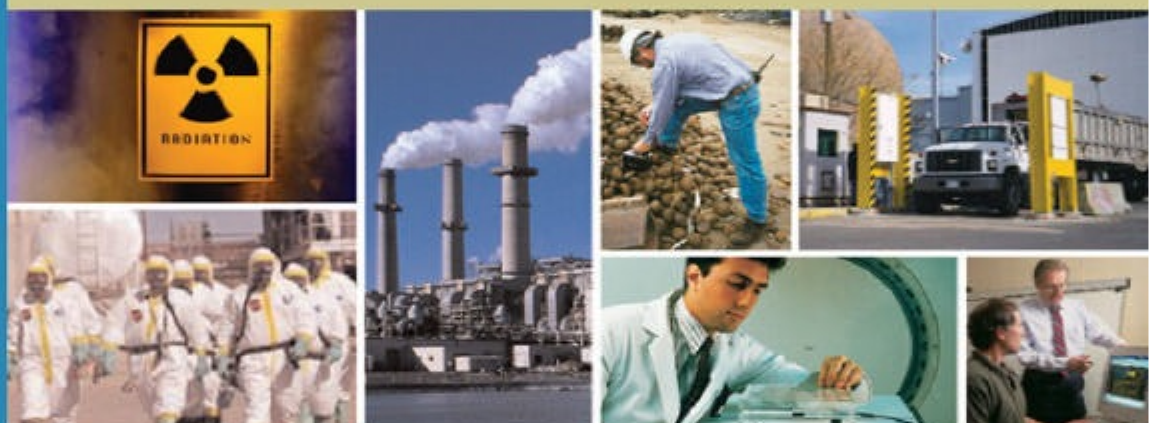
Personnel Contamination Monitor

Eberline PCM-2

Technical Manual

Part No. MA-PCM2 REV. B



Analyze • Detect • Measure • Control™

Thermo
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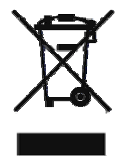
WEEE Compliance

This product is required to comply with the European Union's Waste Electrical & Electronic Equipment (WEEE) Directive 2002/96/EC. It is marked with the following symbol:



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Contents

Chapter 1 Introduction

General Description

The Eberline PCM-2 is a monitoring instrument that provides rapid and convenient detection and localization of alpha and beta / gamma contamination on personnel. Sixteen gas proportional detectors designed for rapid replacement or repair provide superior localization of contamination and background rejection. A contoured array of 34 counting zones, each with separate alpha and beta/gamma channels, provides data from which the instrument can determine the presence of both localized and distributed contamination. In addition, up to 75 sum zones can be defined, each comprised of 2, 3 or 4 adjacent detectors, for a maximum detection of contamination that is spread over two or more detectors. (The PCM-2 outline drawing is reproduced below in Figure 1-1 and also in Figure 22-1 in Chapter 22: "Drawings".)

A sum channel is the summation of all 34 detectors into a single counting channel. With α and ß / ϒ discrimination, the 34 discrete channels, 75 sum zones, and sum channel provide a total of 220 measurements per count cycle. Since a person is measured with two count cycles, there are 440 independent measurements performed per person. The sum channel is thereby capable of detecting low-level, widely distributed contamination.

Individual detector channels within the PCM-2 are independently controlled by distributed microprocessors. In addition, a Pentium class-based single board computer and a large 10.4" LCD panel provide a user-friendly interface for the system. This enhanced controller also simplifies calibration and maintenance of the unit and presents test results to the user in a clear and easily understood graphic format. A full-size keyboard is stored inside the unit for use during setup, calibration and troubleshooting. The PCM-2 is also capable of logging measurement data in any of several formats to a printer or host computer system using RadNet broadcasts over an Ethernet network.

The PCM-2 features a functionally ergonomic design that maximizes user body contact with, and minimizes dead areas between, the detectors. A color VGA LCD panel is used to display information during normal operation as well as during setup, calibration and maintenance. If contamination is detected during a measurement cycle, a color graphic image is presented to indicate contamination locations. The image is one of a user's body outline placed in front of the unit's detector grid, with the alarmed detectors indicated in red.

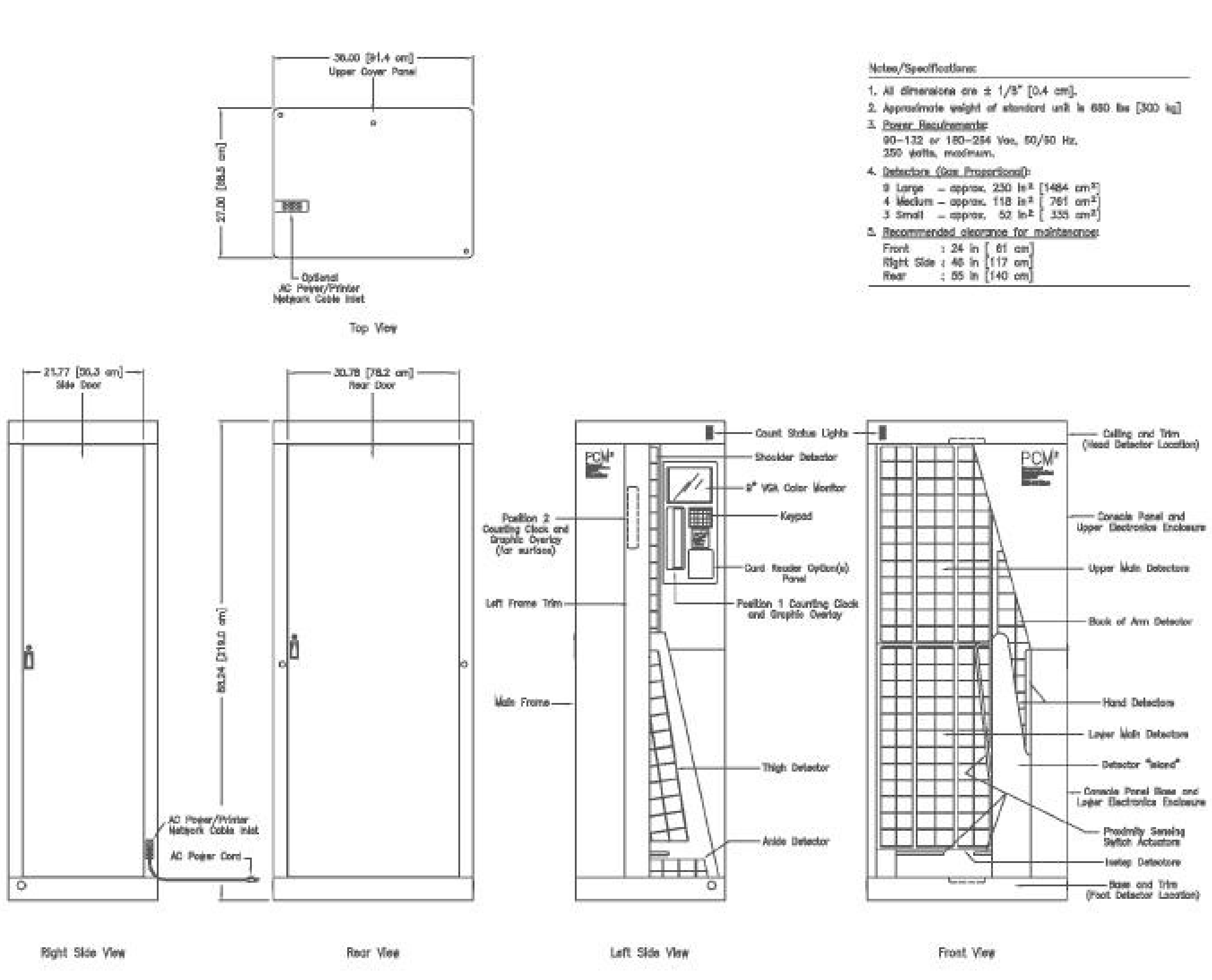

Figure 1-1. 11534-555, PCM-2 outline. (A larger version of this drawing is located in Chapter 22.)

Two additional count-down clock/graphic displays provide information and instructions to help the user assume a correct body position relative to the detector grid for proper measurement. Red LEDs indicate to the user any proximity switches that need to be actuated in order to achieve proper body positioning. During the measurement, the remaining count time (in seconds) is indicated on the active display. A standard audible annunciator and an optional voice annunciator provide user prompts to supplement the visual counting clocks, position indicators and graphic screen.

Input of a user identification (user ID) number and Radiation Work Permit (RWP) number (if either or both are selected) can be performed from the 20-button touch keypad or an optional magnetic or bar code reader. When this information is inputted, it is appended to the date- and time-stamped transaction record for that measurement. The measurement results are stored on a hard disk drive in the PCM-2. The hard drive is large enough to accommodate several years' worth of measurement data. Source check results and calibration reports are also stored on the hard drive.

The PCM-2 is provided with swiveling casters with immobilization levelers for improved mobility. This feature allows the unit to be moved easily by one person, for service access.

In addition, the following optional features are available:

- Hand-held frisking probe for finer localization of contamination.
- Voice-prompting capability to enhance the user interface.
- Printed reports of count results and calibration data.
- Remote alarm and status display module with wall-mounting capability.
- Magnetic or barcode ID badge readers.
- Polyethylene film dispenser for foot-detector protection and maintenance.
- Modular gas bottle enclosure for two Size 1A counting gas cylinders.
- Network cable and supporting network software for integration of the PCM-2 onto an RS-485 or Ethernet network
- Small-hole perforated grid footplate for support of users with high heels.

- Gas management system for minimization of counting gas usage.
- Internally mounted, continuously purging spare detectors
- High-sensitivity screens are available as an option, replacing the heavier rugged steel detector screens normally provided for rough or high-usage environments.

The PCM-2 also features networking capability. A central computer software package which operates on a PC is available for communicating with the PCM-2 network and archiving counting transactions to disk or printer. PCM-2 operating parameters can be controlled by the central computer as well as locally through the keyboard. Local connection of a printer to each PCM-2 is also supported.

Specifications

Mechanical

Width	36.00 in. (91.44 cm)
Depth	27.00 in. (68.58 cm)
Height	86.50 in. (219.71 cm)
Weight	660 lbs. (300 kg).

