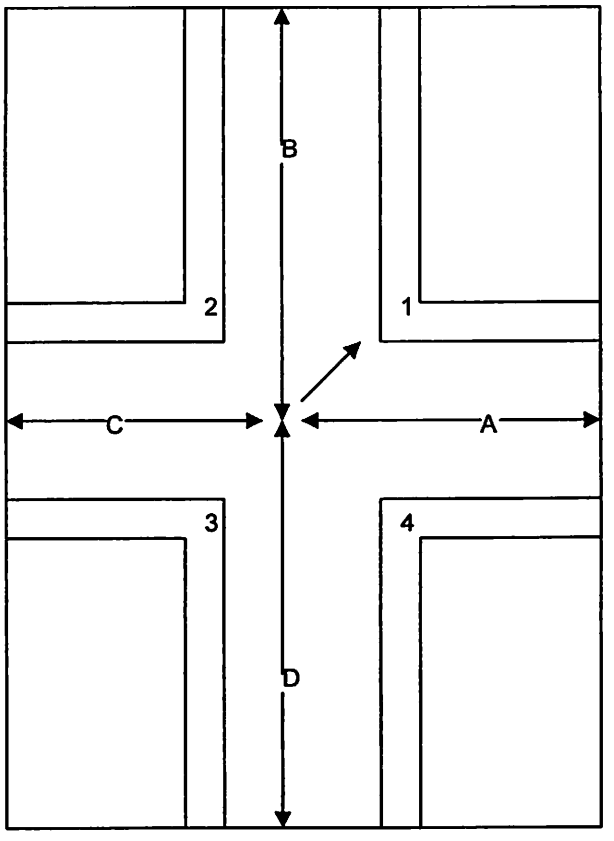


Figure 6.13

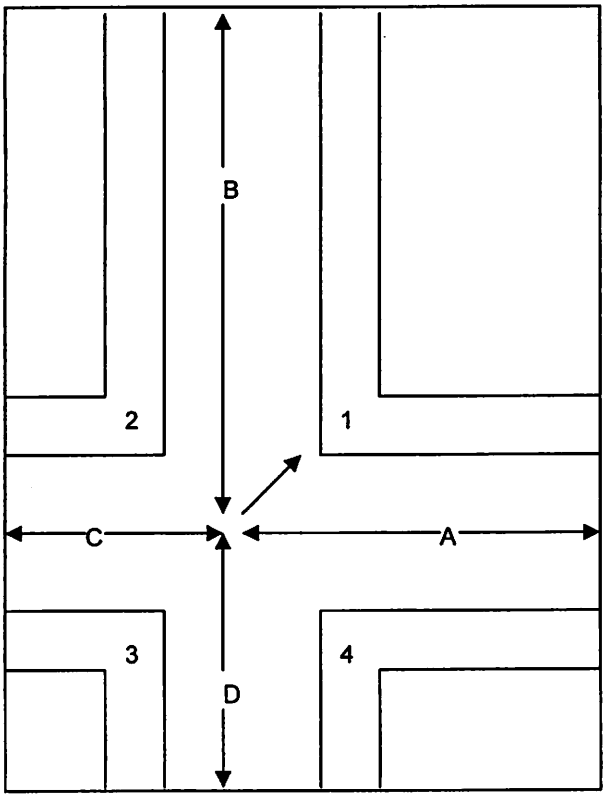


Figure 6.14

NO TEXT

RECORD SHEET

This sheet is to be used by the assembler to assure that all points of compliance are covered. It will also serve as a maintenance log.

HOSPITAL _____ ROOM # _____

DATE OF INSTALLATION _____ ASSEMBLER _____

Requirement	Applicable Paragraph	Installation Date	Date	Date	Date	Date
1. Visual definition of X-Ray light field	XR8/2.14					
2. Intensity of light-field	XR8/2.15					
3. Min. field size	XR8/2.16					
4. X-Ray field/receptor center alignment	XR8/2.17					
5. Indication of field size	XR8/2.18					
6. Positive beam limitation	XR8/2.19					
7. X-Ray field limitation & alignment	XR8/2.20					
8. Return to PBL	XR8/2.21					
9. Half value layer	XR8/2.09					
10. Fluoroscopic X-Ray field limitation	XR8/2.24					
11. Fluoroscopic Source to Skin Distance (SSD)	XR8/2.25					
12. Primary barrier - X-Ray lockout	XR8/2.27					

Requirement	Applicable Paragraph	Installation Date	Date	Date	Date	Date
13. Alignment of X-Ray edges to selected portions of the image receptor.	XR8/2.29					
14. Alignment of center of X-Ray field to center of selected portion of image receptor	XR8/2.30					
15. Remote control inspection/cleaning						
16. Collimator mounting inspection	Section 2 2.3					
17. Cassette tray inspection/cleaning						
18. Electrical cable inspection						
19. SID Monitor Inspection	Sections 7.2 & 7.3					
INITIALS:						
NOTES						

NO TEXT

SECTION 7

CONTINUOUS SID ADJUSTMENT

7.0 CONTINUOUS SID ALIGNMENT PROCEDURE

7.1 GENERAL

The purpose of the continuous SID monitor is to provide an output voltage (VSID) proportional to the SID. The Eureka SID monitor provides a nominal 14.4 OHMS per inch resistance change. If the SID monitor is attached to follow the X-ray tube SID excursion directly, this would then be a 1:1 ratio system. Most integrated tubestand/flat bucky table systems are 1:1 ratio systems. However, if the monitor is attached to an overtable tube carriage, it will probably be attached to a telescopic member that moves at a ratio of 2:1, 3:1, or 4:1 with respect to the X-ray tube movement. Hence, most ceiling suspended tube carrier systems are either 3:1 or 4:1 ratio systems.

The SID interface to the Linear IV has been greatly simplified to accommodate a range of different SID monitors and/or different SID ratios. The Linear IV during calibration will "learn" the rate of tube excursion for the SID monitor attached, thus making it unnecessary to set switches to indicate ratios and making it easier to modify SID circuits to accommodate ratios which are slightly different than their whole number values.

The SID circuit provides a source current of 5mA to the SID monitor. The Eureka SID monitor is a 1 kOhm pot that will thus produce a maximum of 5V, and a minimum of 0V. Any SID monitor can be used as long as the voltage range is linear with respect to SID and does not exceed 5V.

7.2 SID MONITOR INSTALLATION GUIDELINES

CAUTION: To prevent damage to the mechanism which would require replacement of the SID monitor, observe the following guidelines:

Install the SID monitor so that the measuring cable, cable clamp, and SID monitor mechanism will remain unobstructed in all conditions of use.

If the Overhead Table System (OTS) allows the SID to be varied by more than 66 inches (170 cm), positive mechanical stops must be used to limit the range to prevent SID cable breakage and/or mechanical damage.

Do not arbitrarily pull the measuring cable during handling and installation or allow the measuring cable to recoil unrestricted into the monitor.

Do not clamp, kink or knot the measuring cable, which would distort the cable within its working range.

Route the SID monitor interconnection cable directly to the Linear IV power supply unit. Verify that the cable is free of kinks or knots and that it will not come in contact with any other moving parts of the system. Provide adequate strain relief where required.

OPTION - For adjustable height table systems using the differential SID option, follow the above guidelines for the second SID monitor installed in the adjustable height table.

7.3 SID MONITOR POTENTIOMETER ADJUSTMENT

With power to the Linear IV collimator system off, disconnect the red and black wires of the SID monitor interconnection cable from terminal strip locations TS4-2 and TS4-3 in the Linear IV power supply enclosure.

Place a digital ohm meter to the red and black wire. Vary the SID of the OTS and observe that as SID **decreases**, the SID potentiometer resistance **increases**. If a decrease in SID does not produce an increase in resistance, then remove the Buss wire on the SID potentiometer from the red wire and connect it to the black wire.

Set the SID of the OTS to 72 inches (180 cm) or its design operating range (whichever is less). Adjust the SID monitor cable so that the SID monitor resistance will be approximately 40 ohms when properly attached to the cable. Typical good signal to noise ratio setting at 40" (100 cm) SID would be 450 ohms or 2.5 VDC.

NOTE: It is <u>not</u> critical that the specified resistance above be set exactly, as the Linear IV will "learn" the setting and compensate for it. <u>It is critical</u> that the SID monitor move freely within its operating range and provide a voltage linearly proportional to SID.

NOTE: If the specified resistance is not obtainable, it may be necessary to relocate the cable clamp, attach additional cable, or readjust the SID potentiometer by loosening the set screw attaching the flexible coupling and pot shaft, then re-tightening the set screw when finished adjusting.

Reconnect the SID monitor interconnection cable as shown in Figure 2-8. Make sure all cable clamps are properly tightened.

7.4 (OPTION) DIFFERENTIAL (TABLE) SID MONITOR POTENTIOMETER VERIFICATION

NOTE: This section should only be used if the X-ray system under installation employs an adjustable height table top and a second SID monitor is installed in the table for differential SID sensing.

With the power to the Linear IV collimator system off, disconnect the red and black wires of the SID monitor interconnection cable from terminal strip locations TS4-4 and TS4-5 in the Linear IV power supply enclosure.

Place a digital ohm meter to the red and black wire. Vary the SID of the Table and observe that as SID **increases**, the SID potentiometer **increases**. If an increase in SID does not produce an increase in resistance for the table SID monitor **only**, then remove the Buss wire on the SID potentiometer from the black wire and connect it to the red wire.

Set the table to its full up position. Adjust the adjustable table SID monitor cable so that the SID monitor resistance will be approximately 10 to 20 ohms when properly attached to the cable. A typical on a 1:1 ratio is 0.5 VDC when table is in full up position.

NOTE: It is <u>not</u> critical that the specified resistance above be set exactly, as the Linear IV will "learn" the setting and compensate for it. <u>It is critical</u> that the SID monitor move freely within its operating range and provide a voltage linearly proportional to SID.

NOTE: If the specified resistance is not obtainable, it may be necessary to relocate the cable clamp, attach additional cable, or readjust the SID potentiometer by loosening the set screw attaching the flexible coupling and pot shaft, then re-tightening the set screw when finished adjusting.

Reconnect the SID monitor interconnection cable as shown in figure 2.9. Make sure all cable clamps are properly tightened.

7.5 SID CIRCUIT VERIFICATION

The SID circuit of the Linear IV will provide continuous SID indication from 36" to 72" (92 cm to 180 cm) with the correct (compatible) SID monitor installed. Optionally the Linear IV can provide differential SID (adjustable height tables) within the same range of operation with the second (table) SID monitor installed.

The SID circuit on the master board (70-08320) provides two fixed constant current sources for each SID (tube and table) monitor installed. The current from these sources is nominally 5mA, thus any SID monitor that provides a linear voltage within its operating range and does not exceed 1kohm at its output within its operating range is deemed compatible with the circuit.

The constant current sources can be verified using the following procedure.

1. With power applied to the Linear IV power supply, connect a digital DC ammeter to TP1 (mA1+) and TP2 (ma1-) test points on the Linear IV master board (70-08320).

2. Remove jumper W1 and verify a reading of 5mA $\pm$ 0.25mA.

3. Reconnect jumper W1.

4. Connect the digital ammeter to TP3 (mA2+) and TP4 (mA2-) test points on the Linear IV master board (70-08320).

5. Remove jumper W2 and verify a reading of 5mA $\pm$ 0.25 mA.

6. Reconnect jumper W2.

NOTE: No other adjustments are necessary as the SID monitors rate and offset are determined by software during the auto-calibration process. There are no potentiometers to adjust.

