
OPERATIONS AND REPAIR MANUAL

MODEL REM 500B

NEUTRON SURVEY METER



PRELIMINARY

October 2004 Revision B2

This manual is for REM 500B. The model number is displayed at turn on.

The REM-500 may contain a small check source. Please read the section on radioactive material.



health physics instruments

INFORMATION

This instrument is manufactured in the United States of America by:

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Health Physics Instruments is a division of Far West Technology, Inc.

Both Health Physics Instruments and Far West Technology have been manufacturing radiation-measuring devices since 1972.

Repair Service

Although we design and manufacture our instruments to a high standard, we realize that repairs are sometimes necessary. If you believe service is needed on this instrument please call our service department before shipping the instrument to us for repair; often we can help you with simple problems. If you do decide to return it to us for repair then please include:

1. Contact person's name
2. Organization or Company name
3. Address
4. Phone number of contact person
5. Description of the problem
6. Anything else you may think important

We will inform you of the repair charges and wait for your authorization before we repair your instrument.

Emergency Turn On

If the batteries are good and the instrument will not turn on, it is possible that the instrument is actually turning on but the contrast is set too light or dark. To do an emergency contrast setting, hold down the light button and the power button. After 10 seconds release only the power button. When you see the display, release the light button. If this does not work, try it again.

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I. SPECIFICATIONS

MECHANICAL

Size: 12"L x 4.5"W x 4.5"H excluding handle, handle extends height to 6.25".

Weight: 5 lbs, 2 oz including alkaline batteries.

External Controls: 5 pushbutton switches for POWER ON/OFF, MODE, ALTERNATE, RESET and LIGHT.

Internal Controls: Cal and Reset pushbutton; Pole Zero, High Voltage, and LLD trimpots.

DETECTOR

Type: Sealed Spherical TE Proportional Counter. Rossi Type. 2 1/4" ID.

Wall Material: A150 Conducting Tissue Equivalent plastic.

Wall Thickness: 0.12 cm, 144 mg/cm, Aluminum can .065"

Filling Gas: Propane gas, 2 micron (13.3 mmHg) jsh

Optional Internal Source: Less than 1 μ Ci Cm 244

OPERATIONAL

Readout: Alphanumeric 2 line x 16 character LCD

Range: Autoranging from 0.01 urem/h to 999 rem/h and 0.01 urad/h to 999 rad/h rate and .001 mrem to 999 rem and .001 mrad to 999 rad integrate. SI units of Sv and Gy are also selectable.

Multi-Channel Analyzer: 256 Channel MCA. 65535 counts/channel.

Temperature Dependence: less than + - 15 % from 15 to 45 Deg C

Humidity Response: Less than 10 % change from 0 to 95 % RH non-condensing.

Neutron Energy Response: 70 KeV to 20 MeV

Gamma Response: Less than 1% at 1 rad/h (Cs137)

Warm Up Time: 5 seconds

Battery Life: 100 hours; 6 ea alkaline C cells.

Approx 480 counts/mrem (Cf252)

II. INTRODUCTION

The Rem 500 is a Neutron Survey Meter that reads in both rem and rads. It is a small light portable neutron-measuring instrument that is at home both in the field and in the lab. This manual describes its operation and use.

NOTE: This manual covers operation with conventional units. If the instrument is programmed to SI units, then please substitute Gy for rad or Sv for rem. Other slight changes because of the units change may be noticed.

III. GETTING STARTED

The instrument is very easy to use. There are only 5 controls across the top of the instrument. All of the controls are push buttons. To turn the instrument on, push the ON/OFF button. The instrument will first do a self-test and wait until it stabilizes. The display will show the remaining hours on the battery and the version of the software.



Figure 1 Opening Display

When the instrument is finished with the opening display, it goes into normal operation. Assuming that the instrument is not exposed to radiation, it will display .000 mrem/h. You will notice a number in the upper right hand corner; this is the number of counts from the detector in the last second. The bottom line of the display shows a digital log bargraph.



Figure 2 Rate Display

Changing from rem to rad is very easy, just push the ALT button. Each time it is pressed it changes from rad to rem or from rem to rad. It just alternates back and forth between the two.

If you are having difficulty seeing the display because you are in dim light, pushing the LIGHT button will turn on the display backlight, which will turn off automatically in 15 seconds or you can push it again to turn it off.

To change from the rate mode of operation, to the integrate mode, just push the MODE button twice. To get back to the RATE mode, again push the MODE button twice. Switching back and forth between rate and integrate is very easy, just push the MODE button twice.



Figure 3 Integrate Mode Display

The integrate mode has a slightly different display. The Integrate time is shown on the lower left. The counts that have been acquired are on the lower right followed by the letter "c". The upper right is blank. The ALT, RESET, and LIGHT buttons work in this mode just like the rate mode.

You have now run the instrument through its basic operation. More areas of the instrument are discussed in the following sections. Remember you cannot hurt the instrument if you push the wrong button at the wrong time. Turning it on and off will restore it to normal operation.

IV. MODES OF OPERATION

There are two main modes of operation, rate and integrate. In addition may be an optional Check mode, which is discussed in the Check Mode section. Each mode can be identified by the arrangement of the display.

A. Rate Mode

Figure 4 shows the display of the RATE mode. When first turned on, the instrument is in this mode. The integrate mode can be reached by pushing MODE twice from the Rate mode.

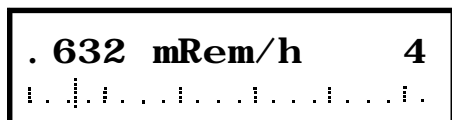


Figure 4 Rate Mode

The radiation level, autoranging from .001 mrem/h to 999 rem/h, is shown on the upper left. If the instrument is reading rads, then it will show between .001 mrad/h and 999 rad/h. The upper right hand corner shows the number of events that have been counted during the last second or cumulative depending on the time constant setting. If the battery is weak, the word BAT will flash in the same place.



Figure 5 Log Bargraph

The bottom line shows a log bargraph. The bargraph is linear between decades. The far left hand is 0 and the major divisions are 1, 10, 100, 100 mrem/h or mrad/h and 1 and 10 rem/h or rad/h.

B. Integrate Mode

Figure 6 shows the Integrate display. The Integrate display can be reached by pushing MODE twice from the RATE display. The display is updated every second. The radiation level, autoranging from 0.01 urem to 999 rem, is shown on the upper left. If the instrument is reading rads, then it will show between 0.01 mrad and 999 rad.



Figure 6 Integrate Display

The lower left shows the time of integration. It displays the time in HRS:MIN:SEC. It updates every second. The lower right hand corner shows the number of counts. You can switch between rem and rad using the ALT button to show the two levels. Pushing the Reset button will reset the time and the dose for both rem and rad. The upper range of time is 194 days but the display will roll over to 00:00:00 after 99:59:59.

The integrate range in both rem and rad is always working except when the instrument is not displaying rate or integrate. When it is in the change mode, Level 1, 2, 3, check or display, the integrate range stops gathering data and the time is also stopped. You can switch between rem and rad without losing data.

V. BUTTONS

There are 5 buttons on the front of the instrument. Their operation is described below.

A. Button description

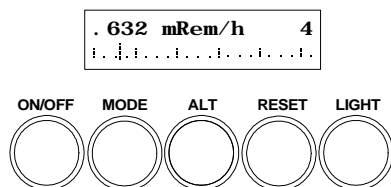


Figure 7 Button Locations

ON/OFF turns the instrument on and off. If the instrument is on, pushing it will turn it off. If it is off, pushing it will turn it on. If the instrument is on it, will reset if the on/off button is held down for 15 seconds.

MODE selects the various modes and displays. Pushing it twice will switch between rate and integrate and vice a versa. Pushing it once will enter the menu of Level 1.

ALT is for ALTERNATE which selects between rem and rad. If the instrument is reading in rem pushing the ALT will switch to rad. If the instrument is reading in rad, pushing it will change to rem.

RESET resets the mode that is showing on the display.

LIGHT turns on the light for 15 seconds when in rate or integrate displays. If you are in the various menus, pushing the light will keep it on until you go back to normal operation. If the light is on, pushing the light button will turn it off.

B. Buttons in each level (Summary)

NOTE: To reach LEVEL 1 from normal operation push MODE.

LEVEL 1 INT Puts the instrument into the Integrate mode.

LEVEL 1 RATE Puts the instrument into the Rate mode.

LEVEL 1 NEXT Changes from level 1 to level 2

NOTE: To reach LEVEL 2 from normal operation push MODE, NEXT.

LEVEL 2 TC Changes the Time constant of the instrument for the Rate mode. Each time it is pressed it changes to the next time constant. There are five time constants, fast, medium, slow, infinite and infinite+. The instrument will remember the time constant when it is turned off. The next time it is turned on it will have the same time constant.

LEVEL 2 BUZ Turns the buzzer on and off.

LEVEL 2 NEXT Changes from level 2 to level 3

NOTE: To reach LEVEL 3 from normal operation push MODE, NEXT, NEXT.

LEVEL 3 CHECK Turns on the optional check source and checks for the peak channel number from this operation. See section on Check.
OR

LEVEL 3 MCA Changes to the optional MCA mode if RS232 is installed with no Source.

LEVEL 3 DISPL Changes to the display menu.

LEVEL 3 NEXT Changes from level 3 to normal operation.

LEVEL 3 DISPLAY MENU Changes the contrast of the LCD. Repeatedly push lite or dark to change the contrast of the LCD Display. There are 32 levels of contrast. Each push of the DISPL button will change the contrast by one level. Just keep pushing the button until the contrast looks correct. When the instrument is turned off, it remembers the contrast setting. Holding down the button will not change the contrast.

VI. CHANGE MODE

The change mode allows adjustment of the display contrast, time constant, buzzer, and a way to enter the optional check and MCA mode.

There are other levels of displays that can be shown besides the rate and integrate displays. We have named them level 1, level 2, level 3, check, MCA, and display. You may have noticed level 1 when you switched between the rate and integrate modes. On these displays the meaning of the keys are changed. The new meaning is shown on the display.

The five levels are shown below. To get to level 1 push the MODE key once. To get to level 2 just push the NEXT key. To get to level 3 just push the NEXT key again, and to get back to normal operation, just push the NEXT key again. If you are in the Check display, pushing NEXT will get you back to normal operation.

A. Level 1 Menu

This is the display for the Level 1 menu if the instrument was in the rate mode when the MODE button was pushed.



Figure 8 Display from Rate Mode

You will note that the new definition of the MODE button is integrate. If the instrument was in the integrate mode when the MODE button was pushed, then the display would look like the next example. This change of definition of the key is the way it is possible to switch between the Rate and Integrate mode just by pushing the mode button twice. To exit this menu, push either the INT or RATE and you will be back in normal operation. NEXT moves you to the next display as shown below.

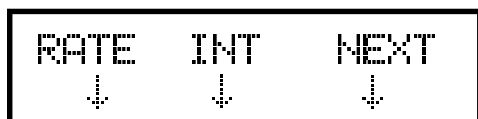


Figure 9 Display from Integrate Mode

B. Level 2 Menu

This is the display for the LEVEL 2 MENU. It allows adjustment of two items, the Time Constant or TC and the buzzer.

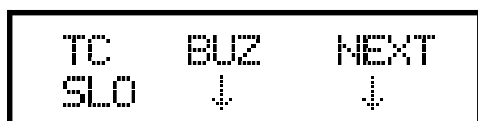


Figure 10 Level 2 Menu

Pushing the buttons under each one changes the corresponding item. For example, pushing the TC button would change the TC from SLOW to MEDIUM. Pushing the BUZZer button would turn the buzzer on if it was off and off if it was on. It will beep when turned on.

NEXT moves you to the next display as shown below.

C. Level 3 Menu

This is the Level 3 menu that only allows you to go into the display contrast mode, optional check mode, or optional MCA mode depending on the options installed on the REM 500.



Figure 11 Level 3 Menu with Source Option

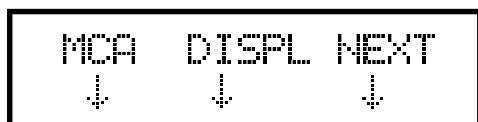


Figure 12 Level 3 Menu with the RS232 Option and no Source

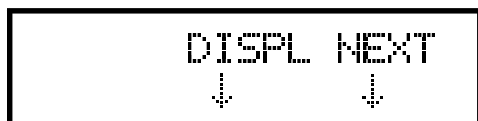


Figure 13 Level 3 Menu with no options

Pushing the DISPLay button changes into the display menu. Pushing the CHECK button changes to the Check menu and pushing the MCA button changes to the MCA mode.

NEXT moves you to the next display as shown below or returns you to the normal operation depending on the options installed on the REM 500.

D. Level 4 Menu

If equipped with both the Source and the RS232 Option, the REM 500 has a 4th menu.



Figure 14 Level 4 Menu with Source and RS232 Options

MCA moves to the MCA mode.

NEXT returns you to the normal operation.

E. Check Menu

This is the Check menu used for validating the detector.