Temperature

Operating	From –32 °F to 113 °F (0 °C to 45 °C)
Storage	From –4 °F to 140 °F (–20 °C to 60 °C).

Humidity

Operating	0 to 95% (non-condensing).

Voltages

Input	90–132 or 180–264 Vac, 50/60 Hz, 250 W maximum.
AC Fuse	3.0 Amp slow-blow at 250 Vac.

Display

10.4" VGA color LCD panel, 640 x 480 resolution, 85–264 Vac, 50/60 Hz, on/off, brightness, contrast controls, 100,000-hour operation reliability.

Serial Ports

Host computer port

Selectable between either uLAN and non-uLAN (standard) binary protocol data format.

1 start bit, 8 data bits, 1 address marker bit (only if uLAN is selected, otherwise no parity), and 1 stop bit.

RS-232C (standard) or RS-485 (optional).

User selected baud rates of 300, 600, 1200, 2400, 4800, 9600 and 19,200 are available. The default baud rate is 9600.

Card reader port

ASCII data format.

1 start bit, 8 data bits, no parity and 1 stop bit.

RS-232C for Computer Identics bar code reader.

TTL for Xico magnetic card reader.

Baud rate is fixed at 9600.

PCM-2 interface port

Binary protocol data format.

1 start bit, 8 data bits, no parity and 2 stop bits.

RS-232C level.

Baud rate is fixed at 9600.

Gas manager communication port

Binary type uLAN protocol data format.

1 start bit, 8 data bits and 1 stop bit.

RS-485 only.

Baud rate is fixed at 19.2K (19,200) baud.

Computer

Minimum Specifications

Pentium-class processor, 300 MHz or faster, with 64 MB RAM or more, VGA graphics video card, RJ-45 Ethernet connection, 2 serial ports, 1 parallel port.

System Memory	SDRAM SODIMM x 1, Max. 256 MB.
System Chipset	AMD CX 5530.
Watchdog Timer Software	Enable/disable 1.6 sec. optional 65 sec.
Expansion Interface	PC/104.
Battery Lithium	3 V / 196 mAH.

I/O

MIO 1 x EIDE (Ultra DMA33), 1 x floppy disk drive, 1 x keyboard, 1 x mouse, 1 x RS-232/422/485, 1 x RS-232, 1 x LPT.

Ethernet

Chipset RealTek 8139C.

Interface IEEE 802.3u 100Base-T Fast Ethernet compatible.

Built-in boot ROM in Flash BIOS.

Display

Chipset AMD CX 5530.

Memory size 1-4 MB UMA share memory.

Resolution up to 1024 x 768 at 24 bpp non-interlaced CRT.

1024 x 768 at 18 bpp TFT-LCD display (supports 3.3 V-LCD).

LCD Interface 18-bit TTL for TFT-LCD only.

Dimensions (L x W) 145 x 102 mm (5.7" x 4").

Power supply voltage	+5 V ± 5%
Maximum	4 A, +5 V
Typical	1.5 A @ +5 V.
Operating temperature	0°–60° C (32°–140° F).
Operating humidity	0%–90% relative humidity, non-condensing.
Weight	0.75 kg (weight of total package).

Counting Computers

Intel 7.3 MHz 87C51FA microprocessor with 32 kB EPROM and 256 byte RAM, separate computer controlled thresholds for beta and alpha pulses, anti-coincidence circuitry to prevent alpha pulses from being counted in the beta channel.

High Voltage Supply

Microprocessor-based, computer-controlled high-voltage adjustment up to 2500 V, failure-sensing provided.

Detectors

16 separate gas flow proportional detectors subdivided into 34 counting zones:

9 large	212 sq in. (1368 sq cm) detectors, split into 3 counting zones.
4 medium	113 sq in. (728 sq cm) detectors.
3 small	50 sq in. (325 sq cm) detectors.

Counting Gas

P-10 (90% argon, 10% methane).

Gas Usage

One size 1A P-10 gas cylinder = approximately 24 days @ 200cc/min flow. Users have reported up to a factor of 10 reduction in gas usage, using the PCM-2 Gas Manager (see "OPT12, Gas Management" on page 19-57).

Theory of Operation

Radioactive emissions cause ionization of the counting gas in the detector chambers. The ions are collected at the detector anode wire causing small voltage pulses on top of the static high-voltage that is applied to the anode wire. Through capacitive coupling, the pulses are stripped from the high-voltage, amplified, and discriminated by pulse height into alpha and beta gamma channels. The detector microprocessors count the pulses, and convert the counts to count rates. Count rate information is communicated to the system controller over an RS-485 bus. The system controller applies the appropriate algorithms to update background count rates and measure for contamination.

Operational Mode

In its main task loop, the computer program continually updates background count rates for all detector channels, performs diagnostic checks, and monitors input devices to determine if a person will be measured. Numerous I/O devices are used to prompt the user and verify correct positioning for a contamination measurement. The results of the measurement are annunciated audibly and visually. The measurement is principally a qualitative determination (an alarm indicates a high probability that the person is contaminated; no alarm indicates a high probability of no contamination present). Notwithstanding, alarm annunciation includes presentation of quantitative information, i.e., activity levels are stated.

Three counting modes are supported: Preset All, Maximum Sensitivity (Fixed Count Time), and Minimum Count Time. In each mode, statistical control of the counting exercise ensures that the performance of the monitor is optimized for that mode's key parameters. The alarm set points (all three modes), RDA (mode 2), and minimum count time (mode 3) are all computed for each new background measurement. The parameters used include average background count rate, count time, sigma factor (which controls false alarm probability), confidence level, RDA and detector efficiency.

Preset All

This mode maintains a fixed confidence level (probability of detection) for the user-selected RDA and count time. False alarm probability is maintained at or below a user-prescribed maximum. This mode is best used when a fixed release limit is established and lower levels of activity are of negligible concern. This mode is also useful when a fixed count time and fixed alarm set points are preferred.

Maximum Sensitivity

This mode is appropriate for ALARA measurements. Using a fixed count time that is selected by the user, the instrument applies the selected confidence level to achieve the lowest possible RDA while maintaining a fixed false alarm probability.

Caution This mode of operation will alarm on very low levels of contamination. Experience has shown that it is often impossible to verify alarms in maximum sensitivity mode using a hand-held frisker. For this reason, this mode of operation is not normally used. ▲

Minimum Count Time

The minimum count time is determined automatically for a fixed false alarm probability and RDA with its associated confidence level. All detectors will count for the full count time as determined by the channel requiring the longest minimum count time.

The PCM-2 setup program recalculates all affected operating parameters whenever a user-defined variable is changed and gives immediate indication of the affects of the change. During operation, whenever background levels increase to the point that the statistical parameters cannot be maintained, the instrument is taken out of service and a high background alarm is issued.

Test Mode

Test mode is a collection of menu-driven routines that are used to perform diagnostics, observe count rate information, edit parameters, perform source checks, and calibrate the monitor. Routines are selected using a system of pull-down menus and hot keys. Many of the procedures are automated, and only requires the user to establish setup parameters. As an example, the computer generates high-voltage plateaus without any need for the technician to adjust or measure high voltages or record data. The computer manages these functions and presents the results in both tabular and graphical formats.

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Chapter 2 Installation

Unpacking

The PCM-2 is shipped upright packed with protective cardboard and bagged foam and is wrapped in plastic. The standard shipping configuration also includes a cardboard “extraneous parts” box that resides on the floor of the unit. This box contains the unit’s P-10 counting gas bottle regulator, lifting eyebolts, spare tubing, door and upper cover lock keys, MS-DOS and PCM-2 boot software disk, and a copy of this technical manual.

For PCM-2s equipped with any options, the associated optional hardware is installed in the unit, with the exceptions of the hand-frisking probe, printer, remote annunciator and remote annunciator wall bracket options 1, 3, 4 and 14 respectively. An additional box or boxes will be provided on the floor of or separately with the PCM-2 for units with these options.

Prior to removal of its shipment packaging, the PCM-2 should be moved to the location of its ultimate use so as to avoid damaging its exterior surfaces in transporting. As mentioned, two large eyebolts are provided for overhead lifting of the unit. These eyebolts install into threaded sockets located in the ceiling of the unit at the front right and rear left corners (see Figure 1-1). For overhead lifting, a chain or webbing strap should be attached through both of these eyebolts to keep the unit upright and to properly distribute the unit’s load when hoisted.

Caution Use appropriately rated equipment and exercise due safety precautions when lifting the PCM-2 unit in this overhead fashion. A large appliance dolly with a retaining strap and incline truck can be used for moving the PCM-2 on the ground. ▲

Note Avoid rolling a PCM-2 unit equipped with swiveling casters across uneven surfaces or at rapid rates across any surface. Casters are intended for quick and easy movement of the unit away from its fixed operating position (i.e., up against a wall or another unit) to access rear and side doors. The spring-loaded caster levelers provided with the caster option stop the unit from being moved over rough or uneven surfaces and should be in their retracted (up) positions prior to moving the unit. The casters are intended for use on smooth surfaces only. ▲

Counting Gas Installation

The PCM-2 uses gas proportional detectors that require an approximate total of 200 cc/min of P-10 counting gas for their operation.

Note The optional gas management system reduces the gas usages significantly. Two gas inputs are provided, for which supply hose feed through grommets at the rear side columns of the instrument are provided. The instrument will select one gas source upon powerup and continue to use that source until its pressure fails, at which time the alternate gas source will automatically be selected via internal gas-switching electronics. If both inputs drop below approximately 2 psi, the instrument will cease to operate. ▲

If portable cylinders are used to supply counting gas, each must be regulated down to approximately 5 psi and connected to one of the gas inputs. The standard PCM-2 unit includes one gas bottle pressure regulator located in the extraneous parts box, as noted above (see "Unpacking" on page 2-1). If the optional gas bottle enclosure ("OPT9, Gas Bottle Enclosure" on page 19-53) is ordered, one additional gas pressure regulator is included. If two counting gas sources are installed, it is important that both regulators be set to the same pressure so that gas flow will remain constant when the second cylinder is selected. If the pressure at either input fails, a message will be displayed on the LCD panel indicating that the gas cylinder needs to be replaced.

