

April 25, 1991

ADDENDUM

SUBJECT: Revision to the Installation and Operation Manual for the HFQ-300, 450 and 600 High Frequency X-Ray Generators

DC reference voltage for HFQ Non-SE units has changed from 330 to 360 volts; this affects the calibration procedures and the line voltage.

The following wire change, as shown in the diagram below, has been made to the units: the black wire(s) from K2 to the 240 volt tap on T2(5) has been moved to a 260 volt tap on T2(6).

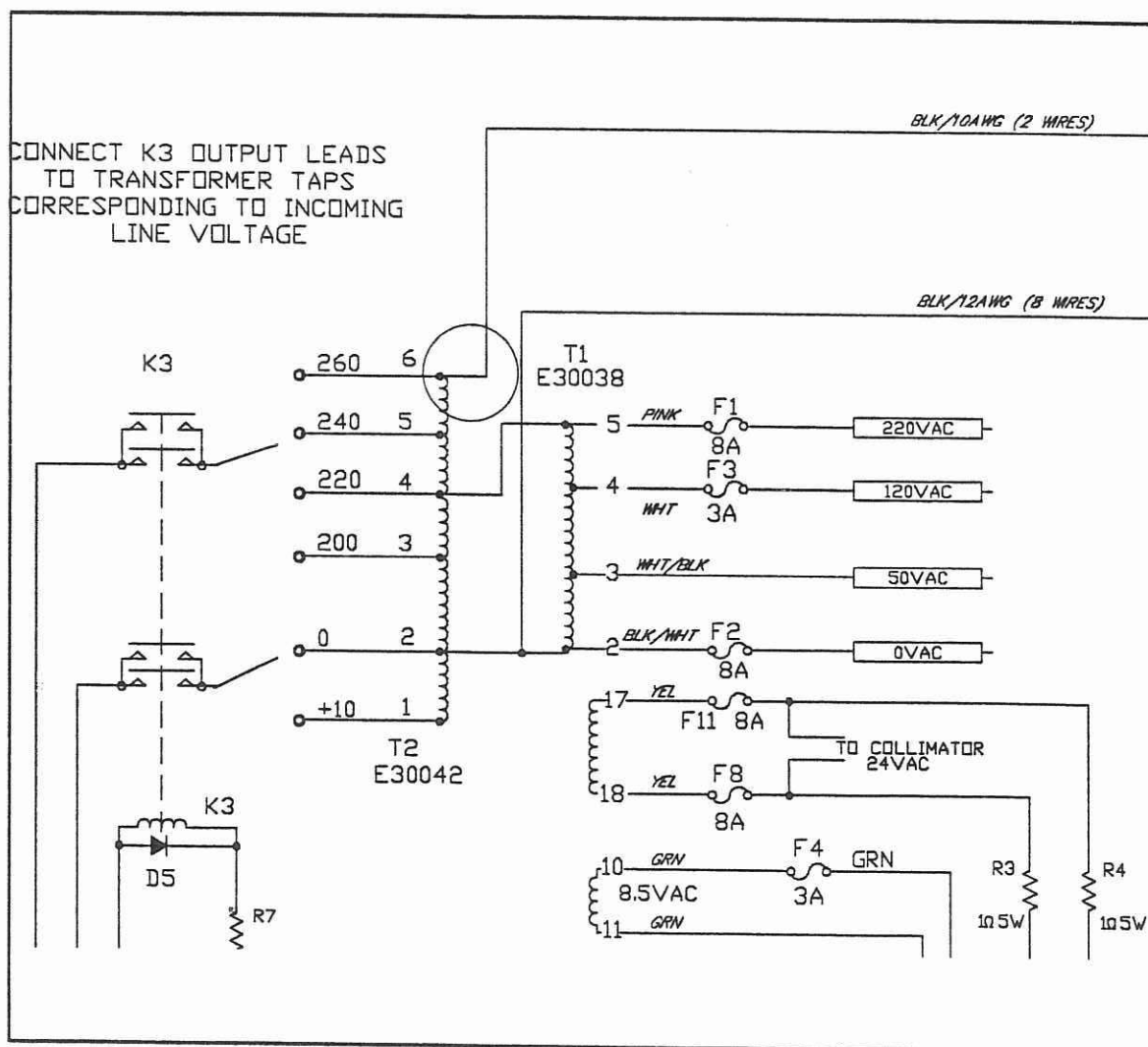


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DATE	REVISION	PAGE	DESCRIPTION
11/13/89	B	3-3	Added seasoning procedures
11/13/89	B	3-4 through 3-11	Update page numbers
11/13/89	B	4-2	Expanded procedures
11/13/89	B	5-2	Clarify HV tank installation procedure
11/13/89	B	5-3	Added description for buss bar adjustment
11/13/89	B	5-4	Added printer connection procedure
11/13/89	B	5-5 through 5-8	Updated page numbers
11/13/89	B	5-9 and 5-10	Added figures for bakelite terminal
11/13/89	B	7-14	Corrected typographical error
11/13/89	B	7-15	Expanded description of source charger
11/13/89	B	7-16	Added theory for power shut off board (A9)
11/13/89	B	7-16	Added theory for distribution board (A7)
11/13/89	B	8-9	Printer installation procedure moved to Section 5, Installation
11/13/89	B	10-1 through 10-21	Added schematics and board layouts
12/19/89	C	2-2	Modified output specification range
12/19/89	C	3-10	Add description of AEC fault reset
12/19/89	C	3-11	Added description of tube heating display
12/19/89	C	3-12	Changed page number
12/19/89	C	4-1	Added KVP-C error message
12/19/89	C	5-5	Added connect procedure for DMP 133
12/19/89	C	6-6	Add caution to season unit
12/19/89	C	6-10	Revised calibration procedure
12/19/89	C	8-1	Corrected figure
12/19/89	C	8-2	Corrected typographical error
12/19/89	C	8-4	Corrected typographical error
12/19/89	C	8-5	Corrected typographical error
12/19/89	C	10-8	Updated schematic
12/19/89	C	10-9	Updated PCB layout
12/19/89	C	10-18	Updated schematic
12/19/89	C	10-19	Added PCB layout

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DATE	REVISION	PAGE	DESCRIPTION
1/15/90	D	5-1	Corrected Typo
1/15/90	D	5-2	Update part number for wire moulding
1/15/90	D	5-5	Add ATM system installation procedure
1//15/90	D	5-6 through 5-9	Changed page numbers/update fig.5-3
1/15/90	D	5-10, 5-11	Update Bakelite Panel drawings
1/15/90	D	5-12, 5-13, 5-14	Added drawings for ATM installation
1/15/90	D	Section 10	Updated schematics/PCB layouts
2/16/90	E	1-4	Updated NCRP report number
2/16/90	E	2-1	Moved Table 2-1
2/16/90	E	2-2, 2-3	Added HFQ power specifications, tables
2/16/90	E	2-4 through 2-8	Incremented page numbers
2/16/90	E	5-3	Added reference to power requirements
2/16/90	E	5-15	Added remote switch connection diagram
2/16/90	E	6-1	Revised source charger calibration proc.
2/16/90	E	6-2	Added line monitor calibration procedures
2/16/90	E	6-3, 6-4	Changed page numbering
2/16/90	E	6-5	Revised SES configuration direction, (step 6)
2/16/90	E	6-6	Added information for VSENSE status menu
2/16/90	E	6-7	Added DC REF. menu
2/16/90	E	7-1	Added line voltage monitor/OCP driver
2/16/90	E	7-8	Changed VBATT to VSENSE
2/16/90	E	7-17	Added theory for line voltage monitor
2/16/90	E	7-18	Added theory for OCP driver
2/16/90	E	10-22 through 10-25	Added schematic and layouts
6/25/90	F	6-1, 6-2	Revised source charger calibration proc.

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DATE	REVISION	PAGE	DESCRIPTION
8/90	F	2-1	Added weights for HFQ models
8/90	F	2-3	Added note to Table
8/90	F	2-4	Added compatible Tubes and Collimators
8/90	F	3-7, 3-9	"FREEZE" value explained
8/90	F	5-3	Added cable information to OCP installation
8/90	F	5-6	Added Tomo Interface
8/90	F	5-6 through 5-8	Revised pagination
8/90	F	5-9	Added Tomo Interface Wiring Table
8/90	F	5-10	Changed Pin O to U
8/90	F	5-11 through 5-17	Revised pagination
8/90	F	6-1, 6-2	Added to Source Charger Calibration
8/90	F	6-3 through 6-12	Revised pagination
8/90	F	6-10, 6-11	Revised MA Calibration procedures
8/90	F	6-11, 6-12	Revised AEC Calibration procedures
8/90	F	7-14	AEC Board 208094 replaced 208091
8/90	F	7-15, 7-16	Source Charger revised; added to Warning
8/90	F	8-8, 8-9	Corrected figure errors
8/90	F	9-1	Added fuse warning
8/90	F	9-1	Replaced Software Test w/ Built-In Diag.
8/90	F	9-2	Revised Calibration Check List
8/90	F	9-4 though 9-7	Using the Built-In Diagnostic Utility
8/90	F	9-7	Added figure for PCB Location
8/90	F	Section 10	Updated schematics/PCB layouts
8/29/90	G	6-7	Added Exposure Counter Menu
8/29/90	G	6-6 through 6-13	Revised page and figure numbering
9/14/90	H	6-1, 6-2	Changed stored energy voltage
9/14/90	H	7-15	Changed stored energy voltage
9/14/90	H	10-19	Changed stored energy voltage

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DATE	REVISION	PAGE	DESCRIPTION
10/3/90	I	2-3	Defined wire size
10/3/90	I	5-8	Corrected connection points
10/3/90	I	6-13	Revised kVp value
10/30/90	J	10-1	Revised Interconnection Diagrams
10/30/90	J	10-2	Revised Interface Board
10/30/90	J	10-17, 10-18	Revised AEC Interface Board
10/30/90	J	10-19, 10-20	Added AEC Board, 208104
10/30/90	J	10-21 - 10-28	Revised paging
12/14/90	K	2-2, 5-3	Added compliance requirement
12/14/90	K	6-7, 6-9	Revised S.E.S. voltage
12/14/90	K	10-4, 10-5	Revised schematics
12/14/90	K	10-8, 10-9, 10-12	Revised schematics
1/91	L	Section 1	Reorganized section
1/91	L	2-1	Revised weights
1/91	L	2-4	Added power specs for 240 VAC, option; added compatible tube
1/91	L	2-5	Corrected typographical errors
1/91	L	2-7, 9-8	Revised generator diagram
1/91	L	2-8	Added Compliance Label location
1/91	L	3-1, 3-2	Auto shut down timer: 60 minutes
1/91	L	3-4	Corrected typographical errors
1/91	L	Section 4	Renamed and revised section
1/91	L	5-2	Added to H.V. tank installation
1/91	L	5-3	Added to Verify Input Power proc.
1/91	L	5-4	Added to System Interconnections
1/91	L	5-7	Added to Final Inspection proc.
1/91	L	5-12, 5-13	Revised panel diagrams
1/91	L	6-1	Added reference to NEMA
1/91	L	6-2	Revised measured voltage levels
1/91	L	6-11, 6-12	Revised mA calibration procedures

***SECTION 1,
PREFACE***

INTRODUCTION

Congratulations on selecting the HFQ Series, the finest radiographic system designed today. BENNETT's HFQ series x-ray generator systems incorporate state-of-the-art technology, a true high-frequency (100 kHz) resonant power source, anatomically programmable technique selection and Quartz accurate electronics.

Manual Overview

The HFQ Series Installation and Operation Manual is intended for use by both technologists and field engineers. It consists of ten sections. The first four sections provide the general information and procedures necessary to operate the BENNETT HFQ system; the second part of the manual provides the technical information required to install, calibrate, and troubleshoot the system. A detailed theory of operation and system schematics are included as well.

The following is a brief overview of the contents of each section:

- Section 1, *PREFACE* - includes a system description, safety notices and recommendations, shipping information, compliance and x-ray protection notices and warranty information.
- Section 2, *GENERAL INFORMATION* - includes component specifications, system options, an overview of operating modes and a description of system controls and indicators.
- Section 3, *SYSTEM OPERATION* - provides complete operating procedures, including power on/off procedures, operating modes and exposure selection criteria.
- Section 4, *SYSTEM DIAGNOSTICS* - contains a description of error messages and a list of common system faults with suggested responses.
- Section 5, *INSTALLATION* - provides installation and interconnection procedures.
- Section 6, *CALIBRATION* - provides calibration procedures, including kVp, mA, and system electronics.
- Section 7, *THEORY OF OPERATION* - provides an analysis of signal flow on both block and component levels.
- Section 8, *PROGRAMMING* - describes procedures for editing existing techniques and creating new techniques in the x-ray control memory.
- Section 9, *PREVENTIVE MAINTENANCE AND TROUBLESHOOTING* - provides routine maintenance guidelines and schedules; built-in system diagnostic utilities are also discussed.
- Section 10, *SCHEMATICS* - includes a set of system schematics.

SYSTEM DESCRIPTION

The HFQ Series are anatomically programmable high-frequency x-ray generators. Operating at 100 kHz resonance, the HFQ systems offer remarkable performance as a diagnostic tool with dramatic reductions in exposure times and patient radiation dose.

The HFQ accommodates up to 72 anatomically programmed techniques. kVp, mAs, and mA are automatically selected depending upon the thickness of the anatomical region. Techniques can be modified at any time by switching to manual mode or by editing the existing techniques.

When the Automatic Thickness Measurement (ATM) option is added, the system has the ability to automatically measure the thickness of a region of interest (ROI) in conjunction with the patented Auto-Tech system.

The HFQ Series is also available as a stored energy system (HFQ SE) that allows you to plug it into a standard household power receptacle (110 VAC).

BASIC CONFIGURATIONS AND OPTIONAL FEATURES

BASIC CONFIGURATIONS

The HFQ Series x-ray generators are state-of-the-art programmable systems. Since the requirements of radiological practices vary widely, BENNETT's basic system design provides for easy future upgrades. The HFQ Series is available in six base configurations, either as Stored Energy (SE) or non-SE systems as follows:

- HFQ-300 or HFQ-300SE (300 mAs at 125 kVp)
- HFQ-450 or HFQ-450SE (450 mAs at 125 kVp)
- HFQ-600 or HFQ-600SE (600 mAs at 125 kVp)

NOTE: BENNETT HFQ 300SE, 450SE, or 600SE models can all be connected to a standard 110 VAC power source.

OPTIONAL FEATURES

A variety of options provide the flexibility to meet individual requirements:

- Automatic Thickness Measurement (ATM) System: the ATM option uses an internal sonar device to measure the anatomical region of interest (ROI) and then select and set the optimal technique factors.
- Automatic Exposure Control (AEC) System: uses an ion chamber to assure proper exposure times. This provides uniform film density from patient-to-patient and film-to-film.

SAFETY NOTICE

The HFQ Series High-Frequency X-Ray generator, manufactured by **BENNETT X-RAY CORP.** will function reliably when operated, maintained, and repaired according to the instructions provided in this manual.

BENNETT X-RAY CORP. cannot assume responsibility for any malfunctioning of this equipment resulting from improper operation, maintenance, or repair, or from damage or modification of its components.

This equipment can be hazardous to both patient and operator unless established safe exposure factors are observed.

X-ray equipment is sold to be used exclusively by or under the prescribed direction of a person who is licensed by law to operate equipment of this nature.

BENNETT X-RAY CORP. disclaims all responsibility from any injury resulting from improper application of this equipment.

SAFETY RECOMMENDATIONS

Mechanical/Electrical

All moveable assemblies and parts of this equipment must be operated with reasonable care. Manufacturer's equipment recommendations described in this manual (included with equipment) must be observed.

Routine inspection of these assemblies should be performed by qualified service personnel on a semi-annual basis. Only properly trained service personnel should be permitted access to internal assemblies, as live electrical components may be present. Be sure line disconnect switches are open or other appropriate safety precautions are followed before service work is performed.

Failure to follow manufacturer's or service personnel's recommendations may result in serious injury.

CAUTION: GROUNDING: this equipment is grounded to an earth ground through the electrical power cord ground wire. It must be connected into a properly grounded electrical box. Under no circumstances should it be operated without the proper three wire power cord attached.

CAUTION: The HFQ/HFQSE Series generators are shipped with a tube loading program specifically designed for the individual x-ray tube and anode rotation speed of the tube supplied. The program is based on focal spot size and anode heat dissipation of the tube insert.

COMPLIANCE NOTICE

The certified model **BENNETT** x-ray system you have purchased has been designed, manufactured, and calibrated to comply with governing Federal Regulations 21 CFR Subchapter J and the performance standards attendant thereto.

Scheduled maintenance is essential to the assurance of continued integrity of this equipment with respect to regulatory compliance. The continuance of certified performance to the regulatory standard is incumbent upon the user's diligent conformance to recommended maintenance instructions.

All certified products installed require the filing of an Assembler's Certification Form FD-2579 (enclosed with the machine) by the Assembler (i.e., the installer). A copy of the Quality Assurance Form (pink copy) must be provided upon completion of the installation.

X-RAY PROTECTION NOTICE

X-ray equipment may cause injury if used improperly. The instructions in this manual must be adhered to when operating the HFQ. **BENNETT X-RAY CORP.**'S authorized dealers will gladly assist you in placing your system into operation.

Personal radiation monitoring and protective devices are available. You are urged to use them to protect against unnecessary x-radiation exposure.

It is important that you be fully acquainted with applicable government radiation protection regulations. Many provisions of these regulations are based on recommendations of the National Council of Radiation Protection and Measurements. Recommendations for medical x-ray protection are published in NCRP Report Number 102, available from:

NCRP Publications
7910 Woodmont Ave.
Suite 1016
Bethesda, MD 20814

Those responsible for the planning of x-ray equipment installations must be thoroughly familiar and comply completely with NCRP Number 49, "Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma-Rays of Energies up to 10 MEV", as revised or replaced in the future.

SHIPPING INFORMATION

The shipper is relieved of any responsibility for damage during shipment after the unit is picked up by the carrier.

Examine all cartons and crates carefully at time of delivery. If damage is apparent, have delivery driver write a "Damaged Shipment Note" on copies of the freight bill, sign it, and file the appropriate carrier claim. Should you discover

SHIPPING INFORMATION (Continued)

concealed damage, immediately notify the transporting agent and ask for an "Inspection of Damage". Carrier will not accept concealed damage claim if filed after 15 days from date of receipt of merchandise.

Open crate or carton marked "packing list enclosed" first. Remove packing list and use as guide to open remaining cartons. Do not dispose of packing material until packing list is matched with actual parts received. Should there be a shortage or damage, notify the manufacturer immediately.

WARRANTY

Providing the warranty card(s) are completed and returned to the manufacturer within ten (10) days after receipt of the equipment, **BENNETT X-RAY CORP.** warrants all new x-ray equipment of their manufacturer and all tubes in that equipment on the following terms:

- **BENNETT X-RAY CORP.** warrants all equipment manufactured by it and bearing its name to be free from defects in material and workmanship under normal use and service. Scope of this warranty extends to the original purchaser from the date of purchase and its applicable only when the equipment is installed and operated according to factory recommendations. The warranty does not extend to damage or wear caused by misuse, abrasion, corrosion, negligence, accident, faulty installation, or tampering in a manner to impair or alter its normal operation.
- X-Ray Tubes used in the x-ray equipment are warranted against defects in material and workmanship from date of shipment from the factory.
- **BENNETT X-RAY CORP.** does not assume responsibility for loss or damage in transit to equipment or tubes returned for examinations. On any item returned for inspection, repair, or replacement, transportation charges both ways must be paid by the buyer.
- **NO REPLACEMENT OR REPAIR WILL BE MADE WITHOUT CHARGE IF THE EQUIPMENT OR TUBE INDICATES AFTER EXAMINATION BY AND IN THE OPINION OF BENNETT X-RAY CORP. THAT THE DAMAGE WAS CAUSED BY IMPROPER HANDLING.**
- **THE FOREGOING WARRANTIES ARE EXCLUSIVE, AND ARE IN LIEU OF ALL OTHER WARRANTIES (WHETHER WRITTEN, ORAL, OR IMPLIED) INCLUDING WARRANTY OR MERCHANTABILITY IN OTHER RESPECTS THAN EXPRESSLY SET FORTH ABOVE AND WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, EXCEPT AS HEREIN PROVIDED, EVERY FORM OF LIABILITY FOR DIRECT OR CONSEQUENTIAL DAMAGES OR LOSS IS EXPRESSLY EXCLUDED AND DENIED.**
- **SEE WARRANTY CERTIFICATE FOR DURATION.**

**SECTION 2,
GENERAL
INFORMATION**

**SECTION 2,
GENERAL INFORMATION**

GENERAL INFORMATION

HFQ SERIES GENERATOR SPECIFICATIONS

As shown in Figure 2-1, the HFQ Series High-Frequency generator is a complete microprocessor based, anatomically programmable x-ray generator system with a 100 kHz resonant power source. A separate operator control panel, attached to the system via cable, affords the operator complete control over the x-ray generator at all times.

DIMENSIONS

<u>Generator Cabinet</u>	<u>Operator Control Panel (OCP)</u>
Height: 63 1/2-inches	8-inches
Width: 24-inches	10-inches
Depth: 17-inches	4 1/16-inches (maximum)
Weight: Model Dependant	3-pounds

SPECIFICATIONS

kVp Range:	40-125 kVp in 1 kVp steps
kVp Accuracy:	$\pm 5\%$
mA Range:	Model dependant (see Table 2-1)
mA Accuracy:	$\pm 10\%$ or 5 mA, whichever is greater
Time Range:	5 milliseconds to 6 seconds, 200 steps
Time Accuracy:	$\pm 1\%$ ± 3 milliseconds. Time is measured at the 90% level of the peak kV
mAs Accuracy:	$\pm 12\%$ for time greater than 100 milliseconds. Below 100 milliseconds accuracy is a product of time and mA
Duty Cycle:	1% of full load or x-ray tube limits, whichever is less

Note: Specifications for all configurations are identical, except as noted in chart and power requirements. All specifications do not include measurement instrumentation accuracy.

Table 2-1. Model Dependant Specifications

SPECIFICATION	HFQ -300 SERIES	HFQ - 450 SERIES	HFQ - 600 SERIES
OUTPUT @ 125 KVP	300 MAS	450 MAS	600 MAS
MA STATIONS:			
SMALL FOCUS	25, 50 AND 75	25, 50 AND 75	25 AND 75
LARGE FOCUS	75, 100, 125 AND 150	100, 150, 200 AND 225	100, 150, 200, 250, 300
WEIGHT (LBS.)	350	375, 450(SE)	400, 475(SE)

GENERAL INFORMATION

POWER REQUIREMENTS (HFQ Model)

For any electrical installation, all electrical wiring/connections must be installed by a qualified electrician and conform to national and local codes. Requirements for health care facilities (National Electric Code NFPA No. 70) must be followed. Common power specifications are described below and configuration dependant electrical requirements are listed in Tables 2-2 and 2-3.

GENERAL ELECTRICAL COMPLIANCE REQUIREMENTS

These general guidelines must be followed in order to comply with the National Electric Code:

- All wiring must be copper.
- Insulation rating of the wire must be at least 50% of momentary current (as listed in Table 2-3, HFQ Electrical Requirements).
- All fuses, circuit breakers and disconnect switches should conform to the above requirement of 50% of momentary current.
- For all installations, a separate earth ground (#6 AWG insulated wire) must be installed. This #6 AWG insulated wire must be the **only** wire connected to the copper ground terminal.

POWER SPECIFICATIONS (HFQ Model)

200-270 VAC 50/60 Hz (configured at time of installation)

Less than 3 amps long term

Line regulation 7% at full load

Fully automatic line voltage compensation, maximum overall line voltage variations (non equipment related) not to exceed +/- 5%

Maximum line current measured at 125 kVp, maximum mA at 7% line regulation; refer to Table 2-2

Table 2-2. HFQ Momentary Line Current Requirements

LINE VOLTAGE	HFQ -300	HFQ - 450	HFQ - 600
200 VAC	190-AMPS	280-AMPS	370-AMPS
240 VAC	160-AMPS	235-AMPS	306-AMPS
270 VAC	140-AMPS	210-AMPS	275-AMPS

GENERAL INFORMATION

MODEL	VOLTAGE	WIRE SIZE/LENGTH *			DISCONNECT TO GENERATOR 15 FT. MAX.	MOMENTARY LINE CURRENT	SERVICE RATING	DISTRIBUTION XFMR RATING	LINE RESISTANCE
		50 FEET	100 FEET	200 FEET					
HFQ 300	208	#2 AWG	#00 AWG	300 MCM	#4 AWG	183 AMPS	100 AMPS	25 KVA	0.08 OHMS
	240	#2 AWG	#0 AWG	250 MCM	#4 AWG	160 AMPS	100 AMPS	25 KVA	0.10 OHMS
HFQ 450	208	#0 AWG	200 MCM	450 MCM	#2 AWG	270 AMPS	150 AMPS	35 KVA	0.06 OHMS
	240	#1 AWG	#000 AWG	350 MCM	#2 AWG	235 AMPS	150 AMPS	35 KVA	0.075 OHMS
HFQ 600	208	#00 AWG	300 MCM	600 MCM	#1 AWG	353 AMPS	200 AMPS	50 KVA	0.04 OHMS
	240	#0 AWG	250 MCM	500 MCM	#1 AWG	306 AMPS	200 AMPS	50 KVA	0.05 OHMS

*NOTE: Wire size from Distribution Transformer to Disconnect Switch

Table 2-3. HFQ Electrical Requirements

GENERAL INFORMATION

POWER SPECIFICATIONS (HFQ SE Model)

SPECIFICATION	HFQ SE	240 VAC OPTION
Input Voltage (configured at time of installation)	105 - 130 VAC 50/60 Hz	220 - 240 VAC 50/60 Hz
Long Term Amps	Less than 6 amps	Less than 3 amps
Momentary Amps	Less than 20 amps during rotor start up time	Less than 10 amps during rotor start up time
Line Regulation	10% at 20 amp load	10% at 10 amp load
Line Voltage Compensation	Fully automatic, max. overall line voltage variations (non-equippt related) not to exceed +/- 5%	Fully automatic, max. overall line voltage variations (non-equippt related) not to exceed +/- 5%

TUBE AND COLLIMATOR COMPATIBILITY

Tube: Eureka: Rad 8 Insert, Rad 9 Insert, Rad 13 Insert, Rad 14 Insert, Rad 21 Insert, Rad 25 Insert, Rad 28 Insert, Rad 74 Insert
Toshiba: DRX1403, E7239X, E7242X



Collimator: BENNETT/Dial-X, D-50M, D-60SA or D-70A Series.

OPERATING MODES

- Manual - permits the operator to select all technique factors.
- Automatic Exposure Control (AEC) - uses an ion chamber to assure proper exposure times (optional feature).
- Auto-Tech^R - exclusively designed by BENNETT to further enhance radiographic imaging. Auto-Tech uses pre-programmed techniques that set kVp, mA, and time automatically. When used in conjunction with the optional Automatic Thickness Measurement (ATM) feature, anatomical thickness of the ROI is automatically calculated and displayed on the OCP. During exposure, the AEC works in conjunction with Auto-Tech to provide uniform, repeatable, high quality images with the smallest variation of optical density between patients.

OPERATOR CONTROL PANEL

The separate Operator Control Panel (shown in Figure 2-2) allows complete control and access to all system functions and features. A twenty-one button touch-sensitive key pad combined with a Liquid Crystal Display (LCD) and Light Emitting Diode (LED) technology provide user-friendly control and indication of system status. Controls and indicators described in the following paragraphs can be referenced to Figure 2-2 by corresponding numbers.

- 1- **LED INDICATOR:** When an indicator lamp is lit, the corresponding function is activated.
- 2- **LCD PANEL:** Displays techniques of corresponding selection keys providing a pre-indication of kVp, mA, Time, and mAs as well as measured thickness of the Region Of Interest (ROI) in cm.
- 3- **DIRECTION KEYS:** Pressing either  or  keys (located above or below the LCD display) will increase or decrease the corresponding factors, respectively.
- 4- **AUTO-TECH^R KEY:** Pressing **AUTO-TECH^R** causes the LCD to display eight available anatomical regions for selection. Upon selection of an anatomical region, up to nine available programs for the region selected will be displayed. Once a program is selected the system will automatically measure thickness of the ROI (optional), select the pre-programmed kV for displayed thickness, select the pre-programmed mA for the selected view and select the pre-programmed time for the displayed anatomical thickness.
- 5- **AEC KEY:** Enables and disables the optional Automatic Exposure Control (AEC) function.
- 6- **MANUAL KEY:** Places the system in manual mode allowing the operator to select all technique factors without system intervention.
- 7- **TABLE BUCKY KEY:** Activates the bucky. This function is automatically activated if "TABLE BUCKY" is used in an Auto-Tech^R program.
- 8- **NON-BUCKY KEY:** Allows for techniques that do not use a bucky. The LED illuminates when "non-bucky" is selected. This function can be pre-programmed to activate if a non-bucky technique is used in an Auto-Tech^R program.
- 9- **WALL BUCKY KEY:** Activates the wall bucky. This function can be pre-programmed to activate when wall bucky techniques are used in the Auto-Tech^R program.
- 10- **AEC FIELD SELECT KEY:** This key selects the field or combination of fields used to sense the amount of radiation entering the film cassette.

OPERATOR CONTROL PANEL (Continued)

- 11 - PREP KEY:** Starts the tube rotor, pre-heats the filament, and performs a self test.
- 12 - EXPOSURE KEY:** Starts exposure. If **PREP** has not been pressed prior to **EXPOSE** there is a time delay prior to exposure of approximately 1-1/2 seconds. When **PREP** is used in conjunction with **EXPOSE**, exposure is immediate.
- 13 - READY INDICATOR:** Illuminates when the system has performed all its self-checks and is ready to take an exposure. On SE versions, the READY indicator also indicates when the Stored Energy Source is at full capacity (ready to take an exposure).
- 14 - TUBE 1:** Selects Tube 1.
- 15 - TUBE 2:** Selects Tube 2 when available.
- 16 - Key Switch:** Allows access to Utility/Maintenance modes.
- 17 - Remote Power Switch:** System can be powered-on or off by this switch without using the main circuit breaker. In addition, system can be re-set with this switch after automatic power-off feature shuts the system down.

GENERAL INFORMATION

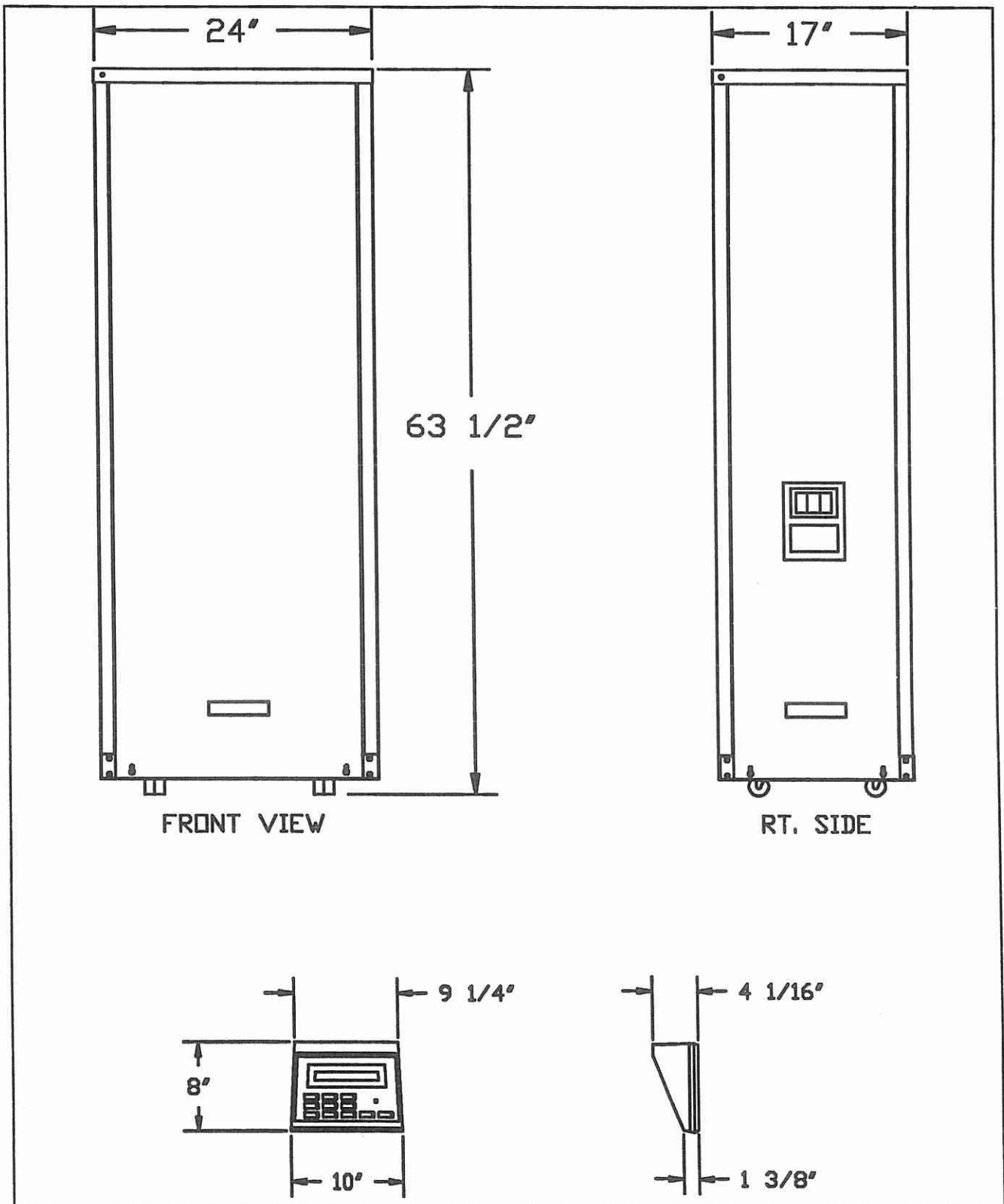


Figure 2-1. HFQ Series Generator and OCP Dimensions

GENERAL INFORMATION

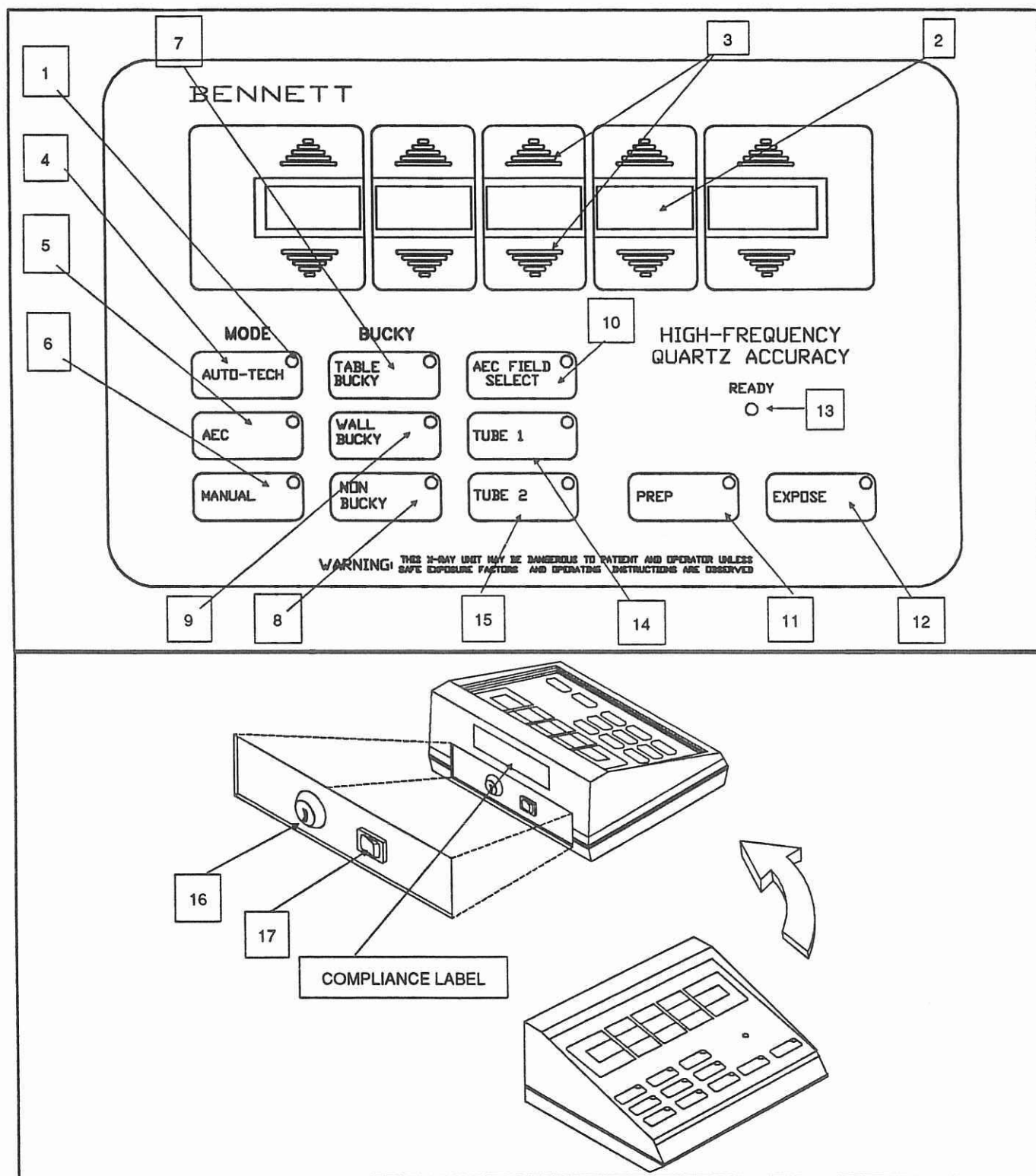


Figure 2-2. HFQ Series Operator Control Panel

**SECTION 3,
SYSTEM OPERATION**

**SECTION 3,
SYSTEM OPERATION**

OVERVIEW

This section provides the information necessary to operate the HFQ Series High-Frequency x-ray generator.

The following operating procedures are outlined and described in detail:

- Power on/off procedures
- Seasoning procedures
- Operating modes and selection: Auto-Tech, AEC and Manual
- Printing techniques

POWER ON/OFF PROCEDURES

The following are step-by-step procedures to power-on/off your system according to its status. There are three possible shut down states:

1. Complete Shut Down - The power switch and main circuit breaker were set to off. The power line might have been disconnected.
2. Remote Shut Down - The system was shut down with the remote ON/OFF power switch on the Operator Control Panel (OCP).
3. Automatic Shut Down - Power to the system was automatically disconnected (via internal timing circuit) after sixty minutes of inactivity.

TO POWER-ON YOUR SYSTEM:

From A Complete Shut Down

1. If necessary, connect the power line into the appropriate power receptacle.
2. Set the main circuit breaker on the system to the **ON** position.
3. Set the remote power switch (located on the OCP) to the **ON** position.
4. Continue with Power-On Self Test.

From A Remote Shut Down

1. Set the remote power switch to the **ON** position.
2. Continue with Power-On Self Test.

From An Automatic Shut Down

1. Set the remote power switch to **OFF**.
2. Wait five seconds and set the remote power switch to **ON**.
3. Continue with Power-On Self Test.

POWER-ON SELF TEST

When the HFQ Series generator system is first powered-on, "BENNETT X-RAY CORP." appears on the display while the system automatically runs a series of self checks to ensure proper operation. If an error is detected, the actual error (i.e., "DOOR?") will appear on the LCD. Upon successful completion of the self checks, the display will return to the last exposure setting that was used.

TO POWER-OFF YOUR SYSTEM:

For Short Periods Of Time -

1. Set the remote power switch on the OCP to the **OFF** position.
2. Ensure indicators are dark. System is now shut down.

For Long Periods Of Time -

1. Set remote power switch on the OCP to the **OFF** position.
2. Locate the main circuit breaker on the generator and set to the **OFF** position.
3. If desired, unplug the power line from the power receptacle or set the main power disconnect switch to the OFF position. System is now shut down.

AUTOMATIC POWER-OFF FEATURE

To help save power and protect system electronics when left unattended, the HFQ Series generator system is equipped with an automatic power-off feature that shuts down the unit.

After approximately sixty minutes of inactivity, the system will automatically power-off through software control, leaving all switches in the ON position.

An audible tone will be emitted for approximately 30 seconds before the system shuts down and "PRESS ANY KEY" will be displayed on the operator control panel.

To Abort The Automatic Power-off Feature - Press any key on the operator control panel.

To Re-start After Automatic Shut Down - Refer to Power-On Procedures.

DAILY SEASONING PROCEDURE

All tube manufacturers recommended seasoning procedures upon installation and daily warm-up. It is important that these procedures be performed to maintain both the tube manufacturers and **BENNETT** X-Ray's extended warranties. Refer to the tube manufacturers instructions. A typical daily seasoning procedure is provided below. This should be performed if the system is not used for several days. For longer periods or on installation, refer to tube manufacturers instructions.

SEASONING PROCEDURES

Take the exposures shown below using a 100 mA large focal spot and allow 30-seconds between exposures.

Table 3-1. Exposure Settings For Seasoning Procedures

EXPOSURE NUMBER	KVP	TIME (Seconds)
1	50	0.1
2	60	0.1
3	60	0.1
4	70	0.1
5	70	1.0
6	80	0.1
7	90	0.1
8	90	0.1
9	100	0.1
10	100	0.1
11	110	0.1
12	110	0.1

OPERATING MODES

The HFQ series can operate in four modes: Manual, Automatic Exposure Control (AEC), Auto-Tech and Auto-Tech with AEC.

- **MANUAL MODE** - requires manual calculation/selection of all x-ray techniques and exposure factors.
- **AEC MODE** - Automatic Exposure Control (optional) uses an ion chamber to ensure proper exposure times. Film density is selectable via key pad control through selection of AEC fields in use and pre-programmed film/screen combinations.
- **AUTO-TECH^R MODE** - (an exclusive BENNETT design) further enhances radiographic imaging by using a sonar Automatic Thickness Measuring (ATM) system (optional) to calculate the anatomical thickness of the Region Of Interest (ROI) and display the thickness (in cm) on the OCP. After a thickness measurement is entered (either manually or via optional ATM system), prior to exposure, the system automatically sets programmed x-ray techniques and exposure factors, including AEC mode (if available), tube selection, bucky selection, kVp, mA, and time. Programmed Auto-Tech settings can be modified at any time through the OCP, either in the actual stored program or for the current exam. During exposure the AEC (optional) works in conjunction with Auto-Tech to provide uniform, repeatable, high quality images with the smallest variation of optical density between patients.

SETTING UP TO TAKE EXPOSURES

All aspects of x-ray techniques are entered at the OCP. Prior to taking an exposure, MODE, BUCKY and TUBE must be selected. In addition, the displayed exposure factors (mA, Time, kVp and mAs) should be verified. When operating in Auto-Tech mode, all x-ray techniques and exposure factors are automatically entered for you. In Auto-Tech mode with the optional ATM system, anatomical thickness is also automatically calculated and entered.

PRE-EXPOSURE SELECTIONS

This procedure outlines step-by-step instructions to set up x-ray techniques and exposure factors prior to exposure. Since these procedures are mode and option dependant, refer to the appropriate operating mode to begin. A flow chart on the following page provides a graphic representation of the pre-exposure selection process. Selections are made by pressing the appropriate key on the OCP or the up/down arrows on the LCD portion of the LCD.

SYSTEM OPERATION

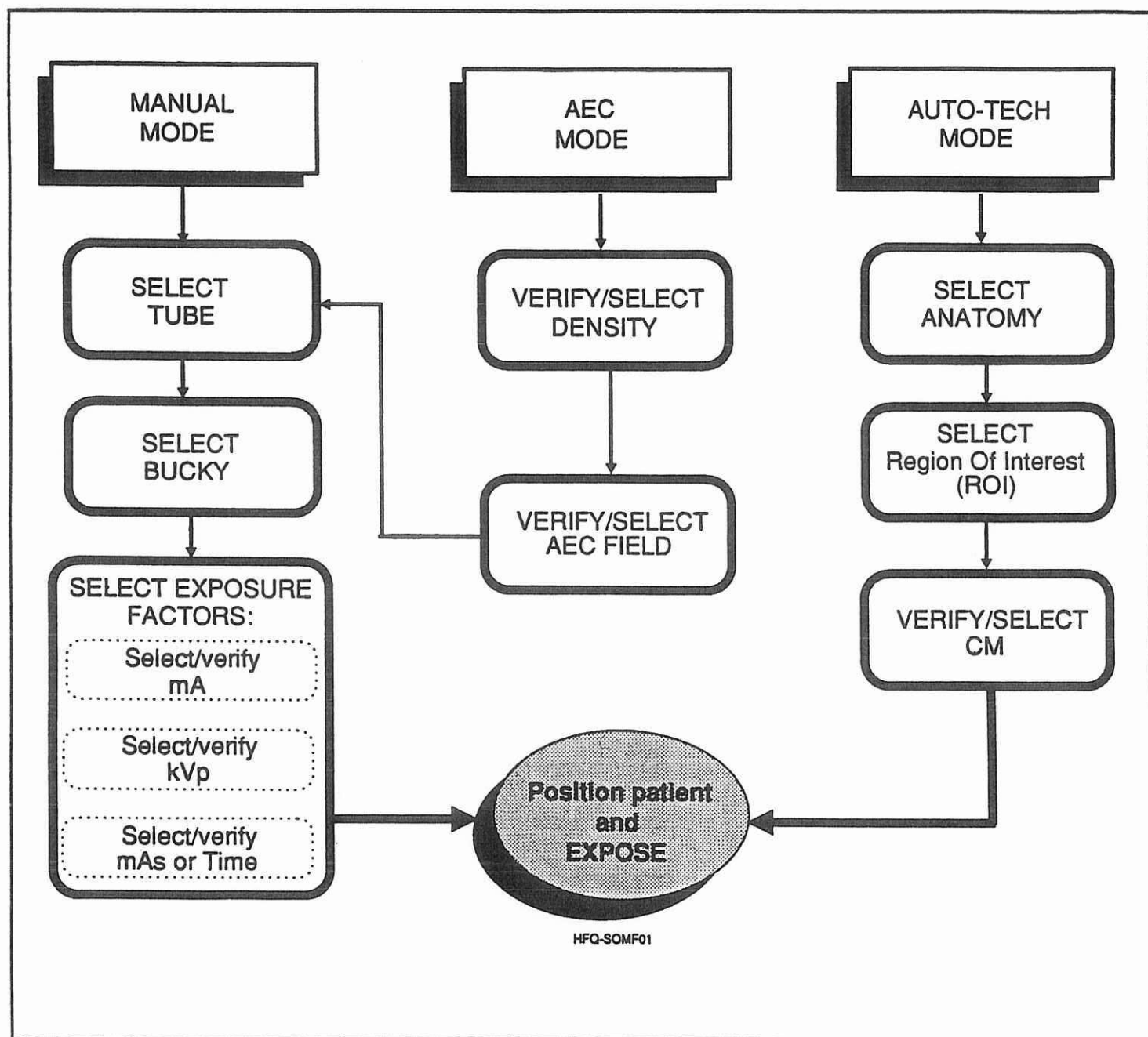


Figure 3-1. Mode Selection Flow Chart

Select An Operating Mode

There are four possible modes of operation, depending on the options selected with your system. The two basic modes are Auto-Tech and Manual. Automatic Exposure Control (AEC) can be used as a stand alone mode (by itself) or in conjunction with Auto-Tech.