Figure 15 Check Menu

The numbers under the LFT, PK and RT will be calculated, the numbers shown are just for reference. See the Check section on page 14 for an explanation of Check. NEXT returns you to normal operation.

F. Display Menu

This is the display contrast menu. This mode allows you to vary the contrast of the LCD display.



Figure 16 Display Contrast Menu

Repeatedly push the LITE button to decrease the contrast of the display. Repeatedly push the dark button to increase the contrast of the LCD. Holding the button down will do nothing.

NOTE: It takes 32 pushes of the buttons to go from full light to full dark.

NEXT returns you to normal operation.

G. MCA MODE

This is the optional multichannel analyzer mode and is used to dump the contents of the memory to an external computer for analysis. For a detailed description of this mode see the MCA section on page 17.



Figure 17 MCA Mode

VII. TIME CONSTANT

The rate mode has five time constants. There are two different types, average and infinite integrate.

A. Average Time Constant

The average time constant is a classical average type. It automatically varies the time constant as the dose-rate varies. In a low radiation field the time constant is slower than it is in a high radiation field. We accomplish this through a table that continually adjusts the time constant depending on the dose-rate. There are three tables, fast, medium, and slow. All three will vary the time constant depending on the dose-rate however the fast one has all of its values shorter than the medium one and the medium one has all of its values shorter than the slow one (see Table 1).

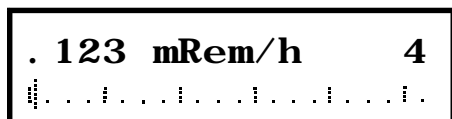


Figure 18 Standard TC Display

If the TC is set on slow then the averaging time is quite long. If you are in a low radiation field and move into a high radiation field the instrument will automatically reset the average so you will not have to wait a long time for the reading to reach a new value. If you are in a low radiation field and move into another low radiation field the instrument may not detect enough of a change to reset the average. In this case you can speed up the new reading by pushing the reset button, Table 1 shows the averaging time for each setting. Note the averaging times for less than 1 second.

If you want the radiation value to be slower and steadier then use the slow setting. If you want it to be faster then choose the medium or fast setting.

Table 1 Time Constant Averaging Times in Seconds

TC	<1CPS	1CPS	2CPS	4CPS	8CPS	16CPS	32CPS	>32CPS
Fast	8	4	2	1	1	1	1	1
Med	50	25	12	6	3	2	2	2
Slow	200	100	50	25	12	6	4	4

B. Infinite Time Constant

The infinite time constant works differently than the average. It is an integrate range and timer that divides the integrated dose by time and reports the average as a rate. As you watch the display the rate level should get better and better with less variation as the number of counts increases. Pushing the Reset button resets both the time and the integrated dose for this TC.

You should use this TC setting if you want a reading in a particular field of radiation. Hold the instrument in a particular place, push the reset, and wait until the counts are high enough to validate the reading. Generally 100 counts are usually sufficient for a good reading. Read the dose-rate and move to another area and push reset again and wait for enough counts. The display shows only dose-rate, not the integrated dose or the time (unless you are on inf+). The timer is good only for about 2.7 hours when it displays an error message to reset the range.

The counts that are displayed on the upper right are integrated counts since reset. They number ranges from 0 to 9999 counts. After 9999 counts the instrument will function correctly, it just will not display a higher number.

The display is different for INF and INF+ TC settings but the values and operation are the same.

The INF time constant is meant to look like a normal dose-rate reading with the bargraph and the counts. The difference is that the counts will continually add up rather than just show the last second. You can distinguish this display from the normal average display by the flashing dot following the /h.



Figure 19 Inf TC Display Note flashing dot after units

The INF+ time constant is the same as the INF time constant except it shows the integrated time on the bottom line rather than the bargraph.

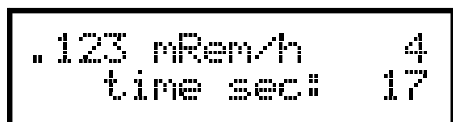


Figure 20 Inf+ TC Display with time on bottom line

NOTE: The integrate range used in this time constant is not the same as the normal integrate range, they are two separate ranges and the integrate range operates independently of the rate range.

Table 2 Time Constant Summary

Time Constant	Name	Type	Display	Counts Displayed	Maximum Averaging time (see Table 1)
FST	Fast	Average	Bargraph	Counts/sec	8 sec
MED	Medium	Average	Bargraph	Counts/sec	50 sec
SLO	Slow	Average	Bargraph	Counts/sec	200 sec
INF	Infinite	Integrate / time	Bargraph with flashing " • " after units	Cumulative since reset	2.7 hours
INF+	Infinite+	Integrate / time	Time on bottom line	Cumulative since reset	2.7 hours

VIII. WHICH TIME CONSTANT TO USE?

The REM 500 uses counts from the detector for the basis of its measurements. The counts are of different sizes and the size of each count is measured. The program in the REM 500 will weight the bigger counts more than the small ones. The weighing means that the largest count will add to the reading 2500 times as much as the smallest one. In other words, if you had 2500 small counts, they would equal 1 large count. This weighing means that it is necessary to smooth or average the readings because you can be reading many small counts when along comes a big one that adds significantly to the rate reading.

For low dose-rates we recommend using either of the infinite time constants, (INT+ or INT) and counting until you reach a number of counts. This may vary depending on the source, radiation, and accuracy. In general, at least 100 counts are necessary for a good reading and even at this number the reading will vary as more counts are accumulated. 1000 counts are better but will take more time.

For higher dose-rates (>1/second), the slow, medium, or fast time constants can be used. You can also use these for low dose-rates and average the values in your head.

For very accurate background type measurements or where accuracy is important, use the integrate range and the internal timer.

IX. CHECK MODE (CM244 SOURCE OPTION)

The optional check mode of operation is used to determine the quality of the detector, and to check the operation of the instrument. It can be used as an operational check. It can only be used if the detector contains a source. To get into the Check mode from normal operation push MODE, NEXT, NEXT, CHECK.

Inside the detector is a small Curium alpha source. When in the Check mode the curium source radiates a small stream of alphas across the center of the detector. These events simulate a neutron event in channel 90 of the instrument.

In the Check mode, the instrument operates as a multichannel analyzer and displays the peak (PK) channel number as well as the left (LFT) and right (RT) half max channel numbers. The number above NEXT is the counts in the peak channel. It updates the display every second. Pushing the ALT or MODE button will reset the MCA data and restart the acquisition. If the display remains on channel 0 or 1 this indicates that the instrument is not functioning properly. Try tapping on the side of the detector to free the shutter that shields the alpha source.



LFT	PK	RT	162
085	090	095	NEXT

Figure 21 Check Display / Menu

The peak channel indicates the Quality Factor calibration of the instrument, and the left and right half max channels indicate the quality of the detector. The peak should be within 15 channels of 90. Each channel away from 90 is an error of about 1.5% if the Calibration Factor remains unchanged. If it is out of this range, then the high voltage needs to be adjusted as described in the Calibration Mode section. The spread of the channels (RIGHT-LEFT) should be no more than 50 channels. If the spread is more than this then the detector needs to be returned to the factory for refilling.

The source may not be strong and it may take up to an hour to get a good peak. The number of counts as shown in the upper right corner should be above 50 for a quick peak check, and 100 for a better peak check. This may take an hour or more to accumulate.

Leave this mode by pushing NEXT. If the rate display reads a high number after leaving Check mode, then the magnet-actuated shutter that shields the alpha source may be stuck. Tapping the side of the detector may free the shutter.

X. OVERFLOW, AND HIGH RADIATION LEVELS

When the instrument receives over 2303 counts in 1 second the rate and integrate displays show a + sign after the units on the top line of the display. This + should be an indication that the readings will need dead time correction. This corresponds to about 25 rem/h with a Cf252 spectrum.



Figure 22 Note + after rem/h in rate mode



Figure 23 Note +++++ after rem in integrate mode

High-level radiation (over 20 rem/h or 2 rad/h) may have some deadtime losses. This depends on the average quality factor of the radiation. The instrument does not correct for dead time and consequently, while the software is capable of going up to 999 REM/h, the detector and electronics may not be.

The dead time associated with each pulse is about 70 mS. The instrument works by acquiring each pulse, measuring its height, and then adding one to one of the 256 channels that correspond to its height. It is a classic multichannel analyzer. Every second the instrument calculates the raw rem and rad data and resets all 256 channels to zero and starts acquiring the data again.

The higher channels contribute much more to the radiation level than do the lower channels, because of their higher quality factor and channel number. Channel 10 has a quality factor of 3.2, while channel 230 has a quality factor of 24.8. The rad ranges have no quality factor. These three items, dead time, maximum counts/channel, and different quality factors lead us to several guidelines:

1. At 1000 counts in a second, the instrument will lose 1% of the counts and response will start to fall off above this amount.
3. If the rem/h range is very high, then suspect the rad/h range has dead time losses.
4. If you have to use the instrument in high radiation levels, then correct for dead time losses.

XI. LOW BATTERY

When first turned on the instrument turns on the light and checks the status of the battery and shows an approximate battery life in the display.

During normal operation the instrument continually checks the status of the batteries. If it sees that there are only 10 hours remaining, then the instrument will show BAT in the upper right hand corner of the display. This is only in the RATE and INTEGRATE modes; it will not show low battery in LEVEL 1, 2, 3, or CHECK.

The light uses the most power. If the batteries just check good, turning on the light may make them check bad. This is the reason the instrument, when first turned on, checks the batteries with the light on. When the batteries are low it is a good idea not to use the light.

When the batteries are too low for proper operation, the instrument will automatically turn off.

XII. BATTERY REPLACEMENT

The Rem 500 uses 6 C cells, either carbon zinc or alkaline. The alkaline will of course last longer but alkalines are subject to leakage after a year. The current drain is less than 40 mA with the light off.

To change the batteries remove the four screws that hold on the small cover on the end of the case. The batteries should fall out. Use the sticker on the inside of the box as a guideline for inserting them. The batteries on the left hand side go in caps first, and those on the right go in with their caps out.

XIII. SHOCK

The instrument has some sensitivity to shock. Banging the case or the detector could result in spurious counts. A sharp rap on the detector with a pencil will indeed produce spurious counts. Just hold the instrument with the handle and don't bang it against anything while making measurements.

XIV. FAILURE IN DISPLAY

The instrument self checks itself at turn on. If it detects a failure it will display FAILURE in the display. If this occurs the instrument cannot be used. See the Maintenance Mode section for repair procedures.

XV. MCA MODE (RS232 OPTION)

The optional MCA mode is used with the RS232 option to dump the contents of the MCA memory to an external computer for analysis. See the RS232 Option section on page 17 for the connection specifications and for a list of the commands.

The external computer can control the operation of the MCA.

The MCA display shows the time and counts on the top line. The bottom line shows the operations.

TIM will go to the time setting display. See below for a detailed description.

NXT will return to the last menu level before the MCA display.

RST will reset the time, counts and the MCA memory. If the MCA is running it will stop it. If time is set to zero, it will reset to zero. If it is set to a number, it will reset to that number.

RUN will start the time, counts, and MCA.

STP will stop the time, counts and MCA.

CK will turn on the optional internal source. To turn off the internal source press RST. If the detector contains the option source, this choice will be shown only when the MCA is running. If the source is not installed, this choice will not be shown.

```
00:01:00  000 ct
TIM NXT RST RUN
```

Figure 24 MCA display in stopped mode. The RUN button will start the MCA.

```
00:00:53  029 ct
CK  NXT RST STP
```

Figure 25 MCA display in running mode. The STP button will stop the MCA. The optional CK mode is shown.

A. POWER BUTTON

If the REM 500 has the optional internal source, the POWER button will alternate between TIM and CK. When the MCA is stopped the POWER button becomes the TIM or time button. When the MCA is running the POWER button becomes the CK or check button.

B. TIME SETTING

Pushing TIM from the MCA display will change to the time setting display.

```
00:00:00 SetTime
R  ←  ↑  NEXT
```

Figure 26 Time setting display

The time setting display is used to set the acquisition time for the MCA.

If the time is set to 00:00:00 then the MCA will count time up until stopped manually with the STP button. If time is set to some number such as 00:01:00 then time will count down to zero where it will stop automatically.

There are 3 buttons that allow you to change the time:

R resets the time to 00:00:00

The up arrow button will increase the time digit that is underlined.

The left arrow will move the underline between the digits in the time display.

To change the time, use the left arrow to position the cursor under the digit that you want to change. Then use the up arrow button to increment the digit. When the underlined number gets to 9 and the up arrow is pushed, the number resets to 0. If you want a number less than the underlined number, just keep pressing the up arrow until it is correct. The up arrow button will not affect any digit except the underlined digit.

You can use the R or resets button to reset the display to 00:00:00.

When the time is correct push the NEXT button to return to the MCA display.

The time is stored in permanent memory. The next time you return to this display the time will be the same as you left it.

XVI. CONNECTING THE REM 500 TO A COMPUTER (RS232 OPTION)

The RS232 Option connects the REM 500 to a computer with the supplied cable.