When the instrument is operated from a permanently installed counting gas manifold, both inputs may be connected to the same 5-psi source. This will eliminate false "Gas Bottle Empty" messages.

Gas Flow Adjustment

Two flow meters are provided along with a single-needle valve to adjust the gas flow rate. For normal operation, use the low-range meter to set a flow rate of approximately 200 cc/minute. When setting up a new instrument or an instrument that has been disconnected from its gas supply, adjust the flow to 0.8 liter per minute (800 cc/min) for four hours to purge the detectors completely.

Note To avoid bursting or damaging the Mylar® entrance windows, do not exceed 1 liter per minute (1,000 cc/min) at any time. ▲

If replacing a detector, the replacement detector should be purged on the bench prior to installation or purged in place after installation using the Quick Detector Purge gas supply hose coil located behind the flow meter mounting bracket. If the latter method is used for detector purging, disconnect the red gas supply hose from the subject detector and plug the quick-purge line in its place. This procedure effectively reroutes the gas flow from the system's gas supply harness to the purging detector. Utilization of this quick-purging hose feature will provide complete purging of a large PCM-2 detector within approximately 20 minutes at a nominal gas flow rate of 200 cc / min. Faster purging times can be achieved by increasing the gas flow rate; however, caution must be exercised to avoid bursting the detector's mylar face. A more thorough explanation of the quick-purging line feature appears in "Quick-Purge Line" on page 9-3.

Each of the sixteen detector chambers is connected to two gas plumbing harnesses/manifolds, a red gas supply harness and a blue gas exhaust harness. For faster purging, because the counting gas is heavier than air the supply hose should always connect to the lowermost gas fittings of vertically mounted detectors.

If the Hand Probe option ("OPT1, Hand Probe" on page 19-1) is installed, a third gas-flow meter and a separate rate adjustment needle valve are provided. This single handheld detector will operate adequately on 5–10 cc/minute of P10 counting gas, regardless of whether a gas manager is present or not.

For units equipped with Spare Purging Detectors ("OPT15, Spare Purging Detectors" on page 19-66), you do not need to apply special gas-flow rate adjustment considerations because these spare detectors are provided with exhaust gas downstream from the main detectors and are ready to be placed into use without additional purging.

For units equipped with a Gas Manager ("OPT12, Gas Management" on page 19-57), refer to Chapter 19: "Options" for detailed system adjustment direction, because operation of the gas supply / exhaust system is significantly different from that of a standard unit.

Electrical Power Installation

Power is brought into the PCM-2 via a four-outlet power strip. Into this strip are plugged power cords from the unit's lower electronics enclosure and options such as a printer or badge reader. The line cord attached to this power strip may exit the unit either through the lower rear corner of the cabinet or through the top of the unit near its right-hand side, depending upon user need. The default configuration for power cord egress is through the lower rear power inlet plate.

While the PCM-2 is relatively immune to line noise and transients, it is possible for very large power line spikes to interfere with the instrument. Avoid connecting the PCM-2 to power circuits shared with large motors or other inductive loads. If clean line power is not available, a line conditioner should be installed.

To prevent unauthorized operation, the unit's On / Off switch is placed on the right side of the electronics enclosure inside the unit behind the side door. This location is also the location of the fuse holder. If the fuse must be replaced, use a 3-Amp 1.25 x 0.25 inch slow blow fuse rated for 250 V.

Two operating voltage ranges are supported: 90–132 and 180–264 V. Moving a recessed slide switch on the main computer power supply inside the lower electronics enclosure makes this selection. An inspection mirror may be used to verify the position of this switch, which is located between the two outlets on the right side of the power supply.

Other Optional Connections

Thermo Electron offers as options a report printer, a remote status and alarm indicator, and a variety of data interfaces (including wireless) to connect the PCM-2 to a host computer or a network. Each of these options is supplied with the required hardware including cables and with specific installation information. As with the power cord, these cables may exit through either power inlet plate (i.e., at the top of the unit or at the lower rear corner of the cabinet).

Configuration

After the instrument is properly installed and purged with counting gas, configuration with the correct operating parameters must be performed before it can be placed in service. Configuration is soft-set through the Test mode edit routines via keyboard input. The configuration routines and the parameters of interest include the following minimum parameters:

Edit Detector Parameters / Edit Override Parameters

Note Detector parameters can be set for individual detectors using the Edit Detector Parameters routine. Edit Override Parameters is used to set the same parameters for all 34 detectors globally. This is particularly useful for setting the high-voltage operating points for all 34 detector channels. ▲

Detector high-voltage and efficiencies should be determined by calibration routines before being set. The PCM-2 is fully calibrated at the factory, which is located at an elevation of 6,480 ft. Different counting gas densities exist at other elevations. If the instrument is installed at a different elevation, it will be necessary to replateau to determine the correct high-voltage setting. Adjusting the high-voltage setting will necessitate measuring new efficiencies. See Chapter 7: "Calibration" for detailed information on high-voltage settings and detector calibration.

Reliably detectable activity (RDA) levels should be set to the values required by plant administration. RDA levels can be edited in Detector Parameters, Override Parameters, or System Parameters.

Edit System Parameters

As noted above, RDA levels can be set for all channels in this screen. If Mode 2 is being used, this parameter is RDA Upper Limit. Default values are 5,000 dpm for the beta channels and 900 dpm for the alpha channels.

The RDA confidence should be edited if it is to be other than the default value of 95%.

The count time (max count time in Mode 3) is set in this screen.

Edit Instrument Parameters

The preferred count rate units (counts per second/cps or counts per minute/cpm); activity units (dpm, dps, Bq, or nCi); and count mode are set in this screen. The three counting modes are:

Mode 1 Preset All

Mode 2 Maximum Sensitivity

Mode 3 Minimum Count Time

If reporting or logging of data either locally or over a network installation is desired, additional parameters will need to be configured in this screen.

See "Instrument Configuration Parameters" on page 5-16 for more information on configuration parameters.

Quick-Start Instructions

These instructions are intended to assist the first-time user in setting up PCM-2 systems. Once this initial setup has been completed, adjustments may be made to comply with site-specific requirements and policies.

Some familiarity with instruments using gas-proportional radiation detectors is assumed in these instructions. See the technical sections of this manual for detailed information regarding the unit and its operation.

Power Connections

The PCM-2 may be operated from either 90–132 V or 180–264 V, 50/60 Hz. A slide switch located on the computer power supply inside the electronics enclosure makes voltage range selection. Power is brought in via a line cord attached to the outlet strip located inside the unit.

1. **Remove either of the two cover plates located on the top of the unit and at the lower rear corner and route this cord out to a convenient power receptacle.**

2. **Ensure that the switch on the power strip is turned on.**

3. **Turn on the unit by actuating the power switch on the side of the electronics enclosure.**

Normal operation is indicated by fan noise from the computer power supply. Within a few seconds, the disk drive will also begin to operate, lights on the detector boards will flash, and text will appear on the LCD panel.

Counting Gas Supply

Two gas-inlet hoses exit from the lower right corner of the electronics enclosure. Each of these should be connected to a supply of P-10 gas (10% methane, 90% argon) at a regulated pressure of 5 psi. Ensure that both gas supplies are regulated to the same pressure so that flow rates will not change when the alternate source is selected. If desired, both inlets may be connected to the same gas source with a T fitting.

Adjust the gas control to obtain a flow of 800 cc/minute as indicated by the second flow meter. Maintain this rate for about 4 hours minimum to ensure that the detectors are fully purged, then decrease flow rate to 200 cc/minute as indicated by the first flow meter. If the hand probe option is installed, a third flow meter is provided; purge this probe at 25 cc/minute for 1–2 hours, then decrease its flow to 5–10 cc/minute for normal operation.

Note The flow indication may require 2 to 3 minutes to stabilize. Do not permit the flow rate to exceed 1000 cc/min at any time. ▲

If a gas manager is installed, see "Gas Management" on page 19-57 for gas adjustment instructions.

Accessing the Computer

Either the front panel keypad or the main computer keyboard may be used to control the instrument; however, for calibration we suggest deploying the larger keyboard next to the LCD panel.

1. **To access the computer's Main menu, press Escape, and type the high-level system password (default value = 9999) followed by Enter.**

2. **Using the four arrow keys, select the Override Parameters screen, located under Edit on the Main menu. Press Enter to open this screen.**

3. **Enter a typical high-voltage setting for gas-proportional detectors operating at your altitude, followed by Enter.**

4. **Press Escape to leave this screen and store the new voltage setting.**

5. **Use the arrow keys to select the Background Averages screen under the Main menu's Data heading.**

Background count rates for all detectors will be displayed within 1–2 minutes and are updated regularly. Once these values have stabilized, the unit is ready for calibration and you may reduce gas flows as described above.

Before proceeding, use the arrow keys, Enter, and Escape to navigate through the various menus and submenus of the PCM-2 program. Examine each screen and learn where various functions are located. Refer to appropriate sections in this technical manual for explanations of anything that is unclear.

Detector Voltage Selection

Two high-voltage plateau programs are provided. We recommend running both before the instrument is put into service. Both are selected from the Calibration menu.

Due to the large number of detectors on the PCM-2, it is not practical to run a full voltage plateau on each. The Background Plateau routine uses natural background radiation as a calibration source and can run all detectors at the same time. This test should be run over a wide range of voltages (typically 1400–1900 V), using long count times (at least 300 seconds per voltage). Once the test has started, no operator intervention is required; we therefore advise running this plateau overnight.

Once the background measurements have been completed, a Plateau screen is available for each detector. Page through these displays and verify that all detectors have similar voltage curves. This verifies that all detector channels have an adequate supply of counting gas and also indicates any problems involving detector channel–high-voltage failure or broken anode wires.

Note Note the voltage range over which alpha background rates begin to increase. Use the left and right arrow keys to move the vertical cursor line and note that the exact count rates displayed at the bottom of the screen are displayed for each voltage. Best results are obtained at a voltage slightly below the point at which alpha background rates begin to increase. ▲

The Source Plateau program determines the response of any one detector to alpha and beta sources. Select starting and ending voltages that bracket the operating point determined from the Background Plateau results and count times appropriate to the sources to be used. If large sources are available, it should not be necessary to correct for background rates. If a Background Plateau has already been run using the same voltage increments and covering a range that matches the source plateau high-voltage range, background corrections may be applied. Both alpha and beta source plateaus should be run to obtain a full set of results. It is appropriate to run a high-voltage plateau on three detector channels to determine the optimum voltage for all channels.

