INSTRUCTION MANUAL

MODEL 2010

AREA MONITOR

Sept 1999

Version 2

Health Physics Instruments

330 South Kellogg Ave, Suite D

Goleta, CA 93117

(805) 967-8422

Division of Far West Technology

FUSES:

Power: MDL 1A, Others: 3AG 3A

TABLE OF CONTENTS

I. GENERAL DESCRIPTION

The HPI Model 2010 Remote Area Monitor System (RAMS) measures penetrating radiation with an ionization chamber detector, an electrometer, and a microprocessor controlled digital circuit which presents the dose rate in digital format, activates the alarms, generates digital signals for transmission to a central console, and performs an internal check on the operation of the monitor every up-date period. The basic Remote Area Monitoring System consists of two enclosures. One is the Head unit, which contains the tissue equivalent ionization chamber detector, high voltage power supply, electrometer and digitizer. This enclosure is cabled to the RAM unit, which contains the microprocessor circuit, the low voltage power supplies for the electronics, the five digit LED read-out, the status board, the visible alarm, the audible alarm, and the circuit for transmitting the data to a central console. The monitor is powered by 110VAC 60 Hz at the RAM unit.

II. HEAD UNIT

The detector is a tissue equivalent ionization chamber made of Shonka A-150 TE plastic walls and filled with TE gas. The chamber is mounted on the external surface of the enclosure and is sealed at approximately one atmosphere pressure. The volume of the chamber depends on the sensitivity of the monitor: XXXX.X mrad/h and XXXXX mrad/h ranges employ 1031 cc chambers, the XXXX.X rad/h range employs a 50 cc chamber, and the XXX.XX krad/h range employs a 6 cc chamber. The energy response of the 1031 cc chamber is shown in Figure 1. The collection voltage of 1000 volts is generated by a DC-to-DC converter. The ionization current is measured with a varactor bridge electrometer operated in a feed back circuit. For the 1031 cc chamber, the current is 2 x 10(-14) A for 0.1 mrad/h. The output of the electrometer, 0 to 10 volts, is changed to a digital signal by a voltage to frequency converter operating from 1 to 100,000 Hz. This signal is sent to the microprocessor circuit by a multiwire connecting cable through an MS type connector in the top of the Head unit.

No external controls are available at the Head unit, but two internal controls are used to set the zero of the electrometer and the overall sensitivity of the unit. The sensitivity of the unit is set so that 1 Hz corresponds exactly with a 1 in the least significant digit of the read-out display. The Head units are thus interchangeable with other RAM units of the same range. The Head units for different ranges employ different feedback resistors.

The high impedance circuit on the base of the electrometer consisting of a feedback resistor and a time constant capacitor is shielded from the rest of the circuit and the collection voltage. The collection voltage power supply is a self-contained variable voltage supply, which is factory set at 1000 volts. At this voltage 90% collection efficiency is obtained for all chambers at the highest dose rate to be measured. The voltage to frequency converter and its associated power supplies and line drivers are mounted on a plug-in circuit board.

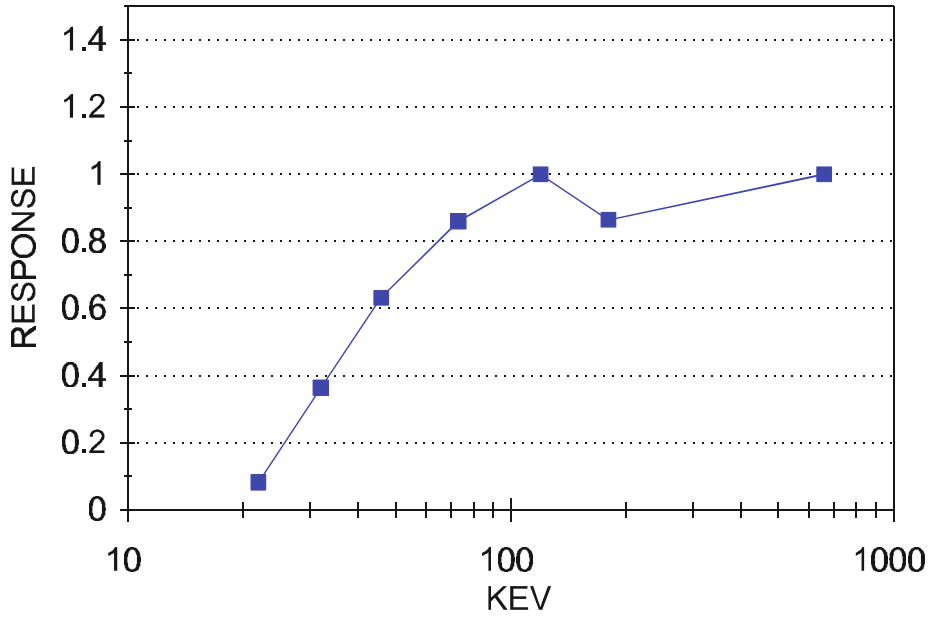

Figure 1 Energy Response of Model 2010 TE **Ionization Chamber, 1031 Cc**

III. RAM UNIT

A. GENERAL

The RAM unit is housed in an aluminum enclosure with a glass window in front of the display. The unit consists of the microprocessor circuit board, display circuit board, low voltage power supplies, and alarms. The enclosure front is hinged and is key lockable. The only controls available outside the locked enclosure are the alarm TEST and the TRIPSET (trip level display) push switches. All other controls are mounted inside the enclosure behind the locked door. Figure 2 shows the location of all the internal controls. Power for the entire monitor comes from the RAM mounting bracket. The power switch and the power fuse are mounted behind the locked door in the lower right hand corner of the enclosure.