A. Operation

The REM 500 with RS232 Option is supplied with a cable with a small round connector on one end, and a rectangular DB9 connector on the other end. To hook up the cable:

1. Connect the small round connector into the jack on the right of the front panel of the REM 500. It pushes in place. To remove it, pull on the outside of the connector.
2. Connect the other end to a COM port in your computer. This is usually COM 1 or 2.
3. Using the Terminal or HyperTerminal program supplied with your Windows program, set your COM port to 9600 Baud, 1 stop bit, 8 data bits, and no parity. Set flow control to off or none. Set it to the COM port that you attached the cable.
4. Turn on the REM 500. You should see a sign-on message "MODEL REM 500" and a prompt.

B. Terminal Display

Typing a "?" or "/" will display the help menu shown below.

```
MODEL REM 500 Ver X.XX
R  Changes to Rate mode
I  Changes to Integrate mode
M  Changes to MCA mode
A  Alternates between units
When in MCA mode:
S  Stops Counting
G  Go, Starts counting
C  Clears MCA memory
D  Downloads the MCA memory
? or / This menu
```

C. Commands

The settings for some commands are in hex and some are in decimal. The "h" following a number indicates hex.

R <ENTER>	Changes to the Rate Mode.
I <ENTER>	Changes to the Integrate Mode.

M <ENTER> Changes to the MCA Mode.

A <ENTER> Alternates between units, rem & rad or Sv & Gy in both all modes.

If the REM 500 is in the MCA mode the following commands apply:

S <ENTER> Stops the MCA

G <ENTER> Starts the MCA

C <ENTER> Clears the memory for the MCA and resets the time

D <ENTER> Downloads the MCA data.

Table 3 Conventional Units

MODE	NUMERIC FORMAT	UNITS	EXAMPLE	Converted to decimal
RATE	Hexadecimal	urem/h	00002B4F	11.0 mrem/h
	Hexadecimal	urad/h	00074FF4	479.2 mrad/h
INTEGRATE	Hexadecimal	urem x100	000056A34B	56.7 mrem
	Hexadecimal	urad x100	0000034C41	2.16 mrem
MCA	Hexadecimal	counts	0A32	2610 counts

Table 4 SI units

MODE	NUMERIC FORMAT	UNITS	EXAMPLE	Converted to decimal
RATE	Hexadecimal	uSv/h x100	000056B4	2.21 mSv/h
	Hexadecimal	UGy/h x100	0001CF20	1.18 mGy/h
INTEGRATE	Hexadecimal	nSv x10	0000598A1C	586 uSv
	Hexadecimal	nGy x10	000013AA1C	128 uGy
MCA	Hexadecimal	counts	0A32	2610 counts

D. DATA FORMAT

Each mode, Rate, Integrate, and MCA, has its own data format and units. Table 3 and Table 4 show the units and format for each mode.

Rate Mode

Data is 4 bytes of hex data in urem/h, urad/h, uSv/h x 100 and uGy/h x100.

Integrate Mode

Data is 5 bytes of hex data in urem x100, urad x100, nSv x10, and nGy x10

MCA Download

The MCA data is downloaded in hex format, 2 bytes per channel. Channel 1 is first, followed by channel 2, channel 3, etc until all 256 channels have been downloaded. There is a space between each channel.

XVII. PRINCIPAL OF OPERATION

The Instrument is basically a 256 channel multichannel analyzer or MCA with a dedicated program coupled to a Tissue Equivalent Rossi type spherical proportional counter.

A. Software

In normal operation the instrument gathers the pulses from the detector, measures their height, counts them and stores them according to their height, and then calculates the correct rem or rad. Every second it goes through this routine. The 3 standard time constants use an averaging algorithm that changes the time constant depending on the count rate. There are 3 lookup tables for the average, one for slow, one for medium, and one for fast. Within each table the TC varies as the dose-rate but the slower TC has all of the values slower than the medium TC table.

The INF and INF + display operate by dividing a integrate register by time. The integrate register is 5 bytes long, and the time register is 2 bytes long. When either register overflows the display shows an error.

The display is derived from the formulas:

For the rate mode for a 1 second update:

$$urem / h = K \sum_{5}^{255} x \frac{Chan\# \times cnts \text{ per chan} \times QF}{20}$$

$$urad / h = K \sum_{5}^{255} x \frac{Chan\# \times cnts \text{ per chan}}{20}$$

The QF for the channels is derived from a smoothing of the ICRP values and ranges from 1 to 24.8. K is the Calibration Factor. If you wish a different QF then please consult HPI. The rad display is thus the same as the rem except for the Quality factors. The average quality factor can be derived by dividing the rem reading by the rad reading.

B. Detector

The detector is a spherical tissue equivalent proportional counter, which measures the absorbed dose in LET (actually P[Y]) spectra. It is based upon the design originated by Rossi using a spiral grid over the electrode for uniform collection characteristics.

The detector is housed in an aluminum shell that serves as a vacuum tight housing. The housing is filled with propane gas that allows the spherical detector to simulate small tissue volumes of approximately 2-micron diameter.

An internal Cm244 alpha source is mounted to allow the alpha particles to traverse the diameter of the sphere in the CHECK mode. The energy deposited by the alpha particle is considered to be 90 KeV/m. Therefore by adjusting the system to place the peak into channel 90, the pulse height of the interactions will correspond to the energy deposition in KeV/m.

When the instrument is placed in a neutron field, the interactions with the neutrons will cause a recoil proton to traverse a portion of the sphere. The neutron collides with a nucleus and is scattered with a loss of energy, which appears as the kinetic energy of the recoil nucleus. In tissue, elastic scattering is the dominant neutron interaction in the energy interval 10 KeV to 10 MeV i.e. the sum of the kinetic energies of the participating particles remains constant before and after the interaction. The average neutron energy loss will be one half for a collision with a hydrogen atom.

In interactions of neutrons with energies below 10 KeV, a recoil proton in tissue no longer has sufficient velocity to ionize matter and will not be efficiently detected. The lowest detection level for the instrument is set at channel 5. Pulses below this value are considered to be gamma ray interactions or spurious noise pulses.

For neutrons with energies above 10 MeV inelastic scattering and nuclear interactions become important. For these high-energy events the spherical detector reproduces the energy losses that would occur in a single tissue cell from such high-energy interactions.

LET distributions from neutron fields interacting with tissue have been studied extensively. Proton recoils from neutrons of energy 10 KeV to 1 MeV have a maximum LET of about 85-90 KeV/m. This maximum LET occurs near the peak of the Bragg Curve. The LET of proton recoils from neutrons with energies above 1 MeV gradually decreased in such a manner that at the neutron energy of 20 MeV the LET has decreased to 5 KeV/m.

Carbon atom recoils from neutron interactions show an increasing LET with increasing neutron energy such that with incident neutron energy of 20 MeV a carbon recoil will exhibit an LET of over 400 KeV/m.

The detector measures the LET from all neutron interactions that are important for radiobiological studies. ICRP has developed radiation protection standards to evaluate the quality factors, which are applied to the pulse heights produced in the detector and processed by the associated electronics.

XVIII. CALIBRATION MODE

The Calibration Mode is used to change the overall sensitivity of the instrument and to adjust the high voltage. It was setup and calibrated at the factory but can be easily changed. The Calibration mode lets you change the Calibration Factor which changes all readings the same; integrate and rate, rem and rad, and it also lets you change the high voltage which changes the alignment of the quality factors with channel numbers.

There are different menus depending on the options that are included with the instrument.

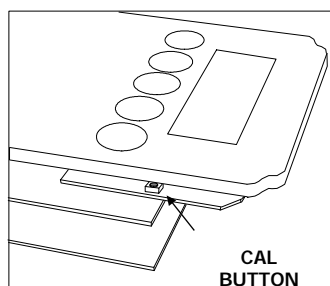
To exit the calibration section turn off the power. If necessary, push the NEXT button until there are no softkeys for the power button, then push the power button.

A. How To Get Into The Calibration Mode

Getting into the Calibration Mode can be accomplished two ways:

Method 1 is to turn the instrument off then push down the cal pushbutton inside the instrument (located on the display circuit board) and hold it down while turning on the instrument. It is

necessary to remove the 4 screws on the front panel to gain access to the inside of the instrument. The Calibrate Mode will be immediately visible showing the High Voltage Adjust display as shown below.



Method 2 is to turn the instrument off. Hold down the ALT button and turn the instrument on. Keep holding the ALT button down, letting it go even for a microsecond will enter normal operation. In 10 seconds the Calibrate Mode will be displayed. If this does not work, then the instrument has been programmed to not enter the Calibrate Mode from the front panel and it will be necessary to open the case and enter the mode by method 1.

Figure 27 CALibration Button
Inside Instrument on Display Circuit Board

B. HV Adjust Mode With Optional Source

The High Voltage Adjust mode allows you to change the high voltage, which changes the location of the peak. The objective is to have the peak on channel 90 within a few channels.



Figure 28 High Voltage Adjust Display Menu with Optional Source

If the peak is below 90, then raising the high voltage will raise the peak. Likewise if the peak is above 90, lowering the high voltage will lower the peak. The top line shows the peak (PK), followed by the High Voltage Factor (HVF) followed by the counts (c) in the peak channel.

The peak takes many counts to stabilize. You can change the HVF at any time but to fine tune it you should wait for at least 100 counts to accumulate so you have a good stable number for the peak.

The High Voltage Factor is proportional to the high voltage. It is displayed instead of the actual high voltage. Using the DN and UP buttons will raise and lower the high voltage factor which will in turn raise and lower the high voltage. The effect will be to also raise and lower the peak.

In this mode all of the buttons except the ON/OFF button are redefined.

The MODE button becomes the DN and the ALT button becomes the UP. They work by raising and lowering the high voltage factor, which raises and lowers the high voltage. To increase the high voltage factor by one, push the UP button, to increase it by 2, push it 2 times. The DN button works in the same way except that it lowers the High Voltage Factor. Pushing either the DN or UP button will also reset the peak values.

The RESET button becomes the NEXT button and will put the new High Voltage Factor into the permanent memory of the instrument, and then go to the Calibration Factor display. Until this button is pushed, the High Voltage Factor is not changed inside the instrument. Turning the instrument off and on will restore the original value. After setting the High Voltage Factor to the correct value in the display push NEXT.

The LIGHT button becomes the RST button or reset button. This resets the peak values and starts the peak calculations all over again.

C. HV Factor Without Optional Source

The High Voltage Adjust mode allows you to change the high voltage.



Figure 29 HV Factor Menu Without Optional Source

The number in the upper left hand is the High Voltage Factor. It is the number that needs to be changed to increase or decrease high voltage of the instrument. Its nominal value is 130 but it is adjusted differently for each instrument. The report that came with the instrument listed the HV factor that was found for that calibration.

In this mode all of the buttons except the ON/OFF button are redefined. The MODE button becomes the DN and the ALT button becomes the UP. They work by raising and lowering the High Voltage Factor. Each time the UP is pushed it raises the factor by 1. Each time the DN is pushed it lowers the factor by 1. Holding the buttons down will do nothing. To raise the factor by 10 it is necessary to push the UP button 10 times.

The RESET button becomes the NEXT button and will put the new High Voltage Factor into the permanent memory of the instrument, and then go to the Calibration Factor display. Until this button is pushed, the High Voltage Factor is not changed inside the instrument. Turning the instrument off and on will restore the original value.

After setting the High Voltage factor push NEXT button.

D. Calibration Factor

The Calibration Factor mode allows you to change the overall calibration of the instrument.



Figure 30 Calibrate Menu

The number in the upper left hand is the Calibration Factor. It is the number that needs to be changed to increase or decrease the sensitivity of the instrument. Its nominal value is 100 but it is adjusted differently for each instrument. The report that came with the instrument listed the calibration factor that was found for that calibration.

In this mode all of the buttons except the ON/OFF button are redefined. The MODE button becomes the DN and the ALT button becomes the UP. They work by raising and lowering the Calibration Factor. Each time the UP is pushed it raises the factor by 1. Each time the DN is pushed it lowers the

factor by 1. Holding the buttons down will do nothing. To raise the factor by 10 it is necessary to push the UP button 10 times.

The RESET button becomes the NEXT button and will put the new Calibration Factor into the permanent memory of the instrument, and then go back to normal operation. Until this button is pushed, the calibration factor is not changed inside the instrument. Turning the instrument off and on will restore the original value.

After setting the calibration factor to the correct value in the display push NEXT button.

E. LET Spectrum and Download

The LET Spectrum and Download Menu controls the operation of the MCA.



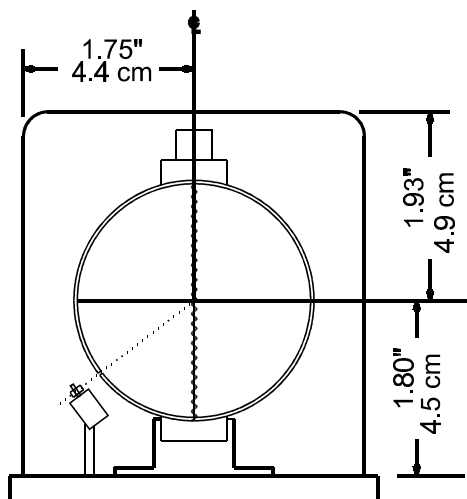
Figure 31 LET Spectrum and Download Menu

The Power Button will Download the LET spectrum to the computer.

