LUDLUM MODEL 49-12-2
HAND AND SHOE MONITOR

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and Succeeding Serial Numbers

LUDLUM MEASUREMENTS, INC.
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Model 49-12-2 Pancake Hand and Shoe Monitor

WARRANTY CERTIFICATE

Ludlum Measurements, Inc. warrants the products covered in this instruction manual to be free of defects due to workmanship, materials, and design for a period of twelve months from the date of delivery, with the exception of photomultiplier tubes and Geiger-Mueller (GM) tubes, which are warranted defect-free for 90 days. This warranty is voided in instances of improper installation, abuse, mishandling, misuse, freight damage, or repair by unqualified persons.

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1. GENERAL DESCRIPTION

The Ludlum M49-12-2 Pancake Hand and Shoe Monitor is designed to check personnel for beta-gamma radiation contamination. The M49-12-2 monitor uses forty pancake G.M. type detectors. The monitor also includes an LMI model 44-9 Pancake Frisker.

A user LED status display quickly shows whether contamination exists, and if so, the location of contamination. This display indicates procedural errors, background errors, or possible hardware problems. User instructions are simple, and are placarded to the front of the instrument. The user has access to only two buttons: the SINGLE HAND request, and the AUDIO ACKNOWLEDGE button.

The cabinet contains a 20-key keypad and LCD diagnostic display for setup of alarm and failure setpoints, diagnostic routines, and readout of the current count or background count. In addition to manual alarm setpoints the monitor has two automatic alarm calculation modes. The maximum sensitivity mode continuously sets the alarmpoints to a specified number of sigma factors above background. The minimum count time mode continuously changes the count time to the shortest time required to detect a specified radiation level.

The electronics is microprocessor-based, and housed in a chassis mounted on the swing-down cabinet door. Failure detection features include high voltage, low count, and high background. Background accumulation takes place automatically when the unit is inactive.

2. SPECIFICATIONS

2.1 Readout / Data Output

The user display consists of LED indicators and a piezo audio speaker. Two switches available to the user allow single hand operation and audio silencing after the first four seconds.

The monitor has an LCD readout that displays the counts, background counts, and alarm points. Each channel reads out on the LCD in counts per minute from 0000-9999. Additional information is accessed through a menu structure.

2.2 Background Update

The monitor continuously updates background, going into the "counting" mode only when hands are sensed. Switches in each hand compartment are used to indicate proper placement for interrogation. The keypad allows the user to set a time limit to ensure that a background is taken during the specified time. If a background update has not occurred within the time limit, a forced UPDATE will be required. The UPDATING BACKGROUND light will come on, and a background update will be taken before operation can resume. If the user remains on the switches after an update is required the PROCEDURAL ERROR light will come on and an audio tone emitted until the user is clear.

2.3 Count Time

The count time and frisk time are keypad-adjustable from 1 to 255 seconds. Once frisk time is up the monitor emits a beep and continues the frisk count until the frisker is placed back on the hook.

2.4 Alarm Output

The monitor has visual and audible alarm indicators. The red alarm lamp lights for any contamination alarm, and red LEDs show the location of contamination. Audio and visual output is held for a keypad-adjustable time, but the audio can be silenced by the AUDIO ACKNOWLEDGE button after the first four seconds.

2.5 Alarm Setpoints

The counting alarm setpoints are all based on counts per minute from 0000 to 9999 including: count alarm, high background, and low count. The high voltage fail alarm will activate whenever the high voltage strays 10% from the high voltage setpoint.

2.6 Ease of Decontamination

The monitor is constructed of anodized and painted aluminum and stainless steel. PVC film covers the user display and wipes clean with a moist cloth.

2.7 Minimum Detector Efficiency

HANDS: 5%-14C; 22%-^{90}Sr/^{90}Y; 19%-^{99}Tc; ^{137}Cs-17%
SHOES: 32%-^{32}P; 15%-^{238}Pu; ^{137}Cs-9%

Efficiencies are stated for a 4π geometry. The hand beta-gamma efficiency is 17% and the foot is 9% with ^{137}Cs. This efficiency was achieved using 47 mm diameter source placed over each tube.

2.8 Design Threshold Sensitivities

The threshold sensitivity for all channels is 100 mV.

2.9 Calibration

Yearly calibration/verification can be achieved in approximately two hours. Calibration includes: setting the thresholds, calibrating high voltage, and verification of each channel.

2.10 Power

115 VAC, 50/60 Hz at 0.5 amps maximum. 240 VAC optional.

2.11 Size and Weight

30 x 28 x 58 inch(76 x 71.12 x 147.32 cm) (D x W x H)

The weight of the M49-12-2 is 190 pounds. Each pancake, except the frisker, is surrounded with approximately ¼ inch lead, excluding the frisker.

3. THEORY OF OPERATION

The following paragraphs will discuss the different alarm calculation modes. Note that the low count alarm points must be entered manually, regardless of the calculation mode. Examples of using the automatic calculation modes are in the appendix.

3.1 Manual Set Mode

In this mode, all required alarm points are entered via keypad. The setpoints range from 0 to 9999 counts per minute. All alarms, high background alarms and low count alarms are calculated and entered manually.

3.2 Maximum Sensitivity Mode

This automatic mode uses the known background to calculate alarm levels a specified amount above background. Thus, the alarm points change as the background changes. This mode is used when maximum sensitivity is desired, and when the changing background prevents MANUAL SET mode. The MAXIMUM SENSITIVITY parameters are:

- Sigma factor
- Confidence level
- Efficiencies
- Maximum allowable source size

Background may vary from one count to the next. The typical distribution is a bell-shaped curve with most of the background counts close to the average background. 50% of the background counts are above the average and 50% are below the average. If the alarm point were chosen to be the average background, then an alarm would occur 50% of the time. On the other hand, the alarm point could be chosen to be many times larger than the background average, eliminating the false alarm rate but also the sensitivity.

The standard deviation is described as the measure of the amount of fluctuation for a given distribution. A small deviation indicates that most counts are near the average; a large deviation indicates that counts are more scattered. The standard deviation is usually defined as the square root of the average and is symbolized with the lower case Greek letter sigma (Φ). The problem is to know the sigma factor that yields an alarm point with a given false alarm rate. Since background usually follows the normal distribution, statistics can provide tables of sigma factors for different false alarm rates. The table below shows some sigma factors and the related false alarm rate.

Φ factor	False Alarm Rate
1	15.87% or 15.87 in 100
2	2.28% or 2.28 in 100
3	0.13% or 1.3 in 1,000
4	0.003% or 3 in 100,000
5	0.00003% or 3 in 10,000,000

Once a sigma factor is selected for a specified false alarm rate, the alarm point may be calculated. The formula is (with background subtract on):

$$\beta - \gamma \text{ alarmpt} = \sigma \text{ factor} x \sqrt{\text{bkgnd av.}}$$

$\exists$-(*alarmpt* = beta-gamma alarmpoint
Φ *factor* = sigma factor
bkgnd av. = background average

When the background count becomes large in MAXIMUM SENSITIVITY mode, the ability of the instrument to detect low levels of contamination becomes more difficult. Therefore, the technician can input a maximum allowable source size in dpm. If the background rises to a point where the M49-12-2 can no longer detect this amount of radiation within the desired confidence level, then the HIGH BACKGROUND alarm will activate. The confidence level is described as the probability of alarming on a specified source size. The table below shows confidence levels and the associated factors.