1. Select a mode of operation by pressing the appropriate key;
AUTO-TECH **AEC** or **MANUAL** .
2. Once selected, ensure that the corresponding indicator is illuminated.
3. Continue with the required procedures as follows:
AUTO-TECH Selected - Go to Select Anatomy
AEC Selected - Go to Select Density
MANUAL Selected - Go to verify /Select Tube and Bucky

Select Anatomy

When Auto-Tech is selected, x-ray techniques and exposure factors are automatically set according to your specific program. An anatomy selection menu (example shown in figure 3-2, below) will be displayed on the LCD.

1. Select the appropriate anatomy by pressing the ☐ or ☐ sector key associated with the desired anatomy.

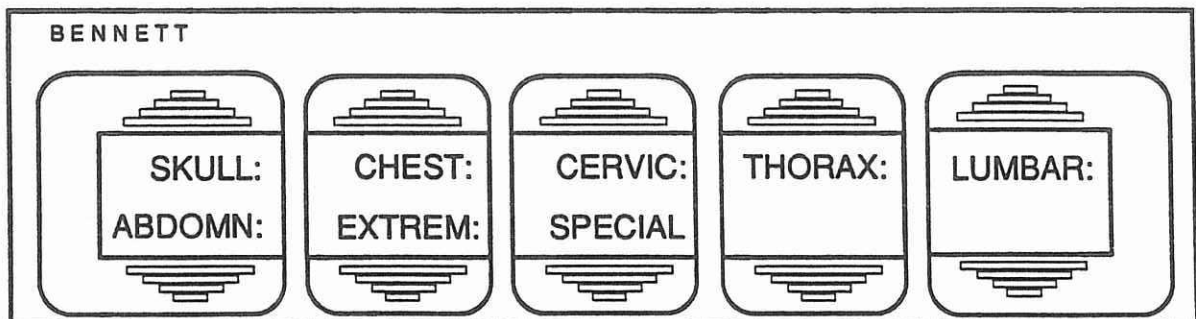


Figure 3-2. Auto-Tech Anatomy Selection Menu

Select an ROI

After anatomy selection is pressed, a selection of available Regions of Interest will be displayed.

1. Select the appropriate ROI by pressing the \wedge or \vee sector key associated with the desired ROI (see figure 3-3). ROI names and/or designations can be modified, added or deleted from the program as described in Section 8, Programming.

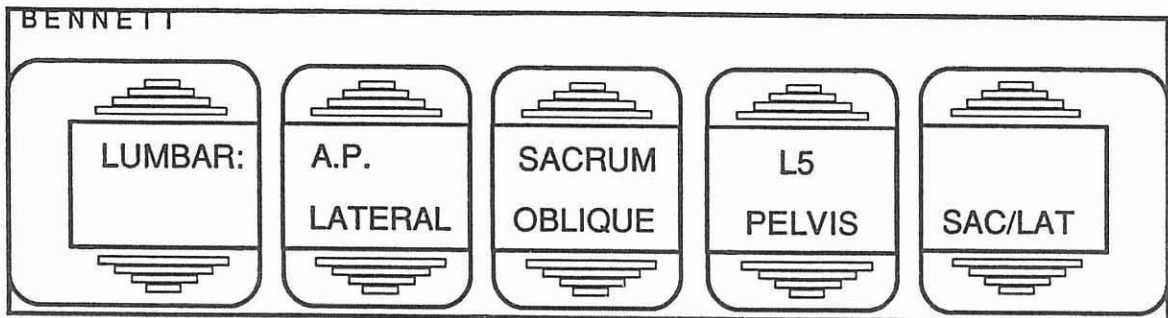


Figure 3-3. Region Of Interest (ROI) Selection Menu

Verify/Select Measurement

If your system is equipped with the optional ATM, thickness of the ROI (in cm) will be displayed automatically when the patient is positioned. In addition, selected SID is indicated by arrow as shown in figure 3-4.

1. If necessary, use the up/down sector keys on the LCD to increase or decrease the displayed cm. Initially, the CM value is set to 0. In Auto-Tech mode, press the down sector key to advance to first (smallest) cm value available, as set in the Auto-Tech program. When CM values are entered manually, an asterisk appears beside the value. This is referred to as the "FREEZE" value.
2. If AEC mode is available and you want it to be enabled in conjunction with Auto-Tech, press **AEC** and continue with Verify/Select Density. If not, continue with Enter/Verify CM.

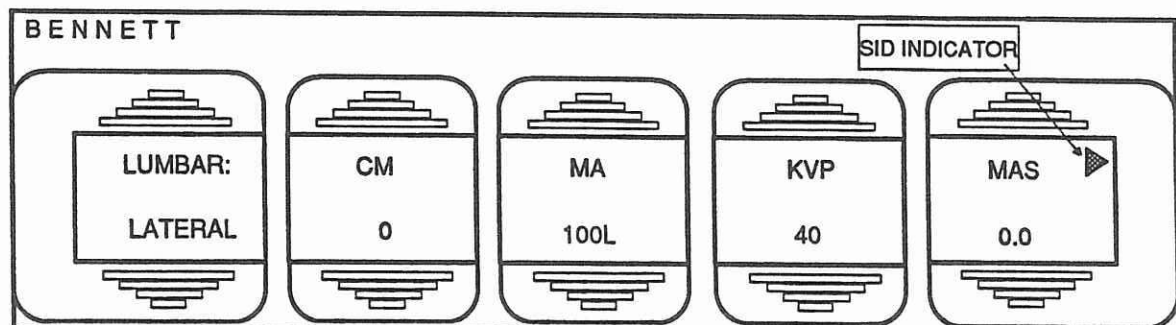


Figure 3-4. Initial Auto-Tech Menu (Non-ATM, AEC Off)

Verify/Select Density

When AEC mode is enabled, a segment of the LCD will display the currently selected film density setting and AEC field (example shown in figures 3-5 and 3-6). Density (DNS) and AEC field selection locations in the LCD depend upon the operating mode. In addition, the AEC FIELD SELECT indicator will be illuminated. Available density settings (DNS value) are from +5 to -5. The 0 (zero) setting is depicted as N (normal), which is the initial setting.

1. To increase or decrease density, press the Δ or ∇ sector keys in the DNS field, respectively. Each density step increases or decreases density by about 15%.

Verify/Select AEC Field

A configuration of three boxes depicted on the LCD (see figures below) displays currently selected fields. A shaded or hollow box indicates whether a field is used or unused, respectively.

Note: Ensure that the appropriate BUCKY mode is enabled prior to AEC FIELD selection.

1. To select a different AEC field, press **AEC FIELD SELECT** until the desired configuration is displayed. There are seven possibilities.

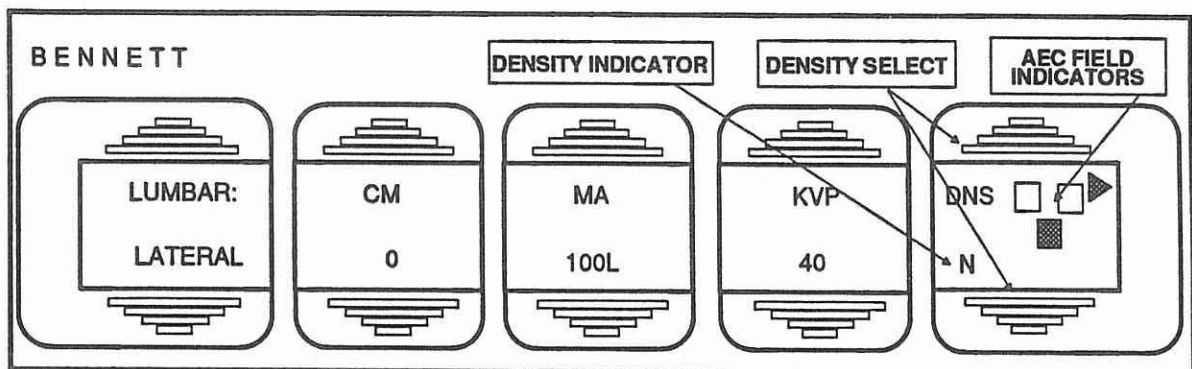


Figure 3-5. Auto-Tech Menu (AEC On, AEC Field Select)

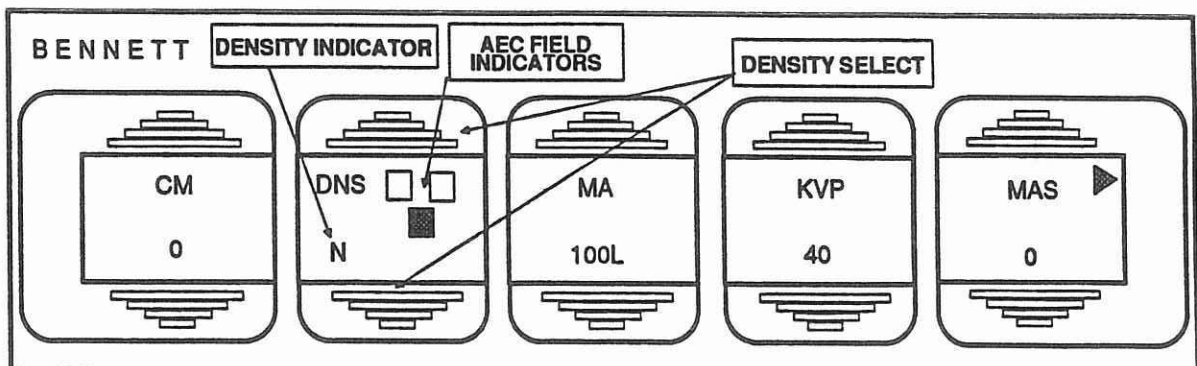


Figure 3-6. AEC Mode Enabled, Field Selection Settings

Verify/Select Tube and Bucky

When Auto-Tech mode is not selected, ensure that the proper tube is enabled (corresponding indicator illuminated).

1. If necessary, press **TUBE 1** or **TUBE 2** as required, and ensure that the associated indicator(s) are illuminated.
2. In any operating mode, verify that the appropriate BUCKY technique is selected (indicator illuminated).
3. If necessary, press the appropriate key: **WALL BUCKY**, **TABLE BUCKY** or **NON BUCKY**.
4. Continue with Verify/Select Exposure Factors

Verify/Select Exposure Factors

In Auto-Tech mode, exposure factors (Seconds, mA, kVp and mAs) are pre-programmed by your program. However, you can modify any displayed factor or enter your own for manual or AEC modes. Once you have verified that all x-ray techniques and exposure factors are correct, you can prepare to take an x-ray exposure.

Displayed exposure factor values (see example displays below) can be increased or decreased by pressing the respective \uparrow or \downarrow arrow keys associated with the factor. When techniques are modified from the original settings, up/down arrows are displayed next to the modified technique to indicate that its corresponding factor was increased or decreased, respectively. For example, as shown in figure 3-8, MA was increased, KVP was decreased and MAS was decreased. A manually selected CM value ("FREEZE" value) is indicated by an asterisk (as shown in figure 3-7).

Note: Values displayed are not necessarily correct techniques, they are used only as an example.

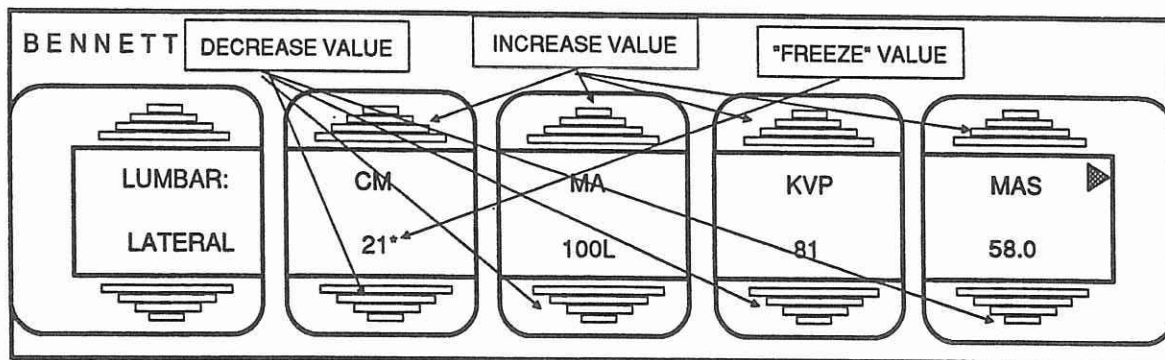


Figure 3-7. Initial Auto-Tech Menu, Manual CM Entry

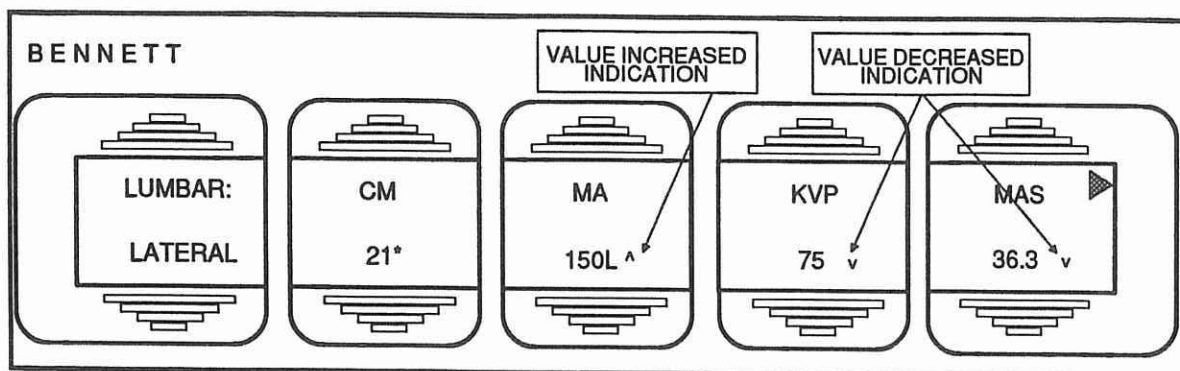


Figure 3-8. Auto-Tech Menu With Modified Techniques

PREPARING TO TAKE AN X-RAY EXPOSURE

After exposure factors have been verified as above, ensure that all other x-ray exposure precautions are met. If you have not already done so, position the patient accordingly and ensure that the patient is comfortable. Refer to Image Quality (page 3-12) for additional suggestions.

TAKING EXPOSURES

For Instantaneous Exposures:

1. Press and hold **PREP** until the PREP lamp is lit steady.
2. Press and hold **EXPOSE** until the exposure is complete (system will emit an audible tone).

For Delayed Exposures:

1. To take exposures that are delayed by approximately one and one-half seconds, press and hold the **EXPOSE** key as described above without using the PREP key.

FAULT RESET

When AEC mode is enabled, exposure time/termination is controlled via ionization chamber sensing circuits. In addition, a back-up time is pre-programmed into the system to help prevent excessive patient dose in the event of an AEC system malfunction. If the AEC exceeds the back-up time, exposure will be terminated and a fault/reset message will be displayed in the current FLM segment of the OCP display (example shown in figure 3-9). Press **RESET** to clear the fault. If the fault persists, the system may be used in manual mode until the fault can be isolated/corrected.

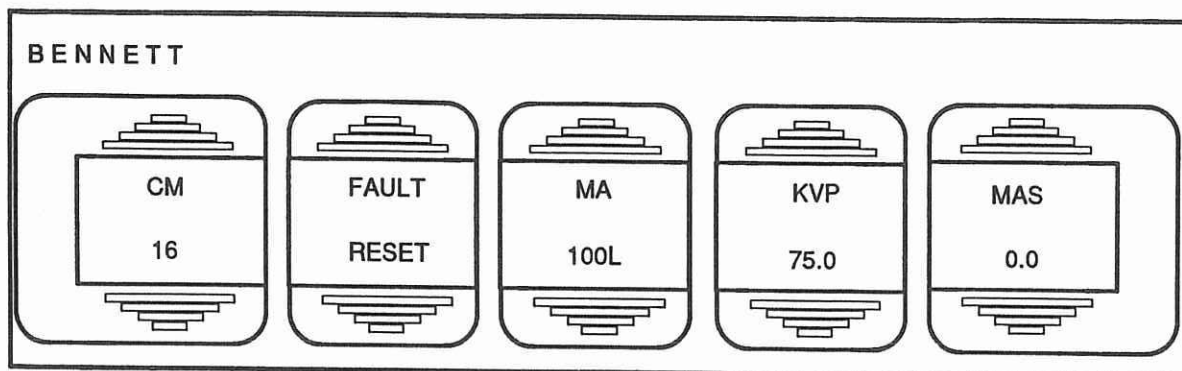


Figure 3-9. AEC Fault/Reset Display

TUBE HEATING DISPLAY

Prior to taking an exposure, the amount of tube anode heating (in thousands of heat units) will be displayed momentarily on the OCP display as KHU (example shown below). The stored anode heat units can be displayed at any time by pressing **PREP**.

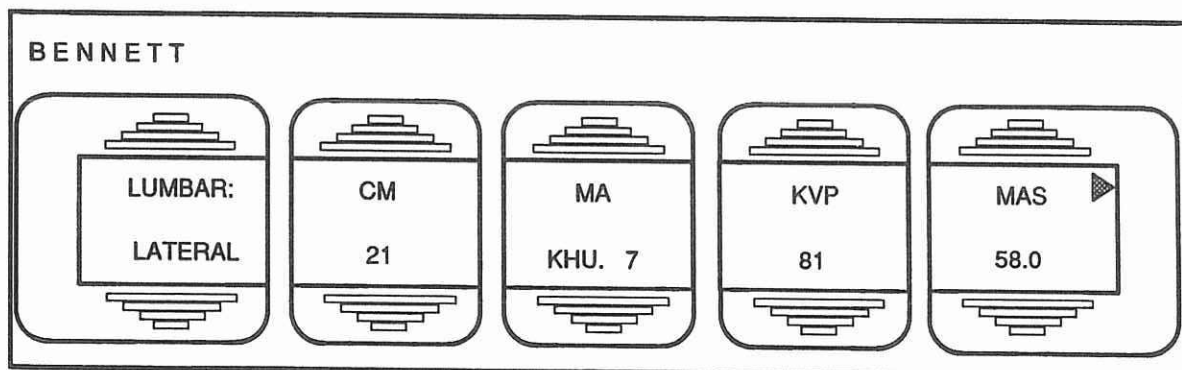


Figure 3-10. Tube Heating Display

IMAGE QUALITY

You should always keep in mind the following basic parameters to achieve the best results in diagnostic film quality:

- Make sure that your system is operating properly by scheduling routine quality assurance and preventive maintenance as required.
- Motion artifacts can be reduced by making the patient as comfortable as possible. Always treat the patient with the utmost care.
- Patient positioning is achieved by making sure the area of interest is on the film.
- Decreasing kVp value increases contrast.
- Increasing mAs value darkens the image.

PRINTER

If a printer is connected to the system, the techniques used will be printed at the end of each exposure. The exposure number, mode selected (anatomical region in Auto-Tech mode), thickness in cm, kVp, mA, and mAs are all displayed. Printer compatibility and connection procedures are described in Section 5, Installation.

A typical printout is shown below:

expos. #1669 LUMBAR: AP 27 CM 62.0 KVP 150L mA 48 mAs

***SECTION 4,
SYSTEM DIAGNOSTICS***

***SECTION 4, SYSTEM
DIAGNOSTICS***

OVERVIEW

This section is for system users or technicians to assist in locating and correcting minor system faults, should they occur. The majority of these faults can be corrected without a service technician. System faults that require the attention of a service representative are referenced in Section 9, Preventive Maintenance and Troubleshooting.

ERROR MESSAGES AND DESCRIPTIONS

When the unit will not fire, an audible alert will sound twice and one or more "error codes" will appear on the display.

Refer to the following descriptions for assistance in interpreting the fault code displayed on the Operator Control Panel:

BUCKY?	A bucky has been selected but it did not return the ready signal to start exposure or AEC is selected and no bucky has been selected.
CALIB?	The calibration data in the EEPROM is not correct.
DOOR?	The door interlock circuit is not closed.
FAULT?	Indicates that there is a problem with the AEC.
FILAM?	Indicates there is a problem with the filament or filament control circuit.
HYFOB?	(Hold Your Finger On Button) Exposure terminated prematurely because EXPOSE key was released before exposure was timed-out.
KVP?	Indicates a problem with the anode circuit or high voltage transformer.
KVP-C?	Indicates a problem with the cathode circuit or high voltage transformer.
LINE?	Indicates a problem with either the A.C. supply or line voltage monitor.
MASTR?	Problem with master EE Prom being copied from or to.
NO MA?	Control tried to take an exposure, but there was no tube current during exposure time.
PBL?	Positive beam limitation circuit is open. Check collimator.
PRNTR?	Indicates a problem exists between the control and the printer.
RETRY?	EEPROM program did not correctly save data. Try again or replace.

ERROR MESSAGES AND DESCRIPTIONS (Continued)

ROTOR?	Tube rotor is too hot or not getting correct current to start. Check rotor circuit.
S.E.S.?	Stored Energy Source voltage (displayed) is low.
TIMER?	A problem exists with the timer circuit.
TUBE OVERLOAD	Indicates that you have exceeded the tube maximum load capability. Reduce technique factors.
WAND?	Wand used in ATM option is in the wrong position.

POSSIBLE FAULTS

MAIN CIRCUIT BREAKER/SYSTEM CIRCUIT BREAKER ON AND OCP IS DARK

- Is the power line plugged into the receptacle or connected to the main circuit breaker ?
- Is there power at the receptacle or the main circuit breaker?
- Is the remote ON/OFF switch on the OCP in the ON position ?
- Auto Shut Off feature activated - If system was left unattended for 60 minutes or more, the Automatic Shut Off feature was activated. You can reset the system by setting either main or remote ON/OFF switch to OFF, then back to ON position. Refer to Section 3, System Operation for additional information.
- If any of the system checks outlined above do not solve the problem, refer to Section 9, Preventive Maintenance and Troubleshooting.

NO EXPOSURE

- Are any error messages displayed ?
- In areas where power is known to be erratic, or if a "brownout" or power reduction has taken place, it is prudent to check your input power.

PRINTER DOES NOT PRINT (OR DOES NOT PRINT PROPERLY)

- Is power on ?
- Is the printer connected to the system at the microprocessor board ?
- Is the cable attached to the printer ?
- Is the printer configured properly ? (Refer to Section 5, Installation.)
- Refer to the printer owner manual for switch configuration/troubleshooting.

IMAGE QUALITY

- Motion artifacts ? Relax the patient. Make the patient as comfortable as possible. Check once again for proper positioning.
- Is there not enough contrast ? Decrease kVp. Check the dark room, film expiration date, chemicals and developer temperature.

THICKNESS MEASUREMENT (CM VALUE)

- Incorrect readout? Check the thickness reference (refer to Section 8, Programming).

***SECTION 5,
INSTALLATION***

***SECTION 5,
INSTALLATION***

GENERAL INFORMATION

The HFQ Series programmable x-ray generators are shipped in two separate crates. The large crate contains the HFQ system x-ray generator cabinet and Operator Control Panel (OCP). The smaller crate contains two high voltage tanks.

Note: The shipper is relieved of any responsibility for damage during shipment after unit is picked up by the carrier. Examine all cartons and crates carefully at time of delivery. If damage is apparent, have delivery driver write a "Damaged Shipment Note" on copies of freight bill, sign it, and file appropriate carrier claim. Should you discover concealed damage, immediately notify the transporting agent and ask for an "Inspection of Damage". Carrier will not accept concealed damage claim if filed after 15 days from date of receipt of merchandise.

UNPACKING

Open crate or carton marked "packing list enclosed" first. Remove packing list and use as guide to open remaining cartons. Do not dispose of packing material until packing list is matched with actual parts received. Should there be a shortage or damage, notify the manufacturer immediately.

PREPARATION

1. Place unit as close to final location as possible.
2. Remove covers from the cabinet as necessary to gain access to the top equipment shelf, microprocessor pull-down tray and input transformer bus bar.
3. Locate the OCP (packed in box) on top equipment shelf, remove and place on the side.
4. If there are any loose wires resting on the top shelf, drape them across side of cabinet.
5. Locate two tank clamps on top shelf and ensure that they are in full open position. Open as necessary.

CAUTION: WHEN UNPACKING AND INSTALLING THE HIGH VOLTAGE TANKS, DO NOT TURN THEM ON THEIR SIDE. KEEP TANKS UPRIGHT AT ALL TIMES.

HV TANKS INSTALLATION

Place H.V. tanks on the top equipment shelf, inside the clamps. When facing the front of the unit, anode tank should be on right side, cathode tank on left side.

1. Locate ground wires for each tank (green, black and purple) and securely fasten to ground lug (GND) on tank with 8/32 kep nut.
2. Connect black and red #10-gauge input wires from backup contactor to input connections (P1 and P2) on both tanks, respectively. Tighten securely.
3. Connect the three filament wires green/white, orange/white and blue/white to cathode tank (LARGE, SMALL and COM). Ensure connections are secure.
4. Connect shielded two-wire lead feed back sense leads to each tank. White wire to HIGH terminal and black wire to LOW terminal.
5. Connect purple/white wire to MA connector on anode tank and purple wire to MA connector on cathode tank.

Note: MA connector on cathode tank should have MA connector wired to ground (purple wire to ground lug).

6. Connect high voltage output cables (anode and cathode) to each tank and secure.
7. Tighten tank clamps securely.
8. Place cover plates around the high tension cables on the outside of the cabinet in order to close off large openings. Refer to Figure 5-10.

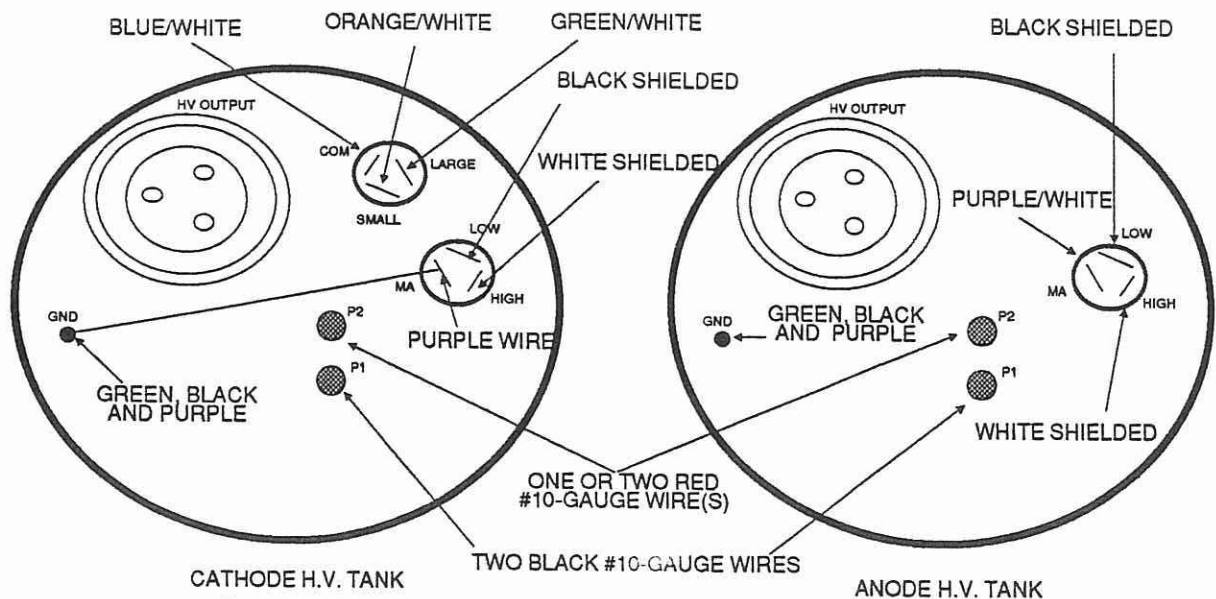


Figure 5-1. High Voltage Tank Connections

INSTALL OPERATOR CONTROL PANEL

1. Remove OCP from box and mount in desired location. OCP is provided with a 20-ft interconnect cable (E15026), consisting of 2 ribbon cables and one power cable. If additional length is required, order per foot, CP-C, for this cable configuration.
2. Optional remote hand and/or foot switches (HS-20 or FS-20) should be wired into the OCP at E1, E2 and E3 connections. Refer to Figure 5-9, Remote Switch Connection, for more information.

CAUTION: REMOTE SWITCH WIRING MUST BE SOLDERED TO THE CONNECTION POINTS DESCRIBED ABOVE. ENSURE THAT EXCESSIVE HEAT IS NOT APPLIED TO THE CIRCUIT BOARD.

3. If OCP is used with optional pedestal (PDL), assemble and mount OCP to the pedestal.
4. Route cables and attach to system. Connect one cable from A12 A2-J1 to A3-J3 (microprocessor). Connect the other ribbon cable from A12 A1-J1 (LCD board) to A15-J2 (LCD driver board). If the unit was ordered with length exceeding 30 ft., then a shielded ribbon cable is provided for the connection from LCD to A15-J2. If shielded cable is to be used, connect ground braids to mounting screws at both ends of the cable. Wire moulding (201506) is ideal for cable routing.
5. Connect gray power cable (remote ON/OFF control) to TB1, connections 1 and 2 on the POWER SHUT OFF board (A9).

VERIFY INPUT POWER

1. Using a calibrated DVM, measure the input line voltage. SE versions can operate between 105 and 130 VAC; non-SE versions can operate between 200 and 270 VAC. Refer to Section 2, Power Requirements.
2. Adjust transformer bus bar to match the input line voltage as closely as possible. Refer to Figures 5-4 and 5-5 for bus bar configurations.
3. On non-SE models, the correct bus bar location will yield 235 to 245 VAC measured between the 0 terminal and the 240V terminal.

POWER CONNECTIONS

1. Non-SE versions require a line disconnect box (or according to your local code) before the x-ray generator. A separate earth ground, #6 AWG insulated wire, must be installed. This wire must be the **only** wire connected to the ground terminal.
2. SE versions can be plugged into a standard switched 110 VAC grounded receptacle. Receptacle switch should be within reach of the OCP.

SYSTEM INTERCONNECTIONS

Bucky, table and tube housing assemblies are interconnected to the HFQ series generator via the INTERCONNECT PANEL, A13. Table 5-1 provides cable color codes and terminal connection data. Install the bucky according to the instructions provided with the bucky. Figures 5-2 and 5-3 are interconnection diagrams for collimator and bucky wiring. If you are connecting a printer to your system, it should be connected through the microprocessor board, A3.

If a reciprocating bucky is installed in the table (BUCKY 1), the jumper connection on interface board A 13 at COM 1 and CONT must be removed. If a reciprocating bucky is installed in the wall (BUCKY 2), the jumper connection on interface board A 13 at COM 2 and CONT must be removed. Please note that all system interconnections must be secured with the strain relief clamp.

Connecting A Printer

The HFQ series is compatible with most printers equipped for serial RS-232 interface configured at 2400 Baud, 1 start bit, 8 data bits, 2 stop bits and no parity (off). Procedures to connect some printers are as follows:

1. Set main circuit breaker to OFF.
2. Remove cover panel from system.
3. Locate the microprocessor board and connect the printer cable to connector J7 labeled PRINTER.
 - a. For Tandy DMP 105 Printers, a special printer cable (P/N BPC-10) is required in order to interface to the connector. The printer should be set for 2400 BAUD, with the switches in the following positions:
Switch 1 - ON
Switch 2 - OFF
 - b. For Tandy DMP 106 printers, a special printer cable (P/N BPC-10) is needed to interface to the connector. The printer should be set for 2400 BAUD, with the switches in the following positions:
Switch 1 - OFF
Switch 2 - ON
Switch 3 - OFF
Switch 4 - OFF

Connecting A Printer (Continued)

- c. For Tandy DMP 132 printers, a special printer cable (P/N BPC-10) is required in order to interface to the connector. The printer should be set for 2400 BAUD, with the switches in the following positions:

SWITCH BLOCK 1

Switch 1 - ON
Switch 2 - OFF
Switch 3 - ON
Switch 4 - OFF
Switch 5 - OFF
Switch 6 - OFF
Switch 7 - ON
Switch 8 - OFF

SWITCH BLOCK 2

Switch 1 - ON
Switch 2 - ON

- d. For Tandy DMP 133 printers, a special printer cable (P/N BPC-10) is required in order to interface to the connector. The printer should be set for 2400 BAUD, with the switches in the following positions:

Switch 1 - ON
Switch 2 - OFF
Switch 3 - OFF
Switch 4 - OFF
Switch 5 - OFF
Switch 6 - OFF
Switch 7 - ON
Switch 8 - ON
Switch 9 - ON
Switch 10 - ON

ATM SYSTEM INSTALLATION

This procedure provides the information necessary to install and interconnect the optional Automatic Thickness Measuring (ATM) device to the collimator and HFQ Series generator. If you do not have the optional ATM system, continue with Calibration (page 5-6).

The ATM option consists of a motor drive unit/sensor (also referred to as transducer assembly), motor drive interface board and sonar board. The motor drive interface and sonar board are attached together and should be mounted in the tube stand fork. The motor drive unit gets mounted on the collimator.

Procedure

1. Access the collimator wiring by removing the rear cover. On D-70A collimators, loosen the thumb screw and pull the logic box down.
2. Hold the motor drive assembly up to the bottom of the collimator and route the two wires (orange and yellow) through the access hole (see figure 5-6).
3. Remove the two rear collimator screws and align the motor drive assembly with the mounting holes (as shown in figure 5-6). LED indicator should face front.
4. Fasten the motor drive assembly with the two screws provided.
5. Locate the terminated orange and yellow collimator wires and splice them to the identical color wires from the motor drive assembly as shown in figure 5-7.
6. Mount the motor drive/sonar board (A8) into the tube fork with four 6-32 screws and lockwashers.
7. Connect the jack (A8A1-J2) from the sonar board to the jack from the motor drive assembly (A9-J2).
8. Connect cable number 10 from the microprocessor board (A3-J9) to the motor drive interface board (A8A2-J1). See figure 5-8.
9. Calibrate the ATM system according to the procedures described in Section 8, Programming Utility.

TOMO INTERFACE

1. Units equipped for tomography are factory-prewired according to table 5.2. For complete installation instructions, please refer to Tomography manual.
2. To activate tomography, program "TOMO" into the special region selection. The system will recognize TOMO as the first four (4) characters and automatically switch to tomography.

CALIBRATION

1. Calibrate the system as described in Section 6, Calibration.

FINAL INSPECTION

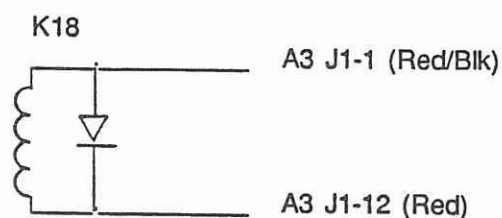
1. Replace all cabinet covers.
2. Ensure unit is securely placed.
3. Check all controls and indicators to verify operation.
4. Ensure that cover plates are placed around the high tension cables on the outside of the cabinet.
5. Installation procedures are now complete.

Table 5-1. Cable Color Codes and Terminal Connection

CABLE DESCRIPTION	GAUGE	WIRE COLOR	CONNECTION
ROTOR	18	BLACK	A 13/7
ROTOR	18	GREEN	A 13/8
ROTOR	18	WHITE	A 13/9
24 VAC POWER SUPPLY (#4) 6.5-amp Maximum	16	GREEN	A 13/G
24 VAC POWER SUPPLY (#4) 6.5-amp Maximum	16	WHITE	A 13/1 (24 VAC)
24 VAC POWER SUPPLY (#4) 6.5-amp Maximum	16	BLACK	A 13/2 (24 VAC)
BUCKY (#5)	18	GREEN	A 13/COMMON
BUCKY (#5)	18	BLACK	A13/0 VAC
BUCKY (#5)	18	WHITE	A 13/CONTACT
BUCKY (#5)	18	RED	A 13/120
EXPOSURE HOLD (#6)	20	BLACK	A 1/TB1-4
EXPOSURE HOLD (#6)	20	RED	A 1/TB1-3
30 VDC POWER SUPPLY (#7) 2.5-amp Maximum	20	BLACK	A 13/4
30 VDC POWER SUPPLY (#7) 2.5-amp Maximum	20	RED	A 13/5
30 VDC POWER SUPPLY (#7) 2.5-amp Maximum	20	WHITE	A 13/6
BUCKY 2 (#8)	18	GREEN	A 13/COMMON 2
BUCKY 2 (#8)	18	BLACK	A 13/0 VAC
BUCKY 2 (#8)	18	WHITE	A 13/CONT
BUCKY 2 (#8)	18	RED	A 13/120

Table 5-2. Tomo Interface Wiring

K18 (SPST, 24VDC)



<u>TOMO CONNECTOR PIN #</u>	<u>TOMO CABLE</u>	<u>TOMO TERMINAL BLOCK*</u>	<u>COLOR</u>	<u>GOES TO:</u>
1	Brown	1	Brown	K18
2	Yellow	2	Yellow	/
3	Red	3	Red/Blk	A2/5 (30 VDC)
4	Black	4	Black	A2/4 (GND)
5	Blue	5	Blue	A2/0 VAC
6	Orange	6	Red	BUCKY COM 1
7	Green	7	Red/White	A1/J3-6
8	White	8	White	A2/CONT
				F3 (bottom of fuse; 120 VAC)

* **NOTES:** A 0.1 mfd 400 v capacitor is converted across pins 1 and 4.

To take an exposure without Tomo System, jump terminals #6 and #7.