The RST button will reset the spectrum and stop the MCA

The RUN button will start acquisition of the LET spectrum. The RUN button will become the STP button once it is running and pushing it will stop the acquisition.

The NEXT button will take you back to the beginning of the Calibration Modes.



Inside Diameter: 2.35-2.40 In, 5.97-6.1 cm
Wall thickness: .05 In, .13 cm

Figure 32 Inside Dimensions of Detector

XIX. CALIBRATION WITH OPTIONAL SOURCE

The instrument is easily calibrated. There are two stages to the calibration. The first is to adjust the high voltage so the channel numbers correspond to known energies. The second stage is to expose the instrument to a calibrated neutron source to set the overall sensitivity of the instrument using the calibration factor. Please read the previous section on how to enter the calibrate mode. The basic principal is to check and set the peak, then expose the instrument to a known radiation field adjusting the calibration factor until the reading is correct. REQUIRED: Calibrated neutron source

A. HV Calibration

The first stage of the calibration is the adjustment of the high voltage. This is accomplished by:

1. Turn the instrument on and enter the Calibrate Mode. You will be in the High Voltage Adjust display. (See Section XVIII.A on page 22 for instructions on how to enter the Calibrate Mode.)
2. Wait about 15 to 30 seconds for the high voltage to stabilize.
3. Push the RST button to restart the peak calculations.
4. Wait for the peak to stabilize with at least 100 counts.
5. We want the peak to be in channel 90. If it is not in channel 90 then it is necessary to change the high voltage factor. If the peak is below channel 90 then it is necessary to raise the high voltage factor, and if it is above channel 90 it is necessary to lower the high voltage factor. You should set it to channel 90 + - 3 channels. Raising the High Voltage Factor by 1 will raise the peak about 1 channel.

Repeat steps 2, 3, 4, and 5 until the peak is on channel 90 +/- 3 channels. When you are satisfied with the reading, push the POWER button to exit the calibration mode or the NEXT button to show the Calibrate Factor.

This completes the high voltage adjustment stage.

B. Calibration Factor

The next stage is to check, and if necessary adjust the overall sensitivity of the instrument.

1. Using the calibrated neutron source, expose the instrument to a known quantity of radiation. It can be calibrated in either the rate or integrate modes. In the rate mode, use the inf+ time constant. It is desirable to expose it for a period of time sufficient to accumulate at least 1000 counts. Expose the detector from the side. See Figure 32 for the inside dimensions of the detector.
2. Calculate the correction factor for the instrument.

$\text{CORRECTION FACTOR} = \text{DESIRED LEVEL} / \text{READING}$

3. Enter the Calibration Mode. See the Calibration Mode section XVIII.A page 22 for a description of how to get into this mode. Bypass the High Voltage Adjust display by pushing NEXT. You are now in the Calibration Factor adjust mode.
4. Multiply the Calibration Factor in the display by the correction factor you just calculated to obtain a new Calibration Factor.
5. Set the new calibration factor in the instrument by using the UP and DN buttons. When the value is correct, push the POWER button to exit the Calibration mode or the NEXT button to return to the HV Calibration Menu.
6. Repeat step 1 to 5 until the instrument reads correctly.
7. We recommend that you calibrate the instrument to one point on every decade on the rate range and at a point over 100 mrem on the integrate range.

XX. CALIBRATION WITHOUT OPTIONAL SOURCE

There are several stages to calibration if the REM 500 does not have the optional source. The source is used to align the quality factors with the channel number. Since this instrument does not have a source, it is necessary to align them using the proton edge of the LET spectrum.

The basic principal of calibration is to obtain an LET spectrum using a Cf252 source, adjust the high voltage until the proton edge falls on channel 90, then use the calibration control to adjust the overall sensitivity of the instrument.

Note: To exit the calibration section turn off the power. If necessary, push the NEXT button until there are no softkeys for the power button, then push the power button to turn off the REM 500.

Please read Section XVIII.A on page 22 for instructions on how to enter the Calibrate Mode.

REQUIRED: uncalibrated Cf252 source and a calibrated neutron source.

A. Preliminary HV Setting

This step is not necessary if the instrument has already been calibrated. If, however you are doing a 1st time calibration with changed components or a new detector, this step will adjust the high voltage very close to the desired value.

In this section the calibration factor is set to 65, the high voltage factor is set to 130, then the instrument is exposed to a known radiation field with a calibrated Cf252 source. The high voltage adjustment control is trimmed until the reading is correct. If a calibrated Cf252 source is not available, skip this section.

The first stage of the calibration is to return the HV Factor to 130 which is the default setting.

1. Enter the Calibration Mode. See the Calibration Mode section XVIII.A page 22 for a description of how to get into this mode.
2. The first menu is the HV factor. Use the UP and DOWN buttons to adjust the high voltage factor to 130.
3. Push NEXT to enter the calibration adjustment.

The next stage of the calibration is the adjustment of the calibration factor. This is accomplished by:

4. Set the calibration factor to 65 using the UP and DN buttons. When the value is correct, push the POWER button to turn the instrument off.

The second stage is to expose the instrument to ~1000 mrem/h with a calibrated Cf252 source and adjust the high voltage until the instrument reads correctly.

1. Open the case by removing the 4 screws on the front panel. The bottom separates from the top but leave the instrument together. Identify the high voltage adjustment control. It is located on the bottom circuit board on the left side of the instrument. See Figure 33.

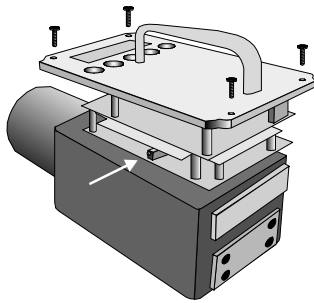


Figure 33 Location of HV Adjustment

2. Turn the instrument on. Wait about 15 to 30 seconds for the high voltage to stabilize.
3. Expose the instrument to a known radiation field. We suggest a level around 1000 mrem/h. This is high enough that the adjustments can proceed quite quickly.
4. Adjust the high voltage adjustment until the mrem/h reading is correct. Turning the high voltage control clockwise will increase the high voltage. The adjustment will change the sensitivity very fast and we recommend changing it in 1/4 turn increments.
5. Turn off the instrument and replace the 4 screws you removed in step 1.

B. Checking the HV adjustment

This step verifies that the high voltage is set correctly. This is important because it checks the alignment between the channels and the quality factors.

This step is recommended during routine calibrations to verify that the instrument will read different energies correctly. The basic operation is to expose the detector to a Cf252 neutron source, download the LET spectrum to the PC, plot the results, and adjust the high voltage if necessary.

1. Serial Connection

If the REM-500 has a front panel serial connection, plug the cable into the front panel jack and the other end to the serial input (COM 1 or 2) of the computer. The front panel serial port can be identified by the small jack on the bottom right hand side front panel. If your computer does not have a serial port, you can use an after-market adapter that converts RS232 to USB.

If the REM-500 does not have a front panel serial connection it is necessary to use the interior connection and cable. Remove the 4 screws on the corners of the front panel. Raise the front panel and plug the cable into the jack on the top circuit board as shown in Figure 34. Lower the front panel back down on the chassis. The cable will be squeezed between the top and bottom. Lightly attach the screws back on the front panel but do not tighten them very much because you do not want to damage the cable just hold the unit together. Connect the other end of the cable to the serial input (COM 1 or 2) of the computer. You may need an extension cable.

Setup the PC as shown in Section XVI CONNECTING THE REM 500 TO A COMPUTER (RS232 OPTION), on page 18, operation Steps 1 to 3.

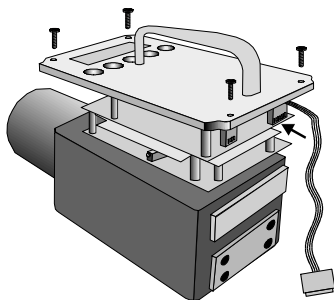


Figure 34 Connecting the RS232 Cable on Instruments Without Front Panel Jacks

2. Acquiring an LET spectrum

Turn the instrument on and enter the calibrate mode. Push NEXT twice to show the LET Spectrum and Download menu. See LET Spectrum and Download on page 24.

Expose the detector to an unmoderated Cf252 source. If the source is small, you can place it next to the detector.

Push the RUN button to acquire a spectrum. The total counts are shown in the top right corner of the display. Wait until there are at least several thousand counts and push the stop button.

Connect the REM 500 to the PC and use a program such as HyperTerminal set to capture text. (HyperTerminal has a transfer mode to capture text.) When the program is in the text capture mode, push the DLD button on the REM 500 to send the data to the PC. This will transfer the spectrum to the computer. In HyperTerminal you will see all of the counts on several lines. Each group of 4 digits is the hex number of counts. The first group is channel 1, the second group is channel 2, etc. The channels are only separated by spaces. The counts are in hexadecimal.

Save the captured text in a file.

3. Plot the LET spectrum

Using the acquired spectrum, plot it with the counts on a log scale. Open the file in Excel as a text file. Convert the counts to decimal with the hex to decimal command and plot it with the counts on the vertical Y axis, and the channel number on the horizontal X axis.

When Excel opens the text file, use fixed width, and text as the column data format. After opening, the channels should be in a single column. Channel 1 is the top group. Next convert the hex numbers to decimal numbers so you can plot them. Excel will not plot hex numbers.

To convert from hexadecimal to decimal numbers use the HEX2DEC conversion. For example if A2 contains the hex counts and we want the decimal equivalent to be on B2, the formula in B2 is: =HEX2DEC(A2). Copy this into all 256 channels to make a column that is decimal. Then highlight the decimal column and click on the chart wizard button. Choose Line as the chart type then finish. Click on the Counts axis and change the scale to log.

The LET Spectrum shown in Figure 35 shows the proton edge which should be in channel 90. If it is in too low a channel, you need to raise high voltage, and if it is too high, you need to lower high voltage. The exact channel of the proton edge is difficult to see. Try to determine the edge as best as possible. Note how many channels you need to raise or lower the proton edge.

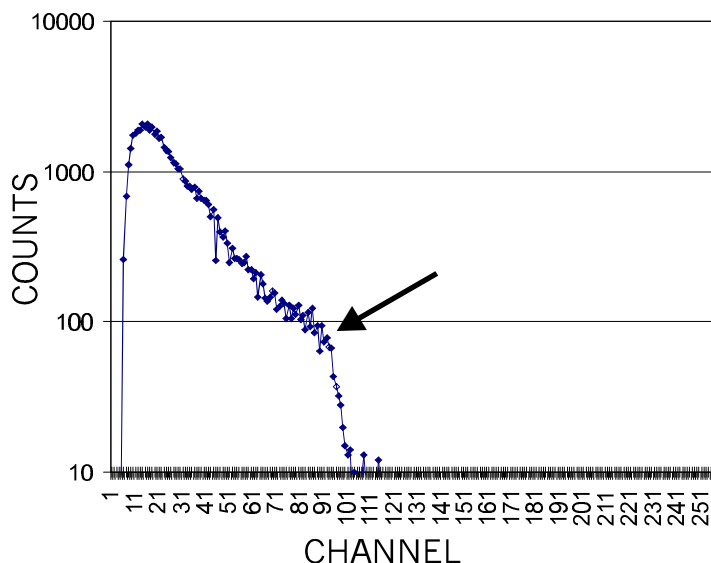


Figure 35 LET Spectrum showing the Proton Edge

4. Adjusting High Voltage

When you know how many channels you need to move the proton edge you can adjust the high voltage, then repeat the proton edge measurement to make sure it is correct.

The high voltage factor adjustment is very close to 1 to 1 for the channel adjustment. If the proton edge needs to be raised 20 channels, then raise the high voltage factor by 20. If it needs to be decreased by 8 channels then lower the high voltage factor by 8.

- 1) If you have just downloaded the LET spectrum, push NEXT to return to the first menu of the Calibration.
- 2) Using the up and down buttons, adjust the high voltage to the new value. Then push the POWER button to turn off the instrument.
- 3) Repeat the measurement cycle of acquiring an LET spectrum, plotting it and seeing if the proton edge is at or close to channel 90.

To exit the calibration section turn off the power. If necessary, push the NEXT button until there are no softkeys for the power button, then push the power button to turn off the REM 500.

C. Calibration Factor

The next stage is to check, and if necessary adjust the overall sensitivity of the instrument.

1. Using the calibrated neutron source, expose the instrument to a known quantity of radiation. It can be calibrated in either the rate or integrate modes. In the rate mode, use the inf+ time constant. It is desirable to expose it for a period of time sufficient to accumulate at least 1000 counts. Expose the detector from the side. See Figure 32 on page 24 for the inside dimensions of the detector.

2. Calculate the correction factor for the instrument.

$\text{CORRECTION FACTOR} = \text{DESIRED LEVEL} / \text{READING}$

3. Enter the Calibration Mode. See the Calibration Mode section XVIII.A page 22 for a description of how to get into this mode. Bypass the High Voltage Adjust display by pushing NEXT. You are now in the Calibration Factor adjust mode.