NO TEXT

SECTION 8

OPERATING INSTRUCTIONS

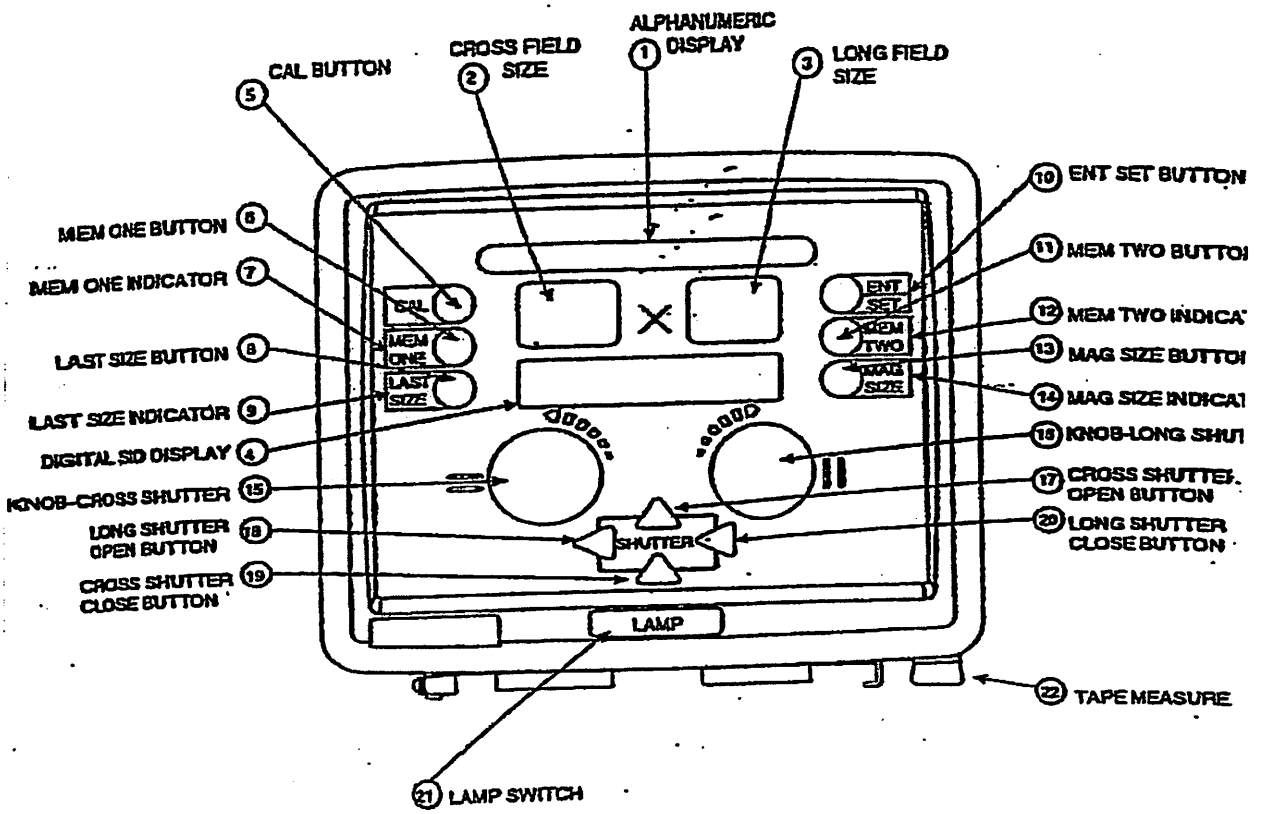


FIGURE 8.1
LINEAR IV FRONT PANEL

8.0 OPERATING INSTRUCTIONS

8.1 GENERAL INSTRUCTIONS

Operation of the Linear IV collimator is accomplished through the front panel of the collimator. The front panel contains an alphanumeric display which provides collimator system status and error messages. Membrane switch buttons are used to control the field size, enter the calibration mode, store memorized field sizes, recall stored field sizes, and toggle between image intensifier sizes in fluoroscopic operation. The front panel also has knobs for manual control of field size as well as a button to illuminate the field lamp. A digital LED display indicates current SID and field size. The next sections provide details of the front panel, its messages and typical operating sequences.

8.2 FRONT PANEL DESCRIPTION

1. Alpha-numeric display for collimator mode information and instructions. Used in run-time operation, calibration and other diagnostic modes.

2. Cross field size display indicates the current cross-table field size in inches or centimeters at the currently selected image receptor.

3. Long field size display indicates the current long-table field size in inches or centimeters at the currently selected image receptor.

4. SID display indicates current SID in inches or centimeters.

5. CAL button – used to initiate a calibration, and/or select the current service mode.

6. MEM ONE button – Used to store the current size into memory, or to change the field size to the currently stored size in MEM ONE.

   To store the current size, press and hold the MEM ONE button until theindicator (7) turns off, then release the button and size will be stored.

   To move the stored size, press and release the MEM ONE button until the indicator (7) will light and the shutters will move to the stored present size.

7. MEM ONE indicator – Illuminates if MEM ONE has been selected.

8. LAST SIZE button – Moves the shutters to the previous shutter size prior to the current PBL cycle. No movement will occur during the current PBL cycle if the shutters are moved manually as this becomes the new LAST SIZE for the next PBL cycle.

9. LAST SIZE indicator – Illuminates if LAST SIZE was chosen.

10. ENT/SET button – Used in service mode to acknowledge questions and instructions.

    Changes the SID display (4) and field size displays (2) and (3) during normal run-time operation to indicate (for approximately 8 seconds) the vertical SID to the table top and a table top field size estimate based on calibration information.

11. MEM TWO button – Used to store the current size memory, or to change the field size to the currently stored size in MEM TWO.

    To store the current size, press and hold the MEM TWO button until the indicator (12) turns off, then release the button and size will be stored.

    To move the stored size, press and release the MEM TWO button until the indicator (12) will light and the shutters will move to the stored preset size.

12. MEM TWO indicator – Illuminates if MEM TWO has been selected.

13. MAG SIZE button – Toggles through three preset II size selections in fluoroscopic operation.

14. MAG SIZE indicator – Illuminates if any one of the preset II size have been selected.

15. Cross shutter manual control knob.

16. Long shutter manual control knob.

17. Cross Open button – Power assisted drive for the cross-table shutter to increase in size.

18. Long Open button – Power assisted drive for the long-table shutter to increase in size.

19. Cross Close button – Power assisted drive for the cross-table shutter to decrease in size.

20. Long Close button – Power assisted drive for the long-table shutter to decrease in size.

21. Lamp switch button – Illuminates the internal projection lamp to activate the timed light field. If pressed again, it will turn off the internal lamp and thus act as a quick turn-off if the full time cycle is not required.

22. SID Tape Measure – Correct measurement made to the end of the ring.

8.3 LIST OF MESSAGES

General Messages

1. LINEAR IV SYSTEM	Start up message.
2. REVISION (number)	Displays current software revision indicated by number.

Run-time Messages

3. READY-RAD	Collimator is ready in radiographic mode
4. (X) READY FLUOR NORM	Collimator is ready in fluoroscopic mode with NORMal II size selected. X indicates F for Full Film mode, P for Preset mode.
5. (X) READY-FLUOR MAG1	Collimator is ready in fluoroscopic mode with MAG 1 II size selected. X indicates F for Full Film mode, P for Preset mode.
6. (X) READY-FLUOR MAG2	Collimator is ready in fluoroscopic mode with MAG 2 II size selected. X indicates F for Full Film mode, P for Preset mode.
7. (X) RDY-SPOTFILM	Collimator is ready in Spotfilm/fluoroscopic mode. X indicates F for Full Film mode, P for Preset mode.
8. MANUAL-TILT	Collimator is in manual mode due to tile (table or collimator) which is 10 degrees or more from vertical or horizontal and no cassette is present in bucky.
9. MAN-WRONG WALL	Collimator is in manual when tilted horizontal opposite to the selected wall with the film bucky.
10. MAN-NO CASS	Collimator is in manual operation in radiographic mode when no cassette is present in the appropriate bucky.
11. MAN-SID NOT SET	Collimator is in manual operation because discrete SID operation is expected, but no discrete SID switches have been set, with no cassette present.
12. STEREO/TOMO	Collimator is in manual operation because a STEREO/TOMO request has been sensed.

13. PBL OVER-RIDE	Collimator is in manual operation because the PBL OVER-RIDE switch has been set.
14. EXP HLD-NOT VERT	Collimator is preventing exposure in fluoroscopic mode if the tile is not vertical.

NOTE: TILT SWITCH INPUTS CAN BE PARALLELED BY A SIGNAL INDICATING THAT THE IMAGE RECEPTOR AND X-RAY SOURCE ARE ALIGNED AND THUS "READY" OPERATION CAN CONTINUE AT ANY ANGLE OF TILT AS LONG AS THE ABOVE CONDITION EXISTS.

15. EXP HLD-LOCK SID	Collimator is preventing exposure because the discrete vertical SID switch has not been set or a cassette is present without an appropriate SID signal.
16. EXP HLD-SID LIM	Collimator is preventing exposure because of the current detected SID is beyond the limits of 36" or 72" (92 cm or 180 cm) with a cassette present.
17. EXPOSURE HOLD	Collimator is preventing exposure in radiographic mode because the shutters are moving to their requested size.
18. TBL TOP ESTIMATE	Indicates that the user has requested a table-top SID and field size estimate to the table-top display.
19. SYSTEM FAILURE	Indicates the system override (same as PBL-OVERRIDE) key has been set during fluoro operation.

Service Mode Messages

Various service mode messages exist. They are explained in Sections 4 and 5 in the manual.

8.4 RADIOGRAPHIC (AUTOMATIC) OPERATION

1. Place X-ray generator in radiographic mode.
2. Insert cassette into tray and close tray.
3. Collimator will switch from MANUAL to EXPOSURE HOLD while the shutters are moving, then to READY-RAD when the shutters are correctly positioned.
4. Press "LAMP" button to activate light field and bucky centering light line.

5. Properly center the bucky/cassette in the light field. This can be done by either moving the bucky/cassette or the tube/collimator if possible. The bucky centering light line should be lined up with the center of the tray handle to ensure centering of the film cassette.

6. An exposure may now be taken. You may reduce the X-ray field size if desired by either using the manual shutter control knobs or the long and cross open and close buttons on the front panel. Please note that automatic PBL operation will not allow the field size to be larger than the cassette size in the tray.

7. Any time a new cassette is put in the tray, the shutters will automatically size to that cassette. Pressing the LAST SIZE button will move the shutters to the size held prior to the new cassette being loaded.

8. The MEM ONE and MEM TWO buttons can be used to store the current field size. Press and hold the MEM button (#6 or #11 in Figure 8.1) until the indicator light (#7 or #12) turns off, then release the button and the size will be stored. To later move to the stored size, press and release the MEM button and the shutters will move to the stored size.

9. Please note the collimator will not move the shutters to a size larger than the current cassette. For example, if a 10 x 10 is stored in MEM ONE while a 17 x 17 cassette is in place and later an 8 x 8 cassette is inserted, pressing MEM ONE will have no effect. If one dimension is smaller than the new cassette size, the shutters will move to that size. In the previous example, if 10 x 7 is stored in MEM ONE, once an 8 x 8 cassette is inserted, pressing MEM ONE will move the shutters to 8 x 7. However, 10 x 7 is still maintained as MEM ONE if a larger cassette is later inserted.

10. The collimator is designed to operate at a fixed vertical SID (typically 40 inches or 100 cm) unless it is a continuous or differential SID system. If the collimator is not at the fixed vertical SID, the display will read either:

    a. EXP HLD-LOCK SID if there is a cassette present but an improper SID for automatic PBL operation, or

    b. MAN-SID NOT SET if there is no cassette present indicating manual table top exposure is allowed but the SID is unknown.

11. If part of the automatic PBL (positive beam limiting) system is not functioning or a special procedure is required, the PBL system can be disabled by turning the PBL override switch located at the collimator power supply. The collimator will allow any shutter size to be selected, even if it is larger than the cassette size. The collimator functions all remain the same except that the MEM ONE, MEM TWO, and LAST SIZE buttons are disabled. When the collimator is returned to normal automatic operation, the shutter size will remain unchanged unless the current size is larger than the cassette. In this case, the shutters will size to the cassette.

8.5 RADIOGRAPHIC (TABLE TOP/MANUAL) OPERATION

1. Place the X-ray generator in radiographic mode.

2. This display should read MAN-NO CASS with " - - x - - " for field size.

3. Place the film cassette on the table top. Press the LAMP button to activate the lamp field. Position the cassette in the lamp field and manually adjust the shutters and SID for desired technique.

4. Press the ENT/SET button to display table top estimates of field size and SID.

5. MEM ONE, MEM TWO, and LAST SIZE buttons perform no function in this mode.

6. If the vertical SID is not the fixed SID (typically 40 inches or 100 cm), the display will read MAN-SID NOT SET allowing table top exposure at an unknown SID.

8.6 CONTINUOUS AND DIFFERENTIAL SID OPERATION

1. The Linear IV collimator is capable of vertical continuous (tubestand movable) and differential (both table and tubestand moveable) operation. Continuous SID operation requires one SID monitor while differential SID operation requires two SID monitors.

2. Operation sequences remain the same as in Section 8.4 with differences only in what is displayed for SID and field size.

3. As the table or tubestand is moved, the SID display is updated to reflect the current SID. If a cassette is loaded in the tray, the message area will display SID MOVING while the shutters adjust to the new SID size. Once the shutters stop moving, the display will revert to READY-RAD. If there is no cassette present while the table or tubestand is moved, the SID display will be updated but the field size will only indicate " - - x - -" and the message area MAN-NO CASS until a cassette is inserted in the tray.

