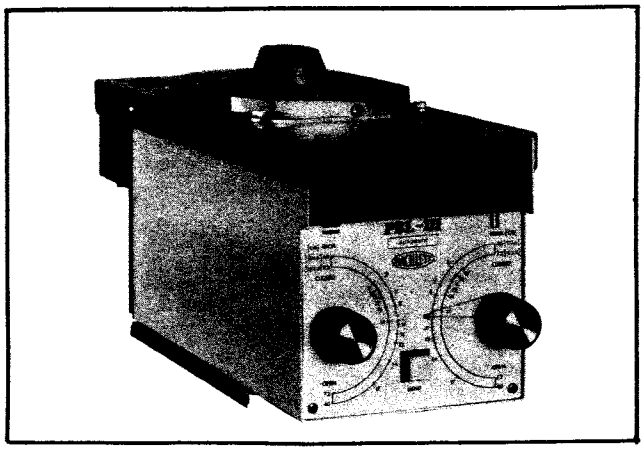
MACHLETT

TECHNICAL MANUAL ST-3631

PBL-III
automatic collimating system



INTRODUCTION

This fully automatic collimating system, designed for use with general purpose radiographic tables, is the cost-effective answer for the busy private practice - in fact it is equally at home in any environment - institutional or non-institutional - where the highest patient throughput consistent with low cost is required. Operating at the most commonly used SID's (40" vertical and both 40" and 72" horizontal), this system also offers continuous size-sensing capability for all standard and metric size cassettes, ensuring compatibility with a wide variety of buckys and cassette trays in addition to the tray supplied.

Two versions of this collimator are available:

- PBL-III 150 - used with x-ray tubes having normal inherent filtration levels, typically below 1.0 mm;
- PBL-III 150LF - used with x-ray tubes having high inherent filtration.

Both provide motorized PBL in accordance with DHHS' regulations[1], and use a time-proven circuit to assure high reliability and serviceability. While suitable for both separate and integrated table/tube-stand applications, they are NOT for applications employing independently tilting tables, mammographic/tomographic procedures, and ceiling tube supports which require longer interconnecting cables than standard.

Designed to mount to the housing port boss or tube support plate, these collimators are compatible with most x-ray tube units. Refer to Machlett compatibility data.

For greater versatility and rapid procedure changes, an accessory track is provided which accepts the full line of Machlett slide-mount accessories.

DESCRIPTION

This collimating system is composed of these units:

- PBL-III collimator (with mounting kit);
- logic unit (with interconnecting cables)
- Liebel-Flarsheim Standard continuous cassette size-sensing tray and installation kit; and
- system power supply for logic unit and projection lamp.

The stylish modern enclosure is constructed of double steel walls, the outer wall lined with lead for x-ray protection, while maintaining a compact size for easy positioning. Two pairs of motorized shutters, mechanically coupled to the front panel dials, limit the x-ray field size.

A unique wedge-shaped filter, part of a retractable mirror/filter assembly, provides uniform filtration. To allow inspection of the x-ray tube target, this assembly can be quickly flipped out of the beam by means of a screwdriver inserted into an externally accessible slot, eliminating the necessity of disassembling or removing the collimator.

For simple, convenient alignment, a high intensity lamp projects a light field and a bucky light line. The light field is coincident with the x-ray field, with well defined edges for visual sizing, and a cross-hair pattern, projected onto the diagnostic area, allows easy centering. The bucky light line provides a narrow beam for longitudinal centering of the bucky cabinet.

A quickly removable rear cover on the collimator allows fast replacement of the projection lamp, and readily accessible adjustment points allow convenient alignment.

A measuring tape is available that mounts on the enclosure for convenient, precise measurement of the SID.

A Liebel-Flarsheim standard duty size sensing cassette tray, offering continuous sizing capability, is supplied. This tray may be used for either upright or table operation, and is equipped with a cassette support block for positive cassette location when used in an upright cabinet. A rugged Heavy Duty tray is also available. This tray is interchangeable with the standard duty tray and should be selected where heavier duty usage is required.

Table or upright operation is selected by loading the film cassette and pointing the collimator towards the desire image receptor. A compatible size sensing wall cassette holder may be substituted for the upright bucky.

The logic unit and power supply mount separately. This modular design uses plug-in cabling, minimizing field installation time. The logic board functions as the central control element in the system, receiving input signals from SID monitors and image receptors, then processes these signals and drives the front panel lamps to assist the operator in setting the shutters. Plug-in integrated circuits mount on a hinged board for replacement in the field to isolate faults. A single cable between the logic unit and the collimator simplifies wiring and provides a neat appearance.

An exposure interlock circuit connects to the x-ray generator to prevent exposures until all controls are properly set, and a lamp timer circuit limits the ON time of the projection lamp to conserve lamp life and help prevent overheating.

An X-ray Field Limitation System Failure keyswitch can place the system in a manual mode to ensure uninterrupted service in the event of an electronic failure. See CABLING DATA.

EQUIPMENT COVERED

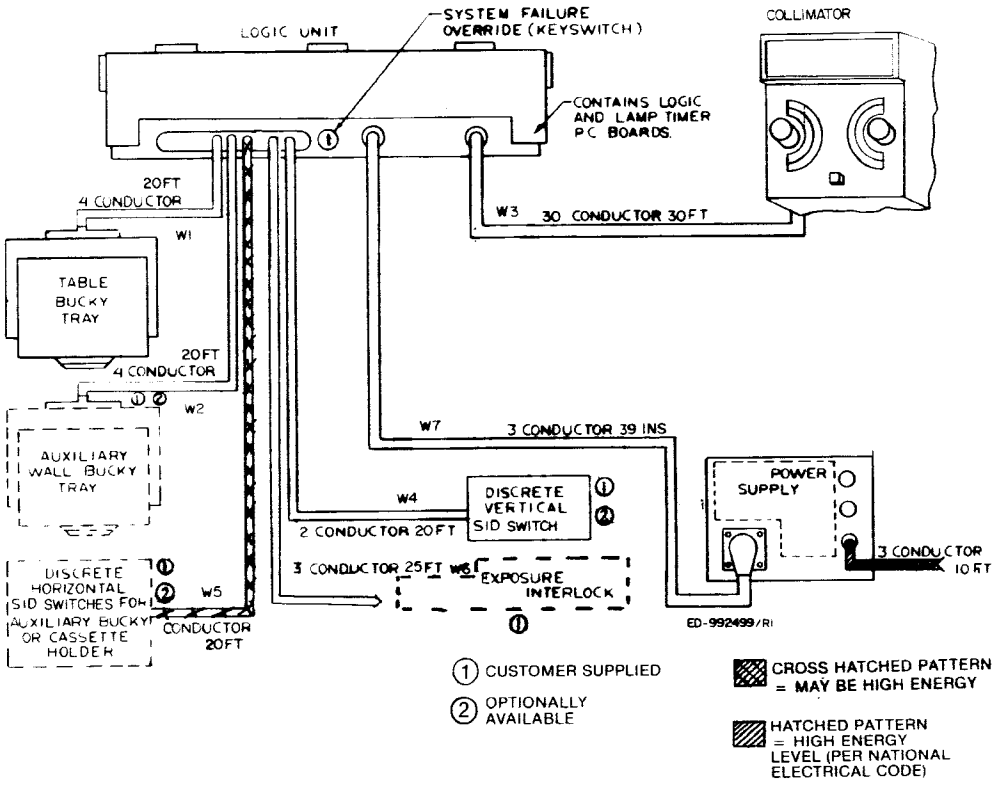
Refer to PARTS LIST to determine the model number and serial number covered by this manual.

SPECIFICATION

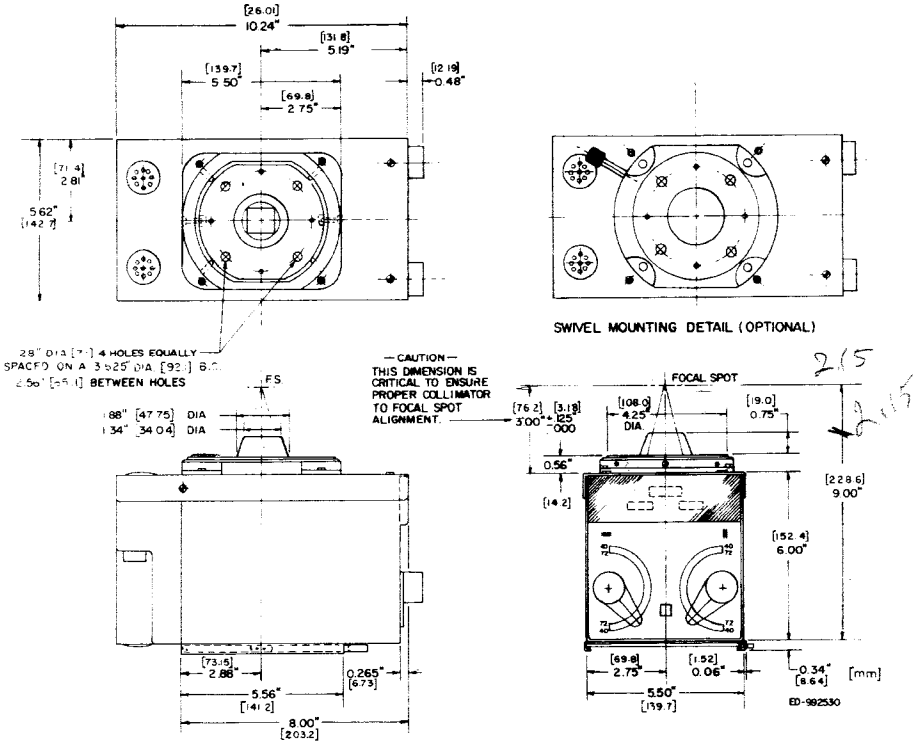
Operation:	either automatic (positive beam limiting); or manual
Cycle time:	1 second (typical) 2 seconds (maximum) smallest to largest film size
Projected x-ray field:	square or rectangular pattern
Film coverage range:	continuously variable from closed to 17" x 17" at 36" SID
SID's for positive beam limiting -	
vertical:	discrete @ 40"
horizontal:	discrete @ 40" and 72"
Indicator dial accuracy:	Corresponds to x-ray field size within 2% of the SID
X-ray field accuracy:	When READY lamp activates, length and width of x-ray field correspond to image receptor dimensions within 2% of source-image distance (4% for the sum of length and width errors)
Repeatability:	within 1% of SID used
Bucky light line alignment:	light line can be centered to x-ray field centerline within 1% of the SID
Light field to x-ray field accuracy:	corresponds to x-ray field size and centering within 2% of the SID
Light field edge contrast ratio:	4:1
Radiation shielding:	For use with equipment rated to 150 kVp
Rayproofing (leakage radiation):	less than 25 mR/hr at one meter from focal spot of x-ray tube, measured at 150 kVp at 4 mA
Inherent filtration: (aluminum equivalent at 70 kVcp and above)	
PBL-III 150:	2.0 mm (minimum)
PBL-III 150 LF:	1.0 mm (minimum)
Projection lamp -	
type:	FCS quartz iodide (Norelco)
power:	150 W
voltage:	24 volts (nominal)
base:	2-prong plug-in
socket:	GE QCS-2
Light output:	more than 15 foot-candles at one meter (40") (complies with **DHHS** regulations[1])
Projection lamp timer:	times out after 25 ± 10 seconds
Fuses -	
logic board:	(2) 3AG type 3 Amp
power supply:	(2) 3AG type 3 Amp (slowblow)
Power requirements:	120 VAC 50/60 Hz @ 3 Amp
Exposure interlock:	isolated form C contacts rated at 2 Amps @ 120 VAC (resistive load)
Weight -	
collimator:	18.5 pounds
logic unit:	8.0 pounds
Mounting:	See OUTLINE DATA
Spacers supplied	
1/4 (0.25) inch:	1 each
1/16 (0.0625) inch:	3 each

[1]**Regulations for the Administration and Enforcement of the Radiation Control for Health and Safety Act of 1968, enforced by DHHS through the Bureau of Radiological Health.**

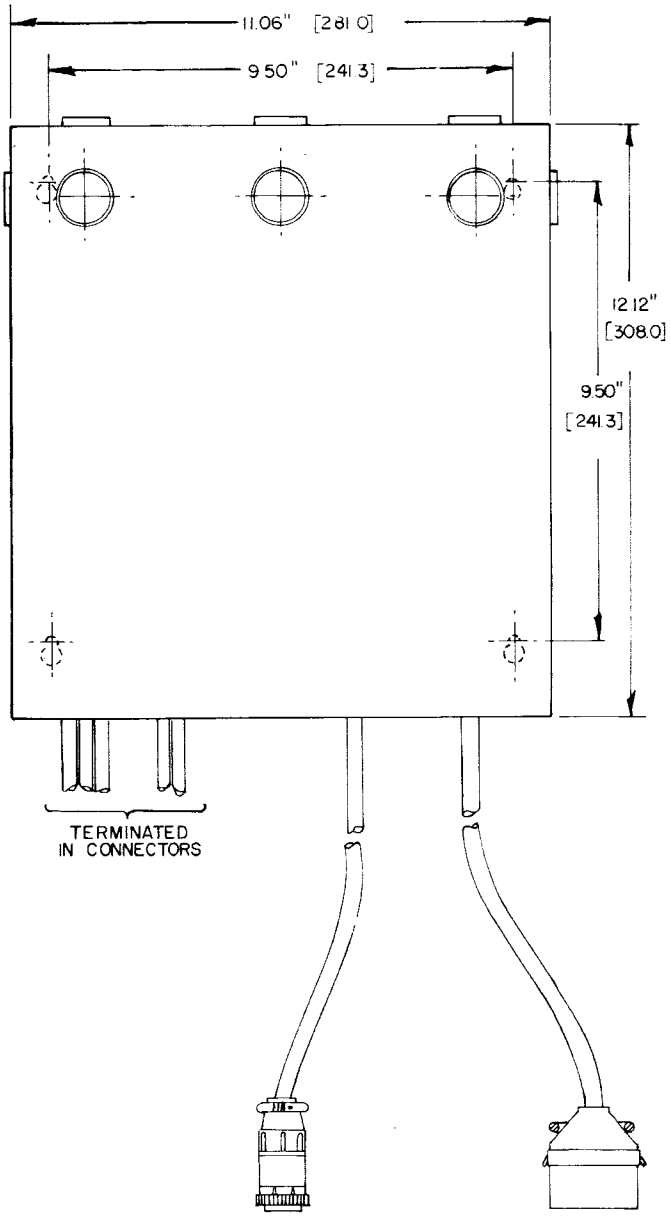
CABLING DATA



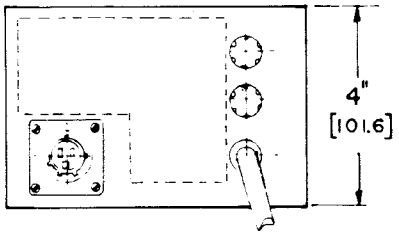
OUTLINE DATA

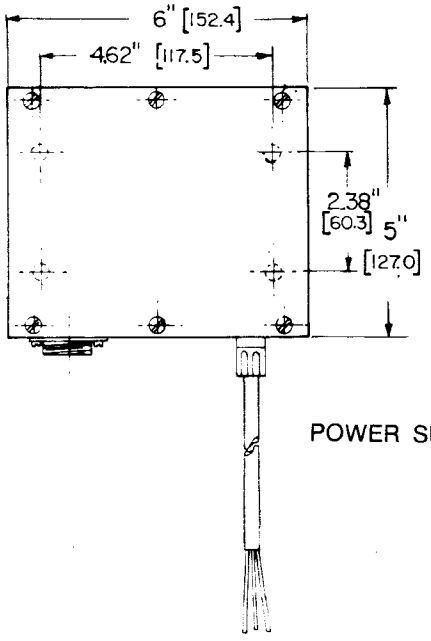


OUTLINE DATA

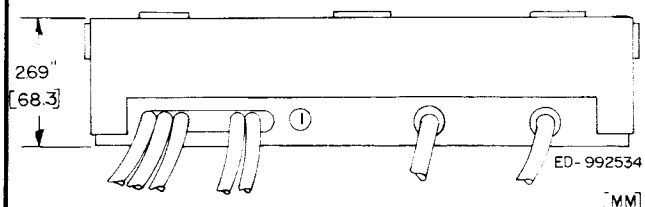


I.C. LOGIC UNIT





POWER SUPPLY



ED-992534

[MM]

You Have Legal Obligations

Those who manufacture and assemble:

- any manufactured or assembled product capable of emitting electronic product radiation; and
- any component affecting that emitted radiation are subject to **DHHS** regulations'.

Any person assembling, repairing or replacing one or more certified products into an x-ray system must follow the instructions of the original manufacturer(s) and file the required **DHHS** ' assembly reports.

Failure to follow the manufacturer's instructions, or modification of any component by user or assembler which will affect radiation safety, causes the user or assembler to assume full responsibility for that product.

The manufacturer is required to prescribe maintenance information and a schedule of performance to ensure equipment complies with specified parameters. After installation the assembler/installer must supply manufacturer's data (including this manual) to the equipment purchaser. The equipment purchaser must follow maintenance instructions.

INSTALLATION

2-1 UNPACKING

Carefully unpack the equipment and check for visible damage incurred during shipment. Any damage should be referred to the agency that delivered the equipment. Verify all contents against the packing list and collect published data for further reference.

NOTE

The plastic window on the bottom side of the collimator is fragile. Do not remove the protective plate until instructed to do so.

The hardware supplied can be checked against the Parts List of this manual. (Interconnecting cables are already prewired to the logic unit.)

Hardware for the cassette tray installation is listed in the PARTS LIST.

2-2 MOUNTING

Spacing between the collimator top cover plate and focal spot is CRITICAL. See OUTLINE DATA. Use spacers as required. Two types of mounts are available:

- non-swiveling mount
- optional swivel mount

2-3 SPECIAL EQUIPMENT FOR INSTALLATION OF COLLIMATOR

- non-swiveling mount — .094" hex key (Allen) wrench with at least 2.75" [70 mm] straight length is recommended so that full turns of each center adjustment set screw can be made without removing the wrench from the screw.
- swivel mount - a ¼ inch open-end wrench is required to adjust the swivel mount retaining screws.

2-4 COLLIMATOR MOUNTING (NON-SWIVEL MOUNT)

Collimator mounting involves removing the inner ring from the collimator, fastening the inner ring to the x-ray tube port boss, and fastening the collimator to the inner ring assembly.

1. Remove inner ring from top of collimator by loosening the two safety screws and four center adjustment set screws located around the periphery of the outer ring.

NOTE

The inner ring of the mount has a factory-assembled lead barrier that should not be removed.

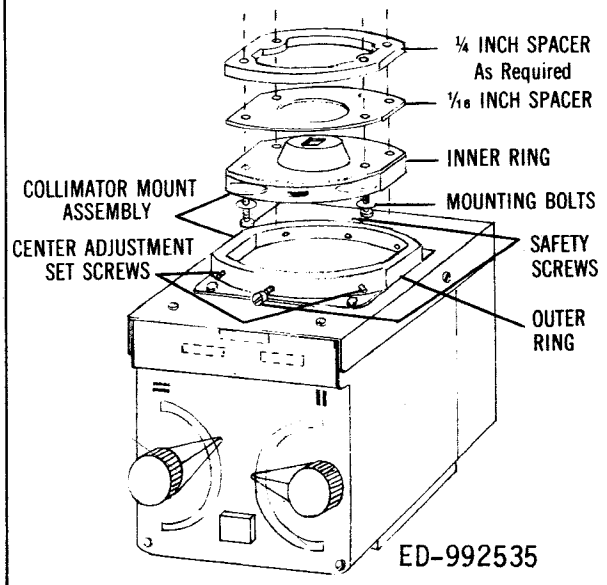
2. Select the spacers and mounting bolts necessary to conform to the critical dimension (see OUTLINE DATA). Use proper length bolts to ensure that at least 5 threads are engaged in tapped holes of port boss or adapter plate.