4. Multiply the Calibration Factor in the display by the correction factor you just calculated to obtain a new Calibration Factor.

5. Set the new calibration factor in the instrument by using the UP and DN buttons. When the value is correct, push the POWER button to turn off the instrument.

6. Repeat step 1 to 5 until the instrument reads correctly.

Steps 2 to 5 correct the instrument Calibration Factor to match the reading i.e. if the reading is 10% low then you need to raise the correction factor by 10%.

7. We recommend that you calibrate the instrument to one point in every decade on the rate range and at one point over 100 mrem on the integrate range.

To exit the calibration section turn off the power. If necessary, push the NEXT button until there are no softkeys for the power button, then push the power button to turn off the REM 500.

XXI. SETUP MODE

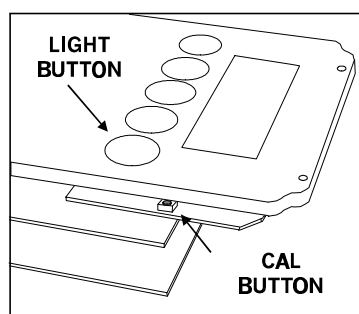
Setup mode changes basic operating parameters such as units, bargraph, RS232, source, and preset values. It is also used if there is a fault in the instrument.

NOTE: Do not change these settings unless you know the features and options of the instrument. Incorrect settings may cause incorrect operation of the REM 500.

A. How To Get Into Setup Mode

To get into setup mode it is necessary to hold down two buttons when the instrument is turned on.

- 1) Turn off the instrument off if it is turned on.
- 2) Hold down both the front panel light button and the CALibration pushbutton inside the instrument (located on the display circuit board) and then push the power button to turn the instrument on. The



first menu should be the Default Menu.

Figure 36 CALibration Button located inside the instrument on the Display Circuit Board

B. Default Menu

The default menu sets up all of the values in the instrument. This includes: Contrast, Time Constant, Display Contrast, Calibration Factor, RS232, Source, and High Voltage Factor. It also programs a check number that must be there or the instrument will display a fault.



Figure 37 Default Menu

If you want the defaults to be reset to their factory settings then push the YES button, if not push NEXT to go to the next menu. If you push YES it asks you if you are sure because you will lose all of the previous settings. The values that this will program can each be changed by the individual menus, for example the calibration factor can be changed in the calibration menu.

NOTE: Pushing YES will reset all of the values including the calibration factor.

It is also used if you change the EEPROM because an unprogrammed EEPROM will show a FAILURE on the display.

Table 5 Default Values

Item	Value	Item	Value
Contrast	Mid level	Units	rem/rad
Calibration Constant	100	Bargraph	Log
High Voltage Factor	130	RS232	Off
Time Constant	Slow	Source	On
Front Panel	On		

C. **Front Panel Select**

The next menu that will appear is the Front Panel Menu.



Figure 38 Front Panel Menu

It means that you will be able to get into the Calibrate Mode from the front panel. Front Panel Off means that you must open the enclosure to get into the Calibrate Mode. Pushing the ON or OFF button will change it. Pushing NEXT will go to the next menu.

To summarize: If you want the convenience of getting into the calibrate mode without opening the case and are not concerned with security of the calibrate number then push YES and then NEXT. If you do not want anyone to be able to enter the calibrate mode without having to open the case then push OFF and then NEXT.

D. **Units Select**

The next menu that will appear is the Units Select Mode.



Figure 39 Units Select Menu

The choice is either for SI units (Sv, Gy) or conventional units (rem, rad). This will affect the units in the rate and integrate displays.

Pushing Sv will put the instrument in the SI Units mode.

Pushing REM will put the instrument in the conventional units mode.

Push NEXT to go to the next menu.

E. Bargraph Type

The scale of the bargraph can be either decade or log.



Figure 40 Bargraph Type Menu

The log bargraph shows 5 decades. With conventional units, the display will cover from 0 to 10 rem/h or rad/h in 5 decades. See

Figure 41 Example of Log Bargraph.

The decade bargraph shows only the decade that is shown in the display. See Figure 42 Example of Decade Bargraph.

Push LOG for the log display, and DEC for the decimal display.

Push NEXT to go to the next menu.

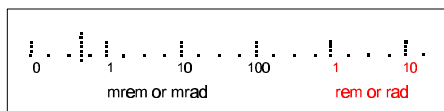


Figure 41 Example of Log Bargraph

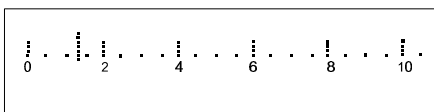


Figure 42 Example of Decade Bargraph

NOTE: The paper strip at the bottom of the display with the scale can be changed. Please consult the factory if you wish to print your own and/or change the existing one.

F. RS232

This turns on the serial port that enables the instrument to communicate over the RS232 connection.



Figure 43 RS232 Mode

Push ON if the front panel contains the RS232 jack.

Push OFF if the front panel does not contain the RS232 jack.

Press NEXT to go to the next menu

G. SOURCE

This tells the instrument that there is a source inside of the detector.

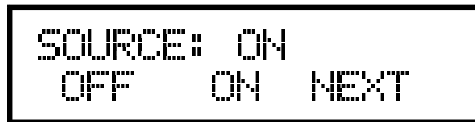


Figure 44 Source Menu

Push ON if the detector contains the Cm244 source.

Push OFF if the detector does not contain a source.

Pressing NEXT will restart the instrument.

XXII. MAINTENANCE MODE

Maintenance Mode is used for electronic checkout. To get into Maintenance Mode Hold down the MODE and RESET keys while turning the instrument on. If the instrument has failed see below. In the Maintenance Mode the 3 digits in the upper left of the display are the channel number of the pulse height. This ranges from 000 to 255. The next three digits are the contents of the pulse counter. Every time a new count is received the counter increments by one. The next item is a hex value that is proportional to the battery voltage. With a 9 volt battery the reading should be about 4E. This will flash on the display about every second. The next item is the number of the last switch that was pushed. The switch numbers are: 1; POWER, MODE; 2, ALT; 3, RESET; 4, LIGHT; and 5, CALibration button. The last item is the last character that was sent to the instrument from a terminal if the instrument has the RS232 option.



Figure 45 Maintenance Mode Display

The buttons are redefined and their abbreviations are shown on line 2. The MODE button becomes the MAG or MAGNET button. The ALT button becomes the CLICK button. The RESET button is the CLR or CLEAR button, and the LIGHT button remains the LIGHT button. In addition the Cal button located next to the display on the display circuit board becomes the buzzer button. The action of each of these buttons is defined below.

MAG Turns on the Magnet attached to the outside of the detector. This causes the internal alpha source to irradiate the detector simulating neutron events with an average energy that should be in channel 90. The electronics can be tested with these signals. The Display should also show the counts, although the peak energy is hard to see because of the number of counts. Turn the magnet off by pushing CLR.

CLICK This checks the operation of the clicker that clicks with each pulse of radiation. Pushing it and the turning on the magnet (mag button) should produce clicks. Pushing CLR turns it off.

CLR This button clears all the parameters set by the other buttons.

LIGHT The light is turned on whenever this button is pushed.

CAL This turns on the beeper. Pushing CLR turns it off.

If the EEPROM has failed the instrument will display FAILURE #1. If this is the case then it is necessary to replace the EEPROM (U3 on the Digital Board). After replacing it enter the Setup Mode and push YES twice. This will program the EEPROM with default values. Then turn the instrument on and off again to resume normal operation. The instrument will need to be recalibrated because the Calibration Factor is in the EEPROM.

XXIII. CIRCUIT DESCRIPTION

The electronic circuit is broken down into two main sections, the analog and the digital circuits. Each circuit has two printed circuit boards associated with it.

A. *Digital Circuit*

The digital circuit comprises the Digital Circuit Board and the Display Board. Both are shown on schematic # REM1-002 REV D and higher.

B. *Power Supply*

The instrument is powered by 6 C cells. The positive side of the batteries is switched to turn the instrument on and off. Q3 is the PNP pass transistor that is the main switch for the power. Pushing S6, the power switch pulls one end of R18 low through D9. This turns on Q3 putting power to the microprocessor. The microprocessor pin 15 will go high pulling one end of R19 high. This turns on Q4, which keeps the base of Q3 low after the power on button is released. The microprocessor turns power off by lowering pin 15.

The battery power goes to a 3 terminal regulator, U15 that has a low drop out voltage. Its output is + 5V. U16 and U17 form a voltage converter that changes the + 5V into - 5V, + 8V, and - 8V. U14: B is a comparator that compares the output of the DAC U13 to the battery voltage. The instrument measures the battery voltage by raising the output of the DAC until the comparator trips.

U14 is a comparator that looks at the battery voltage and the reference of D6 and D7. It will turn off the instrument if the battery voltage is too low and will not allow the instrument to turn on if it is too low.

C. *Microprocessor*

The microprocessor, U6 is an 80C32, a romless version of the 80C32. It is supported by address latch U2, EPROM U7, RAM U8, address decoder U9 and various other gates in U4. The oscillator X1, R2, C2, and C4 oscillates at 14.745 MHz. It is the timebase for the instrument.

Reset is controlled by U1:A. When the power button is held down long enough, R1 charges C3 and when it gets high enough gate U1:A changes, resetting the microprocessor.

D. *Adc Control*

The ADC is memory mapped just like all the other peripherals. Reading it activates the output of U4D and this controls the signal ADC RESET. This is the only signal that resets the ADC.

When a conversion is ready, it signals the system through the ADC INTR line.

E. *In/Out*

In/Out ports for the system are in the microprocessor U6, DAC U13, and output port U11.

The Microprocessor In/Out Lines Control:

The buttons on the front panel and cal button.

The eeprom U3 and DAC U13 use a bi-directional bus.

The Output Port U11 Controls:

The magnet is controlled through a power FET Q2.

The load command for the DAC.

The DAC controls:

LCD Contrast

Battery Voltage Monitor through U14

Backlight on the LCD through Q1

F. Display

The LCD display is U5. It has a contrast input that is controlled by U13 through U12 to set the voltage to go positive and negative depending on the specific LCD.

G. EEPROM

The EEPROM holds 128 bytes of data even when the power is off.

H. Serial Port

The serial port is not used in this version.

I. Analog Circuit

The analog circuit is on two circuit boards, the Preamp and the Analog Circuit Board. They are shown in schematic # REM1-001.

J. High Voltage Power Supply

The supply output, for the detector, is around 500V. U9A is an oscillator which produces a 2 usec pulse every .4 msec. This drives U9B, which expands the pulse width and turns it on and off depending on the output of U10. The output of U9 drives Q5, which in turn drives T1. This is a step up transformer. Its secondary is rectified by D5 and filtered by R46, C31 and in the preamp by C4, C3, and R5. The high voltage is measured by resistor divider R47 and R48 and R49. U10 compares this voltage to that set by R51, the high voltage control and the DAC, and turns on and off the oscillator in U9B to regulate the voltage. R4, and R2 are a voltage divider to provide the helix in the detector with the correct voltage.

The DAC allows the high voltage to be adjusted by the front panel and consists of the ladder network, R56 to R71. The shift register U11 shifts and latches the serial data from the microprocessor to the ladder network

K. Preamp

The high gain charge sensitive preamp uses a low noise 2N4416 as the input FET. Q2 provides bias for Q1. Q3 is an impedance converter and Q4 is the output buffer. Feedback is by R15 and the small amount of stray capacitance across it is the feedback capacitor. The output of the preamp is a series of ramps. The input pulse drives the output positive, and then the signal slowly decays back toward ground. TP1 is an input for an external pulsar.

L. Post Amplifiers

R17 is the pole zero control. U1's four amplifiers shape the pulses for use by the ADC. R28x sets the gain.

M. MCA

U5, a voltage comparator, and U6 a flip flop start the ADC conversion. U5A detects the peak above the Low Level Discriminator (LLD). The signal then is amplified by U2A and U2B. They form a closed loop to charge capacitor C22 to the peak value of the input pulse. The output of U2A drives the input of the Analog to Digital Converter, U4. U7 times the conversion. U3A and U3D reset the peak catcher. The reference voltage of 2.5V for the ADC is set by U8. R32 sets the Low Level Discriminator, below which the pulses will not initiate, a conversion. The microprocessor after processing the signal, resets the ADC by J4:10.

XXIV.ELECTRONIC ADJUSTMENTS

There are 3 electronic adjustments. All controls are independent and do not need to be done in any order; they were factory set and do not usually need adjustment. Replacing the detector would necessitate adjusting the Pole Zero, the high voltage and doing a calibration.

A. High Voltage

The High Voltage control is on the bottom right of the Analog Circuit Board. Set the High Voltage Factor in the High Voltage Adjust display of the Calibrate mode to 130. Exit the Calibrate mode. Enter the Check mode and look at the peak under the Check Mode. Adjust the high voltage until the peak is on channel 90 + - 2 channels.

B. LLD

The LLD, on the upper left of the Analog Board, is set with a voltmeter.