The wall mounting bracket for the RAM unit permits the unit to be swung at an angle from the horizontal. The bracket contains the connection strips to the rest of the monitor and to the 110VAC power. Electrical conduit may be led into the top of this bracket and connected to the monitor through a binding post strip. The RAM unit power, from a twist lock plug in the back of the RAM unit, is connected to the bracket by a cable entering the bottom of the bracket. Other connections which must be made to the RAM unit are the cable from the Head unit, the twisted pair to the central console, the door interlock, and the horn, light and interlock relays. The cables from these external units enter the top of the bracket and fan out to a binding post strip. The connection to the RAM unit is made with a cable from the binding post strip through the bottom of the bracket to an MS type connector in the rear of the RAM unit. By removing the two connectors from the rear of the RAM unit, the entire unit may be easily disconnected and removed from the system for calibration or servicing. The circuit of the RAM unit contains the microprocessor for controlling the various functions. These functions will be discussed in the following sections. Some of the functions may be omitted in any particular monitor, depending on its use, but any of the functions can easily be added to existing monitors. Also three function switches may be replaced with jumpers. These appear in the upper right section of the microprocessor circuit board and are designated UNITS, RANGE and MODE. In this manual these will be referred to as jumpers, but switches could replace the jumpers to obtain a monitor to be used for different purposes.

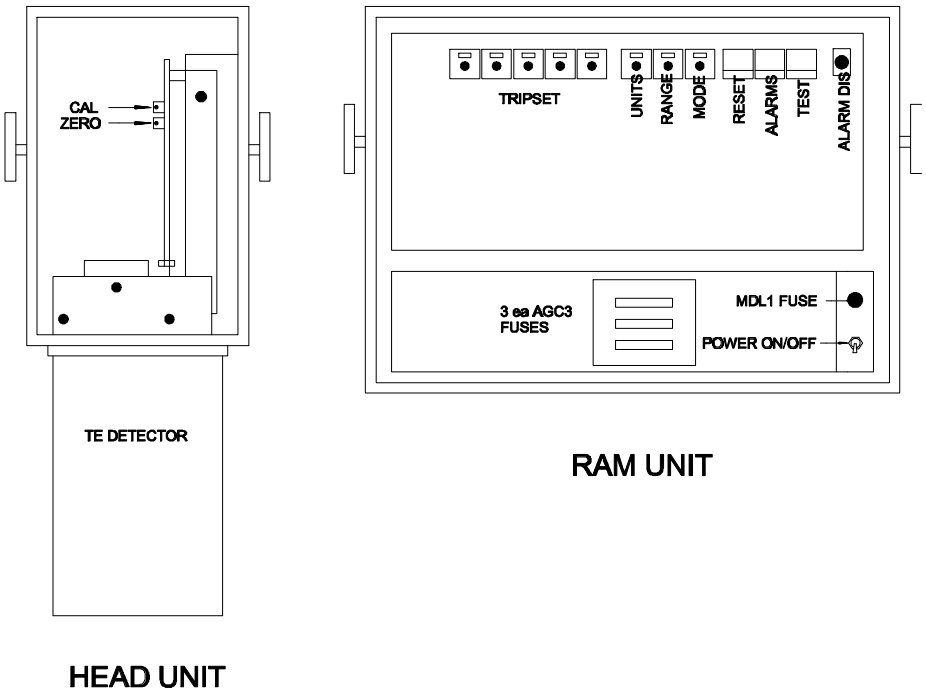

Figure 2 Location Of Controls

B. RAM UNIT FUNCTIONS

1. DISPLAY FUNCTION

The doserate is displayed as a five digit array of one inch red LEDs mounted behind a red plastic filter. The decimal point can be placed as follows: XXXXX, XXXX.X, XXX.XX, or XX.XXX and the units can be mrad/h, rad/h or krad/h depending on the detector and the Head unit. The highest sensitivity monitor has the display XXXX.X mrad/h. The decimal point location and the units can be changed by changing the jumpers in the upper right hand section of the microprocessor circuit board marked RANGE and UNITS. The units jumpers are only used to transmit the units information to the central console. The display updates (displays new data) approximately every 3 seconds and flashes to indicate the update period.