NOTE

For convenience, trunnion ring mounted tube housings may be rotated upward to facilitate mounting of spacer(s) and inner ring.

3. Attach inner ring (lead side up) to either housing port boss or tube support arm, with appropriate spacer inserted. Use lock washers. TIGHTEN SCREWS SECURELY.
4. Thread rear safety screw in about .25" [6.3 mm], leaving front screw flush with inside of outer ring. The centering adjustment set screws should be threaded so that their points are just flush with inside of outer ring.
5. Lift collimator up to the installed inner ring (rear section first), fit outer collimator mounting ring over inner ring and hook rear safety screw into inner ring rear slot.
6. While still supporting collimator, thread front safety screw in, then tighten both front and rear safety screws. The collimator is now supported in place.
7. Center the collimator in mount by first rotating slightly (to square it with tube unit and tabletop cen-

COLLIMATOR MOUNTING NON-SWIVEL MOUNT



terline). Thread four Allen set screws in equally, visually keeping equal spacing between outer and inner rings on all sides of collimator.

8. Inspect installation and verify that collimator is mounted correctly and is safely installed. Tighten screws.
9. Remove the protective plate that guards the plastic window by sliding it off the accessory track.
10. Collimator is installed and ready for ALIGNMENT.

2-5 COLLIMATOR MOUNTING (SWIVEL MOUNT)

CAUTION

OBSERVE MINIMUM CLEARANCE DIMENSION TO ENSURE THAT COLLIMATOR ENTRY BARRIER IS NOT DAMAGED WHEN COLLIMATOR IS MOUNTED TO TUBE. (LEAD DIAPHRAGM OR CONE IN SOME TUBES MUST BE REMOVED OR MODIFIED IN ACCORDANCE WITH MANUFACTURERS' INSTRUCTIONS). SEE OUTLINE DATA.

1. Remove swivel mounting neck from top of collimator by removing the four outer ring mounting screws.

NOTE

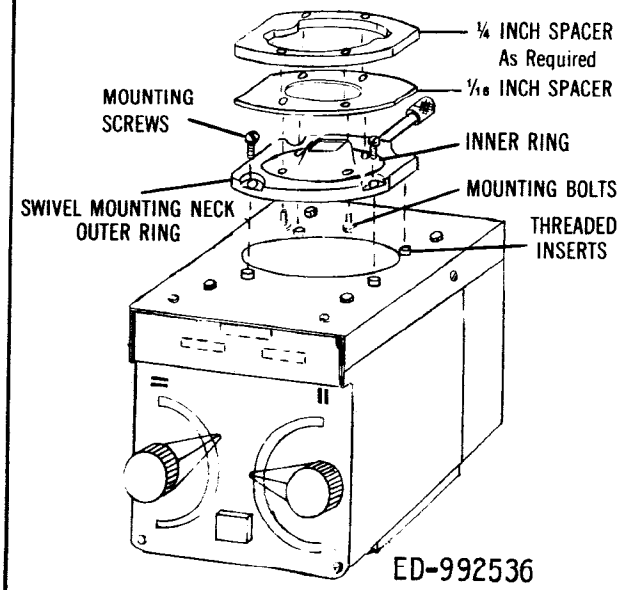
The inner ring of the mount has a factory-assembled lead barrier that should not be removed.

2. Select the spacers, lockwashers and mounting bolts necessary to ensure that the proper collimator to focal spot distance is maintained. (See OUTLINE DATA). Use proper length bolts (with lockwashers) to ensure that at least 5 threads (¼ inch) are engaged in tapped holes of port boss or adapter plate.

NOTE

For convenience, trunnion ring mounted tube housings may be rotated upward to facilitate mounting of spacer(s) and inner ring.

COLLIMATOR MOUNTING SWIVEL MOUNT



3. Attach swivel mounting neck to port boss of x-ray tube housing using four Fillister Head screws and split lockwashers.
4. Reinsert the four outer ring mounting screws into the counterbored holes.
5. Lift the collimator to the swivel mounting neck and engage the four mounting screws into the four threaded inserts.
6. Securely tighten the four screws using a ¼-inch wrench.
7. Check the installation thoroughly for safe and proper mounting.
8. Remove the protective plate that guards the plastic window by sliding it off the accessory track.

2-6 LOGIC UNIT MOUNTING

The logic unit is designed to mount in various installation configurations; however, DO NOT LOCATE logic unit:

- where dirt, moisture or other foreign materials are present;
- in an area of high electrical interference (autotransformers, contactors, motor start cables, locks, etc.);
- in an area which is heated by other apparatus;
- in a manner which prevents convection cooling.

The Logic Unit MUST be located;

- so that the keyswitch is accessible in case of an emergency or for servicing.
- out of range of the primary x-ray beam
- in a manner which allows one of the ventilation holes to be at the highest point of the mounted logic. The cable entrances will therefore be on the side or bottom of the upright logic unit, never on the top.
- in an area where surrounding air is at normal room temperature.

It is recommended that the logic unit be located in the x-ray room as close to the x-ray source/receptor as practical. This permits calibration and maintenance to be performed by one person. Locations distant from the source/receptor require two persons to perform maintenance and calibration; one to perform the procedure and one to observe the results.

Since the chassis of the logic unit is used as the template for mounting, the circuit board should be removed or positioned to avoid damage during this procedure as follows:

1. Remove cover of logic unit;
2. Remove the four screws in the logic board (opposite the connector).
3. Hinge up the board to a comfortable angle, and twist a large screwdriver blade between each corner of the board and the mating connector, until the board is free.
4. Safely store logic board until logic unit is mounted, then follow these steps in reverse order to reassemble logic unit.

Use the chassis as a template. Locate it in its final position and mark the full outline of four key-slots on the mounting surface. Drill the mounting surface and securely mount, using suitable hardware. After fastening in place with the screws located in the small area of the slot, test the security of the mount. If it is likely that the chassis can slide beneath the screw heads, locate two extra screws in the large area of two of the key-slots to prevent loosening.

CAUTION

DO NOT SUPPLY POWER TO THE UNIT WHEN MOUNTING THE CHASSIS.
DO NOT UNDER ANY CIRCUMSTANCES SUBSTITUTE OTHER THAN LABELED FUSE VALUES OR TYPES FOR ORIGINAL EQUIPMENT.

When choosing a location for installation, cable lengths must be considered. In addition, input power must be obtained from a source which will only provide power when the x-ray control is turned on and when the attached x-ray tube is selected.

Measured line voltage AC-60 Hz	Connect to this tap on power transformer
111 - 122	115
122 - 134	125

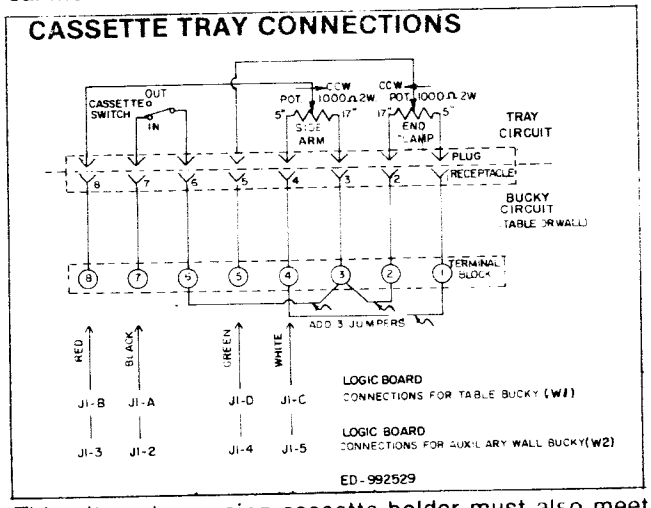
The power transformer has two line input taps, one must be selected depending on the measured line voltage. If the line voltage is less than 122 VAC, the wire remains on the 115 tap. If the line voltage exceeds 122 VAC, the wire should be reconnected to the 125 tap. This step is important in prolonging the life of the collimator lamp.

Verify that a minimum of 21.0 VAC is obtained at the projection lamp pins (with lamp ON).

2-7 CASSETTE TRAY INSTALLATION

Installation is accomplished according to the instructions packed with the cassette tray. This system utilizes a LIEBEL-FLARSHEIM size sensing cassette tray. This cassette tray contains a switch and two potentiometers to signal the presence and dimensions of a cassette. This cassette tray, and the system will accept all cassette sizes from 5 inches through 17 inches or metric equivalents.

All cassette holders used with this system must provide these signals. In addition, any cassette holder that will not accept all cassette sizes from 5 through 17 inches must reject the unaccepted cassette through mechanical means.



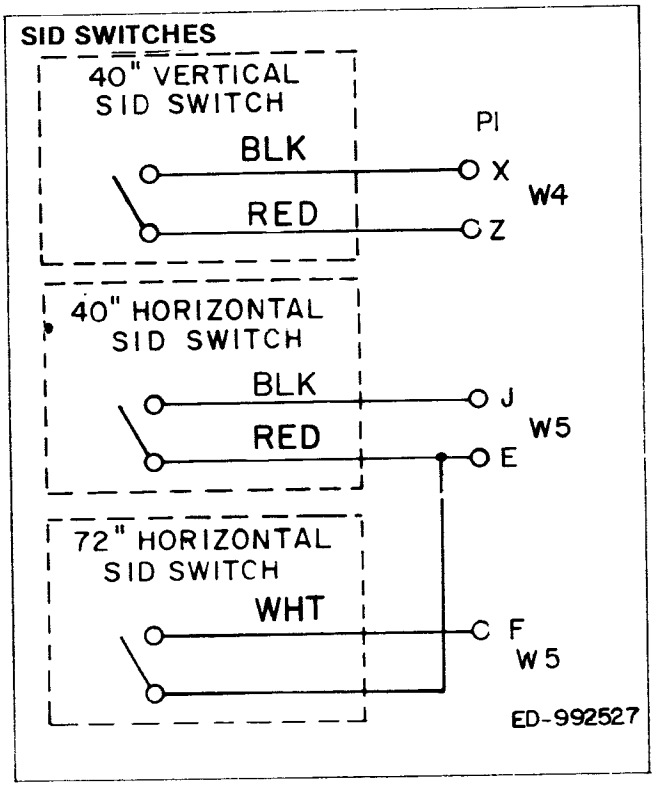
This alternate sensing cassette holder must also meet the following requirements:

- When any size cassette is located in the cassette holder, voltage signals must be produced with values as shown in Table 3-1 for both cross-table and long-table dimensions.
- If a resistive-divider is intended to be connected to the 2.07 v.d.c. source in the logic the maximum allowable load must be 500 ± 20 ohms and connected in an identical manner as the LIEBEL-FLARSHEIM cassette tray.

It is essential that the alignment procedures and lubrication schedule be followed as detailed in the instructions provided with the tray. In addition, it is important to form the pins and leads in the rear of the receptacle in a manner that retains the "floating" action designed into the receptacle. It is also essential that the receptacle and plug not be allowed to fully seat; as instructed, 1/32 inch of insertion distance must remain when the cassette tray is firmly against its mechanical limits. The cassette tray must be adjusted, according to the instructions supplied, to eliminate side-play of the tray in the guide-tracks of the Bucky (or equiv.)

While the alignment guides aid the on-center alignment, they will not compensate for improper installation or inadequate initial alignment of the receptacle. The cassette tray insertion is frequently handled with varying amounts of force, and with the combined tray/cassette weight, the receptacle will fail in a short time if not properly installed.

Finally, jumpers must be added to the terminal block on the bucky cabinet. See CASSETTE TRAY connections.



2-8 UPRIGHT CASSETTE TRAY INSTALLATION

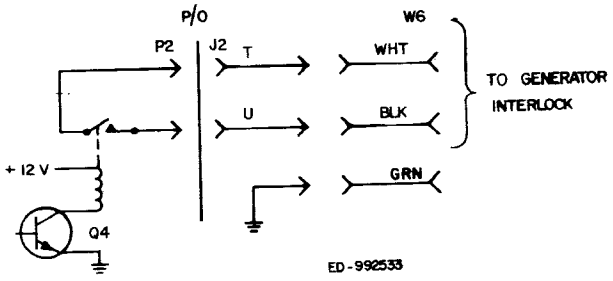
If a wall-mounted cassette tray or automated wall-cassette holder is to be used with the system, its location relative to the collimator must be identified and a jumper must be added to the main logic board. Locate the three grouped terminal pins (labeled "a", "C" and "D") between K6 relay and the fuse-block:

Jumper "a" to "C" IF:
the cassette tray or holder location requires the collimator to be aimed toward the right side of the room (mirror/filter knob up).
Jumper "a" to "D" IF:
the cassette tray or holder location requires the collimator to be aimed toward the left side of the room (mirror/filter knob down).
Only one jumper is to be used.

Refer to CASSETTE TRAY INSTALLATION for further details.

2-9 EXPOSURE INTERLOCK WIRING

A contact of the Exposure Interlock Relay, K5, closes when x-ray production is permitted.



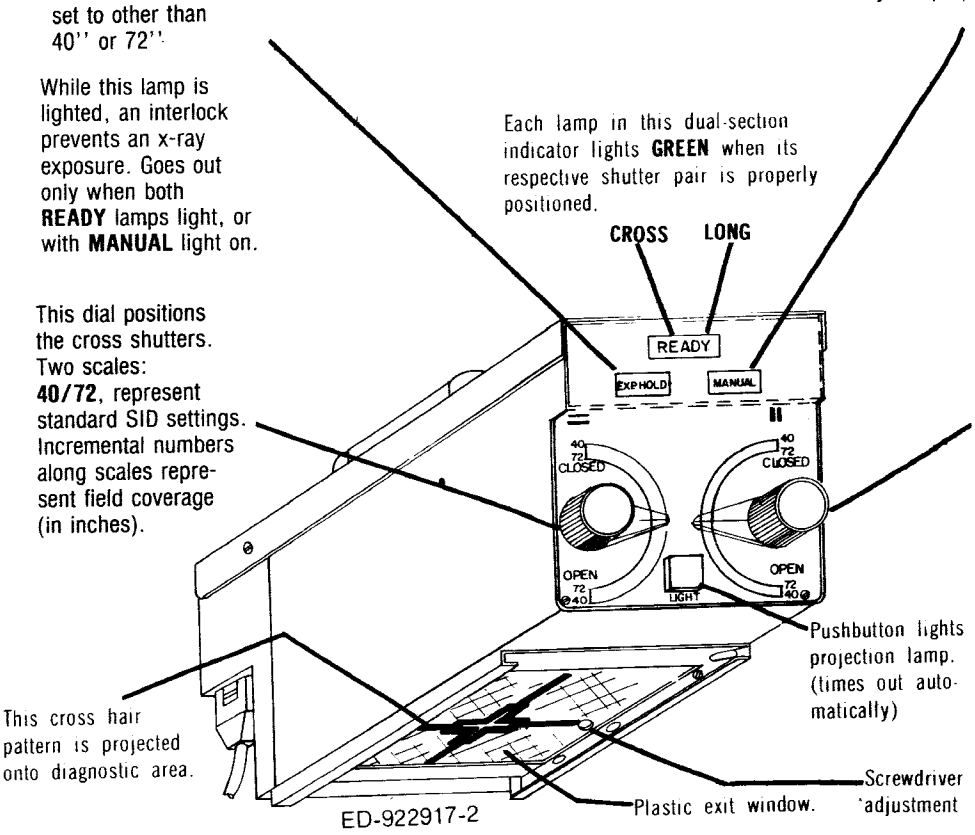
OPERATION

Remains lighted **RED**:
- until shutters are correctly positioned:
- when vertical SID is set to other than 40''
- when horizontal SID is set to other than 40'' or 72''.

Lights **AMBER** when:
- tube/collimator assembly is tilted more than 10° from vertical or horizontal;
- film is not in holding device;
- cassette tray not properly inserted in cabinet.

While this lamp is lighted, an interlock prevents an x-ray exposure. Goes out only when both **READY** lamps light, or with **MANUAL** light on.

Each lamp in this dual-section indicator lights **GREEN** when its respective shutter pair is properly positioned.



This dial positions the cross shutters. Two scales: **40/72**, represent standard SID settings. Incremental numbers along scales represent field coverage (in inches).

This dial positions the long shutters. Two scales: **40/72**, represent standard SID settings. Incremental numbers along scales represent field coverage (in inches).

Pushbutton lights projection lamp. (times out automatically)

This cross hair pattern is projected onto diagnostic area.

Screwdriver access hole for mirror angle adjustment

Plastic exit window.

ED-922917-2

TYPICAL OPERATING SEQUENCE

- Set x-ray generator to desired exposure technique factors.
- Center x-ray tube and collimator assembly over the area to be examined.
- Depress LAMP pushbutton to project light field.

AUTOMATIC OPERATION
(Positive Beam Limiting)

- Center the cassette into the Bucky tray and clamp into position.
- Using Bucky light line to position Bucky cabinet, insert tray into the Bucky cabinet. The EXP. HOLD indicator lights and the shutters open until the x-ray field size is larger than the image receptor size. The shutters then close until the image receptor size is reached. Both halves of the READY indicator light, allowing an exposure.
- The collimator is now set.
- The shutter dials can be adjusted to further reduce the x-ray field size.

MANUAL OPERATION

- Using the light field as a guide, set the CROSS and LONG shutter dials to cover either the x-ray image receptor OR the anatomical area of interest, whichever is smaller.
- The collimator is now set.

3-1 ELECTRONIC SYSTEM ADJUSTMENT PROCEDURES

Refer to GLOSSARY at end of manual (p.33).