Once an operating voltage has been determined, enter it through the Override Parameters screen to set all detectors to this value. Individual detector voltages may be adjusted through the Detector Parameters screen or the View Plateau display for that channel. Return to the Background Averages screen and verify that all detectors give reasonable count rates at the selected voltage. We recommend running source plateaus on at least two detectors to ensure an appropriate selection of operating voltage for the entire system. Verify similar results for all detectors that are plateaued.

Detector Efficiency Calibration

Using the Efficiencies command under the Calibration heading, calibrate each detector with alpha and beta sources of known activities. For this purpose, 100 cm^2 plate sources are preferred over smaller coin sources. Use high-activity sources when possible because they provide accurate results with short count times.

Note The isotopes used for calibration should have similar energies to those isotopes that will be measured during normal operation. ▲

Enter the activities of the sources to be used. (The instrument will correct for source decay if given an initial calibration date and the isotope half-life). Follow the instructions displayed to select a detector, position the source on that detector, and begin the count.

After you have a satisfactory efficiency measurement, store that value and move the source to the next detector. After all detectors are calibrated with one source (alpha or beta), repeat the procedure with the other after selecting the correct channel type.

Shield Factors

In this procedure, background rates are measured first for all detectors with the instrument unoccupied and then with a person in measurement position. The ratios obtained are used to correct for background shielding effects when a user is in position. Follow the instructions displayed; count times of at least 100 seconds are recommended to obtain accurate data at normal background levels.

Selecting Parameters

Edit the Instrument Parameters screen to specify the desired counting mode (Preset All, Fixed Time, or Max. Sensitivity).

Select other appropriate settings on this screen, such as Enabling / Disabling Radon Compensation or Alpha Sum Zone Alarms.

RDA levels, count times, etc., may be entered through the System Parameters screen.

All changes made will be saved on the instrument’s disk and remain in effect until replaced.

Response Check

Before attempting any measurements, place the PCM-2 in operating mode and allow it to accumulate background count data for several minutes. Next, select the Source Check function from the Calibration menu. Allow the instrument to make several measurements with no source present and verify that few (preferably zero) false alarms occur. Use a source to determine that each detector responds adequately. If the results obtained are acceptable, the unit is ready for service.

Tuning the PCM-2

When the PCM-2 is set up, it may be desirable to fine-tune detector and instrument parameters for optimum performance. The important fact to remember when performing such adjustments is that changes that help reduce count times and eliminate false alarms may also reduce the unit's sensitivity to genuine contamination. All changes should be carefully evaluated to insure that overall performance remains acceptable.

Problem Detectors

Regardless of how the unit is set up, there will always be one detector that, due to high background or low efficiency, requires longer count times or provides lower sensitivity than the others. A typical example is the detector located under the foot platform: it is mounted horizontally, making it more sensitive to cosmic radiation; its efficiency is reduced by the heavy metal grid in front of it; and it may also be shielded by plastic film installed to protect it from dirt. These factors combine to make this the least sensitive detector in the PCM-2, particularly for alpha radiation. In order to detect a specific amount of contamination, basic physics dictates that this detector will require a longer count time.

To determine which detectors are the limiting factors, select the Detector Performance screen from the Data menu. This display sorts detectors by performance, with the worst at the head of the list. If the problem detectors are significantly worse than the rest, it may be worth (for example) increasing RDAs in exchange for shorter count times.

Attempting to balance all of the detectors to equal backgrounds or efficiencies is not required or recommended; computations are performed independently for each detector to obtain maximum sensitivity in the shortest possible count time. Excessive changes to individual detector parameters usually results in unnecessary complication with little or no real change in performance. Detectors that are not causing significant problems should be left alone.

Detector Parameters

Individual detectors may be adjusted through the Detector Parameter screen under the Edit menu. Remember that any subsequent entries made through the System Parameter or Override Parameter screens will overwrite the changes made to individual detectors.

The need to modify detector parameters is most frequently motivated by a detector which demands excessive count times due to high background or low efficiency. The most direct approach to this problem is to raise the RDA levels for that particular detector, accepting lower sensitivity in exchange for more practical count times. This assumes that administrative policy does not preclude such changes.

If both alpha and beta backgrounds for one detector are elevated, another useful tactic is to reduce that detector's operating voltage by 10–20 V. If beta counts are normal but alphas are too high, the alpha threshold level may be increased by as much as 10%, which will move some of the excess alpha counts into the beta channel. Increasing the beta threshold will similarly cause some very low-energy particles and extraneous noise to be completely ignored. Large changes to these parameters will also impact detector efficiency and may therefore be somewhat self-defeating. Changes to threshold settings should be accompanied by a replateau of the affected detector.

In rare instances, a detector with acceptable counting performance may trigger sensitivity failures due to high or low backgrounds. This is normally caused by the presence of radiation or shielding which affects one detector more than the others. If moving or reorienting the unit is not acceptable, the detector's geometry factor may be changed. This parameter is used only by the channel sensitivity test and will not change any test results. Background rates are simply multiplied by the geometry factor before being used by the sensitivity test.

Sensitivity failures can be caused by greater fluctuations in ambient background than are allowed by the alpha or beta sensitivity factors. In such cases of environmentally induced failures, the symptoms are not due to poor detector performance. Greater tolerance for background fluctuations is attained by reducing the sensitivity factors in the System Parameters screen under the Edit menu.

Gas Flow Adjustment

If several detectors exhibit low background counts, the counting gas flow rate may be inadequate. Increase the gas flow until acceptable backgrounds are obtained. There may be considerable lag time between increasing the flow rate and observing a resultant increase in count rate. The amount of lag time will depend on the degree of counting gas starvation and the final flow rate setting.

Living With Radon

Two options are provided to reduce the number of false alarms caused by radon gas which attaches to clothing. Both may be enabled or disabled from the Instrument Parameters screen located under the Edit menu.

The first approach is to enable the radon compensation feature. This uses a proprietary computational algorithm which attempts to recognize the radon signature by comparing alpha and beta count rates from each detector. The second and more direct approach is to disable alpha channel sum zone alarms since this is the most frequent alarm pattern caused by radon contamination. Sum zone alarms are disabled by raising the sum zone RDA high enough so that single-channel alarms will always occur before a sum zone alarm will occur. This is accomplished when sum zone RDAs are at least twice the single-channel RDA (or the maximum RDA, if the instrument is operated in Mode 2).

The radon compensation algorithm uses count information from both alpha and beta detector channels and operates on the assumption that nonnatural contaminants will be either pure alpha or pure beta emitters. For this reason, radon compensation should **not** be enabled when isotopes such as uranium, which emit **both** alpha and beta particles, are to be measured.

Software Maintenance

All changes made to instrument and detector parameters, sum zone groups, etc., are immediately written both to the instrument's disk and to nonvolatile memory on the front panel computer board. Whenever the PCM-2 is powered up, it will first attempt to reload its parameters from the disk; if the required files are missing, the program will offer to recreate them using data from the front panel board. The third option is to reinstate the factory default values and start over from scratch. Before deleting any disk files, print a calibration report for the PCM-2 to preserve the current parameters. If the wrong files are accidentally deleted, this will avoid the need to completely recalibrate the unit.

Restoring Default Values

To force a return to the factory default parameters, it is necessary to delete the modified files from disk. Select the Exit to DOS function from the Utilities menu to stop the PCM-2's program and obtain access to DOS (the disk operating system). Type the command “Delete xx.dat” (followed by pressing Enter) where “xx” is one of the following file names:

PCM2SYS This data file contains instrument and system parameters, user-set passwords, etc. Deleting this file will cause **all** defaults to be reinstated, including those in the following files.

PCM2DET Contains the detector parameters.

PCM2ZONE Contains the sum zone definitions.

PCM2MESG Contains the default banner-line messages.

Once the desired files have been deleted, press Ctrl+Alt+Del to reboot the instrument. When the program offers to assign defaults or use the last set of values, select the defaults. Once this has been done, it is necessary to completely recalibrate the PCM-2 or key in the correct values since all efficiencies, voltages and other parameters will have been reset.

If the user-defined high-level system password is ever lost, another computer may be used to delete the data files, thus resetting the system to the default passwords "0000" (low level) and "9999" (high level). It will be necessary to re-enter all operating parameters.

Software Updates

Update diskettes are shipped without the above data files; however, the latest set of parameters may be recovered from the front panel board's memory with the following procedure:

1. **Eject the old diskette from the drive, which is located inside the electronics enclosure.**

2. **Insert the new diskette.**

3. **Reboot the system by pressing the Ctrl+Alt+Del keystroke combination.**

4. **When asked which parameters to use, choose to retrieve parameters from the front panel board, to create a new set of data files on the diskette.**

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Chapter 3 Operation

Normal Operation

When the PCM-2 is not in use, it continually updates background counts on all detector channels. As this data is collected, dependent variables such as count times and alarm set points are recalculated. Approximately two minutes are required to obtain statistically valid beta backgrounds and up to twenty minutes of background counts are necessary for accurate alpha source detection; however, the PCM-2 will begin to operate as soon as the beta channel backgrounds are valid.

Caution The PCM-2 will not be able to accurately monitor alpha contamination using the requirements set by the operational parameters until it has collected a representative background. ▲

If a hand-frisking probe is installed, it may be used during background update. A display of hand probe readings on the background update screen results when the hand probe is removed from its cradle on the side of the instrument. This display disappears when the hand probe is again replaced into its cradle.

When sufficient beta background data is accumulated, the unit's traffic lights, located in the ceiling, change from red to green, indicating that the unit is ready for measurement. Background counts are halted as soon as a user steps onto the measuring platform. At this time, the PCM-2's user interface becomes active and a measurement cycle begins. If an optional badge reader is in use, the user may initiate a measurement by scanning the ID badge either before or after stepping onto the measuring platform.