1. Attach a voltmeter negative lead to Test Point TP5. Attach the positive lead to Test Point TP3. Adjust the LLD SET control until the voltmeter reads 158 millivolts.
2. This adjustment can be checked with a mercury pulsar connected between TP1 and ground, TP5. Enter maintenance mode and adjust the pulsar to channel 10. Then slowly lower the pulsar and note the lowest channel that is displayed on the left of the display. Raise the level back to around channel 10 and slowly lower it again. Do this a couple of times to check the lowest channel number. It should be channel 5. If it is a higher number then lower the LLD slightly and try it again.

C. Pole Zero

The Pole Zero is on the upper left of the Analog Board. Connect an oscilloscope between ground, TP5 and pin 1 of U1. Enter the Maintenance Mode and turn on the magnet. Adjust the Pole Zero control fully CCW. Then adjust the control until the bottom of each pulse is even with the baseline of all the pulses.

XXV. TROUBLE SHOOTING NOTES

1. A mercury pulsar can be used to test the instrument. It connects to TP1 and ground (TP5) on the Analog Board.
2. If the instrument does not work try jumpering the jumper JP2. This will turn on the power without needing the front panel power switch.
4. If the batteries are good and the instrument will not turn on, it is possible that the instrument is actually turning on but the contrast is set too light or dark. To do an emergency contrast setting, hold down the light button and the power button. After 10 seconds release only the power button. When you see the display, release the light button.
5. The two circuit boards hinge on one side. Undo the two screws on the side opposite the hinges on each board and they will open like a fan.

XXVI. RADIOACTIVE MATERIAL INSIDE DETECTOR

The sealed detector may contain a <1 microcurie Curium 244 check source. If it does have a source the detector is marked with a radioactive sticker on the top and a permanent marking on the baseplate that is covered when mounted to the enclosure.

The source material is deposited on the end of a .063 dia stainless steel rod and has a gold flashing over it to secure the source material. It is necessary for you to include this source material on your radioactive materials license.

If it is necessary to ship the instrument it should have a statement as to the type of radioactive material (Cm244) and the amount (1 microcurie). It should also include the following statement in the box so it is the first thing seen when the box is opened. No special packaging material is required other than the normal 2" packing material on all sides and a sturdy cardboard box.

FROM: _____

ADDRESS: _____

This package conforms to the conditions and limitations specified in 49 CFR 173.421 for Excepted Radioactive Material, Limited Quantities, N.O.S., UN 2910 and also IATA section 5.7.27.

This is to certify that this package conforms to all packaging requirements of the U.S. Department of Transportation and the International Aid Transport Association rules and regulations regarding the shipment of Radioactive Materials, Limited Quantities.

The radiation level on the surface of this package is less than 0.5 mR/hr. No other labels required.

NAME: _____

SIGNATURE: _____

TITLE: _____

The above form serves only as a guideline. Your requirements may change depending on government regulations.

XXVII. QUALITY FACTORS

Chan #	QF	Chan #	QF	Chan #	QF	Chan #	QF
0	0	64	14.4	128	22.3	192	24.8
1	0.4	65	14.5	129	22.4	193	24.8
2	0.7	66	14.7	130	22.4	194	24.8
3	1.1	67	14.9	131	22.5	195	24.8
4	1.4	68	15.1	132	22.6	196	24.8
5	1.7	69	15.2	133	22.6	197	24.8
6	2.0	70	15.3	134	22.8	198	24.8
7	2.5	71	15.6	135	22.8	199	24.8
8	2.7	72	15.7	136	22.9	200	24.8
9	3.0	73	15.8	137	22.9	201	24.8
10	3.2	74	16.0	138	23.0	202	24.8
11	3.5	75	16.2	139	23.0	203	24.8
12	3.7	76	16.3	140	23.1	204	24.8
13	4.0	77	16.5	141	23.3	205	24.8
14	4.2	78	16.6	142	23.3	206	24.8
15	4.5	79	16.8	143	23.4	207	24.8
16	4.7	80	17.0	144	23.4	208	24.8
17	5.0	81	17.1	145	23.5	209	24.8
18	5.2	82	17.2	146	23.5	210	24.8
19	5.4	83	17.3	147	23.6	211	24.8
20	5.7	84	17.4	148	23.6	212	24.8
21	5.8	85	17.6	149	23.8	213	24.8
22	6.1	86	17.7	150	23.8	214	24.8
23	6.2	87	17.8	151	23.8	215	24.8
24	6.4	88	17.9	152	23.9	216	24.8
25	6.7	89	18.2	153	23.9	217	24.8
26	6.9	90	18.3	154	24.0	218	24.8
27	7.2	91	18.4	155	24.0	219	24.8
28	7.3	92	18.6	156	24.0	220	24.8
29	7.5	93	18.7	157	24.1	221	24.8
30	7.8	94	18.8	158	24.1	222	24.8
31	8.0	95	18.9	159	24.3	223	24.8
32	8.2	96	19.1	160	24.3	224	24.8
33	8.4	97	19.2	161	24.3	225	24.8
34	8.7	98	19.3	162	24.4	226	24.8
35	8.8	99	19.4	163	24.4	227	24.8
36	9.0	100	19.6	164	24.4	228	24.8
37	9.3	101	19.7	165	24.5	229	24.8
38	9.4	102	19.8	166	24.5	230	24.8
39	9.7	103	19.9	167	24.5	231	24.8
40	9.9	104	20.0	168	24.6	232	24.8
41	10.0	105	20.2	169	24.6	233	24.8
42	10.3	106	20.2	170	24.6	234	24.8
43	10.5	107	20.3	171	24.6	235	24.8
44	10.6	108	20.4	172	24.8	236	24.8
45	10.9	109	20.5	173	24.8	237	24.8
46	11.0	110	20.7	174	24.8	238	24.8
47	11.3	111	20.8	175	24.8	239	24.8
48	11.4	112	20.8	176	24.8	240	24.8
49	11.6	113	20.9	177	24.8	241	24.8
50	11.8	114	21.0	178	24.8	242	24.8
51	12.0	115	21.2	179	24.8	243	24.8
52	12.1	116	21.2	180	24.8	244	24.8
53	12.4	117	21.3	181	24.8	245	24.8
54	12.6	118	21.4	182	24.8	246	24.8
55	12.7	119	21.5	183	24.8	247	24.8
56	12.9	120	21.5	184	24.8	248	24.8
57	13.1	121	21.7	185	24.8	249	24.8
58	13.2	122	21.8	186	24.8	250	24.8
59	13.5	123	21.9	187	24.8	251	24.8
60	13.6	124	21.9	188	24.8	252	24.8
61	13.9	125	22.0	189	24.8	253	24.8
62	14.0	126	22.2	190	24.8	254	24.8
63	14.2	127	22.2	191	24.8	255	24.8

XXVIII. PARTS LIST

DESIG	QUAN	PART NO	VALUE	DESCRIPTION	MFG	SUPPLIER	DRAWING NO.
C01	1		47 pF 600 VDC	Capacitor, film		Mouser	REM1-001
C02	1		33 uF 10 VDC	Capacitor, tant		Mouser	REM1-001
C03	1		.047 600 VDC	Capacitor, film		Digikey	REM1-001
C04	1		.047 600 VDC	Capacitor, film		Digikey	REM1-001
C05	1		5 pF 50 VDC	Capacitor, slv mica		Mouser	REM1-001
C06	1		33 uF 10 VDC	Capacitor, tant		Mouser	REM1-001
C07	1		33 uF 10 VDC	Capacitor, tant		Mouser	REM1-001
C08	1		10 uF 10VDC	Capacitor, tant		Mouser	REM1-001
C10	1		10 uF 10 VDC	Capacitor, tant		Mouser	REM1-001
C11	1		.001 uF 50 VDC	Capacitor, film		Digikey	REM1-001
C12	1		.01 uF 50 VDC	Capacitor, film		Digikey	REM1-001
C13	1		100 pF 50 VDC	Capacitor, film		Digikey	REM1-001
C14	1		.01 uF 50 VDC	Capacitor, film		Digikey	REM1-001
C15	1		100 pF 50 VDC	Capacitor, film		Digikey	REM1-001
C16	1		.1 uF 50 VDC	Capacitor, film		Digikey	REM1-001
C17	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C18	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C19	1		22 pF 50 VDC	Capacitor, mono		Mouser	REM1-001
C20	1		10 pF 50 VDC	Capacitor, mono		Mouser	REM1-001
C21	1		.001 uF 50 VDC	Capacitor, film		Mouser	REM1-001
C22	1		680 pF 50 VDC	Capacitor, film		Digikey	REM1-001
C23	1		100 pF 50 VDC	Capacitor, mono		Mouser	REM1-001
C24	1		.01 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C25	1		.001 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C26	1		.001 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C27	1		100 pF 50 VDC	Capacitor, mono		Mouser	REM1-001
C28	1		47 uF 16 VDC	Capacitor, tant		Mouser	REM1-001
C29	1		.001 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C30	1		.01 uF 600 VDC	Capacitor, film		Mouser	REM1-001
C32	1		33 uF 10 VDC	Capacitor, film		Mouser	REM1-001
C33	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C34	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C35	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C36	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C37	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C38	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C39	1		33 uF 10 VDC	Capacitor, tant		Mouser	REM1-001
C40	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C41	1		.1 uF 50 VDC	Capacitor, mono		Mouser	REM1-001
C42	1		33 uF 10 VDC	Capacitor, tant		Mouser	REM1-001
C43	1		10 uF 10 VDC	Capacitor, tant		Mouser	REM1-001
C44	1		10 uF 10 VDC	Capacitor, tant		Mouser	REM1-001
D1	1		1N4148	Diode		Digikey	REM1-001
D2	1		1N4148	Diode		Mouser	REM1-001
D3	1		1N5711	Diode		HAM	REM1-001
D4	1		1N5711	Diode		HAM	REM1-001
D5	1	FR107-ND	Fast Rec 1000 VDC	Diode	DI	Digikey	REM1-001
J1	1	CHS10G-ND	10 Pin HDR .1x.1	Connector	CW Ind	Digikey	REM1-001
J2	1	WM1105	.093	Terminal	Molex	Digikey	REM1-001
J3	1	WM1105	.093	Terminal	Molex	Digikey	REM1-001
J4	1	CHS26G-ND	26 Pin, MT, ST .1x.1Connector	CW	Digikey	REM1-001	
P1	1	CHR10G-ND	10 Pin RA	Connector, MT .1x.1	CW Indust	Digikey	REM1-001
Q1	1	2N4416A	2N4416	FET	GE	Mouser	REM1-001
Q2	1	2N4416A	2N4416	FET	GE	Mouser	REM1-001
Q3	1	PN4250	2N4450	Transistor	National	Digikey	REM1-001
Q4	1	VN10KM/2N7000	N PWR	FET	Siliconix	HAM	REM1-001
Q5	1	VN10KM/2N7000	N PWR	FET	Siliconix	HAM	REM1-001
R01	1	MOX-300 1000M	1000M ohm 5%	Resistor	Ohmite		REM1-001
R02	1	MOX-300 250M	250M 5%	Resistor	Ohmite		REM1-001
R03	1	MOX-300	1000M ohm 5%	Resistor	Ohmite		REM1-001