To prevent the collimator shutters from being overdriven and forced against the mechanical limits, the following voltages must be set to the required values. These adjustments are to be completed prior to producing radiation exposures for alignment purposes and include:

- adjustment of x-ray field base voltage
- calibration of VSIDL voltage
- calibration of Horizontal Discrete SID Voltages (VSIDC)
- adjustment of voltage applied to the cassette tray
- determination of cassette size/voltage accuracy
- collimator potentiometer checkout and adjustment
- determination of x-ray field accuracy

The following items are required to complete the ELECTRONIC SYSTEM ADJUSTMENT PROCEDURES.

item	description (or equivalent)
digital voltmeter (DVM)[1]	Weston model 4442
special test leads for DVM[2]	small diameter probes
pencil-type soldering iron[3]	small tip (1/8" diameter)
pocket calculator[4]	8-digit, full function, floating decimal
jeweller's screwdriver	

[1] minimum display of 3-1/2 digits (1999 counts) with a maximum inaccuracy of 0.1% of reading ± 1 digit, and input impedance of 10 megohms (minimum)

[2] large blunt probes could cause shorts or damage components

[3] wattage range of 20-40 watts to prevent overheating (used only for troubleshooting)

[4] to save time in calculations of measured data

3-2 ADJUSTING X-RAY FIELD BASE VOLTAGE (VBXF)

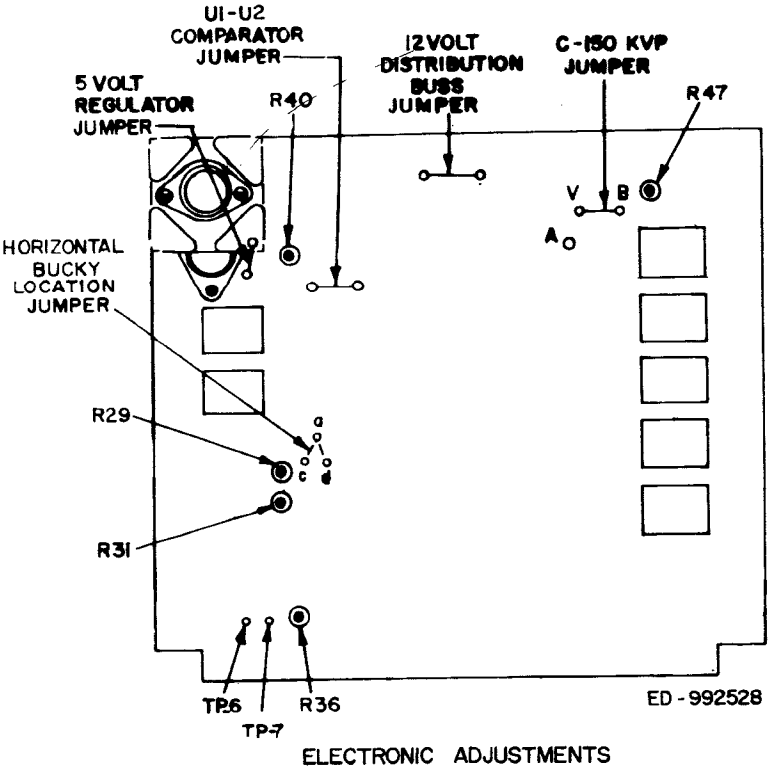
1. Set the x-ray beam angulation to a vertical direction within 2°.
2. Check that the cassette size sensing tray (Bucky) is set within 2° of horizontal.
3. Remove the motor drive relays (K1, K2, K3 and K4) from the Main Logic Board.
4. Disconnect the multiple pin connector P3 from the collimator or remove the wire from J2-W.
5. Measure the voltage from J2-W, or Terminal No.15 on P3, to ground.
6. Set voltage at J2-W to 0.347 ± 0.005 volt using R47. (See LOGIC ADJUSTMENTS for location of adjustment points).
7. Replace the multiple pin plug on the collimator or reconnect wire to J2-W. (Do not replace relays).

3-3 CALIBRATION OF VSIDC AND VSIDL VOLTAGES

Note

Relays K-1 through K-4 on the main logic board must be removed.

1. Set the source-image distance to 40 ± 1/8 inches (measured) and check that the VSIDC voltage at TP-6 is 4.58 ± 0.02 volts. Adjust R29 as required.
2. Measure the VSIDL voltage at TP-7 on the main logic board.
3. Adjust the voltage at TP-7 to 4.21 ± 0.02 volts using R36 on the main logic board.
4. Steps 1-3 may have to be repeated until both values are obtained, as some interaction exists.
5. Replace relays K1 through K-4 on the main logic board.



ELECTRONIC ADJUSTMENTS

3-4 CALIBRATION OF HORIZONTAL DISCRETE SID VOLTAGES (VSIDC)

Perform the following calibration at the two horizontal distances of 40 and 72 inches.

Note

Relays K-1 through K-4 on the main logic board must be removed.

1. Set the x-ray beam angulation to a horizontal direction within 2°. Set the image receptor holder (e.g. Wall Bucky) to the vertical position within 2°.
2. Set the collimator/X-ray tube at an SID of 40 ± 0.25 inches away from the film plane in the image receptor holder (measured only).
3. Check that the Horizontal 40" SID switch is activated.
4. **Measure the VSIDC voltage at TP-6 on the logic board. It should read 4.58 volts as set in CALIBRATION OF VSIDL VOLTAGE.**
5. Repeat previous steps for the 72" horizontal SID. Adjust voltage at TP-6 to 7.60 ± 0.02 volts using R31 on the main logic board.
6. Replace relays K1 through K4 at the completion of all adjustments.

3-5 ADJUSTMENT OF CASSETTE TRAY VOLTAGE (VCT)

Note

In order to set the VCT (voltage applied to the cassette tray), the following conditions must be established:

- Collimator/x-ray beam directed vertically (within 5°)
- Cassette accurately centered and clamped in the cassette tray.
- Tray plugged-in (inserted all the way).

1. **With the above three conditions established, measure the voltage at the 2 volt test point on the logic board.**
2. Set the voltage to 2.07 ± .02 volts using R-40 on the main logic board (far left corner adjacent to K7).

3-6 TABLE CASSETTE TRAY SIZE/VOLTAGE ACCURACY CHECKOUT (VIR)

The VCT adjustment listed above should allow the table cassette tray to produce VIR signal voltages that correspond to the values shown in the table below. This must be verified by clamping all cassette sizes, in turn, in the table cassette tray and measuring the resultant VIRC and VIRL signal voltages at J1-B (W3-RED) for VIRC and J1-D (W3-GRN) for VIRL.

VIR AND VXF VALUES VS. SIZE IN INCHES
(Required Accuracy: ± 0.02 Volt)

Inches	Volts	Inches	Volts
1.0	0.51	9.0	1.25
1.125	0.52	9.125	1.26
1.250	0.53	9.250	1.27
1.375	0.55	9.375	1.28
1.5	0.56	9.5	1.29
1.625	0.57	9.625	1.31
1.75	0.58	9.75	1.32
1.875	0.59	9.875	1.33
2.0	0.60	10.0	1.34
2.125	0.62	10.125	1.35
2.250	0.63	10.250	1.36
2.375	0.64	10.375	1.37
2.5	0.65	10.5	1.39
2.625	0.66	10.625	1.40
2.75	0.67	10.75	1.41
2.875	0.68	10.875	1.42
3.0	0.70	11.0	1.43
3.125	0.71	11.125	1.44
3.250	0.72	11.250	1.46
3.375	0.73	11.375	1.47
3.5	0.74	11.5	1.48
3.625	0.75	11.625	1.49
3.75	0.76	11.75	1.50
3.875	0.78	11.875	1.51
4.0	0.79	12.0	1.52
4.125	0.80	12.125	1.54
4.250	0.81	12.250	1.55
4.375	0.82	12.375	1.56
4.5	0.83	12.5	1.57
4.625	0.85	12.625	1.58
4.75	0.86	12.75	1.59
4.875	0.87	12.875	1.60
5.0	0.88	13.0	1.62
5.125	0.89	13.125	1.63
5.250	0.90	13.250	1.64
5.375	0.91	13.375	1.65
5.5	0.93	13.5	1.66
5.625	0.94	13.625	1.67
5.75	0.95	13.75	1.68
5.875	0.96	13.875	1.70
6.0	0.97	14.0	1.71
6.125	0.98	14.125	1.72
6.250	0.99	14.250	1.73
6.375	1.01	14.375	1.74
6.5	1.02	14.5	1.75
6.625	1.03	14.625	1.77
6.75	1.04	14.75	1.78
6.875	1.05	14.875	1.79
7.0	1.06	15.0	1.80
7.125	1.08	15.125	1.81
7.250	1.09	15.250	1.82
7.375	1.10	15.375	1.83
7.5	1.11	15.5	1.85
7.625	1.12	15.625	1.86
7.75	1.13	15.75	1.87
7.875	1.14	15.875	1.88
8.0	1.16	16.0	1.89
8.125	1.17	16.125	1.90
8.250	1.18	16.250	1.91
8.375	1.19	16.375	1.93
8.5	1.20	16.5	1.94
8.625	1.21	16.625	1.95
8.75	1.22	16.75	1.96
8.875	1.24	16.875	1.97
		17.0	1.98
		17.125	2.00
		17.250	2.01
		17.375	2.02
		17.5	2.03

If the VCT does not result in VIR voltages within ± .02 volt of the values shown in the table, the tray must be adjusted as required.

If the VCT adjustment performed in ADJUSTMENT OF CASSETTE TRAY VOLTAGE does not result in VIR voltages within ± .02 volt of the values shown in the table, the following procedure should be followed:

1. **If longitudinal error is consistent by .01 volt or more, check for a bent sensing arm.**
2. **If sensing arm is not bent, clamp a 10" x 12" cassette in the tray with the 10" dimension in the LONG direction (side-to-side in the tray).**
3. **Check the voltages at the points indicated in the table below.**

	CROSS	LONG
Table Bucky	J1-D (W3-GRN)	J1-B (W3-RED)
Wall Bucky or Cassette Holder	J1-4 (W2-GRN)	J1-3 (W2-RED)
Voltage	1.52 V ± .02	1.34 V ± .02

If readings obtained above are inaccurate, the tray potentiometers must be adjusted as follows:

a. **Consult the LIEBEL-FLARSHEIM instructions supplied with the tray for disassembly details.**
b. **Remove tray, remove protective cover, and loosen the pot gear set screw for whichever pot is indicated.**
c. **Reset pot(s) by rotating a small amount.**
d. **Re-insert tray to recheck voltage. (Several attempts may be necessary.)**

4. **Consult the LIEBEL-FLARSHEIM instructions supplied for further adjustment procedures.**

3-7 AUXILIARY CASSETTE HOLDER SIZE/VOLTAGE ACCURACY CHECK

1. Repeat the VIR Accuracy Check procedure with the x-ray beam angulated to within 5° of horizontal into the Auxiliary Vertical Cassette holder. Measure at J1-4 (W2-GRN) for VIRC and J1-3 (W2-RED) for VIRL.
2. Check the cassette holder manufacturer's instructions if adjustments are necessary.

Note

Make certain that the cassette sizes used are compatible with the cassette holder.

3-8 COLLIMATOR POTENTIOMETER CHECKOUT AND ADJUSTMENT (REFER TO DISASSEMBLY)

The collimator potentiometers are factory-adjusted and should not require readjustment in normal use. In the event that the original adjustment is disturbed, or after extended use the following sequence of steps must be followed to readjust these to the proper settings.

WARNING

RADIATION HAZARD-OBSERVE ALL REQUIRED CAUTIONS AND PRECAUTIONS TO AVOID EXPOSING ANY PART OF THE HUMAN BODY TO X-RAY DIRECT OR SCATTERED. ALSO, OBSERVE ALL EQUIPMENT RATINGS.

1. Remove relays K1, K2, K3 and K4 from the main logic board.
2. Temporarily bypass the exposure interlock circuit by connecting a jumper from J2-T to J2-U or the WHITE and BLACK wires in W6.

CAUTION

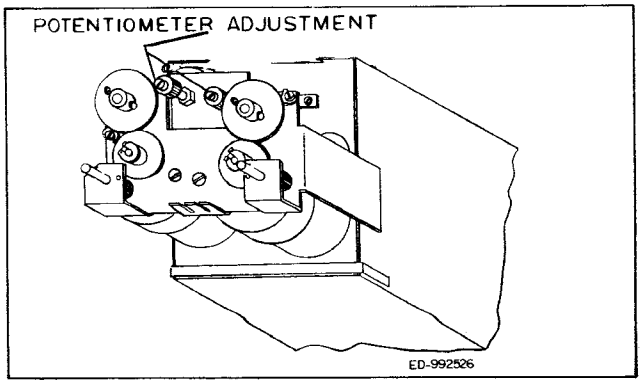
JUMPER J2-T-J2-U MUST BE REMOVED IMMEDIATELY FOLLOWING COMPLETION OF THE CALIBRATION PROCEDURES.

3. Set the x-ray tube/collimator to a vertical ± 5° beam direction and the x-ray table to a horizontal ± 5° position.
4. Position the x-ray tube/collimator to 40" as measured from the focal spot to the film plane in the table cassette tray (do not rely on the equipment scales).
5. Locate a film-cassette in the table cassette tray and center it to the collimator light field.
6. Adjust the collimator shutters to a dial reading of 10" x 10" on the 40" scale.
7. Accurately measure, and record, the voltages at J1-N (VXFL) with respect to ground.
8. Locate a few randomly placed coins on the tabletop to allow reorientation of the film.
9. Expose the film with factors that will produce a density of 1.0.
10. After developing the film, identify and mark the edges of the x-ray image as described in IDENTIFICATION OF X-RAY FIELD EDGES.
11. After developing the film, measure the x-ray image in the cross-table direction.
12. **Measure the x-ray image in the long-table direction. The voltage recorded at J1-N (VXFL) must correspond to the voltage required for the measured x-ray field image size in the long-table direction. Refer to Table 3-2.**

Note

If the VIR value for the CROSS or LONG dimension is in error by more than 0.02 volt, and the collimator-to-Focal-Spot distance is correct (see OUTLINE DATA) readjustment of the collimator potentiometers must be performed.

The collimator cross potentiometer and long potentiometer are adjusted by removing the dial knobs, front panel screws and the front panel. Loosen the potentiometer gear set screws, adjust the potentiometer shafts within the potentiometer gears and retighten the potentiometer gear set screws. Care must be taken not to allow the shutters to move during this operation. Refer to DISASSEMBLY. Recheck by repeating steps 6 through 13, using a different dial setting and film exposure.



13. **After all adjustments are completed and system sizing has been rechecked, reassemble the collimator. Remove the temporary jumper. Replace relays K1-K4.**

CAUTION
BE SURE TEMPORARY JUMPER HAS BEEN REMOVED.

3-9 COLLIMATOR ALIGNMENT

Follow these procedures to ensure that the installed collimator meets DHEW alignment requirements[1]. Complete this entire section and/or all required alignment procedures before operating this collimating system including:

- identification of light field and x-ray field edges;
- verification of light field to x-ray field coincidence;
- verification of shutter dial accuracy;
- verification of x-ray field accuracy;
- centering of cross hairs to light field;
- alignment of Bucky light-line;

These miscellaneous items are required to complete the ALIGNMENT procedures:

- Several sheets of white paper;
- Pencil, fine stylus, or marker;
- Straightedge, measuring tape, or ruler;
- Conventional densitometer or a "neutral density" filter having a density of 1.0 (obtainable from most photographic supply houses);
- Large film cassette (preferably 14" x 17");
- Coins or lead marking letters;
- Philips head screwdriver and a conventional 1/4 inch wide straight-blade screwdriver;
- Masking tape;
- Long-nose pliers. 1/4" wrench or nut driver;
- 3/32" hex wrench with 2 3/4 inch minimum shaft length.

3-10 IDENTIFICATION OF LIGHT FIELD EDGES

CAUTION

MOBILE OR PORTABLE X-RAY UNITS MUST REMAIN STATIONARY DURING THESE PROCEDURES. SECURE THE UNIT TO PREVENT MOTION.

1. Subdue or turn off room lights. Locate a sheet of white paper on the tabletop and turn on the collimator field illumination light. Center the paper to the light field.
2. Using a second sheet of white paper as a light detector, square one edge of it up with the right-hand edge of the light field.
3. Proceeding from the unilluminated portion of the tabletop paper, gradually move the second sheet of paper toward the illuminated area.
4. Observe and initially mark the point on the tabletop paper where illumination on the second sheet of white paper first begins to be visible.
5. Make a second mark 3 mm toward the center of the illuminated field. This mark is to be used as the defined edge for light calibration purposes.

NOTE

The right-hand side of the field corresponds to the direction on the observer's right when facing the collimator front panel.

DEFINITIONS

Light field: area of light projected from collimator lamp that falls on the image receptor plane.

NOTE

Light field alignment is critical and required by DHEW regulations[1]. Alignment must be performed during installation, on a periodic basis **(defined in MAINTENANCE), and at any point misalignment is suspected**

Light field edge: light field whose perimeter is locus of points where illumination is 25% of maximum illumination in the center.

NOTE

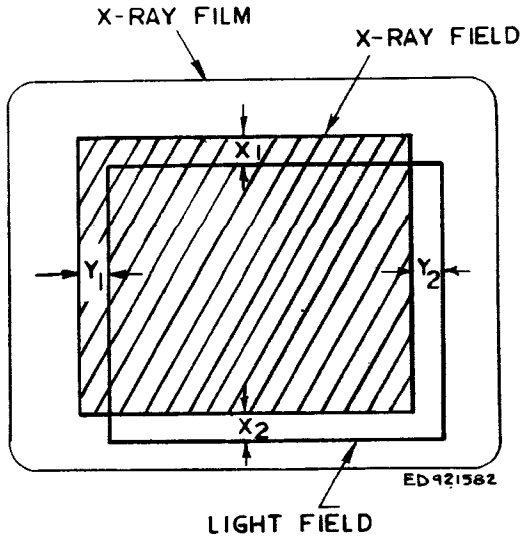
These ALIGNMENT procedures define an acceptable, accurate edge identification for calibration purposes. If defined edges are challenged, a light detecting instrument with a 1 mm apperture must be used.

X-ray field: the area of radiation projected from the x-ray tube unit that falls on the plane of the image receptor.

X-ray field edge: x-ray field whose perimeter is locus of points where the x-ray density is 25% of maximum x-ray density. This edge is precisely identified by use of a scanning densitometer with a. 1 mm aperture and controlled-gamma film.

Light field to x-ray field coincidence: The total misalignment between the light field edges and the respective edges of the x-ray field shall not exceed 2% of the SID in either direction.

LIGHT FIELD TO X-RAY FIELD ALIGNMENT



1. **The sum of X_1 and X_2 shall not be more than 2% of the distance from the focal spot to the film plane**

2. **The sum of Y_1 and Y_2 shall not be more than 2% of the distance from the focal spot to the film plane**

6. Repeat this procedure on the other three sides, measure perpendicular to the edge and make secondary marks 2 mm toward the center of the illuminated field. These secondary marks are to be used to define the other three light field edges.
7. Use a straightedge and carefully draw lines parallel to the edges of the light field using the secondary marks as reference points. The result should produce a square or rectangle that accurately describes the light field edge.

3-11 IDENTIFICATION OF X-RAY FIELD EDGES

WARNING

RADIATION HAZARD: OBSERVE ALL REQUIRED PRECAUTIONS TO AVOID EXPOSING ANY PART OF THE HUMAN BODY TO DIRECT OR SCATTERED X-RAYS. OBSERVE ALL EQUIPMENT RATINGS.

1. Set the collimator shutter dials to expose an area smaller than the film cassette size.
2. Adjust the x-ray generator exposure factors to produce a film having a density of 1.0.
3. Check the density using a conventional densitometer or by visual comparison with a neutral density filter having a density of 1.0.
4. Place the developed film on white paper. Place a second piece of white paper on top of the film and parallel to the edge of the image.
5. Slowly move the second piece of paper from the unexposed border toward the exposed x-ray image. Stop just as the increase in density of the film begins to be barely perceptible.
6. Mark this point with a fine stylus. Repeat the preceding for the other three edges.
7. On the edge corresponding to the direction of the x-ray tube cathode, measure and make a second mark 2 mm toward the center of the image from the first mark. This second mark corresponds to the defined edge for the cathode side only.
8. On the other three edges of the x-ray image, measure and make a second mark 1 mm toward the image center from the original first marks. These second marks correspond to the other three defined edges.

3-12 ENTRY BARRIER TO FOCAL SPOT ALIGNMENT

The focal spot of an x-ray tube may be off-centered to the center of the tube port up to .08 inch (2mm). In order to verify accurate alignment of the lead entry barrier to the focal spot, an examination of a film, taken with the collimator shutters fully open, should be made to verify that there is no x-ray field cutoff caused by misalignment.

NOTE

This procedure assumes that the correct collimator-to-focal-spot distance is maintained. (See OUTLINE DATA).

