ESP-2 Eberline Smart Portable Technical Manual

ESP-2

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ESP-2

SECTION I. GENERAL

A. DESCRIPTION

The Eberline Smart Portable (ESP-2) is a data logging, microcomputer-based, portable radiation survey instrument designed to operate with most Eberline radiation detectors. It is designed to be used for routine radiation surveys and allows multiple readings (up to 500), to be stored and later output to a computer or a printer. The ESP-2 may also be used in remote areas, operated solely by a computer via its RS-232 serial communications port.

The ESP-2 features a liquid crystal display (LCD) along with a single row of seven multi-function pushbutton switches as its interface to the user. Data are presented in either scientific or floating point notation and have selectable measurement units. Complete detector configuration including HV setting, calibration, and operating mode can be specified for up to three different detectors and stored by the ESP-2. This makes changing detectors a simple matter of disconnecting the old detector, specifying (by name) the new detector, and then connecting the new detector. No internal adjustments are required, making the ESP-2 an ideal instrument for multi-detector field kits.

The ESP-2 features a built-in speaker and includes external headphones for use in high-noise areas. It is powered by six "C" cell batteries and can be optionally equipped with a single channel pulse-height-analyzer (PHA).

A powerful feature of the ESP-2 is Enhanced Store operation. This feature allows the operator to switch between three different detector configurations while only one detector is connected to the instrument. It is possible then, to tailor the "MODE/STORE" key to fit the particular application. For example, the three detector configurations could be calibrated so that the specified high voltage setting centered the PHA windows on peaks from three different isotopes. An Enhanced Store Mode could be selected which, upon pressing the "MODE/STORE" key, store the current reading, download the next set of parameters, and continue operation. Thus, three readings for each location could be stored and uniquely identified on the output. A more common use is to configure "MODE/STORE" to store the current reading, increment the location code, and continue operation.

The ESP-2 has two basic operating modes, Ratemeter and Scaler. There are also four "utility" modes which allow the user to configure the data logging, to output data, to set operating parameters, and to set the clock. These routines make extensive use of menus and descriptive prompts which make it simple to set up and operate the instrument.

In operation, the detector signal is input to the computer and converted to count rate. The basic unit is counts per second. The Ratemeter Mode provides the operator with a dual representation of count rate. The first representation is a moving bar graph. The length of the bar graph is proportional to the activity of the detector. The second representation is a numerical value expressed in applicable radiation units of activity. An audible alarm feature alerts the operator when the alarm setting has been exceeded. To enhance accuracy, the ESP-2 provides both a slow and a fast range of time responses, each of which varies automatically with count rate.

The Scaler Mode, (Integrating or Average Rate) allows the operator to select a counting period over which the computer integrates the detector's signal. In the Scaler Mode the first line of the LCD displays the time remaining in the counting period. The second line shows cumulative "events". At the end of the counting period the instrument displays the length of the counting period and the total number of events or radiation units detected, or if in the Average Rate Mode, will display the average rate for the period shown. If Fixed Precision (2, 5, 8, or 10 percent) is set, the instrument integrates the detector signal for whatever time is required for the selected precision and displays the average rate. Both the time and the number of counts or average rate are displayed at the end of the cycle. The instrument features manual store or auto-store, manual reset or auto-recycle, and manual or auto-cycle output while in the Scaler Mode.

An important feature of the ESP-2 is that logging information such as date, time, instrument number, user ID, detector selected, operating mode, and calibration, are all output as a heading to the stored data. Along with each data point output are the date, time, location code and instrument status.

This instrument should be especially useful to personnel associated with radiation safety offices, health physics offices, nuclear medicine departments, research laboratories, or any application where multiple radiation surveys are required. Furthermore, requirements for hard-copy records for legal documentation of surveys can be provided which offer a record of instrument operating conditions as well as the data, user I.D., and date and time of survey.

B. SPECIFICATIONS

1. Mechanical (with batteries, excluding probe):

a. Overall Dimensions (including all protrusions): L = 10.5 in. (26.7 cm), H = 5.0 in. (12.7 cm), W = 5.2 in. (13.2 cm)

b. Weight: Approximately 3.8 lb. (1.73 kg).

2. Temperature:

Operating: -20°C to +50°C (-4°F to 122°F)

Storage: -30°C to +80°C (-22°F to 176°F)

3. Voltages:

a. Low Voltage: 5 Vdc.

b. High Voltage (detector bias voltage): 500 to 2450 Vdc, adjustable from the keypad.

c. Battery Supply Voltage: 5.8 to 10.0 Vdc.

Figure 1-1
Model ESP-2

4. Detectors:

Most Eberline GM, proportional, or scintillation detectors for alpha, beta, gamma, or neutron activity may be used on the ESP-2. The detectors recommended are described in Section VIII. The detectors connect to the ESP-2 via an MHV-series coaxial connector located on the front of the instrument.

5. Readout:

a. Two lines of 16 alphanumeric characters presented on liquid crystal display (LCD).

b. Character size: H = 0.175 inch (4.45 mm); W = 0.124 inch (3.15 mm).

c. Bar graph resolution: 1 in 48 (2.1 percent).

6. Alarm:

a. For Ratemeter and Scaler Operating Modes.

b. A 2000-Hz audio tone from the speaker.

7. External Controls (Refer to Section II.A.6. for Detailed Functional Description):

A single row of seven 3/8-inch-square pushbutton switches on 1/2-inch centers across the face of the instrument. From left to right, they are:

a. ON/OFF: Press on - press off

b. MODE/STORE: Press on - normally off

c. RESET: Press on - normally off

d. LIGHT: Press on - normally off

e. +/INC: Press on - normally off

f. -/CRSR: Press on - normally off

g. SPKR: Press on - press off

8. Internal Controls (Refer to Section II.A.6. for Detailed Functional Description):

The internal controls consist of four potentiometers and five switches accessible by removing the side access panel. They are:

a. GAIN: Potentiometer

b. THRESHOLD: Potentiometer

c. HV LEVEL: Potentiometer

d. HV GAIN: Potentiometer

e. SPEAKER divide by 1: One switch ON/OFF

f. SPEAKER divide by 16: One switch ON/OFF

g. SPEAKER divide by 64: One switch ON/OFF

h. SPEAKER divide by 256: One switch ON/OFF

i. TEST: Switch

j. RESET: Press on - normally off (accessible with bottom cover removed)

9. Power Supply:

The ESP-2 uses six C-cell batteries. In the ESP-2, the end-of-life (EOL) voltage per cell is 0.9 Vdc using carbon-zinc cells. Six carbon-zinc batteries provide approximately 120 hours of continuous use. Six alkaline batteries provide approximately 300 hours of continuous use. Shorter battery life will be realized if the display is lit frequently, the alarm is sounded, or the speaker is turned on at high count rates for extended periods. The ESP-2 senses the low battery condition at 0.95 Vdc/cell and signals the user by blinking the first character on the display. This indicates that at least 2 hours of operation remain before the end of battery life. The ESP-2 is programmed to turn itself off after it has operated for 1 hour under the "low-voltage" condition (first character blinking). The instrument can be turned on by the operator and will operate for another 1 hour after which it will turn itself off again.

The ESP-2 computer always has a supply of power to the memory so that data will be retained when the power switch is off. The typical battery drain with power off is less than 200 µA; therefore, the batteries should be changed at least once every six months. To allow battery change without loss of memory, the ESP-2 uses a 0.047 F capacitor to supply power to the computer. This allows about 20 minutes to change batteries.

10. RS-232 Serial Input/Output Communications Port:

a. Number of data bits: 8

b. Parity: None

c. Number of stop bits: 1

d. Number of start bits: 1

e. Baud Rate (User Selectable): 150, 300, 600, 1200, 2400, 4800, 9600

f. Hardware Handshakes: DATA TERMINAL READY - OUTPUT
REQUEST TO SEND - OUTPUT
DATA SET READY - INPUT

g. Software Handshakes: Eberline document 13000-A08, ESP-2 Communication Specification, is available upon request and contains a detailed description of the software handshaking protocol.

h. Connector: D subminiature, 9 pin female

i. Logic Levels: ±9V No load

11. Data Storage:

8K RAM (approximately 500 data points). Not erased after data output.

12. **Data Logging Heading:**

    Date, Instrument Number, User I.D., Detector Number, Mode, Calibration Constant, Dead Time, High Voltage

13. **Data:**

    Date-time, Location, Reading, Instrument Status

14. **Operating Modes:**

    Ratemeter:

    a. Normal (fast or slow time constant)

    b. Peak Trap (fast or slow time constant)

    Scaler:

    a. Fixed Precision 2, 5, 8, or 10%

    b. Integrating

    c. Average Rate

15. **Data Logging in Ratemeter Mode:**

    a. Manual store and manual output.

    b. Enhanced store.

16. **Data Logging in Scaler Mode:**

    a. Manual reset, manual store and manual output.

    b. Auto-recycle, auto-store, and manual output.

    c. Auto-recycle, auto-store, and auto-output.

    d. Enhanced store.

17. **Utility Modes:**

    a. Log

    b. Operate

    c. Parameters

    d. Clock

18. **Multiple Detectors:**

    Allows user to preset operating parameters for up to three detectors. Detectors can be switched and operation with a new detector is as simple as selecting the detector by user defined identification (up to 13 characters).

19. **Communication Formats:**

    a. Printer (Output Only)

    b. Computer I/O (see ESP-2 Communication Specification, EIC #13000-A08.)

20. **Microcomputer:**

a. CPU: Intel 80C31

b. External RAM: 8,192 bytes

c. EPROM: 16,384 bytes

21. RS-232 Cable Options:

CA-40-80, ESP-2 to printer.
CA-41-80, ESP-2 to IBM-AT computer.
CA-42-80, ESP-2 to IBM-PC computer or IBM PS2 computer.
CA-80-90, ESP-2 to Seiko printer.

NOTE

The CA-40, CA-41, CA-42 and CA-63 are available in lengths from 24 inches to 50 feet. The length is specified in inches. For example: CA-40-60 is 60 inches long. CA-40-600 is 600 inches (50 feet) long. The standard cables are as shown above, 80 inches (2 meters) long. For further details on these cable, see Section VII.

22. Demo Software Option:

YP11383011(2), ESP-2 Demo Software (includes ESP-2 Communication Specification, EIC #13000-A08).

23. PHA Option (EIC #YP11388002(2)):

A Pulse Height Analyzer (PHA) PC board may be purchased separately and plugged into the existing circuitry, providing pulse height discrimination capability. The PHA "window" and "threshold" are continuously adjustable. An external mounted switch is supplied with the option, which selects either GROSS or PHA operation.

SECTION II. OPERATING INSTRUCTIONS

A. INTRODUCTION

1. General

This section is intended to provide the user with a guide to what the ESP-2 does and how to operate it. There are also easy to follow functional flow diagrams in Section III. The user should utilize these steps through all the operational modes of the ESP-2.

The ESP-2 is simple and straight-forward in its operation. The basic principle of operation is that the signal from an attached radiation detector is converted to count rate. The ESP-2 can be used either as a Ratemeter or as a Scaler, and a variety of units can be selected for display of the data.

The ESP-2 Ratemeter Mode has two submodes:

a. The Normal Ratemeter Mode:

- updates and displays selected units per time, such as counts per minute or mR/h;

- provides the operator with a dual representation of count rate; that is, it provides a moving analog bar graph representing count rate and also a digital value for count rate;

- alarms when an adjustable preset value is exceeded.

The Ratemeter Mode is generally used for routine surveys of surfaces, personnel or clothing for either contamination or exposure rate measurements from a radioactive source.

b. The Peak Trap Ratemeter Mode:

- is same as normal Ratemeter Mode except for the following additional functions:

- retains in a memory buffer the peak value of the ratemeter reading since the last "STORE" or "RESET";

- the peak count rate is transferred from the memory buffer to the data logging memory when a manual store is performed.

This mode is useful in recording the highest level of radioactivity, a radioactive "hot spot".

The Scaler Mode may be used for quantitative data accumulation over a selectable period of time. Using the Scaler Mode, comparisons can be made of radioactivity in various samples or situations. This increases accuracy in the data over that obtained using the Ratemeter Mode.

The ESP-2 Scaler Mode has three submodes:

a. The Scaler Integrating Mode:

- allows setting the time interval over which counts or events are to be accumulated;

- registers the number of events or integrated exposure in the selected time interval;

- sounds the audible alarm if the integrated measurement in the selected time period exceeds the alarm setting.

b. The Scaler Average Rate Mode:

- same as the Scaler Integrating Mode except that the average rate is continuously displayed and updated.

c. The Scaler Fixed Precision Mode:

- automatically adjusts count time so that the measurement has a selectable fixed precision (2, 5, 8, or 10 percent at the 2 sigma confidence level).

The ESP-2 has four "utility" modes. These are the Log, Operate, Parameters, and Clock Modes. They are referenced as "utility" modes because they are not used in making measurements, but as "aids" or "utility" to the measurement modes. These modes assist in transferring data, changing detectors, setting calibration parameters, reading and setting the clock, etc.

The four utility modes are:

a. Clock Mode:

- allows the user to read and set the clock.

b. Parameters Mode:

- allows the user to select one of three detectors for use with the instrument; (A group of predefined parameters is used to configure each of the detectors.)

- allows the user to select the name or label given to the detector;

- allows the user to select the particular operating mode;

- allows the user to set the value of high voltage;*

- allows the user to set the dead time;*

- allows the user to set the calibration constant;*

- allows the user to set the alarm level;

- allows the user to select the count time for the Scaler Mode.

*These items are determined at time of calibration of the ESP-2 with a detector. Refer to Section IV and V.

c. The Operate Mode:

- allows the user to view or change the access level;

- allows the user to view or change the user I.D. number;

- allows the user to view or change the instrument number.

- allows the user to select the default or Enhanced Store Mode. The following options are available if the Enhanced Store Mode is enabled:

- allows the user to select manual or automatic selection of different detector configuration parameters (e.g. high voltage, dead time, calibration constant, units, mode, etc.) while using a single detector. This is useful with the PHA option for changing high voltage to shift the window energy or for simply distinguishing between PHA gross measurements made at the same location. Window open/window closed measurements with a beta-sensitive probe can be identified this way as well.

- allows the user to manually or automatically store data with a single key stroke.

- allows the user to select either manual or automatic increment of the location code when a "STORE" is executed.

- allows the user to set a pause of one to five seconds during the auto-store operation. This allows time for the user to view and/or change the location code number before the ESP-2 stores it.

- allows the user to view or change the LOC (location) code (version 2.4 or later).

d. The Log Mode:

- allows the user to display the stored data;

- allows the user to transfer the stored data to a printer or a computer via the RS-232 serial communications port;

- allows the user to "reset" or "erase" all data points stored in the data log memory;

- allows the user to select the baud rate for the RS-232 communications;

- allows the user to select the communications format.

2. Access Levels

The ESP-2 has access levels programmed into its software. These access levels provide for control of access to the instruments calibration parameters. There are five access levels, 0-4. The higher the access level setting, the more the user can change calibration features or control operating features of the instrument. Table 2-1 summarizes the access levels. Access levels may be changed in the Operate Mode as described in Section II.E. The following define the functions which may be performed with the ESP-2 at a given access level:

a. Access level 0:

- the user may observe measurement values for the particular operating mode the instrument is in; (He may not change modes or any parameters, etc.)

- the user may store readings;

- the user may edit the location codes associated with each particular reading;

- the user may observe and change the instrument access level while in the Operate Mode. (The user must know the key word in order to change the access level, see "Using the Operate Mode" in Section E.)

b. Access level 1:

- the user may perform everything in access level 0;

- the user may view stored data on the display;

- the user may transfer data in the Log Mode;

- the user may change the user I.D. number in the Operate Mode;

- the user may change the count time in the Parameters Mode;

- the user may change the alarm setting in the Parameters Mode;

- the user may read the clock in the Clock Mode.

- the user may change the location code in the operate mode (version 2.4 of later).

Table 2-1
ESP-2 Access Levels, 11383-C31A

c. Access level 2:

- the user may perform everything in access levels 0 and 1;

- the user may select detectors in the Parameters Mode;

- the user may reset or erase the data log memory in the Log Mode.

d. Access level 3:

- the user may perform everything in access levels 0, 1, and 2;

- the user may set the clock in the Clock Mode;

- the user may change operating modes in the Parameters Mode.

e. Access level 4:

- the user may perform everything in access levels 0 through 3.

- the user may change the baud rate and/or select the communication format in the Log Mode;

- the user may change the display units, the calibration constant, the dead time and the high voltage in the Parameters Mode;

- the user may change the instrument number (and hence the key word) in the Operate Mode.

3. Data Logging Features

a. Manual Store

This data logging feature requires the user to press the MODE/STORE key in order to log a data point to memory. This can be done in either the Ratemeter or the Scaler Mode. The STORE function will only work following completion of the count cycle in the Scaler Mode. The value stored is "tied" to the current date/time as well as the current location code. The location code can be changed at any time by the user by entering the new six digit identifier.

b. Automatic Store and Automatic Log

This data logging feature may only be used in conjunction with the Scaler Mode. At the completion of the count cycle, the results are logged to memory and the cycle re-started (AUTO-RECYCLE). Associated with this mode is the ability to automatically output each data point to the peripheral (AUTO-RECYCLE/LOG).