The display circuit automatically blanks all left hand zeros to the left of the decimal point except the one immediately preceding the decimal point and automatically presents a maximum of three digits of significant data by changing the fourth and fifth digits to zeros. The highest indicated reading is therefore 99900.

If the radiation level exceeds the range of the monitor, an over-range signal will be displayed. This signal is a rapid flashing of 99900.

2. ALARM FUNCTION

Audible and visible alarms are mounted on the front of the RAM unit. These alarms are activated if a preset level of doserate is reached or exceeded and are not latching. If the radiation level falls below the preset level, the alarms are deactivated. The preset doserate is entered into the unit by five thumb switches mounted inside the enclosure along the upper left hand edge of the circuit board. The trip level setting can be observed at any time by pushing the exterior TRIPSET switch. Pushing this switch replaces the doserate display with the five digits of alarm trip level.

The alarms may be tested at any time by pushing the external TEST switch. This switch activates only the alarms and not the circuits controlling them. Another TEST push switch which may be used to test the alarm circuit is inside the enclosure. This switch places 1000 (regardless of the decimal point location) into the read-out. If the trip level is set below 1000 the alarms will be activated. Note that this switch also tests the read-out.

During calibration or other periods when the audible alarm is not desired, the alarm disable toggle switch in the upper right hand corner of the circuit board may be moved from the down position (NORM) to the up position (TEST). The visible alarm will still be functional, but the audible alarm will be silenced, and no print command will be sent to the console. Note that when this switch is in the TEST position, the malfunction light will come on and if the RAM is operating properly, the green OK light will also be lit.

Two screw driver adjustable rotary switches to vary the frequency of the alarms are provided on the circuit board. The lower switch controls the light alarm, and the upper, the audible alarm. Positions 4, 3, and 2 provide different rates of interrupted alarms with position 4 being the fastest, and position 1 provides a steady alarm. Do not set on 0 since this could turn the alarms off.

The visible alarm contains two 12 volt lamps. One is a long life, low intensity lamp and the other is a high intensity, relatively short life lamp. If one lamp burns out, it is suggested that both be replaced.

3. STATUS BOARD FUNCTION

The status board contains a maximum of six LEDs to show if radiation high (above trip level) or radiation low (below trip level) conditions exist, if the door interlock is open or closed, and if the monitor is OK or malfunctioning. The red RADIATION HIGH light comes on any time the trip level is exceeded, otherwise the green RADIATION LOW light is lit. The yellow DOOR OPEN light comes on when the interlock switch on a controlling door is open, otherwise the green DOOR CLOSED light is lit. This circuit may be used to control additional alarms or to control the radiation producing device. (see MODE FUNCTION below). The yellow MONITOR MALF (malfunction) light comes on any time the monitor fails to pass the automatic internal test, otherwise the green MONITOR OK lamp is lit. The internal test consists of the following sequence of events, which occur every update period. The display is latched at the end of the update period. A small pulse is applied to the collection voltage of a polarity so as to simulate a radiation pulse. This pulse cannot be applied to the chamber if the collection voltage power supply fails. The electrometer responds to this pulse as a pulse of radiation and its output is converted to a number of digital pulses by the voltage to frequency converter. The microprocessor reads the number of pulses and if none or too few occur, the malfunction light comes on. After the test the counters are unlatched and normal operation is resumed. None of the status board functions are latching. All status board information is transmitted to the central console.

4. MODE FUNCTION

The Mode determines which type of monitor is required: the detector outside the radiation area sensing any radiation leakage through the shielding, or the detector inside the radiation area sensing whether the radiation is high and the door interlocks are closed. If they are open an unsafe condition exists, the alarms are activated and the radiation source would be deactivated. Mode 1 designates that the system is set up for the detectors inside the radiation area. Mode 0 designates that the system is set up for operation with the detectors outside the radiation area.

The general operation is as follows:

Mode 0 (detectors outside the area)
Radiation low - Door closed - no alarms
Radiation low - Door open - no alarms and machine interlock relay driver in off condition
Radiation high -Door closed - visual and audible alarms and or open machine interlock relay driver in off condition.

Mode 1 (detectors inside the area)
Radiation low - Door closed - no alarms
Radiation low - Door open - no alarms and machine interlock relay driver in off condition
Radiation high - Door closed - light alarm only
Radiation high - Door open - visual and audible alarms and machine interlock relay driver in off condition

Setting the alarms is covered in section V,D.

If the door is not used and no connection is to the terminal strip, then the door is open.

5. INTERNAL LED INDICATORS

Three red LED indicator lights are provided on the top right side of the microprocessor circuit board. From right to left they are marked INTLK, PRINT, TEST. They indicate the following:

INTLK-: Opposite to the interlock circuit for controlling the radiation source. This light is lit when the monitor is preventing operation of, or shutting down the source of radiation.

PRINT: This light is lit when a print command is being sent to the console, which occurs when there is a tripped condition.

TEST: This light is lit when the Head unit is properly cabled. It will dim at high doserates.