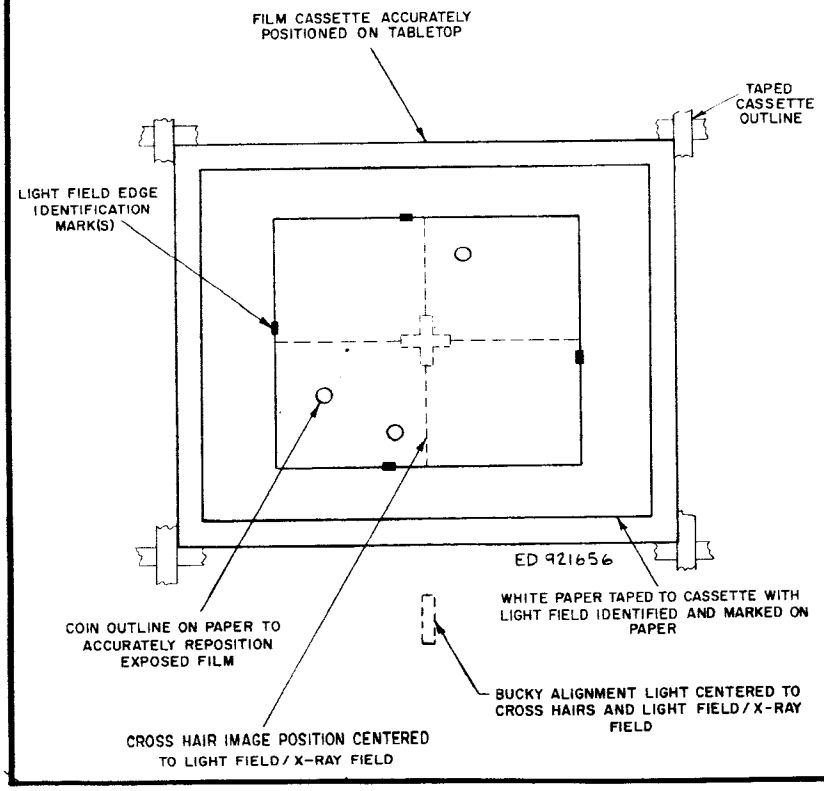
1. Set the collimator dials to 17" x 17" on the 40" scale.
2. Locate a 14" x 17" film-cassette at 27" SID. Since the SID is not variable, place the cassette on a cardboard box or inverted plastic waste receptacle to obtain a 27" SID.

WARNING

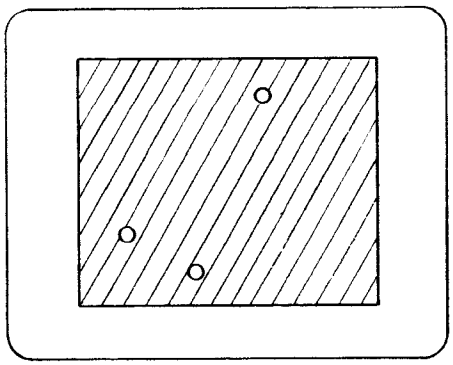
RADIATION HAZARD: OBSERVE ALL REQUIRED CAUTIONS AND PRECAUTIONS TO AVOID EXPOSING ANY PART OF THE HUMAN BODY TO X-RAYS, DIRECT OR SCATTERED. OBSERVE ALL EQUIPMENT RATINGS.

3. Set the x-ray technique factors to produce a film-exposure of about 1.0 density, expose and

LIGHT FIELD, X-RAY FIELD, AND IMAGE RECEPTOR ALIGNMENT CHECKOUT



REFER TO X-RAY FIELD AND IMAGE RECEPTOR CENTER DEFINITION DRAWING FOR CENTERING DETAILS.



EXPOSED X-RAY FILM WITH REDUCED SIZE (MANUALLY DIALED) X-RAY EXPOSURE COIN IMAGES ALLOW ACCURATE SUPERPOSITION OF THE X-RAY FILM OVER THE COIN POSITION IMAGES MARKED PRIOR TO EXPOSURE.

ED 921656

develop the film. Examine the film for edge cut-off.

If edge cut-off is observed, the collimator and mount must be removed to adjust the entry barrier. To remove collimator, refer to COLLIMATING MOUNTING.

1. Loosen the four mounting bolts and slide the inner ring assembly in the direction of the cut-off (blur) as much as the clearance holes in the mount permit.
2. Retighten the bolts, reassemble the collimator, and retest with another film.

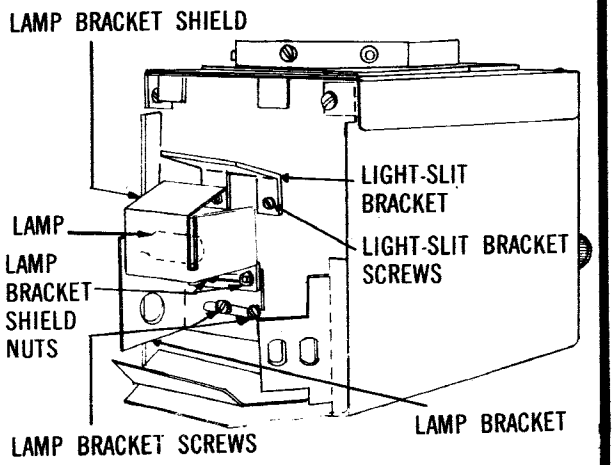
3-13 LIGHT FIELD TO X-RAY FIELD COINCIDENCE

1. Ensure that the x-ray beam is perpendicular to the image receptor.
2. Position the x-ray tube/collimator to 40" as measured from the focal spot to the tabletop.
3. Locate a film cassette on the tabletop and center it to the collimator light field.
4. Use masking tape on the tabletop to "frame" the cassette outline to allow accurate relocation of the cassette each time.
5. Tape a sheet of white bond paper onto the cassette to aid in visualizing and marking the outline of the light field.
6. Adjust the collimator shutters to produce a light field on the bond paper, leaving about a 1-inch unilluminated border.
7. Identify and mark a full outline of the light field as described in IDENTIFICATION OF LIGHT FIELD EDGES.
8. Locate a few randomly placed coins on the paper and trace an outline of each coin.
9. Expose the film with factors that will produce a density of 1.0.
10. After developing the film, identify and mark the edges of the x-ray image as described in IDENTIFICATION OF X-RAY FIELD EDGES.
11. Relocate the cassette in the masking tape frame on the tabletop. Carefully superimpose the film on the paper target by observing the coin images and the coin outline drawing on the paper.
12. The misalignment of the edges of the x-ray field can now be determined as explained above.
13. If the light field is off-centered to the x-ray field in the cross-table direction, locate the mirror adjustment screw through the hole in the exit window being careful not to look directly at the light, (refer to OPERATION AND ADJUSTMENT DETAILS) and adjust the mirror to center the light field by turning the mirror adjusting screw: clockwise to shift the light field forward, counterclockwise to shift it to the rear. Retest for accuracy.
14. If the light field is misaligned in relation to the x-ray field in the longitudinal-table direction, remove the rear cover of the collimator (refer to DISASSEMBLY), loosen the lamp bracket nuts and move the lamp bracket left or right to center the light field to the x-ray image. Retest with another film. Retighten the nuts.
15. If a dimensional irregularity greater than 2% between the light and x-ray field size is found, remove the rear cover of the collimator and lamp bracket heat shield, if necessary, and check the lamp angulation in the lamp socket. Allow rear cover and heat shield to cool before disassembling. (Refer to LIGHT FIELD CENTERING ADJUSTMENT). The lamp must be fully inserted into the socket and the main body of the lamp must be perpendicular to the body of the socket.

LIGHT FIELD CENTERING ADJUSTMENT

CAUTION

THE LAMP BRACKET GETS VERY HOT AND CAN CAUSE SEVERE BURNS. USE LONG-NOSE PLIERS OR SIMILAR TOOLS TO HOLD BRACKET DURING ADJUSTMENTS. PROTECT EYES FROM THE HIGH INTENSITY LIGHT.



3-14 SHUTTER DIAL ADJUSTMENT

1. Ensure that the x-ray beam is perpendicular to the image receptor.
2. Position the x-ray tube/collimator to 40" as measured from the focal spot to the x-ray film plane.
3. Locate a film cassette on the tabletop and center it to the collimator light field.
4. Adjust the collimator shutters to an exact dial reading of 10" x 10" on the 40" scale in a closing motion.
5. Locate a few randomly placed coins on the cassette for later reorientation.
6. Expose the film with factors that will produce a density of 1.0.
7. After developing the film, identify and mark the edges of the x-ray image as described in IDENTIFICATION OF X-RAY FIELD EDGES.
8. Measure the width and length of the x-ray image and compare this measurement to the dial indications (10" x 10") as set in step 3 above.

NOTE

The dial indication must correspond to the x-ray field size to within 2% of the SID in use. Therefore with 40" SID and a 10" x 10" dial setting, the cross table image size must be 10" $\pm$ .80" (9.2" - 10.8") and the long-table x-ray image size must be 10" $\pm$ .80" (9.2" - 10.8"). The actual result, however, must be accurate to within $\pm$ .25" to ensure that all size indications for each SID are accurate.

9. If adjustment is required, (refer to DISASSEMBLY) loosen the dial adjustment screws and turn the knobs to the dial indication that

corresponds to the x-ray image dimensions on the test film. Be sure that shutters do not move during this procedure.

10. Repeat SHUTTER DIAL ADJUSTMENT prior to reassembling the collimator.

3-15 CROSS-HAIR TO LIGHT FIELD CENTER ALIGNMENT (Refer to DISASSEMBLY).

1. Loosen, by one turn, each of the four screws adjacent to the exit window on the bottom of the collimator.
2. Loosen, by one turn, each of the four screws adjacent to the exit window on the bottom of the collimator. (Refer to OPERATION AND ADJUSTMENT DETAILS).
3. Form a ball (wad) of masking tape (do not use, adhesive tape) and press it onto the plastic exit window to assist moving or sliding the window.
4. Activate the collimator field projection light, and center the cross-hair image to the center of the projected light field (the cross-hair must remain squared to the light field edges) to within 0.2 inch of the light field true center.
5. Retighten the six retaining screws.

3-16 BUCKY LIGHT-LINE ALIGNMENT

1. Activate the collimator field projection lamp and by the use of a straightedge, check the centering light-line which is projected forward of and outside of the main light field. It must be in line with the central bar of the cross-table, cross-hair image.

2. If adjustment is required, remove the rear cover. (Refer to DISASSEMBLY.)

WARNING

THE PROJECTION LAMP BRACKET GETS VERY HOT AND CAN CAUSE SEVERE BURNS. USE LONG-NOSE PLIERS OR SIMILAR TOOLS TO HOLD THE BRACKET DURING ADJUSTMENT PROCEDURES. PROTECT EYES FROM THE HIGH INTENSITY LIGHT.

3. Loosen the light-slit bracket screws (refer to LIGHT FIELD CENTERING ADJUSTMENT); move the slit until the light line is centered; then move the bracket up/down to focus.
4. Repeat the Bucky Light-Line Alignment test after retightening the screws.

3-17 LIGHT OUTPUT VERIFICATION

The light level should be verified using a spot brightness meter during final checkout of the completed installation to ensure compliance to actual light output. Also check voltage at projection lamp socket. (See SPECIFICATION.)

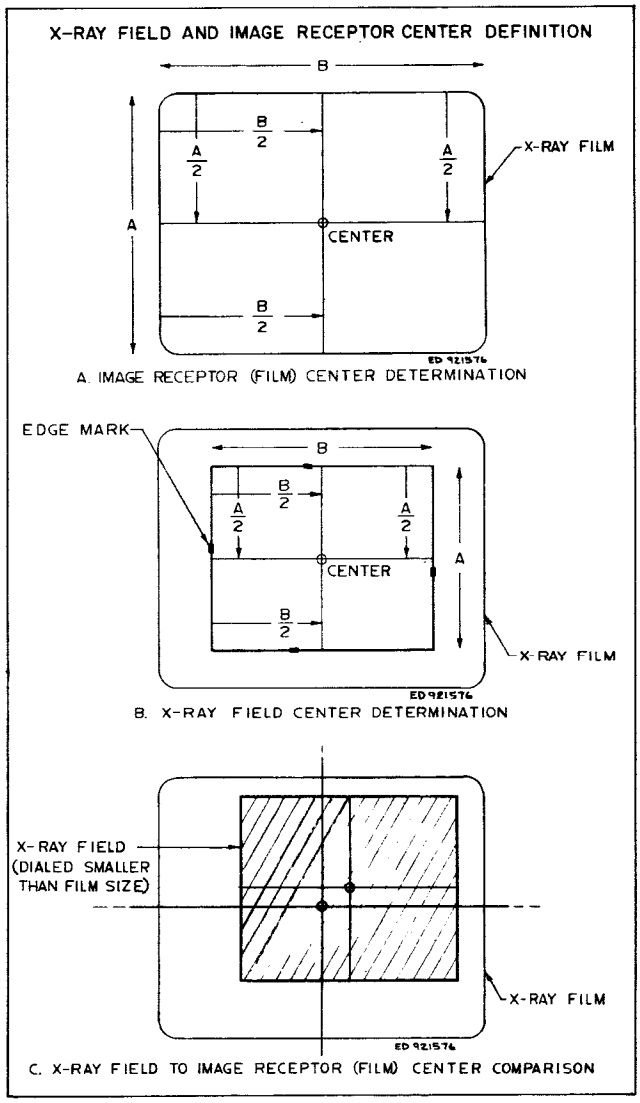
3-18 ACCURACY CHECK

1. Connect a jumper between J2-T and J2-U to bypass the exposure hold temporarily during initial alignment. (Relays must be installed inlogic unit.)

CAUTION

THIS JUMPER MUST BE REMOVED IMMEDIATELY FOLLOWING COMPLETION OF THE CALIBRATION PROCEDURES.

2. Set the x-ray tube/collimator to a 40" SID (measured; do not use equipment scales) for vertical operation into a horizontal table bucky.
3. Carefully center the cassette tray to the x-ray beam. Set all equipment locks to retain this alignment.
4. Insert a mid-size test cassette e.g. (10 x 12), carefully centered and clamped, into the table bucky with the largest dimension in line with the long direction of the table.
5. Collimator must cycle to READY. Leave equipment set and READY light on.
6. Operate the Emergency Logic Failure Override Switch (disabling the logic) or remove relays K1, K2, K3 and K4 from the logic board to retain the collimator shutter position obtained in step 5.
7. Identify the edges and center of the light field on the tabletop (see IDENTIFICATION OF LIGHT FIELD EDGES). Place a cross marker (wire solder or similar strips) carefully centered in the light field, place suitable markers on all four edges of the light field and place a lead number for film identification and orientation in the lower left corner of the light field.



8. Remove the 10 x 12 cassette, carefully center and clamp a 14 x 17 image recording cassette into the table bucky with its largest dimension in line with the long direction of the table. (Do not disturb the cassette to x-ray tube alignment.)

WARNING

RADIATION HAZARD: OBSERVE ALL REQUIRED CAUTIONS AND PRECAUTIONS TO AVOID EXPOSING ANY PART OF THE HUMAN BODY TO X-RAYS, DIRECT OR SCATTERED. OBSERVE ALL EQUIPMENT RATINGS.

Note

The EXP. HOLD light will be on but the film can be exposed because the exposure hold feature is temporarily bypassed.

9. Set the equipment x-ray exposure technique factor to produce a film density of 1.0 and expose and process the film.
10. Identify the center and edge of the x-ray image (see IDENTIFICATION OF X-RAY FIELD EDGES).

Notes

- The length of the x-ray image on the 14" x 17" recording film must coincide with the length of the test cassette-film within 2% of the SID in use.
- The width of the x-ray image on the 14" x 17" recording film must coincide with the width of the test cassette film within 2% of the SID in use.

- The x-ray image size to dial size for the long dimensions must be within 2% of the SID in use and the x-ray image size to dial size for the cross dimension must be within 2% of the SID in use.

11. Return the Emergency Logic Failure Override Switch to the "normal" position or reinstall relays K1, K2, K3 and K4 if previously removed.
12. Repeat this accuracy checkout with a smaller cassette e.g. (8" x 10") and a larger cassette e.g. (11" x 14") with the larger dimension in the long table direction by repeating steps 4 through 11 in the order described.
13. Repeat this accuracy checkout with the three cassettes oriented with the larger dimension in the cross table direction by repeating steps 4 through 12 in the order described.
14. Repeat the alignment checkout with the three test cassettes used previously in both orientations by repeating steps 4 through 13.

NOTE

If all the x-ray field sizes do not conform to the cassette sizes within 2% of the SID, the ELECTRONIC SYSTEM ADJUSTMENT PROCEDURES should be re-checked. If an inconsistency in x-ray field sizing over the range of film sizes exists, the base voltage, (VBXF) may require readjustment. The cassette tray(s) must be properly calibrated before attempting to readjust any potentiometers on the logic board.

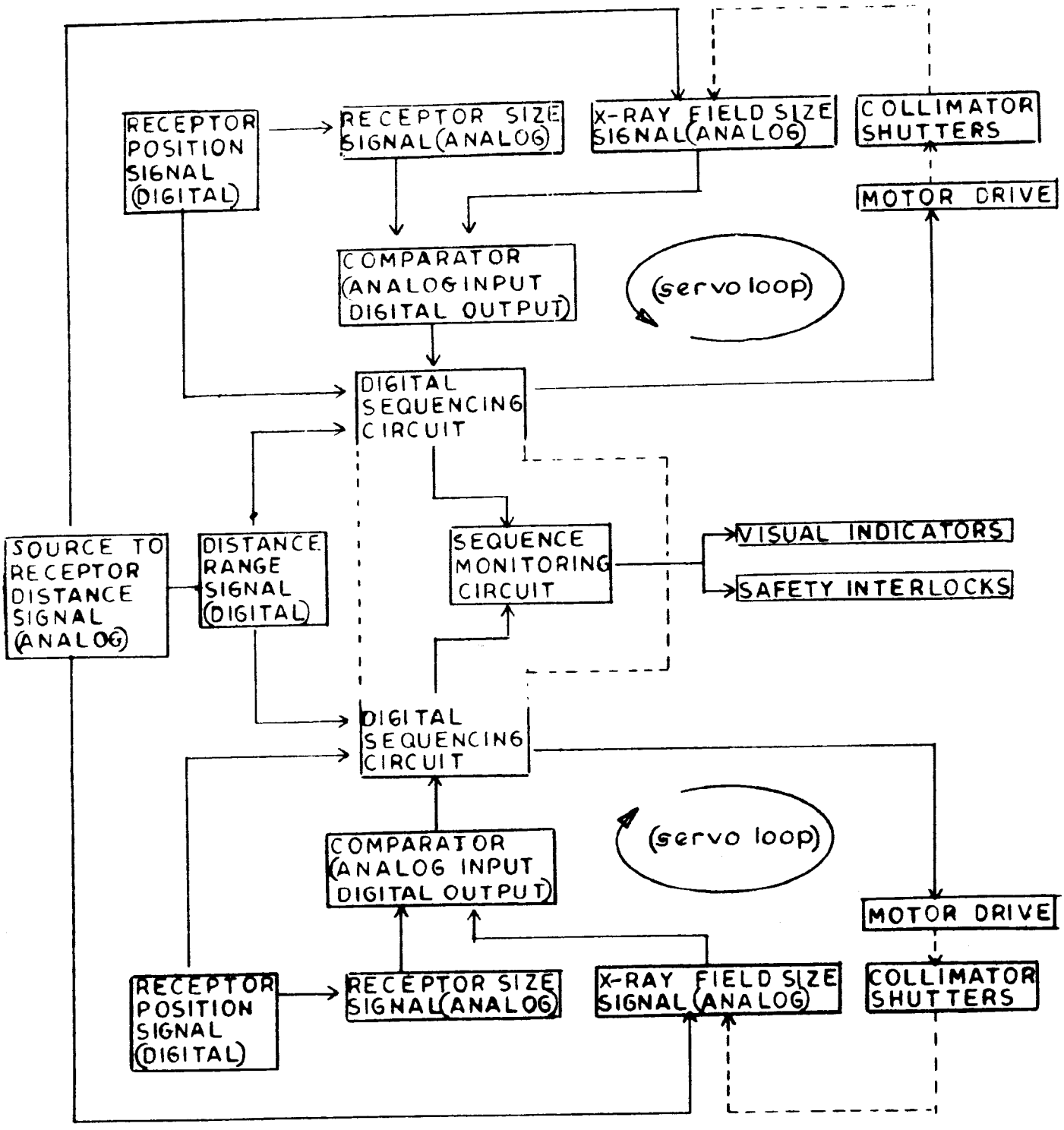
NOTE

Although the x-ray field sizes must correspond to the dimensions of the image receptor within DHEW performance standards (3% either orientation, 4% total error of SID), the system should be adjusted so that all sizes are within 2%. This is best accomplished by adjusting the mid-range (10-12 inch cassette) size error to be less than 1% of the SID.