If the instrument has been set up to accept user ID or radiation work permit (RWP) numbers, a message is displayed on the LCD panel instructing the occupant to provide this information. These numbers must be no greater than nine characters. Keypad entry characters must be numeric, whereas badge reader characters may be alphanumeric. Depending upon the setup options selected, entries may be made from the keypad, badge reader (if installed) or both.

The user is instructed to enter the first counting position as depicted on position display number one. This requires the user to face into the detectors and look to the right, toward the active position display. If feet, hands or body are not in close contact with the instrument, red arrows are illuminated showing which position switches are not being activated. The unit will also issue these prompts verbally if equipped with the optional voice annunciator.

Once the user is correctly positioned, counting begins. A clock on the position display panel counts down the seconds remaining until counting is complete. If the user moves out of position before the measurement is finished, the clock is stopped until a satisfactory position is again assumed.

If mid-cycle results are enabled (an instrument setup option) contamination detected in the first counting position will be displayed at this time. The Alarm Acknowledge key (Alarm Ack) must be pressed to resume operation if alarms are displayed. Position display number two is then active, and the user is instructed to enter the second counting position. As shown on the position display, this requires facing out from the detectors and again looking to the right (toward the active position display panel). As before, red arrows on the position display panel indicate open position sensors. This second count cycle is performed in a manner similar to the first. Again, time remaining is counted down on the position display panel clock.

Alarms, if any, resulting from both count cycles are displayed graphically on the LCD panel. An example of a typical alarm display appears at the end of this section. A display of hand probe readings on the alarm information screen results when the hand probe is removed from its cradle on the side of the instrument. This display disappears when the hand probe is again replaced into its cradle. An audible alarm also sounds; this may be canceled by pressing Alarm Ack. If no radiation has been detected, the user is instructed to exit the unit. Measurement results are printed or stored for host computer retrieval if the instrument is so configured.

Computer Interface

Microprocessors are used at all levels within the PCM-2, from the main system controller down to individual detector modules. There are virtually no switches, jumpers or potentiometers for the technician to set or adjust. This design brings together all system parameters, from detector thresholds and high-voltage settings to count mode selection, in a single powerful user interface. Unavoidably, this also creates a situation in which a single incorrect keyboard entry can change the operation of the entire instrument. In order to prevent accidental changes, it is strongly recommended that the high-level system password be used **only** when it is necessary to change parameters. The low-level password should be used to examine current settings, run response checks and examine status and test results.

This chapter contains detailed descriptions of the menus and parameters that may be accessed from the front panel and the mechanics of viewing and changing them. Detailed explanations of the significance and uses of these parameters are provided in Chapter 5: "Edit".

Accessing the Computer

The PCM-2 is controlled by a single board computer that performs all necessary calculations and also provides the graphical user interface. This computer may be accessed from either the front panel keypad or the full-size keyboard stowed inside the instrument. Most functions are supported by the keypad. The keyboard should be used for instrument setup and testing because some operations require the use of keys not available on the front panel.

When any Escape key is pressed, the system requests a password. The system supports low- and high-level passwords corresponding to the two available access modes; the password entered determines which mode is selected. Default values for these passwords are "0000" and "9999," respectively. These values may be changed to user-selected four-digit values; however, the defaults are reinstated if the PCM-2's parameter files are re-initialized to their default values.

The currently active item within a menu or screen is highlighted in color. Other items are selected by using the arrow keys. If the active item is one with a limited number of possible values such as Count mode or activity units, Enter, F2, or the arrow keys are used to cycle through the list of options. Numeric values may be are typed in, followed Enter.

Pressing Escape returns the user to the next higher level menu. From the Main menu bar, Escape returns the unit to operating mode.

Main System Menu

Upon entering Test mode, a horizontal menu bar is displayed containing five main headings:

View	Access to background and measurement data.
Edit	Submenus containing parameters and system configuration options.
Status	System status information.
Calibration	Routines needed to calibrate and verify PCM-2 operation.
Utilities	Routines used to set up and check the PCM-2's computer hardware.

These headings may be selected by using the left and right arrow keys or by typing the highlighted capital letter in the heading name. Pressing Enter or the down arrow key causes the available functions under the current heading to be displayed. Items from submenus are selected by pressing Enter or by typing the highlighted capital letter. The Escape key is used at any time to exit the present display screen.

Refer to chapters 4 through 8 for detailed operational information on each of the five major Main menu headings and their submenus.

Chapter 4 View

Measurement Results

A color-coded diagram of the PCM-2 detector array is shown. Detectors that were in the normal state (at the time of the last measurement) are indicated in green. Inactive detectors are indicated by white with out-of-service (failed) detectors shown in blue. Individual-channel alarms are indicated by bright red; half-tone red indicates sum-zone alarms, and the sum channel is crosshatched in red if it posted an alarm in the last measurement. Numerical count data are shown for one detector that is identified by a flashing cursor. The cursor will automatically be placed on the alarmed detector that sensed the highest level of activity. The arrow keys can be used to reposition the cursor over any other detectors. The count data shown will correspond to the detector channel that is currently highlighted.

Transaction Report

Selecting this item causes a report to be generated from the results of the last measurement cycle. The report is displayed on the video monitor, and hardcopy may be produced if a printer is available.

Background Averages

Alpha and beta channel background count rates for all active detectors are displayed. These are the values currently being used by the PCM-2 for internal calculations, computed with the current weighting factors. Counts are updated periodically in this display. Count rates are shown in the units selected in the instrument parameters menu, which is either counts per second (cps) or counts per minute (cpm). Pressing the F2 key enables or disables geometry correction of background data. When correction is applied, the raw count data is multiplied by a detector geometry correction factor. This permits easy comparisons of count rates from detectors of differing sizes.

Day File

The user may view the current day files for transactions, status, changes, and source check results. Day files are explained in detail in "Day File Logging" on page 5-19.

Detector Performance Data

Depending upon system operating mode, this screen shows either count times or RDA values calculated for each detector channel at the present background levels and operating parameters. The display is sorted from highest (worst) to lowest (best) to provide a quick assessment of the range of values and to identify which detectors are most likely to cause problems if background levels increase.

Hand Probe Readings

Stored background and current real-time count rates are shown for the optional hand-frisking probe (if installed). Background data is accumulated whenever the probe is in its holder; net count rates are therefore displayed only when the probe is in use. The hand probe alarm set points for the alpha and beta channels are also displayed.

Gross Count Rates

The last count rate from each detector channel is shown, without any averaging or weighting factors applied. This screen is particularly useful for observing the response of detectors to a source.

Chapter 5 Edit

PCM-2 - VERSION V1.9

View **Edit** Status Calibration Utilities

- Detector Parameters
- Hand Probe Parameters
- Override Parameters
- System Parameters
- Instrument Setup Parameters
- RadNet Parameters
- Sum Zone Setup
- Banner Messages
- Preset All Mode

Preset All Mode

System Parameters

In Preset All count mode, the alpha and beta RDAs, confidence factor, sigma factors and count time are specified when the PCM-2 is set up. If background count rates are (or become) too high, it is not possible to detect sources of the specified activities (the RDAs) in the time allowed using the chosen confidence and sigma factors; when this happens, the instrument displays a high background failure message and ceases to perform measurements.

System Parameters–Preset All Mode

ALPHA RDA (DPS):	83.3
BETA RDA (DPS):	417
ALPHA SENSITIVITY:	0.10
BETA SENSITIVITY:	0.50
RDA CONFIDENCE:	95%
COUNT TIME (SEC):	1.00
SIGMA FACTOR:	4.00
BACKGROUND SIGMA FACTOR:	4.00
ALPHA SUM ZONE ALARM (DPS):	23.3
BETA SUM ZONE ALARM (DPS):	117
ALPHA SUM CH ALARM (DPS):	83.3
BETA SUM CH ALARM (DPS):	500
Calculated Values	
ALPHA RDA LOWER LIMIT (DPS):	2.56
BETA RDA LOWER LIMIT (DPS):	17.9
FALSE ALARM RATE (%):	0.19
MIN COUNT TIME (SEC):	0.62

Alpha & Beta RDAs

These are the RDAs (reliably detectable activities) used to compute alarm set points for the alpha and beta channels. Values entered are copied to all alpha and beta detector channels; individual channel RDAs may later be changed in the Detector Parameters screen.

Alpha & Beta Sensitivities

A ratio above and below the mean of background counts beyond which a single detector's background is determined to be indicative of a detector failure. The default value is 0.5 for the beta channels, meaning that a detector with more than twice or less than half as many counts as the system average is considered suspect.

Note Because the size, location and orientation of a detector affect its background counts, each detector has a geometry factor that is used to compensate for these variables. Due to the inherently lower background count rates, the default alpha sensitivity factor is 0.10, allowing an acceptable range in count rates from 0.1 to 10 times the average. ▲

RDA Confidence

The probability of detecting contamination of the specified RDA. Possible values are 50%, 75%, 90%, 95%, 99% and 99.9%. See Appendix A: "Statistical Control of Radiological Measurements" for a detailed discussion of this parameter.

Count Time

The time (in seconds) for which all channels of the PCM-2 will count.

Sigma Factor

A multiplier of the background count rate standard deviation that influences the false alarm rate. See Appendix C: "Sigma Factor and RDA Calculators".

Background Sigma Factor

If a background update count differs from the stored average background rate by the standard deviation value entered, the new rate immediately replaces the old. If the detectors on which this occurs alarmed on the last measurement, they are assumed to be contaminated.

Alpha & Beta Sum Zone Alarm

A sum zone is a user-defined group of two to four detectors that are grouped together to enhance the monitor's ability to detect contamination spread over an area shared by several adjacent detectors. The alpha or beta sum zone alarm set point defines the activity required within the sum zone area before a sum zone alarm is triggered. (See "Alpha & Beta Sum Zone Alarm" on page 5-3, "Alpha & Beta Sum Zone Alarm" on page 5-7, and "Sum Zone Setup" on page 5-21 for more information about sum zones.)

Alpha & Beta Sum Channel Alarm

A sum channel is a sum zone consisting of every channel in the monitor. The alpha or beta sum channel alarm set point is the activity that must be present within the entire monitor before the sum channel alarm is triggered.

Whenever the above parameters are changed, the following dependent values are recalculated and displayed.

Alpha & Beta RDA Lower Limits

At the current background count rates, these limits are the lowest RDA values which are attainable using the specified count time and statistical parameters.