6. DATA TRANSMISSION TO THE CONSOLE

The RAM unit microprocessor circuit transmits the following data to the console on the RS232 data line. The baud rate is 9600, No parity, 1 stop bit.

0 The five digits of doserate

1 The five digits of trip level setting

2 The units, range, and mode codes.

3 The status board data consists of 2 bytes.

Byte #1 Upper 4 bits are always 0100, Bit 1, 2 and 3 not used; Bit 0, H=overrange
Byte #2 Upper 4 bits are always 0100. Duplicates the front panel LED's, Bit 0, H=High radiation LED on; Bit 1, H=low radiation LED on; Bit 2, Malfunction LED on; Bit 3 OK LED on.

IV. ADDITIONAL UNITS

A. SLAVE DISPLAY UNIT

The RAM unit may be equipped with a Slave Display unit that duplicates the display and the status board. The enclosure and mounting bracket are duplicates of the RAM unit enclosure and mounting bracket, but the enclosure contains no electronics. A multiwire cable connects the Slave Display unit with the RAM unit.

The cable goes through the bracket at the Slave Display unit and is connected to the Slave Display unit through the binding post strip and a D type connector on the rear of the enclosure. At the RAM unit the cable does not go through the bracket but plugs directly into the rear of the enclosure.

The RAM unit for systems equipped with a Slave Display unit contains an additional circuit board to drive the Slave Display unit.

B. REMOTE ALARMS

Remote alarms may be driven from the RAM unit. The RAM unit contains the drivers for relays to operate the remote alarms. The relays to operate the remote alarms may be mounted in either the base of the alarm or in the RAM mounting bracket. 110VAC for the remote alarms is either supplied from the bracket power lugs or obtained locally at the remote alarm location. The driver circuit is wired in a fail- safe configuration, that is, a signal must be present at the relay for a no alarm condition.

The remote alarms may be operated in the same fashion as the RAM unit alarms and respond to the predetermined interruption rate or may be operated continuously independent of the RAM unit interruption rate setting. This requires a hardware change, but is necessary if a rotating beacon is used as the visible alarm.

Please consult the factory if you need this change. The visible and audible remote alarms are independently controllable.

C. REMOTE DETECTOR SYSTEMS

In high radiation environments it is necessary to remote the detector in order to avoid radiation damage to the electrometer and voltage to frequency converter. In this case the detector is mounted on the same enclosure and bracket as the Head unit. The detector is cabled to a duplicate of this enclosure containing the electronics mounted in a low radiation environment with a low noise coax cable and a collection voltage coax cable. The cables are connected to the enclosures with BNC and MHV connectors. The cabling from the electronic enclosure is the same as in the standard units.

To prevent microphonic response from cable motion, it is advisable to run the coax cables in a conduit if applicable. Low noise cable such as Essex 21-537 with BNC Teflon connectors must be used for the signal lead. RG 59U with MHV connectors can be used for the high voltage cable.

V. OPERATION

A. TURN-ON PROCEDURE

The power toggle switch is located in the lower right corner of the RAM unit. The power fuse that is mounted beside it should be a type MDL, 1 Amp fuse. The three fuses mounted in the fuse block on the power supply protect the low voltage power supplies. They should be type AGC, 3 Amp fuses. When the instrument is first turned on or immediately following any power interruption, the RAM will go through a wait procedure that requires 20 seconds. During this period no numerals will appear, but the decimal point will be lighted, and the door interlock status lights, if supplied, will function properly. The initializing procedure can be duplicated by pushing the RESET switch on the top right of the circuit board in the RAM unit. This switch is the reset for the microprocessor. *Do not plug in any units while the power is on.* If the Head unit is not connected to the RAM unit the MALF light will come on.

B. SETTING ALARM LEVEL

Five thumb switches mounted in the upper left hand edge of the microprocessor board in the RAM unit correspond to the five display digits. The most significant digit is marked MSD and the least significant digit is marked LSD. The preset trip level is set into the circuit by setting these switches to the desired numbers. The alarms will be activated if only zeros are set in. This preset level may be verified by pressing the TRIPSET push switch on the front of the RAM unit. The preset level will then be displayed in place of the doserate but the left hand zeros will not be blanked.

C. SETTING ALARM CONTROLS

The alarm interrupt rate is set by two screwdriver adjustable switches in the center portion of the microprocessor circuit board. The lower one, marked S6, controls the light and the upper one, marked S5, controls the horn. Position 1 on the switch produces a steady alarm signal, position 2 produces a one second interrupt signal, position 3 produces a 1/2 second interrupt signal and position 4 produces a 1/4 second interrupt signal. The audible and visual interrupt signals are independent. *DO NOT USE POSITION 0*.

The local alarms may be tested by pushing the TEST push switch on the front of the RAM unit. This tests only the alarms and not the alarm circuit. To test the alarm circuit the internal switch in the upper right hand corner of the microprocessor circuit board, marked TEST, is pushed. This switch puts 1000 in the display regardless of decimal point setting, and if the trip level is below this value the alarms will be activated. Note that if the alarm disable switch is in the NORM position, a print command will be sent to the console.