15. Repeat the accuracy checkout with a 10 x 12 cassette at both the minimum and maximum attainable SID's, (e.g. 37 and 58 inches) to ascertain that the x-ray field sizing is consistent over the entire range of SID's. If the sizing is NOT consistent, it will be necessary to repeat the voltage adjustments of the continuous SID monitor board, and/or recalibration of the SID voltages.
16. If there is a discrepancy between the proportion of LONG and CROSS x-ray field dimensions relative to the long and cross image receptor sizes, the LONG COMPENSATION voltage (R36) at TP7 (on the main logic board) can be adjusted accordingly. This determination should be made by evaluating all the different sizes of the x-ray test images.
17. Direct the x-ray beam to the horizontal direction (if used) and perform the alignment checkout for the entire range of cassette sizes to be used (at least a small, (8 x 10) and large, (11 x 14) size in both cross and long orientations) in the x-ray beam horizontal direction.
18. Repeat the accuracy checkout using a 10 x 12 size cassette at all other horizontal SID's used to ascertain proper adjustment of all discrete SID potentiometers. Refer to CALIBRATION of HORIZONTAL DISCRETE SID VOLTAGES.

CAUTION

THE JUMPER (IF USED) MUST BE REMOVED IMMEDIATELY FOLLOWING COMPLETION OF THE CALIBRATION PROCEDURES. (J2-T TO J2-U)



SYSTEM BLOCK DIAGRAM

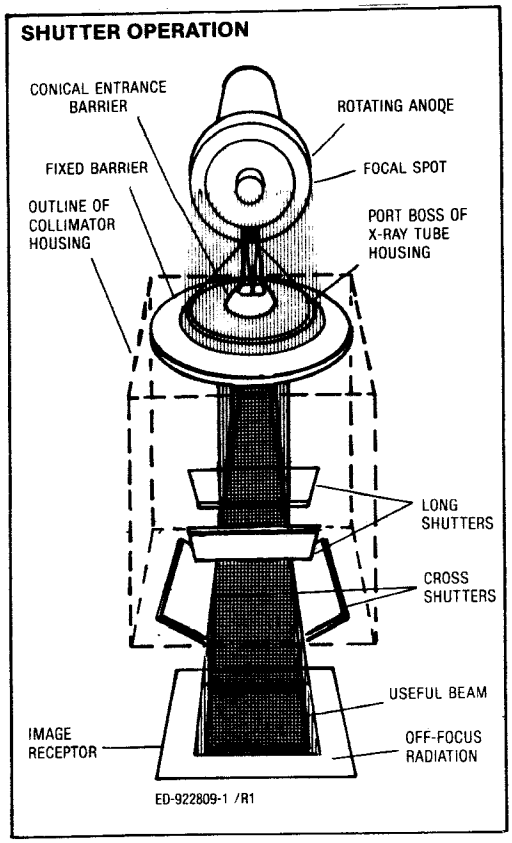
THEORY OF OPERATION

4-1 MECHANICAL OPERATION (see SHUTTER OPERATION)
Two pairs of motorized lead shutters are contained within the collimator to limit the cone of radiation.

The long shutters control the x-ray beam length and the cross shutters control the x-ray beam width.

Each pair of shutters is controlled by a dial on the front panel or by motors in the automatic mode.
the dial marked || controls the long shutters;
the dial marked = controls the cross shutters.

The dials and motors drive gear mechanisms that control the angle of the shutters. These gears require lubrication at intervals based on usage. Refer to PERIODIC MAINTENANCE.



4-2 LOGIC CIRCUIT OPERATION
The basic function of the logic is to compare the x-ray field size to the newly inserted image receptor size, and to adjust the x-ray field size to match the image receptor in a particular sequence. The sequence is chosen to always make the x-ray field adjustment in a closing direction.

This patented feature tends to neutralize any mechanical backlash and also permits further manual x-ray field reduction without special switching by the operator.

4-3 SID MONITOR/IMAGE RECEPTOR SELECTION

This collimating system is equipped with a tilt-monitoring device consisting of three mercury switches that provide the means of signalling the x-ray beam angulation. One switch will close when the beam is vertical-down, one at horizontal-left and one at horizontal-right.

The tilt-monitor operates in a manner to activate one of two image receptor holders (Relay K6 or K7) and to select one of the SID switches

Aiming the beam in a vertical-down direction activates a relay (K-6) which activates the image receptor (bucky tray) located in the x-ray table. Pivoting the beam to a horizontal direction de-energizes that relay and disconnects that image receptor. When a jumper is connected from "a" to either "C" or to "D", a circuit will be completed that will energize a second relay (K-7) which activates the upright Bucky or wall cassette holder.

If the x-ray table is also tilted upright to place the image receptor in a position perpendicular to the horizontally aimed X-ray beam, K-6 will re-activate. A contact on K-6 then de-energizes K-7, thereby de-activating the vertical image receptor. K-6 then activates the X-ray table image receptor.

Voltage is then steered by diodes to activate one of the SID switches.

4-4 ESTABLISHING THE MANUAL MODE
The manual mode is established by the absence of an IR True signal.

The absence of an IR True signal can occur by not locating an image receptor (cassette) in the cassette tray, by not inserting the cassette tray fully into the Bucky or by de-energizing K6 and K7 relays. K6 and K7 relays are de-energized by angulating the collimator to specified angles

NOTE

Without an IR True signal, Q8 transistor will not be turned on and the gates U6A, U5A and U9B establish the logic condition that activates Q4 transistor thus energizing the coil of the Exposure Interlock Relay K5. The EXP. HOLD indicator contacts on K5 will be opened (extinguishing the indicator) while a second contact will be closed to allow x-ray exposures to occur. The remainder of the logic is inhibited via gate U6D (via U6C and U5B).

4-5 SEQUENCING CIRCUIT OPERATION (See SYSTEM BLOCK DIAGRAM)
The system will remain in a Manual mode of operation (all automatic functions are inhibited) until an image receptor is inserted. When the image receptor is activated, a digital IR True signal is produced (along with the VIRC and VIRL analog signals representing the image receptor size).

This IR True signal extinguishes the MANUAL status indicator, blocks x-ray exposures and illuminates the EXPOSURE HOLD status indicator. The automatic functions are started.

When the SID is set to within operating range, a digital SID True signal is produced (along with the VXFC and VXFL analog signals representing the x-ray field size).
When both the IR True and SID True signals are received, the collimator will begin its adjustment sequence. If the VXF analog voltages are less than

the VIR voltages (x-ray field smaller than image receptor) the sequencing circuit starts the collimator motors which drive the shutters in an opening direction. When the collimator shutters have been driven open enough to produce an x-ray field size that slightly exceeds the image receptor size, the voltage comparators cause the collimator to stop. The sequencing circuit then starts the collimator in a shutter-closing direction.

4-6 ESTABLISHING THE AUTOMATIC MODE (Refer to SCHEMATIC DIAGRAM)

The reception of an IR True signal is required to establish the Automatic mode.

Q8 transistor will be turned on by the IR True signal which will de-energize the Exposure Interlock relay K1 through gates U6A, U5A, U9B and transistor Q4.

Q8, U6A, U9A and Q5 act to extinguish the Manual indicator.

The remainder of the logic is still inhibited via U6D (via U6C and U5B).

4-7 AUTOMATIC SEQUENCE (Refer to SIGNAL DICTIONARY for a description of Abbreviations)

When a proper SID (source-image-distance) is set on the equipment, an analog voltage is applied to the collimator potentiometers. The voltage values are referred to as VSIDC (voltage, SID, cross) and VSIDL (voltage, SID, long). The shutter operating mechanisms are coupled to the pot wiper-arms and, through electro-mechanical ratios, the resultant voltages from the pots represent the x-ray field size at the SID established (a patented feature).

These two voltages, from the pot-wipers, are referred to as VXFC (voltage, x-ray field size, cross) and VXFL (voltage, x-ray field size, long) and will be compared to the image receptor size voltages by the logic circuitry.

When an image receptor is selected, two analog voltage values are produced which represent the image receptor size in the Cross direction (VIRC) and in the Long direction (VIRL).

A voltage comparator IC is used to compare VXF to VIR, and when the VXF is greater than VIR, a logic-high signal will be produced by the comparator. When the VXF is less than VIR, the comparator output switches to a logic-low signal.

The x-ray field size (voltage) is, therefore, compared with the image receptor size (voltage) and a digital output is produced.

4-8 COMPLETION OF THE AUTOMATIC SEQUENCE (Refer to SYSTEM SCHEMATIC)

With the IR True signal applied as described above, the addition of an SID True signal will start the sequencing of the system. (Either True signal may be received first, or both may be received at the same time; when both True signals are received, the sequencing will start.)

The True signals are combined by U5B. U6D enables the motor drive circuits via U5C, U8A, U5D and U11A. The READY indicators and the EXP. RELEASE circuits are enabled via U8B and U11B.

The sequencing circuits are enabled by U6D via U3B and U7B.

U6E, U4A, R12 and C12 produce a 100 millisecond pulse (from U4A) that attempts to establish a "set" condition in the timed flip-flops (U3 and U7).

When the IR True signal is received, the Cross and Long size-signals (VIRC and VIRL) are also received. VIRC is applied to Pin 3 of voltage comparator U1 and VIRL is applied to Pin 3 of voltage comparator U2.

When the SID True is received, VSIDC and VSIDL voltages are received by the collimator pots. The pot wiper arm positions divide the VSIDC and VSIDL voltages to produce VXFC and VXFL (x-ray field size) voltages. VXFC is applied to Pin 2 of U1 and VXFL is applied to Pin 2 of U2.

If the Pin 2 voltage(s) on the comparator(s) (VXF) is (are) less than the Pin 3 voltage(s) (VIR), the x-ray field size is smaller than the image receptor size. The comparator(s) output(s) will be Logic Low for this condition.

If the comparator(s) output is Logic Low during the 100 millisecond pulse interval (described above), the time flip-flop(s) will be "set"; U3C and U7C output(s) will be Logic Low.

If the Pin 2 voltage(s) on the comparator(s) (VXF) is (are) more than the Pin 3 voltage(s) (VIR), the x-ray field size is larger than the image receptor size. The comparator output(s) will be Logic High for this condition.

If the comparator(s) output is Logic High during the 100-millisecond pulse interval (described above), the time flip-flop(s) will be "reset"; U3C and U7C output(s) will be Logic High.

The timed flip-flops, U3 and U7, determine whether the collimator shutters should open-stop-close-stop, or just close-stop.

When the x-ray field size has been reduced down to the image receptor size, the comparators again stop the collimator shutters.

The x-ray field size will then match the image receptor size to within the tolerances stated.

If the VXF voltages are greater than the VIR voltages (x-ray field larger than image receptor) when the IR True and SID True signals are received, only the closing sequence will occur.

With the x-ray field size now set to the image receptor size, the READY indicator will illuminate, and when both the Cross and Long sizes become set, the EXP. HOLD indicator will extinguish.

The user may then manually reduce the x-ray field size if desired, and the size will be maintained until the IR True signal is removed and reapplied (changing image receptors) or until the SID True signal is removed and reapplied (SID changed). An attempt to manually increase the x-ray field size to larger than the image receptor re-activates the closing mode which returns the x-ray field size to the image receptor size.

Note that the logic will readjust the x-ray field size to a larger size only when an interruption in the IR True or SID True occurs.

At the completion of the sequence, the shutters are driven in a closing direction until the comparator outputs switch to a Logic Low output. A further reduction in the x-ray field size by manually closing the shutters will retain the comparator outputs at a Logic Low. It should be noted that the shutters will remain where the manual adjustment stopped, or the automatic adjustment stopped, until the IR True or SID True is removed for 100 milliseconds and reapplied. This action produces a new 100-millisecond "set/reset" pulse for U3 and U7 to start a new sequence.

A manual shutter adjustment that causes the x-ray field size to exceed the image receptor size causes the comparator output(s) to revert to a Logic High; this again activates the close-stop sequence. In short, the operator may reduce the automatically set x-ray field size but is prevented from increasing the automatically set x-ray field size.

4-9 LAMP AND LOGIC POWER SUPPLY

The power supply is used to supply 24 volts DC to the logic unit and lamp timer. Each leg of the primary is protected by a 3 amp slow-blow fuse.

The 24 VAC input to the logic board is routed through two fuses and is used by the motor drive circuit to operate the collimator motors and provide d-c operating voltages for the logic and all functions except the lamp timer, triac and lamp circuit.

4-10 MOTOR DRIVE CIRCUIT

The collimator shutters are driven by 24 VAC motors phase-shifted by a 6 μF non-polarized capacitor. Each motor is operated by activating one of two direction-control relays. The relay coils are connected to a source of unfiltered full-wave 24 VDC, and are actuated by switching on a transistor that effectively grounds the relay coil.

4-11 DC POWER SUPPLY CIRCUIT

A full-wave bridge rectifier converts the ac to DC, and a diode connects the DC to a 2200 μF filter capacitor, allowing 24 VDC, unfiltered, to be routed to the motor drive relays K1, K2, K3 and K4. This 24 VDC is filtered and provides 35 VDC to the voltage regulator circuits.

4-12 THE 723 VOLTAGE REGULATOR

The 723 provides a base-drive signal to an internal 2N3055 series-pass transistor. Filtered unregulated voltage is applied to pins 11 and 12 and an internal reference voltage is produced on pin 6. This reference voltage is typically 7.00 -0.20/ +0.50 volts. This reference is connected into pin 5 for later comparison with pin 4 voltage.

When the voltage is first applied to pins 11 and 12, no voltage is yet available on pin 4. The 723 regulator will then bias on the 2N3055 transistor. This then produces an output voltage. A voltage divider samples the output voltage, and when the voltage divider has produced (on pin 4) the same value of voltage as found on pin 5, the 2N3055 bias will be reduced to hold that particular amount of voltage on the voltage divider. By selecting a 5.1 K ohm and a 7.5 K ohm resistor for the voltage divider, pin 4 will receive 7 volts only when the output voltage (found on pin 3) is 12 volts. Thus, the 723, in conjunction with the 2N3055 transistor and voltage divider, forms a 12-volt regulator circuit.

The output current through the 2N3055 transistor is sensed by a resistor connected from pin 2 to pin 3 on the 723 regulator. If the output current produces a voltage from pin 2 to pin 3 that exceeds about 0.5 volts, the 723 reduces the bias on the 2N3055 transistor for over-current protection. An excessive current demand by the load (by short-circuiting the +12 volt line to ground, for example) will cause the +12 volts to be reduced. Under a dead-short condition near the +12 volt supply, the measured output will be as low as 0.5 volt. A short circuit further away from the supply will cause the +12 volt line to drop to about 3 volts or less, depending upon the ohmic resistance between the supply and the shorted area of the circuitry.

4-13 THE 340 VOLTAGE REGULATOR

The LM340 regulator, in effect, contains all of the equivalent circuitry of the 723 and the 2N3055 Transistor. It is internally limited to 1.0 Ampere for the short-circuit protection, and thermally limited to cause a voltage shut-off if it becomes too hot for any reason.

As before, a low or zero output value implies a short-circuit, and, by identification and removal of the short-circuit, the output can be restored.

All logic boards utilize an LM340-5 regulator. The +12 volts produced by the main regulator is dropped down to, and regulated at, 5 volts by this component. A short-circuit on the output of this regulator will, in some cases, shut down the +12 volt supply.

4-14 THE LM3111 VOLTAGE COMPARATOR

This voltage comparator contains an "open collector" output on pin number 7, therefore the output can only sink current, not source it. For this reason a pull-up resistor will always be connected from pin 7 up to the positive supply voltage (+ 5 volts).

When the output switches to a logic high condition, the output of the LM311 is in its off condition.

The voltage found on pin 7 will then be nearly the positive supply value. Then the output switches to a logic low condition, the output of the LM311 is in its on condition, effectively shorting pin 7 to the ground. This causes the full supply to be dropped across the pull-up resistor. The voltage found on pin 7 will then be less than 0.5 volt as measured to ground.

When the positive analog voltage applied to pin 2 equals or slightly exceeds the positive analog voltage applied to pin 3, the output will switch to a logic high. Conversely, when the pin 2 voltage is less than the pin 3 voltage, the output will switch to a logic low.

When pin 2 voltage is the same as pin 3 voltage, an uncertain output is encountered. For this reason, a resistor is connected from pin 7 back to pin 2. This diverts a small percentage of a logic high output voltage back to pin 2 to produce hysterisis which eliminates the uncertainty by forcing the output to definitely continue to a logic high.

4-15 DIGITAL LOGIC DEVICES

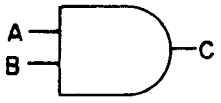
All DIP (dual in-line package) Type I.C. devices have 5 volts applied to pin 14 and ground on pin 7.

Review of Digital Logic Gates and Truth Tables

AND Gate:

U5 is a type 7408 quad-dual input (four section) AND Gate. Each of the four sections (one section shown) is electrically independent. The output of any one section will switch to a logic 1 (Hi) only when both inputs of that section are at a logic 1 state. The output of that section remains at a logic 0 (Lo) when either or both inputs to that section are at a logic 0 state.

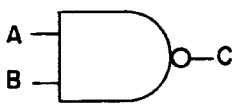
Input A	Input B	Out C
1	1	1
1	0	0
0	1	0
0	0	0



NAND Gate:

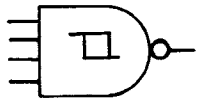
U3, U7 and U9 are type 7400 quad-dual input NAND gates (one section shown). The output of any section will switch to a logic 0 (Lo), only when both inputs to that section are at a logic 1 state. The output of that section remains at a logic 1 (Hi); when either or both inputs to that section are at a logic 0 state.

Input A	Input B	Out C
1	1	0
1	0	1
0	1	1
0	0	1



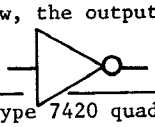
Schmitt Trigger:

U4 is a 7413 type of quad input dual NAND Schmitt trigger. A slow-changing ramp voltage at the input will cause the output to deliver a clean rectangular pulse. The truth table is identical to that of the 7420, but with the provision that the input signals are ramp voltages as opposed to the logic "1s".



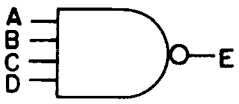
INVERTER:

U6 and U10 are type 7404 hex (six independent section) inverter gates. The output symbol (small bubble), indicates that the output of any section will be the inverse function of the input. If the input is low, the output will be high and vice versa.



U8 and U11 are a type 7420 quad-input dual NAND gates (one half shown). The output of one half section will switch to a logic 0 (Lo) only when all four inputs to that half section are at a logic 1 state. The output of that half section remains at logic 1 (Hi) when any one of the four inputs to that half section are at a logic 0 state.