4. Please note that if you have adjusted the field size smaller than the cassette size and move the table or tubestand to a different SID, the collimator will resize to the full cassette size once movement is stopped. However, the MEM buttons can be used to store and recall desired field sizes.

5. The MEM and LAST SIZE buttons function operate in the same manner as in Section 8.4. In addition, the field size is maintained irregardless of SID. That is, if 15 x 15 is stored in MEM ONE at 40 SID and the SID is changed to 48, recalling MEM ONE will move the shutters to 15 x 15 at 48. If a new cassette has not been loaded, this can also be easily accomplished by pressing the LAST SIZE button. This will recall the last adjusted field size before the SID was changed.

6. SID movement in the automatic mode can then be treated just like an insertion of a new cassette in the tray. The field size is adjusted to the cassette in place and any "coned down" size is placed in LAST SIZE for recall.

8.7 HORIZONTAL (WALL) OPERATION

1. The Linear IV is capable of operating in an automatic mode at four fixed horizontal SID's (36", 40", 48" and 72" or 92 cm, 100 cm, 120 cm, and 180 cm). Please refer to X-ray system information about the availability of these four locations in your equipment.

2. The Linear IV operation horizontally is identical to that described in section 8.4. Please note that continuous or differential operation is only possible vertically.

3. The current SID is displayed on the collimator as the collimator moves to different horizontal SIDs. When the collimator is moved to a new horizontal SID, the shutters automatically resize to the cassette currently in place (if any). The MEM or LAST SIZE buttons function as in 8.4 to recall field sizes used at a previous SID.

4. If the collimator is pointed to a wall device, but is not at one of the four allowed horizontal SIDs, one of two messages will be displayed. If there is a cassette in the wall holder, the display will read EXP HOLD-LOCK SID, indicating an invalid SID position for automatic operation. If there is no cassette in the wallholder, the display will indicate MAN-SID NOT SET which allows for non-bucky horizontal exposures.

5. If the display reads MANUAL-TILT, the collimator is not pointing directly at the wallholder (+/- 10%).

8.8 FLUOROSCOPIC OPERATION

1. Place the X-ray generator in fluoroscopic mode.

2. The message area should read (F) RDY-FLR NORM. The (F) indicates the collimator is in the Full Film spotfilm mode (see Section 8.9); (P) would indicate Preset spotfilm mode (Section 8.9). RDY-FLR indicates the collimator is ready for fluoroscopic operation. NORM indicates the image intensifier (I.I.) set up as NORM is selected.

3. Press the MAG SIZE button to toggle through the three preset I.I. size selections. Each time a new I.I. is selected, the collimator will size to the correct shutter position. You can verify the size of an I.I. selected by either 1) pressing the LAST SIZE button if you have not adjusted the shutters since changing I.I. size, or 2) pressing the ENT/SET button which toggles between Full Film and Preset modes but will also display the I.I. size in the field size display.

4. You can reduce the X-ray field size at the front panel or by the use of an optional remote control. The new field size is not displayed. To return to the full I.I. size, press the MAG SIZE button once. Please note that if you've adjusted the field size smaller then the I.I., the MAG SIZE button will reset to the full size of the current I.I., not change I.I. sizes. If the current I.I. is fully sized, pressing the MAG SIZE button will toggle I.I. sizes. The I.I. is fully sized if the field size display reads " - - x - -". Pressing LAST SIZE when " - - x - -" is displayed will show the I.I. size.

5. The MEM ONE and MEM TWO buttons function the same as in Section 8.4. The sizes in memory are maintained even after switching I.I. sizes. Please note that the shutters will never move larger than the current I.I. size. Unlike radiographic operation, selecting MEM location if larger than I.I. will replace MEM location with current I.I. size.

8.9 SPOTFILM OPERATION

1. While in the FLUORO mode, the Linear IV will enter the SPOTFILM mode when the cassette tray is advanced into the exposure area. See your system information for details on spotfilm operation.

2. The spotfilm operation of collimator will depend on which mode has been selected: FULL FILM or PRESET. The PRESET mode allows the collimator to keep a particular shutter size (as long as it is less than the cassette size) when switching from fluoroscopic to spotfilm applications. Pressing the ENT/SET button in FLUORO will toggle between PRESET and FULL FILM modes.

3. Indication of the current FULL FILM or PRESET operation during FLUORO or SPOTFILM modes is indicated in two ways. First after depressing ENT/SET, FULL FILM or PRESET will be indicated on the alphanumeric display on the front panel for approximately two seconds. Afterwards a (F) or a (P) will precede the message on that display to indicate FULL FILM or PRESET respectively.

4. FULL FILM OPERATION

   When FULL FILM is selected the collimator can still be coned down to sizes smaller than the maximum allowed by the current image receptor in use. But, when switching from FLUORO to SPOTFILM modes, the collimator will always initially cycle the shutters to the full cassette size in use. To return to the previous coned down size, the user must depress the LAST SIZE button.

   Returning to FLUORO, the collimator will resize to maximum II size for the current magnification selected.

   Selecting FULL FILM while in PRESET SPOTFILM mode will cause the collimator to resize to the full cassette size. Pressing LAST SIZE will allow the user to return to the previous coned down size.

Selecting FULL FILM while in PRESET FLUORO mode has no effect on shutter position but does change the mode for the next SPOTFILM. MAG SIZE can be used to open the shutters to the maximum II size for currently selected magnification.

5. PRESET OPERATION

When PRESET is selected and SPOTFILM mode is entered from FLUORO, the collimator will slightly readjust it's position in SPOTFILM mode to obtain the same size it had just prior in FLUORO mode if it is within the limits of the cassette size, without first sizing to the full cassette size. If a shutter is larger than a cassette dimension, the shutter will close to the cassette size.

When PRESET is selected and FLUORO mode is entered from SPOTFILM, the collimator will slightly readjust it's position in FLUORO mode to obtain the same size it had just prior in SPOTFILM mode if it is within the limits of the maximum II size for the current magnification, without first sizing to the maximum II size. Again, a shutter which is beyond the limit will close to the II size.

Selecting PRESET while in a FULL FILM SPOTFILM mode has no effect on shutter position, but it does set the current size as the new PRESET size. Pressing LAST SIZE in this case will have no effect, as the current size is also the LAST SIZE.

Selecting PRESET while in FULL FILM FLUORO mode has no effect on shutter position but does change the mode for the next spotfilm application and engages the size display to indicate numerically.

6. MAG SIZE BUTTON

Operation of MAG SIZE has not changed. It will always cause the shutter to move to the maximum II size for that magnification and toggle the magnification of I.I. between three inches.

8.10 TILTING COLLIMATOR AND TILTING TABLE OPERATION

1. Logic contained in the Linear IV makes sure that the collimator is pointed toward the desired image receptor.

2. If the collimator is angled more than 10°, the collimator will display MANUAL-TILT and blank the SID and field size display (regardless of whether a cassette is present). Continuing to angle the collimator to 90° will lead to an error message of either MAN-NO CASS or MAN-WRONG WALL. MAN-NO CASS indicates the wall is an acceptable image receptor, but no cassette is present. MAN-WRONG WALL indicates the collimator is pointing 180° from the calibrated wall device. If there is a second wall device, only manual operation is allowed.

3. If the display reads MAN-SID NOT SET or EXP HOLD-LOCK SID is displayed when pointing at a wall holder, the collimator is not located at a defined horizontal SID (see Section 8.7).

4. If a table is tilted while the collimator is pointing down vertically, the display will read MANUAL TILT. If a table is tilted to 90° in either direction and the collimator is pointed at the table, the following error messages are possible:

   a. EXP HOLD-LOCK SID: If the collimator is not at a defined horizontal SID.

   b. MAN-NO CASS: If there is no cassette in the table.

5. If the table can tilt 90° and be in the same direction as a wall holder, the collimator logic looks at the table. That is, if a table is at 90° but without a cassette, the display will read MAN-NO CASS irregardless if a wall holder in the same direction has a cassette present.

8.11 STEREO/TOMO OPERATION

1. Stereo/Tomographic operation is enabled by a signal sent from the X-ray system to the Linear IV collimator. Please refer to your specific system documentation for stereo/tomo details.

2. When STEREO/TOMO is enabled, the collimator is placed in a completely manual mode of operation. Field size and SID displays are blanked and the collimator shutter size opening must be set by using the light field.

SECTION 9

REPLACEMENT PARTS LIST

REPLACEMENT PARTS LIST

LINEAR IV

NOTE: THE ITEMS LISTED BELOW ARE THE MOST COMMONLY REQUESTED ITEMS. FOR EUREKA PART NUMBERS OF ITEMS NOT LISTED HERE, PLEASE REFER TO THE BILLS OF MATERIAL IN SECTION 11.

COLLIMATOR

EUREKA P/N	DESCRIPTION
70-11201	Swivel Mounting Ring – Tube Side
70-11008	Swivel Mounting Ring – Collimator Side
70-10036	Swivel Ring Collar
26-00854	Thumb Screw
70-11089	Window - Cross Hair
70-04752	Knob - Front Panel
70-11039	Lamp Switch Pushbutton Assembly
70-04571	Lamp - Light Field - DZE 24 VAC, 150 W
70-04572	Socket - Lamp
70-01901	Current Limit Resistor
70-11129	Cover - Left Side
70-11130	Cover - Right Side
70-11026	Cover - Front Bezel
70-11127	Cover - Top
70-11028	Cover - Rear
70-03051	Triac - 15 A Light Timer
70-10096	Prism - Centering Line
70-10147	Tilt Switch
70-20265	Cone Track Kit (Option)
70-11200	Dual Cone Track (for use with dosimeters)
70-20164	Low Filtration Mirror/Bracket Assembly
70-20024	Mirror/Bracket Assembly
70-20318	Handheld Remote
27-30092	Motor, Linear IV Stepper
70-11075	Tape Measure

EUREKA P/N	DESCRIPTION
70-08167	EEPROM - Linear IV
70-08314	CPU Board Assembly
70-08316	Driver Board Assembly
70-08318	Display Board Assembly
70-08153	Front Panel Touchscreen
70-04280	5 Volt Logic Switching Power Supply

POWER SUPPLY CHASSIS

70-06018	Transformer - Power 27/19 VAC
70-04032	EMI Filter
70-04605	Fuse - 3A Slo Blo - Power
70-04607	Fuse - 8A Slo Blo - Lamp
70-08320	Linear IV Master Board Assembly
70-04001	Relay - 24 VDC

SID MONITOR

70-00652	Potentiometer, 1K, 10 Turn
70-04241	Switch, Snap Action
70-10558	Cable - 70 inch

LIMITED WARRANTY

PROGENY, INC. warrants to Buyer that any new product manufactured by PROGENY, Inc. ("Product") will (i) be free from defects in material and manufacturing workmanship and (ii) conform to applicable specifications in effect on the date of shipment. The criteria for all testing shall be the applicable specifications, utilizing factory-specified calibration and test procedures and instruments.

All product warranties and all remedies for warranty failures are limited in time as shown below:

DURATION OF WARRANTY

All PROGENY products shall be warranted until 1 (one) year from the date of original installation or 1-1/2 (one and one-half) years from the date of shipment by PROGENY, whichever comes first. Any component furnished without charge to Buyer during the warranty period to correct a warranty failure shall be warranted only to the extent of the unexpired term of the warranty of the original product.

WARRANTY TERMS AND CONDITIONS

Warranty consideration will be given only for products returned to the PROGENY factory properly packaged and if applicable, accompanied by a fully completed Returned Goods Authorization/Service Report. All shipping charges resulting from Warranty returns are the responsibility of the Purchaser. Only in the case of repairs effected under Warranty is Progeny responsible for shipping charges.

WARRANTY EXCLUSIONS

The foregoing warranties are exclusive and in lieu of all other warranties, whether written, oral, express, implied or statutory. NO IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE SHALL APPLY.

THE WARRANTIES AND REMEDIES AVAILABLE TO THE BUYER ARE CONDITIONED UPON ALL CLAIMS UNDER THIS WARRANTY BEING MADE WITHIN ONE YEAR AFTER DATE OF INSTALLATION AND WITHIN EIGHTEEN MONTHS AFTER SHIPMENT FROM PROGENY. THE DATE OF INSTALLATION MUST BE ESTABLISHED BY THE RETURN TO PROGENY WITHIN 15 DAYS OF THE DATE OF INSTALLATION OF A FULLY COMPLETED WARRANTY REGISTRATION CARD, SUPPLIED WITH THE PRODUCT. IN THE ABSENCE OF SUCH PROOF, THE DATE OF SHIPMENT FROM PROGENY WILL BE CONSIDERED THE DATE OF INSTALLATION.