The alarm disable toggle switch in the upper right hand corner of the microprocessor circuit board quiets the audible alarm when placed in the up TEST position and prevents print commands from being sent to the console. This switch should only be used during calibration or at other times when the audible alarm and print

command are undesirable. To provide a status board indication that this switch is in the TEST position the yellow MALF status light comes on but the green OK light remains on.

D. SETTING MODE

The mode of operation desired is controlled by hard wire jumpers marked MODE in the upper right hand section of the microprocessor board. For monitors to be used outside a radiation area the proper mode is designated 0. (If a switch replaces the jumpers, the 0 and 1 designations correspond to the switch positions.) In this mode the monitor will activate both alarms any time the preset radiation level is reached or exceeded. Mode 1 is used when the detectors are inside the radiation area, and the audible alarm is activated only when a controlling door interlock is open. In Mode 1 the visible alarm is activated any time the radiation level reaches or exceeds the preset level. For operation in both modes, a relay driver is provided which can be used in an interlock circuit to turn off a source of radiation or a machine if unsafe conditions exist.

The truth table for all the variables is:

			<<<RAD HIGH>>>			<<<RAD LOW>>>		
DOOR	MODE	ALM DIS	LIGHT	HORN	INTRLK	LIGHT	HORN	INTRLK
closed	0	dis	off	off	set	on	off	Off
closed	0	norm	off	off	set	on	on	Off
closed	1	dis	off	off	set	on	off	set
closed	1	norm	off	off	set	on	on	set
open	0	dis	off	off	off	on	off	Off
open	0	norm	off	off	off	on	on	Off
open	1	dis	off	off	off	on	off	Off
open	1	norm	off	off	off	on	on	Off

Notes: ALM DIS refers to the alarm disable toggle switch in the upper right hand corner of the microprocessor circuit board. INTRLK refers to the interlock circuit controlling the radiation source. Mode 2 and 3 are the same as 0 and 1 respectively if the RAM is not equipped with a tripset.

VI. INSTALLATION

The wall bracket for the RAM unit will have three cables attached as it is received. Remove the cover plate from the RAM mounting bracket. The three 1/4" holes in the rear are for mounting. Firmly mount this bracket and the Head unit bracket to the wall with screws or lags. Either electrical conduit or cables can be led directly into the top of the RAM mounting bracket and the wires attached to the binding post strips. The power strip is the three lug strip on the right. If three wires are used when installing the power input, follow the color code of the cord leading to the RAM unit by matching the green, white, and black leads. The green ground lead is grounded in the enclosure and should not be grounded to the bracket. If only two wires are used and the conduit is considered ground, match the white and black leads and move the green lead from the RAM unit to the furthest left lug which is a chassis ground.

The 15 lug binding post strip is for the signal connections. Starting from the far left, the sequence is:

LUG No.	LETTER	COLOR	FUNCTION	TO
1	A	BLK/GRN & SHIELD	GROUND	HEAD UNIT
1	A		DOOR INT	SW RETURN
1	A		HORN RELAY	RETURN
1	A		LIGHT RELAY	RETURN
1	A		INTLK RELAY	RETURN
2	B	WHT	RADF-	HEAD UNIT
3	C	BLK/WHT	RADF+	HEAD UNIT
4	D	GRN	MALFP	HEAD UNIT
5	E	RED	+24V	HEAD UNIT
6	F	BLK/RED	-24V	HEAD UNIT
7	G		DOOR	INTLK SWITCH
8	H		HORN	RELAY
9	I		LIGHT	RELAY
10	J		INTLK	RELAY
11	K		No connection	
12	L		No connection	
13	M		RS-232 SIG	To Console
14	N		RS-232 GND	To console
15	SHIELD			To console

Note: The plug letter refers to the pin letter on the MS type plugs to the RAM unit and the Head unit. The colors apply to the cable (Belden 9503).

After installation of the brackets, replace the cover plates, hang the units on the brackets, and plug them in. The RAM unit should be adjusted at the most convenient angle for viewing. The Head unit is equipped with setscrews that match holes in the bracket to hold it vertically. The setscrews can be unscrewed from the enclosure into the bracket holes. Tighten the hand screws firmly. To replace the RAM to Head cable use Belden type 9503 shielded cable or equivalent and connector type MS 3102A2027S with MS 3057-12A with bushing. For cable lengths up to 100 feet, connect the colored wires to the plug letters A, B, C, D, E, and F according to the above table. Do not connect the shield. Jumper pins A and N in the plug. At the mounting bracket use either solder or crimp lug terminals and connect the colored wires to lugs 1,2,3,4,5, and 6 according to the above table and the shield to lug 1. For distances greater than 100 feet, omit the jumper in the MS connector and connect the cable shield to pin M.

The cable from the RAM to the console is Belden type 9182. At the bracket the shield is connected to lug 15, the black wire to lug 14, and the colored wire to lug 13 using terminal lugs.