Inputs A	B	C	D	Out E
0	0	0	0	1
1	0	0	0	1
0	0	1	0	1
0	0	0	1	1
1	1	0	0	1
1	0	1	0	1
1	0	0	1	1
0	1	1	0	1
0	1	0	1	1
0	0	1	1	1
0	1	1	1	1
1	0	1	1	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0



4-16 COLLIMATOR LAMP TIMER

The projection lamp is controlled by a lamp timer circuit that mounts in the Logic Unit and is composed of an integrated circuit and a triac. It operates with the lamp timer pushbutton switch on the front panel and functions to turn off the lamp after an ON period of approximately 25 seconds.

WARNING

WHEN SERVICING LAMP TIMER AND PROJECTION LAMP USE CAUTION TO AVOID BURNS FROM THE LAMP OR EXPOSURE TO X-RAYS FROM THE X-RAY TUBE.

4-17 TIMER CIRCUIT OPERATION

Refer to LAMP TIMER SCHEMATIC

Diode D1 (CR1) provides half-wave rectification while Diode D2 (CR2) in combination with R1 provides low frequency filtration while C1 provides noise bypass.

R2 and C3 provide the time constant (time = 1.7 RC) for control of the integrated circuit. During the timing interval, the output (pin 3 of M1 or U1) is about 9.5 volts, therefore the relay coil will not be activated. With the contacts relaxed (in a closed position) the triac turns on and actuates the projection lamp.

After applying a negative trigger pulse to Pin 2 (switch closure) a flip-flop in M1 is set. Applying a positive voltage on Pin 4 (switch opening) releases a clamp-transistor in M1 from Pin 7 to 1, removing the short circuit from C3.

While the flip-flop is set and Pin 4 is positive, the output switches to almost Pin 8 voltage level. The relay is de-energized and the triac turns on. With the short circuit removed from C3, the current through R2 starts charging C3. When the voltage on C3 reaches 2/3 of the applied voltage (about 6.33 V), a voltage comparator in M1 resets the flip-flop which switches Pin 3 down to almost Pin 1 potential (relay energizes turning off triac). At the same time the short circuit is again applied from Pin 7 to Pin 1, discharging C3.

A sustained switch closure (Pin 4 to Pin 1) causes the output to remain low (relay energized, triac off) for added safety. The timing cycle may also be interrupted at any time which will reset the timer for a full-timed cycle.

CONDITION	1	2	3	4	5	NOTES:
TEST POINTS (I.C. UNLESS Q, K, P2 OR NAMED) ITEM-PIN	INACTIVE	INACTIVE	OPENING CYCLE	CLOSING CYCLE	CYCLE COMPLETE	(L = LOGIC LOW .01–.25V)
	NO FILM NO SID	FILM NO SID	FILM SID (FIELD IS SMALLER)	FILM SID (FIELD IS LARGER)	FILM SID (FIELD IS CORRECT)	(H = LOGIC HIGH 3–4V)
Q-8	OFF	ON	ON	ON	ON	(U4 LOGIC LOW =.01–.40V)
6-2	L	H	H	H	H	
9-3	H	L	L	L	L	
Q-5	ON	OFF	OFF	OFF	OFF	
P2-6	L	H	H	H	H	
MAN.	ON	OFF	OFF	OFF	OFF	
Q-9	OFF	OFF	ON	ON	ON	
6-4	L	L	H	H	H	
5-3	L	L	H	H	H	
6-12	H	H	L	L	L	
6-10	L	L	H	H	H	
4-1	H	H	(DELAYED) L	L	L	
4-6	H	H	L (PULSE) H	H	H	
6-8	L	L	H	H	H	
"C" 1-7 / "L" 2-7	L	L	L	H	L	
3-11 / 7-11	H	H	H	L	H	
3-6 / 7-6			L	H	H	
3-3 / 7-3			H	L	L	
3-8 / 7-8			H	L	L	
5-8 / 5-6	L	L	H	L	L	
Q-1 / Q-10	OFF	OFF	ON	OFF	OFF	
K-1 / K-4	OFF	OFF	ON	OFF	OFF	(MOTOR OPEN RELAYS)
10-2 / 10-8	H	H	L	H	H	
8-8 / 11-8	H	H	H	L	H	
10-12 / 10-4	L	L	L	H	L	
Q-2 / Q-7	OFF	OFF	OFF	ON	OFF	
K-2 / K-3	OFF	OFF	OFF	ON	OFF	(MOTOR CLOSE RELAYS)
8-6 / 11-6	H	H	H	H	L	
10-10 / 10-6	L	L	L	L	H	
Q-3 / Q-6	OFF	OFF	OFF	OFF	ON	
P2-4 / P2-5	H	H	H	H	L	
RDY / RDY	OFF	OFF	OFF	OFF	ON	
4-8	H	H	H	H	L	
5-11	L	H	H	H	L	
9-8	H	L	L	L	H	
Q-4	ON	OFF	OFF	OFF	ON	
K-5	ON	OFF	OFF	OFF	ON	(EXP. REL. RELAY)
P2-7	H	L	L	L	H	
HOLD	OFF	ON	ON	ON	OFF	

LOGIC CHART

SECTION 5.0 MAINTENANCE AND TROUBLESHOOTING

NOTE

All the J1 and J2 wiring connection points mentioned in the text refer to the edge connectors for the main logic circuit board. These connection points are prewired from the main logic circuit board to cable plugs. The wiring diagram at the end of this section provides a cross index of the edge connectors and cable plugs.

The following sequence of tests provides a systematic method of troubleshooting. A random search easily leads to an incorrect diagnosis. As a preventive maintenance measure, this entire sequence should also be performed every time the collimating system is serviced. For definitions of terms used in this procedure, refer to the SIGNAL DICTIONARY at the end of this section.

5-1 POWER DISTRIBUTION PROBLEMS

The voltage regulator circuits contain current-limiting protection, therefore, a short circuit on either the 5-volt or 12-volt distribution circuit will automatically drop the output voltage to a low value or to zero volts in order to protect the regulators from burn-out.

The 5-volt regulator derives its input power from the 12-volt regulator output. Therefore, a short circuit on the 5-volt line will activate the current limiting protection of the 12-volt regulator.

The presence of 12 volts can be readily certified by observing the collimator unit during operation. One or more of the status indicators should be illuminated at all times. Therefore one possible cause of no indicators being illuminated is the absence of voltage or a low voltage value from the 12-volt regulator.

The following sequence provides correct troubleshooting of the power supply in the event of a short circuit or overload.

- Symptom No. 1: 12-Volt Line Measure 4 to 5 Volts

This problem is usually caused by a short circuit on the 5-volt line. Under these conditions the 5-volt regulator case will become very hot, activating the built-in thermal protection. After the short circuit is removed, the regulator must be allowed to cool with power removed for 3-4 minutes before it will automatically reset the thermal overload protection.

- Symptom No. 2: 12-Volt Line measures 0 to 5 Volts

1. If the 12-volt regulator heat sink is cool, check the manually resetable circuit breaker in the small (LOGIC) power supply and the fuses (3AG, 3 AMP) on the logic circuit board.
2. If 24 VAC is present at the output side of the fuses on the circuit board and 30-37 VDC is measured across capacitor C10 (2200 µF), check the wires on the bottom of the heat sink and check for a defective 723 regulator IC chip (M12, VR1) adjacent to the heat sink.
3. If the 12-volt regulator heat sink is very hot and the 5-volt regulator case is at normal temperature, the 12-volt regulator is probably in a current-limiting condition.
4. If the 12-volt regulator heat sink is hot, measure the voltage dropped across the resistor pair R42 (current-sense resistors).
5. If more than 0.5 volt d.c. is measured across R42, the current-limiting condition is activated by a short on the 12-volt line.
6. Disconnect the 12-volt distribution wire from J2-8.
7. If the current-limiting condition persists with the wire removed from J2-8, all loads can be removed from the 12-volt regulator by removing, in turn, the isolation-jumpers to the 5-volt regulator, M1 (U1) - M2 (U2) comparators and the outgoing 12-volt line.
8. If the voltage regulator output returns to 11.5 to 12.5 VDC with the wire from J2-9 disconnected refer to the SYSTEM SCHEMATIC DIAGRAM for circuit details. Note that the output voltage from J2-8 is routed to the collimator status indicator lamps and tilt switches. The voltage is then routed back to the logic board via J2-1 if the collimator is set for a vertical beam direction, J2-2 if pivoted for horizontal left operation, or J2-3 if pivoted for horizontal right operation. Each switch can be checked by pivoting the collimator in each direction, in turn. The voltage routing continues back to the logic board and to relay K6 or K7, depending on the position of the beam direction jumper.

5-2 COLLIMATOR-DRIVE CHECKOUT

Erratic or questionable collimator operation may be caused by an electronic circuit fault or a drive-circuit fault. The following tests allows a checkout of the relay contact-area of the circuit board, phase shift capacitors, inter-chassis wiring, cable connections, motors and the collimator mechanical shutter drive apparatus for freedom of movement.

NOTE

The following checkout can only be performed if the collimator motors are not being driven continuously by a logic circuit fault. If the motor(s) are being driven continuously, proceed directly to INPUT SIGNAL VERIFICATION

1. Unplug K1, K2, K3 and K4 relays from the sockets on the logic board.
2. Use a thin tool (miniature screwdriver) on each side of a relay to release the catch on the relay cover and remove the cover from the relay.

NOTE

Handle with care, do not apply pressure to the contacts or to the top of the relay frame. Grasp the relay by the frame on opposite sides of the relay coil, and only at the bottom of the coil.

3. Plug one relay at a time into its relay socket, and after applying power, gently squeeze the contacts of one relay at a time toward the top of the coil with an insulated tool and observe that each shutter pair is opened and closed smoothly.
4. After obtaining correct operation remove power and carefully inspect the relay to ensure that it has not been damaged and replace the cover.

NOTE

Do not attempt to replace the relay cover in the reverse orientation; contact damage may result. Compare this relay and cover with the others for proper orientation.

5-3 INPUT SIGNAL VERIFICATION (Vertical Beam, Horizontal Image Receptor)

1. Set the SID to 40 inches with the x-ray beam vertical. Verify the following input signals (relay K6 must be energized).

TEST POINT	VOLTAGE	FUNCTION OF SIGNAL
J1-L	4.58 ± .02	VSIDC to Collimator
J1-11	4.21 ± .02	VSIDL to Collimator
J2-W	0.40 ± .01	VBXF from Collimator
J1-M	0.5 - 2.00	VXFC from Collimator
J1-N	0.5 - 2.00	VXFL from Collimator

2. Insert a cassette in the cassette tray, and measure the voltage at the following points:

TEST POINT	VOLTAGE	FUNCTION OF SIGNAL
J1-A	2.07 ± .01	VCT to Cassette Tray
J1-C	0.80 ± .05 (Nom)	VBCT (IR TRUE from Cassette Tray)
J1-D	0.88 - 1.98	VIRC from Cassette Tray
J1-B	0.88 - 1.98	VIRL from Cassette Tray

5-4 LOGIC BOARD TROUBLESHOOTING Refer to LOGIC CHART

1. VIRC, VCT and VIRL signals must be present and within the values specified before trouble-shooting.
2. The following procedures can be used to check for logic malfunctions on the main logic board.
3. Use only a voltmeter probe that has a thin sharp point. A "Logic High" condition is always more than 2.4 volts. Other values indicate a logic fault that must be corrected.
4. Remove the motor drive relays K1, K2, K3 and K4.
5. The following tests must be followed in the order given:

NOTE

The logic chart lists the status of all gate outputs, transistor, relays and status indicator lamps (on the collimator). The left column lists the test points to be measured and the other five columns list the status of each test point. The central part of the test-point column is separated into two columns; C & L. The "C" and "L" test points refer to two identical schematic sections for the CROSS and LONG shutter controls.

- Condition No. 1
  1. Remove the IR TRUE signal by withdrawing the cassette tray.
  2. Remove the SID TRUE signal by connecting a jumper from anode of CR33 (TP1) to ground. All test points must agree with the Logic Chart.
- Condition No. 2
  1. Restore the IR TRUE signal by placing a cassette in the tray and inserting the tray.
  2. All test points must agree with Logic Chart.
- Condition No. 3
  1. Manually close the collimator shutters.
  2. Restore the SID TRUE signal by removing the jumper from anode of CR33 (TP1) to ground. (IR TRUE must remain.)
  3. All test points must agree with the Logic Chart.

MEASURE POINT	VOLTAGE	SIGNAL FUNCTION	QUALIFICATION
J1-L	4.58		
J1-11	4.21		
J2-W	0.40 (nom)		
J1-M	0.4 - 2.0		Depending on SID & Shutter Opening.
J1-N	0.4 - 2.0		Depending on SID & Shutter Opening.

4. The logic chart indicates all conditions required to cause a collimator opening drive. Note that U4-1 will switch to "L" with a slight delay. Note that U4-6 will pulse "L" for about 0.1 second and return to "H".

- Condition No. 4

  Manually open the collimator. The chart indicates all conditions required to drive the collimator in a closing direction.

- Condition No. 5

  Manually close the collimator. The chart now indicates the condition of cycle-completed.

- Final Check of Logic Board
  1. After completing the sequence for Conditions 1 through 5, replace relays K1, K2 K3 and K4.
  2. Repeat Conditions No. 1, No. 2 and No. 3 above. The collimator should rapidly open-stop-close-stop as implied by Conditions No. 3, No. 4 and No.5.

5-5 TROUBLESHOOTING THE TIMER CIRCUIT

Due to line losses, power supply regulation, and triac voltage drop (1 volt), the voltage measured at the lamp socket (with lamp ON) must be 20-24 VAC true rms.

1. Remove the gate lead from G on the circuit board.
2. Apply power; the lamp must remain off. It it remains on, and all wiring is OK, replace the triac. (Refer to DISASSEMBLY diagram.)

3. Measure the voltage across R1, it must be from 6 to 8 volts indicating that all normal loads are OK.
   If the voltage exceeds 8 volts, M1 is probably internally shorted (continue testing).
4. Measure the voltage across C2; it must be 9.25 to 10.8 volts.
   If the voltage is less than 9.25 volts, a short circuited component is again indicated, confirming step 3 (continue testing).
5. Measure the voltage across R3; it must be from 3.5 to 5 volts (between timing intervals).
   If the voltage is more than 5 volts, K1 coil or D4 (CR3) is the shorted component.

   If the voltage is less than 3.5 volts and if the voltage in step 3 is more than 8 volts, replace M1.
6. If steps 3, 4, and 5 are OK, measure the voltage across R2 by connecting a voltmeter from C2 (+) and C3 (+). Prior to a timing interval, the voltage will read about 8 to 9.5 volts.
   Activate the time-start switch; ensure that the switch is indeed operating by reading across R4; 9.25 to 10.8 V = switch closed.

During the timed interval the reading across R2 will slowly drop to about 3.5 and snap back to its former value of 8 to 9.5 volts. With a 10 megohm meter the time will be (1.7 RC).
   If the reading starts dropping but stops at some mid-value and holds, capacitor C3 is leaking and can either be replaced or exchanged with C2.

   If the voltage does drop slowly to about 3.5 and snaps back to its former value, all timing circuits have now been checked as OK.
7. Finally, check the triac turn-on as follows:
   - First connect ohmmeter from G to T2 on the circuit board; it must indicate an open circuit prior to a timing interval, and 100 ohms during a timing interval. If not, replace K1 (or R5);
   - Second, use a 100 ohm test resistor and momentarily contact the gate lead (which must be attached to the triac) to T2 on the triac or T2 on the circuit board. During the resistor contact, the lamp must be on. If the lamp does not turn on, replace the triac. (Refer to LAMP TIMER WIRING)

CAUTION

DO NOT DIRECTLY CONTACT THE GATE LEAD TO T2. THIS COULD DAMAGE THE TRIAC.

8. Reconnect the gate lead to G on the circuit board.

5- 6 SYSTEM INTERCONNECTING WIRING CHECKOUT

The following tables contain the wiring checkout instructions for this system. Unplug the LOGIC BOARD before performing the resistance checks.

COLLIMATOR WIRING CHECKOUT

FROM: CON-NECTOR	TO: CON-NECTOR	RESISTANCE
P3-17	P3-3	15-22 ohm (MANUAL lamp)
P3-17	P3-6	15-22 ohm (C. READY lamp)
|	P3-5	15-22 ohm (L. READY lamp)
|	P3-4	15-22 ohm (EXP. HOLD lamp)
|	P3-11	2 ohm (max.) Collimator < 10° from vertical
|	P3-12	2 ohm (max.) Collimator > 80° from right of vertical
|	(Gnd)	
P3-17	(Gnd)	
P3-15	P3-10	1,000 ohm (nominal)
|	P3-9	1,000 ohm (nominal)
|	P3-16	0-450 ohm variable (CROSS dial)
|	P3-14	0-450 ohm variable (LONG dial)
P3-15	(Gnd)	
P3-21	P3-8	124 ohm (motor coil)
P3-21	P3-7	124 ohm (motor coil)
P3-21	P3-18	124 ohm (motor coil)
P3-21	P3-20	124 ohm (motor coil)
P3-8	P3-7	248 ohm (motor coil)
P3-18	P3-20	248 ohm (motor coil)

TABLE CASSETTE TRAY CHECKOUT

FROM: CON-NECTOR	TO: CON-NECTOR	RESISTANCE
Gnd	W3-BLK	∞ (Tray in or out)
Gnd	W3-RED	∞ (Tray in or out)
Gnd	W3-GRN	∞ (Tray in or out)
Gnd	W3-WHT	∞ (Tray in or out)
		∞ (Tray retracted; or tray in with no cassette)
W3-BLK	W3-WHT	500 ohm (Cassette in tray; tray fully inserted)

NOTE

Temporarily remove jumper between Bucky terminals 2 and 3 and properly insert a cassette in bucky.

W3-WHT	W3-RED	60-940 ohm (depending on cassette size)
W3-WHT	W3-GRN	60-940 ohm (depending on cassette size)

Replace jumper after completing checkout.

AUXILIARY CASSETTE TRAY CHECKOUT

FROM: CON-NECTOR	TO: CON-NECTOR	RESISTANCE
Gnd	W2-BLK	∞ (Tray in or out)
Gnd	W2-RED	∞ (Tray in or out)
Gnd	W2-GRN	∞ (Tray in or out)
Gnd	W2-WHT	∞ (Tray in or out)
		∞ (Tray retracted; or tray in with no cassette)
W2-BLK	W2-WHT	500 ohm (Cassette in tray; tray fully inserted)

NOTE

Temporarily remove jumper between Bucky terminals 2 and 3 and properly insert a cassette in Bucky.

W2-WHT	W2-RED	60-940 ohm (depending on cassette size)
W2-WHT	W2-GRN	60-940 ohm (depending on cassette size)

Replace jumper after completing checkout.

5-7 SYSTEM EXPECTED USEFUL LIFE AND MAINTENANCE

Periodic preventive maintenance including collimator and tray lubrication, cleaning, electrical and mechanical adjustments are to be performed once every twelve months or 15,000 films unless otherwise specified. The periodic maintenance schedule is required to maintain the collimator system in proper and accurate condition throughout the system's useful life and to extend the useful life of the system.

The minimum useful life with periodic maintenance of the PBL-IIIsystem including the collimator and electronic module is five years or 50,000 films or collimator readjusting cycles. With the specified preventive and corrective maintenance, the collimator and logic module should last beyond the specified minimum life. Corrective maintenance consists of repair or replacement of randomly failed components as soon as a failure is detected and assuring that the collimator exit window mirror and projection lamp are properly maintained and/or replaced when required.

The standard tray should last through the minimum specified lifetime of the system contingent on reasonable and careful usage.