4. Automatic Detector Configuration

Up to three sets of detector calibration parameters may be stored in the ESP-2. Thus, any one of three detectors may be used at any given time simply by disconnecting the cable to the detector in use, selecting the set of new detector parameters from the keypad, and then reconnecting the cable to the new detector. Calibration parameters for that detector must already have been input <u>before</u> the new detector is connected to the instrument.

5. Factory Calibration

The ESP-2 is calibrated at the manufacturing facility. If the instrument was purchased with a detector, the correct calibration factors for that detector are already entered at the factory and the instrument is ready for immediate use. Eberline will calibrate each of the detectors (up to three) purchased with an ESP-2 and input those detectors by name in the parameter files. When less than three detectors are ordered, non-used detector parameter files will have default parameters in them. You should verify that these parameters are the same as those supplied on the Calibration Certificate supplied with the detector. Refer to Section III for directions on viewing the parameters.

If a radiation detector was not purchased with the ESP-2 from the factory, the ESP-2 was calibrated generically at the factory rather than for a specific detector. In that case, calibration factors for the detector or detectors of choice will have to be entered into the ESP-2 before it is ready for use.

CAUTION

Failure to enter the correct parameters for the detector being used may result in erroneous values being presented on the display of the ESP-2.

The parameters which require being set for a particular detector are:

	SECTION
(1) Alarm Point	II.C.4.
(2) Units	II.G.3.
(3) Calibration Constant	II.G.5.
(4) Detector Dead Time	II.G.6.
(5) High Voltage	II.G.7.

The last four are preset at the factory for the detector which was purchased with the ESP-2. The alarm point is set at a high value at the factory and, thus, should be reset to a user determined value if it is desired to use this feature of the instrument. The alarm value may be set to a very high value to disable the alarm.

Section V provides simple instructions on how to change these items when changing detectors or re-calibrating the instrument.

CAUTION

The high voltage should be checked or re-adjusted for a new detector, PRIOR to connecting the detector. FAILURE TO DO SO MAY RESULT IN DAMAGE TO THE DETECTOR.

Regulatory agencies generally require routine laboratory calibration of radiation survey instruments by an approved facility at least once per year. To have your instrument recalibrated return the ESP-2 and detector to the factory in Santa Fe, to the Eberline repair facility in Columbia, South Carolina, or to another approved calibration facility. If your facility has been approved for such calibrations, this may be accomplished by using the procedures given in Section V.A. CALIBRATION.

6. Description of Controls

a. Operator Controls - External (Figure 2-1)

(1) ON/OFF: Pressing the switch turns the instrument on or off.

(2) MODE/STORE: This is a multi-function switch. Pressing the "MODE/STORE" switch while operating in a Ratemeter Mode will initiate the storing process for logging of a data point. After the location code has been verified to be correct, pressing the "MODE/STORE" switch a second time will store the value in memory and return the instrument back to the Ratemeter Operating Mode. Pressing the "MODE/STORE" switch while operating in one of the Scaler Modes will invoke the display showing the Utility Mode Menu. Pressing the "MODE/STORE" switch while operating in one of the utility modes will return the instrument back to the current operating mode (i.e. ratemeter or scaler).

(3) RESET: The functions of the RESET switch depends on the operating mode selected for the instrument.

(a) In Normal Ratemeter Mode: The RESET switch is used to maintain the bar graph on the display.

(b) In Peak Trap Ratemeter Mode: The RESET switch is used to clear the peak trap memory as well as to scale the bar graph on the display.

(c) In Scaler Mode: The RESET switch starts the counting.

(d) Utility Mode Menu: The RESET switch is used to select the Log Mode.

(e) In all utility modes (Log, Clock, Operate, Parameters): The RESET switch is used to initiate change of mode, time, number, or parameters. ""RESET" TO CHG." is displayed. "RESET WHEN DONE" is displayed in most cases where the item is being changed.

Figure 2-1
External Controls and Display.

(f) In the Parameters Mode: The RESET switch is pressed together with "+" or "-" switch to increase or decrease, respectively, values for alarm setting, calibration constant, dead time, high voltage, and count time.

(4) LIGHT: When the LIGHT switch is pressed, the display is illuminated.

(5) +/INC: This is a multi-function switch. "+/INC" is used to answer yes to the question; "LOG THIS VALUE?" in modes where data is manually being stored. Use "+/INC" switch to increment the number over the cursor. When the Utility Mode Menu is displayed "+/INC" selects the Operate Mode. In the Utility Mode "+/INC" switch is used to answer yes to questions displayed and to step through the main menu items. "+/INC" is also used to select the slow time constant in the Ratemeter Mode.

(6) -/CRSR: This is a multi-function switch. "-/CRSR" is used to answer no to the question "LOG THIS VALUE?" in modes where data is manually stored. The Utility Mode Menu will appear in this case. "-/CRSR" switch is used to move cursor to the next position left. At the extreme left position the next "-/CRSR" switch operation will move the cursor to the extreme right position. In the utility modes the "-/CRSR" is used to answer no to questions displayed and step through the main menu items in the reverse direction. When the Utility Mode Menu is displayed "-/CRSR" selects the Parameters Mode.

(7) SPKR: Pressing the SPKR switch turns the speaker on or off. It also turns off the alarm when it sounds. If an alarm occurs, the speaker may be silenced by pressing SPKR.

(8) PHA-GROSS switch: This external control is available with the optional PHA assembly installed. This switch is used to enable or disable the PHA function. In the GROSS position, all pulses above the threshold level are counted.

b. Operator Controls - Internal (Figure 2-2)

Removing the right side door will provide access to the following:

(1) R22, GAIN: This potentiometer adjusts the voltage gain of the detector pulse amplifier. It is usually set to the maximum cw position for maximum gain. When the PHA option is employed the gain may be lowered to increase the energy range of the window.

(2) R27, THRESHOLD: This potentiometer is the threshold adjustment for the detector amplifier pulse height discrimination. It is set for an optimum input sensitivity for the detector being used. (See Section V, Table 5-1.)

(3) R68, HV LEVEL: This potentiometer is used in conjunction with R66, HV GAIN, to calibrate the high voltage. (See Section V.A.2.)

(4) R66, HV GAIN: This potentiometer is used in conjunction with R68, HV LEVEL, to calibrate the high voltage.

(5) S1-A, S1-B, S3-A, S3-B: The positions of these switches select the rate heard from the speaker. They are used to scale down the count rate from a high count rate detector (e.g.; SPA-3) to a more usable rate from the speaker. Available settings are: divide by 1, divide by 16, divide by 64, and divide by 256. When the switch lever is up the switch is off; down is on. Only one should be on at any one time. Figure 2-2 explains the switch settings.

(6) S2-B: This switch is used with automatic testing ONLY and should ALWAYS be set in the operate position (lever down).

These controls are available with the bottom cover removed.

(a) WIN: This internal control is available with the optional PHA assembly installed. This control sets the acceptance range for the pulses from the detector when PHA is in effect. This range is always related to the threshold setting, moving up or down as the threshold level is changed.

(b) RESET: This is a pushbutton switch which when pressed with the batteries removed will reset the computer and memory. ALL STORED CALIBRATION DATA WILL BE LOST.

Figure 2-2
Internal Controls

B. PREPARATION FOR USE AND OPERATIONAL CHECK

Upon receiving the ESP-2 perform the following before proceeding:

1. Set Up the ESP-2 and Detector

The ESP-2 has an MHV connector for connection to a radiation detector. This connector supplies high voltage to the detector and also transmits the detector signal to the ESP-2 for processing and display. If the ESP-2 is already connected to a detector, then it is reasonable to assume that the high voltage has been previously set. If you are not sure that the high voltage has been properly adjusted, disconnect the detector from the instrument by rotating the cable connector counterclockwise. You can proceed through these instructions without the detector being connected.

CAUTION

Failure to disconnect the detector from the instrument BEFORE turning it on can damage the detector if the high voltage is not set properly for the particular detector. Instructions for checking and setting the high voltage can be found in Section II.G.7.

When you are ready to connect the detector, verify that you have the proper cable. It should have a MHV connector on one end and a connector on the other end to mate with the detector. Refer to your detector catalog sheet for the appropriate connector type. A MHV cable connector typically has white insulation in the center which extends slightly beyond the end of the metal portion of the connector. In contrast, a BNC cable connector typically has the insulation flush with the connector end. To connect the cable, rotate the connector clockwise.

2. Turn the instrument "On" or "Off"

Press the "On/Off" switch to turn the instrument "on". The same switch will have to be pressed to turn the instrument "off".

When the instrument is turned on, the display will depend on the selected mode. If the selected mode is Ratemeter, the display should indicate a numerical value on the lower line and a bar graph on the upper line. The bar graph may be off-scale, so press the RESET button to get it back on scale. Refer to Section II.C. for more information on the displayed information. Refer to Section II.D. for the appropriate display if the unit is in one of the scaler modes.

If the instrument has been properly calibrated and is connected to a detector, it is ready to use. Refer to Section II.G. for instructions on how to view and change the calibration parameters.

A quick check to determine that the instrument is functioning is to compare the numerical value being displayed to the background radiation level. If they are close then the instrument is operating and ready to use. Remember that normal statistical fluctuations can cause relatively large changes in the displayed reading at low levels. Press the SPKR button and you should hear clicking proportional to detector events.

3. Determine Battery Level

Examine the first character space in the display (upper left hand corner). If it is blinking, the batteries are discharged and need replacing. The ESP-2 uses 6 C-cell batteries.

The instrument automatically turns itself off 1 hour after the low battery condition signal is given. The ESP-2 can be turned back on after it turns off, but will turn itself off again after 1 hour.

To change batteries, turn instrument off, remove the large screw in the bottom of the case, and carefully remove the case bottom. Replace the batteries while being careful to orient the batteries according to the diagram printed on the bottom surface of the compartment. Replace the case bottom. (See Figure 5.3.)

4. Example Setup

The following procedure is given as an example to set up an HP-270 detector for use with the ESP-2: (These functions may be set up from the Parameters Mode.)

a. Select detector 1 file and assign it the name of "HP-270".

b. Set the high voltage to 900V as shown on the detector's Calibration Certificate. (The nominal value is 900V given in Table 5-1.)

c. Set the units to display "mR/h".

d. Set the calibration constant to be 7.10 + 07 as shown on the detector's Calibration Certificate. (The nominal value is 7.00 + 07 given in Table 5-1.)

e. Set the dead time to 1.10 - 04 as shown on the detector's Calibration Certificate. (The nominal value is 1.20 - 04 given in Table 5-1.)

f. Set the alarm to the desired value.

g. Select the Normal Ratemeter Mode.

h. Exit the Parameters Mode and connect the HP-270 detector to the instrument. It is ready for use.

C. OPERATION IN THE RATEMETER MODE

The Ratemeter Mode has two submodes - Normal Ratemeter Mode and Peak Trap Ratemeter Mode. The instrument acts as a "normal" ratemeter in the first mode. For example, the display will output a bar graph whose length is proportional to the number of detector events per unit time and a numerical reading whose value is expressed in the measurement units selected by the user. The current ratemeter reading may be logged by pressing the STORE key.

The Peak Trap Ratemeter Mode works just like the Normal Ratemeter Mode EXCEPT that the peak ratemeter reading that has occurred since the last pressing of either the STORE key or RESET key is held in an internal memory buffer. When the STORE key is pressed, the peak value is logged instead of the current reading.

1. Analog Bar Graph (at the top of the display)

The length of the analog bar graph is proportional to the detector count rate. One purpose of the bar graph is to permit more rapid recognition of a sudden increase or decrease in the radiation field being measured than can be achieved using the digital display.

If the bar graph is off scale in either direction, it may be brought back on scale by pressing the RESET key. The full scale value of the bar depends upon the level of radiation being measured. Pressing the RESET key always resets the length of the bar graph to a point that is 33 percent of full scale. If the bar graph is displayed and is varying, the ESP-2 is working.

2. Numerical Value of Count Rate (at the bottom of the display)

The second line of the display is the numerical value of the count rate. The value may be expressed in one of two ways. The first way is scientific notation, which is a three digit number followed by a second positive or negative number. The second number corresponds to a power of 10. Example: 1.00 + 02 mR/h is $1 \times 10^2 = 100$ mR/h. The second way the numerical value may be expressed is by a three digit floating point number followed by the units (e.g. µR/h, mR/h, R/h, kR/h). The prefix to the units changes automatically to express the decade the value is in. The decimal point of the integer will float (e.g., .xxx, x.xx, xx.x, xxx) to allow three decades of range for one prefix setting. Thus, the auto-prefix mode will allow twelve decades of range. Above or below this twelve decade range, scientific notation is employed to express the values. The ESP-2 has one decade of hysteresis built in at each prefix change to prevent oscillation in the units display. When the prefix does change, it is flashed for a few seconds to alert the user to the change. The auto-prefix feature is selected in the Parameters Mode while specifying units.

3. Accuracy, Precision and Response Time

Accuracy of the ESP-2 reading depends upon a number of factors, the most important being the calibration procedures utilized. Also critical are the data manipulation techniques employed by the ESP-2 to convert the pulse rate from the detector to the reading output to its display.

There is a direct trade-off in pulse counting instruments between response time and the statistical standard deviation (precision) in the reading. The ESP-2 utilizes a self-adjusting response time to maintain a fixed statistical standard deviation in the value measured. Response time is defined as the time required to reach 90 percent of the final value of the step size due to a step change in the input.

Response time is adjusted automatically by the microcomputer in the ESP-2, using a weighted average algorithm with variable weighting parameters in order to maintain a fixed statistical precision over a wide range of detector pulse rates. Two fixed precision levels are available depending upon whether the fast or slow response time range is desired. The selected nominal precision level is maintained over the range of count rates from approximately 50 to 500 cps. Below and above these count rates the statistical precision is poorer and better respectively. The Normal Operating Mode provides a reading that has a nominal standard deviation of 5 percent within response time constraints of one and ten seconds. This is referred to as the fast response time mode. When the "+" key on the ESP-2 is depressed (and for one minute following its release), the reading displayed has a standard deviation associated with it of nominally 3 percent within response time constraints of one and thirty seconds. The 3 percent mode is always used whenever the ESP-2 is in the menu (Parameters) mode. This is referred to as the slow response time mode.

The ESP-2 reading is calculated every 0.5 seconds. An alarm check is made at that time as well. The ESP-2 minimum response time is fixed at one second and the display is updated every two seconds.

4. Alarm

When the counting rate reaches the selected alarm level, an audible high-pitched tone will be heard. To silence the alarm, press SPKR key. The alarm will sound even if the speaker is off at the time the alarm is activated.

The alarm set point can be viewed and changed, provided the instrument is set for at least access level 1. See Section II.G.4. on how to view and/or change the alarm setting.

5. Over Range Indication

When the detector pulse rate exceeds the capability of the ESP-2 to maintain a linear relationship between radiation level and the displayed reading, the words "OVER RANGE" will appear on the display in place of the analog bar graph. The numerical value will still be displayed but SHOULD NOT BE RELIED UPON as the useful range of the ESP-2 and detector has been exceeded. This is a latching condition and once it occurs the words "OVER RANGE" will be displayed. To clear the condition, the ESP-2 must be turned off and then back on. The over range determination is based upon the detector pulse rate and the dead time (see Section II.G.6.). This feature REQUIRES that the ESP-2 and detector be properly calibrated for it to function correctly.

6. Storing Readings in Ratemeter Mode

To store or log a particular ratemeter reading while using the default "STORE" function press the STORE key. The following will appear on the display:

LOG THIS VALUE?
(ratemeter reading)

Press "+" to answer yes and the following display will appear:

LOC. CODE xxxxxx
(ratemeter reading)

The location code may be edited now. Pressing "+/INC" will increment the numbers above the cursor and pressing "-/CRSR" will shift the cursor. The six digit location code number will automatically increment one unit every time the STORE key is pressed. This feature aids in logging data at sequentially numbered locations.

Press "STORE" again and the measurement value is "stored" and the instrument returns to its normal operating mode. Data is stored in this manner in both the Normal Ratemeter Mode and in the Peak Trap Ratemeter Mode.

To store or log a particular ratemeter reading with the Enhanced Store feature enabled and Auto-store selected, press the STORE key. The following display appears:

LOC. CODE xxxxxx
x.xx ± xx (rate units)

The top line has the location code for the data to be stored. Press any key (except "RESET" or "LIGHT") before the user selected pause of 1 to 5 seconds expires and the number can be edited and then stored by pressing the STORE key again. Otherwise, a display pertaining to the selection of a detector may appear (if auto detector select has been enabled) such as:

#x
(AUTO SELECTING)

The top line is the detector number and identification string. Unless a key is pressed before the pause time expires, this detector's calibration parameters will be loaded and used for taking the next measurement (using the detector presently connected to the instrument). After this display the instrument automatically reverts to the normal ratemeter mode display. Observe that only one key stroke was used to store data in this configuration.