VII. CALIBRATION AND TESTING

A. TESTING OF RAM UNIT

The RAM unit has a built in pulse generator which is controlled by the crystal oscillator. This oscillator is set for 1000 Hz. When the TEST push switch in the upper right hand corner of the microprocessor circuit board is depressed the oscillator is connected to the input of the read-out circuit. The display should show 1000 (disregard the decimal point) after a complete up-date period if the RAM unit display is functioning properly.

B. RADIATION CALIBRATION

Local radiation calibration procedures are usually developed depending on the sources and facilities available. Using a cobalt 60 or cesium 137 source, the following procedure is suggested for calibrating the monitor at a calibration facility:

Remove the front of the Head unit. Two adjustments are available on the circuit board. With the detector in a down position, the upper adjustment is sensitivity and the lower one zero set. Set the unit in a background radiation field and set the zero by first adjusting it to read 1 in the least significant digit and then turning the adjustment until the reading is just zero.

To set the sensitivity of the most sensitive units (XXXX.X mrad/h), set the Head unit in a known field of radiation of approximately 1000 mrad/h. Set the sensitivity control to match the known dose rate. This will have to be done using successive adjustments with the operator making the adjustments only with the source shielded. It should be noted that the Head unit is the variable, the RAM units all have the same sensitivity. Thus any Head unit can be calibrated on any RAM unit for use on any other RAM unit.

After setting the sensitivity set the Head unit in a field of between 4000 and 5000 mrad/h and observe the read-out. Set the Head unit in a field of between 8000 and 9000 mrad/h and observe the read-out. Readings a few percent low may occur due to incomplete collection at high doserates, but should not exceed 10%. Set the Head unit in a field in excess of 10000 mrads/h to observe the overflow indication.

If it is desirable to calibrate the Head unit and the particular RAM unit which is used with that detector, it is suggested that a separate power cord and a separate cable with MS type connectors be made up so that the wiring in the RAM mounting bracket can stay in place. See Accessory parts list.

If calibrations are to be performed in place, a local shielded source can be used in a manner in which the source - detector geometry is reproducible. High radiation level readings may be difficult to attain in this manner, but the calibration of the lower part of the range would be valid. If calibrations are performed in place, the alarm disable switch in the upper right corner of the microprocessor circuit board may be switched from NORM to TEST to quiet the audible alarms. It should be noted that in this condition no print command will be sent to the console.

VIII. MAINTENANCE

The only periodic maintenance required is replacing the desiccant in the detector housing if necessary. Remote read-out units installed in high radiation environments may require new cables and or red plastic filters if the accumulated total dose becomes too great. The outside face of the viewing window is glass and should be cleaned periodically.

If the Head unit is subjected to very high humidity for extended periods and the desiccant is bad, the ceramic feed-through insulator make leak slightly. If this condition arises, the leakage will be downscale, that is in a direction that will try to make the RAM read negative radiation. If this reading becomes approximately -5 in the least significant digit, the MALF light will come on and the monitor will be reading low in the right hand digit. This condition can be quickly corrected by turning the RAM off, removing the front cover of the head unit, removing the small cover plate at the detector end of the enclosure and blowing warm (not hot) air with a hot air gun or hair dryer into the volume with the high impedance circuit and ceramic feed-through. Replace the small cover and

turn the RAM on and wait a few minutes for a steady zero reading. Adjust the zero if necessary, and replace the desiccant. Then replace the outer cover.