Warranty coverage does not include any defect or deficiency (including failure to conform to Product descriptions or specifications) which result in whole or in part, from (1) negligent storage or handling of the Product by Buyer, its employees, agents or contractors; (2) failure of Buyer to prepare the site or provide power requirements or operating environmental conditions in compliance with any applicable instructions or recommendations of PROGENY (3) the absence of any product, component, or accessory recommended by PROGENY but omitted at Buyer's direction; (4) any design, specifications or instruction furnished by Buyer, its employees, agents or contractors; (5) any alteration of the Product by persons other than PROGENY; (6) combining PROGENY'S Product with any product furnished by others; (7) combining incompatible products of PROGENY; (8) improper or extraordinary use of the Product, improper maintenance of the Product, or failure to comply with any applicable instructions or recommendations of PROGENY, or (9) acts of God, acts of civil or military authority, fires, floods, strikes or other labor disturbances, war, riots, or other causes beyond the reasonable control of PROGENY. PROGENY does not warrant any product of others where PROGENY serves solely as a distributor or resaler.

BUYER'S REMEDIES

If PROGENY determines that any Product fails to meet any warranty during the applicable warranty periods, PROGENY shall correct any such failure either at its option (a) by repairing, adjusting, or replacing any defective or nonconforming Product, or defective or damaged part or parts of the Product or (b) by making available at the place of assembly any necessary repaired or replacement parts or assemblies. PROGENY shall have the option to furnish either new or exchange replacement parts or assemblies.

Installation, troubleshooting or repair service are not included in this warranty. Warranty of service is the responsibility of the dealer selling the equipment.

The preceding paragraphs set forth Buyer's exclusive remedies and PROGENY's sole liability for claims based upon failure of the Product to meet any warranty, whether the claim is on contract, warranty, tort (including negligence and strict liability) or otherwise and however instituted, and, upon the expiration of the applicable warranty period, all such liability shall terminate. In no event shall PROGENY be liable for special or consequential damages.

LITHO. IN U.S.A.

FORM # 00-02-0171
ECN # P0180
REV. A

NO TEXT

SECTION 10

APPENDIX

DEFINITIONS

SID	Source to Image receptor Distance
VSID	Voltage representing SID
VCSID	Voltage representing Continuous SID
SID TRUE	Signal representing the Operating SID Range
XF	X-ray Field
VXFC	Voltage at the Collimator Feedback Potentiometer Wiper repesenting the X-Ray Field in the Cross Dimension
VXFL	Voltage at the Collimator Feedback Potentiometer Wiper representing the X-Ray Field in the Long Dimension
IR	Image Receptor (Cassette Tray)
VIRC	Voltage from the Cassette Sensing Element representing the Image Receptor size in the Cross Dimension
VIRL	Voltage from the Cassette Sensing Element representing the Image Receptor size in the Long Dimension
IR TRUE	Voltage representing the Presence of a Cassette
VCPC	Voltage applied to the Collimator Potentiometers in the Cross Position
VCPL	Voltage applied to the Collimator Potentiometers in the Long Position
VXFDC	Voltage representing the X-Ray Field Desired in the Cross Dimension
VXFDL	Voltage representing the X-Ray Field Desired in the Long Dimension

TABLE 10.1

The following list is intended to help the installer determine mounting information only, and does not imply compatibility. See Section 1-7 for compatability information.

MANUFACTURER	TUBE HOUSING	FOCAL SPOT TO PORT MOUNTING	DISTANCE TO COLLIMATOR MOUNTING FLANGE
Eureka	Emerald Series	2 - 1/16"	3/8" (.375)
	Diamond Series	2 - 1/16"	3/8" (.375)
	Sapphire Series	2 - 1/16"	1/4" (.250)
Eimac	B100	2 - 17/64"	11/64" (.171)
	B150	2 - 11/64"	17/64" (.265)
General Electric	Maxiray 100	2 - 5/16"	1/8" (.125)
	HRT, MX75	2 - 1/16"	3/8" (.375)
Picker/Dunlee	DU - 140	2 - 1/16"	3/8" (.375)
	DU - 200	2 - 1/16"	3/8" (.375)
	DU - 300	2 - 9/32"	5/32" (.156)
	PX - 400	2 - 5/16"	1/8" (.125)
	PX - 1300	2 - 3/16"	8/32" (.252)
	PX - 1400	2 - 5/16"	1/8" (.125)
Machlett	DX40 Series	2 - 1/16"	3/8" (.375)
	DX50 Series	2 - 3/16"	1/4" (.250)
	DX60 Series	2 - 5/16"	1/8" (.125)
	DX70 Series	2 - 5/16"	1/8" (.125)

LINEAR IV TILT SWITCH WIRING (70-10147)

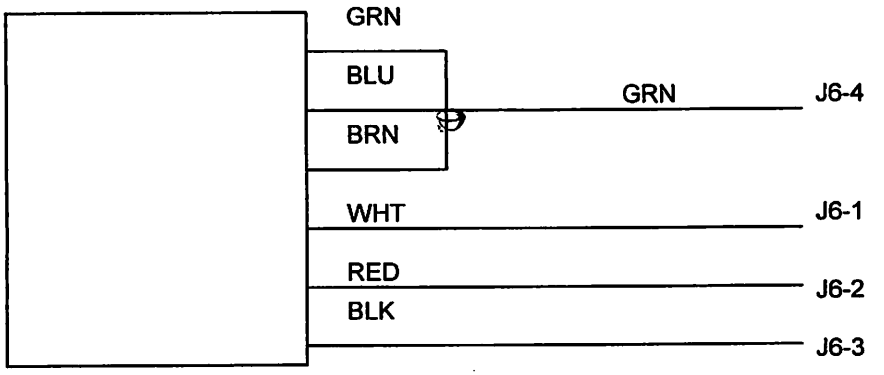


FIGURE 10.1

LINEAR IV FEEDBACK POTS WIRING (70-00655)

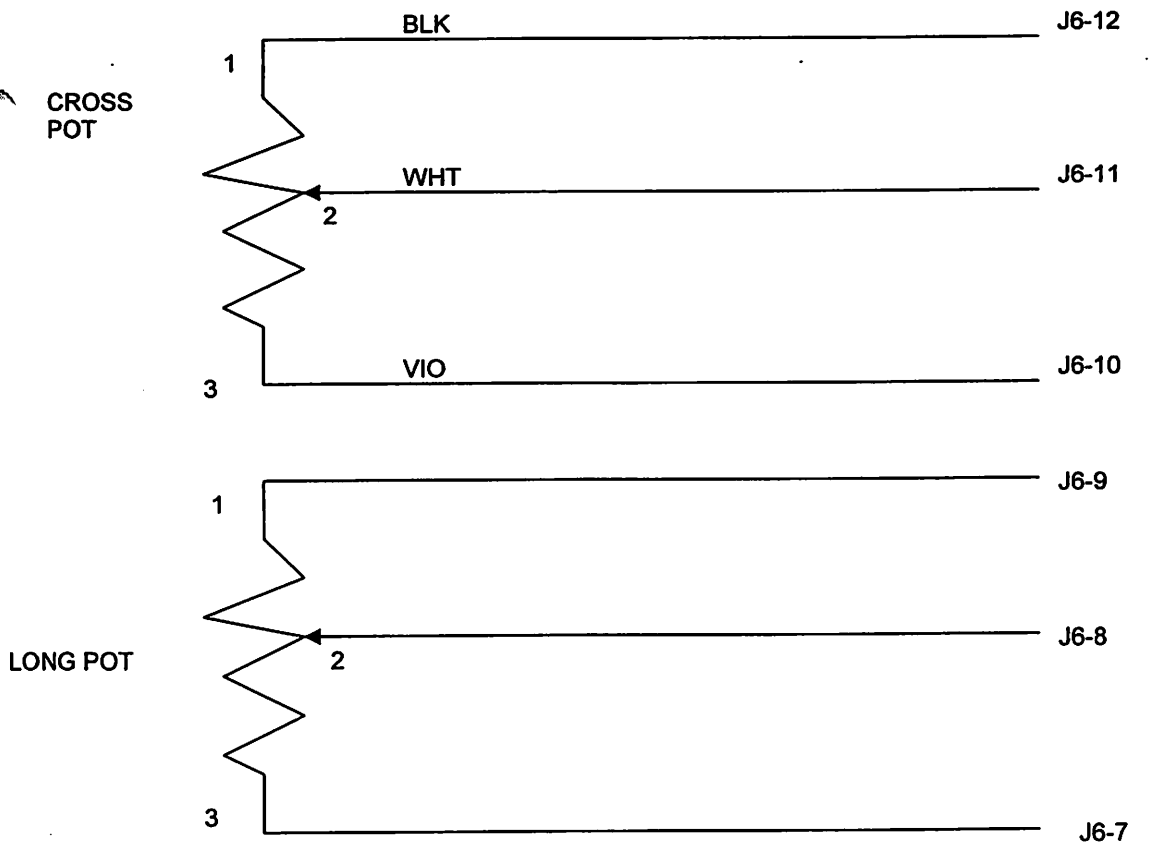


FIGURE 10.2

LINEAR IV MOTOR WIRING (27-30092)

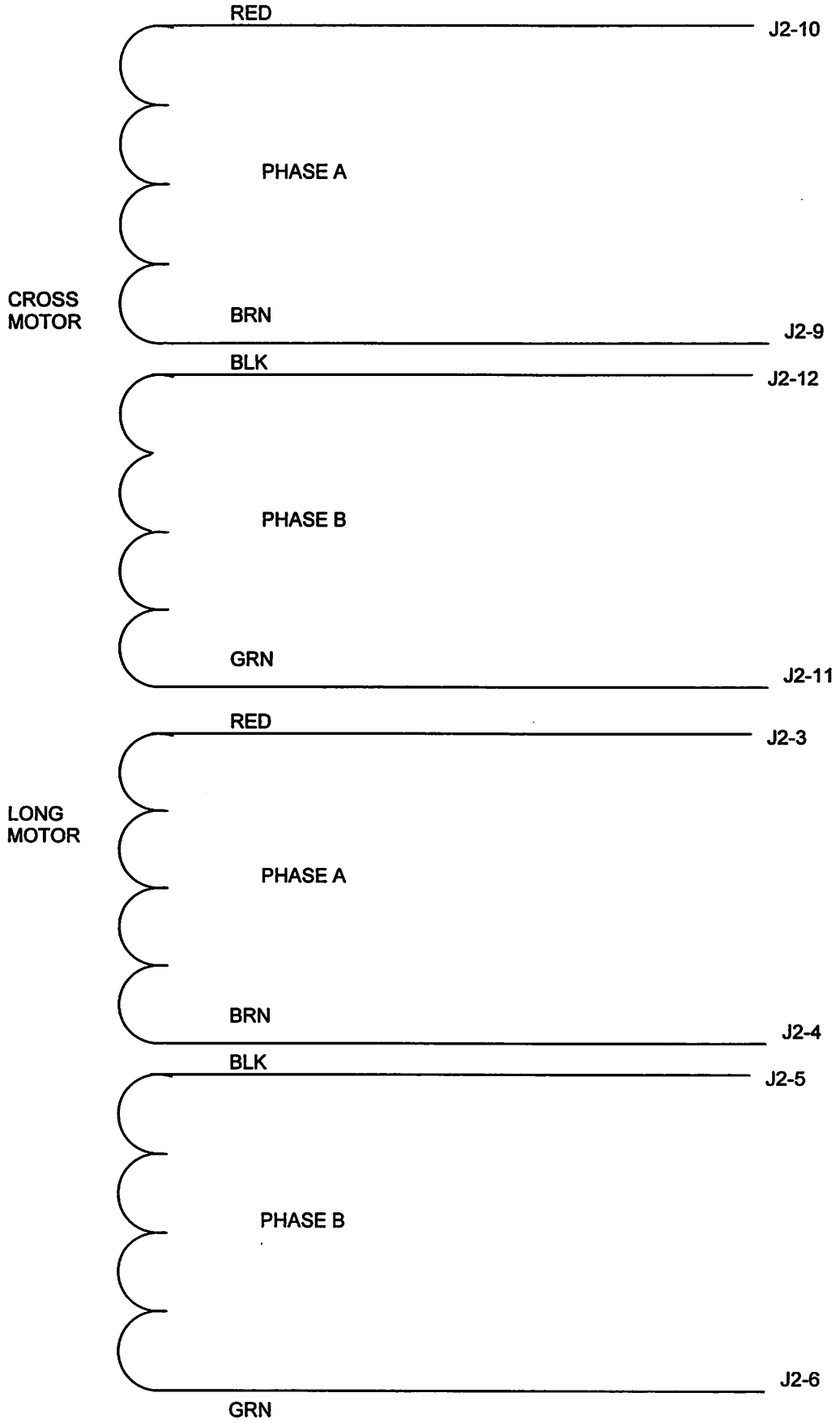


FIGURE 10.3

LINEAR IV COLLIMATOR
PAUSCH URO TABLE INTERFACE

1. Product consists of a single printed circuit card (PCB) to be a maximum dimension of 6" x 4" rectangle. The PCB has a threaded standoff in each corner extending 1 inch below the solder side for mounting in the customer's interface unit.