7. Operating in the Peak Trap Ratemeter Mode

This mode may be selected from the Parameters Mode (see Section II.G.2.). Operation in the Peak Trap Ratemeter Mode is the same as in the Normal Ratemeter Mode, except that the peak ratemeter reading that has occurred since the last pressing of the STORE or RESET key is stored in a memory buffer. It is this peak value that is displayed when the STORE key is pressed. The store operation is not complete until the STORE key is pressed again after the location code is displayed. Normal ratemeter reading (not peak reading) is displayed while measurements are being made in this mode. This mode is useful for locating "hot" spots in an area survey.

D. OPERATION IN SCALER MODE

CAUTION

Both the calibration constant (CC) and the dead time correction (DT) are active in the scaler mode. To read **actual counts detected,** CC must be set to 1.00 + 00 and DT correction should be set to 1.00 - 07. These two parameters must be set back to their original values when something other than actual counts detected is desired.

There are three different Scaler Modes in which the instrument may operate. They are Average Rate, Integrating, and Fixed Precision. In the Average Rate Scaler Mode, the detector events are integrated for a preset time which is selected by the user. The average rate is displayed continually during the scaler interval and is updated as time progresses. The most accurate reading is the one displayed after the scaling interval is over. In the Integrating Scaler Mode, readings are integrated for the preset time selected by the user. The integrated reading in user selected units is displayed at the end of the scaler interval. In the Fixed Precision Scaler Mode, the measurements are integrated for a computed interval as required to generate the selected "fixed" precision of the reading. The reading is displayed in rate units. Thus the low count signals are integrated for a longer period of time than are higher count rates in order to produce the required precision. The interval automatically adjusts between the limits of 5 seconds and 4 hours.

These Scaler Modes may be selected in the Parameters Mode (see Section II.G.2.).

1. Average Rate Scaler Mode

If the Average Rate Scaler Mode has been selected, turning the instrument on will produce the following display:

CNT FOR 0:01:00
RESET TO START

One minute is the default time, i.e., the time the computer selects for scaler preset time unless a different time has been input from the keypad. Pressing RESET starts the count and the following display appears:

0:00:xx LEFT
x.xx (rate units)

The measured rate, averaged from the time the RESET key was pushed, is displayed on the second line. The first line represents the time remaining in the count interval. To change the count time from the default one minute, enter the Parameters Mode (assuming your instrument is set for access level 1 or greater) and step through the Parameters Mode menu using the "+" or "-" key until you get to the following display:

CNT FOR 0:01:00
SCALER MODE

Press RESET and "+" to increase the time or press RESET and "-" to decrease the time. To exit the Parameter Mode press MODE key and you will be back in the Scaler Average Rate Operating Mode.

While selecting any Scaler Mode, including Average Rate Scaler Mode, you have the option of selecting auto-recycle or manual. Auto-recycle will automatically, at the end of the preset scaler interval, store the average rate and reset the Scaler Mode so that a new time interval is begun. If the instrument is in manual control, it will stop scaling at the end of the preset time interval. A beep will be heard at this time. To store the average rate you would press STORE key, press "+" to answer yes, edit the location code, and press STORE key again. To start a new cycle you would press RESET key.

If Auto-Recycle Mode had been selected, then the measurement is automatically stored at the end of the preset interval. If in the manual mode, the following display will appear after the scaling interval is over.

CNT FOR x:xx:xx
x.xx ± xx (units)

Press STORE and the following display appears:

LOG THIS VALUE?
x.xx + xx (rate units)

Press "+" and the following display will appear:

LOC. CODE xxxxxx
x.xx + xx (rate units)

Press "+/INC" to change the location number above the cursor and press"-/CRSR" to shift the cursor position. After editing the location code, press STORE to store the value and return to the initial operating display. Note that if Auto-Recycle Mode had been selected then the location code is NOT automatically incremented.

2. Integrating Scaler Mode

The main difference between this mode and the Average Rate Scaler Mode is that the integrated count is displayed instead of the average rate.

If the Integrating Scaler Mode has been selected, turning the instrument on will produce the following display:

CNT FOR 0:01:00
"RESET" TO START

One minute is the default time and it may be changed. Press RESET key and the scaler count begins. This display will appear:

x:xx:xx LEFT
x.xx (units)

The first line shows the time left for the scaler count and the second line shows the count in selected units. When the scaling interval is over, the following display appears:

CNT FOR x:xx:xx
x.xx ± xx (units)

Press STORE to log the value and the next display is:

LOG THIS VALUE?
x.xx+/-xx (units)

Press "+" and the following display appears:

LOC. CODE xxxxxx
x.xx + xx (units)

Edit the location code, if desired, and press STORE to log the count. RESET key then must be pressed to begin a new scaler count.

3. Fixed Precision Scaler Mode

The user may select a certain precision (2, 5, 8, or 10% at the two sigma confidence level) for the measurement he wants to make. The computer automatically computes the time interval required for the selected precision. The better the precision the longer the interval required. The computed time interval ranges from 45 seconds to 4 hours.

This mode is selected in the same manner as the Average Rate Scaler Mode. Get to the mode select menu in the Parameters Mode and press RESET to change. The following display will appear:

SCALER MODE?
+ = USE/ - = NO

Press "+" and the following will appear:

FIXED PRECISION
+ = USE/ - = NO

Press "+" and the following will appear:

PRECISION xx%
+ = USE/ - = NO

Press "-" until the desired precision is displayed. The choices are 2 percent, 5 percent, 8 percent, and 10 percent. Suppose we want 10 percent, so we press "-" until 10 percent appears in the upper right hand corner of the display. Then press "+" to use it. The next displays prompt whether we want auto-recycle, auto-log, etc. After making those selections, we press "MODE" to exit the Parameters Mode and return to the Fixed Precision Operating Mode. The display of time left in this operating mode is computed based on how fast the counts are arriving. The faster the counts, the shorter the time left. The default time left is 4 hours (for low count rates).

If you have not selected auto-recycle, the display will appear as follows:

PRECISION 10%
"RESET" TO START

Press RESET; the measurement starts and the following appears:

x:xx:xx LEFT
x.xx (rate units)

At the end of the measurement cycle the speaker beeps and this display appears:

PRECISION xx%
x.xx + xx (Rate Units)

Press store and then you will be given the opportunity to log the value. (See Section II.D.1. and 2. above for the description of how to store measurements.) Then you can begin a new cycle.

4. Storing Data in a Scaler Mode

During the selection of a Scaler Mode from the Parameters Mode, you are given the option of selecting auto-recycle or manual-recycle. Auto-recycle will automatically, at the end of the preset scaler interval, store the reading and reset the Scaler Mode. At that time a new measurement interval is begun. If manual-recycle has been selected, the integration will stop at the end of the scaling period and wait. A display showing the resulting integrated value is displayed. Press STORE key to cause the display to ask if you want to log this value. Press "+" to answer yes, edit the location code if desired, and press STORE key again. To start a new cycle the RESET key is pressed.

In auto-recycle mode, the data is automatically stored at the end of the scaling interval. If auto-log has been selected, the freshly-stored data will be output to a printer or peripheral device.

Another ESP-2 store feature that is available in all scaler modes is the Enhanced Store function. This feature provides the capability of automatically switching between any of the three allowed sets of the detector calibration parameters between "Store" operations. Available with Enhanced Store function is one key store operation. See Figures III.18, 19. The Enhanced Store functions are selected from the Operate Mode menu. See Section II.E.3.

E. USING THE OPERATE MODE

1. Entering the Operate Mode

This mode may be entered from either operating mode (Ratemeter or Scaler). Press MODE key and the following display appears:

LOG THIS VALUE?
(reading, units)

Press "-" key to answer no and the following display appears:

R/COMM -/PARAMS
+/OPER S/CLOCK

Press "+" key to enter the Operate Mode.

2. System Level Parameters

On entering the Operate Mode the first display that appears is:

ACCESS LEVEL x
"RESET" TO CHG.

This display appears at all access levels, 0 through 4. The access level may be changed here. Press RESET to change access level. This display will appear:

KEY xxxxx
"RESET" WHEN DONE

3. Notes About the Keyword:

The keyword is a four digit password that is used to change the access level. That is its only purpose. It is really the four least significant digits of the instrument number. The instrument number is a six digit number that can be viewed (and changed) ONLY from access level 4. Many users routinely use the instrument serial number as the instrument number. For example: If the instrument serial number is 567 the instrument number should be 000567 and the keyword would be 0567. This is up to the user. The instrument number should not be confused with the I.D. number of the user. This is a nine digit number, that may be viewed (and changed) at any access level except 0.

The default instrument number is "000000." The instrument is normally shipped in access level 4 and the instrument number is either 000000 or 00XXXX, where "XXXX" is the instrument number.

The editing procedure is the same for all functions:

a. The display should read as shown above (key XXXXX, RESET when done).

b. Use the "-" key to move the cursor to the left to the digit to be changed. This key moves the cursor to the left as far as it will go, and then back to the digit on the extreme right, etc.

c. When the cursor is positioned under the digit to be changed, the "+" key is repeatedly pushed until the digit is the desired value.

d. The "-" key is used to move the cursor to the next digit to be changed, repeat "c."

e. When all digits are as desired, RESET is pushed.

Here is the procedure for changing an instrument from access level 4 to access level 3. The instrument number is 000567. This means the keyword is 0567. (See notes about the keyword.) Using the editing procedure already outlined, the display is made to read 05673. The 3 represents the desired access level. When the instrument "RESET" is pushed, the instrument goes to access level 3.

CAUTION

Before going to a lower access level, the instrument number must be noted somewhere, as it can be viewed only at access level 4.

NOTE

The displays shown in this section all appear at access level 4. Some appear at access level 0, some at level 1, etc. See Section II.A. for which displays appear at which access levels.

Press "+" or "-" to step through the menu in the Operate Mode. Press "+" and the following will appear on the display:

NOTE

In instruments with software version 2.4 and later, the following display will appear between the access level and the ID number display (described below):

LOC CODE XXXXXX
"RESET" TO CHG

The location (LOC) code may just be viewed or it may be changed using the same procedure described below for changing the ID number.

I.D. # xxxxxxxxx
"RESET" TO CHG.

This first line is the user I.D. number. It may just be viewed or it may be changed. Press RESET and the following display will appear.

I.D. # xxxxxxxxx
"RESET" WHEN DONE

The user I.D. number is changed using the "CRSR" key to select the digit and the "+" key to change it. Press RESET and then MODE to exit the Operate Mode.

To change the instrument number, enter the Operate Mode and step through the menu until the following display appears:

INSTR. # xxxxxx
"RESET" TO CHG.

Press RESET and observe the following:

INSTR. # xxxxxx
"RESET" WHEN DONE

Enter the instrument number using the "CRSR" key to select the digit and the "+" key to change it and press RESET.

Also available in the Operate Mode and at Access Level 4 is the capability to switch between Default Store and the Enhanced Store functions. One of these functions is in effect while making and storing measurements in all operating modes. Default Store, when selected, enables the normal or "default" functions described throughout this manual. Enhanced Store provides additional capabilities such as storing by pressing only one key and selection of up to three sets of detector parameters. Press "+" and the following display appears:

DEFAULT "STORE"
"RESET" TO CHG.

Press RESET and the following display appears:

ENHANCED "STORE"
"RESET" TO CHG.

The Enhanced Store function is now selected. Press "+" to select the next menu item under Enhanced Store function. The next display is:

AUTO INC. LOC.
"RESET" TO CHG.

If the "+" key is pressed, the location code will be incremented when the store key is pressed. Pressing RESET shows the alternate option:

MANUAL INC. LOC.
"RESET" TO CHG.

This option is useful when one needs to make several measurements at a single location. Press "+" and the next menu item under Enhanced Store appears:

AUTO "STORE"
"RESET" TO CHG.

If this menu item is selected, single key storage is available. Press "+" and the next display is:

AUTO PAUSE x
"RESET" TO CHG.

Pressing RESET selects values of pause time from 1 second to 5 seconds. If, from the auto "Store" menu, "RESET" had been pressed instead of "+" the following display would appear:

MANUAL "STORE"
"RESET" TO CHG.

This option allows storing to be done in the usual way with a series of keystrokes. Press "+" and the last set of options in Enhanced Store function appears. There are four of these (shown below). They may be stepped between with the RESET key:

DET. SELECT OFF
"RESET" TO CHG.

If this is selected, there is no automatic capability to switch detector parameters while making measurements. Press RESET and the next option appears:

MANUAL DET. SEL.
"RESET" TO CHG.

This option directs the menu to the regular detection selection menu found in the ratemeters Mode. The user may then manually change detectors and/or detector parameters. Press RESET to see the next option:

2 DET. AUTO SEL.
"RESET" TO CHG.

With this one selected, the instrument automatically switches between two sets of detector calibration parameters, permitting the user to make more than one type of measurement with a single detector. The ESP-2 always logs both data points with the same location code. The final option is:

3 DET. AUTO SEL.
"RESET" TO CHG.

This option functions exactly the same as the two-detector option, except with three detectors.

Press MODE key to exit the Operate Mode.

IMPORTANT

When making measurements with Enhanced Store function enabled, pressing MODE key for the scaler modes or pressing MODE and RESET together for the Ratemeter Mode will cause the Utility Mode Menu to be displayed.

F. USING THE CLOCK MODE

Enter the Utility Mode Menu in the display by pressing MODE and "-" key. From the Utility Mode Menu press SPKR to select the Clock Mode. If the access level is 3 or greater you may read and set the clock. Observe the following display:

JUN 15, 86 1230
"RESET" TO CHG.

JUN 15, 86 1230 is the default time. The hour of day is presented in military time, that is, 0000 through 2359 hours. Press RESET to set the clock to current time. Observe the following display:

JUN 15, 86 12xx
"RESET" WHEN DONE

Using "+" to increment the digit above the cursor and CRSR to move the cursor to select digits, set the current date and time. Press RESET and revert back to the initial clock display, with the edited values now displayed. Press MODE to exit the Clock Mode.

G. USING THE PARAMETERS MODE

From this mode you may select one of three detectors, change the detector I.D., change the operating mode or submode, change the mode parameters, (such as count time, and alarm setting) or you may change the detector calibration parameters (such as units, calibration constant, dead time, and high voltage).

The count time and alarm setting may be changed at access level 1 or greater. Detector selection may be made at access level 2 or greater, the mode at 3 or greater, and the units, calibration constant, dead time and high voltage at access level 4.

1. Selecting Detectors:

You may select from three sets of preprogrammed detector parameters stored in the computer memory. When a detector is selected, the user has actually automatically set high voltage, calibration constant, dead time, alarm level, preset time, etc. to properly operate the instrument with the selected detector.

Enter the Parameters Mode and the first menu item to appear is detector selection:

#1 (DET. NAME)
"RESET" TO CHG DET

Press RESET and the following display appears:

USE DET. #1?
#1

Press "-" and you can step through your choice of three detectors. When the user gets to the one they want to use "+" is pressed. The user then will be given the opportunity to edit the detector information:

EDIT DET. INFO?
#1

Press "+" and the following display will appear:

"RESET" WHEN DONE
#1

The cursor appears in the display. Press "+" to step through the alpha-numeric characters available plus "-", ".", "/". When the desired character appears, release "+" and press CRSR to shift the cursor to the next character and so on. Up to 13 characters may be inserted. A typical detector I.D. is "HP-270". Press RESET when completed. Until this particular selected detector is changed again all detector parameter changes such as high voltage, calibration constant, etc. will be "tied" to that detector number and I.D. Press MODE to exit the Parameters Mode.

2. Selecting Operating Modes

Figure 3-14 shows the functional flow diagram for selecting the operating mode. It also shows the various operating modes the instrument functions in.

The two basic modes are Ratemeter and Scaler. The Ratemeter Mode has two operating modes: Normal Ratemeter Mode and Peak Trap Ratemeter Mode. The Scaler Mode has three operating modes: Average Rate Mode, Integrating Mode and Fixed Precision Mode. Coupled with each of the Scaler Modes are the submodes of auto-recycle, auto-log, manual reset, manual store, and manual log output.
You are permitted to change modes in the Parameters Mode only if the instrument is set for access level 3 or 4. For purposes of this discussion we will assume the access level is at 3.

From any of the operating modes, press the MODE key and the following display will appear:

LOG THIS VALUE?
(reading, units)

Press "-" to answer no and we get the Utility Mode Menu.

R/LOG -/PARAMS
+/OPER S/CLOCK

Press "-" to select the Parameters Mode. The first display to appear in Parameters Mode has to do with selecting detectors. Press "+" to step through the Parameters Mode items. The next item is:

(current operating mode)
"RESET" TO CHG.

This display will be any one of those in Figure 3-16. For purposes of illustration, assume we have been operating in the Normal Ratemeter Mode and we wish to change to the Integrating Scaler Mode. The above display would appear thus:

RATEMETER MODE
"RESET" TO CHG.