False Alarm Rate

The percentage of users who will see false alarms given the current set of parameters.

Min Count Time

The shortest count time that can be used to detect the specified RDA at the present background levels.

Detector Parameters

Detector parameters are normally set via the Override Parameters screen. Values entered from that screen are written to all detectors; any entries made previously to a single detector are lost. Parameters for a single channel are examined or adjusted through the Detector Parameters screen by using the arrow keys to select the desired detector.

Detector #0 Parameters–Preset All Mode

```
HIGH VOLTAGE (VOLTS): 1600
GEOMETRY FACTOR:     1.00

 Alpha Channel                       | Beta Channel

 ACTIVE:                  Yes        | ACTIVE:                  Yes
 THRESHOLD (% MAX):       45         | THRESHOLD (% MAX):       5
 EFFICIENCY (%):          22.0       | EFFICIENCY (%):          22.0
 RDA (DPS):               16.7       | RDA (DPS):               83.3
 HI FAIL (CPS):           100000     | HI FAIL (CPS):          100000
 LO FAIL (CPS):           0.00       | LO FAIL (CPS):           0.00
 WEIGHT FACTOR:           50.0       | WEIGHT FACTOR:           10.0
                                     | SHIELD FACTOR:           1.00

 Calculated Values                   | Calculated Values

 BACKGROUND (CPS)          0.00      | BACKGROUND (CPS):        0.00
 ALARM LEVEL (NCPS):      1.00       | ALARM LEVEL (NCPS):      1.00
 RDA LOWER LIMIT (DPS):   1.00       | RDA LOWER LIMIT (DPS):   1.00
 COUNT TIME (SEC):        1.00       | COUNT TIME (SEC):        1.00
```

High Voltage

The detector voltage may be adjusted in steps of approximately 10 V, not to exceed 1750 V, when using P-10 counting gas.

Geometry Factor

Background count rates are multiplied by this factor before being used to test for detector sensitivity. This converts the detector’s average background count rates into count rate per unit area in order to compensate for difference in detector size. It is used only for channel sensitivity test calculations. All detector sizes are referenced to one-third of a full-size triple detector. As an example, the default geometry factor for channel 0 is always 1.0.

Alpha & Beta Channels Active

Detectors marked as inactive are not used in any computations. This is done to keep the instrument operating if one detector fails.

Alpha Threshold

Particles that cause the detector to produce a pulse exceeding this relative amplitude are counted as alpha particles. Lower amplitude pulses register as betas. The default alpha threshold of 45% is seldom changed.

Beta Threshold

Particles that produce pulses below this relative amplitude are counted as either alpha or beta. The default beta threshold of 5% is seldom changed.

Alpha & Beta Efficiencies

The fraction of particles (expressed as a percentage) emitted by the source of interest in all directions (4π) that are counted by the detector,

Alpha & Beta RDAs

Contamination of these activity levels is detected with a probability equal to the system RDA confidence level.

Alpha & Beta High Fail

Channels which show background levels above these limits will be considered too noisy or contaminated to use, and will remove the instrument from service.

Alpha & Beta Low Fail

Channels with backgrounds below these levels are assumed to have failed. The instrument will not operate if this occurs.

Alpha & Beta Weight Factors

These parameters control the speed with which the computed average background rates follow changes in actual background count rates. The weight factors smooth statistical fluctuations in background measurements by synthesizing an exponential moving average. Increasing the weighting factor will enhance the smoothing function at the expense of extending the time constant associated with recognizing step changes in the real average background count rate. The formula for computing the weighted average background count rate is

$$R_{bkg} = \frac{(R_{old} \times WF) + R_{new}}{WF + 1}$$

where

R_{bkg}= the new computed average background count rate,

R_{old}= the previous computed average background count rate,

WF= weight factor, and

R_{new}= the most recently measured (real) background count rate, measured in a single count interval.

Beta Shield Factor

When the instrument is occupied, some detectors are shielded from local radiation sources that account for part of the observed background. The shield factor is defined as *background while occupied divided by background while unoccupied*.

Note Alpha channel shield factors are always equal to 1. ▲

The following values are displayed but may not be edited:

Alpha & Beta Backgrounds

Current background count rates for this channel.

Alpha & Beta Alarm Levels Net count rates (above background) at which this channel will alarm, based on the current backgrounds, RDAs, RDA confidence level, sigma factor, etc.

Alpha & Beta RDA Lower Limits The minimum RDA values that could be specified for this channel, given the present backgrounds, count time, confidence and sigma factors.

Count Time The shortest count time that this channel can use to detect the specified RDA at present background levels.

Fixed Count Time Mode

System Parameters

In Fixed Count Time mode, the confidence factor, sigma factors and count time are specified when the PCM-2 is set up. In addition, upper limits for alpha and beta RDAs are entered. If background count rates are (or become) too high to permit reliable detection of these activities in the time allowed, the instrument will display a high background failure message and cease to perform measurements.

System Parameters–Fixed Count Time Mode

```
ALPHA RDA UPPER LIMIT (DPS):      25.0
BETA RDA UPPER LIMIT (DPS):       150
ALPHA SENSITIVITY:                0.050
BETA SENSITIVITY:                 0.10
RDA CONFIDENCE:                   95%
COUNT TIME (SEC):                 1.00
SIGMA FACTOR:                     4.00
BACKGROUND SIGMA FACTOR:          4.00
ALPHA SUM ZONE ALARM (DPS):       23.3
BETA SUM ZONE ALARM (DPS):        117
ALPHA SUM CH ALARM (DPS):         83.3
BETA SUM CH ALARM (DPS):          500

Calculated Values

MAX ALPHA CHANNEL RDA (DPS):      2.56
MAX BETA CHANNEL RDA (DPS):       17.9
FALSE ALARM RATE (%):             0.19
```

Alpha & Beta RDA Upper Limits These are the maximum acceptable values for RDA. If changes in background count rates raise the calculated RDA for any channels above these limits, a high background alarm is posted.

Alpha & Beta Sensitivities

A ratio above and below the mean of background counts, beyond which a single detector's background is determined to be indicative of a detector failure. The default value is 0.5 for the beta channels, meaning that a detector with more than twice or less than half as many counts as the system average is considered suspect.

Note Because the size, location and orientation of a detector affect its background counts, each detector has a geometry factor that is used to compensate for these variables. Due to the inherently lower background count rates, the default alpha sensitivity factor is 0.10, allowing an acceptable range in count rates from 0.1 to 10 times the average. ▲

RDA Confidence

The probability of detecting contamination of the specified RDA. Possible values are 50%, 75%, 90%, 95%, 99% and 99.9%. See Appendix A: "Statistical Control of Radiological Measurements" for a detailed discussion of this parameter.

Count Time

The time in seconds for which all channels of the PCM-2 will count.

Sigma Factor

A multiplier of the background count rate standard deviation that influences the false alarm rate. (See Appendix A: "Statistical Control of Radiological Measurements".)

Background Sigma Factor

If a background update count differs from the stored average background rate by this many standard deviations, the new rate will immediately replace the old. If the detectors on which this occurs alarmed on the last measurement, they are assumed to be contaminated.

Alpha & Beta Sum Zone Alarm

A sum zone is a user-defined group of two to four detectors that are grouped together to enhance the monitor's ability to detect contamination spread over an area shared by several adjacent detectors. The alpha or beta sum zone alarm set point defines the activity required within the sum zone area before a sum zone alarm is triggered. (See "Sum Zone Setup" on page 5-21 for more information on sum zones.)

Alpha & Beta Sum Channel Alarm

A sum channel is a sum zone consisting of every channel in the monitor. The alpha or beta sum channel alarm set point is the activity which must be present within the entire monitor before the sum channel alarm is triggered.

Whenever the above parameters are changed, the following dependent values are recalculated and displayed:

Max Alpha & Beta Channel RDA

At the current background count rates, these are the highest RDA for any channel in the PCM-2 with the specified count time and statistical parameters.

False Alarm Rate

This is the percentage of users who will see false alarms given the current set of parameters.

Detector Parameters

Detector parameters are normally set via the Override Parameters screen. Values entered from this screen are written to all detectors; any entries made previously to a single detector are lost. Parameters for a single channel may be examined or adjusted through the Detector Parameters screen by using the arrow keys to select the desired detector.

Detector #0 Parameters—Fixed Count Time Mode

```
HIGH VOLTAGE (VOLTS): 1600
GEOMETRY FACTOR: 1.00

Alpha Channel                  Beta Channel

ACTIVE:               Yes      ACTIVE:                  Yes
THRESHOLD (% MAX):    4        THRESHOLD (% MAX):       5
EFFICIENCY (%):       22.0     EFFICIENCY (%):          22.0
HI FAIL (CPS):        100000   HI FAIL (CPS):           100000
LO FAIL (CPS):        0.00     LO FAIL (CPS):           0.00
WEIGHT FACTOR:         50.0    WEIGHT FACTOR:           10.0
                               SHIELD FACTOR:           1.00

Calculated Values     Calculated Values

BACKGROUND (CPS):     0.00     BACKGROUND (CPS):        0.00
ALARM LEVEL (NCPS):   1.00     ALARM LEVEL (NCPS):      1.00
RDA LEVEL (DPS):      1.00     RDA LEVEL (DPS):         1.00
```

High Voltage

The detector voltage may be adjusted in steps of approximately 10 V not to exceed 1750 V.

Geometry Factor

Background count rates are multiplied by this factor before being used to test for detector sensitivity. This factor converts average background count rates into count rates per unit area in order to compensate for differences in detector size. This factor is used only for channel sensitivity test calculations.

Alpha & Beta Channels Active Detectors marked as inactive are not used in any computations. This may be done to keep the instrument operating if one detector fails.

Alpha Threshold Particles that cause the detector to produce a pulse exceeding this voltage are counted as alpha particles. Lower amplitude pulses are registered as betas.

Beta Threshold Particles that produce pulses below this amplitude will not be counted as either alpha or beta.

Alpha & Beta Efficiencies The ratio of counts per disintegration expressed as a percentage.

Alpha & Beta High Fail Detectors which show background levels above these limits are considered too noisy or contaminated to use and will remove the instrument from service.