2. The PCB has a screw down wire terminal strip connector for making all interface connections (the same type of terminal strip as used in the Linear IV Master PCB).

3. The required interface connections are as follows:

FROM PAUSCH CASSETTE TRAY:	**TO PCB TERMINAL STRIP (J1)**
/TRAY IN	J1-1
/17x14	J1-2
/14x17	J1-3

FROM COLLIMATOR MASTER PCB POWER SUPPLY:

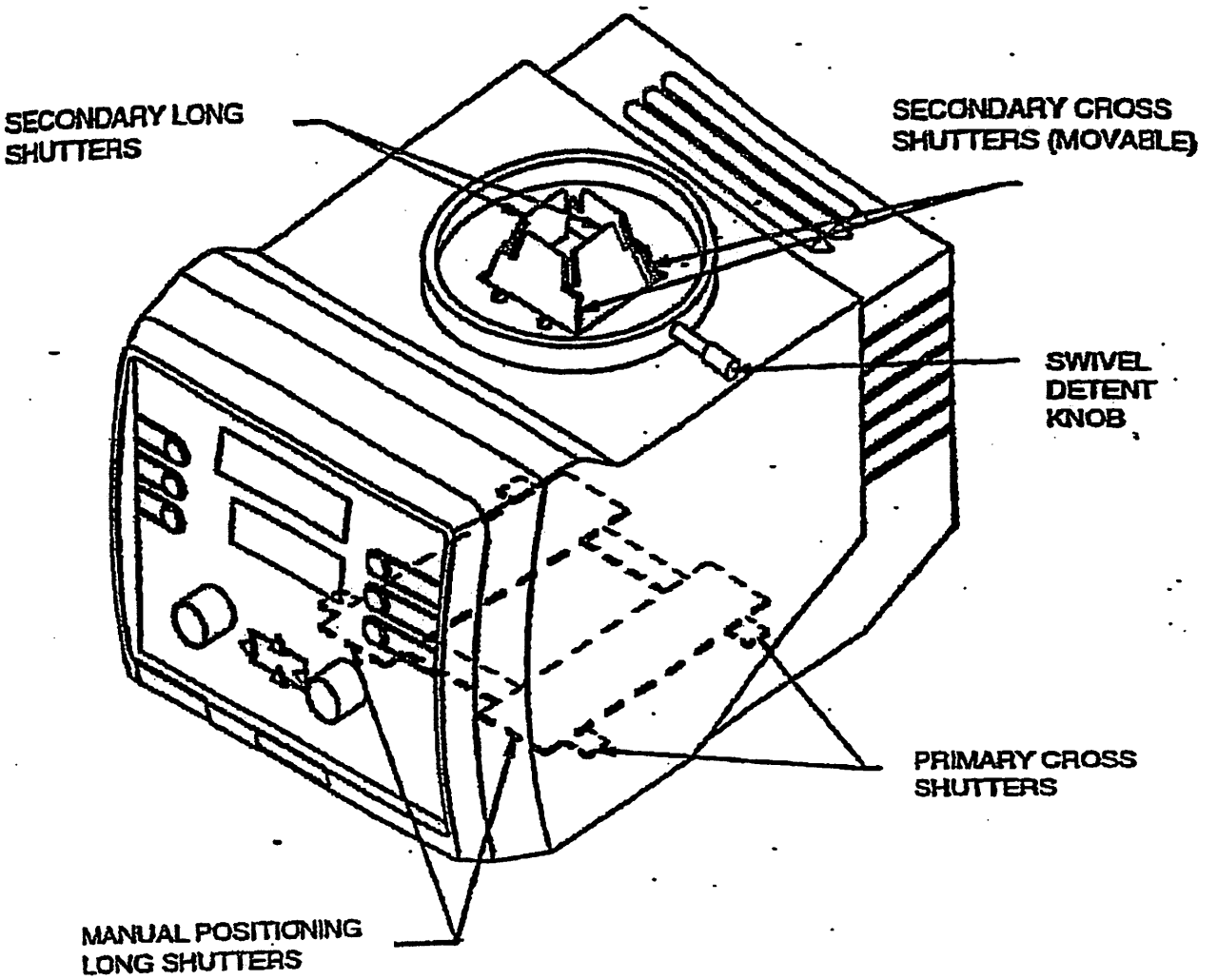
Coll. Ref. Source (TS4-15)	J1-7
Coll. Ref. Return (TS4-12)	J1-8
Coll. +15V (TS1- 3)	J1-5
Coll. GND (TS1- 2)	J1-6
Coll. Long Ref (TS4-13)	J1-9
Coll. Cross Ref (TS4-14)	J1-10

4. The Optional Interface connections are as follows:

Coll. Exp Hold 1	J1-11
Coll. Exp Hold 2	J1-12
RAD/FLUORO Interlock 1	J1-14
RAD/FLUORO Interlock 2	J1-15

SECTION 11

THEORY OF OPERATION



Linear IV Collimator
Figure 11.1

11.1 MECHANICAL OPERATION

Eureka Linear IV collimators contain two major sets of shutters, long and cross, which define the absolute X-ray field size. There are also two secondary sets of shutters which protrude into the port of the X-ray tube to help reduce the effects of off-focus radiation. The secondary cross shutters are mechanically linked to the primary cross shutters and follow the action of the primary shutters to provide additional reduction of off-focus radiation with smaller X-ray field sizes.

Both shutter mechanisms are driven by bipolar stepper motors and the front panel knobs. Spring loaded gears are used to prevent backlash for accurate, repeatable shutter positioning.

All Eureka Linear Series collimators have a swivel mount configuration. Detents are located at 90 degree increments. The collimator may be oriented to any position for achieving proper X-ray field to cassette alignment for table-top or non-bucky operation.

The shutter mechanism has been precisely aligned with respect to the mounting flange at the factory. Therefore, the necessity for field alignment of the central ray has been virtually eliminated.

The shutters may be positioned manually with the remote shutter controls on the optional remote control unit, or the controls on the front panel.

11.2 ELECTRONIC OPERATION

The collimator electronics reside on a number of printed circuit boards:

- CPU Logic PCB
- Master Board
- Driver Board
- Display Board
- Front Panel
- Five Volt Power Supply

For simpler schematic interpretation, each board has been divided into logical subsections.

The operating system is represented by the block diagrams of Figure 10.2 a and b. Refer to section 9 for definitions.