Press RESET key and the following display appears:

SCALER MODE?
+ = USE/ - = NO

Press "+" key and the following display appears:

FIXED PRECISION
+ = USE/ - = NO

Press "-" and the following displays appears:

INTEGRATING
+ = USE/ - = NO

Press "+" and the following display appears:

AUTO RECYCLE
+ = USE/ - = NO

We have the choice of selecting the Auto-Recycle Mode. This mode will automatically store the reading at the end of the preset scaling interval and will automatically start a new interval. Even though the scaling function will continue to recycle, the location code will NOT be incremented. Pressing "-" selects the Manual Store Mode. Pressing "+" selects the Auto-Recycle Mode and the following display appears:

AUTO LOG?
+ = USE/ - = NO

This display offers us the option of using the Auto-Log Mode while operating in the Integrating Scaler Mode. The Auto-Log Mode will work with the Auto-Recycle Mode to automatically output the stored data to a peripheral device. The data is output immediately each time after it is stored. If the Auto-Log Mode has not been selected, but data output is desired, the Log Mode must be entered. Pressing "+" will cause the following display to appear:

SCALER MODE
"RESET TO CHG"
INTEGRATING
AUTO RECYCLE/LOG

Since we have a two line display, the second, third, and fourth lines are displayed alternately. The instrument has been set for the Integrating Scaler Mode. To exit the Parameters Mode and start operating in the Integrating Scaler Mode, press MODE key.

3. Changing Units

The measurement units may be changed at access level 4. Enter the Parameters Mode and step through the Parameters Mode menu items until you reach the following display:

UNITS = (units)
"RESET" TO CHG.

The current measurement units are displayed in the upper line. Cnt/s are the default units. Press RESET and observe the next display:

BASE cnt
+ = USE/- = NO

The selection of the BASE units is now possible. The choices available for base radiation units are:

R	Roentgen
cnt	counts
Gy	Gray
Sv	Sieverts
REM	roentgen equivalent man
dis	disintegrations
rad	radiation absorbed dose

Notice that only the base unit is displayed; thus, if mR/h is desired on the display, select "R" as the base unit. The prefix (milli) and the suffix (h) will be added in the next steps.

Press "-" to reject the displayed base unit, and another selection will be offered. When the display shows the desired base unit, press "+" to accept it.

CAUTION

Selection of a new base unit requires an appropriate change in calibration constant (CC). Refer to Section II.G.5. Changing the prefix or suffix DOES NOT affect calibration, and therefore, requires no change in the calibration constant.

Selection of Suffix:

After the "+" is pressed to accept the base unit, the display will then present the selection of SUFFIX as follows:

SUFFIX /s
+ = USE/- = NO

The suffix is the unit of time used to calculate the displayed ratemeter reading. Three are available:

s	second
min	minute
h	hour

Again, press the "-" switch to reject the suffix displayed and another selection will be offered. When the desired suffix is displayed, press "+" to accept it.

Selection of Prefix:

After the "+" is pressed to accept the suffix, the display will then present a prefix, which may be added to the base unit to give a more convenient unit of actual measurement.

PREFIX (value)
+ = USE/- = NO

The prefix is the value by which the base unit is scaled. Five are available:

(NONE)	no prefix
u	micro (x 10^{-6})
m	milli (x 10^{-3})
K	kilo (x 10^{+3})
AUTO	automatic calculation and display of a prefix and a 3 digit numerical value

If the prefix displayed is not the desired value, then press "-" to reject it and view the next choice. When the desired prefix is displayed, press "+" to select it. The setting of radiation units to be measured would now be complete. An example of this would be:

PREFIX	BASE		SUFFIX
m	R	/	h
(milli)	(Roentgen)	/	(hour)

The units may be selected in any combination of prefix/base/suffix. Exit the Parameters Mode by pressing MODE.

4. Changing Alarm Setting

The alarm setting may be changed at access level 1 or greater in the Parameters Mode. The value of the alarm setting is expressed in units of the current operating mode. For example, if the current operating mode is ratemeter and the ratemeter units are cnt/s, then the alarm setting units are cnt/s. If the current operating mode is Integrating Scaler Mode and the selected units are mR, then the alarm setting will be in units of mR. Note that during the alarm setting the second line will contain rate units (e.g. mR/h). The actual display during and after the scaling interval will be in integration units (e.g. mR) only.

Enter the Parameters Mode and step through the menu by repeatedly pressing the "+" key until the following display appears:

ALM AT x.xx+xx
(rate reading, units)

To change the alarm value, press RESET key and "+" key simultaneously to increase the value or press RESET key and "-" key simultaneously to decrease the value.

NOTE

When pressing RESET and "+" or RESET and "-" simultaneously to change a parameter, always press the RESET key BEFORE "+" or "-". If the computer senses the user pressing "+" or "-" first, it may interpret the entry as a command to display the next menu item.

After the desired value is displayed press MODE key to exit the Parameters Mode. Remember that this alarm value is set for the selected detector and will be stored in memory if another detector is selected. Thus, up to three different alarm values, for three different detectors, are held in memory.

The alarm can be disabled by setting it to an very high value.

5. Setting the Calibration Constant (CC)

a. Definition of Calibration Constant:

The calibration constant (CC) is the number used to convert the counts from the detector to the previously selected base unit. Specifically, the displayed ratemeter reading is derived by dividing the counts per seconds (from the detector) by CC and then scaling the result based on the selected prefix and suffix.

b. Display of Calibration Constant (CC):
Enter the Parameters Mode and step through the menu until the following is displayed:

$$CC = \frac{\text{(numerical value)}}{\text{(ratemeter reading)}}$$

c. Selection of Calibration Constant (CC) for Detectors Which Were Purchased with the ESP-2 from the Factory:

If a detector was purchased with the ESP-2 from the factory, the calibration constant will already be set at the factory for this detector, and the following section may be bypassed until a different type of detector is to be used with the instrument or until time for routine re-calibration of the instrument.

The calibration constant will have to be changed when switching detectors. If the detector is one which has a preset parameter stored in the ESP-2, this can be performed by selecting the detector from the three preset detectors (refer to in Section II.G.1). When changing one detector to another either use the detector parameters stored in the ESP-2 or enter the new calibration constant given on the calibration sheet supplied with the ESP-2.

d. Selection of Calibration Constant for Various Detectors:

(1) If the detector was not purchased with the ESP-2 and, thus, a calibration sheet is not available, use the nominal value for the particular Eberline detector given in Table 5-1.

(2) The display for changing the CC from the Parameters Mode, appears as follows:

$$CC = \frac{\text{(numerical value)}}{\text{(ratemeter reading)}}$$

To increase the value of CC, press RESET and "+" simultaneously. To decrease the value of CC, press RESET and "-" simultaneously.

(3) To calculate a calibration constant for detectors other than those listed in the table, the sensitivity of the detector must be known and is usually found in the list of specifications given on the catalog sheet. Calculation using a HP-270 detector as an example is given as follows:

EXAMPLE (HP-270 detector):

CC = counts/base unit

Sensitivity = 1200 cnt/min/mR/h

Base unit selected is "R"

$$CC = 1200\ \frac{\text{cnt/min}}{\text{mR/h}} \times 1000\ \frac{\text{mR}}{\text{R}} \times 60\ \frac{\text{min}}{\text{h}}$$

$CC = 7.2 \times 10^{7}$ cnt/R (7.20 + 07)

6. Setting the Dead Time (DT)

a. Definition:

The dead time correction constant is a derived number used to correct for counting losses due to the inability of the detector to recover at high counting rates. This correction factor results in a more linear response to the radiation field being measured. This extends the useful range of some detectors used with the ESP-2 by as much as a factor of ten. This is the equivalent of an extra range on a standard ratemeter.

b. Selection of DT for Detectors Which Were Purchased from the Factory with the Instrument:

If the ESP-2 was purchased with a detector(s) from the factory, the DT value(s) will be correctly set at the factory and the next section may be bypassed until it is necessary to use a different detector or until time for routine calibration.

When changing from one detector to a detector purchased with the ESP-2, use the DT stored with the other parameters for that particular detector or the DT given on the calibration sheet supplied with the combined ESP-2 and detector.

c. Selection of DT for Various Detectors:

(1) If the detector was not purchased with the ESP-2 and, thus, a combined calibration data sheet is not available, use the nominal value for the particular detector which is given in Table 5-1.

(2) To change the value of DT, enter the Parameters Mode and step through the menu until the following display appears:

DT (SEC) x.xx-xx
(ratemeter reading)

To increase the value of DT, simultaneously press "RESET" and "+". To decrease the value of DT, simultaneously press "RESET" and "-".

(3) For a detailed discussion of DT consult Section V, MAINTENANCE, A. Calibration,

CAUTION

If you change detectors, the calibration constant (CC), the dead time (DT) and the high voltage must ALL be changed. Use the procedures described in Section II.G., steps 5, 6, and 7.

Table 5-1.

(4) Press MODE to exit the Parameters Mode.

7. Setting the High Voltage for the Detector of Choice

a. Selection of High Voltage for Detectors which were Purchased from the Factory with the Instrument:

If a detector was purchased from the factory with the instrument, the operating high voltage will already be set at the factory for this detector, and the following section may be bypassed until a different type of detector is to be used with the instrument.

b. Selection of High Voltage for Various Detectors:

(1) If the calibration data sheet supplied with the detector is available, use the recommended operating high voltage which is given there.

(2) If the calibration sheet supplied with the detector is not available, use the following general recommendations:

(a) Geiger-Mueller (GM) type detectors (HP-190, HP-260, HP-270): use 900 volts (exception: HP-290 requires 500 volts).

(b) Scintillation and Proportional detectors: You must determine the plateau response of the detector according to the procedure described in Section V.A.3. and Figure 5-1, and select as the operating voltage a value which is 50 volts above the beginning of the plateau.

c. Procedure for Determining the Present Setting for the High Voltage as Viewed on the Display.

Enter the Parameters Mode and step through the menu until the display appears. The display shows the present value for the high voltage setting.

HV = (numerical value)
(ratemeter reading)

If this value is not the recommended high voltage for the detector which you plan to use with the instrument, change the value using the following directions.

d. Changing the High Voltage:

(1) Disconnect the detector from the instrument.

(2) Use the Parameters Mode to change the high voltage. Press MODE and this display will appear:

LOG THIS VALUE?
x.xx cnt/s

Press "-" to answer no and observe the utility modes selection menu:

R/COMM -/PARAMS
+/OPER S/CLOCK

Press "-" and enter the Parameters Mode. The menu of items in the Parameters Mode may now be viewed by pressing either "+" or "-" and stepping through them. Assuming the instrument has been set for access level 4, repeatedly press "+" until the following display appears:

HV = 5.00 + 02
x.xx (units)

The high voltage default value is 500 Vdc. It is adjustable from 500 Vdc to 2450 Vdc. ALWAYS disconnect the detector prior to changing the HV. Press RESET and "+" simultaneously and observe the high voltage setting increase. The value increases more rapidly the longer you press these two keys. Press RESET and "-" to decrease the high voltage. When the desired value of HV is displayed, exit the Parameters Mode by pressing the MODE key.

CAUTION

The operating high voltage MUST be changed when switching to a different type of detector, such as switching from a Geiger-Mueller (GM) type of detector (HP-210, HP-260, HP-190, HP-270) to a scintillation type detector (LEG-1, SPA-3, SPA-6, etc.), or to GM detector requiring a different high voltage (HP-290), or to a proportional detector such as the neutron detector (NRD-1).

Make SURE that you have changed the high voltage to the correct setting when changing between detectors BEFORE you attach the detector to the ESP-2. This will protect your detectors from accidental exposure to voltage which is too high for the detector. While using the detector selection features of ESP-2, MAKE SURE you disconnect the detector before you select another detector from the keypad. Make sure the detector type you select matches the detector you are about to connect.

(3) The detector of choice may now be attached to the ESP-2 since there is now assurance that the correct high voltage will be applied to the detector.

Press MODE key to exit the Parameters Mode.

8. Changing Count time (Scaler Mode)

The count time parameter is only relevant for the Scaler Mode and does not appear in the Parameters Mode menu if any of the Ratemeter Modes have been selected. If you are operating the detector in the Integrating or Average Rate Scaler Mode the count time must be set. Enter the Parameters Mode and step through the items until the following display appears:

CNT FOR 0:01:00 (hrs: mins: secs)
SCALER MODE

Note that the default time is one minute. Press the RESET and "+" key to increase the count time or press the RESET and "-" key to decrease the count time. Press MODE key to exit the Parameters Mode.

H. USING THE LOG MODE

The following functions may be performed from the Log Mode:

- Display the log data (access level 1 or greater).
- Transfer the log data to a printer or computer (access level 1 or greater).
- Reset the log, i.e., erase from memory all stored data points (access level 2 or greater).
- Change the baud rate (access level 4).
- Change the output format (access level 4).

1. Entering the Log Mode and Stepping through the Menu (see Figure 3-15)

Press MODE key and observe this display:

LOG THIS VALUE?
(ratemeter reading)

Press "-" and observe this display:

R/LOG -/PARAMS
+/OPER S/CLOCK

To select the Log Mode press RESET key. If there is data in memory to be output, then the following display will appear:

OUTPUT LOG DATA?
"+" = YES

To step through the Log Mode menu, press "-" to answer no:

DISPLAY LOG DATA?
"+" = YES

If "+" was pressed the instrument would enter a routine to display the data. Press "-" and the following display appears:

RESET LOG DATA?
"+" = YES

Pressing "+" will reset the data memory to zero and the next menu item would appear. Press "-" and the next menu item will appear:

PRINTER FORMAT
xxxx BAUD
"RESET" TO CHG.

WARNING

The ESP-2 MUST ALWAYS be turned on BEFORE any peripheral device (computer or printer) is attached to the RS-232 connector. Failure to follow this instruction can result in a reset of the ESP-2 and loss of parameters and logged data.

From this menu item you can select printer format or computer format and the baud rate. If printer format is selected, the instrument will output to a printer on the RS-232 line. If the computer format is selected, the instrument will communicate with a computer. When entering the Computer Format Mode from the Log Mode, we will be prompted with the following display:

COMMUNICATE?
"+" = YES

If "+" is pressed the following display will appear:

COMPUTER LINK
"RESET" WHEN DONE

If the RS-232 Data-Set-Ready input line is active (positive input voltage), the computer will control the instrument without intervention by the user. If not, the instrument will be disabled until the DSR input is inactive or the MODE key is pressed.

2. Changing Output Format and Baud Rate

There are two output formats with which the ESP-2 operates: Printer Format and Computer Format. The Printer Format is employed when outputting log data to a printer. The Computer Format is employed while interfacing with a computer. Both interfaces are through the RS-232 connector on the instrument. The Computer Format allows bi-directional communication with the computer.

See Communication Specification 13000-A08. It is possible for the computer to control, remotely, the operation of the ESP-2 via the RS-232 interface while the ESP-2 is in the Computer Format. Control is exercised by the computer when the RS-232 input line Data-Set-Ready (DSR) is high.

The ESP-2 RS-232 interface communicates with the printer or computer at a particular baud rate. Baud rates which may be selected in the ESP-2 are 150, 300, 600, 1200, 2400, 4800, 9600.

To output to a printer at 300 baud enter the Log Mode and step through the menu as in the previous section until the following display appears:

COMPUTER FORMAT
2400 BAUD
RESET" TO CHG.

Both the output format and the baud rate must be changed. Press the RESET key and the following display will appear:

COMPUTER FORMAT
+ = USE/- = NO

Press "-" and the display changes to:

PRINTER FORMAT
+ = USE/- = NO

Press "+" and the printer format is selected. The following display will appear:

2400 BAUD
+ = USE/- = NO

Press "-" repeatedly until the following display appears:

300 BAUD
+ = USE/- = NO

Press "+" to use and the following display appears:

PRINTER FORMAT
300 BAUD
"RESET" TO CHG.

It would not have been necessary to go through the previous steps if the printer format and 300 baud rate had already been selected.

3. Transferring Log Data to a Printer

The logged data which is stored in memory may be output to a printer or an external peripheral device capable of accepting the RS-232 signal.

A certain amount of hardware handshaking is required in ESP-2/Printer interface. See Figure 2-3 which shows the MINIMAL interconnecting cable connections. Some printers may require more handshaking. RTS, Pin 7, is wired "high" internally in the ESP-2 and outputs a high condition while the ESP-2 is on. DTR, Pin 4, gates high (positive voltage output) only when the ESP-2 is transmitting data. This information may be used to generate a more complex printer interface than the one shown. See 11383-C39 for wiring diagrams of optional printer and computer cables available from Eberline.

```
ESP-2                      STANDARD
RS-232 PORT        PRINTER
                           RS-232 PORT

TxD       3------------------>RxD
RxD       2
RTS       7
DSR       6<------------------DTR
GND       5-------------------GND
DTR       4
```

Figure 2-3
ESP-2/Printer Cable
Interconnection Diagram

The ESP-2 will send out data at the baud rate selected as long as it detects a "NOT BUSY" signal on its DSR line. The type of peripheral device used will determine what output signal can be used as an input to the ESP-2 DSR line. In Figure 2-3 the standard DTR signal is used for this purpose. If the ESP-2 detects that DSR is no longer asserted it will "slow down" by sending characters at a rate of one character every 1/2 second. If the device re-asserts DSR, the ESP-2 will once again output at the rate determined by the hardware handshaking. In any case, the baud rate does not change, only the rate at which characters are sent.