Confidence level	factor
5%	1.645
10%	1.280
15%	1.035
20%	0.840
25%	0.675
30%	0.525
35%	0.385
40%	0.252
45%	0.125
50%	0
55%	-0.125
60%	-0.252
65%	-0.385
70%	-0.525
75%	-0.675
80%	-0.840
85%	-1.035
90%	-1.280
95%	-1.645
99%	-2.325

The condition for the HIGH BACKGROUND lamp to activate in MAXIMUM SENSITIVITY mode follows. Note that the maximum source size is multiplied by detector efficiency so that the resulting number is the count that the detector receives from the source.

$$\text{if alarmpt} \geq \text{max.} + (\text{cfactor} x \sqrt{\text{max.}})$$

alarmpt = calculated alarmpoint
max. = maximum allowable source size multiplied by efficiency
cfactor = confidence level factor

3.3 Minimum Count Time Mode

The MINIMUM COUNT TIME mode allows the user to input a desired level of contamination to be seen, and the monitor will automatically calculate the count time needed to be able to detect this level of contamination. This mode offers the assurance that a certain level of contamination is reliably detected. The MINIMUM COUNT TIME parameters are:

- Sigma factors
- Confidence level
- Efficiencies
- Desired source sizes
- Maximum count time

$$t = \left(\frac{\sigma F x \sqrt{bkgnd} - CL x \sqrt{desired + bkgnd}}{desired} \right)^2$$

The MINIMUM COUNT TIME mode is complicated by the fact that count time is dependent upon the background and the desired source size. The formula uses normalized values (all counts in counts per second):
t = time in seconds
ΦF = sigma factor
bkgnd = background in cps
CL = confidence level factor
desired = desired source size multiplied by efficiency

The count time is chosen from the longest count time calculated from each detector. If the background becomes large, then the count time becomes unacceptably long. Therefore, a maximum count time limit can be entered. If the calculated count time becomes larger than the maximum count time limit, the HIGH BACKGROUND LED will activate.

4. INITIALIZATION

When the Model 49-12-2 powers up, an initializing routine is entered. All lights on the status display will turn on, the audio will sound, and the LCD will show the LMI logo. The message "BOARDS INITIALIZING... PLEASE WAIT" should appear on the LCD. During power-down the central processor, with its battery backed up memory, stores all system parameters. During initialization all parameters are downloaded from the central processor. If any boards are missing or not working, then the message "_____ BOARD IS MISSING" will be displayed, and operation will stop. When initialization is completed, the status panel lights will clear and the LCD will show the current counts and operating conditions. Under normal conditions, the monitor must take a background before the READY light indicates that the monitor is ready for normal operation.

5. KEYPAD FUNCTIONS

The keypad is used to view or change the alarm points or system parameters. The 20-key keypad has the numerals 0-9, a backspace key, an enter key, and several special function keys. The functions of the special keys are listed in the following sections.
The LCD backlight is turned off during normal operation. Pressing any key on the keypad will activate the backlight for approximately 30 minutes.

5.1 Main Menu Key

The MAIN MENU key displays the main menu in the lower LCD. This menu is the beginning menu from which all other menus can be reached.

5.2 Read Menu Key

The READ MENU key shows the read menu, bypassing the need to go through the main menu. All alarm setpoints and all other parameters may be read. In addition, all current operating conditions may also be viewed.

5.3 Operating Conditions Key

The OPER COND key displays the current operating conditions, such as high voltage, current sensitivity, current alarm calculation mode, and count time remaining.

5.4 Alarm Setpoints Key

The ALRM PTS key displays all the current alarm points or parameters. This key is useful for showing all the present count type alarm setpoints or parameters. The information displayed depends upon which alarm calculation mode (MANUAL SET, MAXIMUM SENSITIVITY, or MINIMUM COUNT TIME) is currently in use.

5.5 Hold Key

The HOLD key "freezes" the counts shown. The HOLD key will also cancel (halt) the parameter setup process.

5.6 Backspace Key

The BKSP key allows changes to be made to a parameter being entered. The backspace key also returns from one menu to the previous menu, if available.

5.7 Enter Key

The ENT key enters in a parameter in the setup mode. The enter key also progresses from one menu to the next, if available.

5.8 The CNT Key

The CNT key forces an interrogation without having to depress the hand switches.

5.9 UPDT Key

The UPDT key forces a full 40-second background count and refreshes all background data.

5.10 INVT SCRN Key

The INVT SCRN key changes the LCD display between black characters on white and white characters on a black background.

6. DESCRIPTION OF OPERATOR CONTROLS

6.1 Single Hand Request

The SINGLE HAND button is used to request single-hand count operation. After pressing the SINGLE HAND button, counting will begin when either of the hand switches are pressed. This request is valid for approximately ten seconds.

6.2 Audio Acknowledge

If an alarm or procedural error occurs, the AUDIO ACKNOWLEDGE button can be used to silence the audio after four seconds of audio output.

7. DESCRIPTION OF STATUS LIGHTS

7.1 Ready

This green LED indicates that the M49-12-2 is ready to monitor personnel. This light is not lit during a count, when the UPDATING BACKGROUND light is lit, or when the TROUBLE light is lit.

7.2 Counting

This green LED indicates that the M49-12-2 is currently monitoring personnel. It is also lit during frisking. Users must keep hands pressed down until this light turns off and either the ALARM light or CHECK OK light turns on.

7.3 Check OK

This green LED indicates that the user is under the radiation contamination limits and is cleared to leave.

7.4 Procedural Error

This orange LED indicates that the user is not properly following procedure. This light will turn on if the user withdraws his hands before the count is finished. Also, insertion of hands while the UPDATING BACKGROUND light is lit will cause the PROCEDURAL ERROR light to light until the hands are removed. If during frisking, the frisker is hung up prior to the end of frisk time this LED and audio will activate. At initial startup the monitor will require the frisker to be hung up in order to obtain a full background update. The procedure LED will light if the frisker is not on the hook during this time.

7.5 Updating Background

This orange LED indicates that the system is updating background. A complete background update replaces the background averaging stack, and takes forty seconds to complete. A contamination check cannot take place when this LED is lit. Standby updates will be taken during inactive periods and will partially replace background stack data as time allows.

7.6 Low Count

This yellow LED indicates that a count has been read in from a beta-gamma channel that is less than the low count parameter for that channel. The audio will be continuous to indicate that a failure condition exists. A red LED will be activated to show the location of the offending channel.

7.7 High Background

This yellow LED indicates that a background has been read in from a channel that is greater than the beta-gamma background parameter for that channel. The audio will be continuous to indicate that a failure condition exists. A red LED locator will also show the offending channel. This indication will continue until the condition clears.

7.8 HV Fail

This yellow LED indicates that the measured high voltage on any of the detectors is not within 10% of the high voltage parameter. The audio will be continuous to indicate that a failure condition exists.

8. OPERATING PROCEDURES

The following section describes how to install and operate the monitor.