5-8 COLLIMATOR CHECKOUT, LUBRICATION AND CLEANING

Perform the following collimator lubrication and mechanical inspection every twelve months or 15,000 films (when the collimator is readjusted), whichever occurs first. This procedure requires the removal of the collimator body cover, inspection of all moving parts, lubrication of all friction points, and careful assembly and cleaning of all critical components. The collimator rear cover and body cover must be removed. Refer to DISASSEMBLY.

5-9 MECHANICAL INSPECTION AND SERVICE

Inspect all front drive gears (behind the front panel) for correct mesh while cycling the collimator through its maximum range. There should be no significant slack between the meshed gear teeth where the backlash springs are not used. Check the right-angle bevel gears on the cross shutter drive shaft (above the left shutter control knob). If the beveled gear pair or the two large spur gear pairs are not meshed properly the front panel will have to be removed. This is accomplished by removing the two dial knobs, two front panel screws and two small top front cover screws.

CAUTION

Support the front panel with a length of cord or wire; DO NOT ALLOW IT TO HANG BY THE ELECTRICAL WIRES.

If the spur gear pair(s) is(are) loose the motor (middle gear) can be adjusted for a better mesh by slightly loosening the motor mount screws on the front drive bracket and pushing the motor gear into better mesh with the large shutter shaft gear (upper) and the lower dial knob pinion gear. Retighten screws firmly after adjusting the gears just enough to allow smooth, even mesh. Relubricate as required. Refer to COLLIMATOR LUBRICATION.

If the bevel gears on the cross shutter drive shaft are not correctly meshed, loosen the set screw on the inside collar on the shaft and, if necessary, loosen the set screw on the large shutter shaft gear. Push on the outer end of the shaft while holding the collar forward against the brass bushing and tighten the collar set screw. Tighten the large shutter shaft gear and test for smooth, even operation.

If the gears inside the collimator chassis are not correctly meshed, or if the shutters or shutter control arms are loose, the collimator must be returned to the factory for corrective repair and a complete mechanical re-alignment.

NOTE

Whenever the collimator gearing is adjusted, the collimator potentiometer calibration must be repeated. Anytime the front panel is removed and/or the collimator gearing is adjusted, the dial accuracy check must be repeated. Refer to COLLIMATOR POTENTIOMETER CHECKOUT AND ADJUSTMENT, and SHUTTER DIAL ADJUSTMENT.

5-10 COLLIMATOR LUBRICATION

Apply a small amount of grease (Lubriplate 630-AA or equivalent) to the meshed teeth of all collimator gears. Wipe off all excess grease after cycling the collimator a few times.

NOTE

Protect the mirror, do not allow grease to contact the reflective surface.

Apply one drop of a medium weight, #20, oil (do not use lightweight household oils) to all shafts and gear pivots at the points of friction. Wipe off all excess oil after cycling the collimator a few times.

NOTE

Protect the mirror, do not allow oil to contact the reflective surface.

Inspect the remainder of the collimator for loose or missing parts and the wires for damaged insulation.

5-11 COLLIMATOR CLEANING

The cleaning functions detailed below are necessary to maintain the collimator within required specifications for light output and edge contrast.

After completing the collimator checkout and lubrication, check the mirror for dust and grease. Clean the mirror only with surgical cotton and alcohol. Be sure that all oily or dirty film is washed free from the mirror.

Clean the plastic window inside and out with a soft damp cloth and any common mild glass cleaner. Wipe away any dirt residue or film with a slightly dampened lens paper or tissue. Ascertain that the inside of the window is clean before assembling the collimator body cover onto the collimator.

5-12 PARTS REPLACEMENT

If the mirror or plastic exit window are cracked, broken, or damaged (stained) they should be replaced immediately. Refer to PERIODIC RECALIBRATION.

If the projection lamp has not been replaced during the past 12 months or after 10,000 exposures have been made, it is recommended that it be replaced during the periodic maintenance procedure.

5-13 TRAY LUBRICATION AND MAINTENANCE

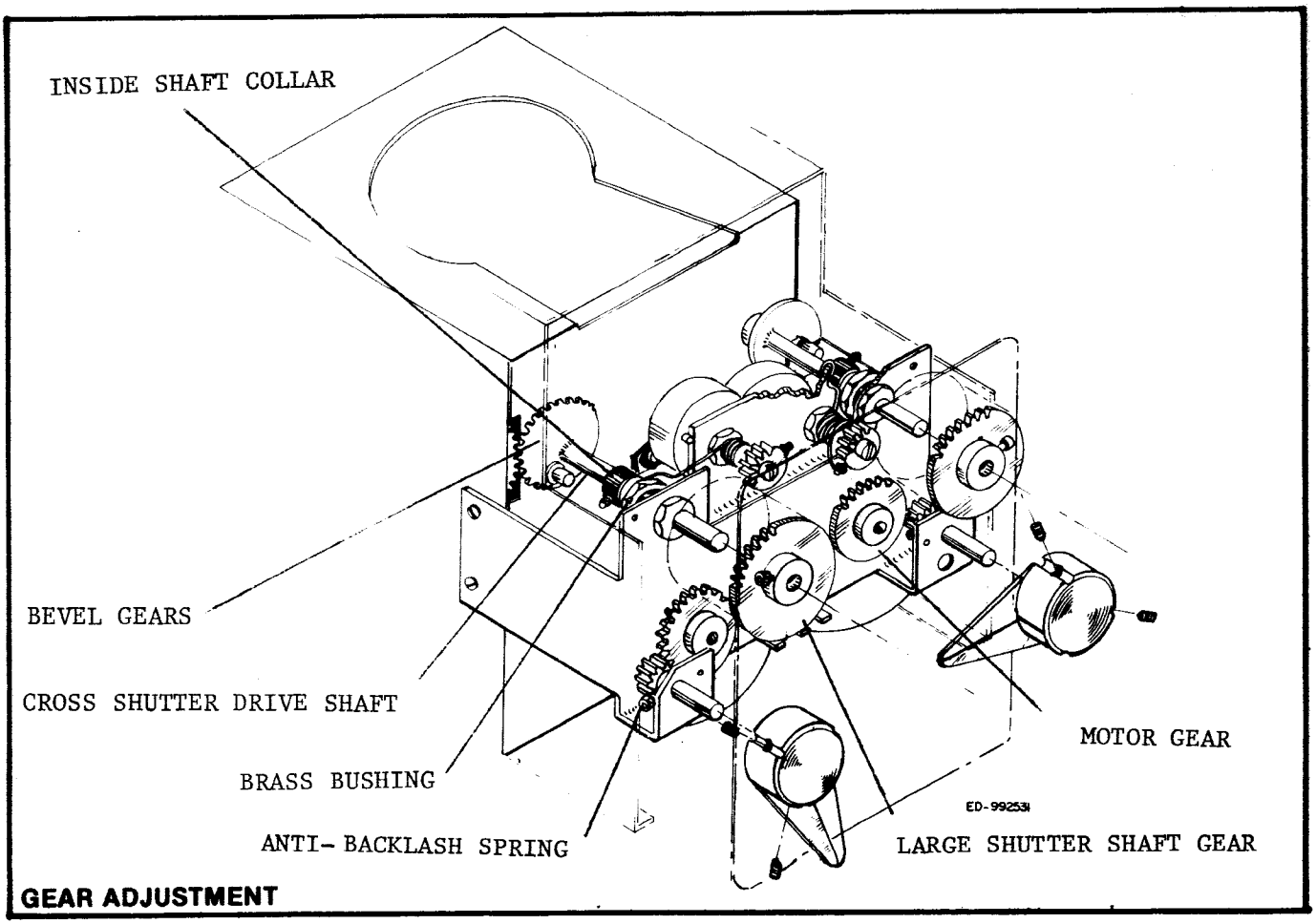
The lubrication schedule listed in the cassette tray operating and service instruction booklet must be followed. Every 10,000 films the tray connector is to be lubricated as described with the proper lubricant. Perform other cleaning and adjusting operations as also prescribed. Refer to TABLE CASSETTE TRAY SIZE/VOLTAGE ACCURACY CHECKOUT procedure if cassette tray calibration is to be checked or if faulty tray operation is suspected.

5-14 PERIODIC RECALIBRATION

Perform the following alignment procedures: SHUTTER DIAL ADJUSTMENT, LIGHT FIELD TO X-RAY FIELD COINCIDENCE, CROSS-HAIR TO LIGHT FIELD CENTER ALIGNMENT, BUCKY LIGHT-LINE ALIGNMENT, and ACCURACY CHECKOUT once every twelve months or 15,000 films (whichever occurs first), or any time the collimator is removed from the x-ray tube (even if reinstalled on the same housing).

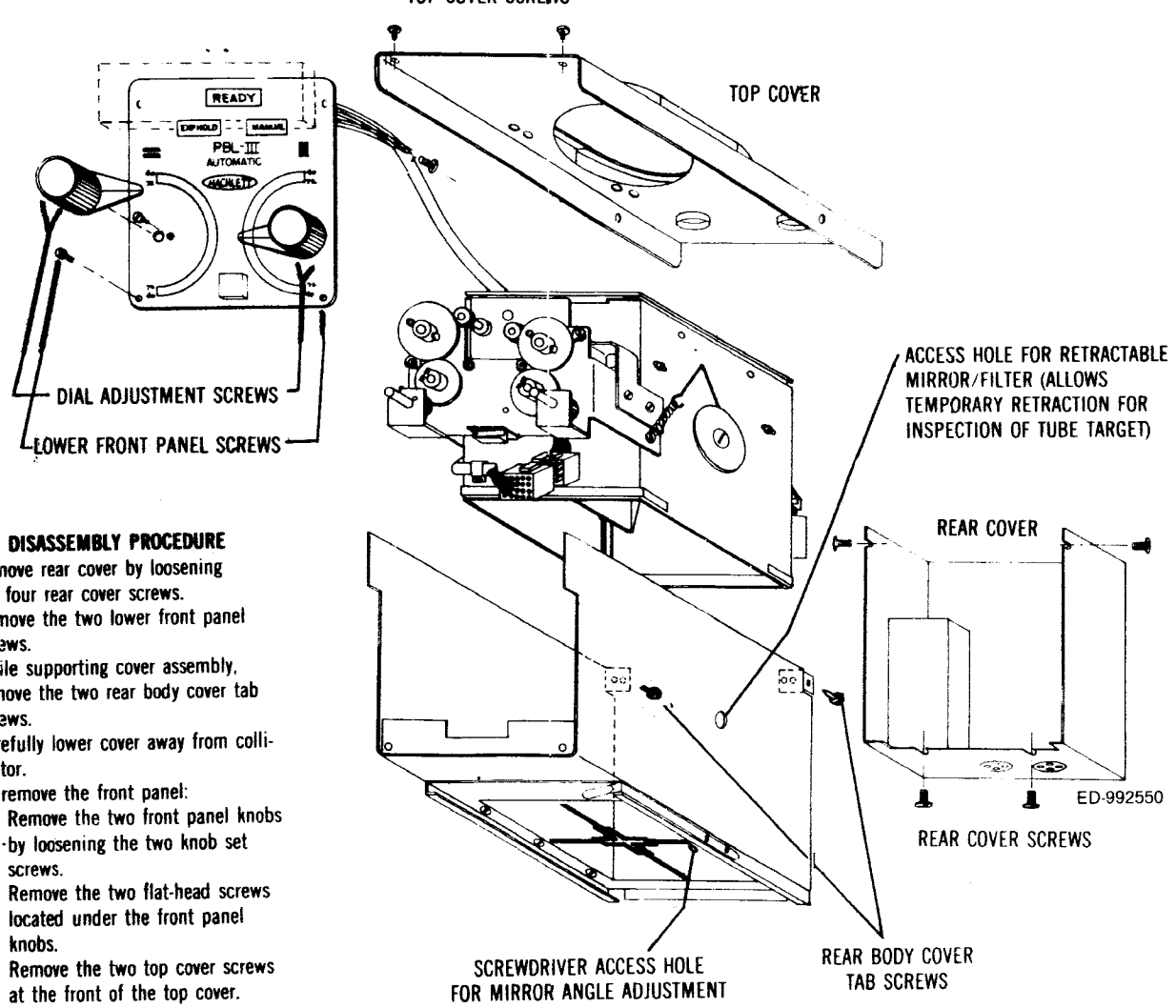
If the accuracy checkout procedure indicates that the system be recalibrated, perform all necessary calibration steps, including tray calibration if this is suspected. Refer to TABLE CASSETTE TRAY SIZE/VOLTAGE ACCURACY CHECKOUT.

If, during replacement of the projection lamp, the lamp is placed correctly in the lamp socket as described in LIGHT FIELD TO X-RAY FIELD COINCIDENCE, and if the old lamp was correctly placed in the socket, the light field may not require readjustment. Refer to LIGHT FIELD TO X-RAY FIELD ALIGNMENT, CROSS-HAIR TO LIGHT FIELD CENTER ALIGNMENT, and BUCKY LIGHT-LINE ALIGNMENT.



GEAR ADJUSTMENT

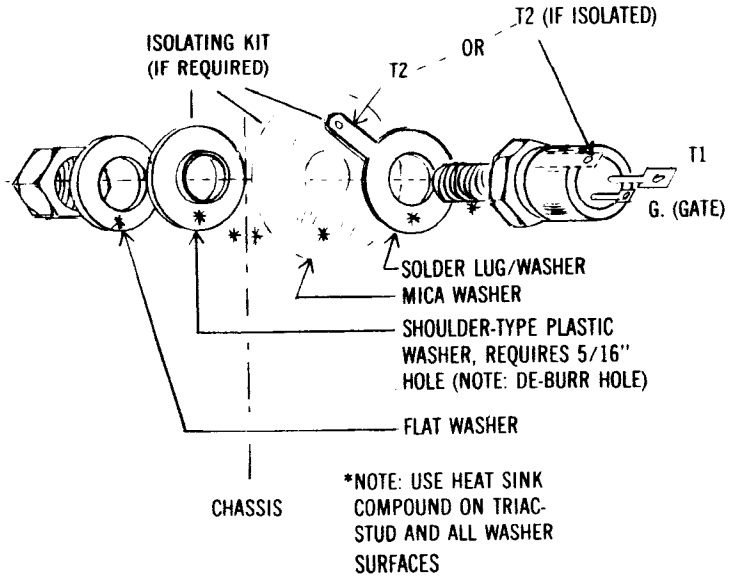
DISASSEMBLY



DISASSEMBLY PROCEDURE

- Remove rear cover by loosening the four rear cover screws.
- Remove the two lower front panel screws.
- While supporting cover assembly, remove the two rear body cover tab screws.
- Carefully lower cover away from collimator.
- To remove the front panel:
  1. Remove the two front panel knobs by loosening the two knob set screws.
  2. Remove the two flat-head screws located under the front panel knobs.
  3. Remove the two top cover screws at the front of the top cover.
  4. Remove front panel.

TRIAC REPLACEMENT



PARTS LIST

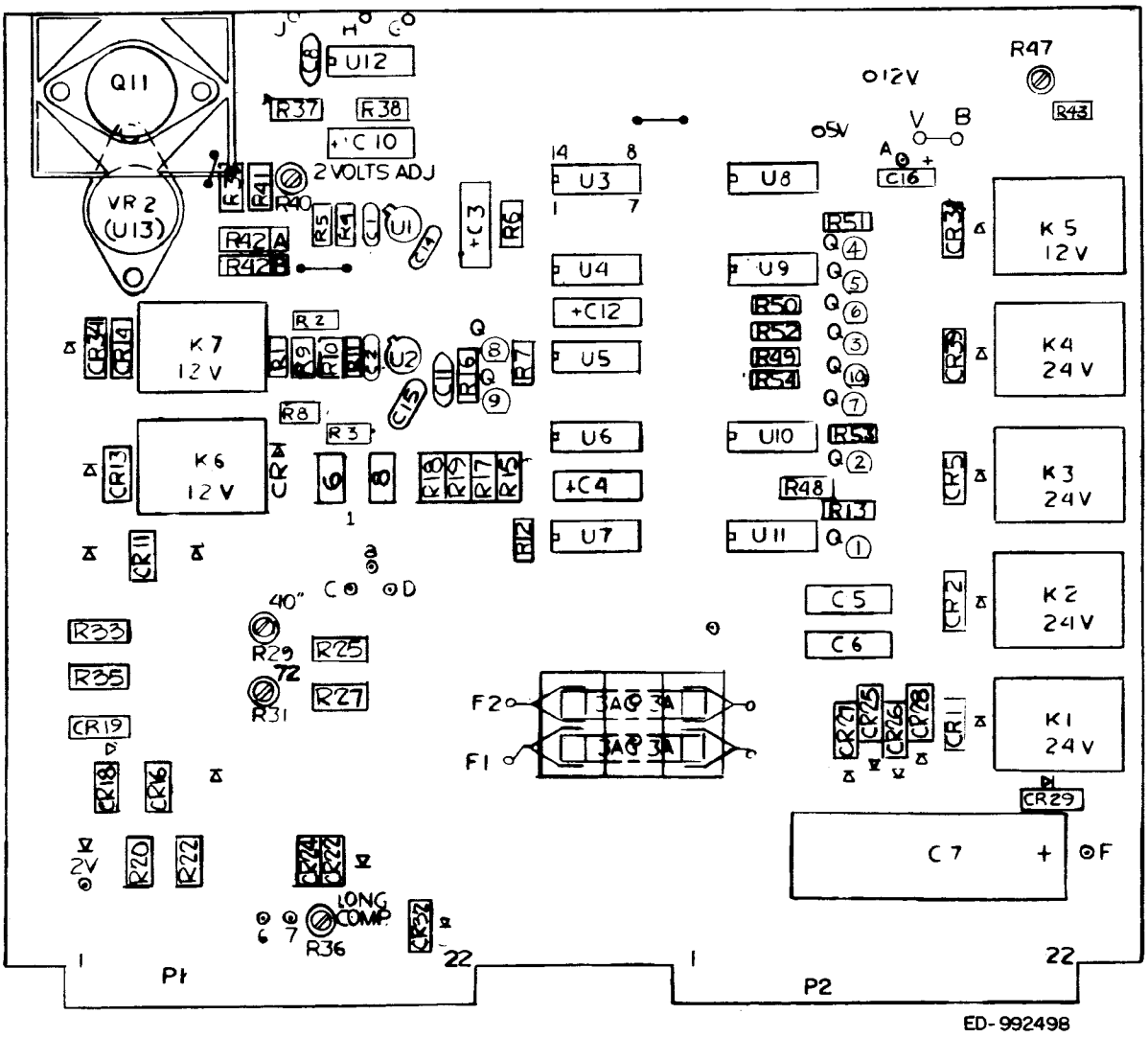
This manual (ST-3631) covers the PBL-III Collimator starting with Serial No. 54-06-0-0001 and the PBL-III LF Collimator starting with Serial No. 55-06-0-0001.