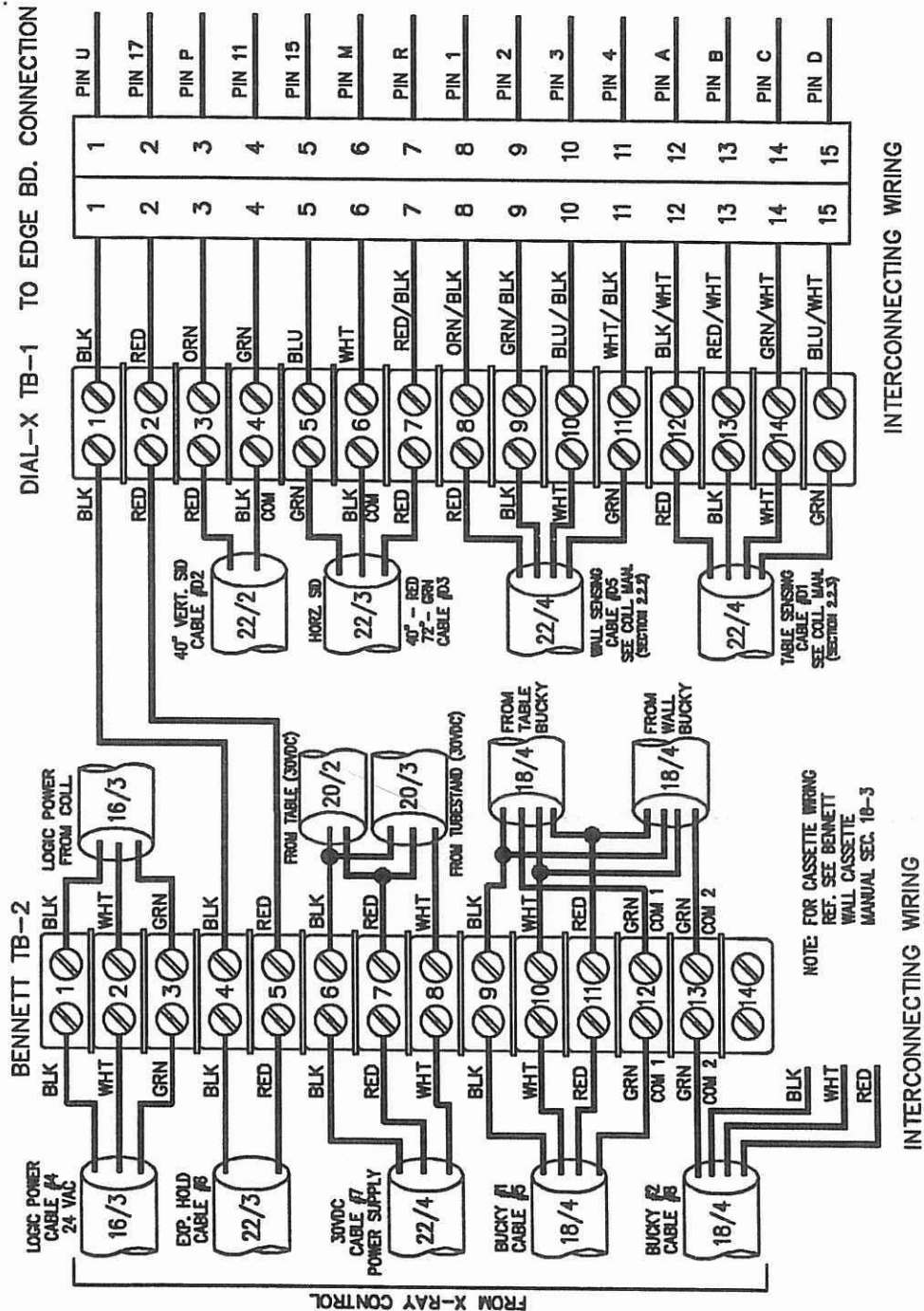


Figure 5-2. Collimator Interconnection Diagram

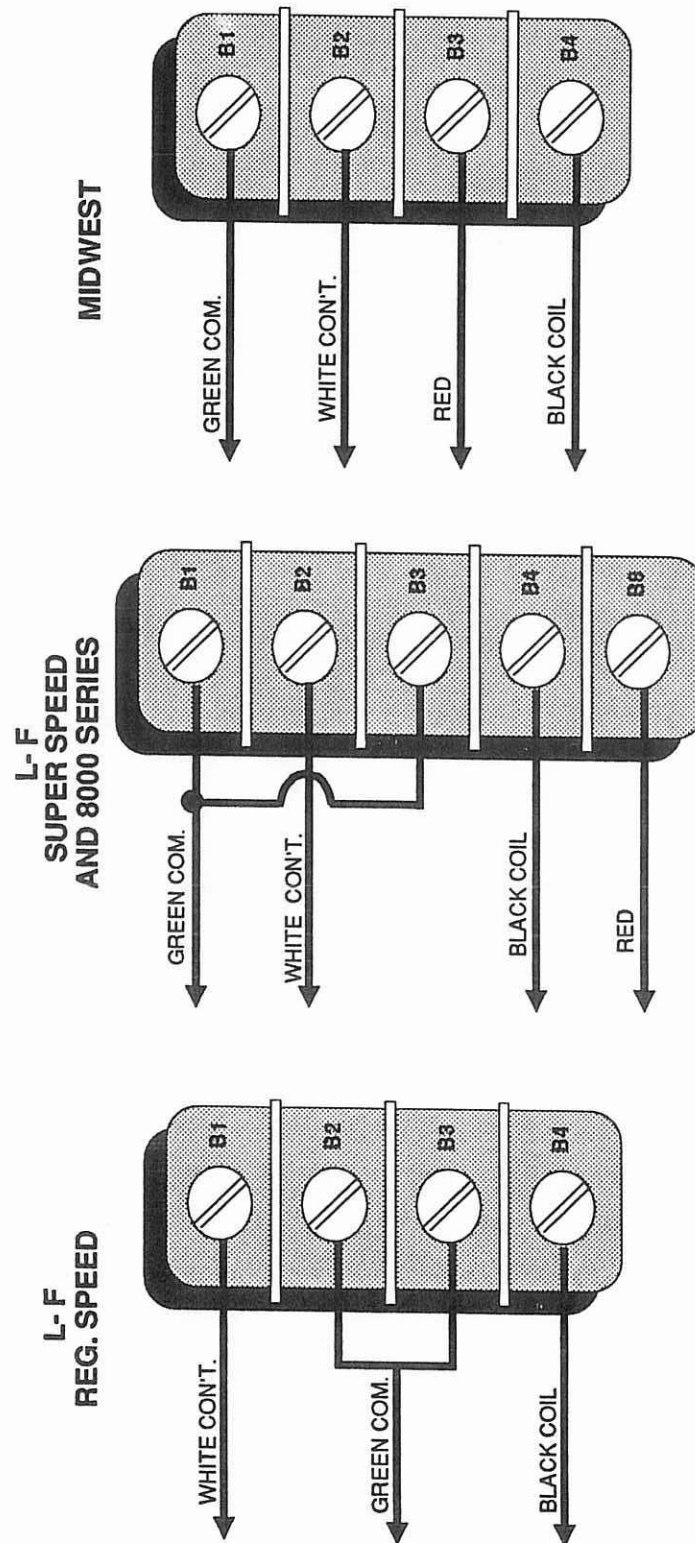


Figure 5-3. Bucky Interconnection Diagram

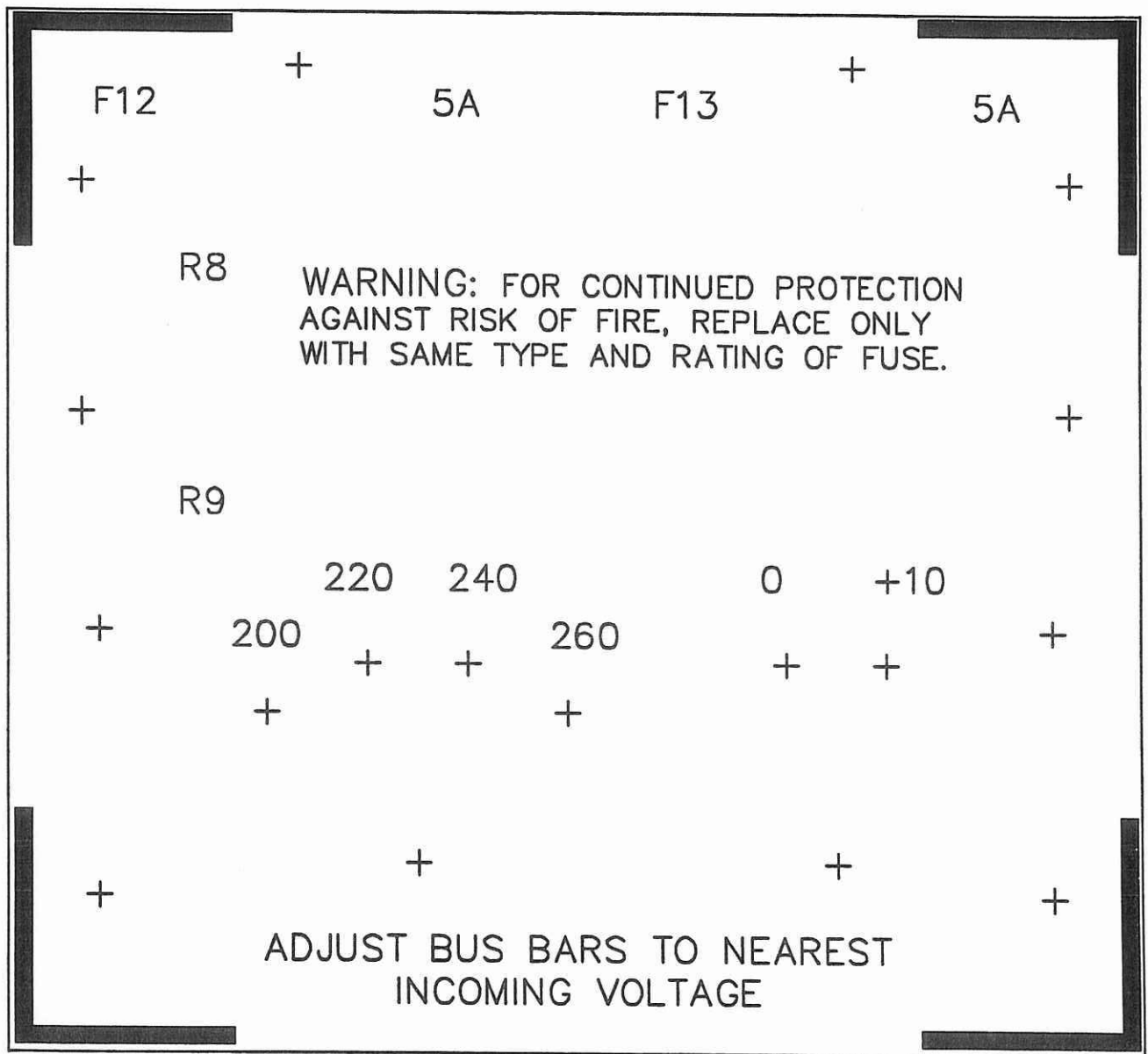


Figure 5-4. Line Tap Panel

INSTALLATION

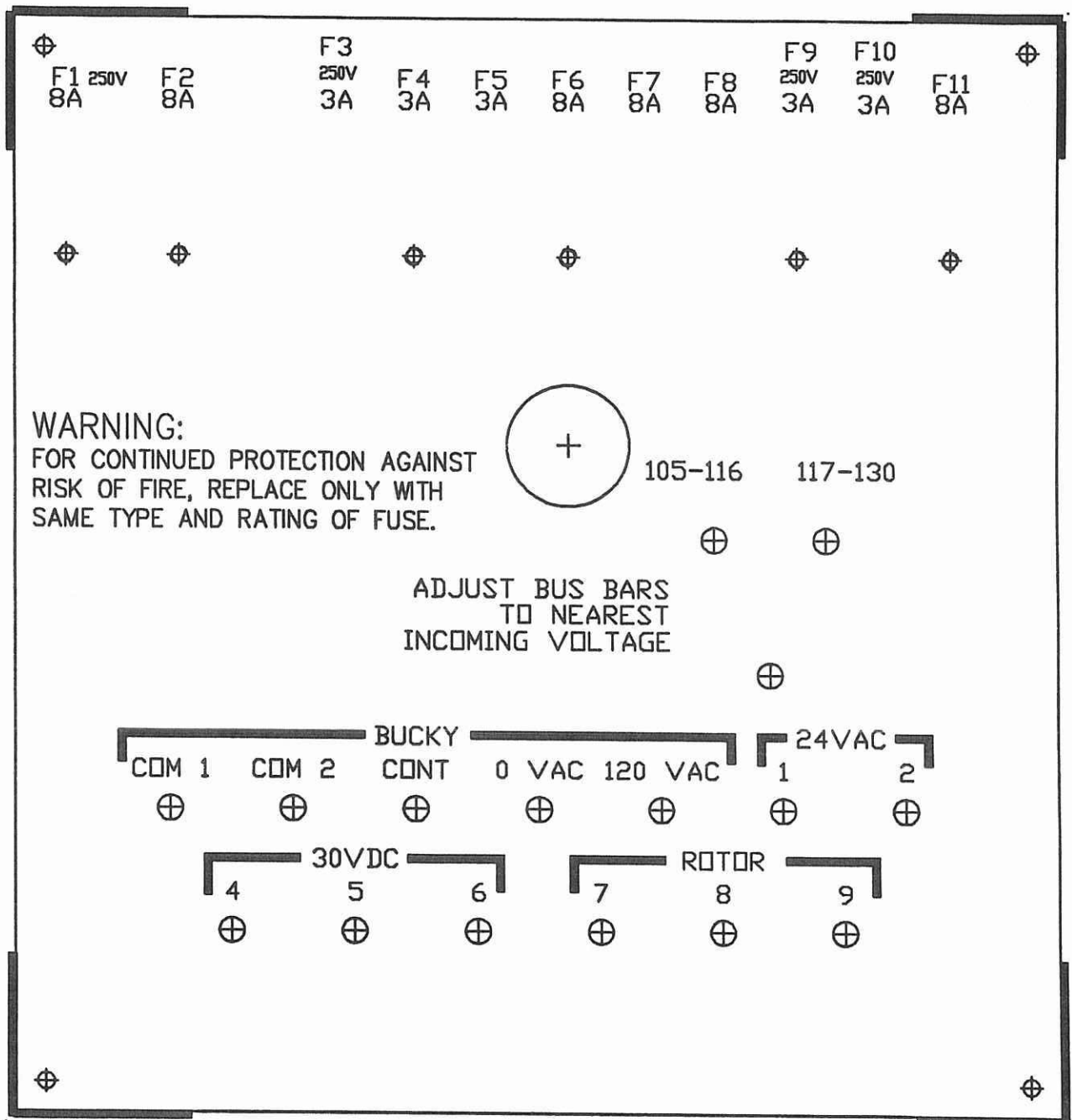


Figure 5-5. Bakelite Terminal/Fuse Panel

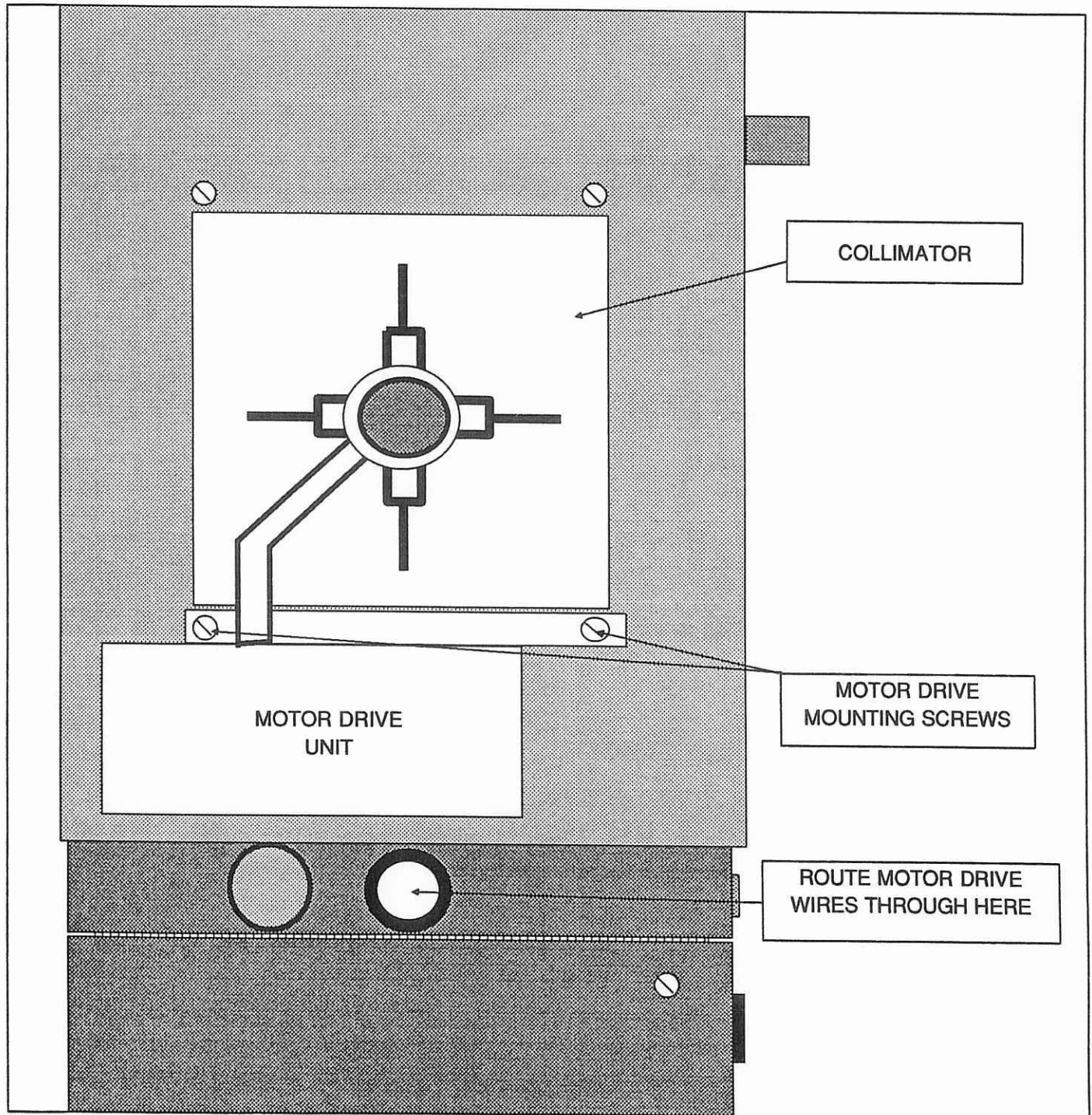


Figure 5-6. Mounting Motor Drive To Collimator

INSTALLATION

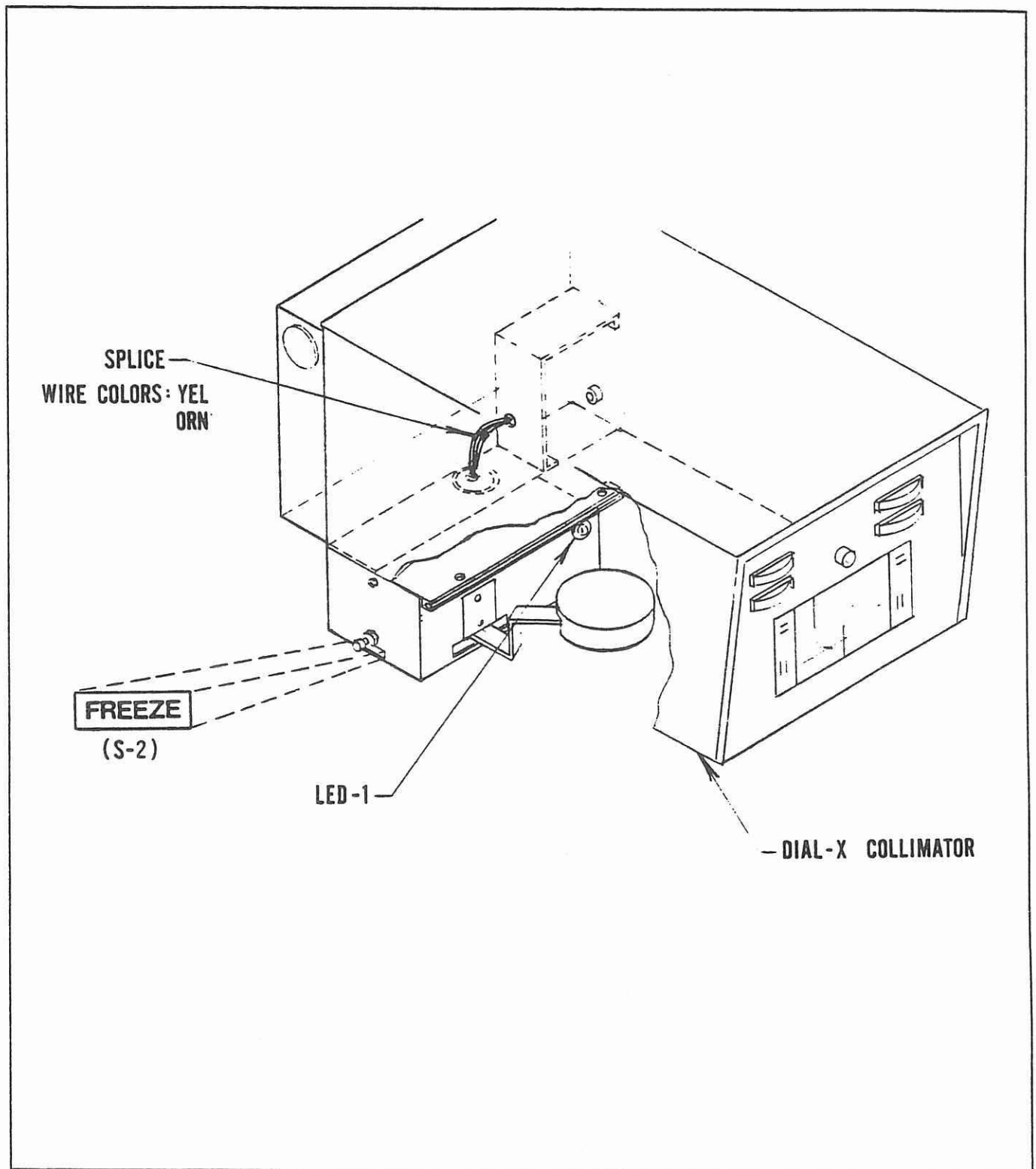


Figure 5-7. Splicing Motor Drive To Collimator Wires

INSTALLATION

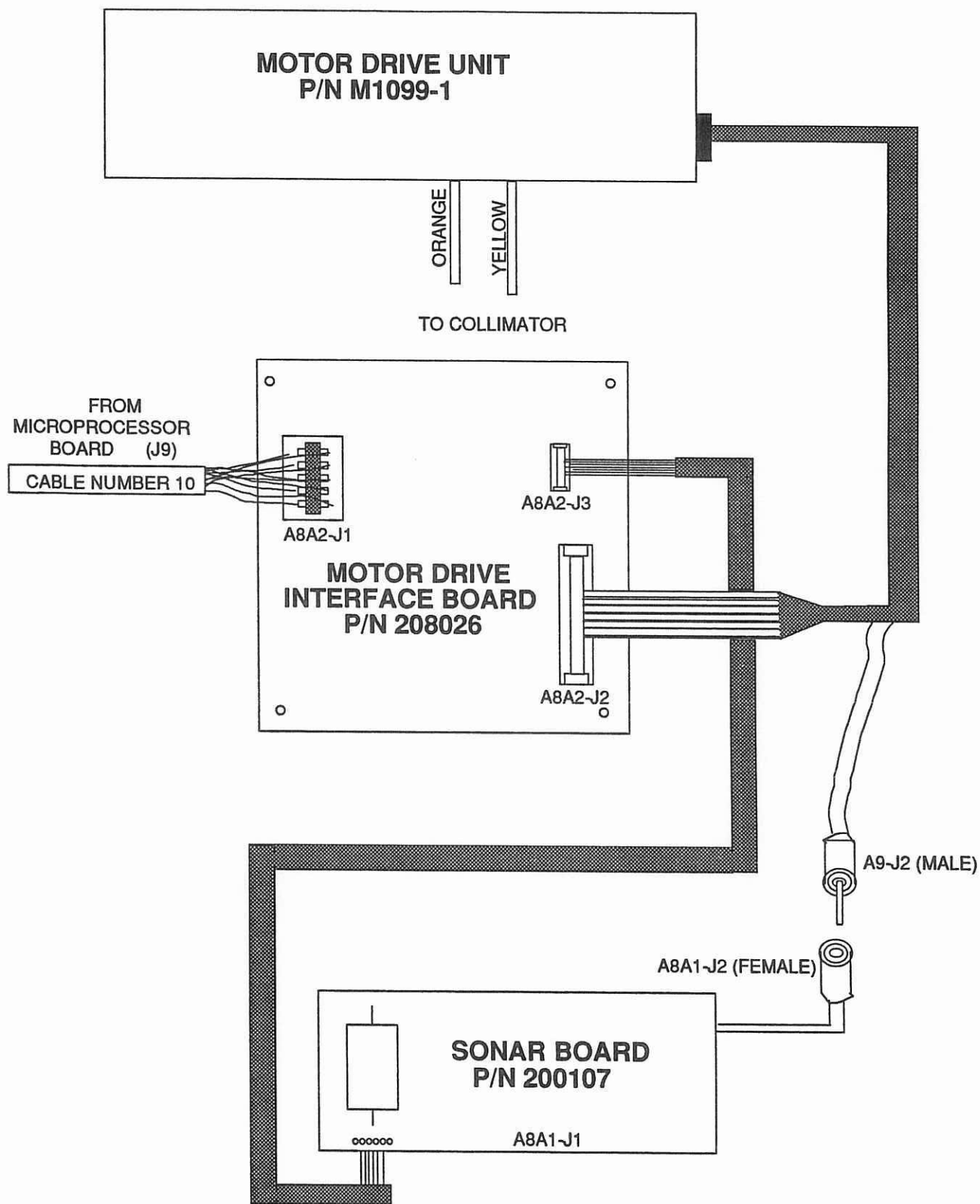


Figure 5-8. ATM Wiring Interconnection Diagram

INSTALLATION

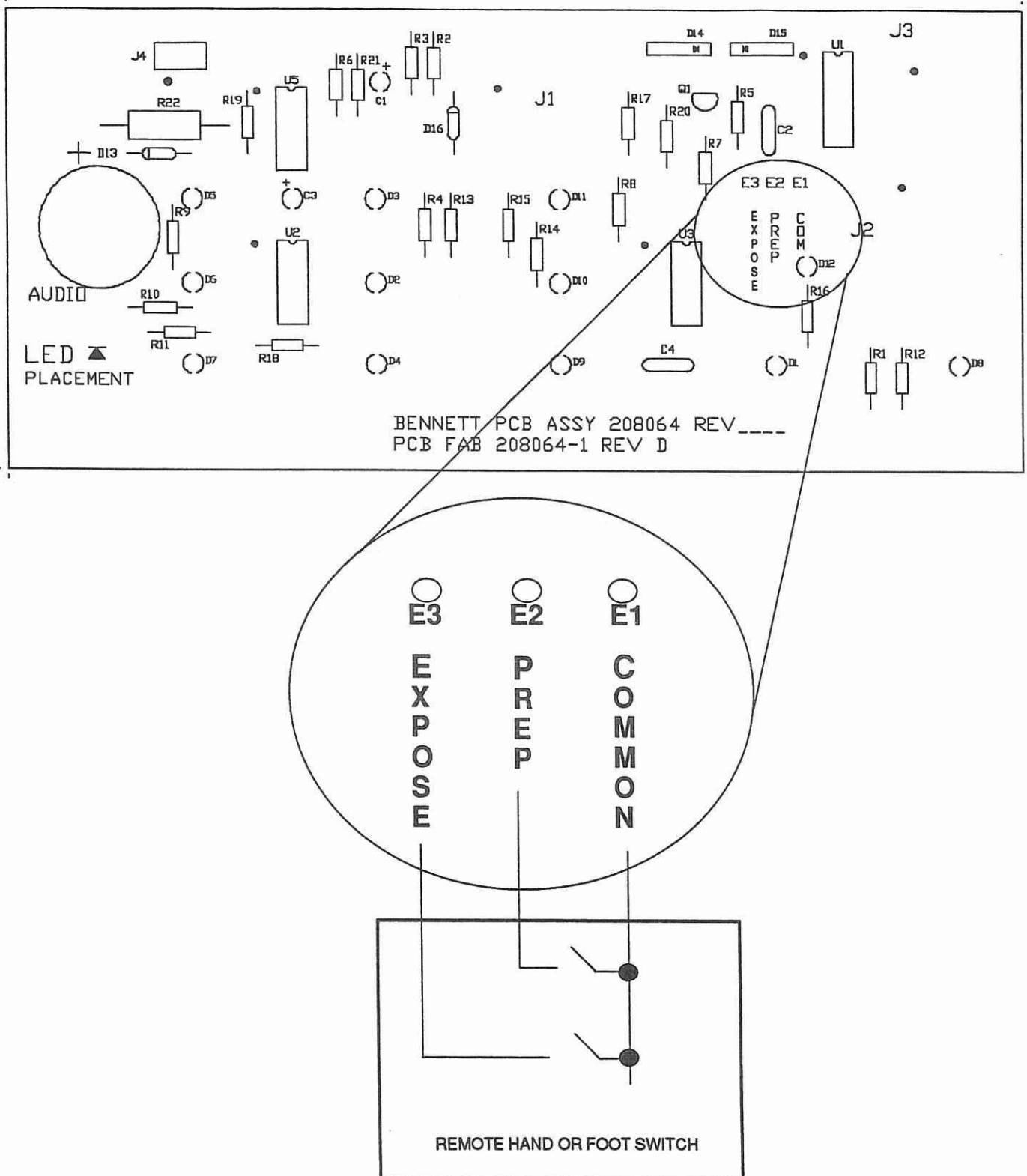


Figure 5-9. Remote Switch Connection Diagram

INSTALLATION

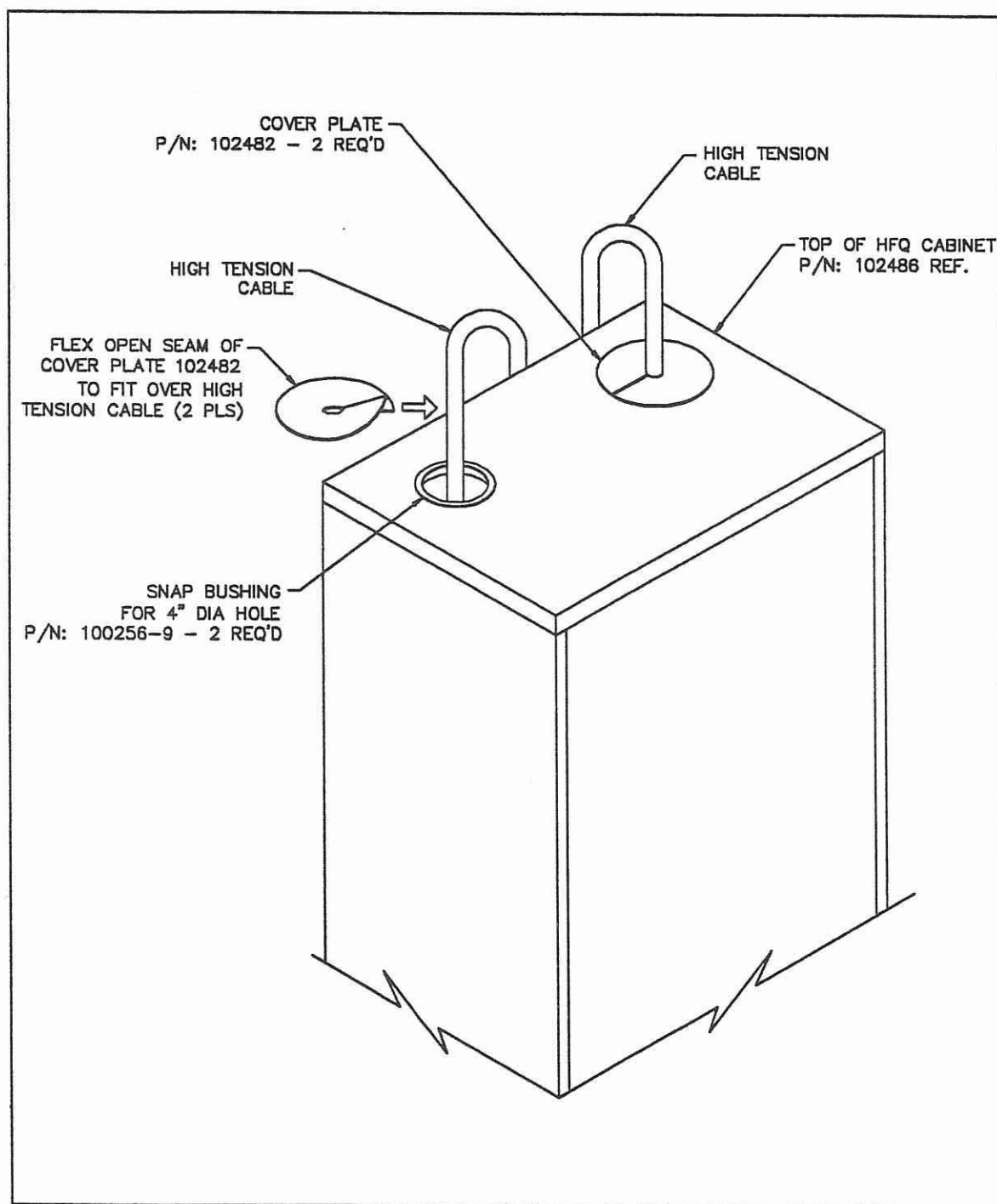


Figure 5-10. Cabinet Top Cable Assembly

***SECTION 6,
CALIBRATION***

**SECTION 6,
CALIBRATION**

INTRODUCTION

This section provides procedures to configure and calibrate the HFQ Series of x-ray generators (refer to Figure 9.7 for PCB locations). For additional information, the NEMA Standards Publication/No. XR8-1979, "Test Methods for Diagnostic X-ray Machines for Use During Initial Installation" is recommended.

REFERENCE VOLTAGE CALIBRATION P/N 208072 (A3)

1. Connect a DVM across TP1 of the microprocessor (A3) and ground. While monitoring the DVM, adjust R17 to $-10.2\text{V} \pm 10\text{mV}$.

ROTOR CALIBRATION

1. This calibration is factory pre-set. It should not have to be adjusted unless a "rotor" error appears on the display. If adjustment is needed, R32 and R33 on the interface board (A1) should be turned counterclockwise. Press **PREP** to cycle the rotor. Do not turn R32 or R33 while **PREP** is pressed.

LIQUID CRYSTAL DISPLAY

1. To adjust the intensity of the liquid crystal display (LCD), rotate R33 either clockwise or counterclockwise on the microprocessor board P/N 208072 (A3).

**SOURCE CHARGER CALIBRATION P/N 208088 (A11 and A14)
(FOR SE SYSTEMS ONLY)**

Note: A fully charged system is required to set R5, R21 and R34 to the proper settings. A14 is not used in HFQ-300 SE.

HFQ-300 SE SYSTEMS

1. Connect the DVM to GND and A11-TP3. Adjust R5 to read between +210 and +212 VDC. D6 should be flashing.
2. Connect the DVM to GND and A11-TP4. Adjust R21 to read between -210 and -212 VDC. D9 should now be flashing.
3. Turn the key switch on the OCP twice and press **CALIB**. Note the displayed SES voltage in the lower portion of the center LCD. 860
4. Connect positive and negative leads of the DVM to A11 TP3 and TP4, respectively. Verify that the measured voltage is 422 ± 2 VDC.
5. If the actual voltage measured on the DVM is equal to or within ± 2 volts of the SES voltage displayed on the OCP, turn the key switch on the OCP twice to return to normal operating mode. If not, adjust A11-R34 until the actual measured voltage and displayed voltage are within ± 2 volts.

HFQ-450 SE AND HFQ-600 SE SYSTEMS

1. Connect the DVM to GND and A11-TP3. Adjust R5 to read between +210 and +212 VDC. D6 should be flashing.
2. Connect the DVM to GND and A11-TP4. Adjust R21 to read between -210 and -212 VDC. D9 should now be flashing.
3. Connect the DVM to GND and A14-TP3. Adjust R5 to read between +210 and +212 VDC. D6 should be flashing.
4. Connect the DVM to GND and A14-TP4. Adjust R21 to read between -210 and -212 VDC. D9 should now be flashing.
5. Turn the main circuit breaker off. Wait until D6 and D9 LEDs extinguish and disconnect A11 J1. Turn the main circuit breaker back on.
6. Connect the DVM to GND and A14-TP2. Adjust A14-R34 to read +4.8 volts. Turn the main circuit breaker off. Wait until A14 D6 and D9 LEDs extinguish, replace A11 J1. Turn the main circuit breaker back on.
7. Turn the key switch on the OCP twice and press **CALIB**. Note the displayed SES voltage in the lower portion of the center LCD.
8. Connect positive and negative leads of the DVM to A11 TP-3 and TP-4, respectively. Verify that the measured voltage is 422 +/-2 VDC.
9. If the actual voltage measured on the DVM is equal to or within +/-2 volts of the SES voltage displayed on the OCP, turn the key switch on the OCP twice to return to normal operating mode. If not, adjust A11-R34 until the voltage on the OCP is within +/- 2 volts of the measured voltage on the DVM.

LINE VOLTAGE MONITOR CALIBRATION P/N 208099 (A11) (NOT APPLICABLE FOR SE SYSTEMS)

1. Access D. C. Reference Mode: Turn the key switch on the OCP twice, then press **CALIB**. Note the value displayed on the bottom center LCD.
2. Connect DVM across C8 (or any of the 2400 mfd capacitors in the bottom of the unit) and note voltage. Voltage should be between 320 and 342 VDC.
3. If necessary, adjust A11-R14 until the bottom value on the LCD is the same voltage as measured on the DVM.
4. Turn the key switch twice to return to normal operating mode.

REGULATED POWER SUPPLY CALIBRATION P/N 208084 (A2)

+/- 15 VDC Supply

1. Connect a voltmeter between +15V TP and GND. Observed voltage should be $+15 \pm 0.2$ VDC.
2. If observed voltage is within specification, continue with step 3. If not, adjust the voltage as follows:
 - a. Observed voltage low - Adjust R7 clockwise until voltage is within specification.
 - b. Observed voltage high - Adjust R7 counter-clockwise until voltage is within specification.
3. Connect a voltmeter between the -15V TP and GND. Observed voltage should be between - 14.4 and -15.6 VDC.

30 VDC Supply

1. Connect the volt meter between the +30V TP and GND. Observed voltage should be $30.0 \pm .02$.
2. If observed voltage is within specification, regulated power supply calibration procedures are complete. If not, adjust the voltage as follows:
 - a. Observed voltage low - Adjust R23 on the (A2) board clockwise until the proper voltage is reached.
 - b. Observed voltage high - Press **PREP** button on the front panel to discharge C4, then adjust R23 counter-clockwise. Continue until voltage is lower than desired and turn R23 clockwise to the proper voltage.

KVP CONTROL BOARD P/N 208089 (A4 and A8)

1. Locate the A4 board and connect a voltmeter between TP1 and GND.
2. Adjust R2 for $-0.80 \pm .005$ VDC.
3. Connect a jumper between TP3 and GND. Remove voltmeter from TP1 and reconnect to TP2.
4. Adjust R5 for -0.75 VDC $\pm .005$ at TP2.
5. Remove jumper and volt meter.
6. Repeat steps 1 through 5 for the A8 KVP Control board.

FILAMENT CONTROL REGULATOR BOARD P/N 208090 (A5)

1. No adjustments are to be made on this board. All adjustments have been made at the factory. If any service to this board is required, notify the factory.

CONFIGURE OPERATING PARAMETERS

To view or configure operating parameters (such as AEC, SES, Back-Up Time, and mA station settings, proceed as follows:

Note: Operating parameters are pre-configured at the factory for optimum operating efficiency. You should not enter this mode to configure operating parameters unless it is required (for example, to derate the system).

1. Set the main power switch to OFF. Remove front panel and pull microprocessor door down to access microprocessor board.
2. Locate TP3 on the microprocessor board (A3) and place a jumper wire from TP3 (R38) to ground. See figure 6-1, Microprocessor Board, TP3, below.

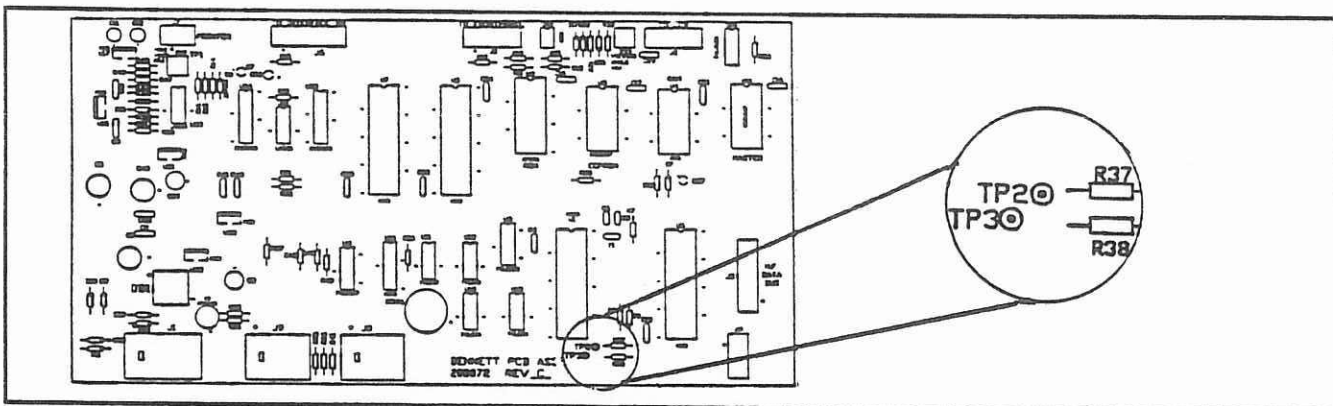


Figure 6-1. Microprocessor Board, TP3

CONFIGURE OPERATING PARAMETERS (Continued)

- Set main power switch to ON. Turn the key switch twice to access the Utility/Maintenance Menu as shown below.

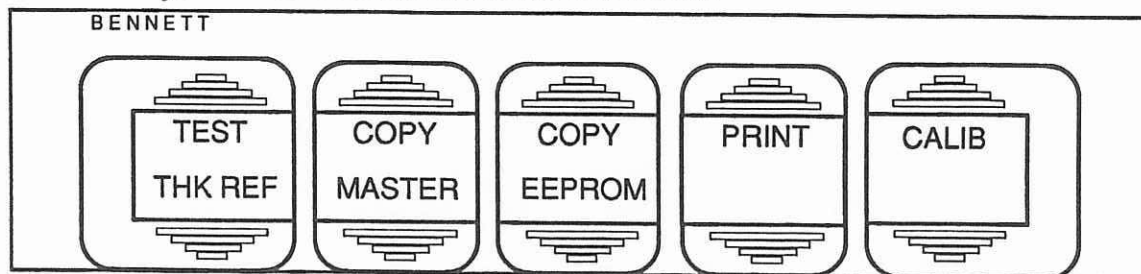


Figure 6-2. Utility/Maintenance Menu

- Press **CALIB** on the LCD to begin the configuration process. The following menu will be displayed:

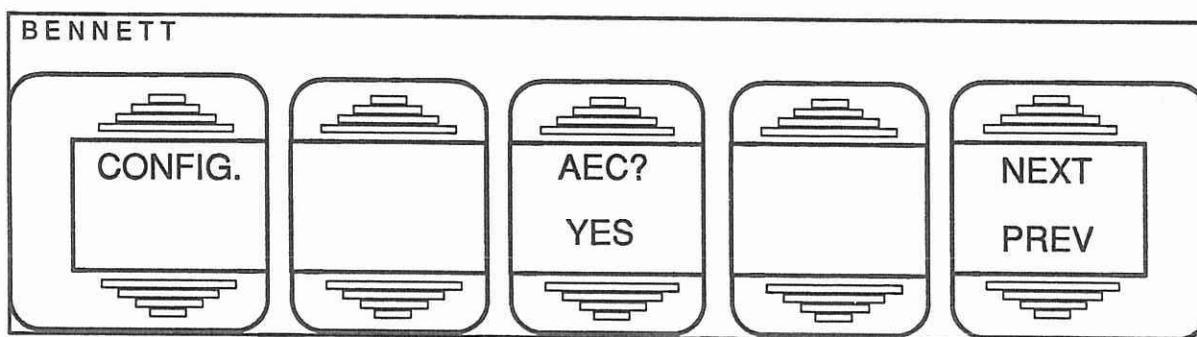


Figure 6-3. AEC Configuration Menu

- AEC? and the current setting should be displayed. If system is equipped with optional AEC, YES should be displayed. If the system does not have AEC, NO should be displayed. Press **AEC** until the appropriate setting is displayed. Then press **NEXT**. The following menu will be displayed:

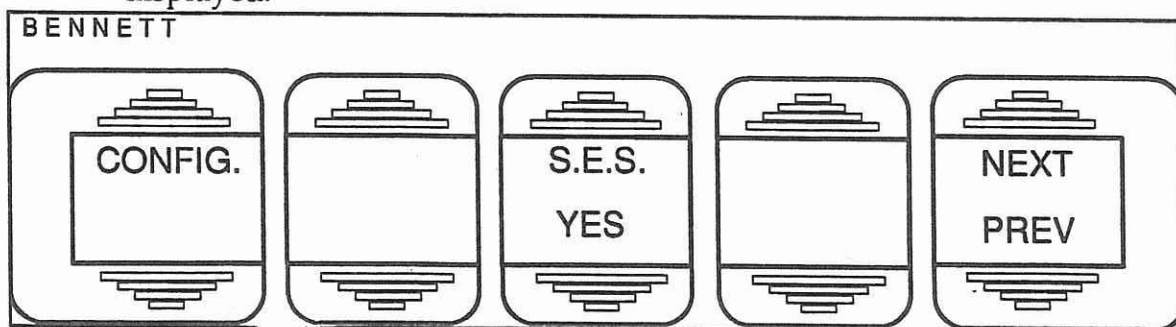


Figure 6-4. SES Configuration Menu

CONFIGURE OPERATING PARAMETERS (Continued)

6. S.E.S. and the current setting should be displayed. If the system is configured as an SE, YES should be displayed. If it is not an SE system, NO should be displayed. Press **S.E.S.** until the appropriate setting is displayed. Then press **NEXT**. The following menu will be displayed:

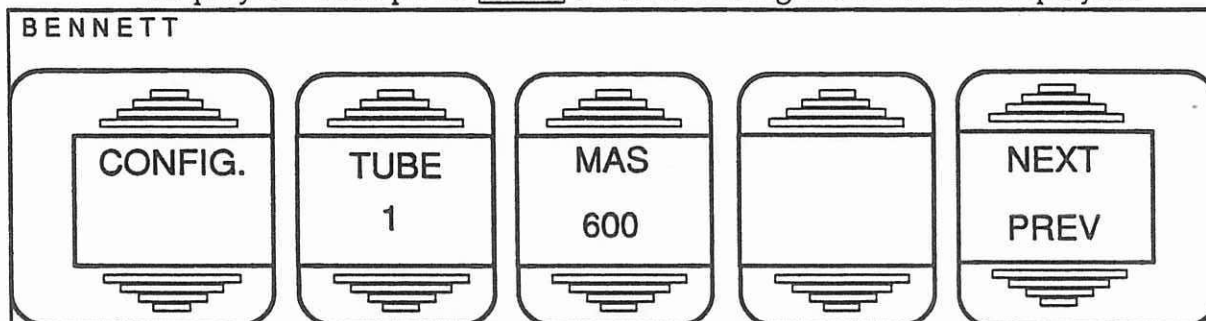


Figure 6-5. MAS Configuration Menu

7. TUBE 1 MAS and the selected back-up MAS will be displayed as shown in fig. 6-5. MAS is selectable in increments of 10 from 10 to 600. To increase or decrease MAS value, press the up or down arrow on the MAS segment of the LCD, respectively. When the desired value is displayed, press **NEXT**. The following menu will be displayed:

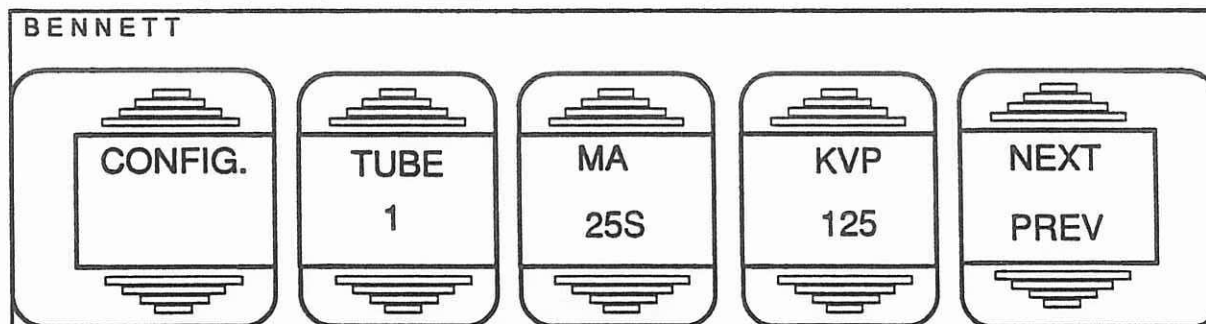


Figure 6-6. MA Station KVP Configuration Menu

8. The lowest MA station and maximum KVP for that station will be displayed as shown above. Press the up or down arrow on the KVP segment of the LCD to increase or decrease the KVP value, respectively. KVP range is selectable in increments of 1 from 41 to 125. When the desired KVP value for the selected MA station is displayed, press **NEXT**. The display will advance to the next MA station. Repeat until maximum KVP values for all MA stations have been selected.

CONFIGURE OPERATING PARAMETERS (Continued)

9. When the last MA station has been set and next is pressed, the Reset Exposure Counter Menu will be displayed:

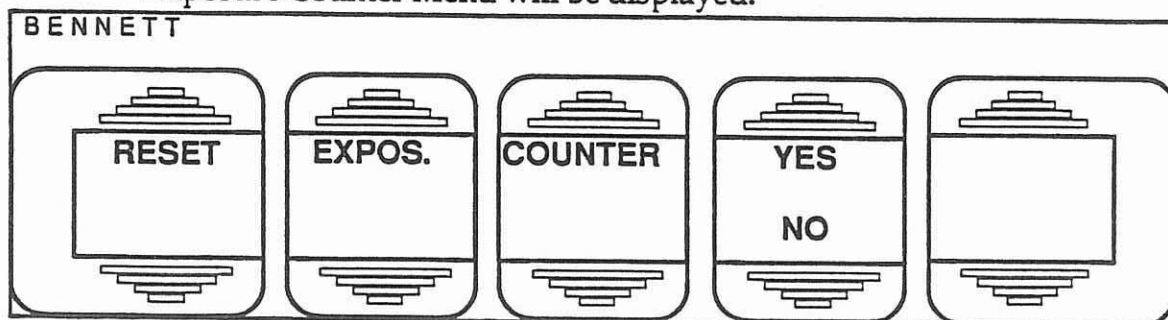


Figure 6-7. Exposure Counter Menu

This menu allows you to keep the current exposure number or reset the exposure number to zero. Press "YES" to reset the exposure to 0 or "NO" to keep the current exposure number. After a selection is made, the LCD advances to KVP and MA calibration mode as shown below:

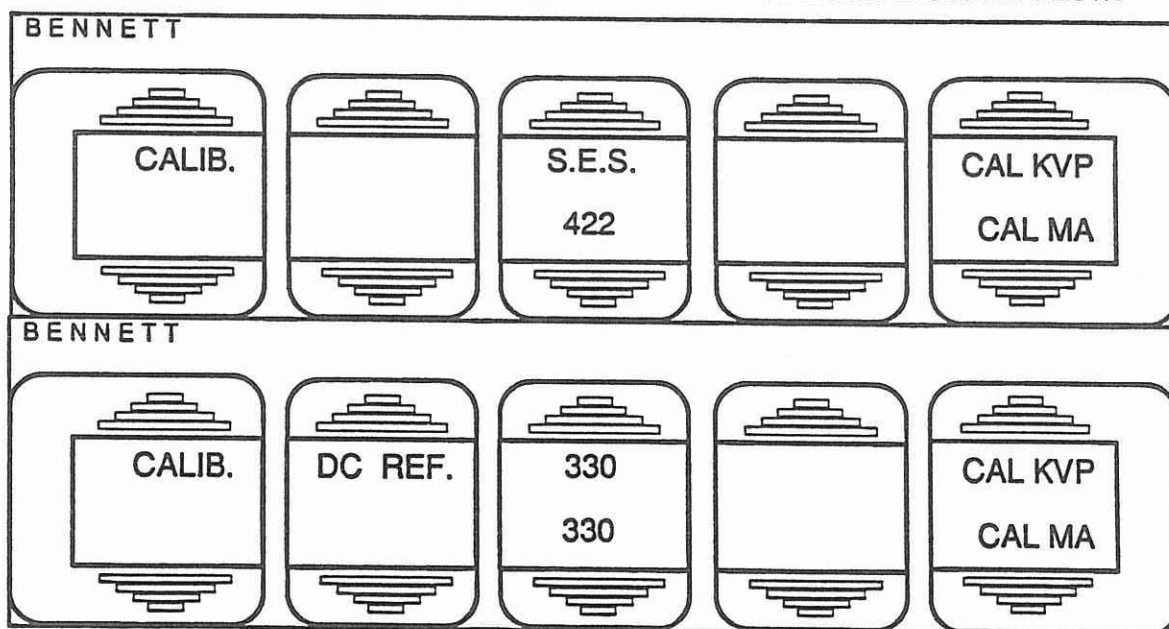


Figure 6-1. Calibration Select/VSENSE Status Menu

10. The center LCD display an S.E.S. voltage or DC REF. level, depending upon the configuration. As S.E.S. voltage level of approximately 422 or a DC REF. number of approximately 330 is displayed (as shown above). Set main power switch to OFF and remove jumper wire from TP3 (R38) and ground. Operating parameter configuration is now complete.

KVP CALIBRATION

To calibrate KVP, proceed as follows:

WARNING: THE FOLLOWING CALIBRATION PROCEDURES INVOLVE TAKING X-RAY EXPOSURES. ALL PERSONNEL SHOULD BE BEHIND THE PROTECTIVE BARRIERS. X-RAYS CAN BE DANGEROUS UNLESS PROPER PRECAUTIONS AND PROCEDURES ARE ADHERED TO.