8.1 Parameter Setup Prior to Operation

All of the parameters of interest may be viewed from the read menus. The following parameters must be set or checked prior to monitor operation:

- Low count setpoints
- High background setpoints
- Alarm setpoints
- Hands and Foot/Frisker high voltages
- Count time
- Background update interval
- Background subtract on/off

- **Low Count Alarm Setup**

The low count alarms monitor the count from the detectors. The low count alarm exists to ensure that the probes are connected and getting some minimum of counts. The low count alarm may be set from 0 to 9998 counts per minute, and defeated by entering 9999. An alarm will occur if the last count is less than or equal to the low count alarm.

- **High Background Alarms Setup**

The high background alarms may be set from 0 to 9998 counts per minute, and defeated by entering 9999. An alarm will occur if the background is greater than or equal to the high background alarm. This alarm should not be disabled except during setup or calibration.

- **Alarm Setpoints or Parameters**

The alarm setpoints may be manually set from 0 to 9999 counts per minute. If the alarm calculation mode is MAXIMUM SENSITIVITY or MINIMUM COUNT TIME, certain parameters need to be set. These parameters include detector efficiency, sigma factor, and the confidence level. In MAXIMUM SENSITIVITY mode, the maximum sensitivity limit (in dpm) is needed. In MINIMUM COUNT TIME mode, the desired sensitivity (in dpm) and the maximum count time are needed. Examples of using the alarm calculation mode are in the appendix.

- **Detector High Voltage Setup**

Typical operating voltage for the pancake G.M. tubes is 900 V.

- **Count Time**

The Count and Frisk Times are adjustable from 1 to 255 seconds. When in MINIMUM COUNT TIME calculation mode, the count time is adjusted automatically to the minimum required to detect a specified contamination level.

- **Background Update Interval Setup**

The maximum time between background update intervals should be set to force the monitor to update background.

- **Background Subtract Status Setup**

Background subtract may be turned on or off. The value used to subtract from the current counts being received is an average of the last four background readings. Under normal operation, the background subtract should be on.

8.2 Optional Parameter Descriptions

- **Setting the Real Time Clock**

The real time clock is defined in standard military format. The time and the date may be set via SETUP MENU III.

- **Setting the Security Code**

A four key security code must be assigned that allows access to the setup menus. The security code consists of any four of the twenty keys on the 20-key keypad. The security code may be reset (but code is not stored when power is turned off) to "0000" by going to READ MENU II and pushing the numeral 9 key.

9. CALIBRATION

Yearly calibration should be performed to guarantee accurate operation. Calibration will include the following (in order of procedure): setting the high voltage using a calibrated high voltage voltmeter, checking threshold levels on the quad amplifier boards, finding the detector efficiencies. An operational check should follow calibration of the monitor. A check source should be selected and either an alarm point established or alarm parameters defined. Finally, the check source should be placed over every detector to verify the calibration and alarm setpoints.

9.1 High Voltage Power Supply (HVPS) Board Calibration

Use the Ludlum Model 500 Pulser or equivalent for the procedure. A voltmeter with an input impedance of 1000 megohms or greater may be used. The high voltage should be set via the keypad so that each high voltage is set to 900 VDC or you may short the test pins on the HVPS board itself. The readout does not need to read 900 VDC at this time. Note:All underlined words below are the exact letters found on the circuit board.

The HVPS board #5323-746 is located in the left most position of the electronics chassis in the slot labelled HVPS1. The potentiometers labeled UH (R183) and LH (R81) set the FEET/FRISKER and HANDS high voltages respectively. Each adjustment should be made to within ± 3 VDC using a high impedance voltmeter. Measure the FEET/FRISKER voltage at the Frisker connector located on the side of the monitor and the HANDS high voltage inside the upper cabinet. The voltage on pins 1 & 2 of the TLC27M7 amplifier (U155 FEET, U77 HANDS) should be measured while adjusting the potentiometer labeled UR (R178, upper) and LR (R82, lower) to 0.900 VDC ± 0.003 VDC.

The OPER COND key can be used to read the current high voltages. The potentiometer labeled HV CAL (R78) is adjusted until the FEET high voltage reads out on the LCD display as 900 VDC ± 3V. The HANDS high voltage should be verified to read 900 VDC ± 3V.

A 4-pin connector P8 is used to configure the beta-gamma threshold (BT), beta-gamma window (BW), and the alpha threshold (AT). Pin 1 labeled GND of connector P8 should be used as a reference for the following measurements. The potentiometer labeled BT (R85) should not be adjusted, it is not used in this unit. The potentiometer labeled BW (R84) should not be adjusted, it is not used in this unit. The potentiometer labeled AT (R83) should be adjusted so that the voltage from AT-GND (pins 2 to 1) on connector P8 is 2.000 VDC ± 0.02 VDC.

- **Sample HVPS Calibration Worksheet**

A sample HVPS Calibration Worksheet is located in the appendix and may be reproduced as necessary.

9.2 Quad Amplifier Board Calibration

The detector amplifiers in the main electronics chassis should now be balanced. Note: The reference voltage for AT on the HVPS board must be set as described in Section 9.1 above, prior to performing the following adjustments.

The amplifiers are balanced by applying a "pulser" input to the respective detector connector in the hand cabinet or the floor pan or frisker panel and adjusting the gain control located on the edge of the Amplifier boards

#5323-440. See Appendix D, Drawings and Diagrams for the location of these detector inputs.

Turn the Model 49-12-2 ON and set the Background Subtract OFF, Calibrate Mode ON, and Count Time to 1 second. Press the OPER COND key to display counts and adjust the pulser to 100 mV and 1,000 CPM rate.

Attach series "C" cable to detector connector and adjust pre-amplifier gain controls for start of counting with 100 mV pulse input.

- **Sample Quad Amplifier Calibration Worksheet**

A sample Quad Amplifier Calibration Worksheet is located in the appendix and may be reproduced as necessary.

9.3 Detector Efficiency

The effiencies of all detectors should be determined using calibrated sources similar in makeup to those you are looking for.

10. MAINTENANCE AND DIAGNOSTIC TROUBLESHOOTING

This section describes daily maintenance and troubleshooting procedures.

10.1 Setting the Contrast On the Displays

The LCD (Liquid Crystal Display) is controlled by the LCD interface board (LMI #5295-512). The board is located on the right hand side of the electronics chassis. The single potentiometer on the board is used to adjust the contrast on the display. The control may be rotated in either direction while watching the LCD to obtain the desired contrast.

10.2 Initialization Failure

During initialization, all microprocessor-based boards must communicate with the central processor board. If one of these boards doesn't communicate, then the central processor tells the display to show the message "_____ BOARD IS MISSING" and initialization ceases. The next step is figuring out the problem with that particular board, or cabling to the board. If the LCD display board is not working correctly, the message may not be seen. Likewise, if the communication between the central processor and the LCD display board is not working correctly then no message will appear, but the "INITIALIZING ALL BOARDS... PLEASE WAIT" message will be overwritten with periods.

10.3 Troubleshooting the HVPS Board

The high voltage power supply (LMI# 5323-746), located in the left side of the electronic chassis, has an LED array on the board. The LED array may be viewed on the HVPS board without removing the board.