With a cable connected to a printer as shown in Figure 2-3, data can be output to the printer. Enter the Log Mode. If no data has been stored in the log, the first display to appear is:

NO DATA STORED!

If, however, data has been stored in the log, then the following display will appear:

OUTPUT LOG DATA?
"+" = YES

Press the "+" key and the next display to appear is:

OUTPUTTING DATA
"+" TO PAUSE

The data is now being output to the printer. At the end of the data transfer, the instrument reverts back to its former operating mode. If we had pressed "+" to pause while the instrument was outputting data, the following display would have appeared:

RESET TO RESTART
"MODE" TO ABORT

If we press RESET, the heading and data would be output from the beginning. If we press MODE the output would be aborted and the instrument would revert back to its current operating mode.

Figure 2-4 is a sample printout. Note that the heading contains a six digit number for the instrument number, a nine digit number for the user I.D. number, the selected detector label, the operating mode of the instrument, and the detector calibration parameters (calibration constant, dead time and high voltage).

Also, note in Figure 2-4 the manner the data is printed out. Along with each data point, the date, time of day, location code, and instrument status are printed. See Table below:

Status Code	Priority	Status
"F"	1	Failed
"O"	2	Overrange
"B"	3	Low Battery
"A"	4	Alarmed
" " (Blank)	5	Normal

The single-character status code above applies to all instruments. In instruments with program version 2.4 or later, AND with the PHA option installed, a second status code character is added:

Status Code	Status
" " (Blank)	Gross Count Data
"P"	PHA Count Data

4. Displaying Log Data

If data has been stored in the log, the data may be viewed on the display. Store some data in the log and then enter the Log Mode. Step through the log items until you get to the following display:

DISP. LOG DATA?
"+" = YES

Press "+" and the data may be viewed in two alternating displays as follows:

(date) (time)
LOC. xxxxxx

(detector no.)
(reading)

Repeatedly pressing "+" will step through the data with two alternating displays for each data point. Press MODE key to return to the current operating mode.

5. Resetting Log Data

After a series of measurements have been stored in the memory and have been output to a peripheral device, then you may want to erase the memory (reset it) and start storing a new series of measurements. The memory is NOT automatically erased when data is being output or after it is output. The only way it is erased or reset is manually from the keypad. The data will be lost if the batteries are taken out for a long while and the instrument is "cold started".

To reset memory from the keypad, the instrument must be set for access level two or greater. Enter the Log Mode and step through the menu, pressing the "-" key (since "+" answers "yes" to the items being stepped through), until the following display appears:

RESET LOG DATA?
"+" = YES

Press "+" key. The memory is reset to zero and the next item in the menu appears. Press the MODE key to exit the Log Mode and to return to the current operating mode.

Figure 2-4
Printer Heading and Data Format, 11383-A35

I. SIMPLE TROUBLESHOOTING

Although detailed troubleshooting will be given in Section V, four simple suggestions for troubleshooting will be given here.

1. Condition: Blinking character or letter display.

If the character in the upper left hand corner of the display is blinking, the batteries are low and need replacing. Turn the instrument Off.

Remove the large screw in the bottom of the case, and remove the case bottom. Replace the batteries, being careful to orient the batteries according to the diagram printed on the bottom of the battery compartment. See Figure 5.3. The batteries should be replaced within 20 minutes or the volatile memory contents may be lost. Replace the bottom of the case.

2. Condition: Display prints erratic numbers or figures, is blank, or has unallowable access levels.

If the display shows characters or letters which are not a part of the usual display mode, the program in the microprocessor may have lost its initialization. To correct this condition and reinitialize the instrument, perform the following:

a. Turn the instrument OFF. Set the instrument upside down and remove the case bottom and batteries.

b. Press the RESET pushbutton switch (S5), on the etched side of the exposed bottom printed circuit board for 10 seconds or more. This will discharge C28.

c. Replace the batteries in the instrument. Be careful to orient them according to the diagram on the bottom of the battery compartment. Reinstall the case bottom.

d. Turn on the instrument and determine if the condition is corrected; that is, that the display presents letters and numbers which are a part of the usual display modes and are "reasonable".

e. If the display is still not functioning correctly, repeat a. through d. If still not functioning, you may wish to consult detailed troubleshooting in Section V or return your instrument to the factory for repair.

f. Note that all calibration parameters and preprogrammed data were erased when the instrument was reset. These will now have to be re-entered.

3. Condition: Sudden loss of battery power.

If the instrument cannot be turned on and the batteries are discharged, the most probable cause is that the microprocessor chip, A108, has been dislodged from its I.C. socket. To correct this situation, remove the bottom cover and PC board (see Section V.C.1.) and check if A108 and all I.C.s are properly in their sockets. Replace the bottom PC board, install fresh batteries and replace the bottom cover. ALL PREPROGRAMMED PARAMETERS HAVE BEEN LOST AND MUST BE REPROGRAMMED.

4. Condition: Display always in the Log Mode.

If the following display occurs and the instrument is locked:

COMPUTER LINK
WAITING FOR COMM

The most probable cause is that Computer Format has been set and a cable is now attached to the RS-232 connector. The cable has a high signal on pin 6, (DSR). Remove the signal or cable and the problem will be corrected.

SECTION III. FUNCTIONAL FLOW DIAGRAMS

Figure 3-1 thru Figure 3-15 are ESP-2 functional flow diagrams which show, (in simplified form) the control key operation and expected displays for all modes which the ESP-2 may operate in. In all these flow diagrams, the "flow" starts at the top and goes toward the bottom. In learning ESP-2 operation, it would be very helpful for the user to operate the instrument as he studies these functional flow diagrams. The diagrams provide feedback to a user, verifying proper control key operation.

Before operating the instrument MAKE SURE that the instrument is set up properly for the detector being used with the instrument. Most operational features may be exercised without a detector, in which case the detector may be disconnected.

Figure 3-1
Normal Ratemeter Mode, 11383-C13

Figure 3-2
Peak Trap Ratemeter Mode, 11383-C12

Figure 3-3
Fixed Precision Scaler Mode, 11383-C16

Figure 3-4
Fixed Precision Scaler Mode with Auto-recycle, Auto-store, and Auto-log, 11383-C15

Figure 3-5
Integrating Scaler Mode, 11383-C14

Figure 3-6
Integrating Scaler Mode with Auto-recycle, Auto-store, and Auto-log, 11383-C17

Figure 3-7
Average Rate Scaler Mode, 11383-C18

Figure 3-8
Average Rate Scaler Mode with Auto-recycle, Auto-store, and Auto-log, 11383-C19

Figure 3-9
Clock Mode, 11383-C20

Figure 3-10
Operate Mode, 11383-C21A

Figure 3-11
Parameters Mode, 11383-C22

Figure 3-12
Selecting Units, 11383-C23

Figure 3-13
Selecting Detectors, 11383-C24

Figure 3-14
Selecting Operating Modes, 11383-C25

Figure 3-15
Log Mode, 11383-C26

Figure 3-16
Selecting Enhanced Store Functions, 11383-C27

Figure 3-17
Ratemeter Mode with Enhanced Store Functions, 11383-C28

Figure 3-18
Fixed Precision Scaler Mode with Enhanced Store Functions, 11383-C29

Figure 3-19
Fixed Precision Scaler Mode with Enhanced Store Functions, Auto-Log, and Auto-recycle, 11383-C30

SECTION IV. THEORY OF OPERATION

A. GENERAL

The ESP-2 employs current technology to provide to the user a compact instrument that can be used to measure and log data from several kinds of radiation, as detected by different detectors. The ESP-2 is portable and will operate for an extended period of time before battery replacement becomes necessary.

B. FUNCTIONAL THEORY

The ESP-2 consists of eight functional sections as detailed below (see Figures 7-1, 7-2, 7-3).

1. Detector

The detector connected to the ESP-2 is selected to optimize its output for the radiation of interest. It provides the pulse signal to the electronics for counting. The pulse rate from the detector is proportional to the radiation field intensity at the detector.

2. High Voltage Supply

The high voltage supply provides the required bias voltage to the detector. The high voltage is keyboard adjustable and provides the correct operating voltages for a large selection of detectors.

3. Amplifier/Discriminator

The amplifier is a linear, adjustable gain, multistage design. It amplifies the signal from the probe to a usable level at the amplifier output. The discriminator provides a signal on its output only if the signal from the amplifier exceeds the adjustable threshold. This provides a means for rejecting noise and/or unwanted signal.

4. Speaker/Alarm

The speaker/alarm section provides an audible "click rate" from the speaker proportional to the output of the amplifier/discriminator. This rate can be scaled down when high-count rate (very sensitive) detectors are employed. When the alarm is activated, the speaker emits a continuous 2000 Hz tone.

5. Microcomputer

The microcomputer is an eight-bit device programmed to function as the interface between the ESP-2 operator and the information provided by the detector (probe). The program logic and speed of execution allows the ESP-2 to be extremely versatile by applying mathematical functions and logic to its input signals and displaying the results to the operator in an understandable format.

6. Low Voltage Supply

The low voltage supply regulates the operating voltage for the ESP-2 electronics.

7. RS-232 Driver

The RS-232 driver is a single chip device designed to generate its own ±10 Vdc supply from +5 Vdc. It provides four buffers, two for input and two for output. It interfaces the serial input and output bus of the microcomputer with an external peripheral device such as a printer or computer.

8. Clock Circuit

The clock circuit is another single chip device that interfaces directly with the microcomputer. It is crystal controlled and provides month, year, day, and time of day information to the computer. Date and time are setable from the keypad. The date-time information is appended to the data stored in the memory log.

C. OPERATIONAL THEORY

For the discussion that follows, please refer to Figure 7-1 through 7-9.

1. Low voltage Power Supply

Power is supplied to the ESP-2 electronics by six C-type dry-cell batteries and regulated to 5.0 volts with A104. The battery output limits are 10 volts for new batteries down to approximately 5.8 volts for "dead" batteries. The lower limit is set by the voltage differential between the input and output of A104 that enables A104.

Computer voltage (V_c) is always applied to the computer to maintain its random access memory (RAM). With the ESP-2 off, battery drain consists of the normal leakage current of CMOS, typically less than 200 microamperes. During battery change out, capacitor C28 (0.047 F) provides power for RAM for about 20 minutes (instrument off). This power maintains all the operating parameters at the values entered during calibration.

Pressing the "ON/OFF" keypad causes the microcomputer to initialize the program.

If the ESP-2 is operating when the keypad is pressed, it sets "PWR ON" of A108, HI (+5 V), turning off the low voltage (Q6, Q7, Q8) to all electronics except the microcomputer and its program access. This powers down or turns off A111, A109, A110 on the ESP basic printed circuit board, and A1, A2, A3, A4, A5, and A6 on the ESP-2 printed circuit board.

If the ESP-2 is off when the ON/OFF keypad is pressed, it sets "PWR ON" LOW (0.0 Volts) turning Q6 on. This supplies the operating voltage (+V) to the amplifier, high voltage control, display, speaker circuitry and RS-232 buffer circuits. It also switches on the battery voltage (V_{BB}) to the HV oscillator and battery sense via Q7, and Q8. (All circuits are now energized.)

Battery condition is monitored by one of the comparators in A101. Pin 15 is connected to the regulated reference (amplifier "bias"). When the voltage at pin 14 falls below this reference, the output (pin 16) goes low. This voltage transition is input to the microcomputer, causing it to initiate blinking of the first character on the LCD. The blinking indicates a low battery condition. This switch point occurs when the battery output is approximately 5.9 volts and allows the instrument to operate properly for about another one hour.

Pressing the "LIGHT" keypad lights the LCD via Q11 and DS1. Diodes CR10 and CR11 set Q11 and R63 as a current source, thus maintaining a constant drain on the batteries. This tends to prolong lamp life.

2. High Voltage Power Supply

High voltage is obtained by stepping up (T1) the voltage of the oscillator (Q2), doubling it (CR3, CR2, C3, and C4), rectifying it (CR1) and filtering the output (C1, C2, R3). High voltage is regulated by feeding back the output to control the oscillator.

At turn-on, Q8 is on, causing Q2 to turn on. Current flow through T1 (pins 2, 3) feeds back via T1 (pins 4, 5) turning off (blocking) Q2. With Q2 off, blocking stops and Q2 turns on. This is a blocking oscillator, the frequency of which is limited, thereby (C25, C9, R12) maintaining the best efficiency of T1.

The high voltage output is fed back, via resistive divider R1 and filter C7, to a voltage follower, A100, pin 3. This stage, with a high input impedance, allows R1 to be large, presenting a minimal current load for the supply. The output of the voltage follower is then proportional to the high voltage output. Because the input impedance to this stage is high, C7 provides filtering to reduce noise interference.

The filtered high voltage sample is input to a operational amplifier (A100, pin 15). This is referenced to the high voltage, thus adjusting reference amplifier (A100). When the sample (pin 15) exceeds the reference (pin 14), the output at pin 16 goes low, reducing the voltage to Q1, which partially turns off the oscillator, reducing high voltage. As the sample decreases to less than the reference, pin 16 goes high, turning Q1 on more. The oscillator then runs harder to increase the high voltage. In this way, the high voltage is regulated to a value set by the HV reference amplifier (A100).

The filtered output of the high voltage sample is also applied to pin 5 of A100. This stage is connected with R13 and R14 to produce a HV indication level for the computer. If the voltage at pin 5 is lower then the voltage at pin 6, the output at pin 7 goes low indicating to the computer that HV has failed.
A100 is used in conjunction with A112, a D/A converter, to establish digital control of the high voltage reference. A112 contains two symmetrical ladder networks each of which produces outputs across R72 and R73 separately. A100, R68, R69, R70, R71, R67, R66 form a differential amplifier. The gain is controlled by R66 and the output level is controlled by R68. R66 and R68 must be adjusted together to calibrate the high voltage. The high voltage is calibrated when the value measured by an accurate, very high impedance (1000 M ohms or greater) meter matches the instruments displayed value. R11 and C6 form an RC filter for the high voltage reference.

3. Amplifier/Discriminator

Transistor Q3 and the amplifier section of A101 form a dc-coupled linear amplifier. The gain of this amplifier is set by R20 and the output impedance of the preamplifier (Q3) along with R21-R22. Feedback via R19 provides dc stability. The dc bias is set by R23-R24 to half of +V (~2.5 volts) for a linear swing of signal on the amplifier outputs. Input protection is provided by CR4 and R15, this gives a charge path for the input capacitor (C11) when high voltage is shorted.

The amplifier output signal is coupled to the Discriminator (A101, pin 11) through capacitor C15. An output (A101, pin 10) occurs when the amplitude of the signal pulse exceeds the reference (A101, pin 12) set by the threshold potentiometer (R27).

The Discriminator output is divided down by 2, (A105), yielding a binary input for the microcomputer. The microcomputer counts the binary transitions and calculates and displays the result as either rate or integrated value.

4. Speaker

Pulses that cause an output from the discriminator are input to the speaker control. They may be fed directly (one click for each pulse) or they may be divided down before being fed. In either case, the rate from the speaker is proportional to the radiation level at the detector (probe). The speaker is enabled or disabled by the microcomputer when the operator presses the "SPKR" keypad. The speaker is enabled when "SPKR" is low (0 volts).

One half of A102 is interconnected as a monostable multivibrator (TRIGGER). The output pulse (TRIGGER) width is set by R54-C18 time constant. The other half of A102 is configured as an oscillator. It is running while the trigger output (pin 11) is low, driving the speaker via Q4 and Q5. The input signal to the trigger is differentiated by C20-R46 to prevent excessive trigger pulse widths.

The alarm is activated by "ALM" and "SPKR" set low (0 volts) by the microcomputer. This sets the trigger output low (pin 11), turning on the oscillator frequency to the speaker.

"ALM" low also activates the auxiliary alarm (ALARM, Q10) providing an active low output for external indication (250 mA, 20 Vdc maximum).

5. Keyboard

The switch poles are etched on the PC board. Contact between the poles is made by a conductive pad in each keypad. Pressing a keypad effectively short-circuits the poles.

The ON/OFF keypad pulls the RST (pin 9) of the microcomputer high. This causes the computer to reset itself and begin running its program at the beginning. The LIGHT keypad causes DS1 to turn on via Q11, lighting the display.

All other keypads are inputs to the microcomputer via its input/output (I/O) port P1, which is configured as an input port under program control. These inputs are normally high. Pressing a keypad pulls the corresponding port input low.