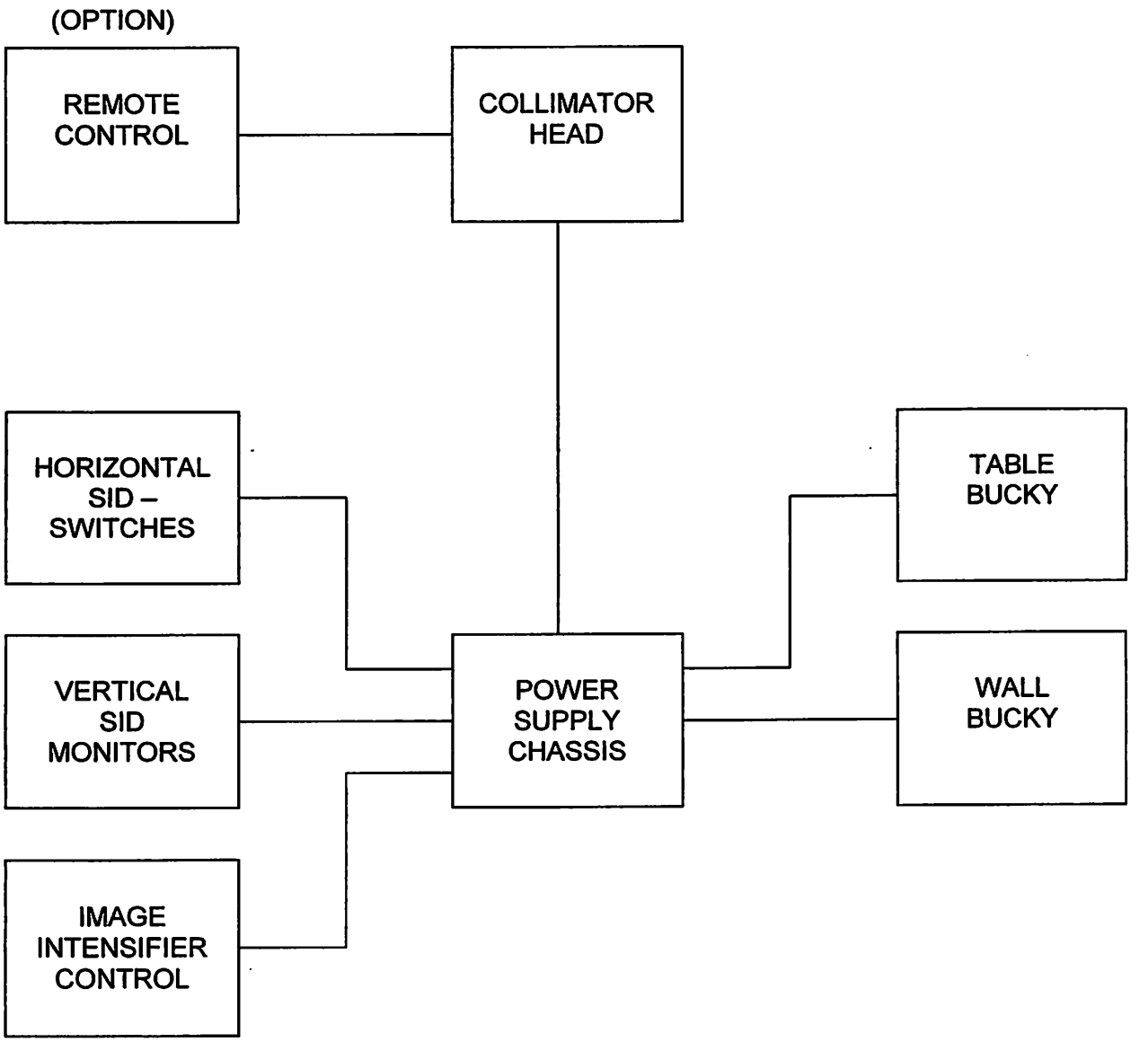


Figure 11-2a - Collimator Block Diagram - General

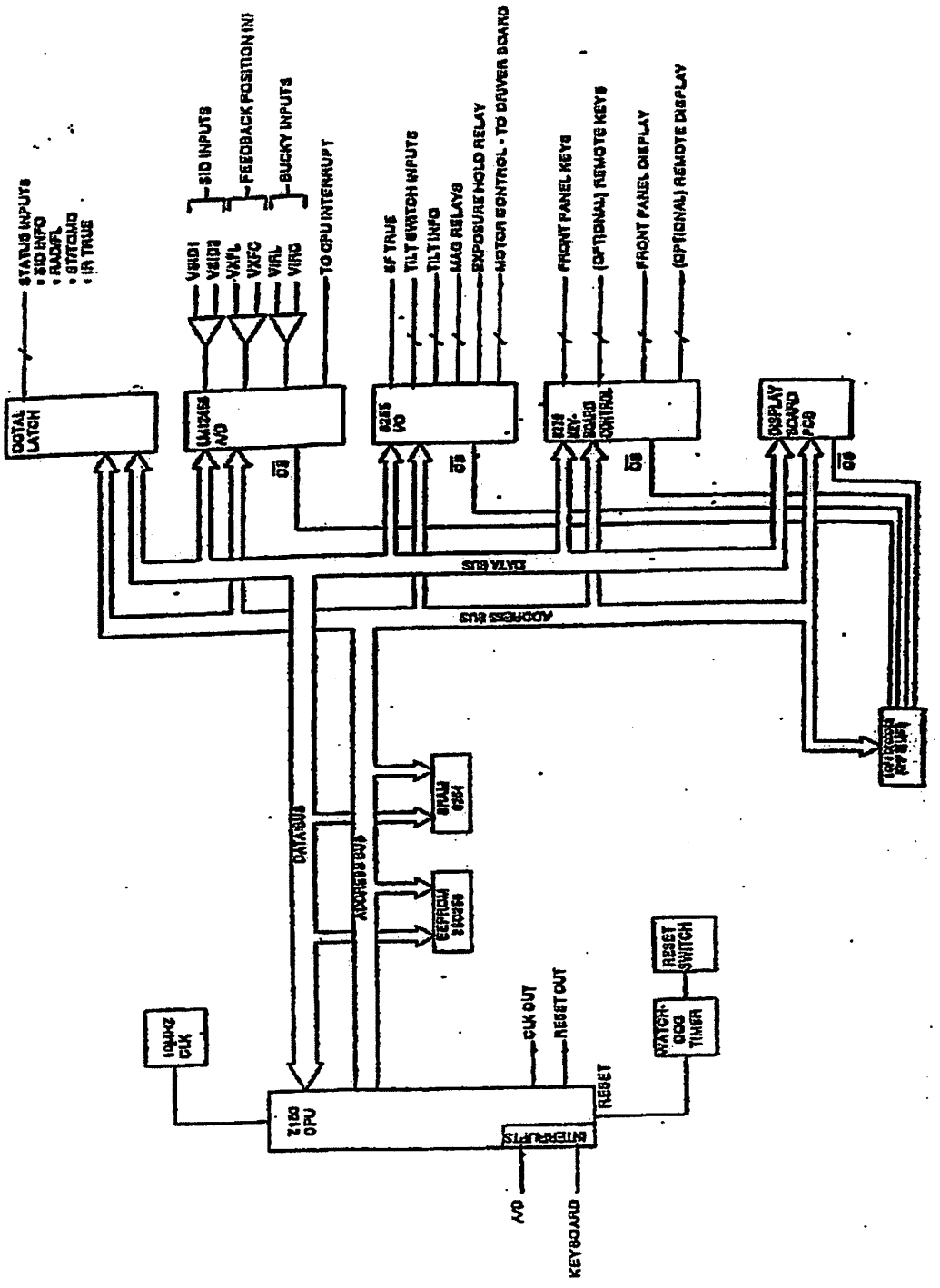


Figure 11-2b - Collimator Block Diagram – Logic

11.3 POWER SUPPLIES

All power supplies are self contained: a transformer with 110, 115, 120, 220, 230, etc. VAC primary windings supplies AC power for the projection lamp (27 VAC) and for the stepper motors (28 VDC). Please note the proper incoming voltage (110V or 220V) has to be selected on the switch on the power supply.

A separate logic supply provides 5 VDC, and ±15 VDC for the PC boards.

11.4 CONTINUOUS SID CIRCUITS

The constant current sources associated with Q2 and Q3 on the Linear IV master board (page 5, 70-08319) provide 5mA nominally to the connected SID monitors. The voltage developed across the SID monitor potentiometer therefore varies proportionally with changes in SID. The voltages VSID1 and VSID2 are fed into the A/D Converter (U30, 70-08313). The software interprets the incoming voltages and based on calibration information, determines the correct SID in inches. This ensures that the collimator shutters open or close to maintain constant frame size for a given format at all SID's in the range of the table vertical carriage.

NOTE: VSID2 is used only if the system has an adjustable height table and a second SID monitor is installed in the table and connected to the collimator (CSID2).

11.5 IMAGE RECEPTOR SIZE CIRCUIT

The voltages representing image receptor size (VIRL, VIRC) are fed into differential amplifiers U11a and U11b (70-08319). These amplifiers are used to provide floating, balanced inputs for the outboard potentiometers. This circuitry minimizes noise induced in the sometimes long interconnecting cables between the potentiometers and logic circuitry.

These voltages are then fed into the A/D converter (U30, 70-08313). The software then interprets these voltages based on calibration information to determine the correct image receptor size.

11.6 COLLIMATOR FEEDBACK CIRCUIT

The voltages representing the position of the shutters is fed into the A/D converter (U30) through the unity gain follower amplifiers of U28a and U28b (70-08313). The software then interprets these voltages based on calibration information and all required inputs (including SID, IR size) as a position (angle) which produces an associated frame size.

11.7 A/D CONVERTER CIRCUIT

The A/D converter (U30, 70-08313, sheet 4) accepts the analog signals described in

10.4 - 10.6. An internal multiplexor samples the given inputs and stores the results in an internal FIFO at a preconfigured rate. An interrupt is generated by the A/D converter when the FIFO is full which causes the CPU to store the current values of the analog inputs.

This technique requires a minimum of overhead from the CPU and allows for a fast, accurate means of always recording the current analog input values for use by the software when required.

11.8 CPU CORE SECTION (Schematic 70-08313 sheet 1, Board 70-08314)

U1 is the microprocessor used in the system. It is a Zilog Z180 running at 10 MHz. It has a 16 bit address space buffered by U4 and U5, and an 8 bit data bus buffered by U3.

The logic associated with U7 provides the required signals to determine I/O and Memory reads and writes.

U8 is a 8K X 8 (6264) static ram used for storing volatile data and the parameter stack.

U6 is a 32K X 8 (28C256) EEPROM and contains the run-time code and is used to store the nonvolatile parameters determined during calibration. The EEPROM is Hardware and Software write protected to provide the maximum security against losing data from false writes which may be encountered during power surges or from noise spikes.

11.9 CPU DISPLAY/KEY BOARD SECTION (70-08313 sheet 2)

U11 provides the correct operational clock speed for U10 the 8279 keyboard display controller.

U10, U16 and part of U23 supply the required scan and return signals for keyboard recognition from the front panel and an optional remote keypad.

U10, U9 and the associated drive circuits provide the required display signals to illuminate the front panel, display board (70-08317), and the optional remote keypad control.

11.10 CPU INPUT/OUTPUT SECTION (70-08313 sheet 3)

U20 the 74LS138 is a 3 to 8 decoder used to develop the appropriate chip enable signals used throughout the CPU board.

U21 is an octal latch and is used to maintain signals concerned with discrete SID switches, Radiographic or Fluoroscopic mode, and Stereo/TOMO mode. The software checks the latch when the information is required.

U19 an 8255 I/O Controller along with the associated buffer circuits provide for the discrete input/output requirements of the collimator system. The chip is divided into 3 ports. Port A Monitors the Tilt switch positions, and Spotfilm true signals. Port B provides the outputs for control of the Stepper Motors through the driver board (70-08315), and Port C outputs current tilt information and the signal required for Image intensifier relays and the Exposure hold Relay.

The 8255 is configured in software and is controlled by the software.

11.11 MASTER BOARD (Schematic 70-08319, Board 70-08320)

Sheet 1 contains the schematic for power supply wiring and the STEREO/TOMO interconnect circuit. The schematic is relatively simple and straight-forward so no further explanation will be provided.

Sheet 2 contains the circuit schematics for the 28VDC supply for the stepper motors, and the drive circuitry for the relays associated with PBL OVER_RIDE, EXPOSURE HOLD, and IMAGE INTENSIFIER selection. Again the circuits here are simple and straight forward and require no additional explanation.

Sheet 3 contains the circuit schematics for discrete SID determination. U7 (74139) and U4 (74148) are used to respectively decode and code the current discrete SID switch status used by the CPU and software. The following logic tables describe the signal dependencies.

Sheet 4 contains the Image Receptor reference and measurement circuits. U11 is described in section 10.5. The circuits associated with Q1 and U9 create a power amplifier circuit which provides a constant voltage to the Image Receptor potentiometers. U10 and U3 compare the currents associated with a cassette in and out of the image receptor to provide a signal which tells the CPU whether a cassette is present in the selected bucky. Relay K5 is controlled by the CPU and connects the desired bucky tray to the reference and output signals.

Sheet 5 contains the SID circuits described in section 11.4.

	TILT INFO B	TILT INFO A
VERT OUT	0	0
TABLE L	0	1
TABLE R	1	0
WALL L/R	1	1

	SID INFO C	SID INFO B	SID INFO A	VERT IN
72"SID	0	1	1	X
48" SID	0	1	0	X
40" SID	0	0	1	X
36" SID	0	0	0	X
VERT IN	X	X	X	1
NO SID	1	0	0	X

Sheet 6 contains the circuit for Radiographic or Fluoroscopic mode selection. Stereo/Tomographic indication, and table tilt indication. These circuits again are relatively simple and no further explanation will be given.

11.12 DRIVER BOARD (Schematic 70-08315, Board 70-08316)

Sheet 1 contains the circuit for illuminating and turning of the internal projection lamp. The logic of U6 and U8 trigger or reset the timer U1 based on current timer status. The timer-in-turn triggers the optically isolated triac which turns on/off the lamp.

If the lamp is off and the lamp switch is pressed the lamp will turn on until it times out (approximately 22 seconds) or until it is turned off by pressing the lamp switch again.

Sheet 2 contains the drive and control circuitry associated with the stepper motor drive. U9 and U7 provide two time bases for manual and automatic motor speeds. The speed selected is determined through the logic of U2. Automatic speed is used during automatic sizing cycles of the collimator. A slower manual speed is introduced for power assisted manual control of the shutter position using the front panel controls or the optional remote keypad controls.

U3 and U10 provide the logic interface for power H-bridges U11 and U4. Together they form a current chopper drive for the stepper motors of the cross and long shutters. Each shutter is controlled by an enable and direction signal fed from the CPU and runs at the speed determined by the logic of U2 fed from the CPU.

11.13 DISPLAY BOARD (Schematic 70-08317, Board 70-08318)

Sheet 1 contains the schematic of the alpha-numeric display section of the display board. DS1-DS4 are "smart" alpha-numeric displays which display the ASCII input on the data bus into the appropriate ASCII character on the selected character of the display.

The logic of U2 selects the display and the character of the display from information from the CPU.

U1 and it's associated circuit provide a dimmer circuit for the displays to maintain a lower current draw and provide for optimum illumination.

Sheet 2 contains the schematic for the field size and SID numeric displays. The circuit is simple and consists of driver chips and seven segment numeric displays. The displays are driven in a multiplexed fashion controlled by the 8279 on the CPU board. U3 selects which is to be illuminated, U4 contains the information on the segments to be illuminated.

11.14 FRONT PANEL 70-08152

The front panel consists of matrix of metallic dome keypad switches which are interpreted by the 8279 on the CPU board for their respective function. There are a number of indicators on the front panel controlled by the CPU's 8279 used to indicated functional status. Section 8.0, Operating Instructions, provides detailed interface instructions.

11.15 INTERCONNECT CABLE 70-08166

Figure 11.3 describes the specific signal and wire information on the cable.

FIGURE 11.3
INTERCONNECT CABLE (70-08166)

POS	SIGNAL NAME	WIRE	PWR SUPPY	HEAD	CPU
1	SID INFO C	RED/WHT/BLK	TS2-1	T	J8 – 16
2	SID INFO B	RED/BLK/GRN	TS2-2	S	J8 – 17
3	SID INFO A	RED/WHT/GRN	TS2-3	R	J8 – 18
4	VIN	ORG/GRN	TS2-4	U	J8 – 15
5	TILT INFO B	WHT/BLU/RED	TS2-5	P	J8 – 19
6	TILT INFO A	WHT/BLK/RED	TS2-6	N	J8 – 20
7	NC		TS2-7		
8	+5 VDC	RED RED/BLK RED/GRN RED/WHT WHT/BLK	TS2-8	c d d e e	J2 – 18 J2 – 17 J2 – 16 J2 – 15 J2 – 14
9	DGND	BLK BLK/RED BLU/RED BLK/WHT ORG/RED/GRN BLK/GRN/WHT BLK/BLU/WHT BLK/GRN/RED	TS2-9	b f f h h j j j	J2 – 19 J2 – 13 J2 – 12 J2 – 11 J2 – 10 J2 – 9
10	PGND	BLK/RED/WHT WHT/RED/GRN BLK/WHT/ORG WHT/RED/ORG	TS2-10	k k l l	J2 – 8 J2 – 7 J2 – 6 J2 – 5
11	28 VDC	ORG GRN/ORG/BLK BLU/WHT/ORG GRN/WHT/BLK	TS2-11	m m n n	J2 – 4 J2 – 3 J2 – 2 J2 – 1
12	0 VAC	BLU/RED/GRN GRN/WHT/BLU	TS2-12	t t	Jumper to u
13	0 VAC	GRN/BLK BLU	TS2-13	u u	To Triac GND
14	27 VAC	WHT/BLU/BLK GRN	TS2-14	r r	Jumper to S
15	27 VAC	ORG/RED BLU/WHT	TS2-15	s s	TO LAMP
16	EHR	ORG/WHT/BLK	TS3-1	NN	J8 – 1
17	M2R	BLK/ORG/RED	TS3-2	MM	J8 – 2
18	M1R	GRN/RED/ORG	TS3-3	LL	J8 – 3
19	N.C.		TS3-4		

FIGURE 11.3 CONTINUED
INTERCONNECT CABLE (70-08166)