The 10 lights have the following meaning:

1) Left light - + 5V REFERENCE
2) + 5V POWER
3) +15V GENERAL
4) + 5V DIGITAL
5) FEET/FRISKER FAIL
6) No connection
7) HANDS FAIL
8) TALKER
9) HANDS READ
10) Right light-- FEET/FRISKER READ

Lights 1 through 4 should always be on, indicating that the +5V and +15V supplies are good. Upon power up with all external lights and audio on (pre-initialization), the TALKER light should blink, the POWER lights and the FEET/FRISKER READ light should be on. After initialization the TALKER light will turn off and LEDS 9 and 10 will alternate between on and off as the local processor reads each high voltage.

Lights 5 or 7 will light if the high voltage read is more than 10 percent from the high voltage setpoint. However, setting either high voltage to 250 disables high voltage fail detection.

If the LEDs indicate a properly working board and the counts are too low, then the high voltage may not be getting to the detector. The following steps should locate the problem.

- The high voltage should be measured at each detector "C" connector.

- The high voltage should be measured at the cable drivers or detector cables.

10.4 Troubleshooting the Counter Boards

The two counter (LMI# 5323-440) located in the main electronics chassis have LED arrays on the board. The LED array may be viewed on the counter board without removing the board. The 10 lights have the following meaning:

1) Left light -- No Connection
2) No Connection
3) No Connection
4) No Connection
5) +5V DIGITAL
6) LOW COUNT1
7) LOW COUNT2
8) LOW COUNT3
9) LOW COUNT4
10) Right light--TALKER

Light 5 should always be on. Upon pre-initialization the four LOW COUNT lights will be on and the TALKER LED will blink at a rate faster than once a second. The TALKER light will blink once every count time after initialization has taken place.

10.5 Troubleshooting the Central Processor Board

The central processor board (LMI #5295-526) has one LED. The LED is located at the top of the board and indicates communication errors. Every time the LED light activates, a communication error has occurred with the central processor. The software on each board can overcome an occasional communication error. However, if the LED stays on, then a continuous communication error has occurred and operation ceases.

Completely Assembled Model 49-12-2, Hand and Shoe Monitor, part no. 48-2513

10.6 LIST OF FIRMWARE:

L.C.D. 29514N04
C.P. 29511N05
CNTR 29502N12
HVPS 29513N00 (displays “32313N00”)
L.E.D. 29510N05

10.7 LIST OF BOARDS:

L.C.D. 5295-512
C.P. 5295-526
QUAD COUNTERS 5323-440
DUAL HVPS 5323-746
L.E.D. DRIVER 5295-685
LVPS 5295-517
PREAMPLIFIER 5323-442
L.C.D. BACKLIGHT 5323-535
L.E.D. DISPLAY 5295-613
MAIN BACKPLANE 5295-657
CABLE DRIVER 5295-484

10.8 Spare Parts Recommendation for Monitor LMI p/n 48-2513.

Based on an inventory of between one and five units.

Part Description	LMI P/N	Qt'y
QUAD COUNTER (8EA PER UNIT)	5323-440	(1)
CENTRAL PROCESSOR (1 PER UNIT)	5295-526	(1)
QUAD PREAMPLIFIER (8/UNIT)	5323-442	(1)
DUAL HVPS (1/UNIT)	5323-746	(1)
LED DISPLAY DRIVER (1/UNIT)	5295-685	(1)
LCD DISPLAY DRVR (1/UNIT)	5295-512	(1)
HAND DETECTOR ASSEMBLY	4295-636	(0)
FOOT DETECTOR ASSEMBLY	4295-637	(0)
PANCAKE DETECTOR	01-5008	(5)
REPLACEMENT BACKUP BATTERY	21-9693	(1)
LCD DISPLAY (AND711AST-30)	07-6360	(1)
HVPS EXTENDER BRD.	5323-631	(1)
QUAD AMP EXTENDER BRD.	5323-632	(1)
ELECTRONICS FUSE 1 AMP	21-9277	(2)
ALARM LAMP CM-756	21-9375	(4)
BNC PULSER CABLE	8303-339	(1)

11. PARTS LIST

11.1 LED Display Board, Drawing 295 x 364

Ref. No.	Description	Part No.
BOARD	Assembled LED Display	5295-613
• **DIODES**		
CR129-131	LED-E120 Yellow	07-6309
CR110	LED-E121 Green	07-6310
CR111,112, 114, 123, 126, 127, 135	LED-E118 Red	07-6308
CR120-121	LED-E121 Green	07-6310
CR118-119	LED-E119 Orange	07-6343
• **MISCELLANEOUS**		
P1	CONN-102159-3	13-8390
*	RIBBON-102312-2	
LATCH		13-7805

Note: The M49-12-2 uses blank board #6295-613, and only the LEDs needed are installed.

11.2 Detector Cable Driver Board, Drawing 295 x 275

Ref. No.	Description	Part No.
BOARD	Assembled Det Cable Driver	5295-484
	• **CAPACITORS**	
C111	100pF, 3kV, C	04-5532
C114	0.0047μF, 3kV, C	04-5547
C124-C125	10μF, 20V, DT	04-5592
C127	100μF, 10V, DT	04-5576
C129	100pF, 3kV, C	04-5532
C139	100pF, 3kV, C	04-5532
C155	100pF, 3kV, C	04-5532
	• **TRANSISTOR**	
Q135-Q136	2N3904	05-5755
Q142-Q143	2N3904	05-5755
Q146	2N3904	05-5755
Q154	2N3904	05-5755
	• **VOLTAGE REGULATOR**	
VR116	LM317LZ	05-5788
	• **DIODES**	
CR137	1N4001	07-6268
	• **RESISTORS**	
R110	10k, 1%	12-7540
R112-R113	1 MEG	10-7028
R115	243 OHM, 1%	12-7698
R117	100k, 1%	12-7557
R119-R120	10k, 1%	12-7540
R122	1 MEG	10-7028
R123	100 OHM	10-7004
R126	523 OHM, 1%	12-7708
R128	1 MEG	10-7028
R133	100k, 1%	12-7557
R134	10k, 1%	12-7540
R141	10k, 1%	12-7540

R145	10k, 1%	12-7540
R147	100k, 1%	12-7557
R148	1 G	12-7686
R150	10k, 1%	12-7540
R151	100k, 1%	12-7557
R152	10k, 1%	12-7540
R156	1 MEG	10-7028