1. If you have not already connected a dynalyzer tank to the system, it should be connected in series between tube and H.V. tanks.

CAUTION: BEFORE CALIBRATING UNIT, PERFORM SEASONING PROCEDURES RECOMMENDED BY TUBE MANUFACTURER OR, AT LEAST THE SEASONING PROCEDURE DESCRIBED IN SECTION 3, OPERATION.

- a. Switch dynalyzer to Anode and take an exposure at 100 kVp, 100 mA, 10 mAs. The dynalyzer will read near 50 kVp. Adjust kVp on panel and repeat exposure until the dynalyzer reads 50 kVp.
 - b. Switch dynalyzer to cathode and take an exposure without changing the OCP settings. If the dynalyzer does not read 50 \pm 1kVp, adjust A8-R5 and repeat exposure until the dynalyzer reads 50 \pm 1kVp.
2. Access KVP calibration mode as follows:
 - a. If power to the system has been off, set main power switch to ON and turn the key switch twice. The Utility/Maintenance Menu will be displayed:

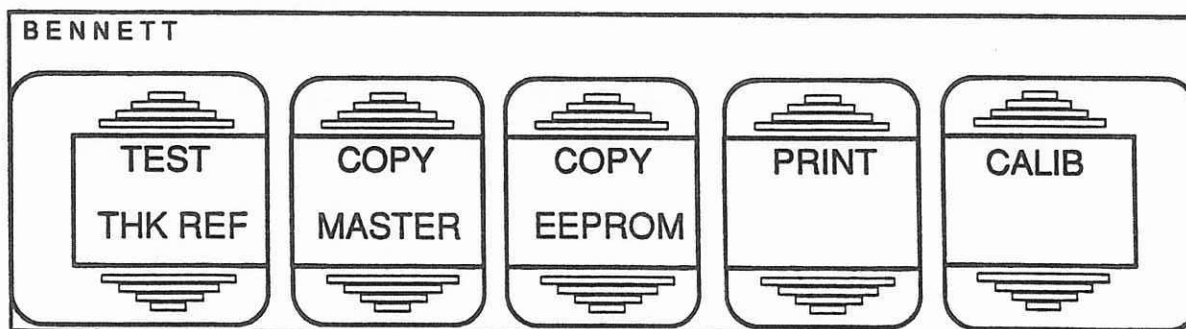


Figure 6-9. Utility/Maintenance Menu

- b. Press CALIB to access the KVP/MA Calibration Select Menu as shown in figure 6-10.

KVP CALIBRATION (Continued)

NOTE: If you have used the CONFIG mode and you have not disconnected the jumper lead from TP3 to ground, CONFIG mode will be accessed. Press **NEXT** until the Calibration Select Menu is displayed.

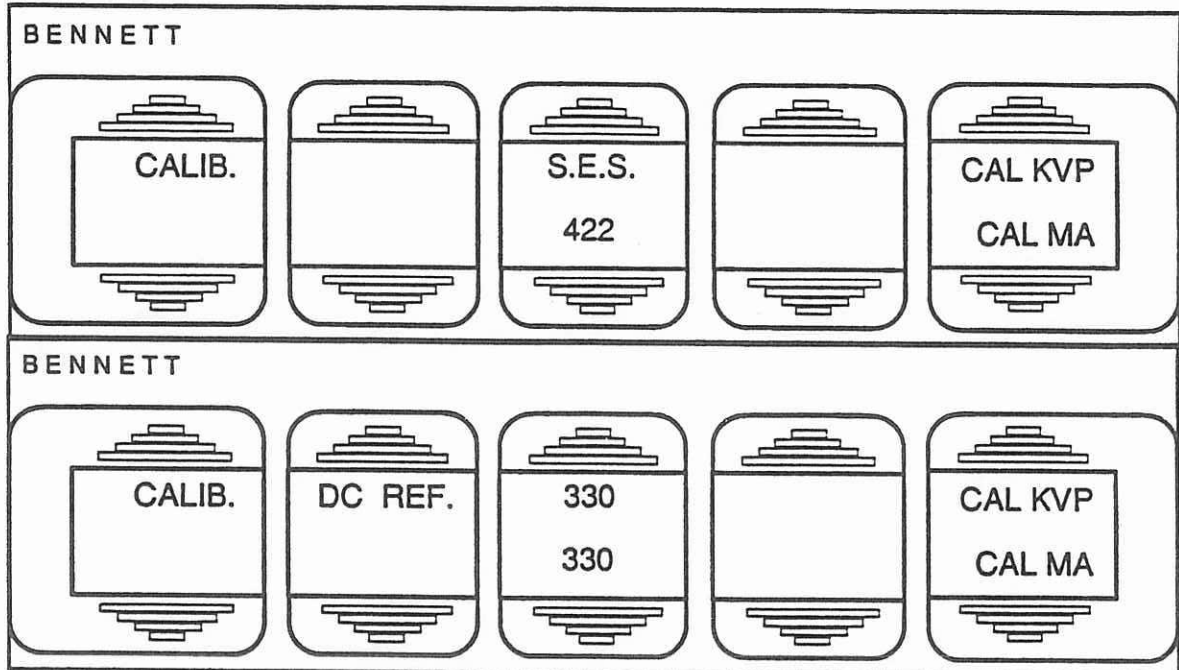


Figure 6-10. KVP/MA Calibration Select Menus

C. Press **CAL KVP**. The LCD will display the KVP Calibration Menu:

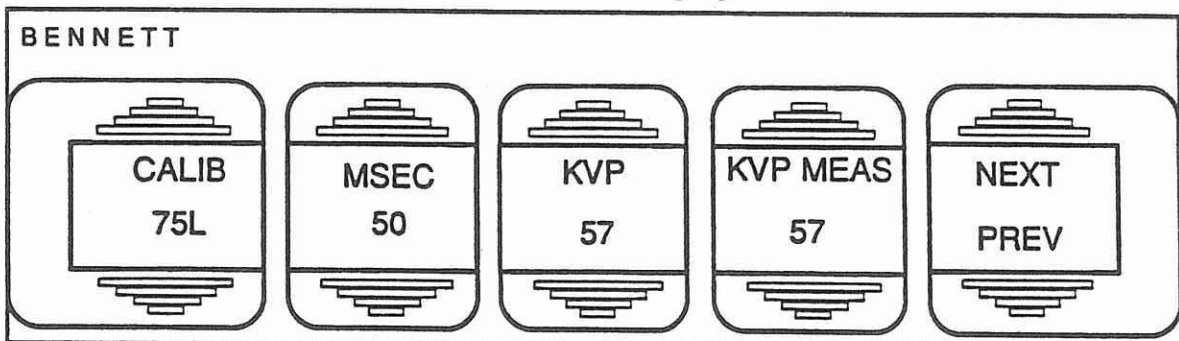


Figure 6-1. KVP Calibration Menu

3. Take an exposure and verify that the dynalyzer display indicates a KVP value identical to the value selected.

KVP CALIBRATION (Continued)

4. If measured kVp is correct, continue with Step 5. If not, press KV MEAS up or down buttons until the KV MEAS value corresponds with the actual kVp output displayed on the dynalyzer.
5. Press **NEXT**. The LCD display will change to calibrate at the next KVP setting with the same mA and time.
6. Take another exposure and verify that the dynalyzer display indicates a KVP value identical to the value selected.
7. If measured kVp is correct, continue with Step 8. If not, press KV MEAS up or down buttons until the KV MEAS value corresponds with the actual kVp output displayed on the dynalyzer.
8. Press **NEXT**. The microprocessor will calculate and display the slope and offset and store these numbers in memory. The LCD will display the KVP/MA Calibration Select menu (figure 6-10).

MA CALIBRATION

WARNING: THE FOLLOWING CALIBRATION PROCEDURES INVOLVE TAKING X-RAY EXPOSURES. ALL PERSONNEL SHOULD BE BEHIND THE PROTECTIVE BARRIERS. X-RAYS CAN BE DANGEROUS UNLESS PROPER PRECAUTIONS AND PROCEDURES ARE FOLLOWED.

1. To measure mA, use either a dynalyzer or Fluke PM 2618 mAs meter or equivalent.
 - a. If you are using a dynalyzer, it should be connected in series between the tube and anode H.V. tank. The cathode tank should be directly connected to the x-ray tube. The dynalyzer should be set for kVp trigger at 90%.
 - b. If an mAs meter is used, connect in series with MA on the anode can; however, this may not be as accurate for times less than 50 msec.
2. Access MA calibration mode as follows:
 - a. Press **CAL MA** directly from the KVP/MA Calibration Select Menu.
 - b. Or, if power to the system has been off, set main power switch to ON. Turn the key switch twice. The Utility/Maintenance Menu appears.

Press **CALIB** to access the KVP/MA Calibration Select Menu.

Note: If you have used the CONFIG mode and have not disconnected the jumper lead from TP3 to ground, CONFIG mode will be accessed. Press **NEXT** until the calibration select menu is displayed.

Press **CAL MA**. The LCD displays the MA Calibration Menu:

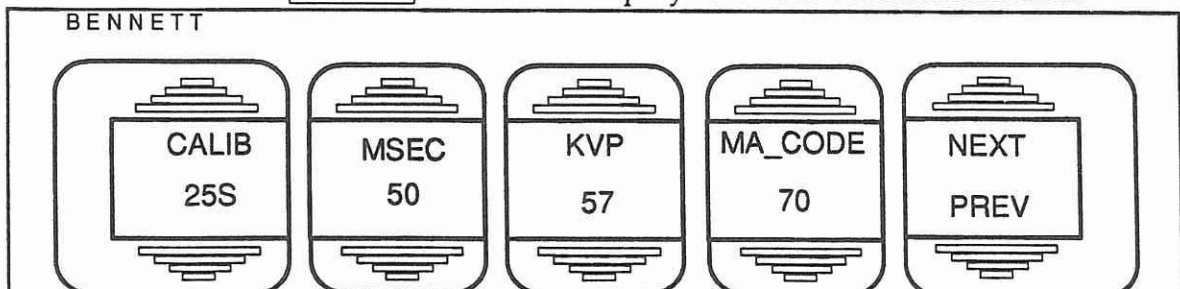


Figure 6-12. MA Calibration Menu

Note: kVp and mA have been pre-set; the displayed values are model dependant.

MA CALIBRATION (Continued)

3. Take an exposure and verify that the dynalyzer display indicates an MA value identical to the value displayed under CALIB (25S as shown in Figure 6-12).
4. If measured MA is within specification (as indicated in Section 2, General Information), continue with Step 5. If not, adjust the MA code up or down (by pressing the corresponding buttons on the LCD) to increase or decrease the mA code reading, respectively.
5. Repeat Steps 3 and 4 until the dynalyzer reading and displayed MA value are within specification. When the measured and displayed values are within specification, press NEXT to calibrate at the next kVp step.
6. Repeat the calibration procedure (Steps 3 through 5) for each mA station and using each kVp step. *Each mA station requires calibration at each of the four (4) pre-set kVp steps.*

Note: When NEXT is pressed at the end of each mA station setting, the LCD momentarily displays a "PLEASE WAIT" message. During this time, the microprocessor is entering the calibration data.

7. After completion of all mA stations, turn the key switch twice to return to normal operation. Set main power switch to OFF and re-connect the system.

MAXIMUM DEVIATION KVP, TIME, MA, MAS

1. Set the dynalyzer for mA (90% trigger level on kVp).
2. Refer to the data sheet in Section 9, Preventive Maintenance and Troubleshooting, and take exposures at the required settings.
3. Run a printout and record on the data sheet.
4. Make sure that the following are within tolerance:
 - a. mA - $\pm 10\%$ or 5 mA, whichever is greater.
 - b. kVp - $\pm 5\%$
 - c. Timing - $\pm 1\% \pm 3$ milliseconds. Time is measured at the 90% level of the peak kV.
 - d. mAs - $\pm 12\%$ for time greater than 100 milliseconds. Below 100 milliseconds, accuracy is a product of time and mA accuracy.

LINEARITY TEST

1. Take ten (10) exposures with the exposure factors from the appropriate data sheet in Section 9, Preventive Maintenance and Troubleshooting. Ensure that the dynalyzer or radiation monitor is set for mR, run a printout and record as Test #1.
2. Take ten (10) exposures with the exposure factors from the appropriate data sheet in Section 9. Ensure that the dynalyzer or radiation monitor is set for mR, run a printout and record as Test #2.
3. Using the data from Tests #1 and #2, refer to the Linearity Data Sheet (in Section 9) and calculate the Average Exposure Ratio. It must be equal to or less than 0.1.

REPRODUCIBILITY

1. Take ten (10) exposures using the settings indicated on the data sheet in Section 9, Preventive Maintenance and Troubleshooting. Ensure that the dynalyzer or radiation monitor is set for mR, run a printout and record as Test #3.
2. After the tenth exposure, select coef. on dynalyzer, mR reading must be less than or equal to 0.05. If a Dynalyzer III is not used, calculate the C.O.V. (coefficient of variation) according to NEMA Standards Publication No. XR 8, Part 2, Page 11, par. D.
3. Record on the data sheet.

AEC CALIBRATION (Sets Normal to 1.2 O.D. Nominal)

Note: The following procedures are required only when the AEC option is installed in the system.

1. Position ionization sensor under beam at 40-inches from the focal spot.
2. Set control to 75 kVp, 100 mA, AEC, DNS normal. Select wall or table bucky according to the chamber being used.
3. Place a plastic container with 5-inches of water in the beam. Ensure that the water covers all three fields.
4. Connect negative voltmeter lead to COM TP. Connect positive voltmeter lead to TP2. Adjust R33 for 0.00 ± 0.01 volts.
5. Connect a voltmeter at A10 TP3. Press **PREP** and hold until the PREP LED comes on. If measured voltage is not 2.2 VDC, adjust R32 and repeat this step until 2.2 VDC is attained.
6. Put a loaded cassette under the ionization chamber. Take an exposure and record mAs.
7. Develop the film and measure the optical density. If optical density is less than 1.2, turn R15 counter-clockwise to adjust. If optical density is greater than 1.2, turn R15 clockwise to adjust. Verify adjustment by repeating the procedure.
8. Take exposure at lowest mA station with 110 kVp. Note mAs as displayed on dynalyzer.
9. Take exposure at highest mA station with 110 kVp. Note mAs as displayed on dynalyzer.
10. Compare dynalyzer mAs readings for lowest and highest mA exposures. If difference is less than 10%, AEC is calibrated, if not continue with next step.
11. If difference is greater than 10%, adjust R12 on AEC board and repeat steps 8 and 9 until the difference is less than 10%.
12. Take exposure at 100 mA, 75 kVp and verify that dynalyzer measures the mAs as recorded in Step 6. If necessary, adjust R15 on AEC board and repeat procedure from Step 6.
13. Put a loaded cassette under the ionization chamber. Take an exposure at 110 kVp, 100 mA, AEC, DNS normal, and wall bucky. Density should be 1.2 ± 0.1 . If not, adjust R15 to balance the error at 75 kVp and 110 kVp.

AEC LINEARITY TEST

1. Take ten (10) exposures in the AEC mode using the settings indicated in the appropriate data sheet in Section 9, Preventive Maintenance and Troubleshooting.
2. Take ten (10) exposures in the AEC mode using the settings indicated in the appropriate data sheet.
3. Using data from Test #1 and #2, refer to the linearity data sheet and calculate the average exposure ratio. Results must be equal to or less than 0.1.

AEC REPRODUCIBILITY

1. Take ten (10) exposures using the settings indicated in the appropriate data sheet in Section 9, Preventive Maintenance and Troubleshooting.
2. After the tenth exposure, select coef. on the dynalyzer. The mR reading must be less than or equal to 0.05.
3. Record on the data sheet.

***SECTION 7,
THEORY OF OPERATION***

**SECTION 7,
THEORY OF
OPERATION**

OVERVIEW

This section provides a detailed theory of operation from a system block level to a detailed circuit analysis.

The center of the system is the Microprocessor Printed Circuit Board, A3. It controls all system operations, including the Operator Control Panel (OCP) interface, MA selection, KVP control, timing functions, and built-in diagnostics. Please refer to Figure 7-1, HFQ X-Ray Generator Block Diagram for a representation of the system's circuitry.

INTRODUCTION

The HFQ Series High-Frequency programmable x-ray generators are available in six different models to provide 300 mAs at 125 kVp, 450 mAs at 125 kVp and 600 mAs at 125 kVp. Each of these models can be configured with a Stored Energy Source (SES), allowing for connection to a standard 110 VAC power source. Since all models utilize identical x-ray control electronics, only one model will be discussed in this section. Specific differences are referenced in text and schematic diagrams where applicable.

In SES configurations, a Stored Energy Source and Source Charger are used while a Line Voltage Monitor is not. When the ATM option is installed, a Motor Drive and Logic circuit are added, together with a sonar device.

POWER INPUT AND CONTROL

Input power is applied to the power shut off circuit (A9) through a magnetic circuit breaker. When the remote power switch on the Operator Control Panel (OCP) is closed, power is applied to transformer T1. The power shut off contains a relay latch device that applies and disconnects power to transformer (T1). When the system has not been used for 60 minutes, the microprocessor sends a shutoff signal to the power shut off, which latches a relay open, disconnecting input power from the transformer. The latch can be reset by setting the remote power switch or main circuit breaker off and then on. One-minute prior to automatic shut-off being activated, the microprocessor will transmit a signal that will cause an audible tone to be generated and display the message "PRESS ANY KEY" on the OCP. If any activity is detected, the shutoff signal will not be transmitted and the relay latch will remain closed. In addition, the power shut off circuit has an internal 30 VDC power supply that provides power for the 30 VDC magnets as long as AC power is applied to the unit and the main circuit breaker is on.



TRANSFORMER

Switched VAC is applied to transformer (T1) via the power shut off circuit. Power is stepped up or down (according to system configuration) and applied to the following circuits:

- 24 and 8.5 VAC to microprocessor
- 19.2, 15 and 10.5 VAC to regulated power supply circuit
- 220 VAC to source charger (if equipped)
- 24 VAC to tube housing assembly for collimator
- 50, 120 and 220 VAC to the interface board; 50 and 220 VAC are used to power the rotor in the x-ray tube; 120 VAC is used to power optional buckys

POWER PROTECTION/CONTROL

This circuit is comprised of relay switching devices (back-up contactors) that isolate either D.C. or SES input power from current amp input circuits. In addition, current amp output is isolated from the HV tank circuits. Control is accomplished via CONT 24 VDC which energizes relays when the EXPOSE signal is detected. K1 provides current amp output isolation; K2 provides current amp input isolation (K2 and K3 are used for input isolation in 450 SE and 600 SE models).

REGULATED POWER SUPPLY

19.2, 15 and 10.5 VAC are applied to the Regulated Power Supply (A2). Regulated +/-15 VDC and +30 VDC is distributed to KVP Control, Filament Control (resistor circuit), Source Charger or Line Voltage Monitor as required.

MICROPROCESSOR

The Microprocessor circuit (A3) provides control and indication for all system functions and input/output (I/O) devices. Operator interface is accomplished through the OCP, with push buttons sensing input and Liquid Crystal Display (LCD)/Light Emitting Diode (LED) providing status indication. An HF bus provides control address/data between the microprocessor and KVP Control, Filament Control, and optional AEC circuits. In addition, the Interface Control (A1) I/O is accomplished via microprocessor connection J6. When the ATM option is installed, all I/O functions are controlled by the microprocessor circuit. The Power Protection/Control circuit that controls all isolated high-voltage I/O functions is managed by microprocessor control. MA selection, timing functions and built-in diagnostics are also controlled by the microprocessor.

MICROPROCESSOR (Continued)

In normal operation, the microprocessor is operating in an executive program mode, scanning the OCP (A6), to see if any buttons are pressed. When a key operation is sensed, it switches over to the program called for by that key. When the program ends, the microprocessor returns to the executive routine.

KVP CONTROL

There are two separate circuits for cathode and anode control. KV level data is transmitted to the KVP Control circuits (A4 and A8) over the HF bus. An active feed back loop transmits a voltage level (that corresponds with actual high voltage) from the HV tanks back to the KVP Control circuits. KVP Control increases or decreases the output to the current amp circuits to precisely control the output KVP. If the appropriate corrections are not detected, exposure is automatically terminated and a KVP error message is displayed on the OCP. When the system is equipped with an optional Automatic Exposure Control (AEC), this device is connected to both KVP Control circuits to terminate exposure by sensing the level of radiation.

AUTOMATIC EXPOSURE CONTROL (AEC) (Optional)

The AEC (A10) terminates exposure (when operating in AEC mode) by detecting the x-ray energy that passes through the body. When the x-ray energy on the detector reaches the required amount, the exposure is terminated by an EXPSTOP signal sent to the KVP Control.

CURRENT AMP

Current amplifier I/O is controlled by Power Protection/Control circuits. There are two separate current amplifier circuits for cathode and anode inputs. Inputs from the KVP Control are transmitted to current amp circuits via the Distribution Control (A7). Amplified 100 kHz current is sent to high voltage tanks through back-up contactors.

FILAMENT CONTROL REGULATOR

Filament voltage is regulated by the high-frequency Filament Control Regulator (A5). Data is transmitted between the microprocessor circuit and filament control circuit via the HF Bus. Filament current is controlled by the microprocessor reference voltage and limited by filament resistor circuit (A6); the small or large filament signals are switched on this board and sent to the cathode high voltage tank.

INTERFACE CONTROL

The Interface Control Circuit (A1) receives data and control from the microprocessor circuit. MA signals are sensed from the anode high voltage tank and transmitted to the microprocessor. Bucky and rotor control signals generated by the microprocessor are sent to the appropriate device via the Interconnect Panel (A13). In addition, the door interlock circuit and Positive Beam Limitation (PBL) circuit are connected to the Interface Control, sending DOOR/N and PBL/N signals to the microprocessor. When these signals are active, they indicate to the microprocessor that a door is open or that the collimator is not in a PBL condition, respectively.

HIGH VOLTAGE TANKS

There are two separate high voltage tanks for the cathode and anode. These tanks generate high voltages according to x-ray generator technique inputs for use by the x-ray tube. Actual output is monitored and controlled by an active feed back loop to the KVP Control circuits.

STORED ENERGY SOURCE

When the SES configuration is selected, Source Charger(s) A11 (and A14) are added to the system in addition to the Stored Energy Source itself. This configuration lowers the required input power from 220 VAC, 100-amp to 115 VAC, 15-amp. Power required for current amplifiers is supplied from the SES, where the SES is replenished by the Source Chargers.

DETAILED CIRCUIT THEORY

The following component descriptions detail signal flow for each circuit. It is suggested that you refer to Section 10, Schematics for the corresponding component schematic diagram as you review this section.

OPERATOR CONTROL PANEL, 208064 (A12)

The Operator Control Panel (OCP), which features a liquid crystal display (LCD), contains most of the control switches and displays which interface the operator to the microprocessor.

Control Switches

The microprocessor scans the front panel keys as a row and column matrix consisting of eight rows and three columns of switches. The row is selected by a three-bit code applied to pins 1, 2 and 3 of U1. A code of "0" selects the top row of switches by putting a low level on U1 pin 15. The microprocessor senses the column outputs J1 pin 6, 7, and 8 for a low level. A low level on any of these three pins would indicate that a switch in that column has been pressed. If all of the column outputs are high, the microprocessor would then send a code of "1" to U1, which would apply a low level to U1 pin 14, thereby selecting the second row of switches. Again, the microprocessor senses the column outputs for a low level. This is repeated until all rows of the switches are scanned.

In addition to the front panel switches, one additional switch is connected to pins 1 and 3 of J3: the key switch. This switch is scanned when the microprocessor sends a code of 7 to U1, which applies a low level to U1 pin 7.

If any column output is sensed low, the microprocessor terminates scanning and returns to the executive program with the information as to which key has been selected.

EXPOSE Switch

Another output line from the front panel is J1 pin 11. This indicates the closure of the EXPOSE switch and is used for the "Dead Man" switch function of the EXPOSE key. Whenever the EXPOSE key is released, this signal goes high opening the backup contactor. In normal operation, the exposure is completed before EXPOSE is released so the contactor is not switching any signals.

LED Indicators

The LED's are controlled by a two-wire sequence. J1 pin 10 is a clock input to a 16-bit shift register consisting of U2, U3. Whenever this clock signal goes high, the logic level on J1 pin 5 is loaded into the input to the shift register U2 pin 2. Updating the LED's consists of 16 clock pulses shifting in 16 bits of data, indicating which of the LED's are on and which are off.

LED Indicators (Continued)

The shift register clock signal is also connected to U5 pin 1 and 2. This is the input to a one-shot which drives transistor Q1 which blanks the LED's during the time that the shift register is being updated. It is triggered on the first update clock pulse and turns off all LED's for the duration of the update.

Q2 is used to control the EXPOSE LED (D8). This LED is only illuminated when the following two conditions are met: the EXPOSE button is depressed and the microprocessor data specifically selects the EXPOSE LED.

MICROPROCESSOR, 208072 (A3)

The microprocessor board controls all functions of the high frequency generator and supplies 5 volts to all other circuitry. 8.5 VAC is applied to J1 pin 10 and 11, which connects to the bridge rectifier, D1. The output of the bridge rectifier is filtered by C41 and C40 and connected to +5 volt regulators, U22, U31, and U32. The output of U22 is further filtered by C3 and provides +5 volts for the whole system, except the front panel. The front panel +5 volts is regulated by U32.

24 VAC is applied to J1 pins 5 and 6 and connected to D9 through D12. The voltage at this point is filtered by C8 and connects to a 24 volt regulator U16. The output of U16 is filtered by C11 and provides +24 VDC. This voltage is connected to U17 and to J6 pin 2.

U17 is a +15 volt regulator. The output is filtered by C12 and is the source for +15 VDC used by circuits on the microprocessor board.

U1 is an 8-bit microprocessor. C5, C6 and Y1 connect to the microprocessor forming a 3.58 MHz clock. This clock is divided by four and appears at U1 pins 34 and 35 as a 2-phase system clock, E and Q. These two signals control all data transfer timing. The microprocessor communicates with the other circuits on the board through an address bus, U1 pins 8-23, and a data bus, U1 pins 24-31. The microprocessor is started by a reset circuit consisting of R10, D7 and C27. This circuit holds U1 pin 37 low after power is applied for about a 1/4 second enabling all power supplies to achieve a stabilized voltage before the microprocessor starts running its program.

The four high address lines, A12-15, are connected to the address decoder, U8. This chip selects the appropriate PIA, DAC, EEPROM, EPROM, LCD or RAM chips that the microprocessor needs to address. For example, if the microprocessor is going to write data into U4 (RAM), A12-15 will be at a low level and the address of the location in RAM will appear on the address lines A0-10. U8 pin 15 will be at a low level enabling U4. At this time, the microprocessor provides the appropriate data to the data bus and pulls U1 pin 32 (READ/WRITE) low. This line, together with the E clock signal, generate a write enable pulse on U11 pin 11, which writes the data into RAM at the address specified on the address bus.

The RAM, U4, is a Random Access Memory used by the microprocessor for all calculations. It contains 2,048 8-bit words. All data in U4 is erased each time the power is turned off. New data is written into and read out of U4 by the microprocessor while programs are running.

The EPROM, U2, is an Erasable Programmable Read Only Memory consisting of 32,768 8-bit words which contain all of the program instructions for the operation of the unit as well as the tube limits for the particular x-ray tube being used. Therefore, whenever changing this circuit board, be sure that the replacement board has an EPROM which has been programmed for the same x-ray tube or

MICROPROCESSOR (Continued)

use the EPROM from the board being replaced. Data in U2 is programmed only at the factory and remains when power is turned off.

The EEPROM, U3, is an Electrically Erasable Programmable Read Only Memory which is used by the system for storage of all Auto-Tech data, set up data, and calibration data. It is necessary, therefore, that U3 be kept with the system and used if the A3 circuit board is replaced since all of the calibration data for the system is stored in this PROM. U3 also stores a total count of exposures and the parameters of the last exposure, allowing the system to return to the parameters of the last exposure when powered on. This circuit can be written to by the microprocessor.

U15 is a voltage sensing circuit that inhibits writing to the EEPROM during power on and power off.

A second EEPROM (MASTER) can be placed in the U26 socket to enable the microprocessor to make a duplicate copy of U3. A master EEPROM can also be copied into U3 by the microprocessor. A master copy should be removed from the microprocessor and stored in a safe static-free place.

NOTE: Calibration data will not be copied into U3 from an EEPROM placed in the master socket.

Peripheral Interface Adapters (PIAs), U5-U7, are used to connect the microprocessor to the rest of the system. U5, which is the Front Panel Interface (FPI), connects to the front panel and is used for scanning the keys and updating the LED's. It also interfaces to the optional automatic thickness measuring system (ATM) and provides the control signals for PREP, the audible signal and the back-up contactor. U6 interfaces to the digital-to-analog converters, U24 and U25, and contains the data lines for the HF data bus and the control signal for the timed automatic power-off. U7 provides the EXPOSE signal, the three select signals for the HF data bus and all of the signals to the Interface Board, (A1) (rotor, bucky, tube mA SENSE and Interlocks).

U20, U21, and U24 form a successive approximation digital-to-analog converter. D8 is a zener diode reference which supplies 6.2 volts through R15 to op amp U20. R17 is used to adjust the output of U20 pin 14 (TP1) to -10.2 VDC, which is the reference for the digital-to-analog converter, U24 and U25, and the HF data bus. VSENSE J1 pin 12 is applied to voltage divider R57 and R19 and filtered by C26. This is buffered by U21 and applied to U24 pin 9. The microprocessor controls U24 through the data bus, successively trying different codes until it finds the code that provides the portion of VREF (U24 pin 8) that is equal in magnitude to the voltage at U24 pin 9. This code is used by the microprocessor to calculate the source voltage.

D/A-2, U25 is a digital-to-analog converter which is used as a reference voltage for the AEC Board (A10). This reference is varied as required, based on kVp, mA, and film screen combination.

MICROPROCESSOR (Continued)

The LCD (Liquid Crystal Display) on the OCP is connected to the microprocessor through the data bus. Timing for the LCD data transfer is controlled by the Q clock signal gated in U14 with the LCD enable signal from U8 pin 9 and the read/write line. The address line A0 controls which register in the LCD data is written to or read from. The vertical viewing angle of the LCD can be controlled by adjusting R33, which applies a bias voltage to J2 pin 4. The LCD is back lit by an LED lighting unit mounted to the rear of the LCD.

The microprocessor controls the x-ray by the issuance of the EXPOSE signal to the kVp control circuit. This signal is a logic high during x-ray and a logic low otherwise. In addition to the EXPOSE signal, a second signal is required for the kVp control circuit to produce an exposure. Normally at a rate of 400 Hz, the microprocessor produces a pulsed signal which triggers a one-shot on the kVp board. The presence of this signal is required for the kVp control board to provide an output for the current amplifiers to produce the high voltage drive. Should the microprocessor board or software fail while the EXPOSE signal is high, this pulsed signal would also cease to be generated since it is generated by the software. In the event of any microprocessor malfunction, the exposure will be terminated.

This system is additionally backed up by the operator's ability to intervene by releasing the EXPOSE switch. In addition to the switch being constantly monitored during exposure (every 2.5 milliseconds), there is a second circuit which is hardware activated independently of the software. Releasing the EXPOSE button will terminate the x-ray by the software and open up the backup contactor, K2.

Before taking an exposure, the backup contactors, K1, K2 are turned on. This is done by U5 pin 13 going high causing the output of the driver U10 pin 17 to go low. If at the same time Q2 is on, then the back-up contactors are enabled. Q2 is turned on by J3 pin 11 being low, indicating that the EXPOSE switch is held down causing U13 pin 13 to be low, U10 pin 4 to be high and U10 pin 15 to be low.

The microprocessor communicates to the other circuits (ie., kVp control board and filament control board, through the HF data bus). This is a bi-directional 8-bit bus used for control as well as data transfer to and from the high frequency control circuits. It is also used to check the status of these circuits to ensure reliable, repeatable x-rays.

INTERFACE BOARD, 208067 (A1)

The interface board connects the microprocessor to all of the high voltage circuits, including the rotor and bucky controls.

J1 pin 12 controls the bucky. If J1 pin 12 (BUCKY 1 TABLE) is high, U3 pin 2 goes high causing U3 pin 17 to go low, turning on Relay 2 and applying 120 VAC to J3 pin 5, which turns on Bucky 1. When the bucky is in position for an x-ray to begin, the bucky applies 120 VAC to J3 pin 6. This voltage is connected to R31, R45, CR22 and photocoupler U10. U10 then turns on, causing U10 pin 4 to be a high. The high level goes to J1 pin 14 (BUCKYRDY). This tells the microprocessor to start an exposure. J1 pin 13 (BUCKY 2 WALL) functions in the same manner.

J2 pin 1 and J2 pin 2 are connected across M1 and M2 on the high voltage transformer. This is a current sense signal sensing the current in the x-ray tube. Any current flowing through the secondary winding of the transformer passes through R22 and U4. When a current flows, U4 turns on applying a low level to J1 pin 5 (XRAYON). This indicates to the microprocessor that current is flowing through the x-ray tube. If no current is sensed by this circuit during an x-ray exposure, an indication ("NO MA?") is made on the LCD. D11-14 are used to limit the voltage across U4.

The rest of the circuitry on the interface board concerns the x-ray tube rotor control. At the beginning of the PREP cycle, J1 pin 10 (R50) and J1 pin 15 (R220) are both high.

When R220 goes high at the start of PREP, the microprocessor is directing the rotor starter circuit to go into the high speed start mode (220 VAC applied to the rotor) causing U3 pin 12 to go low, causing U3 pin 8 to be low. R19 and C10 form a 2-second time delay such that U3 pin 8 would go high after 2 seconds even if R220 remained high. At the start of PREP, U3 pin 8 being low causes U3 pin 14 to be low turning on optocoupler U9 and also keeping U3 pin 4 low and optocoupler U8 off. U9 being on turns on triac Q5 applying 220 VAC to J3 pin 10, which is the rotor common line. The rotor is connected between J3 pin 10 and J3 pins 8 and 9. Rotor current flows through R28-30 to the 0 VAC return. R28 senses the current in the phase shift winding and R29 and R30 sense the current in the main winding. If the rotor is working, the voltage across these current sense resistors appears on CR21 and CR20, which detects the voltage and turns on optocouplers U6 and U7. Then Q4 turns on, producing a low level on J1 pin 9 (ROTOR). If either of these currents is not present, J1 pin 9 stays high, indicating to the microprocessor that there is no rotor current and preventing an exposure.

After 1 1/2 seconds, the microprocessor will pull R220 low indicating that it is time to apply 50 VAC to the rotor, which is the run condition. When R220 goes low, U3 pin 12 goes high, U3 pin 11 goes low and U3 pin 14 goes high, turning off U9. When U9 turns off, Q5 turns off and there is no voltage applied to the rotor. R13, R14, and C9 form a time delay of about 1/4 second, after which time U3 pin 4 goes high causing U3 pin 15 to go low causing U8 to turn on. U8

INTERFACE BOARD (Continued)

turning on turns on triac Q6 applying 50 VAC to the rotor. This condition is sustained until the operator releases PREP and EXPOSE, causing R50 to go low at which point triac Q6 turns off.

U2 is a 12 volt regulator. +24 VDC comes in on J1 pin 2 and is connected to U2. The output of U2 (+12 VDC) is supplied to optocouplers U8 and U9.

In addition, the interface board connects the door interlock and PBL circuits to the microprocessor. TB1 pins 1 and 2 are connected through normally closed door interlock circuits. When the circuit is opened (door open) J1 pin 6 (DOOR) becomes active (high), indicating to the microprocessor that the door is open. TB1 pins 3 and 4 are connected to normally closed collimator contacts. When the collimator is not in a PBL condition, the circuit opens, generating an active PBL signal (high) at J1 pin 8, indicating to the microprocessor that PBL is not active.

REGULATED POWER SUPPLY, 208084 (A2)

The regulated power supply provides +30 VDC, +15 VDC, and -15 VDC for the system.

The circuit is comprised of full wave bridge rectifiers, a -15 volt 3-terminal regulator, pulse width modulators and FET's.

Since the +30 and +15 VDC circuits are identical capacitive input boost switching supplies, only the +15 VDC circuit is discussed.

+ 15 VDC Circuit Description

10.5 VAC is connected to DB1 through transformer T1, into terminals E1 and E2. 10.5 VAC is full wave rectified and filtered by C1, providing 13 VDC across C1 which is connected to inductor L1. L1 is connected to a parallel pair of FETS, Q1 and Q2 which are a pulse width modulated switch connected to ground. This switch causes bursts of current to flow through L1. The current bursts in L1 create a voltage greater than the input voltage that is peak detected in D1 and smoothed by capacitor C3. C2 and R1 are configured as a "snubber" network to limit spikes and transients. The voltage on C3 is sensed by resistor network R6, R7 and R8 and fed back to pulse width modulator U1 (error amp inputs, pins 1 and 16). The voltage at pin 1 is compared with the reference voltage at U1 pin 2 and varies the pulse width of the switching signal at U1 pin 9. U1 pin 9 is connected to the gates of Q1 and Q2 and controls the switching waveform. The rate of the switching pulses is controlled by the RC time constant of C5 and R12 connected to U1 pins 5 and 6. R7 is used to adjust the output voltage.

- 15 VDC Circuit Description

15 VAC is connected through J1 pins 1 and 2 to a diode bridge composed of D3 - D6. The output of the bridge (-21 VDC) is filtered by C11 and connected to voltage regulator U3. The output of U3 supplies -15 VDC.

KVP CONTROL BOARD, 208089 (A4, A8)

When an EXPOSE signal is received to begin x-ray, backup contactors (K1 through K4) are turned on and power is applied to the bucky, if a bucky has been selected. The filament current and x-ray power supply voltage are checked before the exposure signal can be transmitted. All switching is accomplished via solid state controls. Timing is accomplished from the microprocessor control via quartz crystal reference. The system operates in a fail-safe mode since the microprocessor is controlling the EXPOSE signal and in addition pulsing a second signal at a 400 Hz rate. In the event of a malfunction during exposure, this pulsed signal would cease and the EXPOSURE signal would be terminated. Output kVp is selected by the microprocessor prior to the start of x-ray. Data is loaded into the kVp digital to analog converter on A4 and A8.

The following discussion will focus on only one system since the anode and cathode transformers are controlled separately and identically.

The accuracy of the output voltage to the x-ray tube is accomplished with the high frequency feedback power supply. A KV voltage divider circuit is built into each High Voltage transformer assembly. The KV output is sampled by this divider and compared to the required kVp. Adjustments are made to the system continually to hold the output KV constant for all line variations expected. Operation of these circuits are as follows:

A digital code corresponding to the output kVp is sent to the digital-to-analog converter, U1, through the HF data bus on J1. This generates a voltage at TP3 proportional to kVp. Slope and offset pots R5 and R2, together with the adjacent resistors, form a voltage scaling network providing the reference voltage at TP2. The actual codes necessary are computed during the digital kVp calibration procedure.

The output of the kVp divider from the High Voltage Transformer is connected to a buffer amplifier, which is part of U4, through the + and - "sense in" inputs, which are on J2-1 and J2-2. The kVp sample at TP4 is compared to the reference voltage, TP2, in a linear comparator, which is another part of U4. R14 - R16 and C5 form a loop gain compensation circuit.

The output of the comparator at U4 pin 7 controls the kVp oscillator, U5, through a current driver, Q9. The output of U5 drives a flip-flop, U6, which generates a two phase output signal at pins 12 and 13. These clock signals trigger dual one-shots in U9, which in turn, connects to the two drivers.

The driver consisting of U10, Q5, and Q6 is switched 180 degrees out of phase with the driver consisting of U11, Q7, and Q8. These drivers control a FET output stage consisting of Q1-Q4 arranged as a bridge. For one half of the cycle, Q1 and Q3 are conducting, driving current from +15V to J2-6, through the current driver, then back into J2-5, through Q3 to ground. For the other half cycle, current from +15V is conducting through Q4 to J2-5 through the current amplifier in the

KVP CONTROL BOARD (Continued)

opposite direction to J2-6 through Q2 ground. This AC signal appears at J2-5 to J2-6 which will be amplified in A15 and applied to the resonant circuit and then to the high voltage transformer.

These operations occur only during the exposure time. J1-1 is the EXPOSE signal, which must be a logic high to enable both U6 and U8. If this is low, there will not be any loop oscillator output and therefore no x-ray exposure.

U8 is a re-triggerable one shot which has to be triggered every 2.5 msec to enable U9. This is done by the microprocessor continually setting and resetting the select lines (SEL1, SEL2, SEL4) to a code "3". This is decoded in U2 to provide an output pulse train at U2-12, which resets U8, thus continuously enabling the x-ray. This is done so that if a failure should occur during x-ray, this pulse signal would cease and x-ray would terminate.

During normal system operation, x-ray is terminated at the end of the selected time interval by microprocessor control signals or, when the system is equipped with the optional Automatic Exposure Control (AEC), exposure is terminated by the AEC control sensing the level of radiation. However, x-ray can also be terminated as a result of a malfunction. A malfunction can occur if the operator releases the EXPOSE button prior to the end of the selected time interval. This is indicated on the control panel by the message "HYFOB?".

The sampling of kVp voltages is one example of how exposure conditions are monitored. This is accomplished through the constant comparison of sample voltages in the High Voltage Transformer to a reference voltage. If the sample voltage is correct, a logic low is generated; if not, a logic high exists and x-ray is terminated. The circuitry is as follows: the kVp sample voltage at TP4 is continuously compared with the kVp reference voltage at TP2 in U3. If the sample voltage is correct, a logic low is generated at U3 Pin 8, which is connected to U7, which is, in turn, read by the microprocessor every 2.5 msec. However, should a logic high be found to exist, x-ray will be terminated. The microprocessor detects this as a kVp error and indicates the message "KVP?" on the Operator Control Panel to indicate that the problem is in the anode supply. If the problem is in the cathode supply, the message "KVP-C?" will be indicated.

Generating an excessive kV would also serve to terminate exposure. Excessive kV can be detected as follows: the + and - sense lines (J2-1 and J2-2) are connected respectively to U12 pin 9 and U12 pin 2, which are configured as voltage comparators. Should the sense voltage exceed a preset level, U12 pin 8 or pin 14 would provide a logic low which will hold U9 pin 5 low and disable U9, thereby terminating exposure.

KVP CONTROL BOARD (Continued)

The AEC control can also terminate exposures. If AEC is selected, a combination of data signals on the HF data bus and select line will set flip flop U6 pin 9 to a logic low, enabling U7 to read the AEC EXPSTOP signal on J5 pin 4. When the AEC Board detects the correct exposure level, the J5 pin 4 signal will be a logic low. This in turn will cause U7 pin 11 to be at a logic low, which is connected to U8 pin 3 as well as U7 pin 9. A logic low at U8 pin 3 will disable U8, causing U8 pin 6 to stay at a logic low and disable U9, thereby terminating exposure. With U9 disabled, U3 pin 8 will be at a logic high, indicating a kVp error. Additionally, U7 pin 8, which is connected to the microprocessor, will be at a logic low and therefore, will be interpreted as an AEC EXPSTOP signal.

FILAMENT CONTROL REGULATOR, 208090 (A5)

The filament power supply is a high frequency regulated system. A digital code proportional to the required filament current is computed by the microprocessor. The data is applied to HFDO-HFD7 at J1 and the digital to analog converter, U2. The select (SEL1-4) lines are set to a '1' which is decoded by U4. U4 pin 14 goes low strobing the data into U2. The reference thus appears on U3 pin 14 and TP3 as a voltage between 0 and -5 volts, depending on the filament current required. An offset voltage determined by R26-R28 is summed with this reference and inverted, generating at TP1 a final reference voltage for the filament feedback. The voltage at TP1 passes through a voltage divider, R31, R25 and R41 and is applied to U1 pin 2.

U1 is a pulse width modulated power supply control circuit. The output of this circuit at U1 pin 11 and U1 pin 8 controls the inverter transistors Q5 and Q6, which in turn, control the output amplifier Q1-Q4.

The output amplifier is configured as a bridge circuit. The primary of the filament transformer is connected in parallel with R24 through J2 pins 4 and 6 or 5 and 6, depending on whether the small or large filament is activated. This output amplifier provides a balanced AC voltage to the filament transformer.

When U1 pin 11 is low, Q2 and Q4 are on, so the current flows from the 30V power supply through Q4, through the filament transformer, through Q2 and then through the current sense resistors R12 and R13. When U1 pin 8 is low, the current flows through Q1, the filament transformer in the opposite direction, Q3, and the current sense resistors.

The voltage across R12 and R13 is proportional to the filament current. This signal is filtered by R11 and C15. The filtered voltage is connected to U1 pin 1 and compared to the reference described above. U1 controls the pulse width of the output to control the filament current.

One section of U3 senses whether the filament circuit is in regulation and causes the output at U3-7 to be at a logic low. The microprocessor reads the output at

FILAMENT CONTROL REGULATOR (Continued)

U3-7 through buffer U6. This buffer is enabled when the select lines are set at a code of '3', causing U4-12 to be at a logic low.

U5 monitors the sense current through R33. It compares this to the maximum current allowed in the tube which is set at the factory using R36. If the maximum current is exceeded (U5 pin 1 goes to a logic low causing U5 pin 8 to be at a logic high), or if U3 pin 7 indicates that the feedback is not working (U3 pin 7 goes to a logic high), then the microprocessor will indicate a filament error and turn off the filament supply.

The small or large filament is selected by the state of U7 driving Q7. U7 pin 12 is at a logic low for large filament and at a logic high for small filament. Q7 energizes relay K1. U7 is set by the state of HFD0 and HFD1 being clocked into U7. The clock pulse occurs when the select lines are set to a "2", causing U4-13 to be at a logic low.

FILAMENT RESISTOR BOARD, 208086 (A6)

This printed circuit board mounts the filament resistors and is used to match the characteristics of different tubes.

AUTOMATIC EXPOSURE CONTROL BOARD, 208094, (A10) (Optional)

The Automatic Exposure Control Board terminates exposure when the system is operating in AEC mode. The AEC sensor (chamber) detects the x-ray energy that enters the film cassette. When the x-ray energy on the detector reaches the required amount, the x-ray is terminated.

The board is configured to allow the selection of two chambers named for their location (wall and table) and three fields in those chambers, if the chambers are so equipped.

Compatible chambers used with this board function by providing a D.C. potential which is ionized by the x-ray energy and generate a D.C. current. This D.C. current is proportional to the x-ray energy and is integrated in the chamber, generating a linear ramp.