POS	SIGNAL NAME	WIRE	PWR SUPPY	HEAD	CPU
20	T0	ORG/WHT/BLU	TS3 – 5	X	J8 – 12
21	T + 90	ORG/BLK/GRN	TS3 – 6	W	J8 – 13
22	T – 90	ORG/BLK	TS3 – 7	V	J8 – 14
23	SFT	BLU/BLK/WHT	TS3 – 8	z	J8 – 9
24	R/F	ORG/RED/BLU	TS3 – 9	AA	J8 – 8
25	IRT	RED/WHT/BLU	TS3 – 10	CC	J8 – 7
26	VIRL	GRN/WHT	TS3 – 11	EE	J8 – 5
27	VIRC	WHT/BLK/GRN	TS3 – 12	DD	J8 – 6
28	VSID2	BLU/BLK	TS3 – 13	a	J8 – 11
29	VSID1	WHT/RED	TS3 – 14	w	J8 – 10
30	ST	BLU/RED/ORG	TS3 – 15	JJ	J8 – 4
31	IR ALIGN	WHT	N.C.	x	To Fast On

SECTION 12

SCHEMATICS AND BILLS OF MATERIAL

Eureka Progeny Inc.• 1407 Barclay Blvd. •Buffalo Grove, IL 60089

BILL OF MATERIAL

Bill of Material No. 70-08314
Rev. D ECN: P0804

-ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
REF	0		70-08318		Schematic, CPU Board		
0001	1		70-06303		CPU PCB Fabrication Dwg		
0002	1		70-03152		Z180 MPU	Z80180	U1
0003	1		70-03121		IC 8 Pin Dip Watchdog Timer	DS1232	U2
0004	1		70-03150		IC 20 Pin Dipo Octal Bus/Line Tranceiver	74LS245	U3
0005	2		70-03151		IC 20 Pin Dip Octal Buffer & Line Driver	74LS244	U4, U5
0006	1		70-08167		Programmed EEPROM Rev. 2.04	28C256	U6
0007	1		70-03142		IC 14 Pin Dip Quad 2 – Input or Gate	74LS32	U7
0008	1		70-03157		8K x 8 RAM	6264	U8
0009	1		70-03139		IC 24 Pin Dip, 14-16 Decoder/Demultiplexer	74L154	U9
0010	1		70-03118		PRO Keyboard Display Controller	8279	U10
0011	1		70-03153		D-Type Flip Flop 14 Pin	74LS74	U11
0012	4		70-03138		Hex Inverting Buffer 14 Pin	7406	U12, 13, 15, 24
0013	3		70-03119		Hex Buffer/Hi Voltage 14 Pin	7407	U22, 23, 26
0014	1		70-03087		8 Channel Source Buffer 18 Pin	UDN2585	U17
0015	2		70-03086		8 Channel Current Sink Buffer 18 Pin	UDN2595	U18, 25
0016	1		70-03140		Programmable I/O 40 Pin	8255	U19
0017	2		70-03128		Decoder/Demultiplexer 16 Pin	74LS138	U16, 20
0018	1		70-03124		Octal D – Type Latch 20 Pin	74LS373	U21
0019	3		70-03351		Dual Op-Amp 8 Pin	LM358	U27-29
0020	1		70-03148		12 Bit A/D Data Acq System 44 Pin	LM12458	U30

BILL OF MATERIAL

Bill of Material No. 70-08314
Rev. D ECN: P0804

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
0022	33		70-02010		Capacitor, .1 MFD 50 V		C1-C30, C32, C34, C41
0024	9		70-02511		Capacitor, Tant. 10 MF, 35V-10%		C31,C33,C35,C36, C37,C46,C49,C52, C53
0025	2		70-02031		Capacitor, MICA, 22PF 300V		C38,C39
0026	1		70-02510		Capacitor, Tant. 100 MF, 10 V		C40
0027	2		70-02506		Cap. Solid Tant. 2.2UF 35 WVDC		C47,C48
0028	2		70-03012		Rectifier 1 Amp 100 V		CR2, CR3
0029	1		70-03071		Suppressor, Transient +5V		CR1
0030	1		70-03302		3 Term Adj. Regulator LM317		VR1
0031	1		70-03154		Crystal 10 MHZ		Y1
0032	1		70-04253		Switch, Pushbutton		SW1
0033	2		70-00700-11		Resistor, Metal Film 237 Ohms 1%		R1, R2
0034	1		70-00314		Resistor, 4.99K Ohms-1/4W 1%		R3
0035	3		70-00042		Resistor, 1K Ohms-1/4W 5%		R4,R7,R8
0036	1		70-00069		Resistor, Carbon Film, 20K Ohms 1/4W 5%		R5
0037	8		70-00510		Resistor, Array, 10 Pin sip, 10K Ohms		RP1-RP4 RP7-RP10
0038	3		70-00511		Resistor, Array, 6 Pin sip, 10K Ohms		RP5,RP11,RP12
0039	1		70-00518		Resistor Network, 6 Pin, 1K Ohms		RP6
0041	4		70-04726		Header 20 Pin		J1, J2, J3, J8
0042	1		70-04727		Conn., Header 20 Pin IDC Rt. Ang.		J4
0043	1		70-04526		Header, 34 Pin		J5

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BILL OF MATERIAL

Bill of Material No. 70-08314
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ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
0044	1		70-04731		Conn., HDR 12 Pin Mini PV Rt. Ang.		J6
0045	1		70-04730		Conn., Header 6 Pin Mini PV Rt. Ang.		J7
0046	1		70-04282		Socket, IC 68 Pin PLCC to PGA		U1
0047	1		70-04279		Socket, IC 44 Pin PLCC to PGA		U30
0048	2		70-04220		Socket, Mach. 40 Pin Dip		U10,U19
0049	2		70-04219		Socket, Mach. 28 Pin Dip		U6, U8
0050	1		70-04283		Socket, Open Frame 24 Pin		U9
0051	4		70-04221		Socket, Mach. 20 Pin Dip		U3,U4,U5,U21
0052	3		70-04281		IC Open Frame Collet Socket 18 Pin		U17,U18,U25
0053	2		70-04217		IC Socket Mach. 16 Pin		U16,U20
0054	9		70-04216		Socket, Mach. 14 Pin Dip		U7,U11,U12,U13, U15,U22,U23,U24, U26
0055	4		70-04222		Socket, Mach. 8 Pin Dip		U2,U27,U28,U29
0056	1		70-04806		Two Circuit Shunt		W1
0057	1		70-04758		2 Pin Header		W1
0058	2		70-00064		Resistor, 10K Ohms, 1/4W, 5%		R6,R9

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BILL OF MATERIAL

Bill of Material No. 70-08314-1
Rev. C ECN: P0793

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
REF	0		70-08318		Schematic, CPU Board		
0001	1		70-06303		CPU PCB Fabrication Dwg		
0002	1		70-03152		Z180 MPU	Z80180	U1
0003	1		70-03121		IC 8 Pin Dip Watchdog Timer	DS1232	U2
0004	1		70-03150		IC 20 Pin Dipo Octal Bus/Line Tranceiver	74LS245	U3
0005	2		70-03151		IC 20 Pin Dip Octal Buffer & Line Driver	74LS244	U4, U5
0006	1		70-08389		Programmed EEPROM Rev. 2.041	28C256	U6
0007	1		70-03142		IC 14 Pin Dip Quad 2 – Input or Gate	74LS32	U7
0008	1		70-03157		8K x 8 RAM	6264	U8
0009	1		70-03139		IC 24 Pin Dip, 14-16 Decoder/Demultiplexer	74L154	U9
0010	1		70-03118		PRO Keyboard Display Controller	8279	U10
0011	1		70-03153		D-Type Flip Flop 14 Pin	74LS74	U11
0012	4		70-03138		Hex Inverting Buffer 14 Pin	7406	U12, 13, 15, 24
0013	3		70-03119		Hex Buffer/Hi Voltage 14 Pin	7407	U22, 23, 26
0014	1		70-03087		8 Channel Source Buffer 18 Pin	UDN2585	U17
0015	2		70-03086		8 Channel Current Sink Buffer 18 Pin	UDN2595	U18, 25
0016	1		70-03140		Programmable I/O 40 Pin	8255	U19
0017	2		70-03128		Decoder/Demultiplexer 16 Pin	74LS138	U16, 20
0018	1		70-03124		Octal D – Type Latch 20 Pin	74LS373	U21
0019	3		70-03351		Dual Op-Amp 8 Pin	LM358	U27-29
0020	1		70-03148		12 Bit A/D Data Acq System 44 Pin	LM12458	U30

BILL OF MATERIAL

Bill of Material No. 70-08314-1
Rev. C ECN: P0793

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
0022	33		70-02010		Capacitor, .1 MFD 50 V		C1-C30, C32, C34, C41
0024	9		70-02511		Capacitor, Tant. 10 MF, 35V-10%		C31,C33,C35,C36, C37,C46,C49,C52, C53
0025	2		70-02031		Capacitor, MICA, 22PF 300V		C38,C39
0026	1		70-02510		Capacitor, Tant. 100 MF, 10 V		C40
0027	2		70-02506		Cap. Solid Tant. 2.2UF 35 WVDC		C47,C48
0028	2		70-03012		Rectifier 1 Amp 100 V		CR2, CR3
0029	1		70-03071		Suppressor, Transient +5V		CR1
0030	1		70-03302		3 Term Adj. Regulator LM317		VR1
0031	1		70-03154		Crystal 10 MHZ		Y1
0032	1		70-04253		Switch, Pushbutton		SW1
0033	2		70-00700-11		Resistor, Metal Film 237 Ohms 1%		R1, R2
0034	1		70-00314		Resistor, 4.99K Ohms-1/4W 1%		R3
0035	3		70-00042		Resistor, 1K Ohms-1/4W 5%		R4,R7,R8
0036	1		70-00069		Resistor, Carbon Film, 20K Ohms 1/4W 5%		R5
0037	8		70-00510		Resistor, Array, 10 Pin sip, 10K Ohms		RP1-RP4 RP7-RP10
0038	3		70-00511		Resistor, Array, 6 Pin sip, 10K Ohms		RP5,RP11,RP12
0039	1		70-00518		Resistor Network, 6 Pin, 1K Ohms		RP6
0041	4		70-04726		Header 20 Pin		J1, J2, J3, J8
0042	1		70-04727		Conn., Header 20 Pin IDC Rt. Ang.		J4
0043	1		70-04526		Header, 34 Pin		J5

Eureka Progeny Inc.• 1407 Barclay Blvd. •Buffalo Grove, IL 60089

BILL OF MATERIAL

Bill of Material No. 70-08314-1
Rev. C ECN: P0793

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
0044	1		70-04731		Conn., HDR 12 Pin Mini PV Rt. Ang.		J6
0045	1		70-04730		Conn., Header 6 Pin Mini PV Rt. Ang.		J7
0046	1		70-04282		Socket, IC 68 Pin PLCC to PGA		U1
0047	1		70-04279		Socket, IC 44 Pin PLCC to PGA		U30
0048	2		70-04220		Socket, Mach. 40 Pin Dip		U10,U19
0049	2		70-04219		Socket, Mach. 28 Pin Dip		U6, U8
0050	1		70-04283		Socket, Open Frame 24 Pin		U9
0051	4		70-04221		Socket, Mach. 20 Pin Dip		U3,U4,U5,U21
0052	3		70-04281		IC Open Frame Collet Socket 18 Pin		U17,U18,U25
0053	2		70-04217		IC Socket Mach. 16 Pin		U16,U20
0054	9		70-04216		Socket, Mach. 14 Pin Dip		U7,U11,U12,U13, U15,U22,U23,U24, U26
0055	4		70-04222		Socket, Mach. 8 Pin Dip		U2,U27,U28,U29
0056	1		70-04806		Two Circuit Shunt		W1
0057	1		70-04758		2 Pin Header		W1
0058	2		70-00064		Resistor, 10K Ohms, 1/4W, 5%		R6,R9