- **MISCELLANEOUS**

P1	CONN-640456-3 MTA100	13-8081
P2-P5	CONN-640456-2 MTA100	13-8073
*	CLOVERLEAF-011-6809-000-599	
*	FUSE-CCL	21-9524

11.3 LCD Driver Board, Drawing 295 x 292

Ref. No.	Description	Part No.
BOARD	Assembled LCD Driver	5295-512
	• **CAPACITORS**	
C112	0.1µF, 100V, C	04-5521
C118	10µF, 20V, DT	04-5592
C123	10µF, 20V, DT	04-5592
C125	27pF, 100V, C	04-5614
C131	100µF, 10V, DT	04-5576
C132	0.0047µF, 100V, C	04-5570
C137	1µF, 35V, DT	04-5575
C138	0.0047µF, 100V, C	04-5570
C140	0.0047µF, 100V, C	04-5570
C145	10µF, 20V, DT	04-5592
C146	27pF, 100V, C	04-5614
	• **TRANSISTORS**	
Q133	2N7000	05-5820
Q149	BUZ 71A	05-5837
	• **INTEGRATED CIRCUITS**	
U113	MM74C923	06-6072
U114	P80C51FA	06-6236
U115	CD74HC573	06-6093
U117	CD74HC14	06-6257
U120	CD74HC573	06-6093
U121	ICL7662	06-6261
U122	CD74HC14	06-6257
U124	CD74HC245	06-6267
U126	27C512	06-6264
U127	CDM6264	06-6098
U128	CD74HC138	06-6104
	• **RESISTORS**	
R116	10k TRIMMER	09-6824
R141-R143	4.7k	10-7014
R144	10k	10-7016

R150	0.1 OHM, 3W	12-7647

- **RESISTOR NETWORK**

RN119	22k SIP 10P	12-7566
RN155	22k SIP 10P	12-7566

- **CRYSTALS**

Y148	12 MHZ HC18	01-5224

11.4 LED/Switch Board, Drawing 295 x 484

Ref. No.	Description	Part No.
BOARD	Assembled 8x8 LED Driver/20 Key switch	5295-685
	• **CAPACITORS**	
C110	10µF, 20V, DT	04-5592
C116	27pF, 100V, C	04-5614
C122	100µF, 10V, C	04-5576
C143-C145	0.0047µF, 100V, C	04-5570
C148	100µF, 10V, DT	04-5576
C149	27pF, 100V, C	04-5614
C174	0.1µF, 100V, C	04-5521
C175	100µF, 20V, DT	04-5583
	• **TRANSISTORS**	
Q112	2N7000	05-5820
Q126-Q128	2N7000	05-5820
Q130	2N7000	05-5820
Q172	2N3904	05-5755
	• **INTEGRATED CIRCUITS**	
U113	P80C51FA INTEL	06-6236
U115	87C257-200V10	06-6278
U117	CD74HC564E	06-6262
U118	UDN2595A DRIVER	06-6170
U120	UDN2981A	06-6271
U121	CD74HC238E	06-6246
U124	CD74HC14	06-6257
U165	CD74HC573E	06-6093
U173	LM358	06-6024
	• **DIODES**	
CR159-CR163	1N4148	07-6272
	• **RESISTORS**	
R111	33 OHM, 2W, 10%	12-7799
R119	4.7 OHM, 1/4W, 5%	10-7095
R125	5.6k	10-7042
R129	33 OHM, 2W, 10%	12-7799

R131-R132	5.6k	10-7042
R133-R139	4.7 OHM, 1/4W, 5% 10-7095	
R140	5.6k	10-7042
R141-R142	4.7k	10-7014
R146	10k	10-7016
R147	4.7k	10-7014
R150-R151	33 OHM, 2W, 10%	12-7799
R177	1 MEG, 1/4W, 5%	10-7028
R178	10k	10-7016

- **RESISTOR NETWORK**

RN114	22k SIP, 10P	12-7566
RN157	470OHM SIP, 10P	12-7825
RN158	22k DIP, 16P	12-7715

- **CRYSTAL**

Y123	12 MHZ HC18 MP120	01-5224

- **MISCELLANEOUS**

P62-P63	CONN-1-640456-0 MTA100	13-8066
P66	CONN-640456-6 MTA100	13-8095
P67	CONN-102153-3	13-8339

11.5 LVPS-100 VAC Input Board, Drawing 295 x 290

Ref. No.	Description	Part No.
BOARD	Assembled LVPS Input	5295-517
	• **CAPACITORS**	
C173	2200µF, 35V, E	04-5621
C176-C177	0.01µF, 100V, C	04-5523
C178	0.1µF, 100V, C	04-5521
C181	2200µF, 35V, E	04-5621
C184	1µF, 35V, DT	04-5575
C222	0.1µF, 100V, C	04-5521
C224-C25	1µF, 35V, DT	04-5575
C229	0.1µF, 100V, C	04-5521
C280-C281	470µF, 25V	04-5628
C282	100µF, 35V	04-5595
C298	10µF, 20V, DT	04-5592
	• **TRANSISTORS**	
Q168	MPS6534	05-5763
Q171	MPS6534	05-5763
Q190-Q191	MPSU01	05-5778
Q321-Q322	BUZ71A	05-5837
	• **VOLTAGE REGULATORS**	
VR277-VR278	LT1076	05-5835
VR283	LT1170	05-5836
VR323	LM340T-15	05-5823
	• **INTEGRATED CIRCUITS**	
U163	DS1231-20	06-6234
U164	TLC372I	06-6265
U165	LM385Z-1.2	05-5808
	• **DIODES**	
CR119-CR120	MBR340	07-6347
CR122	MBR340	07-6347
CR127	CBR4-L010	07-6316
CR129	CBR4-L010	07-6316

CR305	1N4001	07-6268

- **DIODE NETWORK**

CRN268	HDSP-4830	07-6336

- **RESISTORS**

R131	15k, 1%	12-7545
R132	3.4k, 1%	12-7600
R133	10k	10-7016
R134	3.4k, 1%	12-7600
R135	15k, 1%	12-7545
R136	2.21k, 1%	12-7509
R137	1k	10-7009
R138	10k	10-7016
R139	1.24k, 1%	12-7703
R140	19.6k, 1%	12-7530
R141	10k	10-7016
R142-R143	1k	10-7009
R145-R147	10k	10-7016
R148-R150	100k	10-7023
R151	5.9k, 1%	12-7616
R152	10k	10-7016
R153	2.7k	10-7055
R155	100k	10-7023
R157	2.87k. 1%	12-7649
R159	2.87k, 1%	12-7649
R160	2.21k, 1%	12-7509
R161	2.7k	10-7055
R262	680 OHM	10-7056
R264-R265	2.7k	10-7055
R269	680 OHM	10-7056
R270	2.7k	10-7055
R341	12.1, 1%	12-7628

- **INDUCTOR**

L193-L194	PE92102K 100UH	21-9672
L195	PE92114K 55UH	21-9673

11.6 Central Processor Board, Drawing 295 x 302

Ref. No.	Description	Part No.
BOARD	Assembled Central Processor	5295-526
	• **CAPACITORS**	
C113	27pF, 100V, C	04-5614
C122	18pF, 100V, C	04-5635
C150	100µF, 10V, DT	04-5576
C155	0.1µF, 100V, C	04-5521
C165	18pF, 100V, C	04-5635
C166	27pF, 100V, C	04-5614
	• **INTEGRATED CIRCUITS**	
U111CD74HC14		06-6257
U11580C51FA		06-6236
U117DS1211		06-6255
U120CD74HC573		06-6093
U121MM58274		06-6254
U127CDM6264		06-6098
U12927C512		06-6264
U141ICL7667		06-6250
	• **DIODES**	
CR118	SLH56-VR3	07-6308
CR151	1N5817	07-6290
	• **RESISTORS**	
R110	100k	10-7023
R130	1k	10-7009
R135	330 OHMS	10-7053
R138	1k	10-7009
	• **RESISTOR NETWORK**	
RN116	22k SIP 10P	12-7566
	• **CRYSTALS**	