The program running in the microcomputer performs the contact debounce, determines the switch (or switches) pressed, and logically performs the task(s) associated with the keyboard condition.

6. Microcomputer

Simply stated, a computer must have provisions for moving data in and out (I/O), a logical means of handling and saving data (memory), and logical elements to control I/O and memory (central processing unit-CPU). To perform any task, the CPU must execute a series of logical steps (program), which is contained in read-only memory (ROM). Memory used to save data written to or read from it is called random access memory (RAM). The RAM contains the parameters (variables), logic flags, data, scratch pads, etc. used by the program.

a. Inputs:

(1) The keyboard is the operator's input to the computer. Under program control, these inputs cause the task associated with the keypad to be performed (see Section II.A.6.).

(2) Received Data (RXD) is the serial data input port. Serial data emanating at an external computer or peripheral device is received at A8 (RS-232 buffer) and passed on to this input.

(3) HV IND is active high and indicates to the computer that high voltage is present. If high voltage has failed, HV IND goes low and signals to the computer that HV has failed.

(4) Lo Batt (low battery) input (normally high) switches low when the low battery condition is sensed. This causes the program to blink the first character on the display at each display update, warning the operator of the low battery condition.

(5) The rate of the CNT (count) input is proportional to the intensity of radiation being detected. The rate is calculated by the program (counts/time). The calibration constant (CC) and correction factor (CF [based on detector dead time]) result in a value of radiation units as calibrated. The results are then output to the display.

b. Outputs:

(1) "PWR ON" (Power on, active low) is output, under program control, to turn the power to the instrument on or off.

(2) "SPKR" (Speaker on, active low) is output, under program control, when the SPKR keypad is pressed. The output is complemented at each press of the keypad. This results in a push-on/push-off action of the SPKR keypad.

(3) "ALM" (Alarm output, active low) is activated when the program has sensed that the calculated reading has exceeded the value input by the operator for "ALM AT" (alarm setting). SPKR output is also activated.

(4) "DTR" (Data Terminal Ready, active high) is transmitted to a peripheral device via the RS-232 buffer, A8. This signals to the peripheral device that the computer desires to send it serial data.

(5) "TXD" (Transmitted Data) is 8 bit per character, 2 stop bits, no parity serial ASCII data transmitted to a peripheral device via the RS-232 buffer, A8.

(6) The display is a liquid crystal (LCD) 5 x 7 dot matrix character with 2 lines of 16 characters per line. This allows the full alphanumeric ASCII character set as well as the special characters used to display the analog bargraph. The LCD is a "smart" display in that it is supported by its own microprocessor and program. This relieves the computer of this processing load.

The computer sends command instructions and data to the display. These data/commands are passed to the display via the 8-bit address-data bus (A108, Port P0). A command (instruction) is differentiated from data (character to display) by address line 8 (A108, pin 21). High equals a command on this line. The command/data are accepted by the display when "WR" (A108, pin 16) is low at the same time decoder A109, pin 9 is low. This causes the display "E" (enable) pin 6 to be strobed.

The viewing angle of the display is set permanently by connecting V_o input (pin 3) to ground thru R47.

The display is not considered to be field repairable.

(7) The D/A converter, A112, is input from the computer via the P0 (AD0 to AD7) bus lines. This D/A outputs to a differential amplifier, A100, and together the pair form a digitally controlled high voltage supply. 00H creates the reference for minimum high voltage (500 Vdc) while FFH creates the reference for maximum high voltage (2,450 Vdc). A112 is selected by the computer by output of the decoder A109, pin 7.

(8) The clock (A6) is connected directly to four bus lines on P0 (AD0-AD3). The 4 bit I/O data at A6 pins 11, 12, 13, 14 is addressable via pins 4, 5, 6, and 7. The data provides seconds, minutes, hours, day of week, date, month, and year. Data access is controlled by a 4-bit address; chip selects (pins 15, 2). WR (pin 10), RD (pin 8), and ALE (pin 3). Data can be written to or read from the clock. The clock contains its own oscillator and an external 32.768 kHz (X1) crystal oscillator.

(9) Decoders A109 and A5 decode bits A12 thru A15 (from P2), to select one of several devices the CPU interacts with. Devices that are selected through the decoder on ESP-2 PC board (A5) are the Clock (A6), the Input Port (A4), RAM (A3), and EPROM (A2). Decode line A12 selects between Input Port A4 and the Clock (A6). Devices that are selected through the decoder on the ESP-1 basic PC board are the display and the D/A converter (A112). EPROM A111 is selected (via data line A15) from the buffer A110.

c. Memory and CPU:

RAM registers are contained in the RAM chip (A3) and within the microcomputer chip. The timers are also contained within the microcomputer chip. The timers regulate the program counter and stack pointer.

Port P0, (A108) is the address-data bus. It is bidirectional (input and output). Port P2 (A108) outputs the upper eight bits of the address. During a typical program step:

(1) The address program counter is output at P0 (low byte) and P2 (high byte).

(2) "ALE" (address latch enable) is asserted and latches the address low byte in A111 and A1.

(3) "PSEN" (program store enable) is asserted, enabling the addressed byte to be input to the computer via P0.

(4) The program step is executed.

The program is stored in A111 and A2. The socket for A111 is wired in such a way that an 87C256 EPROM can be utilized providing up to 32K program memory. In this case, jumper r to s is cut and a jumper wire added between s and t. Space for more RAM will then become available in A2, when proper connections are made to pins 22 and 27.

d. RS-232 Buffer:

A8 is a RS-232 chip which contains its own power supply for converting from +5 Vdc to ±10 Vdc. These voltages are used for RS-232 serial data transmission. C7, C8, C9, C10 are capacitors which are used in creating the ±10 Vdc supplies. A8 contains four buffers, two for receiving and two for transmitting. The two transmit buffers convert the logic level from TTL to ±10 V level and the two receive buffers convert the ±10 V logic levels to TTL.

e. Input Port:

A4 is an input port buffer. It takes the Data Set Ready (DSR) signal from A8, pin 9, and inserts it on the CPU P0 bus line. Provisions are made for inputs of future applications on pins 4, 6, 10, 12, and 14. Resistor array R3 contains pull down resistors for all inputs. This reduces current thru A4 when the instrument is off.

7. Optional PHA Circuit

When the pulse height analyzer (PHA) board is installed, the shorting header is omitted. A voltage divider from the +5 volt line is formed by R28, R33, R32 (window), R27 (threshold) and R31. Each of the 5 resistors is 10K ohms so each resistor has a nominal one volt drop across it. The upper two comparators shown in A106 are the threshold and window comparators. The threshold comparator reference (A106 pin 7) is held at 2 volts and the pulse driven input (A106 pin 6) is dc biased between 1 and 2 volts by the threshold control. Any positive pulse large enough to take pin 6 to 2 volts has crossed the "threshold".

The reference input of the window comparator, A106 pin 5, is adjusted by the window control between 2 and 3 volts. This reference is the "top" of the "window". The pulse driven input (A106 pin 4) is tied directly to the pulse input pin of the threshold comparator. It too, is dc-biased between

1 and 2 volts by the threshold control. Any pulse that drives both input pins up to 2 volts has crossed the "threshold" and has entered the "window" area. If the top of the pulse stays in the window, (does not reach the window reference voltage at A106 pin 5), then it is an "acceptable" pulse and will be counted. If the pulse is so large that it exceeds the window reference voltage at A106 pin 5, then it is has gone out of the "top" of the "window" and it will not be counted. In this way, the PHA circuit may be set to accept only a small range of pulse amplitudes. This may represent a specific radiation energy. Since the threshold crossover point is always at 2 volts and the window reference adjusts from 2 volts upward, the window width is independent of the threshold setting.

If the pulse height is "in the window," A106 pin 1, A106 pin 9 and A107 pin 1 (clock A) go low when the pulse crosses the threshold. When the pulse returns below the threshold, clock A goes high and the first binary in section A of A107 changes state, since a positive transition at the clock input advances the counter. The binary output at A107 pin 3 goes high. This signal is carried to the comparator input at A101 pin 11. A101 pin 10 goes low and A105 registers the count. The high at A107 pin 3 is carried to reset pin A107 pin 7 by CR32. The binary stage is reset to zero, causing A107 pin 3 to return to a low output.

If the pulse height is above the window, A106 pin 1, A106 pin 9 and A107 pin 1 go low, as before, when the pulse first crosses the threshold. When A106 pin 9 goes low, A106 pin 14 also goes low and C32 is discharged through CR31. When the pulse continues upward out of the window, A106 pin 2 goes low and if S31 (PHA-GROSS switch) is closed, A107 pin 9 (clock B) also goes low. When the pulse amplitude comes back into the window on the way down, A106 pin 2 and A107 pin 9 return high and the first binary of section B of A107 changes state. (Positive clock transition). Pin A107 pin 11 immediately goes high and CR33 holds section A in the reset condition. When the pulse falls below the threshold, A106 pin 1, A106 pin 9 and A107 pin 1 return high. Section A of A107 does not change state because of the reset signal through CR33. As A106 pin 9 goes high, A106 pin 14 goes high, coupling the high through C32 to pin 11. This causes A106 pin 13 to also go high, resetting section B of A107. This removes the reset signal of section A. A106 pin 13 and B reset return low when R39 recharges C32. A106 pin 11 then goes low. The circuit is now ready for the next pulse.

If the PHA-GROSS switch is in the GROSS position (open), A107 section B cannot hold section A in reset and all pulses above the threshold will be counted.

NOTE

When the PHA option is installed in an instrument with program version 2.4 or later, another feature becomes available. The instrument will sense whether the data is acquired in the PHA or GROSS mode. The second section of the PHA-GROSS switch is used to toggle the input bit sensed by the microcomputer. The microcomputer determines when the data is acquired, with which mode, and flags it accordingly. When the data is printed out, this will become the second character in the status code.

SECTION V. MAINTENANCE

A. CALIBRATION

1. General

The ESP-2 is an extremely versatile instrument. It is usable with a wide variety of detectors and can be calibrated in a large variety of radiation units. The end result of the calibration process is the reading provided by the instrument. The accuracy of that reading depends on the accuracy achieved in the calibration process.

Properly set up and calibrated, the instrument is inherently linear and accurate, because of its microcomputer based design. The only real limitation is the detector and its application in a particular measurement. For detector application information, see Section VIII.

The calibration procedure should include testing for instrument/detector quality (plateau) as well as adjusting the reading to the radiation field at the detector. A recommended procedure follows:

NOTE

To change the parameters that calibrate the ESP-2, the instrument must be set for access level 4. (See Table 2-1.)

2. High Voltage

The high voltage readout, which can be viewed in the Parameters Mode, is a computer-generated number, which is not only displayed, but is supplied to a D/A converter. This converter generates the reference voltage for the high voltage supply. The readout must be calibrated to equal the actual high voltage. Connect a voltmeter to the detector connector. The input impedance of the voltmeter must be 1000 megohms or greater. Display the high voltage reading in the Parameters Mode. Using the RESET and "+" or "-" as required, adjust the display to read HV = 6.07 + 02.

Remove the access cover on the right side (see Section V.C.3.). Adjust internal potentiometer R68, HV level, until the measured voltage is 607 Vdc. Use the keypad to readjust the high voltage reading on the display to read HV = 1.80 + 03. Adjust internal potentiometer R66, HV GAIN, until the measured voltage is 1800 Vdc. Readjust the high voltage reading on the display to read HV = 6.07 + 02. Readjust R68, HV level, until the measured voltage is 607 Vdc. Readjust the high voltage reading on the display to read HV = 1.80 + 03 and adjust R66, HV GAIN until the output measures 1800 Vdc. Repeat this procedure back and forth until the measured readings are the same as the ones read on the display.

The instrument is shipped with the high voltage calibrated.

3. Instrument/Detector Quality

The overall gain of the instrument is adjustable with the detector bias (High Voltage), R22 GAIN potentiometer, and the discriminator setting (R27, THRESHOLD potentiometer). The gain should be adjusted for the maximum detector efficiency that also provides the best stability for the measurement. Usually R22 is adjusted full CW for maximum amplifier gain.

The discriminator setting (threshold input sensitivity) is set based on the detector type to be used (see Table 5-1) and may be set by either of the following methods. The pulse generator method is preferred.

a. Pulse Generator (Eberline MP-1 or MP-2 recommended).

Connect a pulse generator with a calibrated pulse amplitude output to the ESP-2 detector connector. Set the ESP-2 input sensitivity as recommended in Table 5-1, by adjusting the R27, THRESHOLD control. (See Figure 2-2).

b. Voltmeter (20K ohms/volt minimum)

Measure the voltage on "TEST" connector, pin 9, (see Figure 2-2). Adjust R27, THRESHOLD control, for a voltmeter reading corresponding to the proper input sensitivity referenced in Tables 5-1 and 5-2. Make sure the GAIN control R22, is fully clockwise.

WARNING

The high voltage should be set to the "Nominal Operating Voltage" or less (reference Section VIII) BEFORE connecting the detector to the ESP-2, to prevent damage to the detector. Check the high voltage by selecting the "HV =" parameters on the display while in the Parameters Mode. Make sure high voltage calibration has been performed.

Table 5-1
Suggested Calibration Levels

Table 5-2
Input Sensitivity vs. Threshold Voltage

Input Sensitivity (mV)	Vthld* (volts)
1.0	0.072
2.0	0.220
5.0	0.662
10.0	1.45
15.0	2.18

*Test connector, pin 9 (see Figure 2-2).

c. Connect the detector to the ESP-2. With the THRESHOLD properly set, the plateau curve can be plotted. This is the ONLY data that can truly verify that the detector and instrument are operating properly and, with the possible exception of G-M detectors, should be plotted anytime a detector is changed or repaired.

The bias (High Voltage) operating point for a G-M detector is fixed by its physical properties (i.e., size, counting gas, anode size, and fill pressure). Because of these factors, a check of its sensitivity, or efficiency, may preclude the plateau. It should be within ±20 percent of specified sensitivity at the specified operating voltage (see Section VIII).

To plot the plateau (Figure 5-1):

(1) Select the "HV=" parameters on the display (Parameters Mode). The second line of the display shows the current average rate from the detector.

(2) Adjust the "HV" for a low reading from the detector. Record the reading and the high voltage.

(3) Increase "HV" in steps of 50 volts, recording the reading and high voltage at each step. Allow enough time at each step for the reading to stabilize.

(4) Select the operating high voltage and adjust the "HV" control accordingly.

Figure 5-1
Typical Detector Plateau, 11338-B25

4. Ratemeter Calibration

For clarity, a brief overview of the readout determination follows:

a. The average count rate is calculated each 1/2 second. This average is maintained in counts per second (cnt/s) and is the basic unit for all readout displays. This average is also corrected for detector dead time (parameter "DT").

b. The average (AVG) is divided by the calibration constant (parameter "CC") (see Table 5-3) and the proper factors, (specified in units, prefix, and suffix) are applied, converting the cnt/s to the radiation units selected. This is performed and displayed every 2.0 seconds.

   The calibration is performed by adjusting the "CC" and "DT" values so that the ratemeter readout agrees with the radiation intensity at the detector.

   Note that the dead time correction is applied to the average BEFORE "CC". At lower count rates, this correction is insignificant.

   Refer to Table 5-1 for the following:

   (1) Set the instrument to Parameters Mode.

   (2) Set high voltage and input sensitivity to suggested values for detector being calibrated.

   (3) Set "CC=" and "DT" equal to nominal values for detector being used.

   (4) Select the "CC=" parameter. The current ratemeter reading is always displayed on the bottom line of the LCD (this applies to all parameters, DT, HV, etc.).

   (5) Expose the detector to the radiation field indicated under "set CC at" (See 11292-A36), and adjust "CC=" until ratemeter reading matches the field strength. Note that increasing the value of CC will decrease the ratemeter reading, and decreasing CC will increase the ratemeter reading. See Table 5-3.

   (6) Select the "DT (SEC)" parameter. Expose the detector to the field indicated under "set DT at" (See 11292-A36), and adjust DT until ratemeter reading matches the field strength.

   (7) Recheck reading taken in step 5. If not in agreement, repeat steps 5 and 6 until both readings are correct without having to vary the "CC" and "DT" parameters.

   (8) At this point no further adjustment is necessary. However, a few linearity readings at fields in between the CC and DT settings would be an added verification of correct detector/instrument operation. Increasing the radiation field above the DT set point will eventually cause an over-range alarm. This is useful in determining the upper range limit of that particular detector and instrument combination.

NOTE

The instrument may be rough-calibrated by adjusting nominal values to those in 11292-A36. For detectors for which nominal values are not specified, the user may determine his own nominal values for ease and/or speed of the calibration process.

Table 5-3
Calculating Calibration Constant

CC = counts/base unit.

Example:

a. HP-270 sensitivity is 1200 cnt/min/mR/h (nominal).

b. Base unit selected is R.