To provide compatibility with various types of chambers, this board can be supplied with a 300 volt power supply for use with chambers that do not have a built-in D.C. supply.

The 300 volt power supply consists of oscillator U10 driving FET Q2, which provides a switching voltage to the primary winding of transformer, T1. The output of T1 is rectified by D1 and filtered by C15, R50 and C16. R48 and R49 sample the output voltage and provide a feedback signal to U10 to keep the voltage constant.

AUTOMATIC EXPOSURE CONTROL BOARD (Continued)

All of the AEC control signals are generated by the microprocessor and connected by the HF data lines (J1 pins 10, 12, 14, 16, and 18) and the select lines (J1 pins 15, 17, and 19). These control signals are decoded by latch U2 and decoder U1. All of the control signals are initiated during the Expose cycle after the EXPOSE key on the control panel is pressed.

Chamber selection is accomplished by U2 pin 2. WALL is selected by U2 pin 2 being high, which feeds inverter U3. U3 pin 8 being low closes switches U4 pins 2 and 3 and U4 pins 14 and 15. TABLE is selected by U2 pin 2 being low, which feeds buffer U3. U3 pin 14 being low closes switches U4 pins 6 and 7 and U4 pins 10 and 11.

Field selection is accomplished by U2 pins 5, 6 or 7 being high, in turn causing inverter U7 pins 12, 13, or 14 to be low, which enables fields 1, 2 or 3, respectively. The fields can be enabled in any combination.

The exposure start signal resets the chamber integrators and the exposure stop flip-flop (U9) in the following sequence: when U2 pin 12 (EXPSTART) goes low, the output of OP amp U3 (U3 pin 7) goes low. This low level is connected through switch U4 to inverter U7. The outputs of U7 (U7 pins 17 and 18) reset the integrator in the selected chamber. The low level at U3 pin 7 also triggers one-shot U8, the output (U8 pin 4) provides a negative pulse to reset the EXPSTOP flip flop (U9).

The board functions in the following manner: the output ramp from the chamber selected by switch U4 is connected to TP4, which feeds OP amp U5. U5 is divided into a summing amplifier, a comparator and an anticipator circuit.

The summing amplifier combines the ramp output voltage at TP4 with the anticipator output voltage at TP6. R15 is used to calibrate the circuit for the desired film density. The summed output voltage appears at TP7 and is one input to the U5 comparator.

An AECVREF voltage (generated by the microprocessor) which varies according to selected kVp and density, is applied to J1 pin 13. The voltage is buffered and scaled with OP amp U6. R32 allows calibration of the reference voltage measured at TP3. R33 allows for voltage offset adjustment of 0 volts, measured at TP2. The scaled AECVREF voltage is applied to comparator U5, pin 12 from U6, pin 7.

When the DC ramp voltage TP7 exceeds the AECVREF voltage, U5, pin 14 goes low, turning Q1 off. The positive going voltage at the collector of Q1 triggers D flip-flop U9, which transmits an EXPSTOP signal to the KVP control boards terminating exposure. The EXPSTOP signal is high during x-ray and goes low to terminate exposure.

The Anticipator circuit compensates for ramp voltages with slow rise times (usually associated with low mA settings) and causes the EXPSTOP signal to be generated before the ramp voltage reaches AECVREF voltage. Ramp voltage is

THEORY OF OPERATION

AUTOMATIC EXPOSURE CONTROL BOARD (Continued)

amplified and applied to U5 pin 2 as an Anticipate ramp voltage. The Anticipate ramp voltage is summed with the ramp voltage and applied to comparator U5, pin 13.

SOURCE CHARGER(S), 208088 (A11)(A14 added, model dependant)

Note: Source charges are not included in non-SE versions of the HFQ series.

The key to the low input current for this system is the stored energy system. Plus and minus 211 volt high efficiency, maintenance-free batteries are housed in compartments at the bottom of the system.

WARNING: DANGEROUS VOLTAGES EXIST INSIDE THESE COMPARTMENTS. IF THESE COVERS HAVE TO BE REMOVED FOR SERVICE, IT IS RECOMMENDED THAT THE FUSES INSIDE EACH ASSEMBLY BE REMOVED (TWO FUSES, F12 AND F13, FOR THE HFQ 300; FOUR FUSES, F12, F13, F14 AND F15 FOR THE HFQ 450 AND HFQ 600). THE BATTERIES ARE CONTINUALLY CHARGED BY A11 (AND A14, WHEN APPLICABLE). WHEN THE LED'S (D6 AND/OR D9) ARE ILLUMINATED, CURRENT IS FLOWING INTO THE RESPECTIVE BATTERY.

Source Charging

440 VAC is applied across the bridge D1-4 through J1 pins 1-3 from a center tapped winding on the auto transformer. The positive charger voltage is connected to the battery through J1-7. This voltage is sensed through the voltage divider R4-R6, with R5 used to adjust the charging voltage by U1 pin 2 and compared to the +6.3V reference diode D5 on U1 pin 3. The output, U1 pin 1, goes high if the battery voltages goes low, turning on Q2, D6 and the opto coupler, U2. U2 is used as a triac driver which, when activated, turns on the triac, Q1, which then charges the battery through the current limiting resistors, R3, R32, and fuse F1. When the desired battery voltage is achieved, Q1 turns off.

The negative charge voltage is connected to the battery through J1 pin 8. This voltage is sensed through the voltage divider R20-22 by U3 pin 2 and compared to the -6.3V reference diode D8 on U3 pin 3. The output, U3 pin 1 goes low if the battery voltage goes low, turning on Q4, D9 and the opto coupler U4. U4 is used as a triac driver, which when active turns on Q3, charging the battery through the current limiting resistors R19, R31 and fuse F2. When the desired voltage is achieved, Q3 turns off.

The output voltage of divider R4-R6 is also connected to a second section of U1 and compared with 90% of the D5 reference voltage to define a minimum effective source voltage for proper x-ray operation. The output of this section

SOURCE CHARGER(S) (Continued)

(U5 pin 1) goes to a negative voltage if the source voltage is too low and is summed with an identical circuit located in the negative charger voltage divider R33-35.

SES Sensing Circuit

The source charger circuit is equipped with a circuit that senses the stored energy potential and transmits it to the microprocessor circuit as the VSENSE signal on J1 pin 4. The microprocessor checks for this voltage to be in a preset range. If VSENSE is not in the preset range, it will cause the microprocessor board to disable the x-ray exposure. VSENSE is generated through a voltage divider using R33-35 and the input resistance of VSENSE on the microprocessor board with respect to ground. This voltage can be lowered by one of three comparator outputs going low. Two of these comparators, U1 and U3, monitor the state of charge, and the third, U5, monitors the balance of the outputs. D14 is to prevent VSENSE from going below -.7 VDC.

POWER SHUT OFF BOARD, 208087 (A9) (FOR SE SYSTEMS ONLY)

The power shut off circuit consists of a transformer, full-wave bridge rectifier and three relays. This circuit controls input power to system transformer T1 and supplies +30 VDC to the magnetic brakes in the table and tubestand.

Input power is applied to J1 pins 1 and 10 from the main circuit breaker to the transformer primary through F2. 35 VAC from the transformer secondary is applied to the full-wave bridge rectifier (DB1). When input power is on, +30 VDC is provided at J1 pin 6 and for relays K1, K2 and K3 through fuse F1. +30 VDC (J1 pin 6) is provided for the magnetic brake circuit constantly, independent of the remote power switch or automatic shut off status.

When the remote power switch (TB1) is set in the ON position (closed), a ground path is provided for relays K1 and K2 to energize, closing the contacts and allowing input power to be applied to the system transformer (T1) via E2 and E4. If the system is left with the power turned on and no x-rays are taken for a period of one hour, the microprocessor will time-out the system: it transmits a SHUTOFF signal (logic low) to J1 pin 3 energizing relay K3. Normally closed relay K3 contacts open, removing the ground path from TB1 and de-energizing relays K1 and K2 which remove input power from the system transformer T1.

Relay K3 will then be latched in the energized position. K3 must be de-energized to turn the system power back on. This can be done by either setting the remote power switch (TB1) or main circuit breaker to OFF (open) position, then back to ON.

POWER SHUT OFF BOARD, 208101

(FOR HFQ SYSTEMS WITHOUT STORED ENERGY)

This board functions in a similar manner to the 208087 Power Shut Off Board previously described, with the exception that K1 and K2 are not included on this board.

When the Remote Power Switch (TB1) is set in the ON position, J1 pin 2 supplies a ground path to contactor K3, which when energized, provides AC power to the system. The microprocessor time out system also functions in a similar manner to the 208087 board by removing the ground path at J1 pin 2.

DISTRIBUTION BOARD, 208085 (A7)

This board contains two relays and two bleeder-resistors and is connected in series between the KVP control circuit and current amplifiers. Quick-disconnect plugs allow for easy connection/disconnection of current amplifier circuits to (or from) the system. The bleeder-resistors discharge the capacitors to remove any stored potential voltage.

When the system is powered-on, +24 VDC from the microprocessor board is applied to relays K1 and K2 via J1, pin 4, causing them to energize. Normally closed contacts open, disconnecting the bleeder-resistors from the circuit.

When the system is powered-off, relays K1 and K2 de-energize, causing the contact to close, providing a discharge path for the capacitors through bleeder-resistors R1 and R2.

NOTE: HFQ-300 SE System Distribution Boards contain only one relay (K1) and one resistor (R1).

LINE VOLTAGE MONITOR, 208099 (A11)

The Line Voltage Monitor circuit is not used in SE versions of the HFQ series. It provides a VSENSE signal to the microprocessor indicating that the line voltage is at the proper level to take an exposure. In addition, two LEDs on the top side of the board illuminate to indicate that power is being applied to each capacitor bank.

The circuit monitors anode and cathode voltages at the capacitor banks applied to J1 pins 1 and 6, and pins 7 and 12, respectively.

With power on, a positive voltage from the anode capacitor bank is applied to U1 non-inverting input pin 3 and a negative voltage from the anode capacitor bank is applied to inverting input pin 2. These voltages cause U1 output pin 1 to generate a positive voltage which can be seen at TP1. This positive voltage causes LED D2 to illuminate, indicating that power is applied to anode capacitor bank. The cathode capacitor bank is monitored identically, with the output of U1 pin 7 generating a positive voltage at TP2 and illuminating LED D1.

LINE VOLTAGE MONITOR (Continued)

Outputs from U1 pins 1 and 7 are applied to U1, inverting input pin 9 and summed at pin 8. The summed voltage is applied to U1, inverting input, pin 13 through R16 and potentiometer R14. R14 allows for adjustment of required voltage level for VSENSE signal.

This adjusted positive voltage is output at U1, pin 14 (seen at TP3) and transmitted to the VSENSE input on the microprocessor board, A3. The VSENSE signal indicates to the microprocessor that voltage is the required level to take an exposure.

OPERATOR CONTROL PANEL DRIVER, 208098 (A15)

When the OCP is used from a remote location, this driver/buffer circuit is used to help ensure accurate data transfer to and from the microprocessor board.

It is comprised of two monostable multi-vibrators for circuit timing, two 8-bit buffer registers, two 8-bit buffer/drivers and a NAND gate. J1 and J2 interconnect the board to the microprocessor board and OCP, respectively.

Typically, data from the microprocessor is sent to U1 and U2, the 8-bit buffer registers. The LCDEN signal (a clock pulse) from the microprocessor is buffered through two NAND gates and transmitted to the clock input of the buffer registers and B clock input of the multi-vibrator. At the positive edge of the clock pulse, data is clocked to each of the outputs and applied to the buffer/drivers.

The two monostable multivibrators function to delay the LCDEN signal, thus allowing for data transfer time between the registers and drivers. The delayed LCDEN signal is transmitted from pin 5 of U5B and applied to the OCP via U3 pin 9, allowing the OCP to read the data.

***SECTION 8,
PROGRAMMING/UTILITIES***

**SECTION 8,
PROGRAMMING/
UTILITIES**

OVERVIEW

The HFQ Series High-Frequency x-ray generator features powerful programming and utility capabilities that include the following:

- Auto-Tech technique programming
- IC (integrated circuit) duplication
- Printing of Auto-Tech technique parameters
- Setting the thickness reference for the ATM option
- System calibration
- Automated testing

AUTO-TECH TECHNIQUE PROGRAMMING

The following procedures provides step-by-step instructions for editing an existing technique or writing a new one and adding it to the Auto-Tech memory. Auto-Tech has the capability of recalling up to 72 techniques by storing up to 9 techniques in each of the 8 anatomical regions. Any of the existing x-ray techniques can be edited to suit the individual needs of your practice.

For the purpose of this description, the LCD display is divided into 10 sectors as shown in Figure 8-1, below. Each sector is controlled by the corresponding sector key located above or below that sector.

AUTO-TECH PROGRAMMING PROCEDURES

1. Press **AUTO-TECH** to select Auto-Tech mode.
2. Select the anatomical region where the technique is (to be) stored by pressing the corresponding sector key. For example, to edit the LUMBAR region in the main menu (see Figure 8-1), press sector key 5.

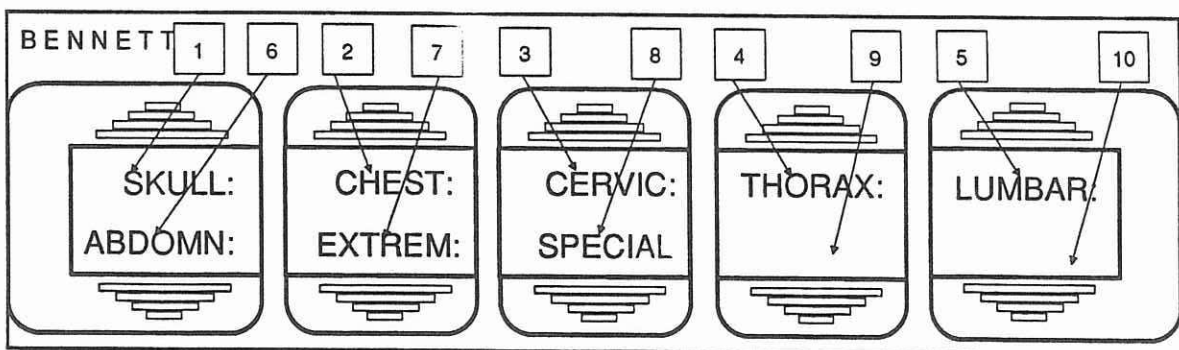


Figure 8-1. Auto-Tech Anatomical Region Selection

AUTO-TECH PROGRAMMING PROCEDURES (Continued)

3. Select the Region of Interest for the particular anatomical region where the technique is located by pressing the associated sector key. To add a new ROI (if a blank sector is available) press a blank sector key. For example, see Figure 8-2. To edit LATERAL, press sector key 7. To add a new ROI to the blank sector, press sector key 5.

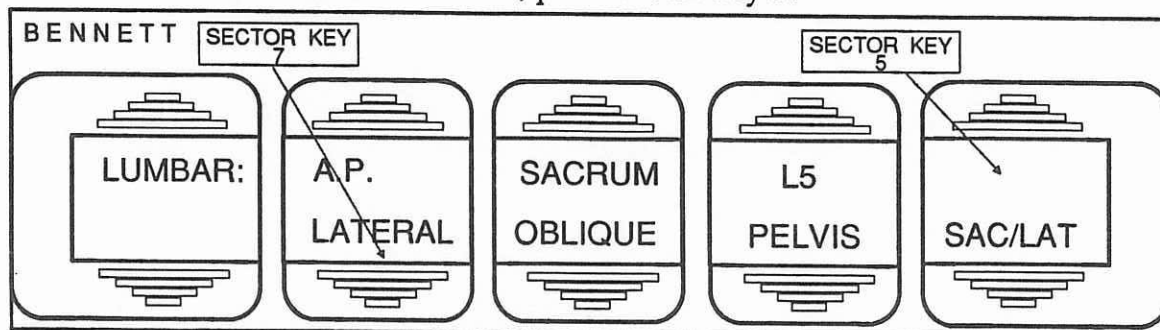


Figure 8-2. ROI Selection

4. Turn the key switch on the rear panel of the OCP once to enter program edit mode. The selected anatomical region (1) and ROI (6) will be displayed (or blank for new ROI) in the main program edit menu as shown in Figure 8-3. Sector keys function as follows:
 1. UP/DOWN arrow keys (3 and 8) allow selection of alphanumeric characters at the designated (cursor) location.
 2. RIGHT and LEFT sector keys (4 and 9) allow for movement of the location designated for edit (cursor).
 3. NEXT and PREV keys (5 and 10) allows you to advance to the next menu (or process) and return to previous menu/selection, respectively.

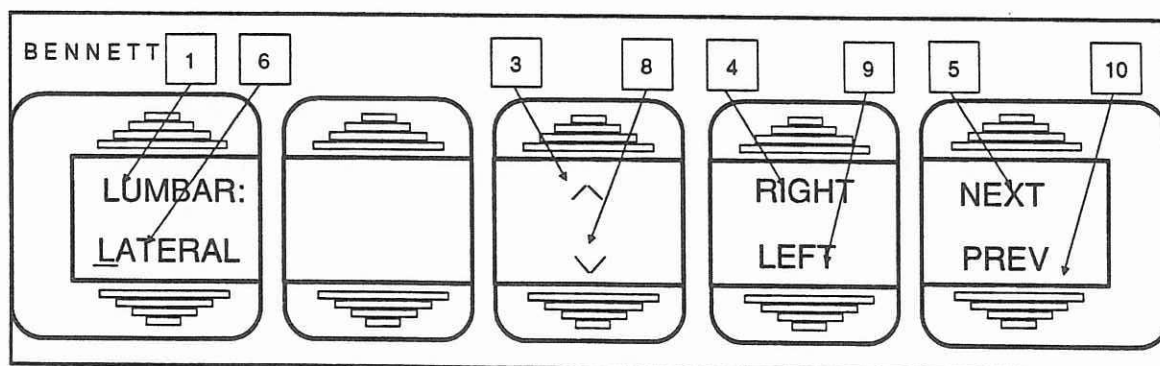


Figure 8-3. Main Program Edit Menu

AUTO-TECH PROGRAMMING PROCEDURES (Continued)

5. To edit the displayed ROI, use the RIGHT or LEFT sector keys to position the cursor, then use the up/down arrow keys to select the desired alphanumeric character. You can name an ROI containing up to seven alphanumeric characters. Blank spaces, the first selectable alphanumeric character before the letter "A", are displayed as a blank in the appropriate space. When ROI edit is complete, press NEXT to advance to the Tube, SID and mA Selection Menu.

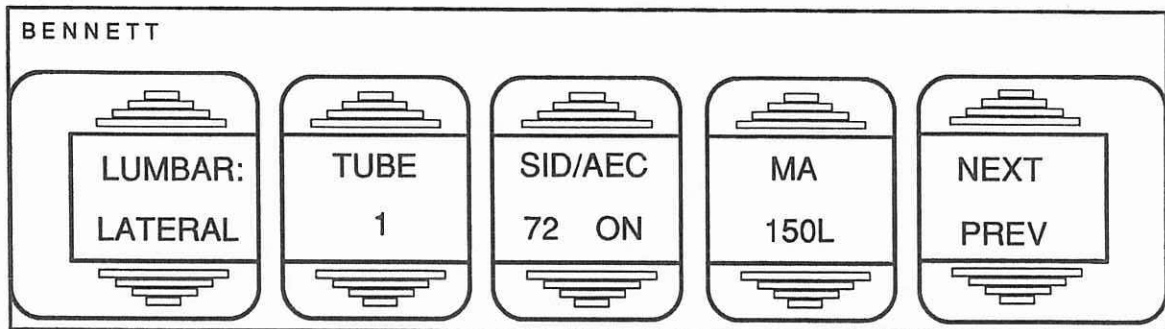


Figure 8-4. Tube, SID and mA Selection Edit Menu

6. Select the displayed TUBE (1 or 2) by pressing the appropriate up/down key on the TUBE sector.

Note: TUBE sector selection is disabled for single tube units.

7. Select the displayed SID/AEC setting by pressing the appropriate up/down key on the SID/AEC sector. You can also select an AEC-on feature (if optional AEC system is present), that will automatically enable AEC mode for the selected ROI. When ON is displayed under AEC, AEC mode will automatically be enabled for the selected ROI. Possibilities are: 40 or 72-inches with AEC OFF and 40 or 72-inches with AEC ON. Selected SID is indicated (in Auto-Tech mode) with a shaded arrow that points to the respective SID as indicated on the right side of the OCP.

AUTO-TECH PROGRAMMING PROCEDURES (Continued)

8. Select an mA station to be used by pressing the appropriate up or down MA sector key to increase or decrease mA, respectively. When TUBE, SID and MA sectors display the desired values, press NEXT to advance to the Bucky and CM Range Selection Menu (example shown in Figure 8-5).

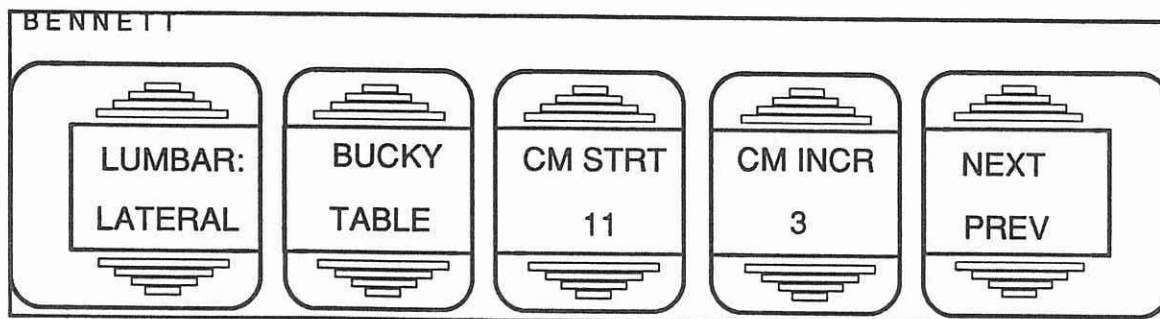


Figure 8-5. Bucky and CM Range Selection Edit Menu

9. Select BUCKY mode to be used by pressing the appropriate up/down key associated with the BUCKY sector. Possibilities are: WALL, TABLE NON-W(all) and NON-T(able).
10. Select ROI measurement parameters with the CM STRT and CM INCR sector as described below. The CM STRT sector defines that start value (lowest possible selection) for the selected ROI. Possible selections are 1 through 16. The CM INCR sector defines the value by which the CM measurement will be incremented each time the cm select key is pressed. There are ten available selections. For example, if CM STRT is 1 and CM INCR is 3 for a selected ROI, some cm selection possibilities would be 1, 4, 7, 10, etc. In general, you should establish a cm range for the selected ROI. The cm range is the total thickness range of the desired anatomical part. If the cm range is 10 or less, use 1 as a cm increment. If the range is between 11 and 20, use 2 as a cm increment. If the cm range is between 21 and 30 use 3 as a cm increment. If the range is over 30, use 4 as a cm increment.
 - a. To increase or decrease CM STRT value, press the appropriate up/down sector key until the desired value is displayed.
 - b. To increase or decrease CM INCR value, press the appropriate up/down sector key until the desired value is displayed.

AUTO-TECH PROGRAMMING PROCEDURES (Continued)

- c. When BUCKY, CM STRT and CM INCR sectors display the desired values, press NEXT to advance to the Exposure Factor Selection Edit Menu (example shown in Figure 8-6).

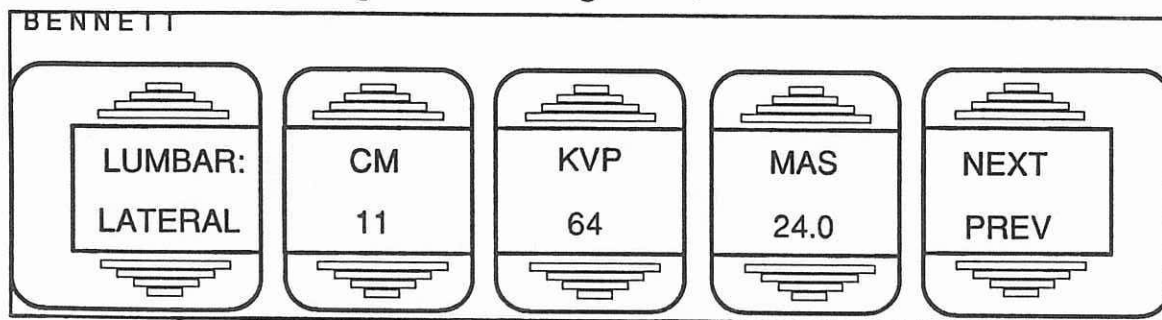


Figure 8-6. Exposure Factor Selection Edit Menu

11. You are now ready to select exposure factors for the selected ROI for each cm selection. For each ROI cm setting, select a base kVp and mAs value. These set values can be manually modified for each individual exam, at random without returning to program edit mode.
 - a. To increase or decrease displayed KVP setting, press the up/down associated sector keys, respectively.
 - b. To increase or decrease the displayed MAS setting, press the associated up/down sector keys, respectively. When the desired exposure factors for the displayed ROI cm setting are displayed, press NEXT. Repeat step 11 for each cm setting displayed.

If the optional AEC system is selected for this ROI, the AEC stop signal will terminate the x-ray. The programmed mAs settings will not be in effect (refer to Configure Operating Parameters in Section 6 for setting the AEC back-up time). The AEC may be turned off in this ROI by pressing the AEC key on the OCP.

- c. After the tenth cm setting has been set and next is pressed, the edited ROI x-ray techniques will be stored in memory. "TECHNIQUE COMPLETE" will be displayed momentarily on the fifth sector. After the technique has been stored, the program edit menu will automatically advance to the next ROI for the selected anatomy to be edited. You can continue to edit or exit program edit mode.

AUTO-TECH PROGRAMMING PROCEDURES (Continued)

12. To edit additional ROI x-ray techniques, repeat this entire process as necessary for each. To exit program edit mode and return to normal operating mode, turn the key switch once. The Utility/Maintenance Menu (Figure 8-7) will be displayed. If operations accessed from this menu are required, refer to the following section for more information or turn the key switch once again to exit utility mode and return to normal operating mode.

Note: Program edit mode can be only be exited when the main program edit menu is displayed (as shown in Figure 8-3).

UTILITY/MAINTENANCE OPERATIONS

The Utility/Maintenance Menu provides access to perform test routines, print currently stored Auto-Tech techniques, copy MASTER and EEPROM program data, and perform calibration and thickness measurement settings.

This menu (shown in Figure 8-7) is accessed as follows:

Note: If you need to connect a printer or remove/replace an Integrated Circuit (IC) chip, perform that procedure before you access the utilities menu.

ACCESSING UTILITY/MAINTENANCE MENU

From Program Edit - When the Main Program Edit Menu (Figure 8-3) is displayed, turn the key switch once.

From Normal Operating Mode - Turn the key switch twice.

Exit Utility Menu - To exit from Utility/Maintenance mode and return to normal operating mode, turn the key switch once.

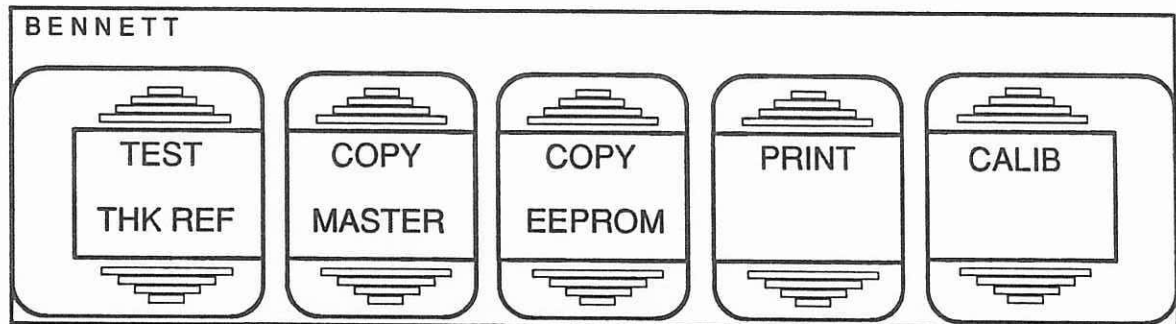


Figure 8-7. Utility/Maintenance Main Menu

RUN SYSTEM TEST PROGRAM

This facility allows you to manually select and run an automated memory, bucky or cm measurement test. For detailed information, refer to Section 9, Preventive Maintenance and Troubleshooting.

Procedure

1. To access the test facility, press the **TEST** sector key. The Test Utility Menu (Figure 8-8) will be displayed.
2. Press the sector key that corresponds with the test you want to be performed. Test status and messages will be displayed on the LCD.
3. When the test is complete, the Test Utility Menu will be re-displayed.
4. Press **DONE** sector key to exit and return to the Utility/Maintenance Menu.

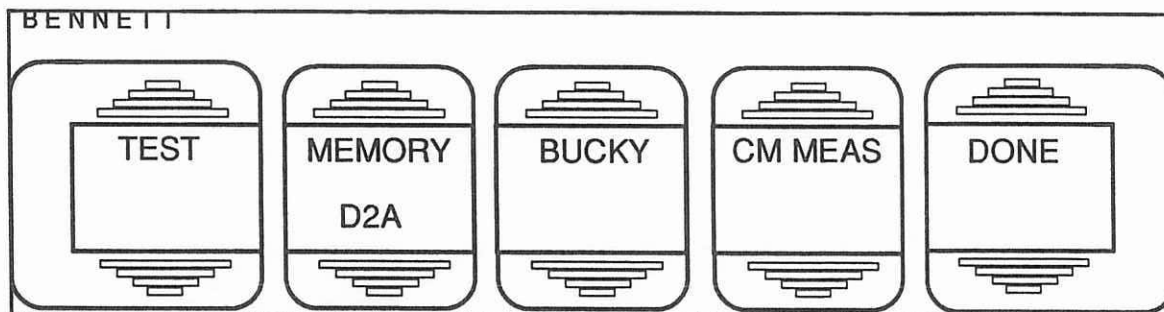


Figure 8-8. System Test Program Selection Menu

COPY MASTER

This procedure provides the information necessary to copy imaging technique data from IC's located in the MASTER socket (U26) to IC's placed in the EEPROM socket (U3) of the microprocessor board (A3). Any imaging technique data resident on the IC in the EEPROM socket will be erased and overwritten with the imaging technique data of the IC located in the MASTER socket. All other data resident on the EEPROM socket IC (including calibration data) will remain unaffected. Proceed as follows:

1. Turn power off and remove the cover panel to access the microprocessor board. Insert master EEPROM (P/N 205516-816) into MASTER socket (U26) on the microprocessor board (A3).
2. Turn power on and access the Utility/Maintenance Menu as described on page 8-6.

COPY MASTER (Continued)

3. Press the COPY MASTER sector key. The LCD panel will display:

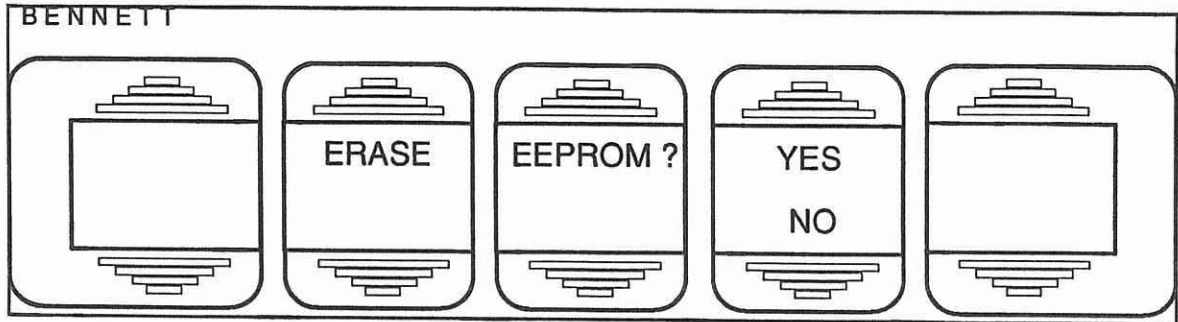


Figure 8-9. Copy MASTER Verification Menu

- a. To continue with copy procedure; press YES. Resident EEPROM imaging technique data will be erased and imaging technique data contained on the IC in the MASTER socket will be copied onto the IC in the EEPROM socket. Current copy status (address locations) will be updated / displayed in the last LCD segment.
 - b. To abort the copy procedure, press NO. Any imaging technique data existing on the IC in the EEPROM socket will remain and MASTER IC imaging technique data will not be copied.
4. When the procedure is complete, turn power off, remove IC's as necessary and re-install cover panel.

COPY EE PROM

This procedure provides the information necessary to copy data from IC's located in the EEPROM socket (U3) to IC'S placed in the MASTER socket (U26) of the microprocessor board (A3). Any data resident on the IC in the MASTER socket will be erased and overwritten with the entire data content of the IC in the EEPROM socket. Proceed as follows:

1. Turn power off and remove the cover panel to access the microprocessor board.
2. Insert an EEPROM (P/N 205516-816) into the MASTER socket (U26) on the microprocessor board (A3).
3. Turn power on and access the Utility /Maintenance Menu (as described on page 8-7).

COPY EE PROM (Continued)

4. Press the **COPY EE PROM** sector key. The LCD will display:

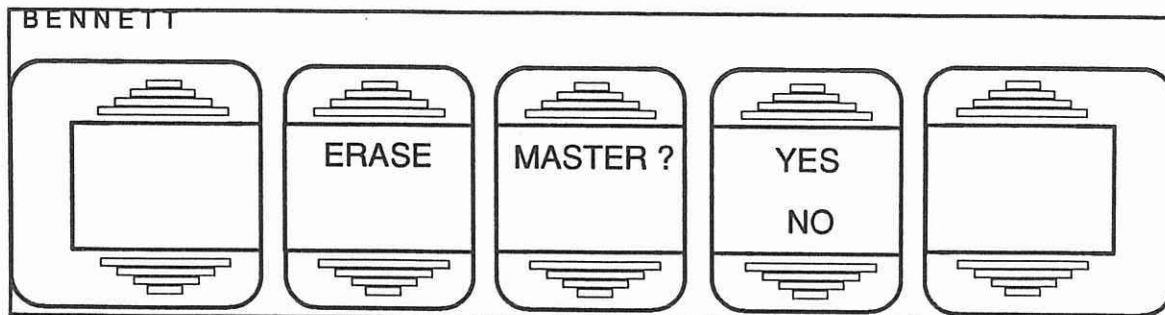


Figure 8-10. Copy EEPROM Verification Menu

- a. To continue with copy procedure, press **YES**. Resident EEPROM technique and calibration data will be copied to the **MASTER**. Current copy status (address locations) will be updated/displayed in the last LCD segment.
 - b. To abort the copy procedure, press **NO**. Any data existing on the **MASTER** will remain and EEPROM data will not be copied.
5. When the procedure is complete, turn power off, remove IC's as necessary and re-install cover panel.

PRINT

This facility allows you to print all techniques stored in Auto-Tech memory. If a printer is already connected to your system, continue with this step. If not, refer to Connecting A Printer (Section 5, Installation).

1. Press **PRINT** sector key. Printing will be displayed on the LCD while the printer provides you with a hard copy of all techniques stored in memory.
2. When printing is complete, the Utility/Maintenance Menu will be re-displayed.

CALIBRATION

This facility allows you to calibrate the SES measurement, the D.C. reference measurement, the kVp accuracy and the mA accuracy. Please refer to Section 6, Calibration for detailed procedures.

SETTING THE THICKNESS REFERENCE (THK REF)

When an Automatic Thickness Measurement (ATM) option is installed, the unit must be calibrated to a zero reference point for each of the six possible patient positions. This reference point is the distance from the tube to the film, which can vary according to the SID, table, wall or bucky selection. The six possible references are:

1. SID=72, WALL, BUCKY
2. SID=72, WALL, NON-BUCKY
3. SID=40, WALL, BUCKY
4. SID=40, WALL, NON-BUCKY
5. SID=40, TABLE, BUCKY
6. SID=40, TABLE, NON-BUCKY

Note: Grid and bucky (reciprocating or non-reciprocating) applications must be referenced identically. A "non-bucky" reference is one that does not use a grid or bucky, for example, a table top technique.

Procedure

1. To calibrate a zero reference point for each of the six positions, access one of the applicable auto-tech techniques for that reference point. For example, most systems will generally select SID 72, WALL and BUCKY for a CHEST PA/GRID auto-tech program.
2. With the appropriate reference position displayed, turn the key switch twice to display the Utility/Maintenance Menu.

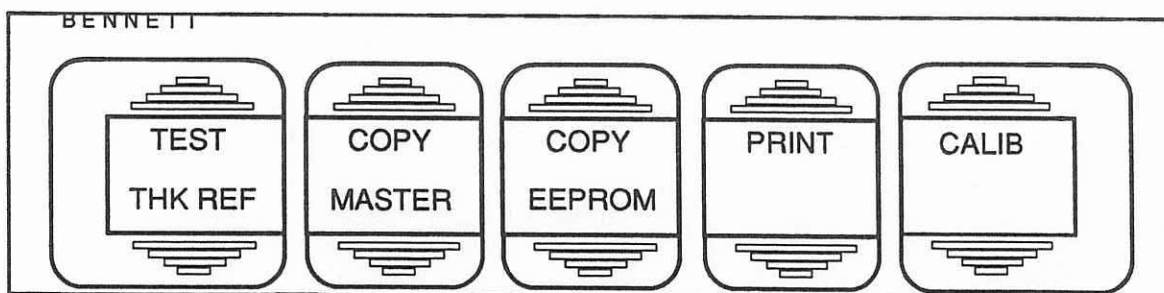


Figure 8-11. Utility/Maintenance Menu

3. Ensure that the tube is at the correct position and the field is clear of all objects, then press the THK REF sector key. Turn the key switch once to return to normal operating mode.
4. Re-select the auto-tech technique that was just calibrated and verify that the CM measurement displays "0".
5. Repeat this procedure for each of the positions used at your facility.

***SECTION 9,
PREVENTIVE MAINTENANCE
AND TROUBLESHOOTING***

**SECTION 9,
PREVENTIVE
MAINTENANCE AND
TROUBLESHOOTING**

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

INTRODUCTION

This section contains preventive maintenance schedules and calibration/maintenance checklists as well as system troubleshooting details and fault isolation diagrams.

PREVENTIVE MAINTENANCE

To keep the *BENNETT* HFQ Series System operating properly, it must be inspected and checked in accordance with the maintenance procedure at regular intervals depending on the age and use of the equipment. When there is a problem, call a Bennett recognized service technician. Do not operate equipment until all repairs are completed.

PREVENTIVE MAINTENANCE INTERVALS

Periodic preventive maintenance including cleaning, electrical and mechanical adjustments are to be performed every twelve months. The periodic maintenance is required to maintain the system in proper and accurate working conditions.

CALIBRATION CHECKLIST

Refer to Table 9-1, Calibration Checklist and verify that all calibrations are within specified tolerances to demonstrate compliance. If necessary, calibrate according to the procedures in Section 6, Calibration.

MAINTENANCE CHECKLIST

Refer to Table 9-2, Maintenance Checklist and verify that all maintenance steps are performed if needed.

WARNING: For continued protection against risk of fire, replace only with same type and rating of fuse.

BUILT- IN DIAGNOSTIC UTILITY

The *BENNETT* HFQ Series system has a built-in selectable self diagnostic TEST utility to help locate problems rapidly and reduce down time.

Test utility routines can be performed (if necessary) to help isolate potential faults. A facility is provided to selectively run these tests in the Utility/Maintenance Menu, as described on page 9-4.

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

Table 9-1. HFQ Series Calibration Checklist

SERIAL NUMBER:	_____
REFERENCE VOLTAGE:	_____
S.E.S. VOLTAGE/ D.C. REFERENCE LEVEL:	_____
SOURCE CHARGER VOLTAGE (SE ONLY):	_____
REGULATED POWER SUPPLY +30 VDC:	_____
REGULATED POWER SUPPLY +/-15 VDC:	_____
KVP ALIGNMENT:	_____
SET-UP:	_____
KVP CALIBRATION:	_____
MA CALIBRATION:	_____
MAXIMUM DEVIATION: KVP, TIME, MA, MAS:	_____

LINEARITY:	_____
REPRODUCIBILITY:	_____
FOR SYSTEMS WITH THE AEC OPTION:	
_____ AEC CALIBRATION:	_____
_____ AEC LINEARITY:	_____
_____ AEC REPRODUCIBILITY:	_____
CALIBRATED BY:	_____ DATE: _____

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

HFQ-300 SERIES

MAXIMUM DEVIATION: KVP, TIME, MA, MAS

HFQ-300 SERIAL NUMBER: _____

TUBE SERIAL NUMBER: _____

LIMITS

mA: +/- 10% or 5 mA

kVp : +/- 5%

Time: +/- 1% or 3 Milliseconds

Record mA (TIME = 100 Milliseconds):

	25S	75S	100L	150L
50 KVP				
70 KVP				
90 KVP				
110 KVP				

Record kVp (TIME = 100 Milliseconds):

	25S	75S	100L	150L
50 KVP				
70 KVP				
90 KVP				
110 KVP				

TEST UNIT AT FOLLOWING SETTINGS

	kVp	mA	Time
1 Setting	40	50S	500 ms
Reading	_____	_____	_____
2 Setting	60	75L	10 msec.
Reading	_____	_____	_____
3 Setting	80	150L	50 ms
Reading	_____	_____	_____
4 Setting	100	100L	3 sec.
Reading	_____	_____	_____
5 Setting	120	125L	100 msec.
Reading	_____	_____	_____

SETTINGS FOR LINEARITY

	NON - AEC		AEC	
	TEST 1	TEST 2	TEST 1	TEST 2
KVP	80	80	50	50
MA	150	125	75	100
MAS	15	12.5	-----	-----

SETTINGS FOR REPRODUCIBILITY

	NON-AEC	AEC
KVP	100	55
MA	150	50S
TIME	10 msec	-----

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

HFQ-450 SERIES

MAXIMUM DEVIATION: KVP, TIME, MA, MAS

HFQ-450 SERIAL NUMBER: _____

TUBE SERIAL NUMBER: _____

LIMITS

mA: +/- 10% or 5 mA

kVp : +/- 5%

Time: +/- 1% or 3 Milliseconds

Record mA (TIME = 100 Milliseconds):

	75S	100L	150L	225L
50 KVP				
70 KVP				
90 KVP				
110 KVP				

Record kVp (TIME = 100 Milliseconds):

	75S	100L	150L	225L
50 KVP				
70 KVP				
90 KVP				
110 KVP				

TEST UNIT AT FOLLOWING SETTINGS

	kVp	mA	Time
1 Setting	40	50S	500 ms
Reading	_____	_____	_____
2 Setting	60	200L	10 msec.
Reading	_____	_____	_____
3 Setting	80	225L	50 ms
Reading	_____	_____	_____
4 Setting	100	25S	3 sec.
Reading	_____	_____	_____
5 Setting	120	200L	100 msec.
Reading	_____	_____	_____

SETTINGS FOR LINEARITY

	NON - AEC		AEC	
	TEST 1	TEST 2	TEST 1	TEST2
KVP	80	80	50	50
MA	150	200	75S	50S
MAS	15	20	-----	-----

SETTINGS FOR REPRODUCIBILITY

	NON-AEC	AEC
KVP	100	55
MA	100	100
TIME	10 msec	-----

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

HFQ-600 SERIES

MAXIMUM DEVIATION: KVP, TIME, MA, MAS

HFQ-600 SERIAL NUMBER: _____

TUBE SERIAL NUMBER: _____

LIMITS

mA: +/- 10% or 5 mA

kVp : +/- 5%

Time: +/- 1% or 3 Milliseconds

Record mA (TIME = 100 Milliseconds):

	75S	100L	200L	300L
50 KVP				
70 KVP				
90 KVP				
110 KVP				

Record kVp (TIME = 100 Milliseconds):

	75S	100L	200L	300L
50 KVP				
70 KVP				
90 KVP				
110 KVP				

TEST UNIT AT FOLLOWING SETTINGS

	kVp	mA	Time
1 Setting	40	25S	500 ms
Reading	_____	_____	_____
2 Setting	60	250L	10 msec.
Reading	_____	_____	_____
3 Setting	80	300L	50 ms
Reading	_____	_____	_____
4 Setting	100	100L	3 sec.
Reading	_____	_____	_____
5 Setting	120	150L	100 msec.
Reading	_____	_____	_____

SETTINGS FOR LINEARITY

	NON - AEC		AEC	
	TEST 1	TEST 2	TEST 1	TEST2
KVP	80	80	50	50
MA	300	250	150	200
MAS	30	25	-----	-----

SETTINGS FOR REPRODUCIBILITY

	NON-AEC	AEC
KVP	100	55
MA	300	75S
TIME	10 msec	-----

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

LINEARITY TEST AVERAGE EXPOSURE RATIO

HFQ SERIES SERIAL NUMBER: _____

TUBE SERIAL NUMBER: _____

$$\frac{X1 - X2}{X1 + X2} \leq 0.1$$

TEST 1

NOMINAL SETTINGS

KVP = 80

MA = _____

TIME = 100 milliseconds

MAS = _____

EXP. MR

A1 _____

A2 _____

A3 _____

A4 _____

A5 _____

A6 _____

A7 _____

A8 _____

A9 _____

A10 _____

SUM _____

AVG. _____

$$X1 = \frac{\text{AVG}}{\text{MAS}} = \frac{\text{_____}}{\text{_____}}$$

$$\text{C.O.V.} = \frac{X1 - X2}{X1 + X2} = \frac{\text{_____}}{\text{_____}}$$

TEST 3

REPRODUCIBILITY

Set exposure factors to: 100 kVp, _____ mA and 10 milliseconds.

C.O.V. _____ \leq 0.05

CALIBRATED BY: _____

DATE: _____

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

AEC LINEARITY TEST AVERAGE EXPOSURE RATIO

HFQ SERIES SERIAL NUMBER: _____

TUBE SERIAL NUMBER: _____

$$\frac{X1 - X2}{X1 + X2} \leq 0.1$$

TEST 1

NOMINAL SETTINGS

KVP = 50

MA = _____

DENSITY = N (normal)

WATER (inches) 5 in field

EXP. MR

A1 _____

A2 _____

A3 _____

A4 _____

A5 _____

A6 _____

A7 _____

A8 _____

A9 _____

A10 _____

SUM _____

AVG. _____

X1 = AVG

$\frac{X1 - X2}{X1 + X2} =$ _____

X1 + X2

TEST 3

AEC REPRODUCIBILITY

Set exposure factors to: 55 kVp, _____ mA, +5 DENSITY with 5-inches of water in the field.