DESIG	QUAN	PART NO	VALUE	DESCRIPTION	MFG	SUPPLIER	DRAWING NO.
R04	1	1000M MOX-300 1000M	1000M 5%	Resistor	Ohmite		REM1-001
R05	2		2 ea 10M	Resistor CF 5% 1/4W		Mouser	REM1-001
R06	1		47.5	Resistor MF 1% 1/4W		Digikey	REM1-001
R07	1		2.00K	Resistor MF 1% 1/4W		Digikey	REM1-001
R08	1		10K	Resistor MF 1% 1/4W		Digikey	REM1-001
R09	1		10K	Resistor MF 1% 1/4W		Digikey	REM1-001
R10	1		10 ohm	Resistor MF 1% 1/4W		Digikey	REM1-001
R11	1		1.00M	Resistor MF 1% 1/4W		Digikey	REM1-001
R12	1		10K	Resistor MF 1% 1/4W		Digikey	REM1-001
R13	1		10 ohm	Resistor CF 5% 1/4W		Digikey	REM1-001
R14	1		10 ohm	Resistor CF 5% 1/4W		Digikey	REM1-001
R15	1	MOX-300 1000M	1000M	Resistor CF 5% 1/4W	Ohmite		REM1-001
R16	1		10 K	Pot, 3/8 top	Panasonic	Digikey	REM1-001
R17	1		4.99K	Resistor MF 1% 1/4W		Digikey	REM1-001
R18	1		2.00K	Resistor MF 1% 1/4W		Digikey	REM1-001
R19	1		10 ohm	Resistor MF 1% 1/4W		Digikey	REM1-001
R20	1		100.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R21	1		562	Resistor MF 1% 1/4W		Digikey	REM1-001
R22	1		100.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R23	1		100.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R24	1		562	Resistor MF 1% 1/4W		Digikey	REM1-001
R25	1		100.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R26	1		100.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R27	1		10K	Resistor MF 1% 1/4W		Digikey	REM1-001
R28	1		100 K	Pot, 3/8 top	Panasonic	Digikey	REM1-001
R29	1		51.1K	Resistor CF 5% 1/4W		Digikey	REM1-001
R30	1		100.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R31	1		100.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R32	1		100 K	Pot, 3/8 top	Panasonic	Digikey	REM1-001
R33	1		1.00K	Resistor MF 1% 1/4W		Digikey	REM1-001
R34	1		1.50K	Resistor MF 1% 1/4W		Digikey	REM1-001
R35	1		1.00K	Resistor MF 1% 1/4W		Digikey	REM1-001
R36	1		681	Resistor MF 1% 1/4W		Digikey	REM1-001
R37	1		20K	Resistor MF 1% 1/4W		Digikey	REM1-001
R38	1		10K	Resistor CF 5% 1/4W		Digikey	REM1-001
R39	1		10K	Resistor CF 5% 1/4W		Digikey	REM1-001
R40	1		10.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R41	1		200	Resistor CF 5% 1/4W		Digikey	REM1-001
R42	1		511K	Resistor MF 1% 1/4W		Digikey	REM1-001
R43	1		2.7K	Resistor CF 5% 1/4W		Digikey	REM1-001
R44	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R45	1		100	Resistor CF 5% 1/4W		Digikey	REM1-001
R46	1		10M	Resistor CF 5% 1/4W		Digikey	REM1-001
R47	1		1000M	Resistor CF 5% 1/4W	Ohmite		REM1-001
R48	1		1.00M	Resistor MF 1% 1/4W		Digikey	REM1-001
R49	1		1.00M	Resistor MF 1% 1/4W		Digikey	REM1-001
R50	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R51	1		100K	Pot, 3/4" rect	Panasonic	Digikey	REM1-001
R52	1		300.0K	Resistor MF 1% 1/4W		Digikey	REM1-001
R53	1		10	Resistor CF 5% 1/4W		Digikey	REM1-001
R54	1		10	Resistor CF 5% 1/4W		Digikey	REM1-001
R55	1		499K	Resistor MF 1% 1/4W		Digikey	REM1-001
R56	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R57	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R58	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R59	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R60	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R61	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R62	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R63	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
R64	1		49.9K	Resistor MF 1% 1/4W		Digikey	REM1-001
R65	1		49.9K	Resistor MF 1% 1/4W		Digikey	REM1-001
R66	1		49.9K	Resistor MF 1% 1/4W		Digikey	REM1-001
R67	1		49.9K	Resistor MF 1% 1/4W		Digikey	REM1-001
R68	1		49.9K	Resistor MF 1% 1/4W		Digikey	REM1-001
R69	1		49.9K	Resistor MF 1% 1/4W		Digikey	REM1-001
R70	1		49.9K	Resistor MF 1% 1/4W		Digikey	REM1-001

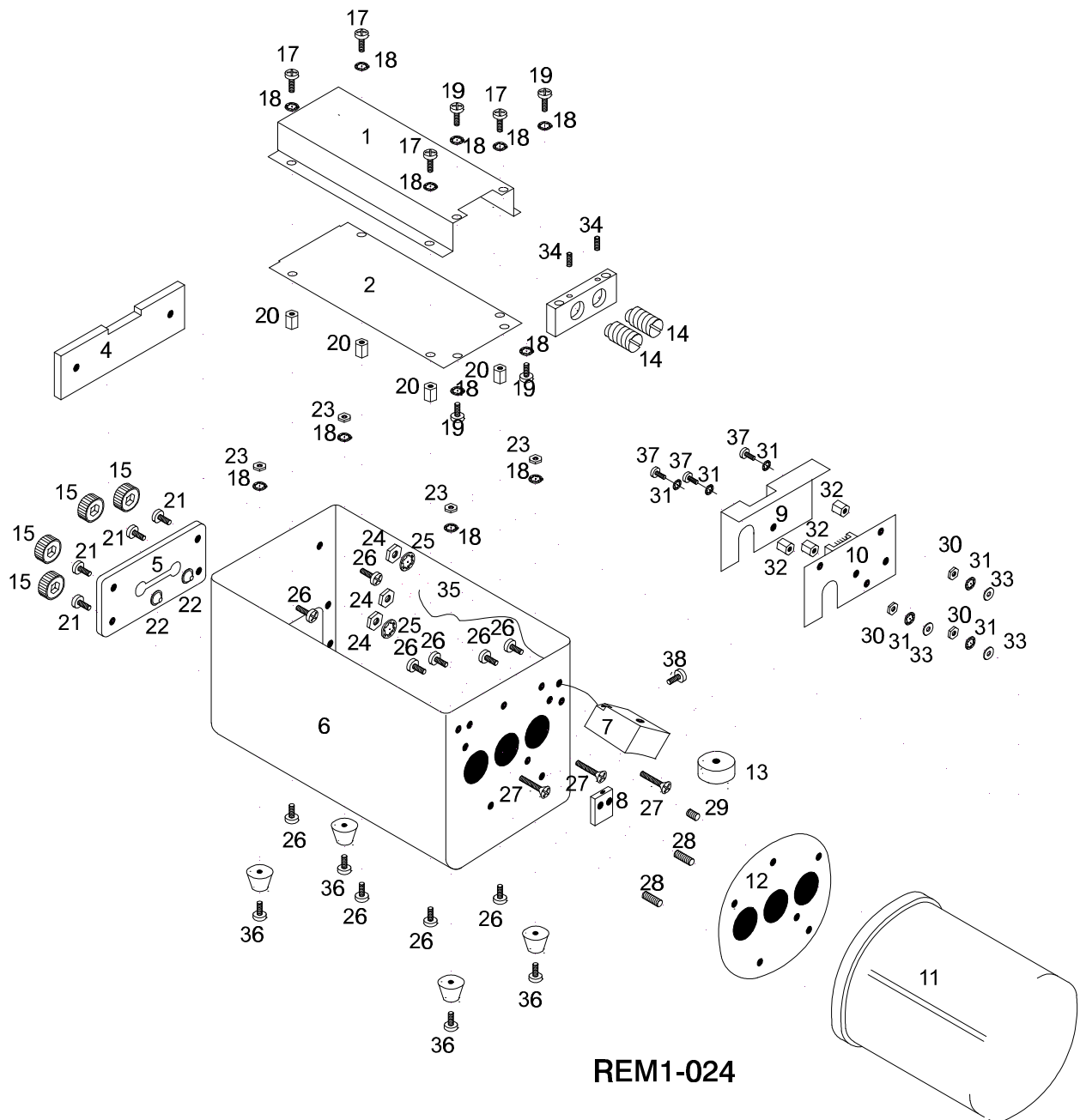
DESIG	QUAN	PART NO	VALUE	DESCRIPTION	MFG	SUPPLIER	DRAWING NO.
R71	1		100K	Resistor MF 1% 1/4W		Digikey	REM1-001
T1	1	T1-REM500	Pot core	Transformer	HPI	HPI	REM1-001
TP1	1		T44	Stake, test point	Vector	Digikey	REM1-001
TP2	1		T44	Stake, test point	Vector	Digikey	REM1-001
TP3	1		T44	Stake, test point	Vector	Digikey	REM1-001
TP4	1		T44	Stake, test point	Vector	Digikey	REM1-001
TP5	1		T44	Stake, test point	Vector	Digikey	REM1-001
TP6	1		T44	Stake, test point	Vector	Digikey	REM1-001
U01	1	TL064CN	TL064	Quad op amp	TI		REM1-001
U02	1	TL062CP	TL062	Dual op amp	TI		REM1-001
U03	1	CD4066NCN	4066	Switch, quad	National	Digikey	REM1-001
U04	1	ADC0804LCN	ADC0804	A-D Conv 8 bit	National	Digikey	REM1-001
U05	1	LM393N	LM 393	Dual Comparator	National	Digikey	REM1-001
U06	1	CD4013BCN	4013	Dual D Flip Flop	National	Digikey	REM1-001
U07	1	511-CD4098	4098	Mono Multivibrator	SGS	Mouser	REM1-001
U08	1	LM385Z	LM 385Z	2.5 V Reference	National	Digikey	REM1-001
U09	1	ICM7556IPD	ICL7665	Dual Timer	Harris	Digikey	REM1-001
U10	1	TLC271CP	TLC271	Op amp	TI		REM1-001
U11	1	4094	CD4094BE	Shift Register			REM1-001
BZ1	1	GCM-1206BX		Buzzer			REM1-002
C01	1		1uF 10V	Capacitor, Tantalum			REM1-002
C02	1		100 pF	Capacitor, Mono			REM1-002
C03	1		10 uF 10V	Capacitor, Tantalum			REM1-002
C04	1		100 pF	Capacitor, Mono			REM1-002
C05	1		22 uF 10V	Capacitor, Tantalum			REM1-002
C06	1		22 uF 10V	Capacitor, Tantalum			REM1-002
C07	1		22 uF 10V	Capacitor, Tantalum			REM1-002
C08	1		22 uF 10V	Capacitor, Tantalum			REM1-002
C09	1		470 uF 16V	Capacitor, Electrolytic			REM1-002
C10	1		0.1 uF	Capacitor, Mono			REM1-002
C10	1		0.1 uF	Capacitor, Mono			REM1-002
C11	1		47 uF 10V	Capacitor, Tantalum			REM1-002
C12	1		47 uF 10V	Capacitor, Tantalum			REM1-002
C13	1		47 uF 10V	Capacitor, Tantalum			REM1-002
C14	1		47 uF 10V	Capacitor, Tantalum			REM1-002
C15	1		47 uF 10V	Capacitor, Tantalum			REM1-002
C16	1		47 uF 10V	Capacitor, Tantalum			REM1-002
C17	1		47 uF 10V	Capacitor, Tantalum			REM1-002
C18	1		0.1 uF	Capacitor, Mono			REM1-002
C19	1		0.1 uF	Capacitor, Mono			REM1-002
C20	1		0.1 uF	Capacitor, Mono			REM1-002
CX1	1		0.1 uF	Capacitor, Mono			REM1-002
CX2	1		0.1 uF	Capacitor, Mono			REM1-002
CX3	1		0.1 uF	Capacitor, Mono			REM1-002
CX4	1		0.1 uF	Capacitor, Mono			REM1-002
CX5	1		0.1 uF	Capacitor, Mono			REM1-002
CX6	1		0.1 uF	Capacitor, Mono			REM1-002
CX7	1		0.1 uF	Capacitor, Mono			REM1-002
CX8	1		0.1 uF	Capacitor, Mono			REM1-002
CX9	1		10 uF 10V	Capacitor, Tantalum			REM1-002
D1	1	1N4148		Diode			REM1-002
D2	1	1N4148		Diode			REM1-002
D3	1	1N4148		Diode			REM1-002
D4	1	1N4148		Diode			REM1-002
D5	1	1N5817		Diode			REM1-002
D6	1	1N4148		Diode			REM1-002
D7	1	1N4148		Diode			REM1-002
D8	1	1N5817		Diode			REM1-002
D9	1	1N4148		Diode			REM1-002
J1	1		26P	Connector			REM1-002
J3	1		7P	Connector	Molex		REM1-002
J4	1		4P	Connector	Molex		REM1-002
L1	1			Electro Magnet			REM1-002
P1	1		26P	Connector			REM1-002
P2	1		36P	Connector			REM1-002
P4	1		4P	Connector	Molex		REM1-002
Q1	1	2N7000		Vfet Power			REM1-002
Q2	1	2N7000		Vfet Power			REM1-002
Q3	1	MPS6534		PNP Transistor			REM1-002