CC = (1200 cpm/mR/h x 60 min/h)/1 x 10^{-3} R/mR

CC = 7.2 x 10^{7} cnt/R

SPECIFIED PREFIX	PREFIX FACTOR (PF)	SPECIFIED SUFFIX	SUFFIX FACTOR (SF)
(none)	1	s (second)	1
µ (micro)	1 x 10^{-6}	min (minute)	60
m (milli)	1 x 10^{-3}	h (hour)	3600
K (kilo)	1 x 10^{+3}		
AUTO			

(AVG/CC) x SF x PF = READOUT IN RADIATION UNITS AS SPECIFIED.

NOTE

PF and SF are applied automatically as defined by the "units" selected and do not affect "CC".

B. CALIBRATION WITH PHA

To utilize the pulse-height analyzer (PHA) function, the amplitude of the detector pulses must be proportional to the energy of the radiation and must vary with the high voltage applied.

The installation of a new PHA option should be performed at the factory. To replace a PHA PC board perform the following: Turn off the ESP-2 and remove the bottom case cover. Disconnect the PHA switch cable at the connector. Remove the one screw holding the PHA PC board in place. Remove the old board from the socket and install the new board. Repeat in reverse order the steps used to remove the first board.

The most reasonable readout units for PHA operation are counts per unit time (cpm, cps, etc.), since the detector is producing pulses from other energies which are not being counted. The PHA circuit operation is the same, regardless of the readout units chosen. A review of the PHA circuit description and terms used in the "Theory of Operation" section may be helpful. The adjustment of the window width relative to the threshold setting is always a compromise. Refer to the curves of Figure 5-2. In each case, the narrower window results in a sharper peak (better exclusion of adjacent energies), but the count rate is lower and the peak may be harder to find. Experimentation using the particular detector and a check source of the isotope of interest will help select the best window width for the application. In general, a window width between 25 percent and 100 percent of the threshold level is reasonable.

The following gives examples of various methods of setting the threshold and window controls.

Method 1. No test equipment required.

1. Set the GAIN control (R22) fully clockwise, maximum gain.

2. Set the THRESH control (R27) fully clockwise, least sensitivity. This will result in about 6 mV input sensitivity.

3. Set the WIN control (R32) fully clockwise, widest window. This will set the window about 6 mV wide, a 100 percent window. (For a 50 percent window, set the WIN control midway between the end points [count the turns]).

4. Set the PHA-GROSS switch to PHA.

5. Expose the detector to the isotope of interest and adjust the high voltage until the energy peak lies in the window. This is indicated by a decrease in reading when the high voltage is adjusted either way. Remove the source to verify that the proper peak was found.

6. Switch to GROSS position. The reading will increase if energies above the window setting are present at the detector. Reset to PHA for PHA operation.

Method 2. Voltmeter method.

1. Set the GAIN control (R22) fully clockwise, maximum gain.
2. Set the THRESH control (R27) fully clockwise, least sensitivity.
3. Connect the reference lead of a voltmeter to pin 3 of the PHA socket.
4. Measure the voltage at pin 16 of the PHA socket (pin 9 of the test-edge connector). It will be approximately 1 V negative.

5. Connect the voltmeter lead to pin 13 of the PHA socket. Adjust the WIN control for a positive voltage equivalent to the percent window desired. For a 25 percent window, make this voltage one-quarter as large as that found in step 4, and so forth.

6. Set the PHA-GROSS switch to PHA.

7. Expose the detector to the isotope of interest and adjust the high voltage until the energy peak is in the window. Remove the source to verify that the proper peak was found.

8. Check the PHA-GROSS switch operation. Return to PHA for PHA operation.

Method 3. Pulser Usage.

A calibrated pulser could have taken the place of the voltmeter in method 2. Instead of measuring the threshold and window voltages, the pulser, connected to the detector connector, could have been used to establish the desired signal levels and the THRESH and WIN controls set accordingly. For example, if the threshold was found at 6 mV, the pulser could have then been set for 9 mV, and the WIN control adjusted for crossover. The window would then have been at 50 percent (threshold 6, window width 3).

The next procedure uses the pulser to set up the PHA circuit to correspond to actual energy levels. Once set, a voltmeter can be used to select a different specific energy.

1. Connect the calibrated pulser (Eberline MP-2, for example) to the detector connector.
2. Set the pulser for 10 mV output, between 2k to 20k cpm.
3. Set the PHA-GROSS switch to GROSS.
4. Set the THRESH control (R27) fully clockwise, minimum sensitivity.
5. Adjust the GAIN control (R22) until pulses are just counted.
6. Set the PHA-GROSS to PHA.
7. Set the pulser for 12 mV.
8. Adjust the WIN control until crossover is located.
9. Set the pulser at 5.6 mV output.
10. Set the PHA-GROSS switch to GROSS.
11. Adjust the THRESH control until pulses are just counted.
12. Remove the pulser and connect the detector to be used.
13. Select PHA.
14. Expose the detector to a ^{137}Cs source and adjust the high voltage until the cesium peak (660 keV) is in the window. Remove the source to help make sure the proper peak was found.

    As now set up, the nominal span of the threshold and window controls is from zero to 1 MeV, corresponding to zero to one volt as measured on the THRESH and WIN lines, referenced to the PHA REF line. (For measurement points, see method 2 above.) A voltmeter can now be used to set new specific energies for the threshold and window widths. Remember, the peak is centered in the window, which is one-half a window width above the threshold setting.

    If, in step 9 the pulser had been set at 2.3 mV instead of 5.6 mV, the nominal calibration would have been from zero to 2 MeV for the spans, instead of zero to 1 MeV. An alternate method to obtain zero to 2 MeV is to use ^{60}Co (1.25 MeV, average of two peaks) instead of ^{137}Cs and set the pulser at 5.25 mV in step 9.

    In all cases where possible, the isotope of interest should be used to make the final setup adjustment to make sure the energy is peaked in the window.

    NOTE

    If the high voltage cannot be adjusted low enough to sufficiently include the peak of the isotope emissions, then adjust the THRESH control (R27) fully clockwise (least sensitivity) and adjust the GAIN control (R22) counter clockwise for less than maximum gain. In the case where the pulser is employed, adjust the GAIN control (R27) for about 10 mV sensitivity. Thus, the high voltage will have to be increased to increase the output of the detector, and the required high voltage will then be within the adjustment range of the instrument.

C. PREVENTIVE MAINTENANCE

1. Periodic Maintenance

Because of the simplicity of the ESP-2, periodic maintenance is neither time consuming nor overly frequent.

a. Install fresh batteries at least once every 6 months.

b. Remove the bottom cover and the side access and blow out the inside with clean, dry, low pressure air once each year.

c. Keep the outside of the case clean.

d. Open the bottom and side accesses only when calibration, maintenance, or battery change are necessary.

2. Battery Replacement

a. Turn the instrument off. Approximately 20 minutes are available for battery change with the ESP-2 turned off.

b. Remove the large screw in the bottom cover.

c. Remove the bottom cover.

d. Dispose of the expended batteries.

e. Install six fresh C-size batteries, observing polarity as shown in the battery compartment.

f. Reinstall the bottom cover and secure it with the screw.

3. Right Side Access

a. To open, turn the fastener in the center of the access cover about one turn counterclockwise and pull straight out.

b. To close, press the cover into the opening and turn the fastener about 1/2 turn clockwise.

D. CORRECTIVE MAINTENANCE

1. Disassembly/Assembly

WARNING

When starting screws, exercise care, use screw holders and other proper tools. Don't over-tighten!

Use care to minimize the tension on the ribbon cables connecting the PC boards and the display. The cables are short and can be damaged.

a. Removal of PC Boards:

NOTE

For proper orientation, the front is the end with the MHV connector. The lower PC board is the board closest to the bottom cover and the upper PC board is closest to the keypad and display.

(1) Set the ESP-2 on its top, exercise caution to prevent operation of the pushbutton switches.

(2) Remove the bottom cover and the batteries.

(3) Unsolder the coaxial connector from the lower PC board at the front of the instrument.

(4) Unsolder the battery leads and speaker wires from the lower PC board.

(5) Remove the lower-board mounting screws (one at each corner, one in the center of the opposite end near speaker).

(6) Fold the lower PC board over the front of the instrument case.
(7) Remove the screws on either side of the speaker (in the semicircular retainer).

(8) Remove the side access cover.

(9) Remove the two screws at the corners of the upper PC board.

(10) Lift the upper board and fold it toward the front of the instrument. The speaker will come up out of its mounting and the retainer/spacer will be freed from its position. Set the retainer/spacer aside.

(11) Disconnect the RS-232 molex connector from the upper PC board.

(12) Pull the upper and lower boards clear of the display assembly. The display assembly is secured by the four large screws at the corners. Loosen these screws completely.

(13) Carefully lift the PC board set. The display assembly will come out of its position. Take the screws out of the lucite mounting.

(14) The light leads extend from the button contact board to the lucite mounting. Be careful not to break these leads.

b. Reinstallation of PC Boards:

(1) Insert the four screws into the corner holes of the lucite display mounting so that it holds the keypad board in place and the screws in the lucite line up with the threaded holes in the case. Tighten the screws.

(2) Reconnect the RS-232 molex connector.

(3) Position the upper PC board, component side up, so that the holes in the board line up with the threaded holes in the corners of the instrument case. Insert the screws and screw them down loosely.

(4) Holding up the lower board, position the speaker in its mounting.

(5) Pulling up carefully on the lower board, raise the forward edge of the upper board enough to allow the speaker retainer's channel- shaped upper board support to be positioned so that the board is in the channel. The holes in the speaker retainer should be lined up with the threaded holes in the case.

(6) Making sure that the speaker leads are not pinched under the retainer, screw the retainer in tight.

(7) Tighten the two screws on the upper board.

(8) Guide the coaxial-connector lead through the cutout at the front of the lower board.

(9) The hole in the center (rear edge) of the lower board should line up with the threaded hole in the speaker retainer.

(10) Insert the screw and turn it down loosely.

(11) Insert the screws to hold each corner of the upper board.

(12) Tighten the mounting screws on the lower PC board.

(13) Solder ground wire of the coaxial connector to the ground feed-thru hole near the HV feed-thru terminal.

Figure 5-2
ESP-2 with Bottom Cover Removed

(14) Solder the center conductor or the coaxial connector to the HV standoff terminal.

(15) Solder the speaker leads to the points on either end of the label "SPK" on the lower circuit board.

(16) Solder the batteries' red lead to the "+" point and the black lead to the "-" point on the lower circuit board.

(17) Install the side access cover.

(18) Install the batteries, noting polarity.

(19) Install the bottom cover.

2. Troubleshooting

The ESP-2 uses the latest state-of-the-art components and circuitry available at the time of its design. Eberline's experience using similar components has shown them to be very reliable and trouble free. Realizing that failures and problems will occur, this section is intended to assist the technician with the task of repair.

Eberline provides a repair and calibration service at two locations in the United States and one in England for the European market. Contact Eberline for details (see front of manual).

To hold down-time to the minimum possible, users might consider changing the entire printed-circuit-board set. By maintaining a spare board set and exchanging the board set when a failure occurs, down- time (including recalibration) can probably be limited to less than one hour. The inoperative board(s) can then be repaired in-house, or by Eberline, without taking the ESP-2 out of service for lengthy periods of time.

NOTE

ALWAYS recalibrate after repair.

a. General Procedure

A thorough understanding of the ESP-2 circuitry and program operation is necessary before any field repairs are attempted. For component problems, review Section IV (Theory of Operation) and the schematic and logic drawings (Section VII). For problems related to operation, review Section III (FUNCTIONAL FLOW DIAGRAMS).

The incorporation of a microcomputer in the ESP-2 does not change the general approach to troubleshooting and repair. In short, the problem must be defined, the trouble isolated, and the defect identified. Only then can effective repair be accomplished.

The circuitry used in the ESP-2 employs CMOS technology. These CMOS devices are sensitive to electrostatic discharge. To prevent damage, they should be properly grounded before and during handling.
Generally, problems can be defined in one of two categories. These would be a nonfunctioning microcomputer or a nonfunctioning counter.

NOTE

"Counter" refers to the pulse amplifier, low-voltage circuits, and high-voltage circuits.

A nonfunctioning microcomputer can be recognized by:

(1) No information on the display.

(2) Erratic display information.

(3) Unidentifiable/wrong characters on the display.

A nonfunctioning counter can be recognized by:

(1) Ratemeter readout too low.

(2) Ratemeter readout too high.

(3) Readout not statistical (erratic).

The first step in determining any problem should be the condition of the batteries. If battery life is shorter than specified, turn the ESP-2 OFF and check the drain on the batteries by inserting an ammeter in series with the + lead from the battery. The current should be less than 230 µA. With the ESP-2 turned ON, this drain should be less than 25 mA.

If the drain is too high in either condition, isolate the faulty component and replace it.

The second step is to check all voltages. Use Table 5-4. The test connector (board edge) is reached through the side access door. Viewed through the access door, pin 1 is toward the board center on the bottom. Pin 2 is toward the board center on the top. Even numbers on the top and odd numbers are on the bottom. (Refer to Figure 2-2.)

Table 5-4
Check Voltages

TEST CONNECTOR (FIG. 2-2)	DESIGNATION	LIMITS	DESCRIPTION
2	V_B	+5.8 to +10V	Battery voltage
20	V_C	+4.97 to +5.03V	Regulated low voltage
24	+V	+4.85 to +5.0V	Switched V_C
4	V_{BB}	+5.5 to +9.7V	Switched V_B
18	GND	--	Reference

Any voltage not meeting these limits is a reason for repair BEFORE proceeding. See "Repairing LV Supply."

b. Nonfunctioning Microcomputer

(1) Check the position of the "TEST" switch (S2-B). The correct operating position is with the switch arm down (toward bottom of instrument). If the switch is in the correct position, go on to (2). If the switch is in the wrong position, it must be switched back to the correct position and the instrument MUST be initialized, as follows:

(a) Remove the batteries.

(b) Press RESET switch. This will discharge C28. (See Figure 5-2.) Allow 10 seconds.

(c) Re-install batteries.

NOTE

Reinitializing the computer resets ALL parameters including HV calibration. Complete recalibration should be performed BEFORE putting instrument back into service.

(2) Remove batteries and lower PC board to expose the upper PC board. Check all the integrated circuits (ICs) for proper seating in their sockets. If a loose IC is found, replace the batteries and perform initialization (step 1). If the problem persists, proceed to step 3.

(3) This leaves the following possibilities:

(a) Shorted keypad switch or test connector.

(b) C27 shorted.

(c) A108 or X1 inoperative.

(d) A111 inoperative.

(e) A1 inoperative.
(f) A2 inoperative.

(g) A109, A110, or A5 inoperative.

(h) Display not operating.

(i) Damaged PC board or ribbon cable(s).

c. Nonfunctioning Counter

The two most common symptoms of a nonfunctioning counter are: failure of the counter or a noisy counter.

NOTE

The instrument must be turned OFF and back ON to reset an "OVERRANGE" condition. An OVERRANGE indication could be caused by an incorrect "DT" setting for the detector in use.

First determine that the problem is not caused by the detector or cable. The best way to do this is to connect a known good detector and cable then recheck the operation.

Next, remove the lower board so its components are exposed. Visually inspect for loose and/or poorly seated components, broken wires, broken components, etc.

If the counter has failed, check:

(1) High voltage at the detector connector. Use a voltmeter with 1000 megohms or greater input impedance. The voltage should be set for the detector being used. If not correct, see "Repairing the HV Supply" below before proceeding.

(2) Amplifier output at pin 7 of A101 using an oscilloscope with an Eberline MP-2 (or MP-1) connected to the detector connector. Set the pulser to 15 mV and 40k counts per minute.

The positive pulse on the scope should be 2.0 volts or greater. If good, go to step 3 below.

If bad the probable causes are:

(a) A101 inoperative.

(b) Q3 inoperative.

(c) CR4 shorted.

(d) C11 defective.

(3) Discriminator output at pin 10 of A101 using the scope (MP-2 still connected and set as in step 2 above). This should be a negative square pulse of 4.0 volts or greater. If good, go to step 4.

If bad, the probable causes are:

(a) A101 inoperative.

(b) THRESHOLD control (R28) defective.

(c) A105 inoperative.

(4) Binary output at pin 9 of A105 using the scope (MP-2 still connected and set as in step 2 above). This signal should change state at the rate of the MP-2 and switch between ground and 4.0 volts or greater.

If the signal is not present, A105 is bad.

If the signal is present, move the scope to pin 14 of A108 (microcomputer chip). The signal should be as above. If it is, A108 is bad. If not, check for damaged PC board, or bad contact at A108 pin 14.

If the counter is noisy, the most common causes of counter noise are:

- High voltage too high.

- Loose or bad ground connections.

- High voltage breakdown.

- Input sensitivity (R27 THRESHOLD), set too sensitive.

- Noisy low voltage supply.

Loose or bad ground connections are best detected by visual inspection. Check for:

(a) Damaged PC board.

(b) Broken wire(s) in ribbon cables.

(c) T1 frame is grounded.

If the high voltage is too high, try readjusting it (keypad control in Parameters Mode). If it will adjust and control, then recheck with the detector attached to prove the fix.