C.O.V. _____ \leq 0.05

CALIBRATED BY: _____

DATE: _____

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

Table 9-2. HFQ Series Maintenance Check List

SERIAL NUMBER: _____

OPERATOR CONTROL PANEL (OCP) BUTTONS FUNCTIONING ? _____

OPERATOR CONTROL PANEL (OCP) LCD SEGMENTS FUNCTIONING ? _____

OPERATOR CONTROL PANEL (OCP) LED'S FUNCTIONING ? _____

ARE SAFETY INTERLOCKS IN PLACE AND FUNCTIONING ? _____

REMOVE CABINET COVERS, CHECK MOUNTING HARDWARE, SUPPORT BRACKETS, WIRING AND CONNECTORS. REPAIR/REPLACE OR SECURE AS NECESSARY. _____

ALL CABINET COVERS IN PLACE AND SECURE ? _____

VISUALLY INSPECT ALL EXTERNAL CABLES AND WIRING FOR WEAR.

VERIFY CALIBRATION CHECK LIST. ALL ITEMS COMPLETE ? _____

PERFORM DIAGNOSTIC TEST UTILITY ROUTINES. RECORD ERRORS: _____

INSPECT RECENT FILMS FOR IMAGE QUALITY/ARTIFACTS. RECORD QUALITY, ARTIFACTS _____

OPERATOR COMMENTS: _____

CHECKED BY: _____ DATE _____

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

Using The Built-In Diagnostic Utility

To access diagnostic test mode, proceed as follows:

1. Access the Utility/Maintenance menu (shown below) by turning the key switch on the OCP two times.

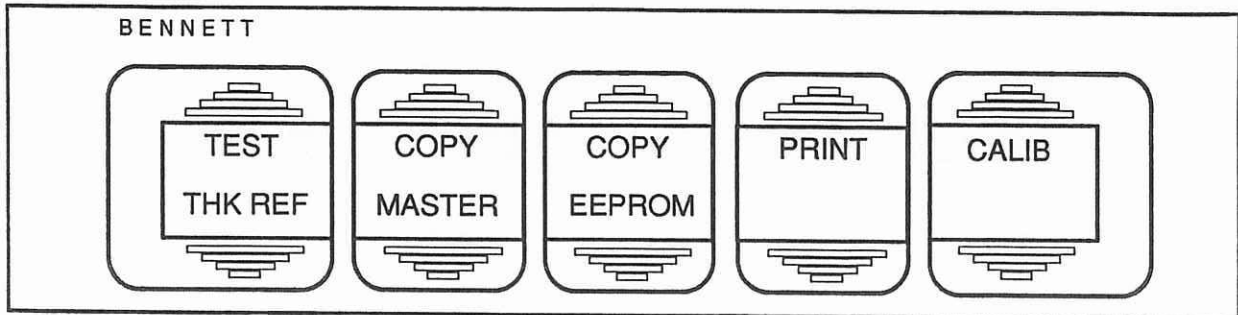


Figure 9-1. Utility Maintenance Menu

2. Press **TEST**. The following menu will be displayed.

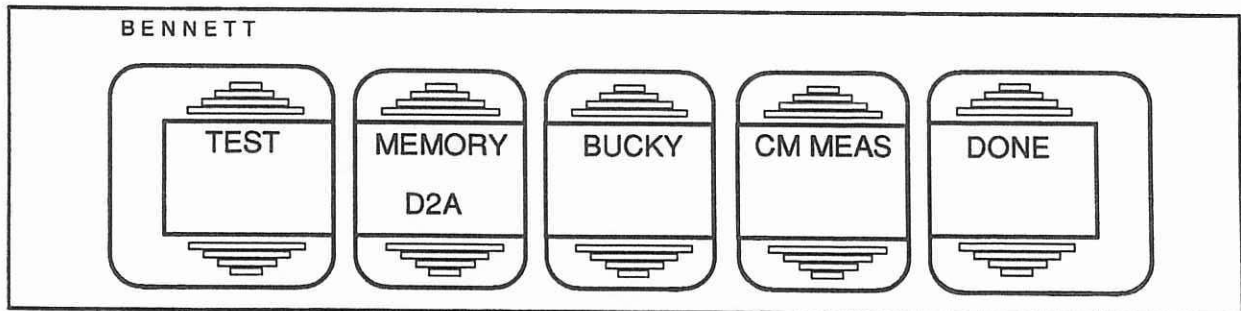


Figure 9-2. System Test Program Selection Menu

3. To access any of the test utilities, press the LCD sector key that corresponds with the desired test.
4. To exit test mode without selecting a function, press **DONE** and turn the key switch on the OCP one time. The system will return to normal operating mode.

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

Test Utility Routine Description

Memory Diagnostic. If you choose to test the memory, it will immediately start to test the ROM (read only memory) Then the EE Prom (electrically erasable programmable read only memory) and the RAM (random access memory). These tests will continue until the power is turned off. The number of times each is tested will appear on the display. For each failure that occurs the number in the fourth sector will be incremented. See examples below. To exit memory diagnostic test routines and return to normal operating mode, set the power switch to OFF, then back to ON position.

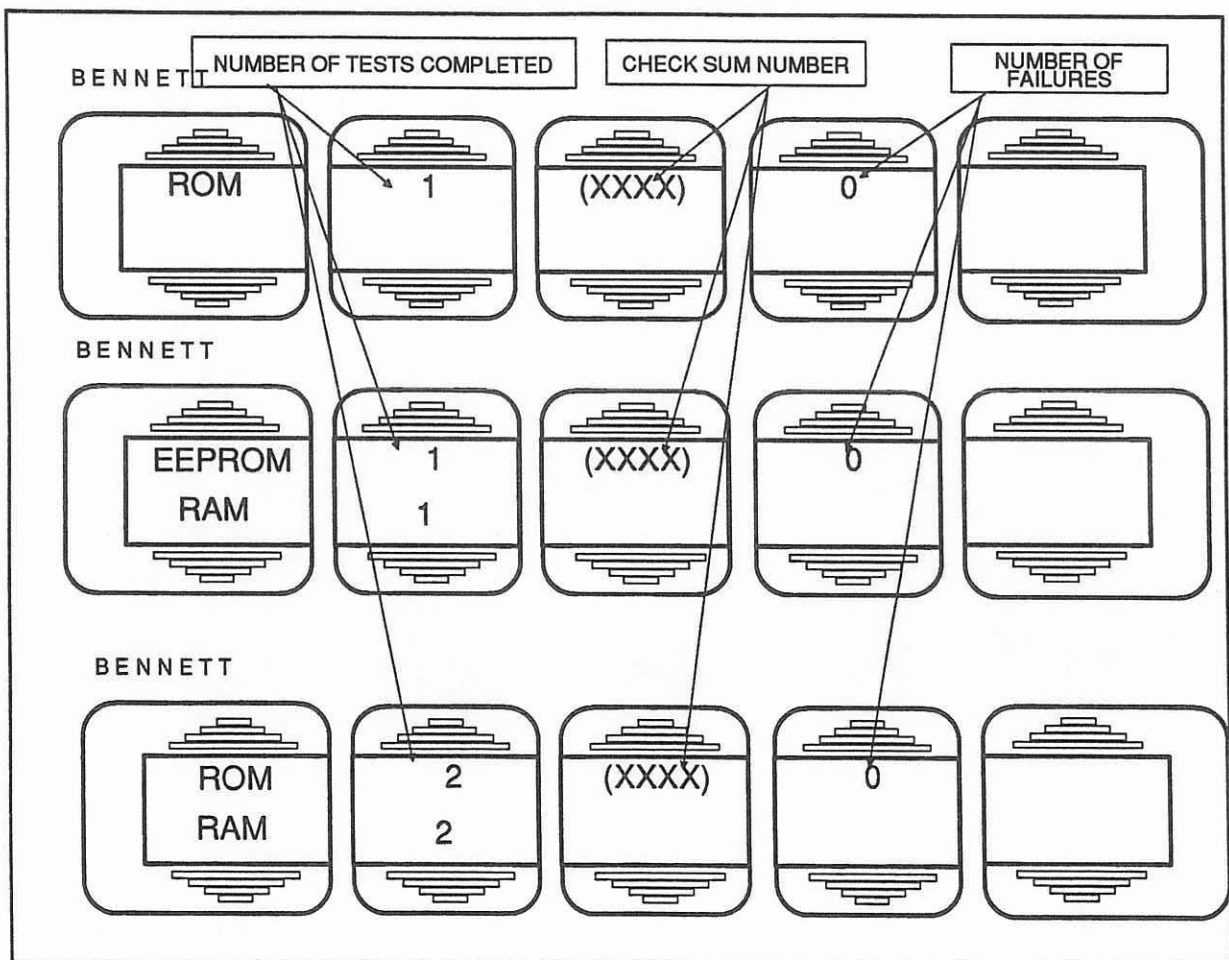


Figure 9-3. Example Displays For Memory Diagnostics

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

Bucky Diagnostic. Counts response time of the bucky and displays an OK or ERROR message (as shown below). If an error is detected, the OCP will emit two audible tones. Upon completion of the test, the test menu will be re-displayed.

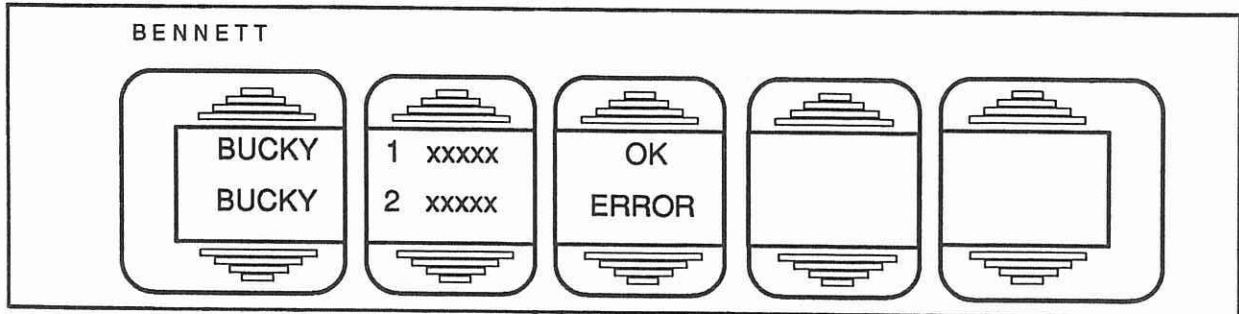


Figure 9-4. Bucky Diagnostic Test Display

Automatic Thickness Measuring (ATM) Device Test. The sonar ATM system (optional) can be tested with the CM MEAS test. If the message "OK" appears on the display (example shown below) next to CM MEAS (1), the system is operating correctly. The fifth sector will continue to increment indicating the number of tests completed until the system is turned off. CM MEAS (2) will indicate "NONE" meaning that there is no second measuring device.

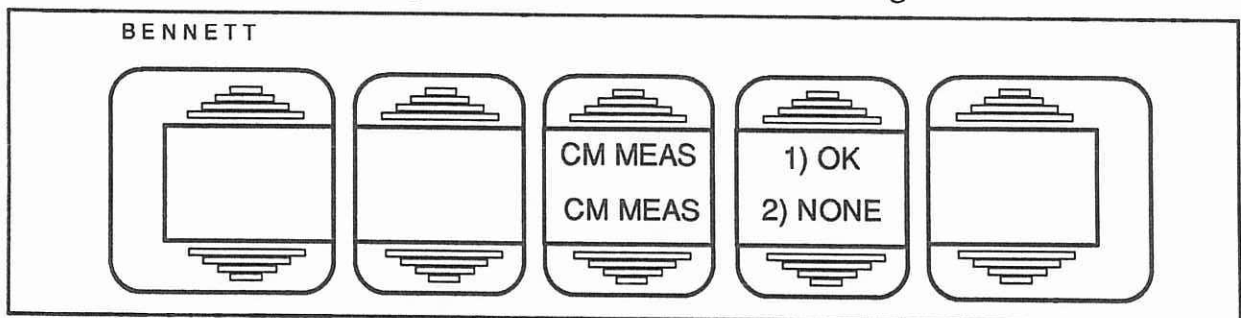


Figure 9-5. ATM Diagnostic Test Display

D2A Self Test. This facility generates a stepped voltage ramp to test Digital to Analog circuits.

1. If system is equipped with AEC, un-plug A10-J1 connector.
2. From the test program selection menu, press **D2A** . The LCD will display:

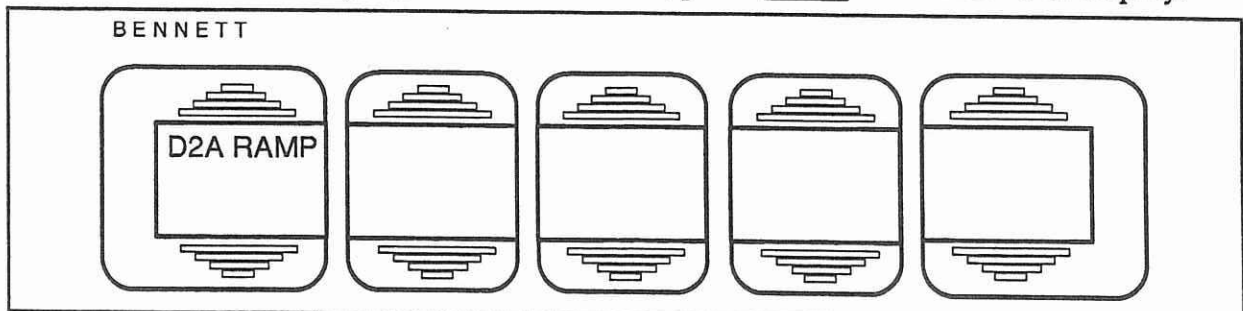


Figure 9-6. D2A Test Function Display

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

D2A Self Test (Continued)

3. Connect a scope to A4-TP3 to verify that a 0 to 10.2 volt positive going ramp exists (with no missing steps). The ramp should have a 0.5 second duration and repetition.
4. Repeat step 3 with the scope connected to A8-TP3.
5. Connect the scope probe to A5-U3-Pin 14. A negative going ramp (from 0 to -5.0 +/- 0.3 volts) should be observed with no missing steps. Duration and repetition rates should be 0.5 seconds.
6. Exit and return to normal operating mode by setting the power switch to OFF, then back to ON.

TROUBLESHOOTING

The HFQ series X-ray generators are equipped with built-in automatic test facilities that check for errors each time the system is powered-on. In the event that an error is detected, a message will be displayed on the OCP. Severe errors will lock out the system and an authorized *BENNETT* dealer should be called to ensure that the unit is operating within specification. (Refer to figure 9-7 for the printed circuit board location.)

ERROR MESSAGES

The OCP may display an error message that can indicate a hardware error or user error. If you need help decoding a message, refer to Section 4, Problem Determination Procedures.

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

PCB LOCATION

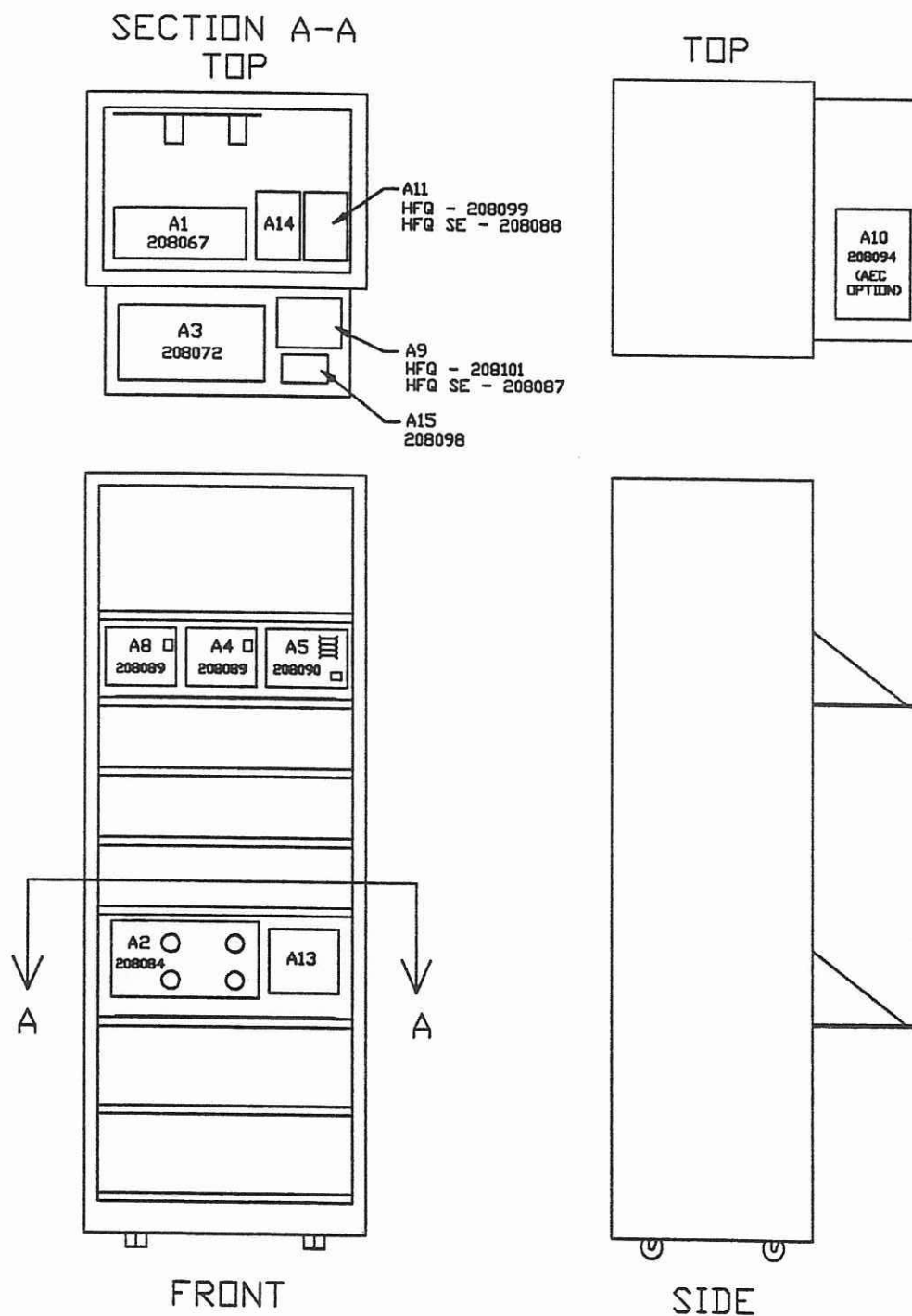
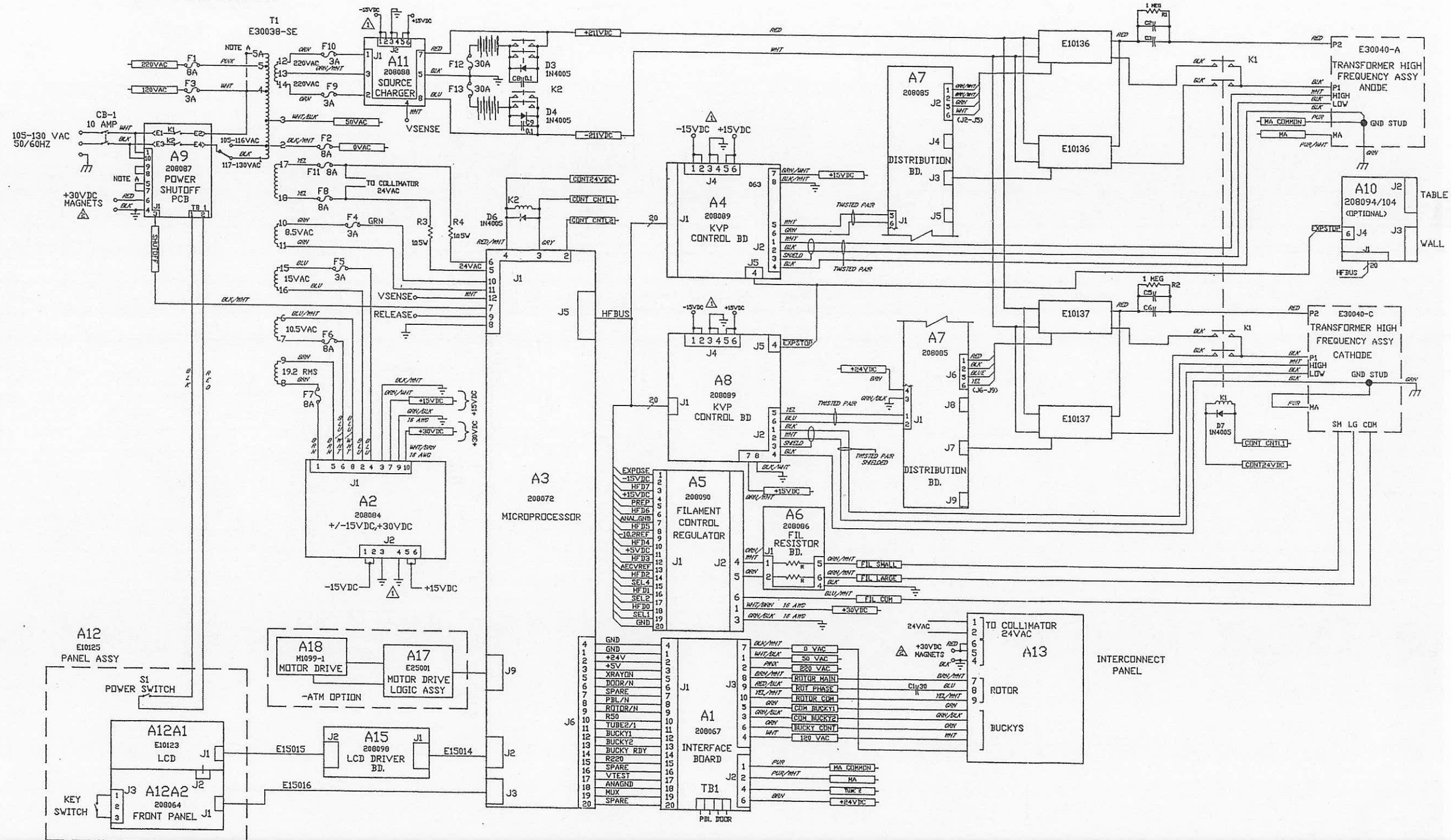


Figure 9-7. PCB Location

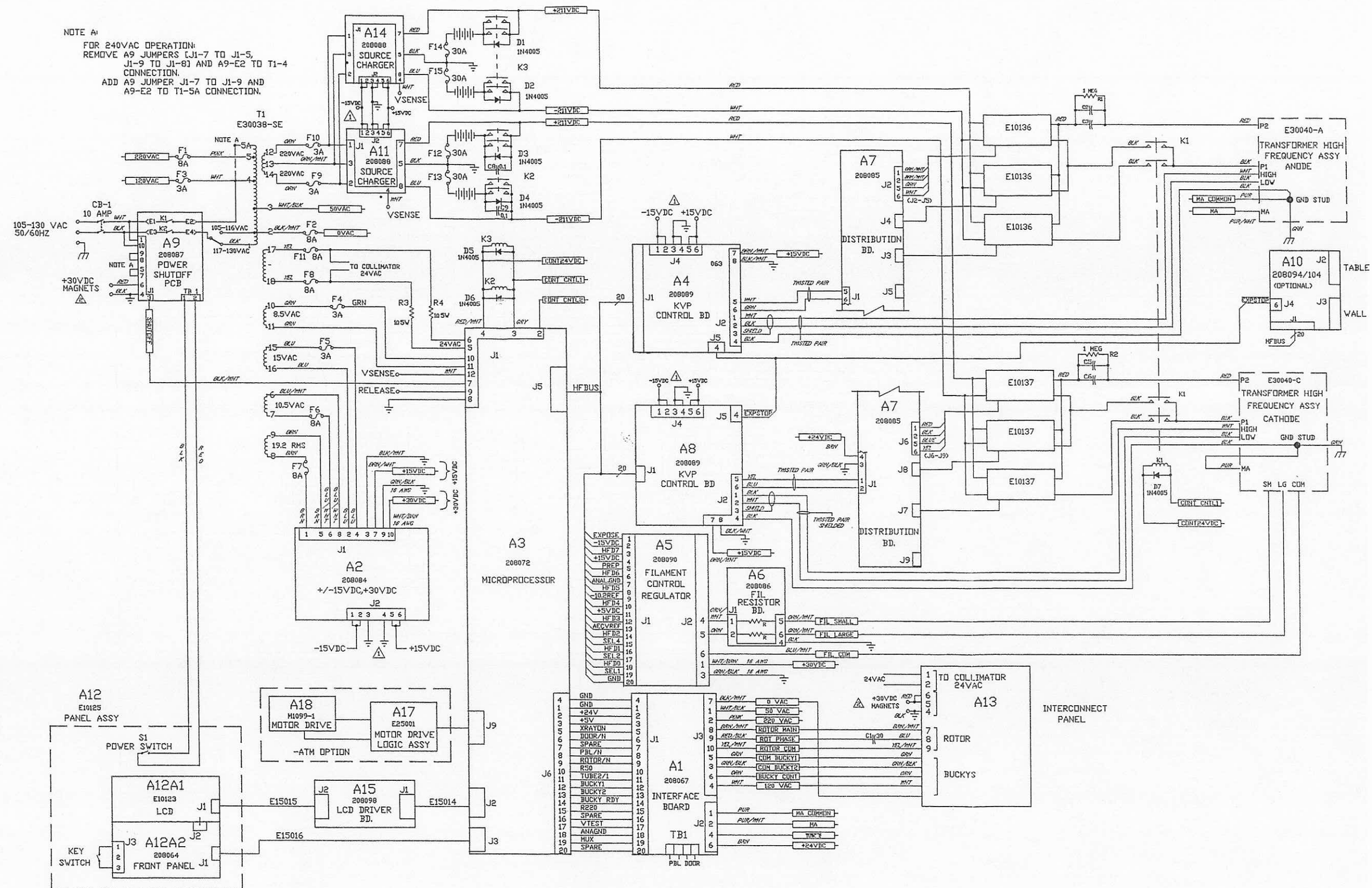
***SECTION 10,
SCHEMATICS***

***SECTION 10,
SCHEMATICS***

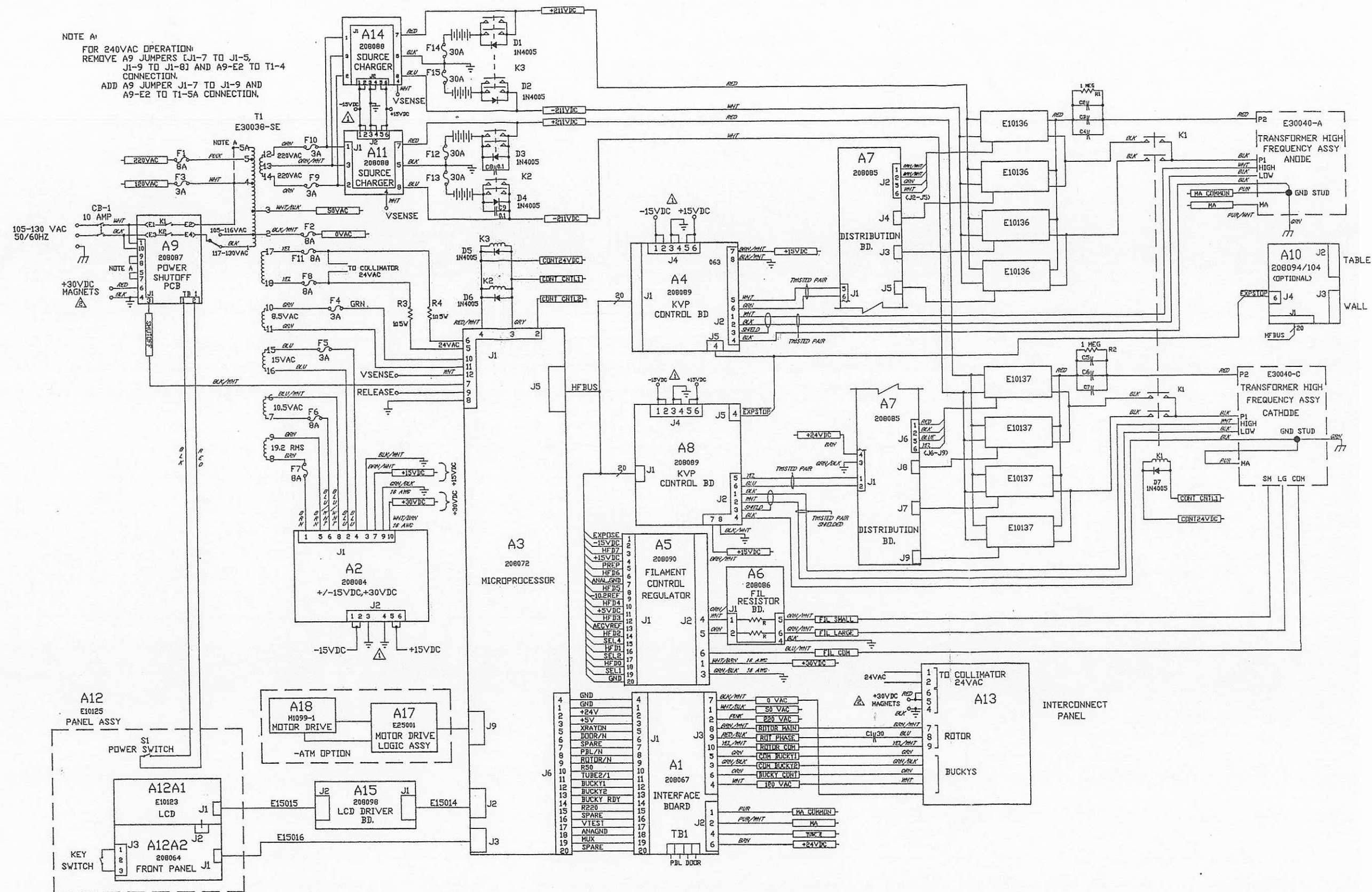
NOTE A:
FOR 240VAC OPERATION:
REMOVE A9 JUMPERS (J1-7 TO J1-5,
J1-9 TO J1-8) AND A9-E2 TO T1-4
CONNECTION.
ADD A9 JUMPER J1-7 TO J1-9 AND
A9-E2 TO T1-5A CONNECTION.



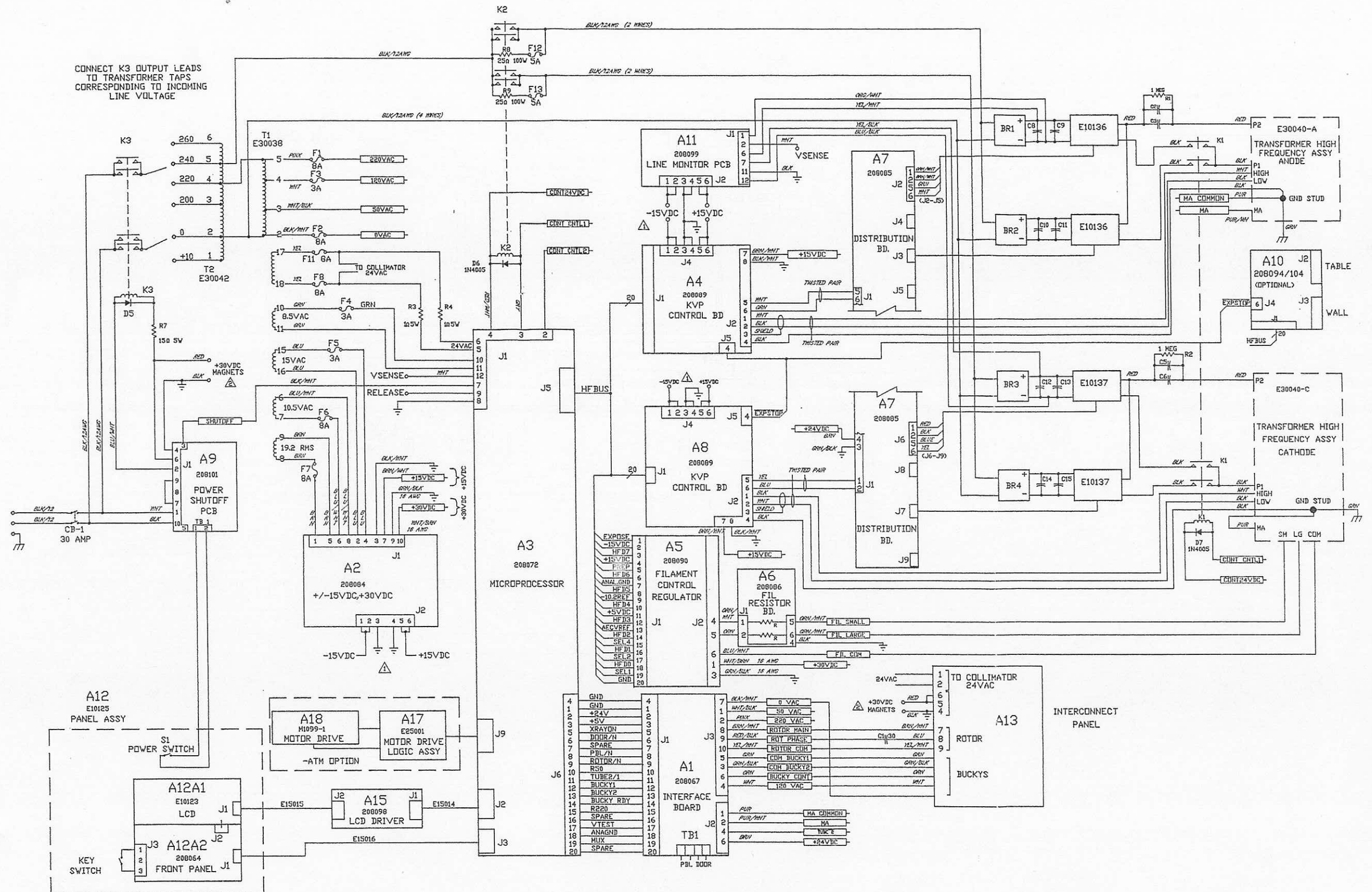
HFQ 300-SE INTERCONNECTION DIAGRAM

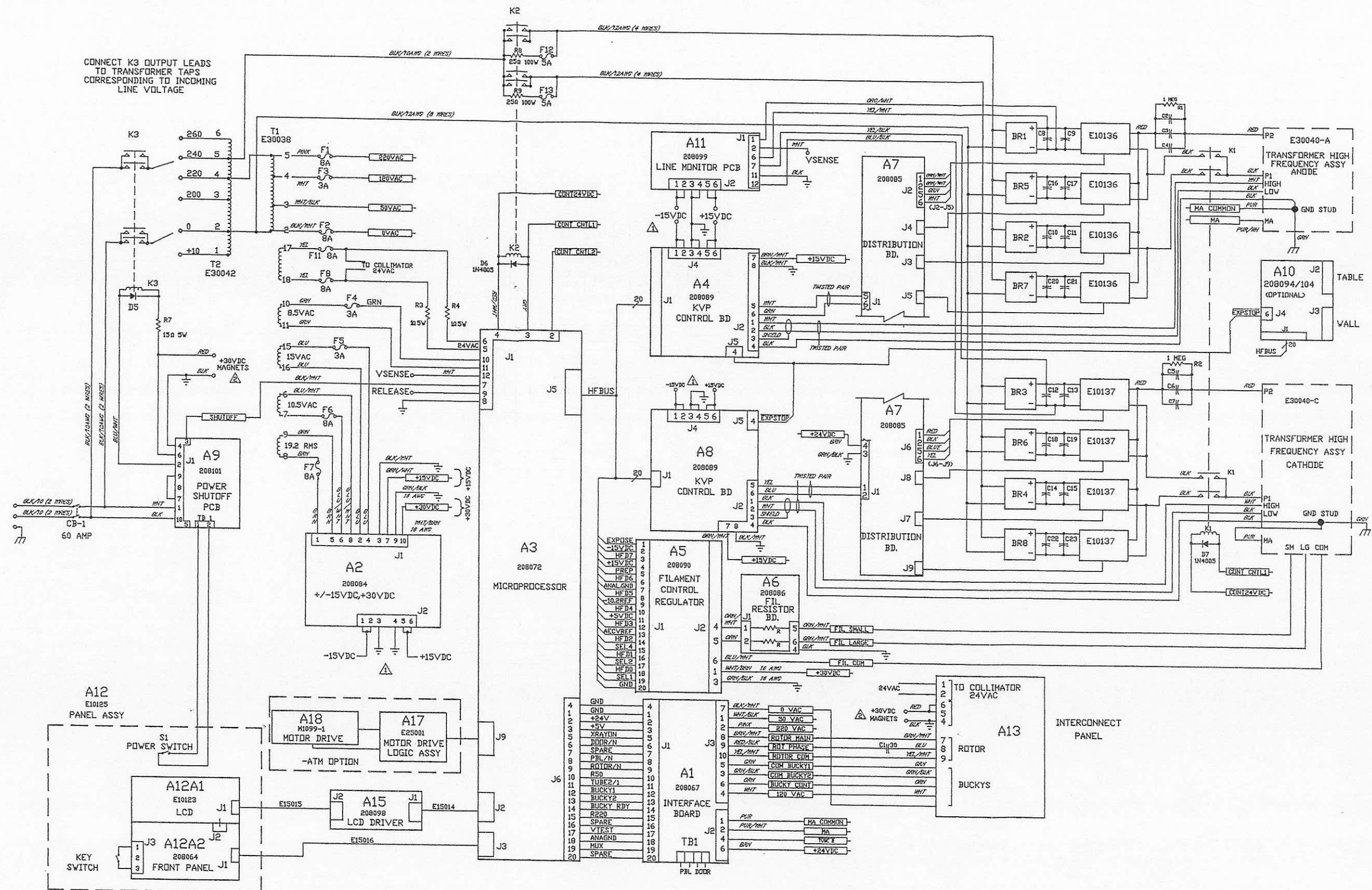


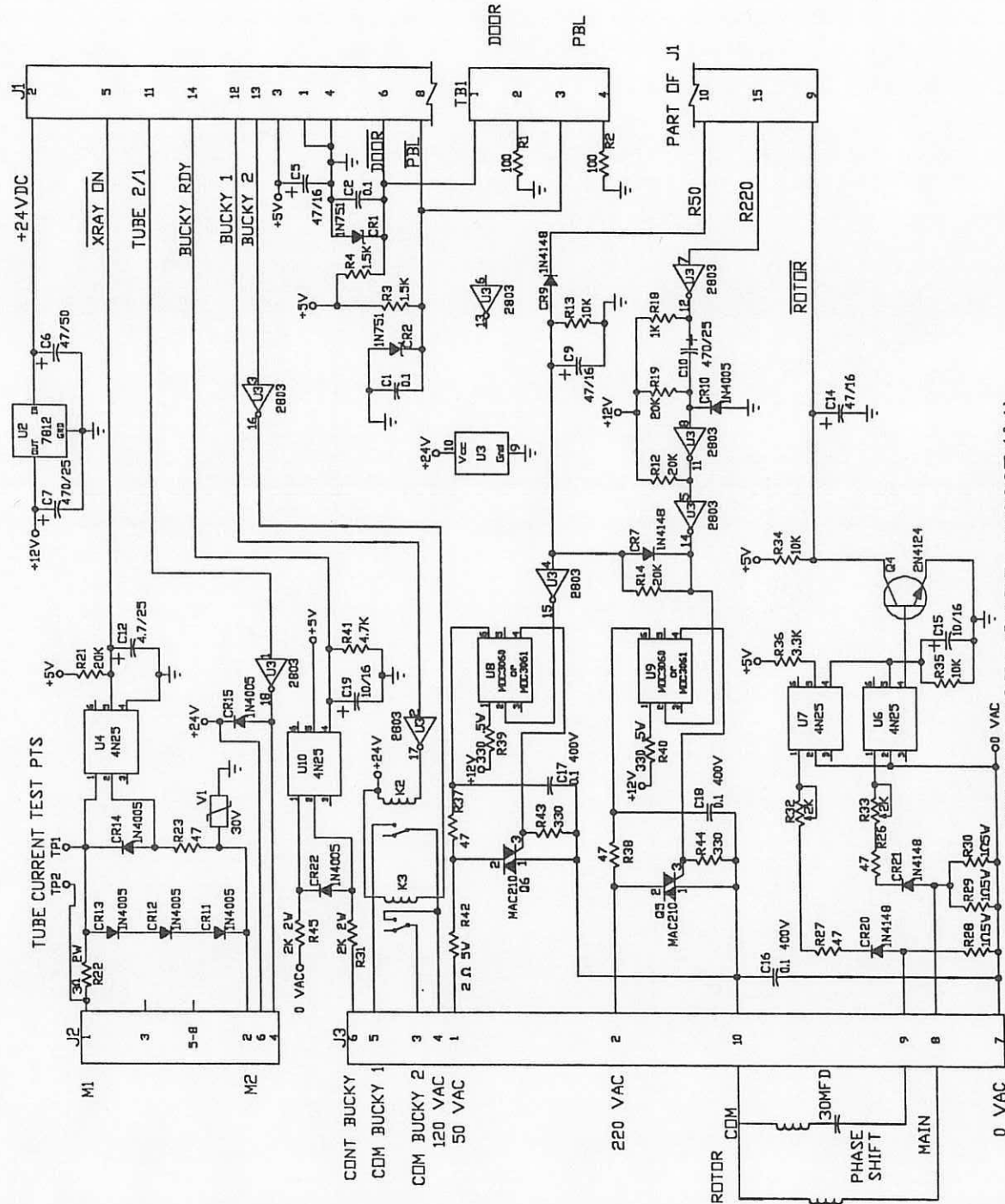
HFQ 450-SE INTERCONNECTION DIAGRAM



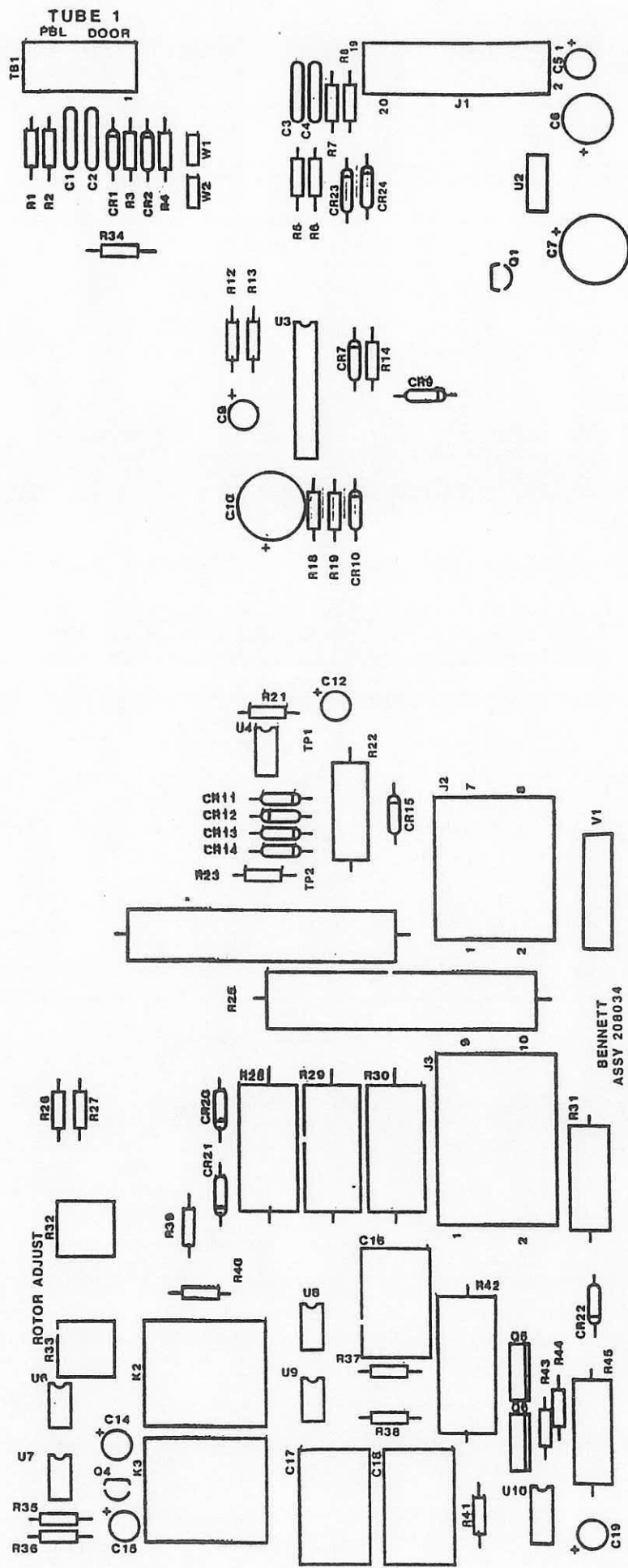
HFQ 600-SE INTERCONNECTION DIAGRAM



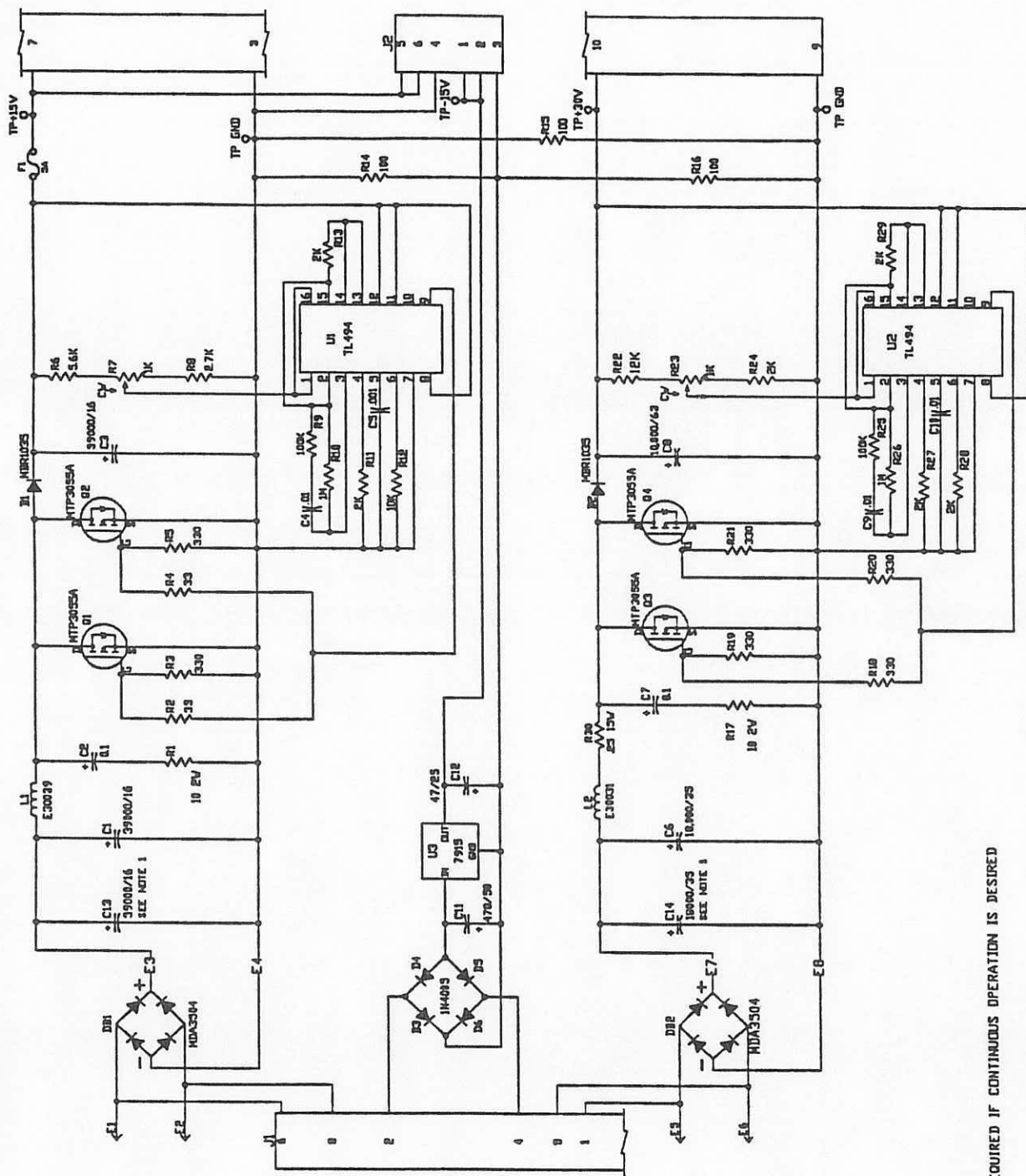




INTERFACE BOARD, 208067 (A1)