Y114	12 MHZ HC18	01-5224
Y133	32.768 KHZ	01-5219

11.7 Backplane Board, Drawing 295 x 384

Ref. No.	Description	Part No.
BOARD	Assembled Backplane	5295-657
•	**CONNECTORS**	
J1-J2	CJ50-50B-10	13-8046
J3	D PLUG CBD21WA4F3	13-8316
J4	CJ50-50B-10	13-8046
J5	D PLUGCB21WA4F3S6000	13-8316
J6-J8	CJ50-50B-10	13-8046
J11	D PCB CBD27W2F3S6000	13-8314
P50	1-640456-0 MTA100X10	13-8066
P51-P52	640456-5 MTA100X5	13-8057
P94	640456-4 MTA100X4	13-8088
P95	640456-9 MTA100X9	13-8094
P96	102153-4	13-8338
P97	640445-6 MTA156X6	13-8071
P98	640456-5 MTA100X5	13-8057
P99	640456-6 MTA100X6	13-8095

11.8 Backlight Power Supply Board, Drawing 295 x 309

Ref. No.	Description	Part No.
BOARD	Assembled Backlight Power Supply	5295-535
	• **CAPACITORS**	
C110	10µF, 20V, DT	04-5592
C111	0.1µF, 100V, C	04-5521
	• **RESISTORS**	
R112	0.1 OHM, 3W, 1%	12-7647
	• **MISCELLANEOUS**	
P90	CONN-640456-3 MTA100	13-8081
P91	CONN-640456-5 MTA100	13-8057
*	POWER SUPPLY-CXA-L10A	21-9689
*	INSULATING SPACER-939-125	18-8960

11.9 Quad Counter Board, Drawing 323 x 261

Ref. No.	Description		Part No.
BOARD	Assembled Quad Counter		5323-440
	• **CAPACITORS**		
C13	100µF, 10V, DT		04-5576
C14-C15	27pF, 100V, C		04-5614
	• **TRANSISTORS**		
Q16	2N7000		05-5820
	• **INTEGRATED CIRCUITS**		
U5	CD74HC14		06-6257
U9	CD74HC00		06-6260
U17-U19	CD74HC573		06-6093
U21	27C512-15N		06-6264
U22	CDM6264	06-6098	
U23-U26	LS7062		06-6201
U27	80C51FA		06-6236
U28	CD74HC14		06-6257
	• **DIODE NETWORK**		
CRN20	HDSP-4830		07-6336
	• **RESISTORS**		
R29-R30	100k		10-7023
	• **RESISTOR NETWORK**		
RN31	220k SIP 10P		12-7578
RN32	22k SIP 10P		12-7566
RN33	220k SIP 10P		12-7578
RN34	2.2k SIP 8P		12-7776
	• **CRYSTALS**		
Y12	12MHZ HC18		01-5224

11.10 Quad Preamp Board, Drawing 323 x 263

Ref. No.	Description	Part No.
BOARD	Assembled Quad Preamp	5323-442
	• **CAPACITORS**	
C134	22µF, 35V, DT	04-5594
C135	100µF, 15V, DT	04-5583
C138	1µF, 35V, DT	04-5575
C140	100µF, 10V, DT	04-5576
C141	330pF, 100V, C	04-5531
C142-C143	10pF, 100V, C	04-5573
C144	100pF, 100V, C	04-5527
C145	10pF, 100V, C	04-5573
C147	0.1µF, 100V, C	04-5521
C148	0.01µF, 100V, C	04-5523
C149	10pF, 100V, C	04-5573
C150	0.1µF, 100V, C	04-5521
C151	47pF, 100V, C	04-5533
C152	10pF, 100V, C	04-5573
C153	0.1µF, 100V, C	04-5521
C154	0.01µF, 100V, C	04-5523
C158	0.1µF, 100V, C	04-5521
C159	10pF, 100V, C	04-5573
C160-C161	100pF, 100V, C	04-5527
C162-C163	47pF, 100V, C	04-5533
C164	100pF, 100V, C	04-5527
C165	47pF, 100V, C	04-5533
C166	0.1µF, 100V, C	04-5521
C169	10pF, 100V, C	04-5573
C170	100pF, 100V, C	04-5527
C171	10pF, 100V, C	04-5573
C172-C173	47pF, 100V, C	04-5533
C174-C175	0.1µF, 100V, C	04-5521
C177	100pF, 100V, C	04-5527
C178	47pF, 100V, C	04-5533
C179	10pF, 100V, C	04-5573
C180-C181	0.1µF, 100V, C	04-5521
C182	10pF, 100V, C	04-5573
C183	0.1µF, 100V, C	04-5521
C186	10pF, 100V, C	04-5573
C187	100pF, 100V, C	04-5527

C188	10pF, 100V, C	04-5573
C189	0.1µF, 100V, C	04-5521
C190	100pF, 100V, C	04-5527
C191	47pF, 100V, C	04-5533
C192	0.1µF, 100V, C	04-5521
C226	0.01µF, 100V, C	04-5523
C233	0.01µF, 100V, C	04-5523
C236	1µF, 35V, DT	04-5575
C237	330pF, 100V, C	04-5531
C256	0.01µF, 100V, C	04-5523
C263	0.01µF, 100V, C	04-5523
C266	1µF, 35V, DT	04-5575
C267	330pF, 100V, C	04-5531
C270	1µF, 35V, DT	04-5575
C277	0.01µF, 100V, C	04-5523
C279	0.01µF, 100V, C	04-5523
C282	330pF, 100V, C	04-5531
C309-C310	0.1µF, 100V, C	04-5521

- **VOLTAGE REGULATORS**

VR1	LM317LZ	05-5788

- **INTEGRATED CIRCUITS**

U97-U102	TLC372I	06-6265
U105	CD4098	06-6066
U109	CD4098	06-6066
U115	CD4098	06-6066
U116	CA3096	06-6023
U119	CD4098	06-6066
U258	CA3096	06-6023
U278	CA3096	06-6023
U283	CA3096	06-6023

- **DIODES**

CR300	1N4001	07-6268

- **RESISTORS**

R3	10k TRIMMER	09-6822
R7	47k	10-7020
R8	470k	10-7026
R9	10k	10-7016
R10	1 MEG	10-7028

R11	100k	10-7023
R12-R14	10k	10-7016
R15-R16	1k	10-7009
R17	10k	10-7016
R18	1k	10-7009
R19	10k	10-7016
R20	1k	10-7009
R21	47k	10-7020
R24	4.7k	10-7014
R25	10k	10-7016
R28-R29	1k	10-7009
R30-R31	47k	10-7020
R32	10k	10-7016
R34	5.6k	10-7042
R37	10k	10-7016
R38	4.7k	10-7014
R39-R41	10k	10-7016
R45-R46	10k	10-7016
R47	1k	10-7009
R48	10k	10-7016
R51-R53	10k	10-7013
R54	1k	10-7009
R55	10k	10-7016
R56	4.7k	10-7014
R57	10k	10-7016
R61	5.6k	10-7042
R62	330 OHMS	10-7053
R63	100 OHMS	10-7004
R64	10k	10-7016
R65	4.7k	10-7014
R66	47k	10-7020
R69	10k	10-7016
R70	1k	10-7009
R71	47k	10-7020
R72	1k	10-7009
R73	47k	10-7020
R76	47k	10-7020
R77	1k	10-7009
R78-R79	10k	10-7016
R80	22k	10-7070
R81	5.6k	10-7042
R82-R84	10k	10-7016
R89	1k	10-7009
R90	10k	10-7016
R94	1 MEG	10-7028
R223-R224	1 MEG	10-7028