Alpha & Beta Low Fail Detectors with backgrounds below these levels are assumed to have failed. The instrument will not count if this occurs.

Alpha & Beta Weight Factors This parameter controls the speed with which the computed average background rates will follow changes in actual background count rates. The weight factors smooth statistical fluctuations in background measurements by synthesizing an exponential moving average. Increasing the weighting factor will enhance the smoothing function at the expense of extending the time constant associated with recognizing step changes in the real average background count rate. The formula for computing the weighted average background count rate is

$$R_{bkg} = \frac{(R_{old} \times WF) + R_{new}}{WF + 1}$$

where

R_{bkg} = the new computed average background count rate,

R_{old} = the previous computed average background count rate,

WF = weight factor, and

R_{new} = the most recently measured (real) background count rate, measured in a single count interval.

Beta Shield Factor When the instrument is occupied, some detectors may be shielded from local radiation sources that account for part of the observed background. The shield factor is defined as background while occupied divided by background while unoccupied.

Note Alpha channel shield factors are always equal to 1. ▲

The following values are displayed but may not be edited:

Alpha & Beta Backgrounds

The current background count rates for this detector.

Alpha & Beta Alarm Levels

Net count rates (above background) at which this detector will alarm, based on the current backgrounds, RDAs, RDA confidence level, sigma factor, etc.

Alpha & Beta RDA Levels

The activity levels that can reliably be detected within the allowed count time given current background rates and using the specified RDA confidence level and sigma factor.

Minimum Count Time Mode

System Parameters

In Minimum Count Time mode, the alpha and beta RDAs, confidence factor, and sigma factors are specified when the PCM-2 is set up. In addition, a maximum allowable count time is entered. If background count rates are (or become) too high, it will not be possible to detect sources of the specified activities (the RDAs) within the specified maximum count time using the chosen confidence and sigma factors; when this happens, the instrument will display a high background failure message and cease to perform measurements until the condition clears.

System Parameters—Min Count Time Mode

```
ALPHA RDA (DPM):                  5000
BETA RDA (DPM):                   25000
ALPHA SENSITIVITY:                0.050
BETA SENSITIVITY:                 0.10
RDA CONFIDENCE:                   95%
MAX COUNT TIME (SEC):             60
SIGMA FACTOR:                     4.00
BACKGROUND SIGMA FACTOR:          4.00
ALPHA SUM ZONE ALARM (DPM):       1400
BETA SUM ZONE ALARM (DPM):        7000
ALPHA SUM CH ALARM (DPM):         5000
BETA SUM CH ALARM (DPM):          30000

Calculated Values

COUNT TIME (SEC):                 1.00
FALSE ALARM RATE (%):             0.16
```

Alpha & Beta RDAs The reliably detectable activities used to compute alarm set points for the alpha and beta channels. Values entered here will be copied to all detector channels. Individual detectors may later be changed.

Detector Parameters

Detector parameters are normally set via the Override Parameters screen. Values entered on this screen will be written to all detectors; any entries made previously to a single detector will be lost. Parameters for a single channel may be examined or adjusted through the Detector Parameters screen by using the arrow keys to select the desired detector. (See "Detector Parameters" on page 2-10.)

Detector #0 Parameters–Min Count Time Mode

```
HIGH VOLTAGE (VOLTS): 1600
GEOMETRY FACTOR: 1.00

Alpha Channel                Beta Channel

ACTIVE:              Yes     ACTIVE:             Yes
THRESHOLD (% MAX):   45      THRESHOLD (% MAX):5
EFFICIENCY (%):      22.0    EFFICIENCY (%):     22.0
RDA (DPS):           16.7    RDA (DPS):          83.3
HI FAIL (CPS):       100000  HI FAIL (CPS):      100000
LO FAIL (CPS):       0.00    LO FAIL (CPS):      0.00
WEIGHT FACTOR:       50.0    WEIGHT FACTOR:      10.0
                             SHIELD FACTOR:      1.00

Calculated Values            Calculated Values

BACKGROUND (CPS):    0.00    BACKGROUND (CPS):   0.00
ALARM LEVEL (NCPS): 1.00     ALARM LEVEL (NCPS): 1.00
COUNT TIME (SEC):    1.00    COUNT TIME (SEC):   1.00
```

Alpha & Beta Sensitivities

A ratio above and below the mean of background counts beyond which a single detector's background is determined to be indicative of a detector failure. The default value is 0.5, meaning that a detector with more than twice or less than half as many counts as the system average is considered suspect. Note that because the size, location and orientation of a detector affects its background counts, each detector has a geometry factor that is used to compensate for these variables.

RDA Confidence

The probability of detecting contamination of the specified RDA. Possible values are 50%, 75%, 90%, 95%, 99%, and 99.9%. See Appendix A: "Statistical Control of Radiological Measurements".

Max Count Time

The longest acceptable count time which the PCM-2 may use for measurements. If increases in background levels require a measurement time exceeding this value, a high background alarm condition occurs.

Sigma Factor

A multiplier of the average background count rate standard deviation that influences the false alarm rate. (See Appendix A: "Statistical Control of Radiological Measurements".)

Background Sigma Factor

If a background update count differs from the computed average background rate by this many standard deviations, the new rate will immediately replace the old. If the detectors on which this occurs alarmed on the last measurement, they are assumed to be contaminated.

Alpha & Beta Sum Zone Alarm

A sum zone is a user-defined group of two to four detectors that are grouped together to enhance the monitor's ability to detect contamination spread over an area shared by several adjacent detectors. The alpha or beta sum zone alarm set point defines the activity required within the sum zone area before a sum zone alarm is triggered. Refer to the upcoming section or sum zone setup for more information on sum zones.

Alpha & Beta Sum Channel Alarm

A sum channel is a sum zone consisting of every channel in the monitor. The alpha or beta sum channel alarm set point is the activity which must be present within the entire monitor before the sum channel alarm is triggered.

Whenever the above parameters are changed, the following dependent values are recalculated and displayed:

Count Time

The measurement count time required at present background rates. This is the longest count time calculated for any detector channel.

False Alarm Rate

This is the percentage of users who will see false alarms given the current set of parameters.

High Voltage

The detector voltage may be adjusted in steps of approximately 10 volts.

Geometry Factor

Background count rates are multiplied by this factor before being used to test for detector sensitivity. This converts average background count rates into count rate per unit area in order to compensate for differences in detector size. This is used only for channel sensitivity calculation.

Alpha & Beta Channels Active

Detectors marked as inactive will not be used in any computations. This may be done to keep the instrument operating if one detector fails.

Alpha Threshold

Particles that cause the detector to produce a pulse exceeding this voltage will be counted as alpha particles. Lower amplitudes register as betas.

Beta Threshold

Particles that produce pulses below this amplitude will not be counted as either alpha or beta.

Alpha & Beta Efficiencies

The ratio of counts per disintegration expressed as a percentage.

Alpha & Beta RDAs

Contamination of this activity level will be detected with a probability equal to the system RDA confidence level.

Alpha & Beta High Fail

Detectors which show background levels above these limits will be considered too noisy or contaminated to use and will remove the instrument from service.

Alpha & Beta Low Fail

Detectors with backgrounds below these levels are assumed to have failed. The instrument will not count if this occurs.

Alpha & Beta Weight Factors

This parameter controls the speed with which the computed average background rate will follow changes in actual background count rates. The weight factors smooth statistical fluctuations in background measurements by synthesizing an exponential moving average. Increasing the weighting factor will enhance the smoothing function at the expense of extending the time constant associated with recognizing step changes in the real average background count rate. The formula for computing the weighted average background count rate is

$$R_{bkg} = \frac{(R_{old} \times WF) + R}{WF + 1}$$

where

R_{bkg}= the new computed average background count rate

R_{old} = the previous computed average background count rate,

WF = weight factor, and

R_{new} = the most recently measured (real) background count rate, measured in a single count interval.

Beta Shield Factor

When the instrument is occupied, some detectors may be shielded from local radiation sources that account for part of the observed background. The shield factor is defined as background while occupied divided by background while unoccupied.

Note Alpha channel shield factors are always equal to 1. ▲

The following values are displayed but may not be edited:

Alpha & Beta Background

The current background count rates for this detector.

Alpha & Beta Alarm Level

Net count rates (above background) at which this detector will alarm based on the current background, RDA, RDA confidence level, sigma factor, etc.

Alpha & Beta Count Time

The count times calculated for the alpha and beta channels of this detector given the current RDA, RDA confidence level, sigma factor and background count rates.

Hand Probe Parameters

If the hand probe option is installed, this screen may be used to set its high voltage, alpha and beta thresholds, and alpha and beta alarm set points. An alarm set point may be entered for both the alpha and beta channels. This set point is expressed in the count rate units selected for the PCM-2, counts per second (cps) or counts per minute (cpm). In addition, a weighing factor and a background sigma factor may be entered for both the alpha and beta channels. These parameters are used in a smoothing algorithm that has been incorporated for the hand probe readings to allow the user to control the response time and the step change for the hand probe readings

Hand Probe Parameters

```
HIGH VOLTAGE (VOLTS): 1550

Alpha Channel                 Beta Channel

THRESHOLD (% MAX):     45       THRESHOLD (% MAX):     5
ALARM SET POINT (NCPS) 61.6     ALARM SET POINT (NCPS) 9.50

Measured Value                  Measured Value

BACKGROUND (CPS):      0.032    BACKGROUND (CPS):      6.19
```

Channel Override Parameters

Values for detector parameters may be entered from the override screen as an alternative to editing individual detectors. Entries made here will be written to all detectors simultaneously, replacing the existing values. This capability is useful during initial setup of the instrument; however, care must be taken to preserve any special values required for individual detectors. (See "Detector Parameters" on page 2-10.)