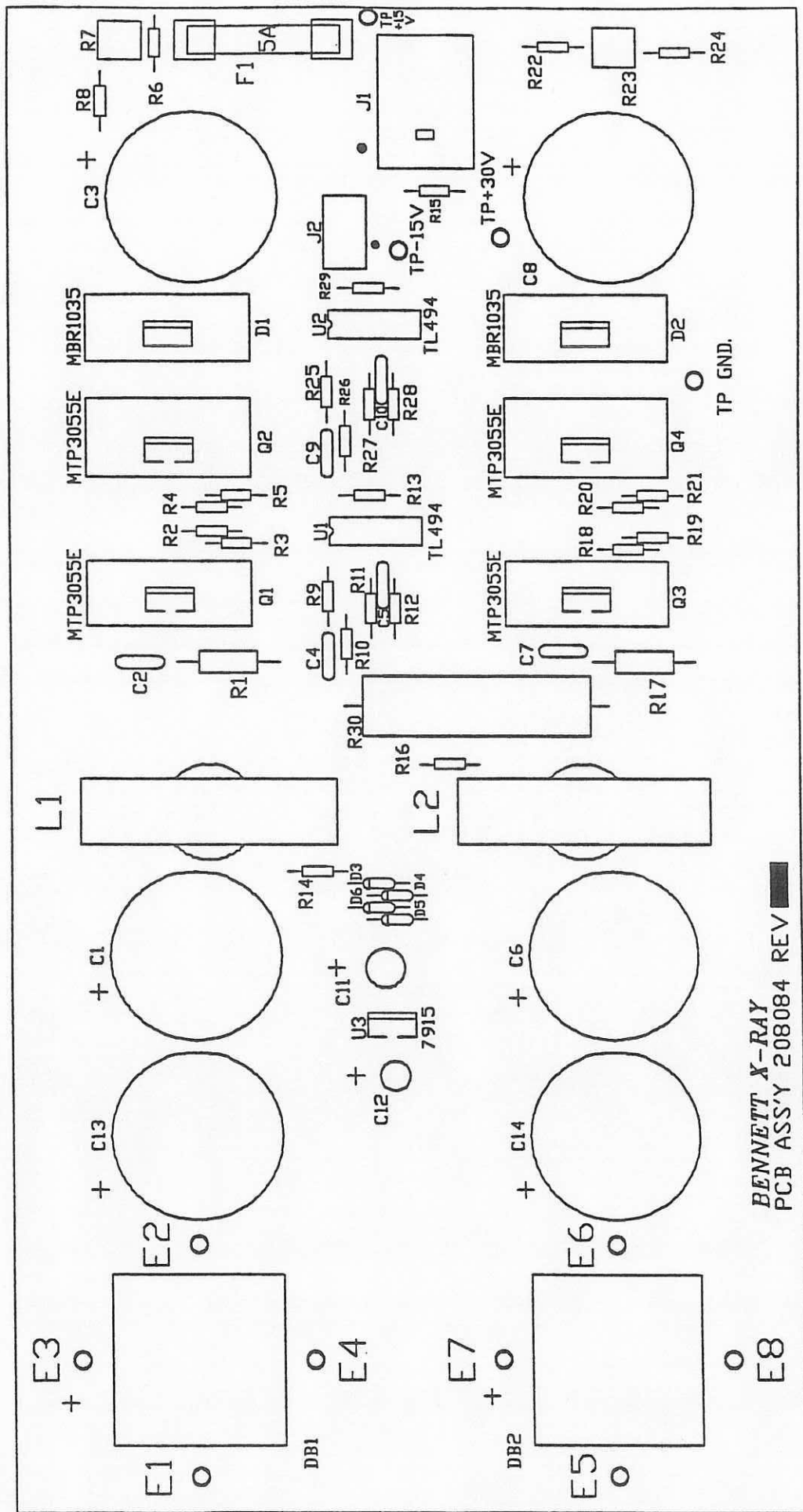
INTERFACE BOARD (A1) LAYOUT



REGULATED POWER SUPPLY, 208084 (A2)

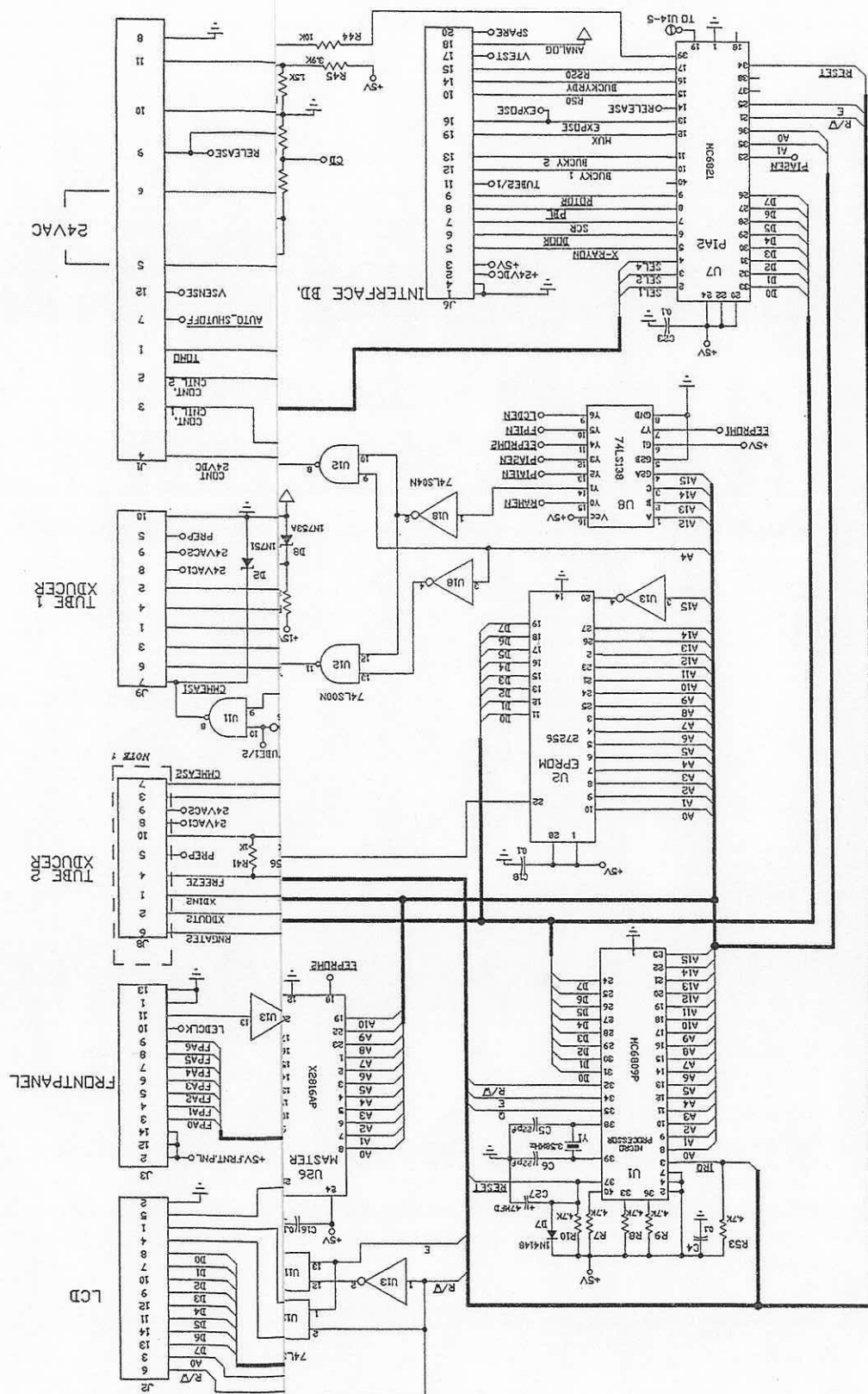
NOTES

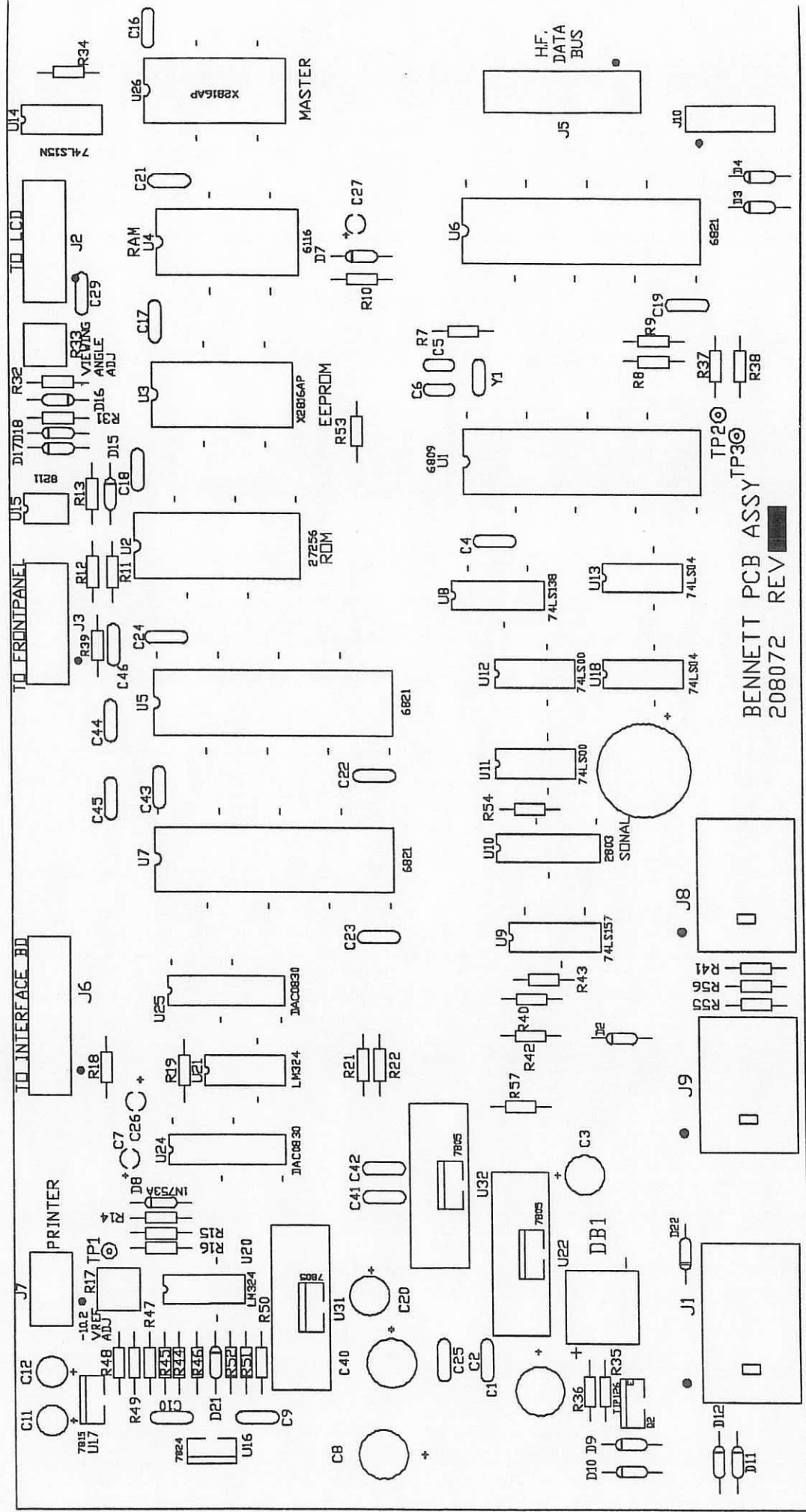
1) THIS CAPACITOR IS REQUIRED IF CONTINUOUS OPERATION IS DESIRED



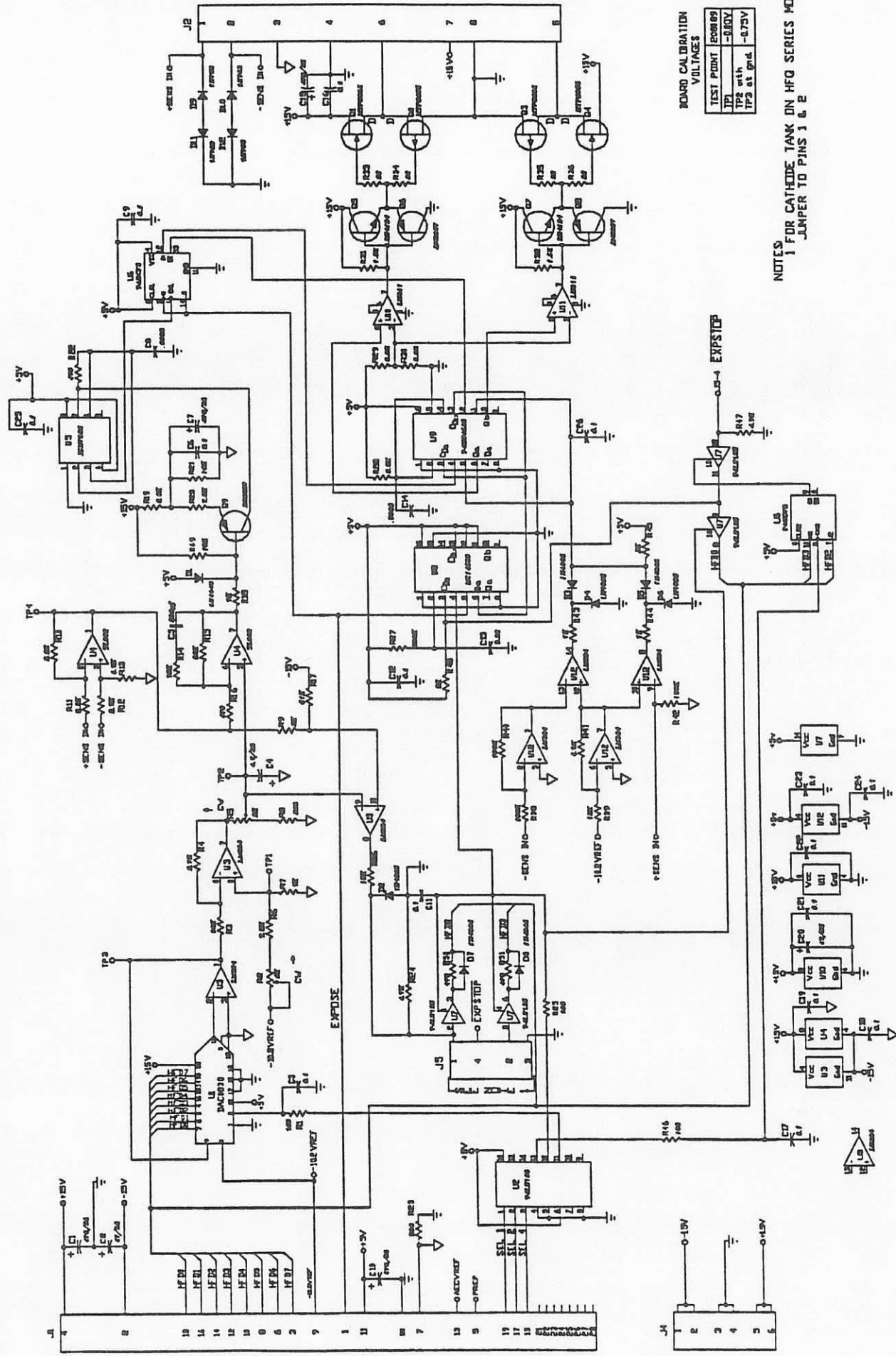
REGULATED POWER SUPPLY BOARD (A2) LAYOUT

NOTE: 1. INSTALL FOR 2 TUBE VERSION (208072-2)



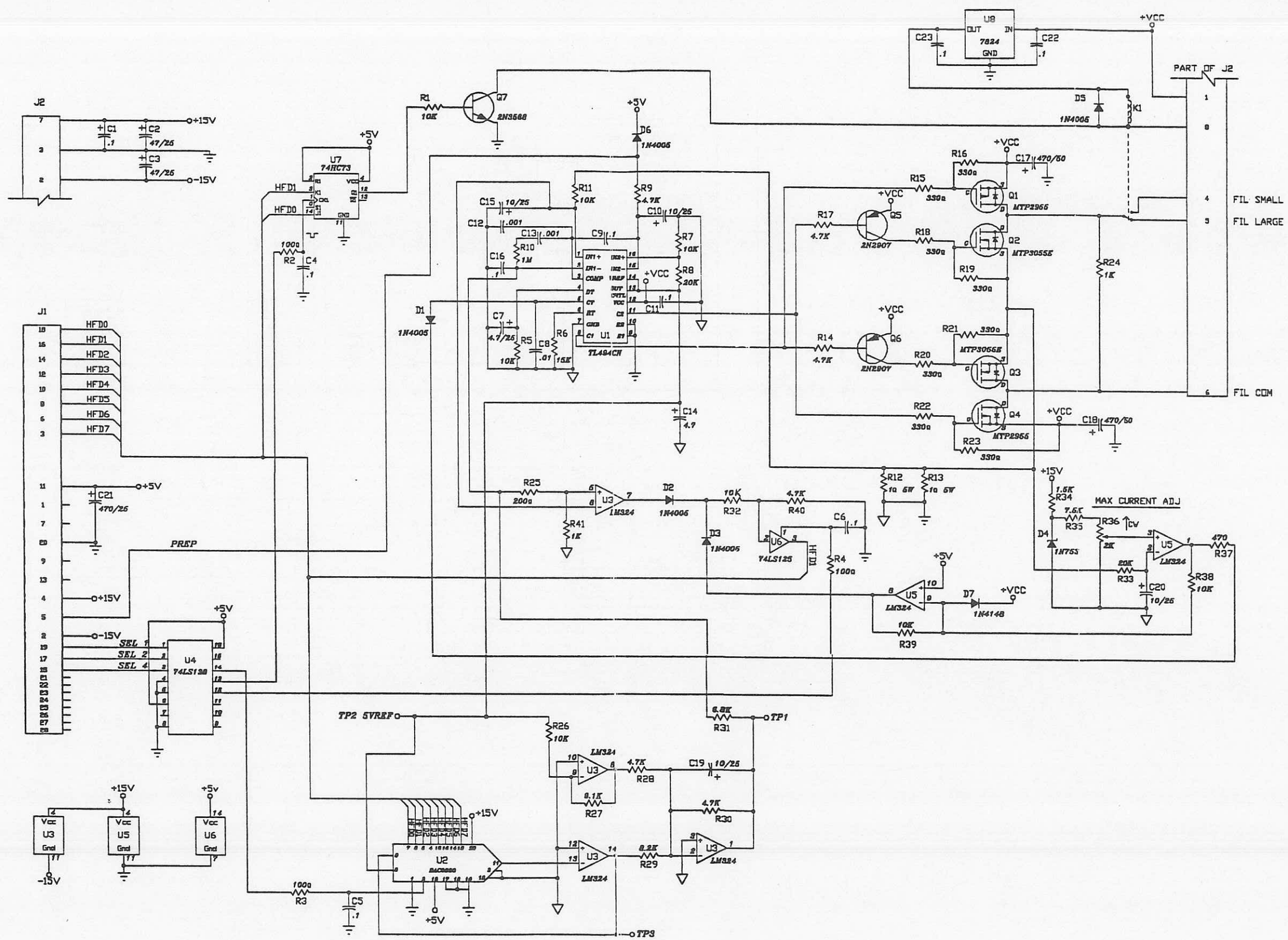


MICROPROCESSOR BOARD (A3) LAYOUT

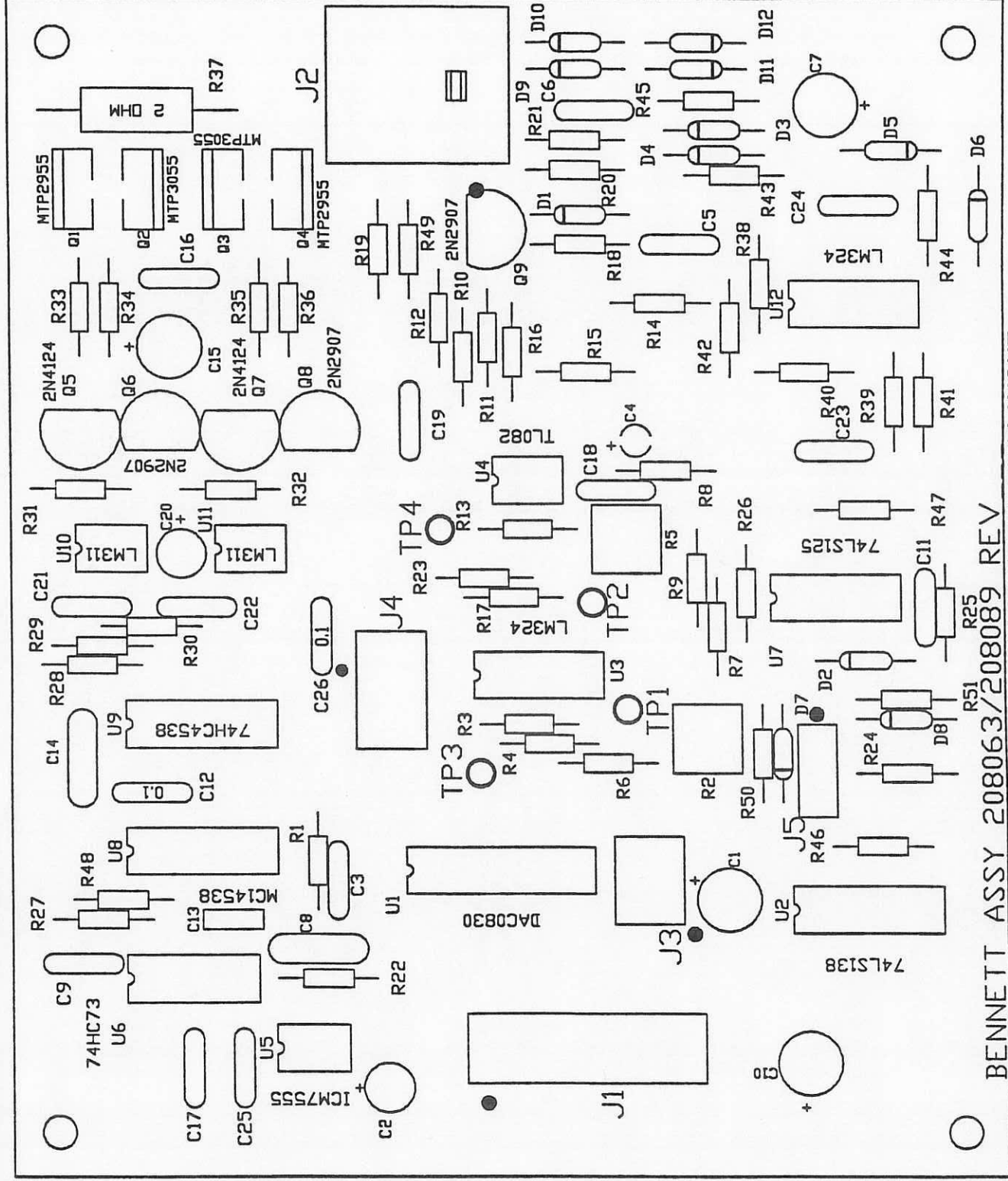


NOTES:
1 FOR CATHODE TANK ON HFQ SERIES MOVE
JUMPER TO PINS 1 & 2

KVP CONTROL PCB, 208089 (A4, A8)

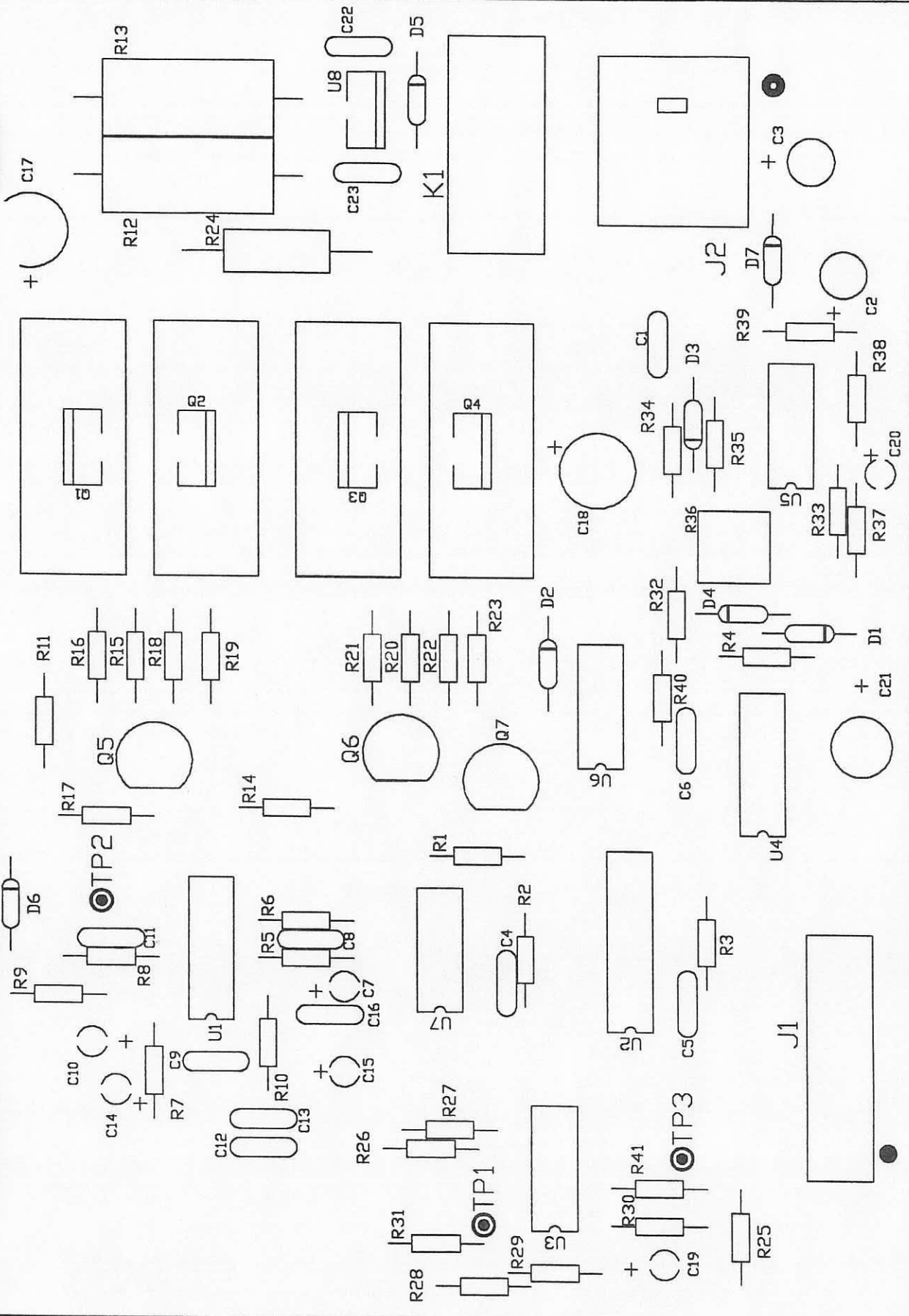


FILAMENT CONTROL REGULATOR, 208090 (A5)



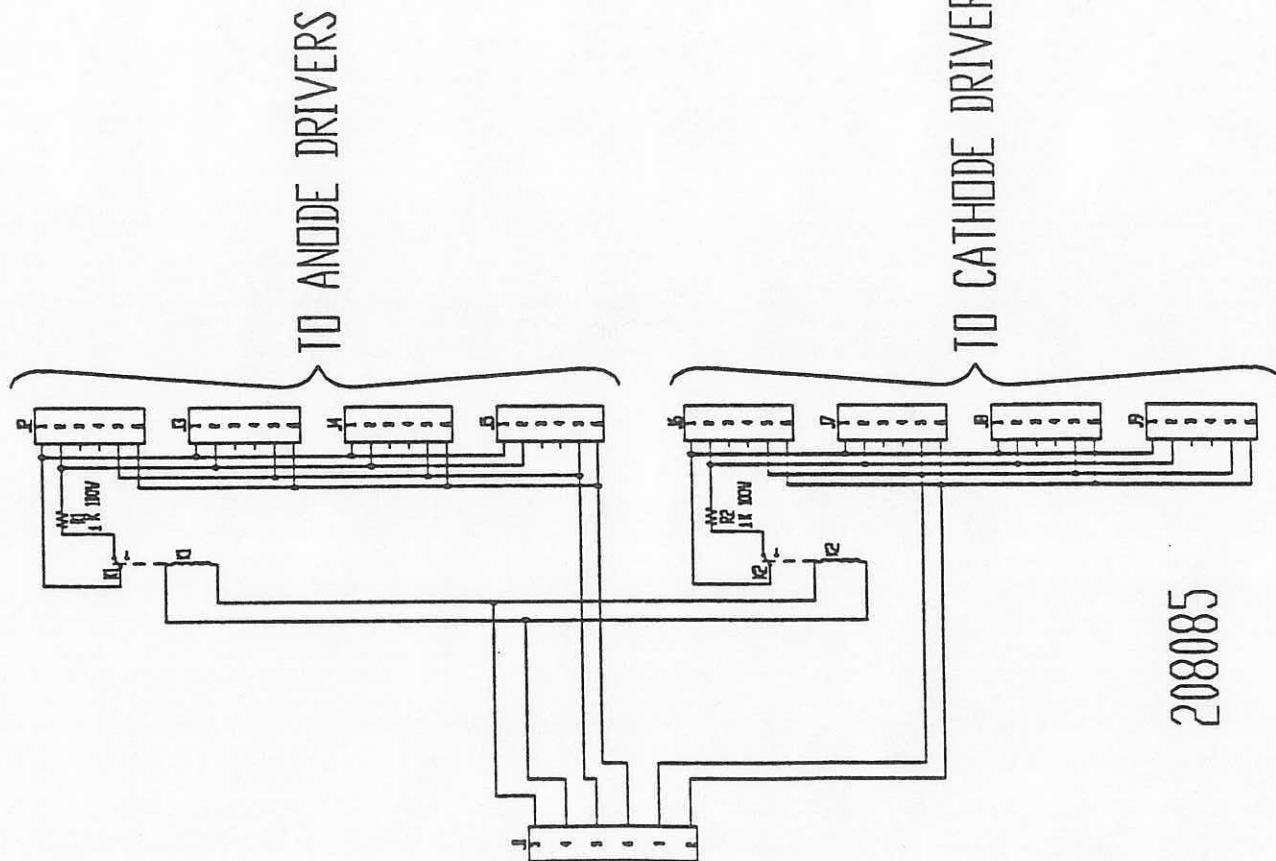
BENNETT ASSY 208063/208089 REV
KVP CONTROL BOARD (A4 AND A8) LAYOUT

BENNETT X-RAY P

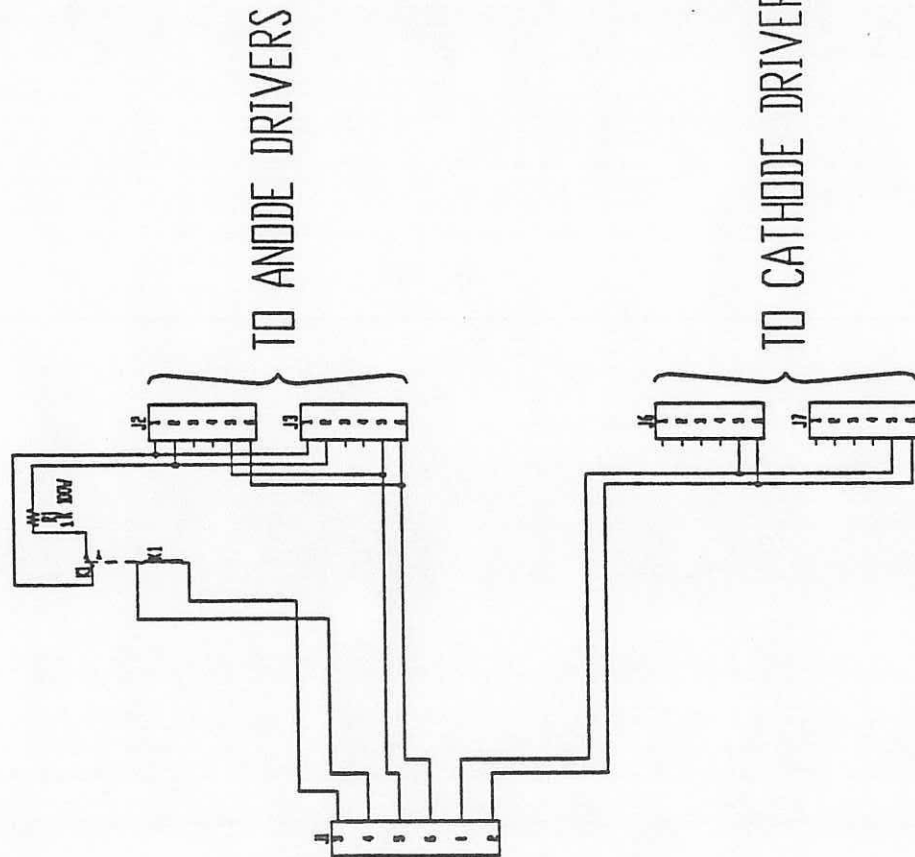


FILAMENT CONTROL REGULATOR BOARD (A5) LAYOUT

SCHEMATICS



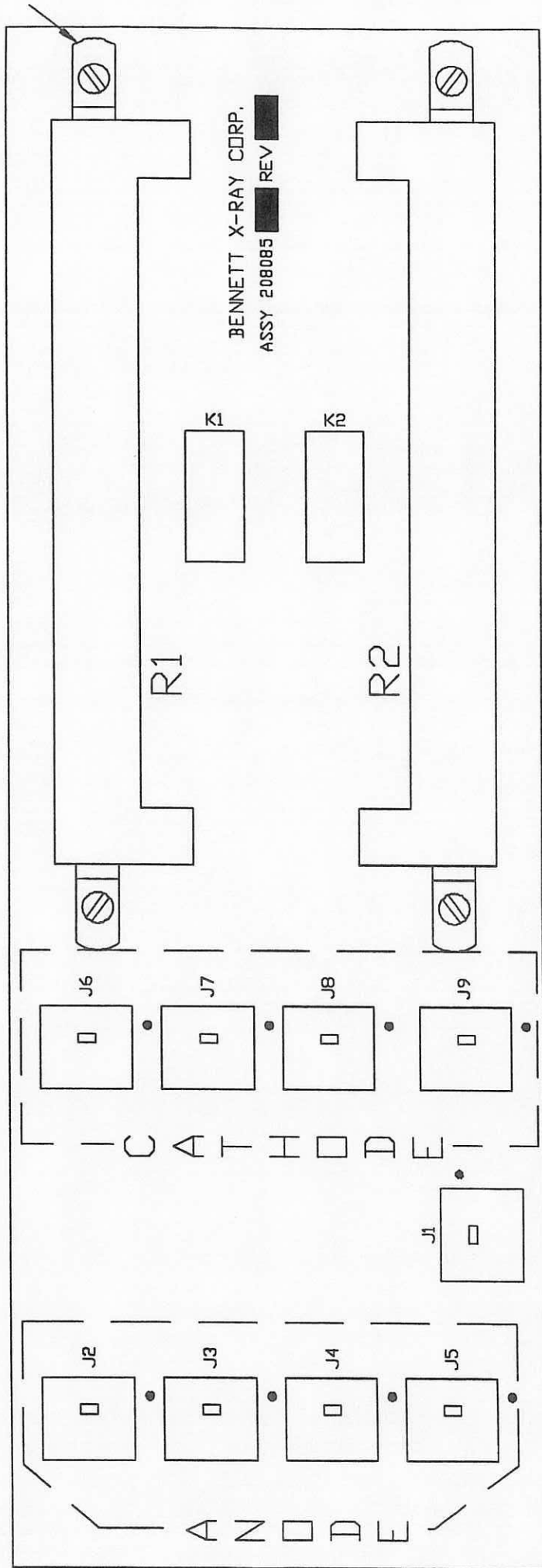
208085



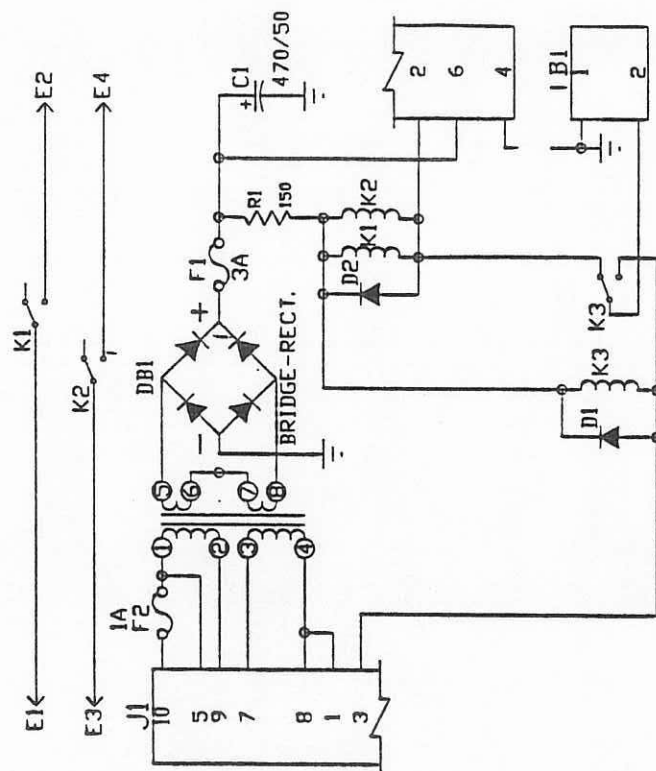
208085-3

FOR HFQ-300 SE ONLY

DISTRIBUTION BOARD, 208085 (A7)

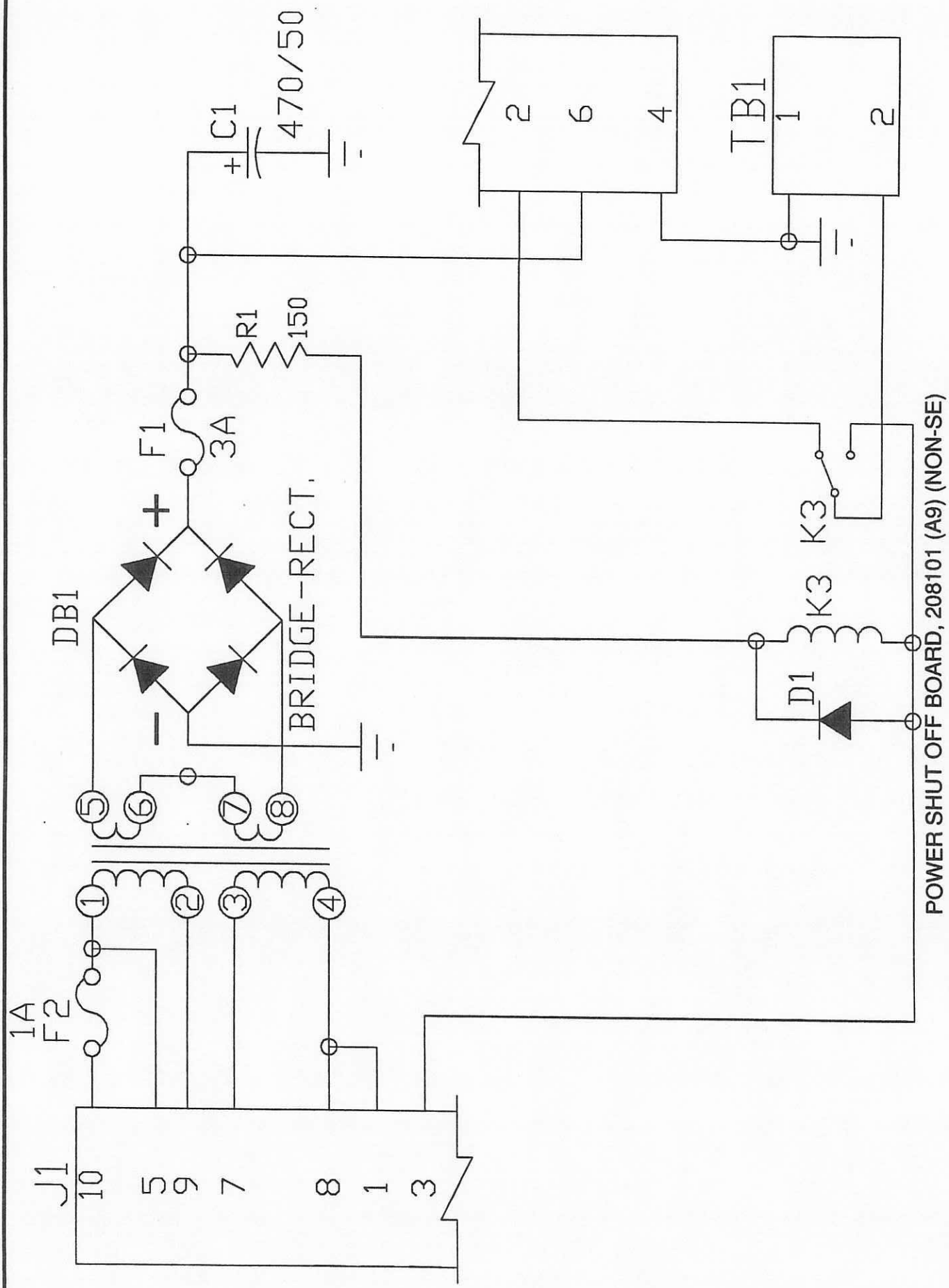


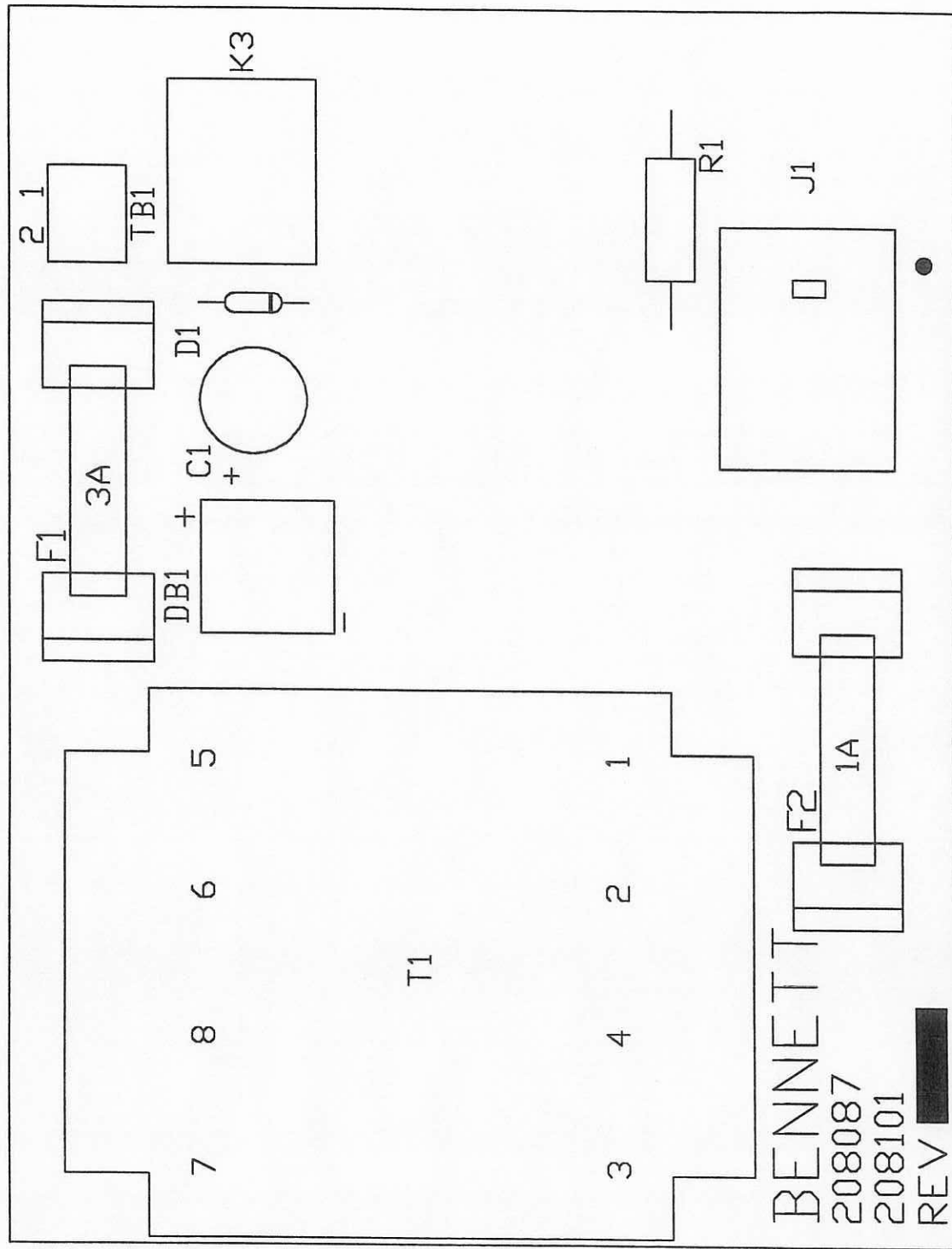
DISTRIBUTION BOARD (A7) LAYOUT



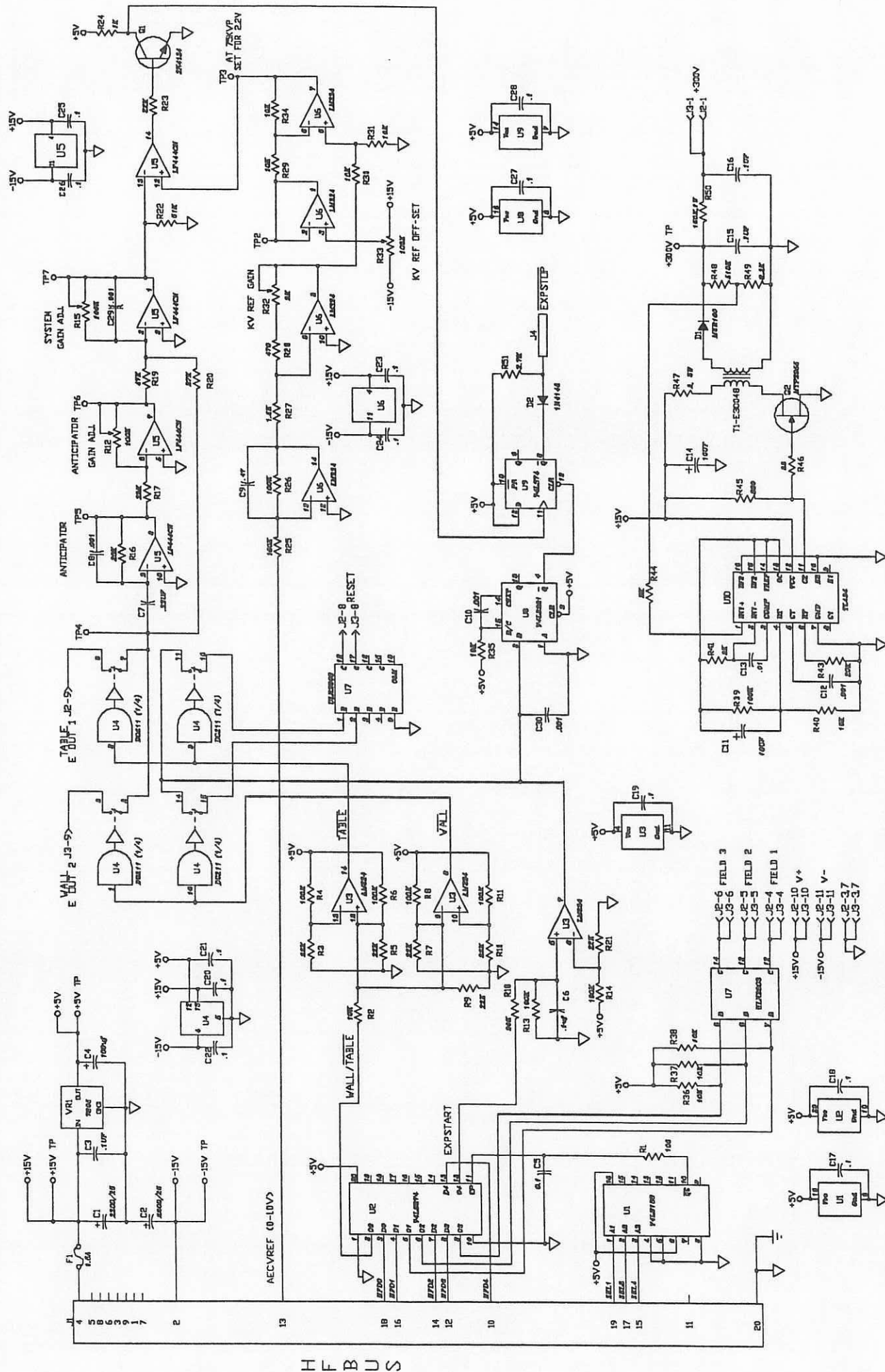
POWER SHUT OFF BOARD, 208087 (A9) SCHEMATIC AND LAYOUT (SE)