IX. PARTS LIST

COMPUTER BOARD PARTS LIST

QTY REQ	UNIT	DRAWING NUMBER	PART NUMBER	DESCRIPTION	MFG
1	EA	R1	89PR1MEG	1 meg pot	Beckman
1	EA	R2		51K 5% 1/4W CF	Mepco
1	EA	R3		3 meg 5% 1/4W CF	Mepco
1	EA	R4		1K 5% 1/4W CF	Mepco
1	EA	R5		3.3K 5% 1/4W CF	Mepco
16	EA	R6 to 21,24		1K 5% 1/4W CF	Mepco
2	EA	R22,23		180 ohm 5% 1/4W CF	Mepco
1	EA	R25		390 ohm 5% 1/4W CF	Mepco
3	EA	C1,2,3	TAC225K025P03	2.2 uf, 25VDC tant	Mallory
2	EA	C4,5	C320C10425U1EA	.1 uf, disc ceramic	U-CAR
1	EA	C6	TAC226K010P04	22 uf, 10VDC tant	Sprague
25	EA	FC	C320C104Z5U1EA	.1 uf disc ceramic	U-CAR
33	EA	D1,8 to 39	1N914	diode	
3	EA	D2,3,7	TIL209A	LED, red, T 3/4	T.I.
3	EA	D4,5,6	1N4004	diode	Fair
1	EA	Y1	MP-061	6.144 MHZ XTAL	Crystek
1	EA	U1	P8085A	MICROPROCESSOR	Intel
1	EA	U2	DS1488N	RS 232 LINE DVR	
1	EA	U3	7432N	QUAD OR	
1	EA	U4	74156	3 to 8 DECODER	
1	EA	U5	P8212	ADDRESS LATCH	Intel
1	EA	U6	74LS14N	HEX INV SCH TRIGGER	
1	EA	U7	2716	EPROM/program	HPI
1	EA	U8	P8156	RAM/IO	Intel
1	EA	U9	74L08N	QUAD AND	
1	EA	U10	7406N	HEX INV.	
1	EA	U11	P8253-5	16 DEC COUNTER	Intel
1	EA	U12	7400N	QUAD NAND	
1	EA	U13	8279-5	KEYB/DISPL INTERFACE	Intel
1	EA	U14	MC4040BCP	BINARY DIVIDER	MOT
3	EA	U15,16,17	6N139	OPTO ISOLATOR	H.P.
1	EA	U18	8211	VOLTAGE DETECTOR	Intersil
1	EA	VR2	78L12CP	+12V reg 5%	MOT
3	EA	Q1,2,3	2N6121	NPN PWR trans	
2	EA	S2,4,7	REK	SPDT	ITTShadow
1	EA	S3	MTA106D	SPST switch pcmt.	Alco
2	EA	S5,S6	230065G	5 pos. rot. sw.	EECO
8	EA	S8 to S15	210002G	BCD switch 0-9	EECO
1	EA	J1	609-3428	34 Pin Header	Ansley
1	EA	J3	03-09-2092	10 cond. connector	Molex
1	EA	J3	03-09-1093	10 cond. connector	Molex

RAM CHASSIS PARTS LIST

QTY REQ	UNIT	DRAWING NUMBER	PART NUMBER	DESCRIPTION	MFG
1	EA	LC1		Line cord with C2F attached	
				or	
1	EA	LC1A		3 wire cord with C2F attached	
1	EA	LF1	1B1	Line Filter	Corcom
1	EA	F4H	342014	Fuse holder panel	Bussman
1	EA	F4	AGC-3	Fuse	
1	EA	F1 to F3H	3823-3	3 pole fuse holder	Bussman
1	EA	F1	MDL-1A	Fuse	
1	EA	F2	AGC-3A	Fuse	
1	EA	F3	AGC-3A	Fuse	
1	EA	PS1	HBAA-40W	Power supply	POWER-1
1	EA	J1M	7595	twist lok M chassis	Hubbell
1	EA	J1F	7593	twist lok F cable	Hubbell
1	EA	J2M	MS3108A20-27P	14 pin #20 RA	Cannon
1	EA	J2M	MS3057-12A with bushing		Cannon
1	EA	J2F	MS3102A20-27S	14 pin box #20	Cannon
1	EA	C4	609-3428	34 pin pcmt strip con	Ansley
1	EA	CAB1		cable consists of	
2	EA		609-3430	connector mass term	Ansley
1	FT			34 cond cable	Ansley
2	EA		609-3431	cable strain release	Ansley

1	EA		609-3428	34 pin connector	Ansley
1	EA			Printed Circuit Board	

DISPLAY BOARD PARTS LIST

QTY REQ	UNIT	DRAWING NUMBER	PART NUMBER	DESCRIPTION	MFG
13	EA	R1-8,R25-29		3.3K 1/4W 5% CF	Mepco
20	EA	R9-24,R41-44		1K 1/4W 5% CF	Mepco
8	EA	R45-52		15 ohm 1/2W 5% CF	Mepco
6	EA	R35-40		180 ohm 1/4W 5% CF	Mepco
1	EA	C1	TVA1207.5	150 uf 25VDC	Sprague
2	EA	C2,3	C320C104Z5U1EA	.1 uf ceramic	U-CAR
1	EA	D1	TIL 209-A	red 3/4 LED	T.I.
1	EA	D2	TIL 228-1	red 1-3/4 LED	T.I.
3	EA	D3,5,7	TIL 234-2	green 1-3/4 LED	T.I.
2	EA	D4,6	TIL 240-1	yellow 1-3/4 LED	T.I.
9	EA	Q1-8,29	2N3392	NPN sig trans	G.E.
13	EA	Q9-16,18,20 22,24,26	2N6125	PNP pwr trans	FAIR
5	EA	Q17,19,21 23,25	2N6067	PNP sig trans	G.E.
2	EA	Q27,28	2N6121	NPN pwr trans	MOT
1	EA	U1	7407	hex buff HV	NAT
2	EA	U2,3	7406N	Hex O.C. Invert.	NAT
5	EA	DS1-5	LR1723R	1" 7 seg red display	IEE
1	EA	HORN	X70W06	horn	Project Design
1	EA	LIGHT	106R	light	Peterson
1	EA		259	Light Bulb for light	SYLVAN
1	EA		194	Light bulb for light	GE
2	EA	S1,2	MPA106F	SPST push mom	Alco
1	EA	S3	MPA206R	DPDT push mom	Alco
1	EA	J1	609-3428	34 pin PC connector	Ansley