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BILL OF MATERIAL

Bill of Material No. 70-08316
Rev. G ECN P0719

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
0001	1	B	70-06304		Linear IV Driver Board Fabrication		
0002	1	A	70-03030		Bridge Rectifier	DF02	CR2
0003	16	A	70-03034		Ultrafast Rectifier	MUR105	CR3-CR10, CR12-CR19
0004	6	A	70-02509		Capacitor, Solid Tantalum 35 WVDC	2.2 UF	C27-C32
0005	11	A	70-02010		Capacitor, CER 50V	0.1 UF	C2, C3, C4, C11, C13, C15, C16, C17, C22, C24, C33
0006	2	A	70-02524		Capacitor, ELEC 50V	100 UF	C5, C23
0007	2	A	70-02525		Capacitor, Polyester Film 63V	0.22 UF	C6, C25
0008	7	A	70-02012		Capacitor, CER	0.01 UF	C7, C10, C12, C14, C18, C19, C20
0009	3	A	70-02511		Capacitor, TANT 35 VDC	10 UF	C8, C9, C34
0010	1	A	70-02032		Capacitor, CER	.003 UF	C21
0011	1	A	70-02523		Capacitor, ELEC 50 VDC	47 UF	C26
0012	1	A	70-02011		Capacitor, CER 50 VDC	0.47 UF	C35
0013	1	B	70-04288		Connector, Header 20 Pin		J1
0014	1	B	70-04289		Connector, Header 12 Pin Straight		J2
0015	2	A	70-00511		Resistor Array 6 Pin sip	10 K	RP1, RP4
0016	1	A	70-00518		Resistor Array 6 Pin sip	1 K	RP2

BILL OF MATERIAL

Bill of Material No. 70-08316
Rev. G ECN P0719

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
0017	1	A	70-00501		Resistor Array 8 Pin sip	680	RP3
0018	1	A	70-00018		Resistor, Carbon Film 1/4 W +/- 5%	100	R1
0019	1	A	70-00110		Resistor, Carbon Film 1/4 W +/- 5%	2.2 M	R2
0020	1	A	70-00085		Resistor, Carbon Film 1/4 W +/- 5%	91 K	R3
0021	3	A	70-00079		Resistor, Carbon Film 1/4 W +/- 5%	51 K	R4, R9, R15
0022	1	A	70-00056		Resistor, Carbon Film 1/4 W +/- 5%	4.7 K	R5
0023	4	A	70-00325		Resistor, Carbon Film 1/4 W +/- 5%	1.0	R6, R7, R13, R14
0024	1	A	70-00100		Resistor, Carbon Film 1/4 W +/- 5%	470 K	R8
0025	1	A	70-00070		Resistor, Carbon Film 1/4 W +/- 5%	22 K	R10
0026	1	A	70-00035		Resistor, Carbon Film 1/4 W +/- 5%	510	R11
0027	1	A	70-00030		Resistor, Carbon Film 1/4 W +/- 5%	330	R12
0028	1	A	70-00421		Resistor, Wirewound 3 W +/- 5%	47	R16
0029	3	A	70-03353		Timer 555 8 Pin Dip	LM555	U1, U7, U9
0030	1	A	70-03136		Quad 2-Input NAND Gate 14 Pin Dip	7400	U2
0031	2	A	70-03084		Stepper Motor Controller	L297	U3, U10
0032	2	A	70-03035		Dual Full - Bridge Driver	L298	U4, U11
0033	1	A	70-03043		Opto Coupler/Isolator	MOC3011	U5
0034	1	A	70-03160		I.C. Schmitt Trigger	74HC132	U6
0035	1	A	70-03104		Dual D Flip-Flop	14013	U8

BILL OF MATERIAL

Bill of Material No. 70-08316
Rev. G ECN P0719

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
0036	1	A	70-03303		Voltage Regulator, +5V	7805	U12
0037	3	A	70-03094		Opto Isolator	MCT62	U13, U14, U15
0038	2	A	70-06524		Jumper, Buss Bar, 24 AWG	JMP	W1, W2
0039	1	A	70-00108		Resistor, Carbon Film 1/4 W +/- 5%	1 M	R17
0041	3	A	70-11166		Nut, 6-32 "Thin"		
0042	1	B	70-04778		Heat Sink		U12
0043	6		70-04222		Socket		U1, U7, U9, U13-15
0044	3		70-04216		Socket		U2, U6, U8
0045	1		70-04506		Socket		U5
0046	2		70-04221		Socket		U3, U10
0047	3	A	26-00830		Screw, #6-32 x ¼" Phillips Pan Head		
REF	0	B	70-08315		Schematic, Linear IV Driver Board		
REF	0	B	70-08316		Assembly, Linear IV Driver Board		

Eureka! Progeny Inc.• 1407 Barclay Blvd. •Buffalo Grove 60089

BILL OF MATERIAL

Bill of Material No. 70-08318
Rev. C

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Design
.Ref	0		70-08317		Schematic, Display PCB		
0001	1		70-06305		Linear IV Display PCB Fabrication		
0002	1		70-04733		Right Angle Header		J1
0003	1		70-03353		Timer 555 pin dip	LM555	U1
0004	1		70-03136		Quad 2 – Input Nand gate, 14 pin dip	74LS00	U2
0005	1		70-03087		8 Channel Source Buffer, 18 pin dip	UDN2585	U3
0006	1		70-03086		8 Channel Current Sink Buffer, 18 pin dip	UDN2595	U4
0007	4		70-03088		5 x 7 Dot Matrix: Alpha Numeric Display	2416	DS1-4
0008	8		70-03089		.56" Seven Segment Display	HDSP-5601	DS5-12
0009	1		70-03064		Green LED Light Bar	2855	DS13
0010	1		70-00064		Resistor, Carbon Film, 10 K ohms, ± 5%		R1
0011	1		70-00089		Resistor, Carbon Film, 150 K ohms, ± 5%		R2
0012	2		70-00042		Resistor, Carbon Film, 1 K ohms, ± 5%		R3, 5
0013	1		70-00086		Resistor, Carbon Film, 100 K ohms, ± 5%		R4
0014	8		70-00324		Resistor, Carbon Film 10, ± 5%		R6-13
0015	8		70-02010		Capacitor Ceramic, .1 uF, 50V		C2-7, 10, 11
0016	1		70-02033		Capacitor Ceramic, 150 pF, .50V		C8

Eureka! Progeny Inc.• 1407 Barclay Blvd. •Buffalo Grove 60089

BILL OF MATERIAL

Bill of Material No. 70-08318
Rev. C

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Design
0017	1		70-02511		Capacitor Tant, 10 uF, 35V		C1
0018	1		70-03071		Transorb	MPTE-5	CR1
0019	2		70-03001		Diode 1N914		CR2, 3
0020	2		70-04281		Socket 18 pin dip		U3, 4
0021	1		70-04216		Socket 14 pin dip		U2
0022	1		70-04222		Socket 8 pin dip		U1
0023	4		70-04754		Socket Sip 10 pin		DS5-8
0025	1		70-04501		Socket 8 pin		DS13
0026	1		70-00014		Resistor Carbon Film, 68 ohm, ± 5%		R14
0027	1		70-04220		Socket, 40 pin machined		DS9-12
0028	8		70-04586		Socket, Terminal Strip		DS1-4

Eureka! Progeny Inc.• 1407 Barclay Blvd. •Buffalo Grove 60089

BILL OF MATERIAL

Bill of Material No. 70-08320
Rev. A

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Design
.Ref	0		70-08319		Schematic, Master Board		
0001	1		70-06306		Master PCB Fabrication		
0002	2		70-03201		Transistor – Arrays	ULN20004	U1, 5
0003	1		70-03041		Opto-coupler	MCT2	U2
0004	2		70-03119		Hex Buffer	7407	U3, 15
0005	1		70-03158		Encoder 8 to 3 line	74LS148	U4
0006	1		70-03138		Hex Inverter	7406	U6
0007	1		70-03159		Decoder 2 to 4 line	74139	U7
0008	1		70-03087		Source Driver	UDN2585	U8
0009	4		70-03351		Dual Op Amp	LM358	U9, 12-14
0010	1		70-03352		Dual Comparator	LM393	U10
0011	1		70-03355		Dual Op Amp	LF442	U11
0012	1		70-00056		4.7 K, 5% Resistor		R1
0013	7		70-00064		10 K, 5% Resistor		R2-4, 21, 34, 43, 54
0014	1		70-00220		390 ohms, ½ w Resistor		R6
0015	5		70-00018		100 ohms, 5% Resistor		R7, 8, 10, 52, 63
0016	1		70-00045		1.5 K, 5% Resistor		R9

BILL OF MATERIAL

Bill of Material No. 70-08320
Rev. A

0017	7		70-00042		1K, 5% Resistor		R11, 23, 24, 29, 33, 64, 65
0018	9		70-00010		47 ohms, 5% Resistor		R12-20
0019	3		70-00048		2.2 K, 5% Resistor		R22, 42, 53
0020	3		70-00314		4.99 K, 5% Resistor		R25, 30, 31
0021	2		70-00700-1		2.00 K, MF Resistor		R26, 28
0022	1		70-00108		1M, 5% Resistor		R27
0023	14		70-00700-7		100 K, MF Resistor		R32, 35-41, 47, 49, 50, 56, 60, 61
0024	2		70-00700-11		237 MF Resistor		R44, 45
0025	6		70-00700-6		33.2 K, MF Resistor		R45, 48, 51, 57, 58, 62
0026	2		70-00700-5		10.0 K, MF Resistor		R46, 59
0027	1		70-00515		1K, 8 pin sip Bussed		RP1
0028	1		70-00517		390 ohms, 8 pin sip Bussed		RP2
0029	1		70-00516		10 K, 8 pin sip Bussed		RP3
0030	1		70-02516		Elec Cap 2200 uF		C1
0031	1		70-02510		Tant Cap 100 uF		C3
0032	3		70-02511		Tant Cap 10 uF		C4, 5, 15
0033	1		70-05223		Elec Cap 47 uF		C6

BILL OF MATERIAL

Bill of Material No. 70-08320
Rev. A

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Design
0034	16		70-02010		Cer Cap .1 uF		C7-13, 16-23, 26
0035	1		70-02514		Tant Cap 4.7 uF		C14
0036	2		70-02509		Tant Cap 2.2 uf		C24, 25
0037	2		70-03032		Bridge Rect.		CR1, 9
0038	5		70-03012		Diode	IN4002	CR2-5, 15
0039	1		70-03071		5V Rect.	MPTE5	CR6
0040	2		70-03069		15V Rect.	MPTE15	CR7, 8
0041	3		70-03301		LM113		CR10, 16, 18
0042	4		70-03001		Diode	1N4148	CR11-14
0043	2		70-03021		Zener	IN750	CR17, 19
0044	2		70-04016		Relay	Type 603	K1, 4
0045	2		70-04015		Relay	Type 683	K2, 3
0046	1		70-04001		Relay 24v	4PDT	K5
0047	1		70-04002		Relay Socket		K5
0048	1		70-04003		Retaining Clip		K5
0049	1		70-04605		Fuse	3A	F1
0050	2		70-04635		Fuse Holder		F2

BILL OF MATERIAL

Bill of Material No. 70-08320
Rev. A

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Design
0051	1		70-03402		Trans.	2N2222	Q1
0052	2		70-03401		Trans.	2N2905	Q2, 3
0053	1		70-04521		22 Position Header		TS5
0054	5		70-04535		15 Position Header		TS1-4, 6
0055	1		70-04748		6 Pin Header		J1
0056	1		70-04506		6 Pin Socket		U2
0057	4		70-04217		16 Pin Socket		U1, 4, 5, 7
0058	1		70-04281		18 Pin Socket		U8
0059	3		70-04216		14 Pin Socket		U3, 6, 15
0060	6		70-04222		8 Pin Socket		U9-14
0061	2		70-04758		2 Pin Header		W1, 2
0062	2		70-04806		Two Circuit Shunt		W1, 2
0063	4		70-04595		Jack, Test		TP1-4

Eureka Progeny Inc.• 1407 Barclay Blvd. •Buffalo Grove, IL 60089

BILL OF MATERIAL

Bill of Material No. 70-08355
Rev. B

ITEM NO.	QTY	DWG SIZE	PART NO.	ITEM CLS	DESCRIPTION	Vendor Part No.	Ref. Designator
.Ref	0	B	70-08354		Schematic, Pausch URO Interface PCB		
0001	2	A	70-02524		Capacitor, Aluminum 63 VDC	100 uF	C1, C2
0002	1	A	70-02511		Capacitor, Tantalum 35VDC 10%	10 mF	C3
0003	4	A	70-03012		Rectifier, 1 Amp	1N4006	D1 - D4
0004	1	A	70-04521		Header, 22 Position Terminal Strip		J1
0005	2	B	70-04014		Relay, DPST Miniature Sealed, 12 VDC	DS2E-M-DC2	K1, K4
0006	2	A	70-04006		Relay, 4PDT 12 VDC	DS4E	K2, K3
0007	4	B	70-00654-3		Potentiometer, 25 Turn	5 K	R1 - R4
0008	1	A	70-04201		Dip Switch, 4 SPST	CST-206-4	SW1
0009	1	A	70-04778		Heat Sink		U1
0010	1	B	70-06315		Fabrication, Pausch URO Interface PCB		
0011	1	A	70-03305		12V 3 Term. Pos. LM340-12 7812		