SCHEMATICS



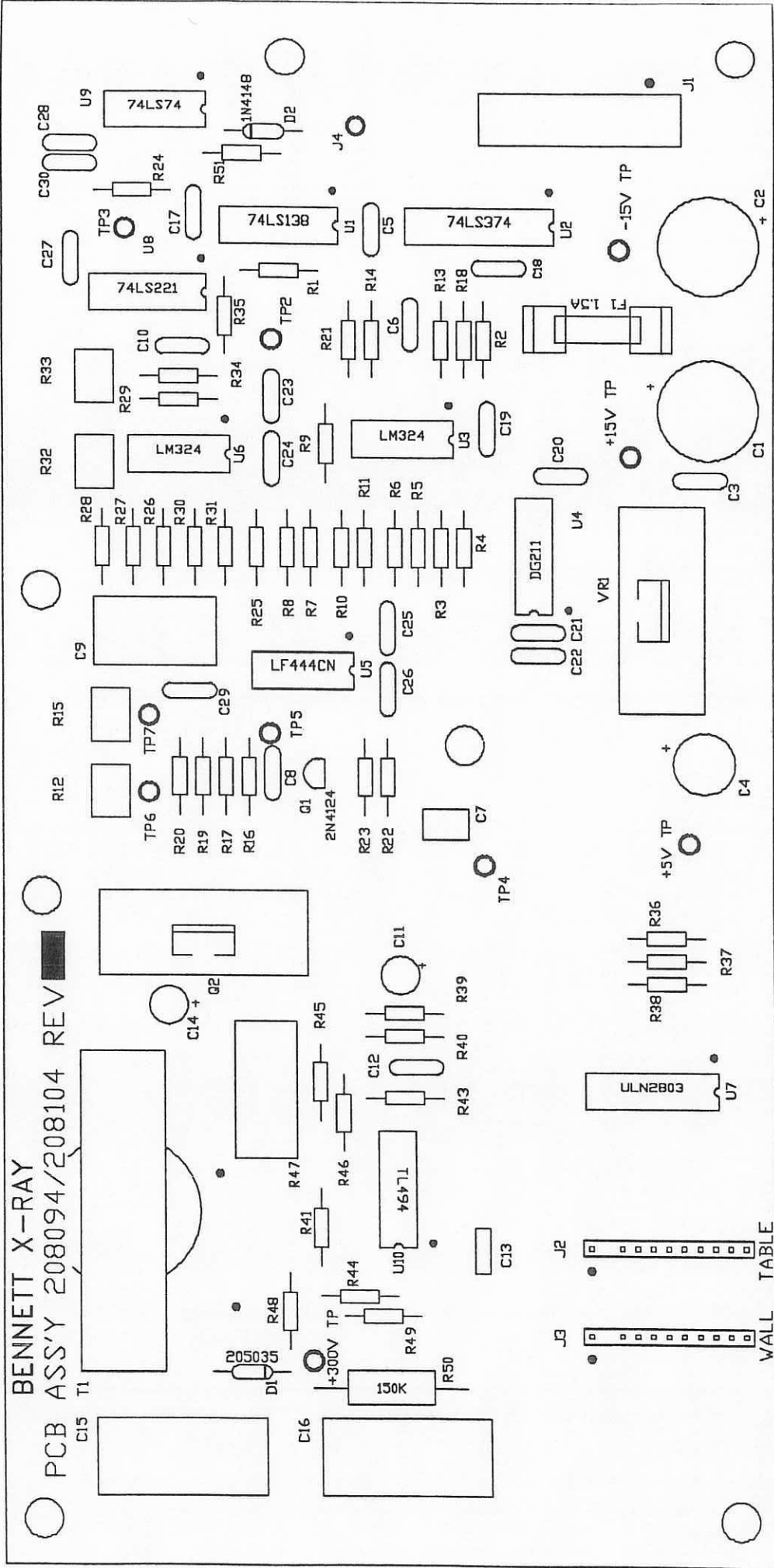


POWER SHUT OFF BOARD (A9) LAYOUT (NON-SE)

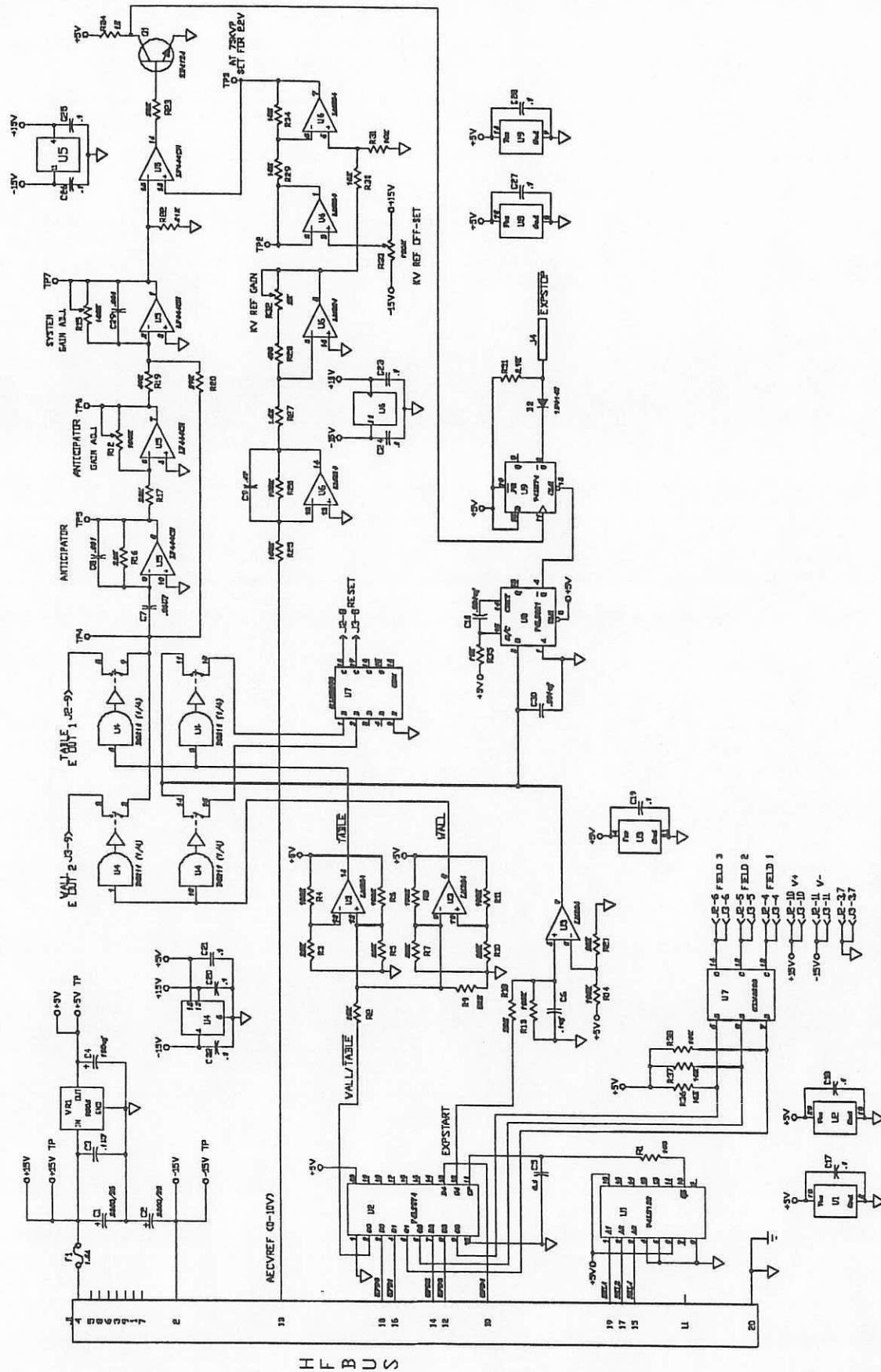


U2 CONNECTS TO CHAMBER "I" (TABLE).

AEC INTERFACE BOARD, 208094 (A10)

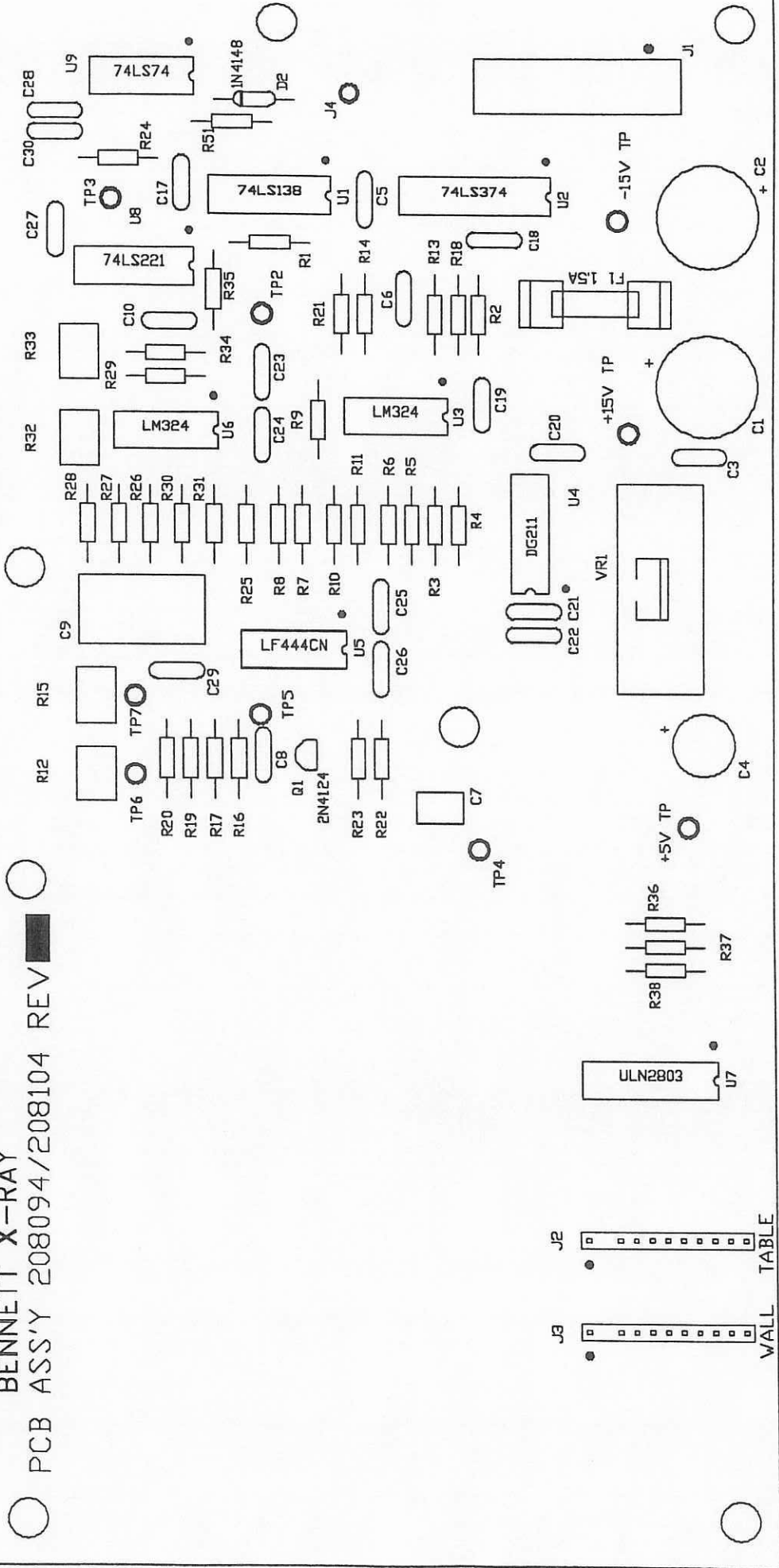


AEC INTERFACE BOARD (A10) LAYOUT

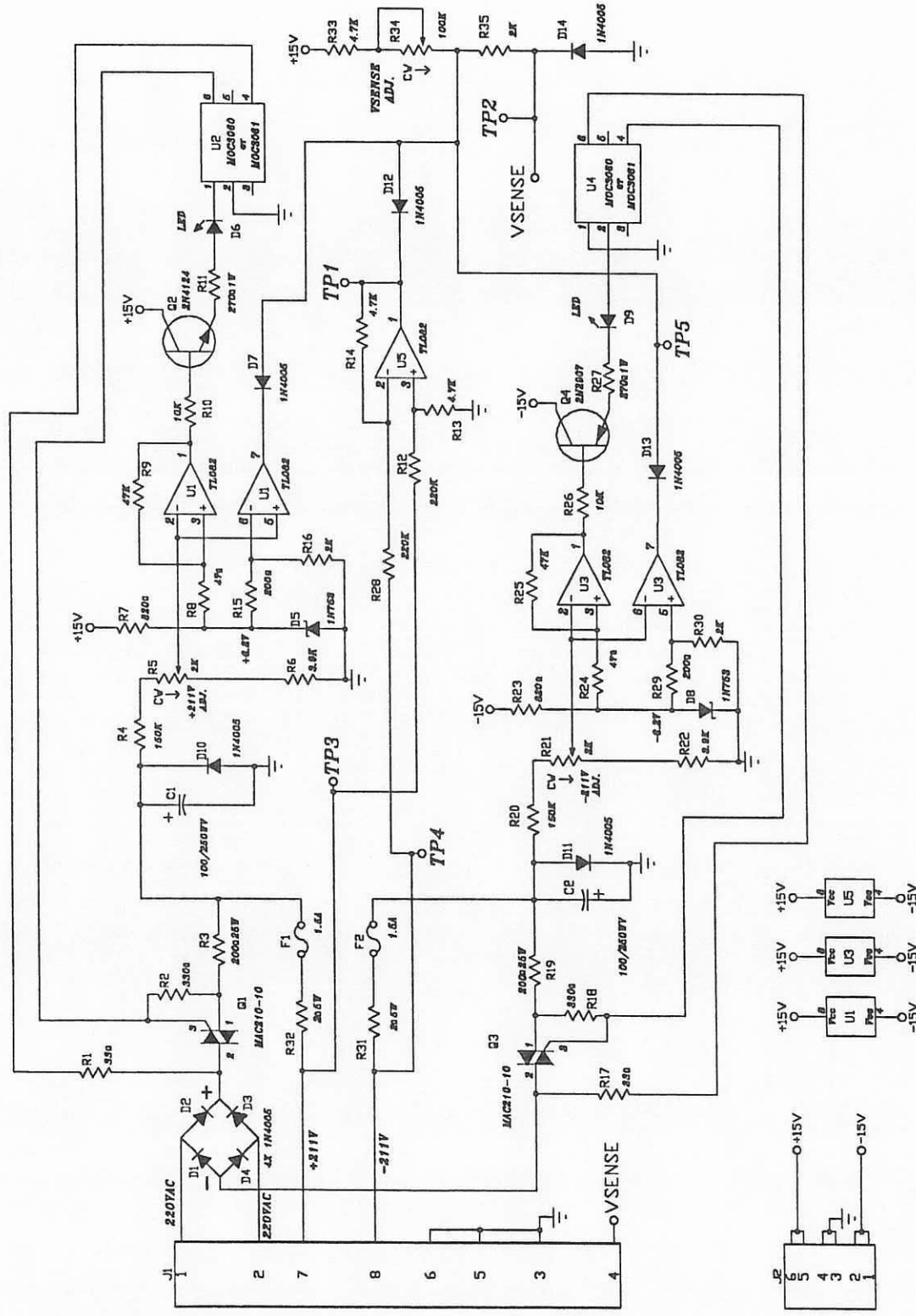


J2 CONNECTS TO CHAMBER "1" (TABLE).
J3 CONNECTS TO CHAMBER "2" (TABLE).
AEC INTERFACE BOARD, 208104 (A10)

○ BENNETT X-RAY
○ PCB ASS'Y 208094/208104 REV



AEC INTERFACE BOARD (A10) LAYOUT



BENNETT X-RAY

BENNETT X-RAY



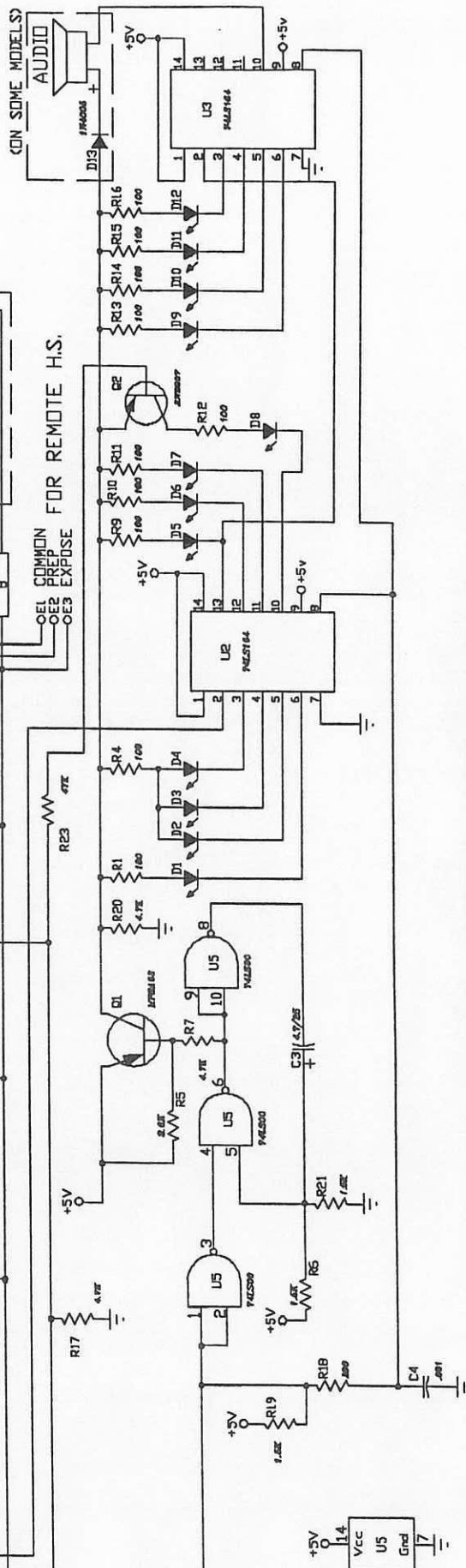
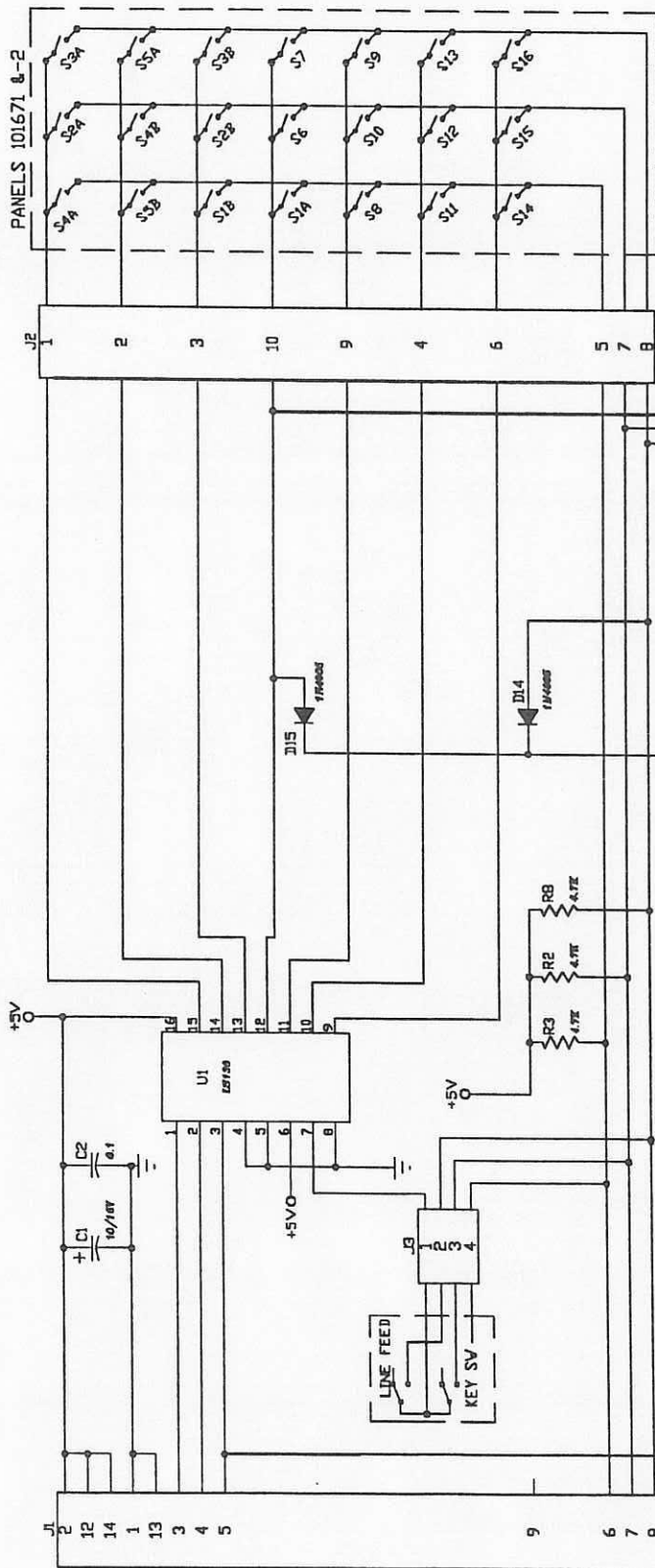
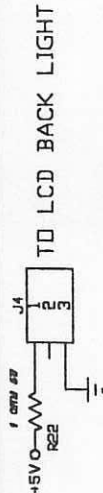
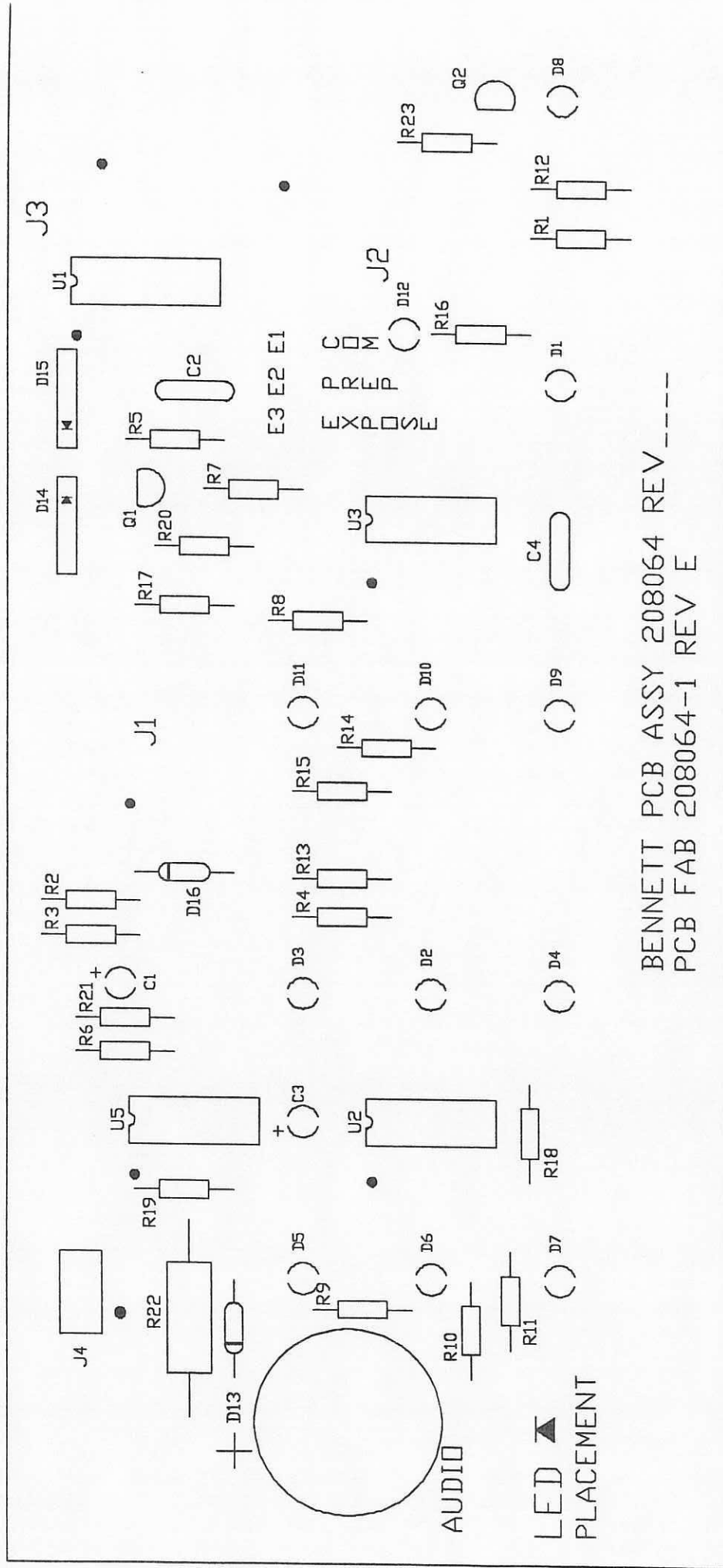


TABLE OF TEXT VARIABLES
AND LED REFERENCE

REF	TEST	TV2 TUBE
S1A	ADL UP	ADL UP
S1B	ADL DN	ADL DN
S2A	ADL UP	ADL UP
S2B	ADL DN	ADL DN
S3A	ADL UP	ADL UP
S3B	ADL DN	ADL DN
S4A	ADL UP	ADL UP
S4B	ADL DN	ADL DN
S5A	ADL UP	ADL UP
S5B	ADL DN	ADL DN
D1S6	PREP	PREP
D1S9	GRD	VALL 3
D1S10	BUCKY	TABLE 3
D1S11	NON-3	NON-3
D1S12	ACE	ACE
D1S13	MANUAL	MANUAL
D1S14	EXPOSE	EXPOSE
D1S15	RELEASE	TUBE 2
D1S16	FILE SCREEN	TUBE 1
D1S17	AUTO REL	ACE FIELD 3 SD
D1S18	READY	READY

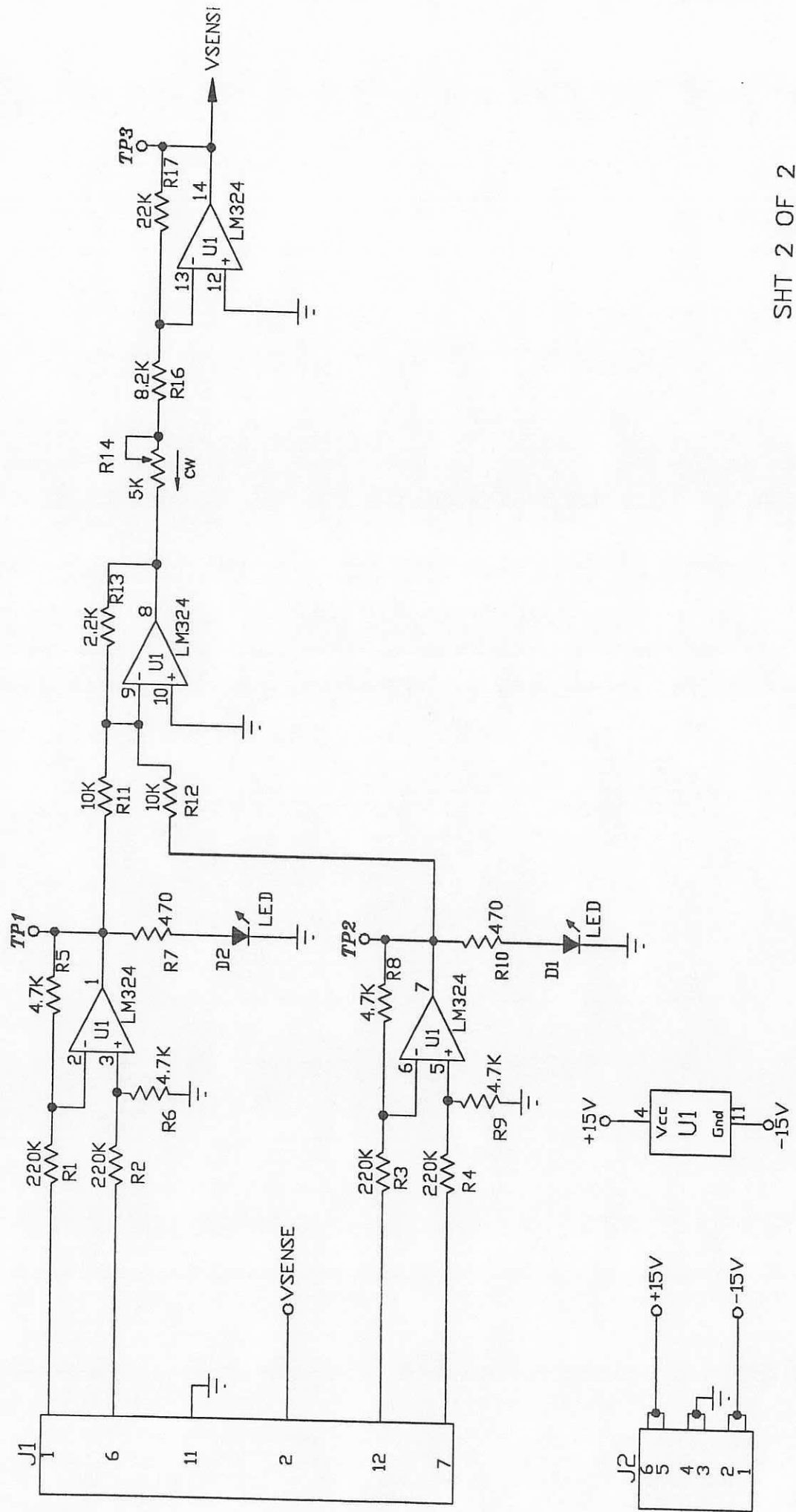
OPERATOR CONTROL PANEL, 208064 (A12)

SCHEMATICS



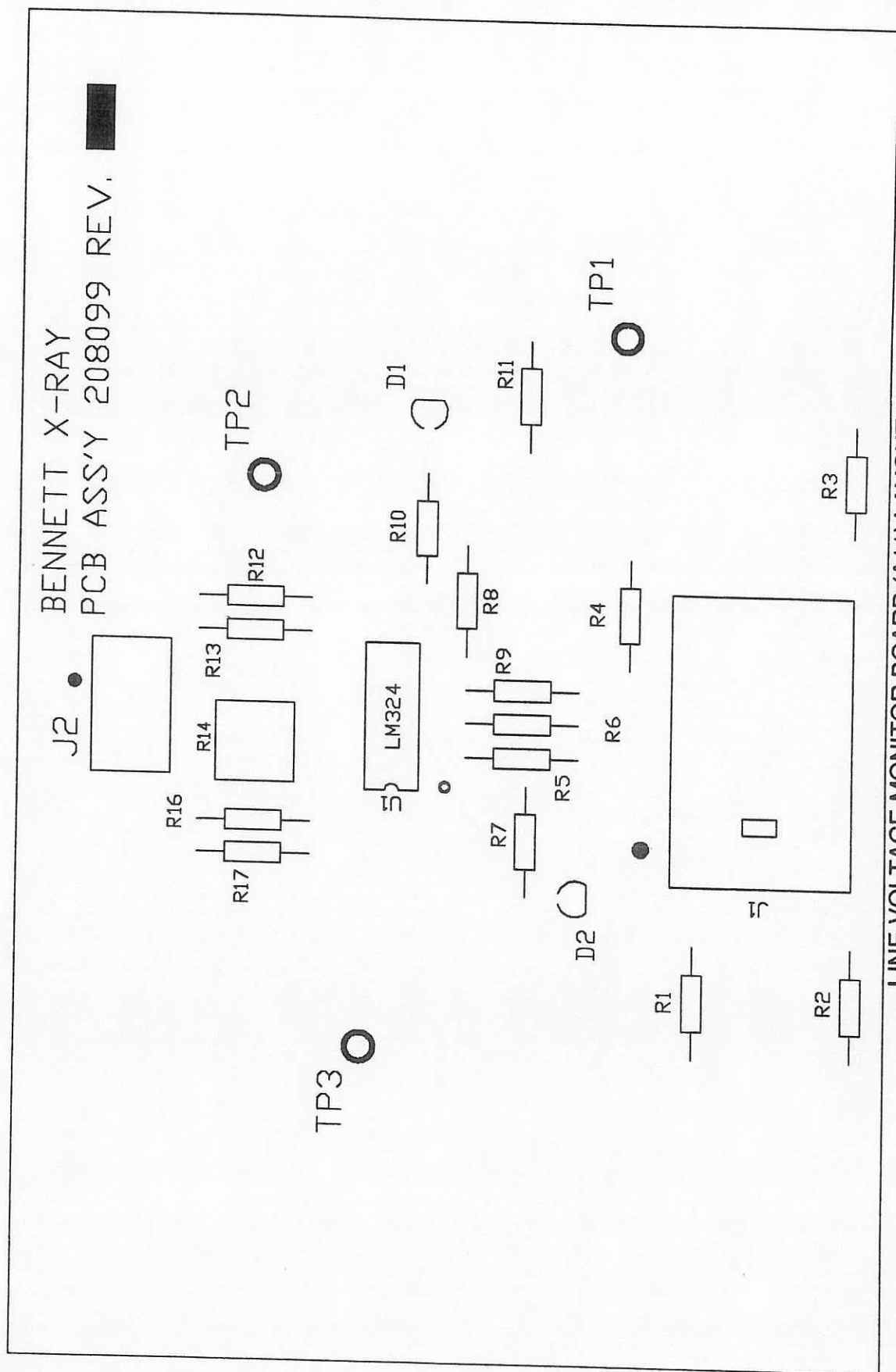
OPERATOR CONTROL PANEL BOARD (A12) LAYOUT

SCHEMATICS

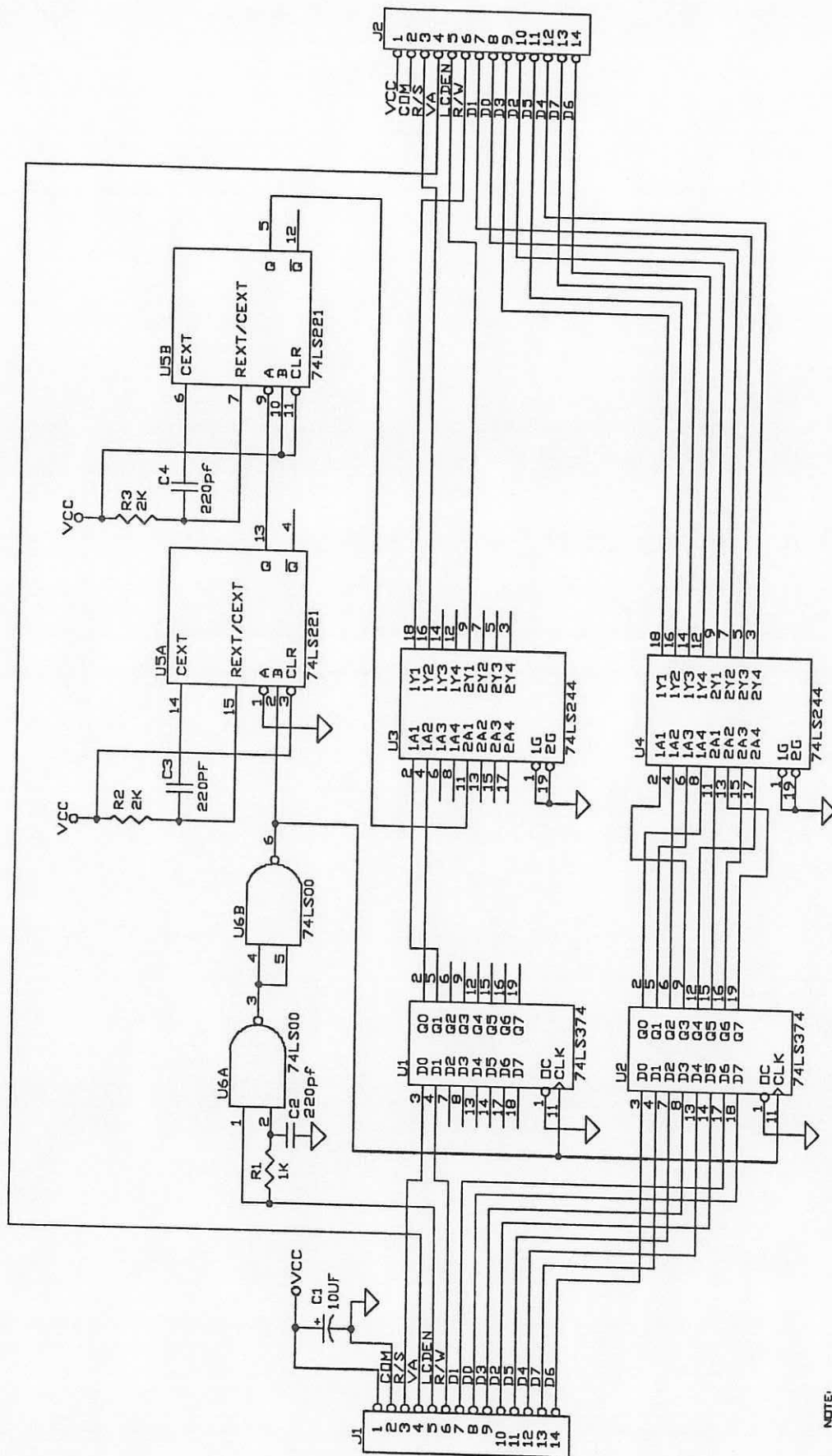


SHT 2 OF 2

LINE VOLTAGE MONITOR, 208099 (A11)



LINE VOLTAGE MONITOR BOARD (A11) LAYOUT

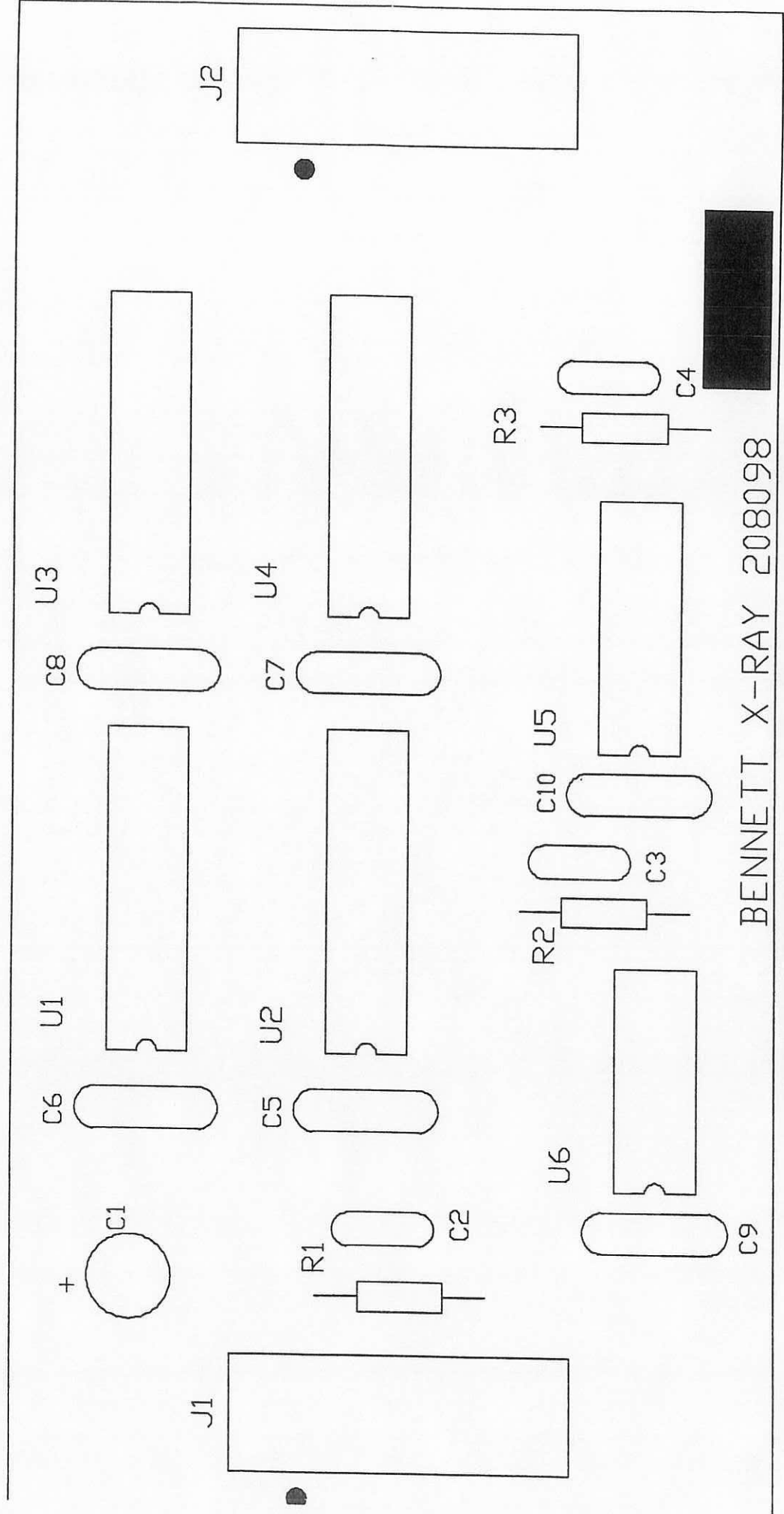


NOTE:
All ICs get .1uF bypass caps on their power supply lines.

IC	VCC	GN
74LS00	P1 13	P1 8
74LS244	P1 13	P1 8
74LS374	P1 20	P1 10
74LS244	P1 20	P1 10

OPERATOR CONTROL PANEL DRIVER, 208098 (A15)

SCHEMATICS



BENNETT X-RAY 208098

OPERATOR CONTROL PANEL DRIVER BOARD (A15) LAYOUT