HEAD PARTS LIST

QTY REQ	UNIT	DRAWING NUMBER	PART NUMBER	DESCRIPTION	MFG
1	EA	R1	104	5 x 10 (09)ohm	ELTEC
1	EA	R2	89PRl00K	100K pot	Beckman
1	EA	R3	89PR20K	20K pot	Beckman
1	EA	R4		24K 5% 1/4W CF	Mepco
1	EA	R5		1K 5% 1/4W CF	Mepco
1	EA	R6		50K 5% 1/4W CF	Mepco
1	EA	R7		3.3K 5% 1/4W CF	Mepco
1	EA	R8		10 ohm 5% 1/4W CF	Mepco
1	EA	R9		820 ohm 5% 1/4W CF	Mepco
1	EA	R10		dependent on PWR SUPPLY	
1	EA	C1	SXK series	10 pf to 10000 pf	Mallory
5	EA	C2,5,8,9,12	C320C104KM5	.1 uf ceramic	U-CAR
1	EA	C3	SXK333	300 pf poly	Mallory
1	EA	C4	SX210	1000 pf poly	Mallory
1	EA	C6,7	TDC685M050FL	15 uf 25 VDC tant	Mallory
3	EA	C10,11,13	TT25X150	150 uf 25VDC	Mallory
1	EA	U1	3430J	Var. Electrometer	BurrBrown
			MC2800	Socket	BurrBrown
1	EA	U2	VFC-32KP	V-F connector	BurrBrown
1	EA	U3	DS8830N	Line Driver	National
1	EA	U4	6N139	opto iso	H.P.
1	EA	U5	LM7815CT	+15V reg	National
1	EA	U6	LM7915CT	-15V reg	National
1	EA	U7	LM7805CT	+5V reg	National
1	EA	HVPSI	PMT20A-N opt. 3	2KV PWR SPLY	Bertan
1	EA	D1	1N914	diode	
2	EA	D2,3	1N4004	diode	
		J1	MS3102A20-27	#20 14 pin MS con.	AMPH
		J2	250-22-30-170	22 pin card edge con.	Cinch
		J3	143-012-01	12 pin card edge con.	AMPH
2	EA		THM6073	heat sink	
2	EA		105-0851-001	connector	Johnson
2	EA		14-2010-1027	elect. cover	HPI
2	EA		14-2010-1026	HVPS mount	HPI
1	EA		14-2010-1025	elect. shield	HPI
1	EA		14-2010-1022	det. encl. bottom	HPI
1	EA		14-2010-1023	det. encl. cover	HPI
1	EA		14-2010-1024	wall bracket	HPI
1	EA		820	lug post (R1,C1 MTG)	HH Smith
1	EA		21-2010-004	ribbon cable	HPI

ACESSORY PARTS LIST

QTY REQ	UNIT	DRAWING NUMBER	PART NUMBER	DESCRIPTION	MFG
1	EA		21-2010-001	connector cord from RAM to mounting bracket for 110VAC	
1	EA		21-2010-002	connector cord from RAM to mounting bracket for signal	
1	EA		21-2010-003-5 *	connector cord from RAM mounting bracket to head 5' long	
1	EA		21-2010-003-XX	connector cord from RAM mounting bracket to head XX' long. Specify length.	
1	EA		21-2010-004	(see head ribbon cable listing)	
1	EA		21-2010-005	Connector cord from RAM to head. For calibration or stand alone use.	

*consists of: 1EA MS3102A-27
1EA MS3057-12A with bushing
5' 9503 Belden wire

SPARE PARTS LIST

The following items are recommended for spare parts to maintain the instrument on two levels. Level 1 is a plug-in replacement level and level 2 is a component parts replacement level.

LEVEL1

QTY REQ	UNIT	PART NUMBER	DESCRIPTION	MFG
1	EA	17-2010-110000	COMPUTER BOARD WITH WIRING HARNESS	HPI
1	EA	17-2010-509120	DISPLAY BOARD COMPLETE	HPI
1	EA	17-2010-713300	V/F BOARD COMPLETE	HPI
1	EA	HBAA-40W	Power Supply	POWER1
1	EA	3430J	ELECTROMETER	BURRBRN
1	EA	2010-5	DETECTOR	HPI
1	EA	PMT20A-N OPT3	HV POWER SUPPLY	BERTAN
5	EA	MDL 1	Fuse	BUSSMAN
5	EA	AGC 2	Fuse	BUSSMAN

LEVEL2

ALL U's from parts list
ALL D's from parts list
ALL Q's from parts list

2	EA		GLASS PANEL FRONT	HPI
1	EA	X70W06	HORN	PROJDES
12	EA	259	LIGHT BULB	SYLVAN
12	EA	194	LIGHT BULB	G.E.
10	EA	LR-1723R	1"7SEG DIGITAL DISPLAY	IEE