R225	22k	10-7070
R227	10k TRIMMER	09-6822
R229	5.6k	10-7042
R230	100k	10-7023
R231	470k	10-7026
R232	100 OHM	10-7004
R234	330 OHM	10-7053
R235	10k	10-7016
R253-R254	1 MEG	10-7028
R255	22k	10-7070
R257	10k TRIMMER	09-6822
R260	10k	10-7023
R261	470k	10-7026
R262	100 OHM	10-7004
R264	330 OHM	10-7053
R265	10k	10-7016
R268-R269	1 MEG	10-7028
R271	330 OHM	10-7053
R272	10k TRIMMER	09-6822
R274	100k	10-7023
R275	470k	10-7026
R276	100 OHM	10-7004
R280	22k	10-7070
R281	10k	10-7016
R294	243 OHM, 1%	12-7698
R295-R297	10k	10-7016
R298	1.69k, 1%	12-7680
R301	10k	10-7016
R308	10k	10-7016

11.11 Dual HVPS Board, Drawing 323 x 447

Ref. No.	Description	Part No.
BOARD	Assembled Dual HVPS	5323-746
	• **CAPACITORS**	
C5	100pF, 3kV, C	04-5532
C8	0.0015µF, 3kV, C	04-5518
C10	0.0015µF, 3kV, C	04-5518
C13	0.0015µF, 3kV, C	04-5518
C14-C15	33pF, 100V, C	04-5616
C16-C17	27pF, 100V, C	04-5614
C18	470pF, 100V, C	04-5555
C19-C20	0.047µF, 100V, C	04-5565
C21	27pF, 100V, C	04-5614
C22-C24	0.1µF, 100V, C	04-5521
C29	0.1µF, 100V, C	04-5521
C30	0.01µF, 100V, C	04-5523
C31	100pF, 100V, C	04-5527
C32	0.1µF, 100V, C	04-5521
C36	0.0056µF, 3kV, C	04-5522
C37-C38	10µF, 20V ,DT	04-5592
C39-C43	1µF, 35V, DT	04-5575
C45-C47	100µF, 10V ,DT	04-5576
C48	10µF, 20V ,DT	04-5592
C49	100µF, 10V, DT	04-5576
C143	0.0056µF, 3kV, C	04-5522
C145	0.0015µF, 3kV, C	04-5518
C148-C149	0.0056µF, 3kV, C	04-5522
C152	0.01µF, 100V, C	04-5523
C156	0.1µ, 100V, C	04-5521
C161	100µF, 10V, DT	04-5576
C162	100pF, 100V, C	04-5527
C166	0.0015µF, 3kV, C	04-5518
C169	0.0015µF, 3kV, C	04-5518
C172	0.0015µF, 3kV, C	04-5518
C173	100pF, 3kV, C	04-5532
C177	0.0015µF, 3kV, C	04-5518
C180	0.15µF, 100V, C	04-5521

• **TRANSISTORS**

Q1	MPSU51	05-5765
Q131	2N7000	05-5820
Q133	2N3904	05-5755
Q154	MPSU51	05-5765
Q171	2N3904	05-5755

- **INTEGRATED CIRCUITS**

U64	CD74HC14	06-6257
U65	CD4052	06-6141
U67	CD74HC573	06-6093
U69	87C257	06-6278
U68	AD7549JN	06-6253
U70	80C51FA	06-6236
U71-U72	LM358	06-6024
U73	LT1078	06-6251
U74	LM331	06-6156
U75	ICL7660	06-6132
U77	TLC27M7	06-6248
U134	LM385Z-2.5	05-5791
U135	LM385Z-1.2	05-5808
U136	LM385Z-2.5	05-5791
U155	TLC27M7	06-6248

- **DIODES**

CR51-CR52	1N4148	07-6272
CR54-CR55	MR250-2	07-6266
CR60-CR61	MR250-2	07-6266
CR63	MR250-2	07-6266
CR160	1N4148	07-6272
CR163	MR250-2	07-6266
CR165	MR250-2	07-6266
CR167-CR168	MR250-2	07-6266
CR176	MR250-2	07-6266
CR181	1N4148	07-6272

- **DIODE NETWORKS**

CRN66	HDSP4830	07-6336

- **RESISTORS**

R78	10k TRIMMER	09-6824
R81-R82	1 MEG TRIMMER	09-6778
R83-R85	100k TRIMMER	09-6829
R86-R87	1 G	12-7686
R90	820 OHM	10-7060
R91	8.2k	10-7015
R92	2.2 MEG	10-7052
R93	8.2k	10-7015
R94	56k	10-7021
R95	100k	10-7023
R96	33k	10-7019
R97	100k, 1%	12-7557
R98	100k	10-7023
R99-R101	4.7k	10-7014
R102	10k	10-7016
R103	6.81k, 1%	12-7619
R104	10k, 1%	12-7540
R105	100k, 1%	12-7557
R106	47 OHM	10-7002
R109	10k	10-7016
R110	22k	10-7070
R111	100k	10-7023
R112	470k	10-7026
R113	470k	10-7026
R114	4.7k	10-7014
R115	1 MEG	10-7028
R121-R122	2.2k	10-7012
R123	5.6k	10-7042
R141	4.7 MEG	10-7030
R142	1 MEG	10-7028
R151	4.7k	10-7014
R157	1 G	12-7686
R158	4.7 MEG	10-7030
R159	10k	10-7016
R164	470k	10-7026
R170	1 MEG	10-7028
R174	1 MEG	10-7028
R175	1 G	12-7686
R178	1 MEG TRIMMER	09-6778
R179	100k	10-7023
R182	470k	10-7026
R183	1 MEG TRIMMER	09-6778
R184	22k	10-7070

- **RESISTOR NETWORK**

RN128	220K SIP 10P	12-7578
RN129	22K SIP 10P	12-7566
RN130	2.2k SIP 8P	12-7776

- **TRANSFORMER**

T138	HVPS	4275-037
T153	HVPS	4275-037

- **CRYSTAL**

Y188	12 MHZ HC18	01-5224

- **MISCELLANEOUS**

HD189	CONN-640456-2 MTA100	13-8073
P6	D PCB CBD27W2M5B80000	13-8313
P7	CONN-640456-2 MTA100	13-8073
P8	CONN-640456-4 MTA100	13-8088
*	CLOVERLEAF-011-6809-000-599	18-8771
*	CARD EJECTOR-CE-110-062	22-9725

APPENDIX A

HVPS BOARD CALIBRATION

1) Rotate chassis door down and turn instrument "ON". Access to the high voltage board is through holes on the left end of the chassis.