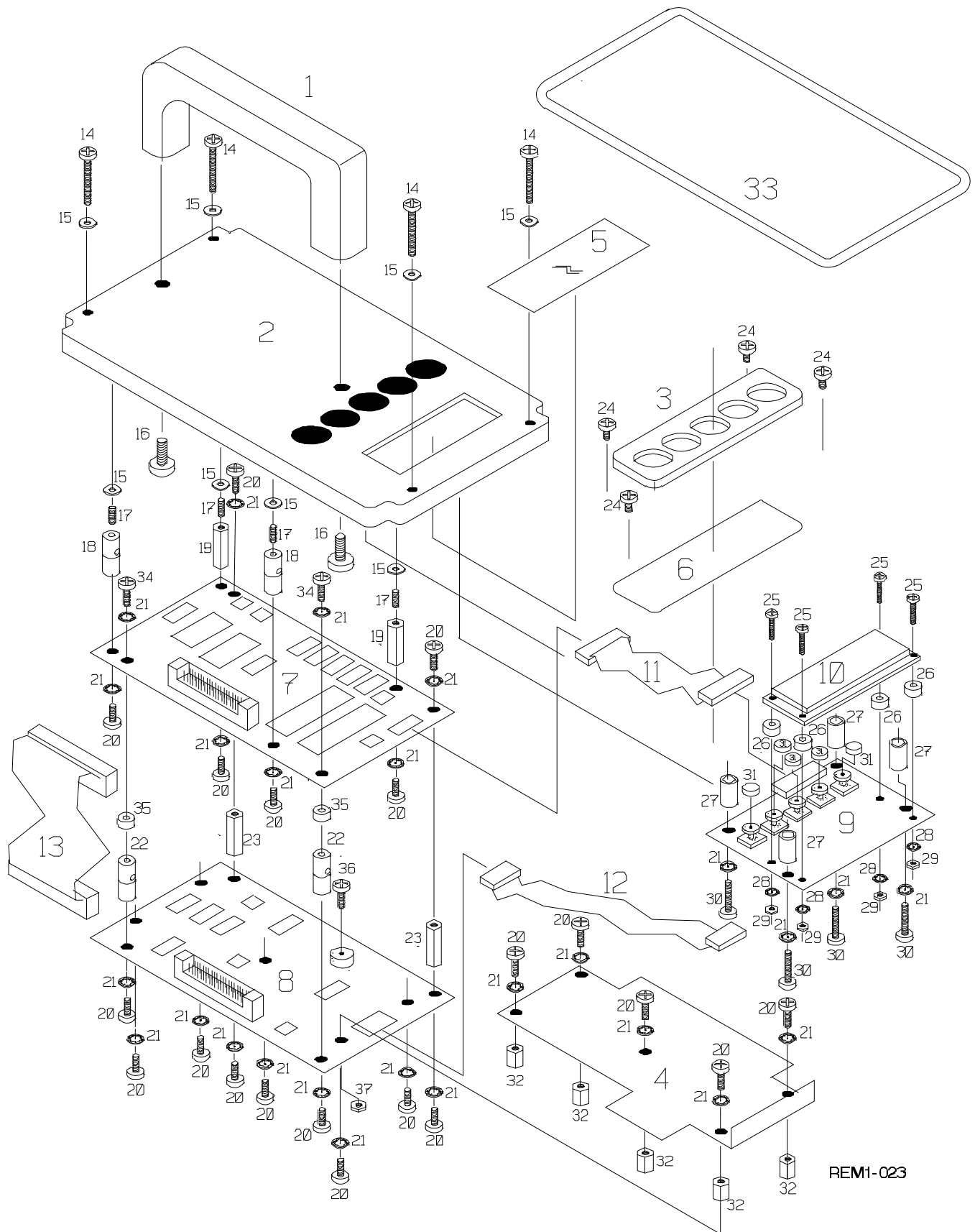
DESIG	QUAN	PART NO	VALUE	DESCRIPTION	MFG	SUPPLIER	DRAWING NO.
Q4	1	2N4124		NPN Transistor			REM1-002
Q5	1	2N7000		Vfet Power			REM1-002
R01	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R02	1			Resistor, CF, 5% 1/4W			REM1-002
R03	1			Resistor, CF, 5% 1/4W			REM1-002
R04	1		20K	Resistor, CF, 5% 1/4W			REM1-002
R05	1		10 ohm	Resistor, CF, 5% 1/4W			REM1-002
R06	1		10K	Resistor, CF, 5% 1/4W			REM1-002
R07	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R08	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R09	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R10	1		47K	Resistor, CF, 5% 1/4W			REM1-002
R11	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R12	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R13	1		24K	Resistor, CF, 5% 1/4W			REM1-002
R14	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R15	1		470K	Resistor, CF, 5% 1/4W			REM1-002
R16	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R17	1		20K	Resistor, CF, 5% 1/4W			REM1-002
R18	1		6.2K	Resistor, CF, 5% 1/4W			REM1-002
R19	1		47K	Resistor, CF, 5% 1/4W			REM1-002
R20	1		10M	Resistor, CF, 5% 1/4W			REM1-002
R21	1			Resistor, CF, 5% 1/4W			REM1-002
R23	1		100K	Resistor, CF, 5% 1/4W			REM1-002
R24	1		100K	Resistor, CF, 5% 1/4W			REM1-002
S1	1	EVQ		Pushbutton N.O.	Panasonic		REM1-002
S2	1	520.02BLU		Pushbutton N.O.	E-Switch		REM1-002
S3	1	520.02BLU		Pushbutton N.O.	E-Switch		REM1-002
S4	1	520.02BLU		Pushbutton N.O.	E-Switch		REM1-002
S5	1	520.02BLU		Pushbutton N.O.	E-Switch		REM1-002
S6	1	520.02BLU		Pushbutton N.O.	E-Switch		REM1-002
S7	1	520.02BLU		Pushbutton N.O.	E-Switch		REM1-002
U01	1	40106		Hex Inverter Sch Trig			REM1-002
U02	1	74HC573		Octal Latch			REM1-002
U03	1	24C02		EEPROM 1K			REM1-002
U04	1	74HC00		Quad NAND			REM1-002
U06	1	80C32AH		Microprocessor			REM1-002
U07	1	HPI PGM	27C256	EPROM HPI Programmed			REM1-002
U08	1	62256		Memory 32K			REM1-002
U09	1	74HC139		Mux 4 x 2			REM1-002
U10	1	MAX232		Rs232 Driver/Rcvr			REM1-002
U11	1	74HC574		Octal Latch			REM1-002
U12	1	TLC271		Op Amp			REM1-002
U13	1	TLC5620		Quad DAC			REM1-002
U14	1	LM393N		Dual Comparator			REM1-002
U15	1	LP2931		Volt Reg 5Volt			REM1-002
U16	1	ICL7660		Voltage Mult			REM1-002
U17	1	ICL7660		Voltage Mult			REM1-002
U18	1	7555		Timer			REM1-002
X1	1	14.745MHz		Crystal			REM1-002
U5	1	2 x 16	SSM21625-BT-BY-GY-5	LCD	Shelly	Shelly	REM1-002
M01	1	11093-A-1032-1B	HANDLE	Amatom	Amatom		REM1-023
M02	1	REM1-007	Top Plate	HPI	Neal Feay		REM1-023
M03	1	REM1-015	Switch Panel	HPI			REM1-023
M04	1	REM1-004	Shield, Analog Bd	HPI	VALY PREC		REM1-023
M05	1		LEXAN	WINDOW	HPI		REM1-023
M06	1		GASKET, SWITCH	HPI			REM1-023
M07	1	REM1-002	DIGITAL CIRCUIT BD	HPI	HPI		REM1-023
M08	1	REM1-002	CIRCUIT BD ANALOG	HPI	HPI		REM1-023
M09	1	REM1-0021	PCB FRONT PANEL	HPI	HPI		REM1-023
M10	1	See REM1-	LCD DISPLAY				REM1-023

DESIG	QUAN	PART NO	VALUE	DESCRIPTION	MFG	SUPPLIER	DRAWING NO.
		018					
M11	1	REM1-025-2	Cable, Ribbon	HPI	HPI		REM1-023
M12	1	REM1-025-3	Cable, Ribbon	HPI	HPI		REM1-023
M13	1	REM1-025-1	Cable, Ribbon	HPI	HPI		REM1-023
M14	4		6-32 x 5/8	Screw, Pan Phil PS			REM1-023
M15	6		#6	Washer, Nylon			REM1-023
M16	2		10-32 x 1/2	Screw, Pan Phil PS			REM1-023
M17	4		6-32 x 3/8	Screw, Set SS			REM1-023
M18	2	354K-ND	6-32 x 1 FF	Spacer, Angle	Keystone	Digikey	REM1-023
M19	2	J181	6-32 x 1	Spacer, Hex	EF JOHNSO NDigikey	REM1-023	
M20	2	0	6-32 x 1/4	Screw, PAN PH PS			REM1-023
M21	2	6	#6 Int Star	Lockwasher			REM1-023
M22	2	353K-ND	6-32 x 3/4 FF	Spacer, Angle	Keystone	Digikey	REM1-023
M23	2	J246	6-32 x 7/8	Spacer, Rnd	EF Johnson	Digikey	REM1-023
M24	4		6-32 x 1/8	Screw, Pan PH PS			REM1-023
M25	4		2-56 x 3/8	Screw, Pan PH PS			REM1-023
M26	4	J230	#4 x 1/8	Spacer, Nylon	EF JohnsonDi gikey	REM1-023	
M27	4	313-1437-014	#6 x 7/16	Spacer, Rnd	EF Johnson		REM1-023
M28	4		#2	Lockwasher, Int Star			REM1-023
M29	4		2-56	Nut, Hex PS			REM1-023
M30	4		6-32 x 3/4	Screw, Pan PH PS			REM1-023
M31	5	REM1-026	Nylon	Spacer, Button			REM1-023
M32	5	J178	6-32 x 1/2	Spacer, Hex	EF Johnson	Digikey	REM1-023
M33	1		1/8 x 18"	O ring, Rubber			REM1-023
M34	2		6-32 x 3/8	Screw, Pan PH PS			REM1-023
M35	2	J168	#6 x 1/8	Spacer, Rnd	EF Johnson	Digikey	REM1-023
M36	1		4-40 x 1/2	Screw, Pan Nylon			REM1-023
M37	1		4-40	Nut, Nylon			REM1-023
M01	1	REM1-005	Box, Battery top	HPI	VAL PREC		REM1-024
M02	1	REM1-006	Box, Battery Bottom HPI	VAL PREC		REM1-024	
M03	1	REM1-011	Batt End Plate	HPI	VAL PREC		REM1-024
M04	1	REM1-010	Bracket, Bottom	HPI	VAL PREC		REM1-024
M05	1	REM1-008	Battery Cover	HPI	VAL PREC		REM1-024
M06	1	REM1-013	Bottom Can	HPI	VAL PREC		REM1-024
M07	1	REM1-014	Magnet Housing	HPI	VAL PREC		REM1-024
M08	1	REM1-009	Bracket, Top	HPI	VAL PREC		REM1-024
M09	1	REM1-003	Cover, Preamp	HPI	VAL PREC		REM1-024
M10	1	REM1-0041	Preamp PCB	HPI	HPI		REM1-024
M11	1	REM1-LET	Detector	HPI	HPI		REM1-024
M12	1	REM1-028	Neoprene	Gasket, Detector	HPI	HPI	REM1-024
M13	1		12VDC	Electromagnet			REM1-024
M14	2		Ball Plungers				REM1-024
M15	4	99-600-9	#6	Thumbscrew Cap	SPI	One Way	REM1-024
M17	4		6-32 x 1/4	Ssrew, Pan PH PS			REM1-024
M18	4		#6	Lockwasher, Int Star			REM1-024
M19	4		6-32 x 1/4	Screw, Pan PH PS			REM1-024
M20	4		6-32 x 3/8	Spacer, Hex			REM1-024
M21	4		6-32 x 3/8	Screw, SHCS SS			REM1-024
M22	2	REM1-028	Battery Contact	HPI	HPI		REM1-024
M23	4		6-32	Nut, Hex PS			REM1-024
M24	3		10-32	Nut, Hex PS			REM1-024
M25	2		#10	Lockwasher, Int Star			REM1-024
M26	1	0S/6-32 x 1/4	6-32 x 1/4	Screw, Pan Sealing	APM Hexsel		REM1-024

DESIG	QUAN	PART NO	VALUE	DESCRIPTION	MFG	SUPPLIER	DRAWING NO.
M27	3		4-40 x 1/2	Screw, CS PH 100deg		REM1-024	
M28	2		10-32 x 1/2	Screw, Set SS			REM1-024
M29	1		10-32 x 5/16	Screw, Set SS			REM1-024
M30	3		4-40	Nut, Hex PS			REM1-024
M31	6		#4	Lockwasher, Int Star			REM1-024
M32	3		4-40 x 5/8	Spacer, Hex	EF Johnson		REM1-024
M33	3		#4	Washer	PS		REM1-024
M34	2		6-32 x 3/8	Screw, Set SS			REM1-024
M35	1		REM1-025-4	Cable, SIP	HPI	HPI	REM1-024
M36	4		6-32 x 3/8	Screw, Pan PH PS			REM1-024
M37	3		4-40 x 1/4	Screw, Pan PH PS			REM1-024
M38	1		10-32 x 1/4	Screw, PHCS SS			REM1-024
P1	1	CKC26G-ND	26 pin	Socket Connector	CW	Digikey	REM1-025
P2	1	CKC26G-ND	26 pin	Socket Connector	CW	Digikey	REM1-025
P3	1	CKC26G-ND	26 pin	Socket Connector	CW	Digikey	REM1-025
P4	1	CKC26G-ND	26 pin	Socket Connector	CW	Digikey	REM1-025
P5	1	CKC10G-ND	26 pin	Socket Connector	CW	Digikey	REM1-025
P6	1	CKC10G-ND	26 pin	Socket Connector	CW	Digikey	REM1-025
P7	1	WM2002	4 pin	Terminal Housing	Molex	Digikey	REM1-025
P7-A	4	WM2200	.1 Tin	Pins for housing	Molex	Digikey	REM1-025
W1	1	R025-ND	26 conductor 6"long Cable, Ribbon		OKI	HPI	REM1-025
W2	1	R020-ND	10 conductor 10"longCable, Ribbon		OKI	HPI	REM1-025
W3	1	R025-ND	26 conductor 3"long Cable, Ribbon		OKI	HPI	REM1-025

XXIX.DRAWINGS





REM1-023