If the high voltage does not adjust and/or control, go to "Repairing the HV Supply."

Breakdown or arcing of the high voltage is normally caused by a dirty PC board, damaged component, or dirty/bad detector connector.

Input sensitivity can easily be checked using an Eberline MP-2 (or MP-1). Refer to Table 5-1. If the input sensitivity is incorrect, reset it to the proper value and check instrument operation. If it is still noisy, proceed.

Check the low voltage (V_c, +V) ripple, using a scope. The AC component should be less than 10mV. If not, the probable causes are:

- A104 inoperative (if noise is on V_c).

- Q6 defective.

- Leaky filter capacitors.

d. Repairing the HV Supply.

NOTE

All measurements of the high voltage require a voltmeter of 1000 megohms or greater input impedance. Use an electrostatic voltmeter or a high voltage measurement device such as a Fluke model 8020A with 80K-40 high voltage probe.

It is normal that the high voltage will fluctuate around the control point (±2 percent). Adjust HV using the HV controls in the Parameters Mode.

NOTE

The actual High Voltage is within ±2% of the displayed voltage from 600 V to 1800 V. Outside this range, the actual high voltage may be as much as 10% lower than the displayed voltage, but will never be more than 2% higher than the displayed value.

(1) No high voltage. Probable causes:

(a) Q2 and/or T1 defective.

(b) Q1 defective.

(c) A100 inoperative.

(d) CR1, CR2, or CR3 defective.

(e) C8 defective.

(f) HV reference (A100, pin 10) not right value.

(2) HV too high. Probable causes:

(a) A100 inoperative.

(b) Q1 defective.

(c) C8 defective.

(d) R1 defective.

(3) Fluctuating high voltage. Probable causes:

(a) A100 inoperative.

(b) R1 defective.

e. Repairing the LV Supply

(1) V_c Low.

Check for excessive current drain. Isolate to faulty component by removing one IC at a time until fault is found.

(2) V_c High.

Replace A104.

(3) Error in +V. Probable causes:

   (a) Q6 defective.

   (b) "PWR ON" from computer > 0.4 volts.

   (c) Excessive current drain on +V supply.

(4) Error in V_{BB}. Probable causes:

   (a) Q8 defective.

   (b) Q7 defective. Also check Q2 and C10.

f. Speaker Nonfunctioning (Note: Check S1-A, S1-B, S3-A, and S3-B for proper settings.) Probable causes:

(1) Speaker defective.

(2) Q4, Q5 defective.

(3) A102 inoperative.

(4) S1-A, S1-B, S3-A, or S3-B defective.

(5) CR6 defective.

(6) "SPKR" from computer > 0.4 volt with speaker ON. Check contact at pin 8 of A108, and board damage. If they are satisfactory, A108 or keypad switch is defective.

(7) A105 inoperative.

If speaker works but alarm does not:

   (a) CR5 defective.

   (b) "ALM" from computer > 0.4 volt when in alarm condition. Check contact at pin 7 of A108, and board damage. If they are satisfactory, A108 is inoperative.

g. Loss of logged data or reset to default parameter. There are two known causes which result in an unintentional reset (clearing) of the RAM memory in the ESP-2.

(1) Static Charge

The ESP-2 can develop a static charge which can cause problems if it is not discharged correctly.

It is suggested that when connecting to an external communications cable that the instrument be placed on a conductive surface. The user should ground themselves to the surface and ground the shell of the interconnecting cable to the surface. The intent is to place the user, the ESP-2 and the cable connector all at the same voltage potential before an inter connection is made.

Should the user be at a different potential from the ESP-2 and they should touch the keypad, a static discharge can result, which enters the ESP-2 and causes a reset. Likewise, if the cable is connected while it is at a different potential, the static shock may cause problems with the ESP-2.

(2) Connecting the communications cable with the ESP-2 Turned off.

Refer to the manual insert sheet number 1801 in the front of this manual.

WARNING:

If the ESP-2 is off when the communications cable is connected, it may be reluctant to turn on and parameters may be reset to default values, and logged data may be lost (erased).

SECTION VI. PARTS LIST

The following table lists the mechanical and electronic items incorporated in the ESP-2 and should contain any part necessary for normal repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

1. PC Board Set (2 boards plus display) part no. YZ11384000

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
A100	Integrated Circuit	Operational Amplifier	Motorola MC14573	ICAOA14573
A101	Integrated Circuit	Operational Amplifier	Motorola 14575	ICAOA14575
A102	Integrated Circuit	Quad Nor Gate	RCA 4001B	ICCMA4001B
A104	Integrated Circuit	MCR PWR, 5v	National LP2950CZ	ICAVA2950C
A105	Integrated Circuit	12 Bit Binary Counter	RCA 4040 or 440	ICCMA4040B
A108	Integrated Circuit	Microprocessor	Intel 80C51	ICXXRM14SA
A109	Integrated Circuit	Decoder	3 IN TO 8 LINE	ICCMAHC138
A110	Integrated Circuit	Nor Gate C MOS	Texas Inst. 74HC02	ICHCA00002
A111	Integrated Circuit	EPROM	Intel 87C64	ICCMA87C64
A112	Integrated Circuit	75248 Bit D/A Converter	Analog Devices Converter	ICCMA07524

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
C1	Capacitor	0.047 µF, 10%, 4.0 kV	SHIZUKI X675HV.047104000V020	CPPF503PXY
C2, C4	Capacitor	0.01 µF, 20%, 3 kV	Sprague 30GA-S10 or Centralab DD30-103	CPCE103P4Y
C3	Capacitor	0.001 µF, 10% 3kV	Centralab DD30-102	CPCE102P3Y
C5, C14	Capacitor	0.1 µF, 10%, 50 V	Centralab CW20C104K	CPCE104P3N
C6	Capacitor	0.1 µF, 10%, 80 V	Sprague 192P	CPPF104P3O
C7	Capacitor	0.0033 µF, 1 200 V	Type 192P	CPPF332P3P
C8	Capacitor	0.47 µF, 10%, 35 V	150D/T110	CPTA474P3L
C9	Capacitor	0.27 µF, 20%, 50 V	Centralab CW30C274M	CPCE274P4N
C10, C29	Capacitor	33 µFD, 10%, 10 V, Tantalum	Sprague 1C25Z5U	CPXX12
C11	Capacitor	220 pF, 10%, 3 kV	Centralab DD30-221	CPCE221P3Y
C12, C19	Capacitor	0.047 µF, 20%, 50 V	Sprague 1C25Z5U	CPCE473P4N
C13, C27	Capacitor	10 µF, 20%, 16 VDC, Tantahum	Sprague 199D106X0016CA1 or ITT TAP-B10K35	CPTA100M4X
C15	Capacitor	820 pF, 10%, 100 V	Erie CK12BX821K or equivalent	CPCE821P3P

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
C16, C20, C21	Capacitor	100 pF, 50 V	AVX SR151A101KAA	CPCE101P3N
C17	Capacitor	1000 pF, 10%, 100 V	Centralab CN20A102K	CPCE102P3P
C18	Capacitor	0.022 μF, 10%, 100 V	Mallory CK06BX223K	CPCE223P3P
C25	Capacitor	0.01 μF, 80 V	Sprague 192P	CPPF103P3O
C28	Capacitor	0.047 F, Super Capac.	NEC FA0H473Z	CPSP473MXC
C30	Capacitor	15 μFD, 10%, 20 V, Tantalum	Sprague 196D	CPXX10
C31	Capacitor	0.01 μF, 10%, 50 V	Centralab CK103	CPCE103PXN
C36, C37	Capacitor	33 pF, 10%, 100 V	Erie CK12BX330K or Equivalent	CPCE330P3P
CR1, CR2, CR3	Diode	VA 25 Rectifier		CRSIVA0025
CR4, CR5, CR6, CR7, CR10, CR11,	Diode	Silicon Switching	1N4148	CRSI1N4148
DS1	Bulb	T-1 1/4, 6 V, 60 mA incandescent		LPBU17
Q1, Q4, Q5, Q10, Q11	Transistor	NPN, Silicon	2N4401	TRSN2N4401
Q2	Transistor	PNP, Silicon	Motorola 2N4234 or National 2N4234, 2N4236, only	TRSP2N4234

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
Q3	Transistor	NPN, Silicon	2N5088	TRSN2N5088
Q6, Q8	Transistor	PNP, Silicon	2N4403	TRSP2N4403
Q7	Transistor	NPN, Silicon	2N4124	TRSN2N4124
R1	Resistor	1000M/1M, 10 percent, Voltage Resistive Divider	IRC RD5 Custom	REXX22
R2	Resistor	100 k, 5%, 1/4 W, Carbon Composition		RECC104B22
R3	Resistor	10 M, 5%, 1/4 W, Carbon Composition		RECC106B22
R4, R49, R75	Resistor	1 k, 5%, 1/8 W, Carbon Composition		RECC102B21
R5	Resistor	62 k, 5%, 1/8 W, Carbon Composition		RECC623B21
R6, R8	Resistor	30 k, 5%, 1/8 W, Carbon Composition		RECC303B21
R7, R47	Resistor	100 ohm, 5%, 1/8 W, Carbon Composition		RECC101B21
R9, R16, R21, R25, R26	Resistor	20 k, 1%, 1/4 W	RN55D	RECE203B12
R10	Resistor	470 ohm, 5%, 1/8 W, Carbon Composition		RECC471B21

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
R11, R51	Resistor	510 k, 5%, 1/8 W, Carbon Composition		RECC514B21
R12	Resistor	270 ohm, 5%, 1/4 W, Carbon Composition		RECC271B22
R13	Resistor	47 k, 5%, 1/8 W, Carbon Composition		RECC473B21
R14, R52	Resistor	270 k, 5%, 1/8 W, Carbon Composition		RECC274B21
R15, R18	Resistor	2.1 k, 1%	RN55D	RECE212B12
R17	Resistor	68.1 k, 1%	RN55D	RECE683B12
R19, R20, R29, R67	Resistor	150 k, 1%	RN55D	RECE154B12
R22	Potentio-meter	100 k, 1/2 W	Spectrol 64X	PTCE104B83
R23, R24	Resistor	200 k, 1%	RN50	RECE204B11
R27	Potentio-meter	10 k,	Spectrol 64X	PTCE103B93
R28	Resistor	10 k, 1%	RN55D	RECE103B12
R30	Resistor	22 ohm, 5%, 1/4 W, Carbon Composition		RECC220B22
R43	Resistor	20 k, 5%, 1/8 W, Carbon Composition		RECC203B21

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
R44	Resistor	5.6 k, 5%, 1/8 W, Carbon Composition		RECC562B21
R45, R76	Resistor	10 k, 5%, 1/8 W, Carbon Composition		RECC103B21
R46	Resistor	100 k, 5%, 1/8 W, Carbon Composition		RECC104B21
R50	Resistor	18 k, 5%, 1/8 W, Carbon Composition		RECC183B21
R54, R62	Resistor	75 k, 5%, 1/8 W, Carbon Composition		RECC753B21
R55	Resistor	3.3 k, 5%, 1/8 W, Carbon Composition		RECC332B21
R56	Resistor	130 k, 1%	RN50	RECE134B11
R57	Resistor	100 k, 1%	RN50	RECE104B11
R63	Resistor	12 ohm, 5%, 1/8 w, Carbon Composition		RECC120B21
R64	Resistor	270 ohm, 5%, 1/8 W, Carbon Composition		RECC271B21
R65	Resistor	1 M, 5%, 1/8 W, Carbon Composition		RECC105B21
R66	Potentio-meter	200 k, 10 %	Spectrol 64X204	PTCE204B33

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
R68	Potentio- meter	500 k,	Spectrol 64X	PTCE504B23
R69	Resistor	562 k, 1%,	RN55D	RECE564B12
R70, R71	Resistor	49.9 k, 1%,	RN55D	RECE493B12
R72, R73	Resistor	536 ohm, 1%, 1/4W	RN55D	RECE531B12
R74	Resistor	4.7 k, 2%, SIP (4 resistor array)		REAR472B12
S5	Switch	Pushbutton,	Alco TPA11CG-PC	SWPB17
T1	Transformer	Blocking Oscillator	Microtran M8149	TFHV5
X1	Crystal	7.373 MHz		CYOS12

2. ESP-2 PC Board Part No. ZP11385000

A1	Integrated Circuit	Octal Buffer	National 74HC373 or 54HC373J	ICHCA74373
A2	Integrated Circuit	EPROM	Intel 87C257	ICCMA87257
A3	Integrated Circuit	RAM, 8K X 8	Hitachi HM6264LP-15	ICCM6264
A4	Integrated Circuit	Hex Bus Driver	National MM74HC365	ICHC74365
A5	Integrated Circuit	Decoder 3 In to 8 line	National MM74HC365	ICCMAHC138
A6	Integrated Circuit	Clock, Real Time	OKI Semi- conductor MSM6242RS	ICCM6242

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
A8	Integrated Circuit	RS-232 Xmitter/ Receiver	Maxim MAX232EPE	ICXXA32EPE
C1, C2	Capacitor	18 pf, 10%, 100 V	Type ET05	CPCE180P3P
C5, C6, C11	Capacitor	0.1 µF, 10%, 100 V	Erie CK06BX104K or Equivalent	CPCE104P3P
C7, C8, C9, C10	Capacitor	22 µF, 20%, 15 V	Sprague 196D/T362	CPTA220M4H
R1	Resistor	30 k, 5%, 1/8 W, Carbon Composition		RECC303B21
R2	Resistor	3 k, 5%, 1/4 W, Carbon Composition		RECC302B22
R3	Resistor Array	1 Meg, 5%, Resistor SIP, 1 common pin (7 Resistors)		REAR105B21
R12	Resistor	510 k, 5%, 1/4 W, Carbon Composition		RECC514B22
X1	Crystal	Quartz, 32.768 KHz	Statek CX-1V	CYOS08
J1	Connector	7 Pin, PC Board Mounted	Molex 22-23-2071	COMR107

3. Miscellaneous Parts

	Part	Description	Manufacturer & Part Number	Eberline Part Number
	Speaker	Buna N O-Ring	Parker 2-021	ORBN2021
	Speaker	1 in. dia. x 0.6 Dp., 8 ohm	SPECO U101	ADSP4

Ref. Desig.	Part	Description	Manufacturer & Part Number	Eberline Part Number
	Display	2 line x 16 character (LCD)	Hitachi LM016L	OPDS19
	Case	Upper		YP11383004
	Case	Lower		ZP11292011
	Screw	Lower case retaining screw	3/8 - 16 x 1 flat head stainless steel	SCFH3716
	Flat Cable	Keyboard cable (9 conductor)		WRFC092602
	Flat Cable	Display cable (14 conductor)		WRFC142601
J2, J3	Flat Cable	ESP-2 PC Board (16 conductor)		WRFC162601
	Access door			ZP11292012
	Access door latch		Southco 84-20-120-10	HDFA10
	Battery	1.5 V "C" cell alkaline		BTAK2
	Display lens			ZP11292023
	Speaker retainer			ZX11292013
J1	Connector Housing	7 pin	Male PC MTG	COMR107
	Terminals	Crimp	Molex 08-50-0005	COHD110

4. ESP-2 Options

YP11388002, PHA

RS-232 Cable Assemblies:

***CA-40-80, ESP-2 to Printer.**
***CA-41-80, ESP-2 to IBM-AT Computer.**
***CA-42-80, ESP-2 to IBM-PC or PS2 Computer.**
***CA-63-80, ESP-2 to Seiko Printer (EIC #RCDI15)**
YP11383011, Demo Software (includes ESP-2 Communication Specification, EIC #1300-A08).

***These cables are available in lengths from 24 inches to 50 feet. The length is specified in inches. For example: A CA-40-60 is 60 inches long, a CA-40-600 is 600 inches (50 Ft.) long. See 11383-C39 in Section VII for wiring diagrams of these cables.**

ESP-2

SECTION VII. DIAGRAMS

Figure 7-1
Functional Block Diagram, Microcomputer, 11383-C32A

Figure 7-2
Functional Block Diagram, Amplifier, High Voltage and Speaker, 11383-C33

Figure 7-3
Functional Block Diagram, Low Voltage, 11383-C34

Figure 7-4
Component Layout, ESP Basic PC Board Assembly, 11384-D05A

Figure 7-5
Component Layout, ESP-2 PC Board Assembly, 11385-C04B

Figure 7-6
Component Layout, ESP PHA PC Board Assembly, 11388-C03B

Figure 7-7
Amplifier High Voltage and PHA Schematic, 11384-D03F (Sheet 1 of 2)

Figure 7-8
Microcomputer Schematic, 11384-D03F (Sheet 2 of 2)

Figure 7-9
ESP-2 PC Board Schematic, 11385-D03D

Figure 7-10
Wiring Diagrams for Optional Cables, 11383-C39A

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SECTION VIII. DETECTORS AND ACCESSORIES

Table 8-1
Detectors Recommended for Use with ESP-2
11292-A37