REF DES.	MACHLETT PART #	DESCRIPTION
		LOGIC CHASSIS
	P-754564	Triac, 30 Amp RCA 40805
	RM-543921	Thermally Conductive Grease
	P-921729	Keyswitch
		IC LOGIC BOARD ASSEMBLY
C1, C2 C14, C15	P-754529-5	Capacitor, 220 pF, 200 V, 10%
C3, C4 C10 C12, C13	P-750107	Capacitor, 150 uF, 15 V, Electrolytic
C5, C6	P-750122	Capacitor, 6 uF, 50 V, Non-polarized
C7	P-750104	Capacitor, 2200 uF, 50 V, Electrolytic
C8	P-754529-22	Capacitor, 100 pF
C11	P-754529-12	Capacitor, .1 uF
CR 1-3, 5,6,8, 11,13,16, 18,19,22, 24-28, 34, 39	P-750119	Diode IN2070
F1, F2	P-754525-22	Fuse, 3A-3AG Littelfuse
K1-K4	P-754518-8	Relay, 24 VDC J4-14D-25 P5
K5-K7	P-754518-9	Relay, 12 VDC KHU 17 D11
Q1-Q7 Q10	P-754509-1	Transistor, PN 2222A TO-92 Case
Q8, Q9	P-750120	Transistor, 2N3903 TO-92 Epoxy
Q11	P-754651-1	Transistor, 2N3055 TO-3 Case
R1, R2 R8, R9	P-754534-25	Resistor, 100 K ohm, 0.25 W
R3,	P-754533-25	Resistor, 27 ohm, 0.25 W, 5%
R4, R11	P-754534-81	Resistor, 22 M ohm, 0.25 W
R5, R10 R15-R19	P-754533-75	Resistor, 3.3 K ohm, 0.25 W
R6, R12	P-754533-47	Resistor, 220 ohm, 0.25 W
R7, R13 R24, R25, R48-R54	P-754533-51	Resistor, 330 ohm, 0.25 W
R20,R22, R39	P-754533-33	Resistor, 56 ohm, 0.25 W
R27, R41	P-754533-27	Resistor, 33 ohm, 0.25 W
R29,R31, R36	P-754580-5	Potentiometer, 200 ohm

REF DES-	MACHLETT PART #	DESCRIPTION
		IC LOGIC BOARD ASSEMBLY Cont'd
R33	P-754533-63	Resistor, 1 K ohm, 0.25 W
R35	P-754533-67	Resistor, 1.5 K ohm, 0.25 W
R37	P-754533-80	Resistor, 5.1 K ohm, 0.25 W
R38	P-754533-84	Resistor, 7.5 K ohm, 0.25 W
R40, R47	P-754580-1	Potentiometer, 10 ohm
R42A R42B	P-750124-1	Resistor, 1 ohm, 0.50 W
R43	P-754533-39	Resistor, 100 ohm, 0.25 W
U1, U2	P-754579-1	IC,LM311H TO-5 Voltage Comparator
U3, U7 U9	P-754570-2	IC, TO-116 Case SN 7400N, Quad 2 Input Positive NAND Gate
U4	P-754570-5	IC TO-116 Case SN 7413N, Dual 4 Input Positive NAND Schmitt Trigger
U5	P-754570-4	IC, SN 7408N TO-116 Case Quad 2 Input Positive AND Gate
U6, U10	P-754570-3	IC, TO-116 Case SN 7404N Hex Inverter
U8, U11	P-754570-6	IC, TO-116 Case SN 7420N Dual 4-Input Positive NAND Gate
VR1	P-750127	IC, LM723H Voltage Regulator
VR2	P-754569-1	Voltage Regulator, LM340K, 5 VDC
VR19	P-754567-20	Diode, IN758A, Zener
		LAMP TIMER ASSEMBLY
	F-543726	Lamp Timer Board
C1, C4	P-754529-12	Capacitor, .1 uF, 100 V, ± 10%
C2, C3	P-750107	Capacitor, 150 uF, 15 V
C5	P-754529-9	Capacitor, .01 uF, 100 V, ± 10%
D1, D3 D4	P-754506-4	Diode, IN4004
D2	P-754567-20	Diode, Zener, IN5240B, 10 V
K1	P-754578-2	Relay, Dry Reed
R1	P-754535-49	Resistor, 270 ohm, 0.50 W, 5%
R2	P-754534-25	Resistor, 100 K ohm, 0.25 W, 5%
R3	P-754533-49	Resistor, 270 ohm, 0.25 W, 5%
R4	P-754534-1	Resistor, 10 K ohm, 0.25 W, 5%
R5	P-754533-39	Resistor, 100 ohm, 0.25 W, 5%
U1	P-754514	IC, NE555 V Timer
		COLLIMATOR
	P-544384	Panel Light, 1/2 "READY"
	P-544385-2	Panel Light, "MANUAL"
	P-544385-1	Panel Light, "EXP. HOLD"
	P-543746	Lamp Base, GE Type QCS
	P-543715	Lamp, Projection, FCS
	P-541815	Motor, A.W Haydon
	P-541814-2	Potentiometer, 1000 ohm, Long Shaft
	P-754731-1	Light Switch
	P-754731-3	Light Switch Lens
	P-751743	Tilt Switch Assembly

REF DES.	MACHLETT PART #	DESCRIPTION
	COLLIMATOR Cont'd	
	P-924250	Plastic Window
	P-924249	Accessory Track
	P-921862	Extension Rails
	P-539278	Microswitch, Filter
	P-543617	Mirror
	A-543703	Dial Knob Assembly (Black Line)
	A-990450	Dial Knob Assembly (White Line)
	P-543635	Dial Indicator
	P-924202	Lamp Cover Display
	A-923234	Tape, Measuring
	P-924248	Spring, Adapter Locking

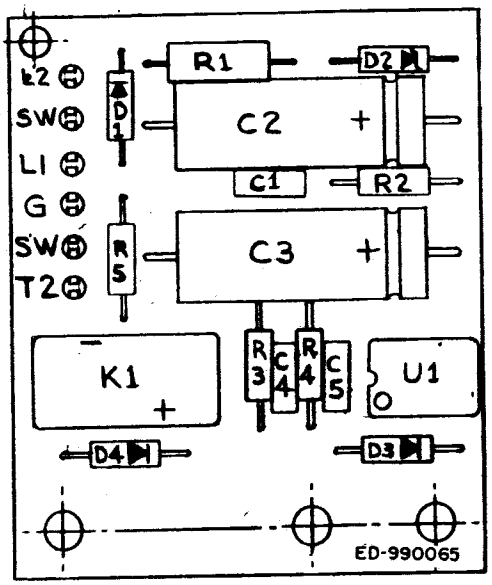
REF DES	MACHLETT PART #	DESCRIPTION
	HIGH ENERGY TRANSFORMER ASSEMBLY (LAMP)	
	C-544375	High Energy Transformer Assembly, Complete
	P-543772	Fuse, (2), 3AG 3 Amp. S.B.
	MISCELLANEOUS	
W3	A-992399	Cable, 30-Conductor
W1, W2	A-992403	Cable, 4-Conductor
W5	A-992400	Cable, 3-Conductor
W6	A-992402	Cable, 2-Conductor
W7	A-992404	Cable, 3-Conductor
W8	A-992405	Cable, 3-Conductor



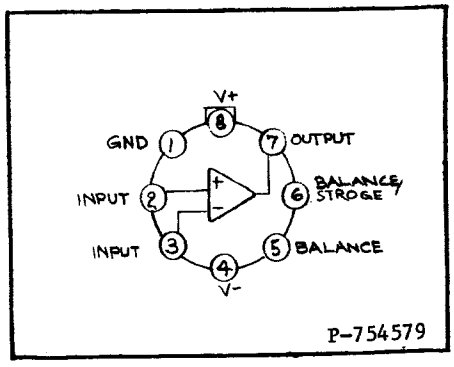
LOGIC BOARD COMPONENT LAYOUT

ABBREV.	DESCRIPTION	ORIGIN	LOCATION	VALUE (UNDER LOAD)
SID	Source (focal-spot)-To-Image Cassette-Film) Distance			
VSIDC	Applied directly to CROSS potentiometer in Collimator	LOGIC BOARD	TP-6 J1-L (P3-9)	4.58 V @ 40" SID
VSIDL	Voltage value derived from VSIDC by attenuation through adjustable resistance (R36, 'Long Comp' Main Logic). Applied directly to the "LONG" potentiometer in Collimator.		TP-7 J1-11 (P3-10)	92% of VSIDC
VBXF	Voltage applied to low ends both collimator potentiometers.	LOGIC BOARD	J2-W (P3-15)	0.347 V
SID TRUE	Signal indicating SID is in operational range.	JUNCTION	CR6-CR8/R18	More than 5 Volts
XF	X-Ray Field Size in plane of cassette/film.			
VXFC	Voltage value representing CROSS X-Ray Field size at distance represented by VSIDC.	Collimator	J1-M (P3-16)	Refer to VIR vs VXF table
VXFL	Voltage value representing LONG X-Ray Field size at distance represented by VSIDC.	Collimator	J1-N (P3-14)	Refer to VIR vs VXF table
IR	Refers to image receptor size.			
VIRC	Voltage representing CROSS Image receptor size:	Cassette Tray/Holder	J1-D GRN * J1-4 GRN †	Refer to VIR vs VXF table
VIRL	Voltage value representing LONG image receptor size.	Cassette Tray/Holder	J1-B RED * J1-3 RED †	Refer to VIR vs VXF table
IR TRUE	Signal indicating Cassette in Cassette Tray/Holder	Cassette Tray/Holder	J1-C WHT * J1-5 WHT †	See VBCT
VCT	Voltage value applied to L-F cassette tray.	LOGIC BOARD(R40)	J1-A BLK * J1-2 BLK †	2.07 V
VBCT	Voltage value at low ends of cassette tray potentiometers.	Cassette Tray/Holder	J1-C WHT * J1-5 WHT †	0.8 V

* at table bucky tray
† at auxiliary bucky tray



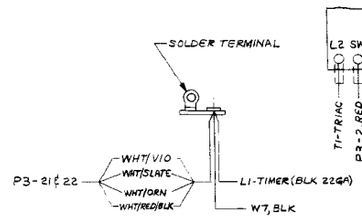
LAMP TIMER BOARD

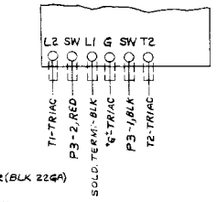


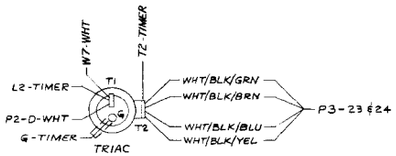
TOP VIEW OF U1 AND U2

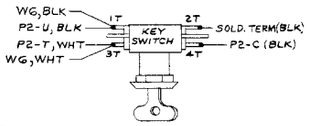
TABLE OF CONTENTS

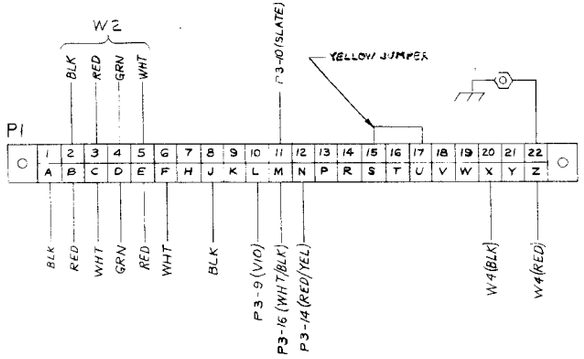
CABLE NO. & LENGTH	PIN NO.	COLOR CODE	FROM	TO
P3 W3 30 COND P-752229 30 FT	1	BLK	P3 -1	SW TIMER P.C. BD
	2	RED	-2	
	3	WHT	-3	P2-G
	4	GRN	-4	P2-7
	5	ORN	-5	P2-5
	6	BLUE	-6	P2-4
	7	BRN	-7	P2-M
	8	YEL	-8	P2-L
	9	VIO	-9	P1-L
	10	SLATE	-10	P1-11
	11	PINK	-11	P2-1
	12	TAN	-12	P2-2
	13	RED/GRN	-13	P2-3
	14	RED/YEL	-14	P1-N
	15	RED/BLK	-15	P2-W
	16	WHT/BLK	-16	P1-M
	17	WHT/RED	-17	P2-8
	18	WHT/BLK/ORN	-18	P2-R
	19	WHT/GRN, WHT/YEL	-19	CHAS GRD
	20	WHT/BLUE	-20	P2-11
	21	WHT/ORN, WHT/SLATE	-21	SOLDER TERM P-544747
	22	WHT/VIO, WHT/BLK/RED	-22	
	23	WHT/BLK/GRN, WHT/BLK/YEL	-23	T2 (TRIAC)
	24	WHT/BLK/BLU, WHT/BLK/BRN	P3 -24	
W2 4 COND P-539077 20 FT	1	BLK	W2	P1-2
	2	RED		P1-3
	3	GRN		P1-4
	4	WHT	W2	P1-5
W1 4 COND P-539077 20 FT	1	BLK	W1	P1-A
	2	RED		P1-B
	3	WHT		P1-C
	4	GRN	W1	P1-D
W4 2 COND P-752991 20 FT	1	BLK	W4	P1-X
	2	RED	W4	P1-Z
W5 3 COND P-539240 1 20 FT	1	RED	W5	P1-E
	2	BLK	W5	P1-J
	3	WHT	W5	P1-F
W6 3 COND P-544732 25 FT	1	WHT	W6	3T KEY SW
	2	BLK	W6	1T
	3	GRN	W6	CHAS GRD
W7 3 COND P-544732 39"	1	BLK	W7	SOLD. TERM. P-544747
	2	GRN	W7	CHAS GRD
	3	WHT	W7	T1 (TRIAC)



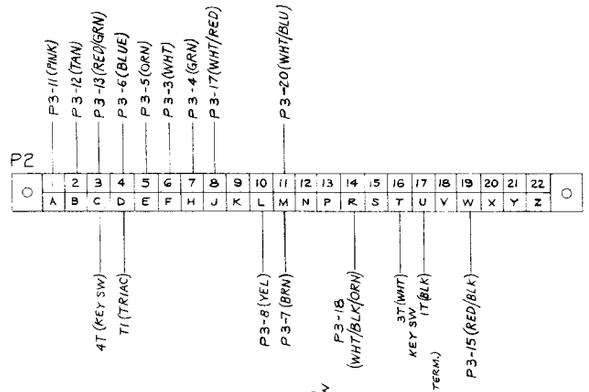


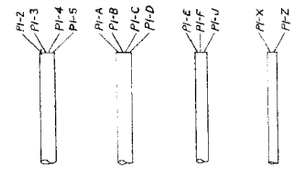


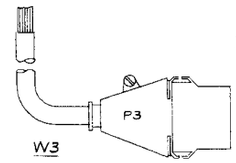


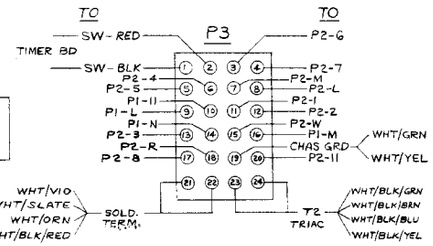


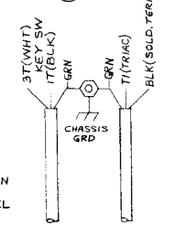
LOGIC BOARD











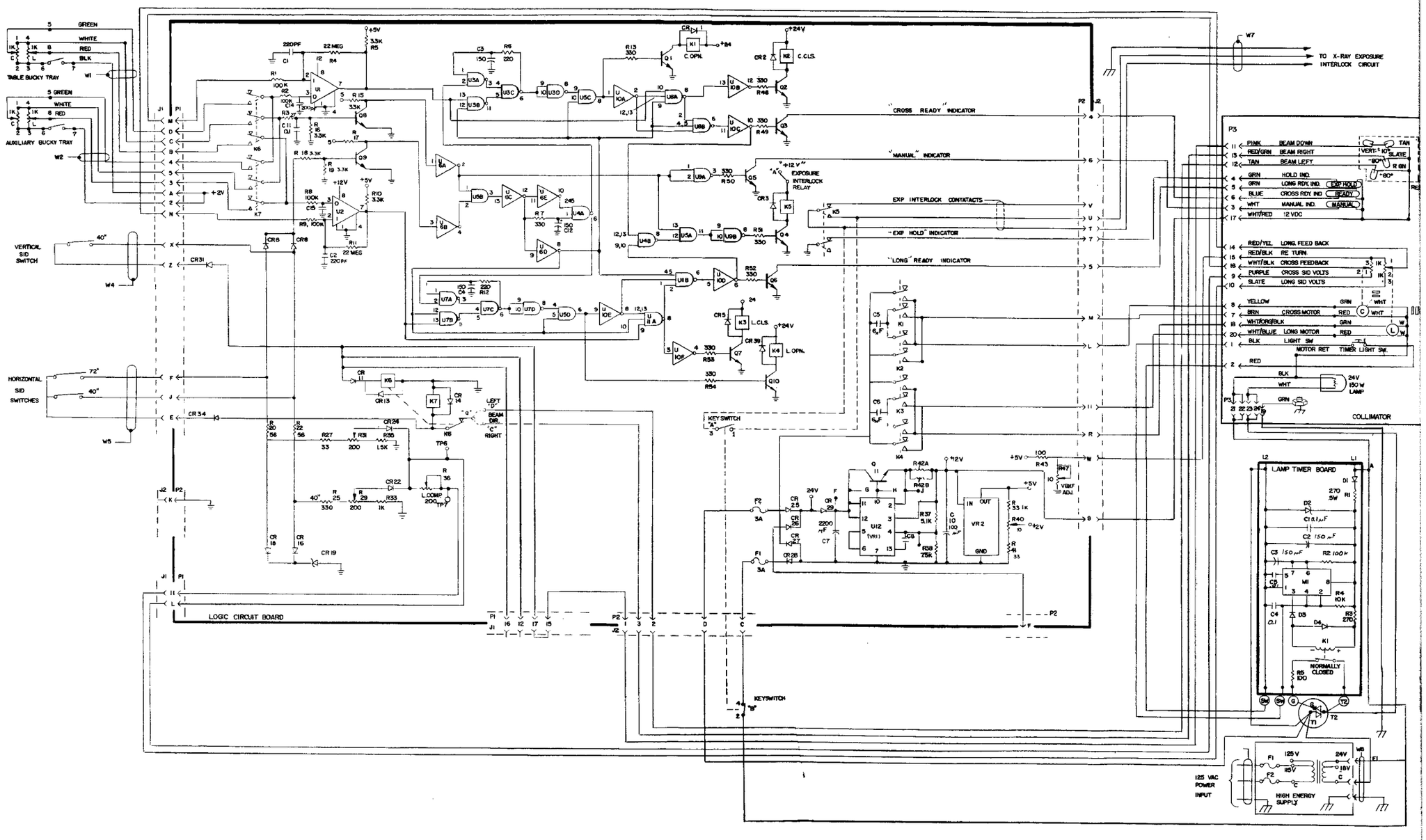


TABLE BUCKY TRAY
AUXILIARY BUCKY TRAY
VERTICAL SID SWITCH
HORIZONTAL SID SWITCHES
LOGIC CIRCUIT BOARD
KEYSWITCH "A"
KEYSWITCH "B"
"CROSS READY" INDICATOR
"MANUAL" INDICATOR
EXP INTERLOCK CONTATACTS
"EXP HOLD" INDICATOR
"LONG" READY INDICATOR
EXPOSURE INTERLOCK RELAY
C. OPN.
C. CLS.
L. CLS.
L. OPN.
TO X-RAY EXPOSURE INTERLOCK CIRCUIT
BEAM DIR. "C" RIGHT
LEFT "D"
LAMP TIMER BOARD
COLLIMATOR
MOTOR RET
TIMER LIGHT SW.
24V 150 W LAMP
NORMALLY CLOSED
125 VAC POWER INPUT
HIGH ENERGY SUPPLY
BEAM DOWN
BEAM RIGHT
BEAM LEFT
HOLD IND.
LONG RDY. IND.
CROSS RDY IND.
MANUAL IND.
12 VDC
LONG FEED BACK
RE TURN
CROSS FEEDBACK
CROSS SID VOLTS
LONG SID VOLTS
CROSS MOTOR
LONG MOTOR
LIGHT SW
VERT-105
SLATE
R GRN
EXP HOLD
READY
MANUAL