2) Push MAIN MENU key to select the setup menu.

a. Push 1 to select SETUP MENU. Enter the required security code. Push ENT to go to SETUP MENU II.

b. Push 2 to select BACKGROUND UPDATE INTERVAL. Set interval to 999 and push ENT. Push BKSP to return to SETUP MENU I.

c. Push 2 to select HIGH VOLTAGE SETUP. Set HANDS and FEET/FRISKER high voltage to 900 and push ENT.

d. Select OPER COND key to view the high voltage.

3) The HANDS high voltage should be measured by connecting a Ludlum Model 500 Pulser or equivalent to the LHB connector located in the floor of the hand cabinet. Measure the FEET/FRISKER high voltage at thefrisker connector located underneath the hand cabinet and on the right hand side.

4) Adjust the potentiometer labelled UH (R183) until the actual high voltage output is 900 VDC ±3 VDC.

Hands High Voltage:_____V.

5) Now measure the FEET /FRISKER high voltage at the frisker connector.

6) Adjust the potentiometer labelled LH (R81) until the actual high voltage output is 900 VDC ±3 VDC.

Foot High Voltage:_____V.

7) Measure the reference voltage for high voltages supply by carefully inserting test lead through access hole at pins 1 and 2 of the TLC27M7 op amps.

8) For the hands reference measure through the lower access hole and adjust UR (R178) if necessary for a voltmeter reading of 0.900 VDC ±3 mV.

Hands Reference Voltage:_____mV.

9) For the feet reference measure through the upper access hole and adjust LR (R82) if necessary for a voltmeter reading of 0.900 VDC ±3 mV.

Feet Reference Voltage:_____mV.

10) Now view the LCD HV Readouts and adjustif necessary the HV CAL control located on the outer edge of the HVPS board. The Readouts should be 900 VDC ±9.

11) The Threshold and Window Reference voltages are generated on the HVPS board. Access to these adjustments are again through the left end of the chassis.

12) Place a voltmeter ground lead on pin 1 of connector P8, located on the edge of the HVPS board.

13) Measure the voltage at pin 2 of P8 and adjust the AT potentiometer (R83) until the meter reads 2.000 VDC ±0.02 VDC. Note: This is the threshold reference voltage used on the m49-12-2. It will yield a sensitivity level of 100 mV and is the beta-gamma and alpha threshold from a pancake G.M. detector.

Threshold Reference:_____VDC.

16) Return the Background update time interval to the original values. The high voltage will normally be left at this 900 V level for pancake tubes.

QUAD AMPLIFIER BOARD CALIBRATION

a) Turn monitor on.

Push MAIN MENU key.
#1 key to select SETUP MENU,
Enter security code,
#3 key to select COUNT TIME,
#1, ENT key to enter value,
Press ENT key to accept value.
Press ENT to continue to SETUP MENU II.
#2 key to select BACKGROUND SUBTRACT OFF.
Press ENT to accept.
#1 key to select BACKGROUND UPDATE INTERVAL,
#9, #9, #9, ENT key to enter value,
Press ENT key to accept value.
#4 key to select SET CALIBRATE MODE ON/OFF
#2 key to set ON. Press ENT key twice to accept value.
Select OPER COND key to return to operating conditions screen.

b) Adjust pulser for a 100 mV pulse height and 1000 CPM.

c) Use a 39" "C" cable attached to pulser and open the hand cabinet lid.

d) Disconnect the LHB detector cable and attach "C" cable to this input.

e) Rotate potentiometer (R3) labelled SIG1 on board **AMP1** until counts just cease as viewed in the upper LCD.

Repeat steps d) & e) for all other channels (LHP,RHP, & RHB), the two feet channels and the frisker channel on the other amplifier board (LF and RF). To access the feet and frisker inputs it is necessary to open the plastic wrap cover and remove the roll of plastic.

SETUP EXAMPLES

1. Example #1

The M49-12-2 is placed at the egress of a laundry. All personnel leaving the laundry must check through the Hand and Shoe Monitor. Background in this area is relatively stable.

Setup: The best alarm calculation mode to use would probably be the MAX SENSITIVITY mode. The sensitivity in this mode is governed by the sigma factors. Too high a sigma factor gives poor sensitivity, and too low a sigma factor gives an unacceptable false alarm rate. The following setup gives some rationale for the numbers entered.

High voltage (hands): 900
High voltage (feet): 900
Count time: 10 seconds to give good sensitivity but not excessive delay
Background Update Limit:10 minutes
Background Subtract: On
Alarm Hold Time: 10 seconds
Low Count Alarms: (see below)
Beta Sigma: 3.10 gives false alarm rate of 1 in 1000
Beta Hand Efficiency: 26% as found in efficiency operation
Beta Foot Efficiency: 12% as found in efficiency operation
Confidence Level: 90%
Maximum Allowable Source:1500 dpm
Alarm Calculation Mode:Maximum Sensitivity

When all the above parameters are set, the M49-12-2 updates the background for the new count time and then the READY light turns on. The beta sensitivity, as shown in the OPERATING CONDITIONS window is approximately 1500 dpm. The low count alarms can now be set. If the lowest hand background is about 300 counts per minute, set the hand low count alarms at 200 counts per minute. Similarly, the foot low count alarms should be set based on the normal background from these detectors. The LOW COUNT alarm will then activate if the drops. The poly roll is not used here because its use completely blocks alpha particles and hinders beta senitivity. The false alarm rate (1 in 1000) refers to a single detector. Since the M49-12-2 has six detectors, the false alarm rate could be restated as 6 in 1000 employees or 0.6%. For a 1 in 1000 employee false alarm rate, the sigma factor should be 3.54.

2. Example #2

The M49-12-2 is used during an outage period at a power plant. It is desired to check people through a certain area as quickly as possible, but not allow anyone through with more than 2000 dpm beta contamination or 1000 dpm alpha contamination. Background fluctuates considerably in this area.

Setup: The best alarm calculation mode to use would probably be the MINIMUM COUNT TIME mode. The following setup gives some rationale for the numbers entered.

High voltage (hands): 900
High voltage (feet): 900
Count time: 10 seconds (see below)
Background Update Limit: 10 minutes
Background Subtract: On
Alarm Hold Time: 10 seconds
Low Count Alarms: (see below)
Beta Sigma: 3.10 gives false alarm rate of 1 in 1000
Beta Hand Efficiency: 26% as found in efficiency operation
Beta Foot Efficiency: 12% as found in efficiency operation
Confidence Level: 90%
Desired Source Size: 2000 dpm
Maximum Count Time: 25 seconds
Alarm Calculation Mode: Minimum Count Time

When all the above parameters are set, the M49-12-2 calculates the count time required to achieve the desired sensitivity and updates the background for the new count time and then the READY light turns on. The count time will fluctuate, becoming longer as the background rises, and shorter as the background becomes less. If the background ever rises high enough so that 2000 dpm sensitivity cannot be achieved in under 25 seconds, the HIGH BKGND alarm will activate. The background update interval is fairly short, to ensure that the background is re-evaluated frequently. The low count alarms should be set relatively low since the background and count time can both decrease. Setting the low count alarms to 0000 will cause a low count alarm only when any detector is completely "dead" or disconnected.