Channel Override Parameters

```
HIGH VOLTAGE (VOLTS): 1550

 Alpha Channels                   Beta Channels

 ACTIVE:               Yes        ACTIVE:              Yes
 THRESHOLD (% MAX):    45         THRESHOLD (% MAX):   5
 EFFICIENCY (%):       22.0       EFFICIENCY (%):      22.0
 RDA (DPM):            5000       RDA (DPM):           25000
 HI FAIL (CPS):        100000     HI FAIL (CPS):       100000
 LO FAIL (CPS):        0.00       LO FAIL (CPS):       0.00
 WEIGHT FACTOR:        50.0       WEIGHT FACTOR:       10.0
                                  SHIELD FACTOR:       1.00
```

Instrument Configuration Parameters

Instrument Configuration Parameters

SERIAL NUMBER:	0000	SYSTEM ADDRESS:	1
COUNT RATE UNITS:	CPS	BKG UPDATE AFTER ALARM?	No
ACTIVITY UNITS:	DPS	DAY FILE DIRECTORY STORAGE:	
COUNT MODE:	Min Count Time	TRANSACTIONS?	No
ID ENTRY METHOD:	Keypad Only	STATUS CHANGES?	No
RWP ENTRY METHOD:	None	SOURCE CHECK RESULTS?	No
ALARM HOLD (SEC):	1	DISPLAY MIDWAY RESULTS?	No
SYSTEM BAUD RATE:	9600	HAND SWITCH REQUIRED?	Yes
SYSTEM PROTOCOL:	uLAN	HIP SWITCH REQUIRED?	Yes
ANTI-COINCIDENCE:	Enabled	L.FOOT SWITCH REQUIRED?	Yes
RADON COMPENSATION:	Disabled	R.FOOT SWITCH REQUIRED?	Yes
RADON RATIO:	0.00	SHOULDER SWITCH REQUIRED?	No
STATUS LOGGING:	Disabled	ACCESS CONTROL OPTION?	No
STORE TRANSACTIONS:	No	LO LEVEL PASSWORD:	
PRINT TRANSACTIONS?	No	HI LEVEL PASSWORD	
PRINTER TYPE:	Epson	ACK LEVEL PASSWORD:	
ALM HELP LINE_1:		SOUND CARD VOLUME:	15
ALM HELP LINE_2:		VOICE DELAY (SEC):	5
USES BEFORE BKG UPDATE:	0	GAS TYPE	P10
DAY FILE DIRECTORY:			
PRINTER INIT:			

Note The PCM-2's default gas is P10. Argon CO2 can be used as an alternative, although Thermo Electron does not recommend doing so. ▲

Serial Number

All reports generated by this PCM-2 are identified with this unit number.

Count Rate Units

Count rates are displayed in either cps or cpm, as specified by this field.

Activity Units

The activity units are selected to be dps, dpm, Bq or nCi.

Count Mode

The PCM-2 may be operated in Preset All, Minimum Count Time, or Fixed Count Time modes. This selection changes the format of several other display screens.

ID & RWP Entry Methods

User ID and RWP numbers, if used, are entered via the keypad or an optional badge reader.

Alarm Hold Time

The number of seconds for which an alarm sounds if contamination is detected.

System Address, Baud Rate & Protocol

If the PCM-2 is connected to a host computer, these parameters determine the address of this particular instrument and the communications baud rate and protocol to be used. uLAN protocol may only be used with hardwired (RS-232, RS-485) connections. Select non-uLAN for modem connections.

Anti-Coincidence When anti-coincidence is enabled (default mode) particles are classified as beta or alpha on the basis of signal amplitude. Disabling this feature causes the beta counter channels to return a total particle count, including alphas. Users who wish only to measure total radiation may do so by disabling anti-coincidence and turning off all alpha count channels through the Override Parameter screen.

Radon Compensation This software algorithm attempts to recognize and compensate for alarm patterns typically caused by attached radon daughters. Radon compensation is always disabled when combination alpha-beta emitting isotopes are expected.

Radon Ratio Radon Compensation (above) must be enabled for this parameter to be recognized. The parameter for Radio Ratio is 1:1.0 ... 1:6.0 (alpha-beta).

Status Logging Enables and disables the storage of instrument status changes on disk. If enabled, the latest 200 status changes are stored. Status changes include High Background, Out of Gas, Comm Failure, HV Failure, Channel Sensitivity Failure, Hi/Lo Count Failure, and Normal.

Voice Delay If the voice annunciator option is installed, the PCM-2 will delay for the specified number of seconds before prompting the user audibly.

Store Transactions? A “Yes” in this field causes the PCM-2 to save measurement results for transmission to a site host computer. An “Alarms” in this field causes the PCM-2 to save only alarmed measurement results for transmission to a site host computer.

Note If this value is set to “Yes” or “Alarms” when the instrument is not connected to a host computer, the transaction buffer will eventually overflow, causing the unit to remove itself from service. To reset the transaction buffer, escape back to the Status menu and select Overall Monitor Status. Pressing the F2 key while in this display will clear the buffer. ▲

Print Transactions? If a printer is attached to the PCM-2 and this field contains a “Yes” value, a report of each measurement cycle is automatically printed. If this field contains an “Alarms” value, the report is printed only after an alarm has occurred during the measurement cycle.

Printer Init An initialization string sent to an attached parallel printer just prior to printout of PCM-2 reports and data.

Note A character pitch of not less than 12 cpi is necessary for printing the PCM-2 Calibration Report. ▲

Day File Directory

A string identifying a directory path for day file logging. See "Day File Logging" on page 5-19 for more information.

Printer Type

If a printer is connected to the PCM-2, this setting determines the set of character and control codes used. The printer type is only important when printing graphics such as high-voltage plateaus.

Uses Before Background Update

The instrument is removed from service to update background information after the specified number of measurement cycles. If there is time between users to obtain background counts, this forced update will not be required. Entering '0' disables this function.

Background Update After Alarm?

Setting this field to "Yes" forces the PCM-2 to update its background counts after every measurement that results in an alarm. This detects contamination left on the detectors.

Day File Directory Storage

Transactions?	Enables/disables storage of transactions in a day file if desired. Alarms only may be stored by selecting "Alarms."
Status Changes?	Enables/disables storage of status changes in a day file.
Source Check Results?	Enables/disables storage of source check results in a day file.

See "Day File Logging" on page 5-19 for more information.

Display Midway Results?

A "Yes" value causes the PCM-2 to display contamination detected during the first measurement cycle. "No" requires users to complete both measurements before any results are displayed.

Switch Req'd?

Any of the four standard Body and optional Shoulder Position switches (Hand, Hip, L. Foot , or R. Foot) may be disabled. Disabling these switches when less precise body positioning is deemed acceptable makes the PCM-2 easier to operate.

Access Control Option?

Setting this value to "Yes" informs the instrument that an access control unit is present and must be controlled.

Hi & Lo Level Password

These fields permit the entry of new four-digit values for the two test modes passwords. Current values are not shown.

Day File Logging

Transaction records, source check results, and status changes can be stored in daily disk files (day files) if the user so desires. This storage is enabled using the three menu items under the Day File Directory Storage heading in the Instrument Configuration edit screen. The information is stored as follows:

DayFileDirectory\DIRYY\MMDDYY.TXT

Transaction record day file for day MM/DD/YY.

DayFileDirectory\DIRYY\MMDDYY.SCK

Source check results day file for day MM/DD/YY.

DayFileDirectory\DIRYY\MMDDYY.CHG

Status change day file for day MM/DD/YY.

MM represents the month (01–12), DD represents the day (01–31), and YY represents the year (00–99) in which the information was stored. These files are stored in directory \DayFileDirectory\DIRYY, where YY is the year the information was stored.

The files are created when the first transaction, source check report, or status change is written to a day file. Subsequent transactions, source check reports, and status changes occurring on the same day are appended to the same file.

To use this feature, first specify a DayFileDirectory using the field Day File Directory in the Instrument Configuration edit screen. If this field is left blank and day file storage is enabled, the files will be stored in MainDirectory\DIRYY, where MainDirectory is where the PCM-2 system files reside. The directory may specify a drive but is only necessary if a drive other than the main drive is used. For example, if the main drive is C: and the day file directory is specified as \DATA or C:\DATA, the day files will be stored in C:\DATA\DIRYY. If the main drive is C: and the day file directory is specified as A:\DATA, the day files will be stored in A:\DATA\DIRYY.

Note Take care not to terminate the string with a backslash (e.g., A:\DATA\). ▲

Note If one floppy drive is in use either alone or with a hard disk, DOS will allow the floppy drive to be named A or B. If the floppy is specified by default as A (which is normally the case) and it is to be used for day file storage, **do not** define the day file directory as using drive B (e.g., B:\DATA). ▲

Day File Directory Storage

Next, enable the desired file storage by toggling the three menu items under the Day File Directory Storage heading in the Instrument Configuration edit screen to the desired setting.

Transactions?	(No, All, Alarms Only)
Status Changes?	(No, Yes)
Source Check Results?	(No, Yes)

Storage of transactions can be done for all transactions or only alarmed transactions. These are stored in MMDDYY.TXT.

Status changes are stored in MMDDYY.CHG.

Source check results are stored in MMDDYY.SCK.

RadNet Parameters

The PCM-2 supports the RadNet protocol. RadNet allows the automated collection of data from different types of instruments from different manufacturers. Typically, this ability is used with an Ethernet network.

RadNet Transmission

Choice is "Enabled" or "Disabled."

RadNet Server Address

Choice is a number from "0" to "255."

Normal Transmission Frequency

Sets the time interval between broadcasts that the PCM-2 sends a message to state that it is functioning properly.

Abnormal Transmission Frequency

Sets the time interval between broadcasts that the PCM-2 sends a message to State that it is **not** functioning properly.

Note The PCM-2 sends the results of a measurement immediately after the measurement cycle is completed. The selection of the transmission frequency does not affect this transmission. ▲

PCM-2 Location

Enter a text string that is included with the RadNet broadcast describing the PCM-2.

Sum Zone Setup

Up to 75 sum zones, each containing two to four detectors, are supported by the PCM-2. A default set of definitions is provided which creates zones from adjacent detectors; however, these may be deleted or changed to meet site-specific requirements. Sum zone activity is checked and results displayed along with single-detector results. Distributed contamination which does not trigger an alarm on any one detector may still be sensed if it spans two or more detectors within a single sum zone.

Note Sum zones may overlap. One detector may belong to several zones. ▲

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Chapter 6 Status

PCM-2 - VERSION V1.9

View Edit **Status** Calibration Utilities

Overall Monitor Status

Detector Status

Log File

Overall Monitor Status

Problems such as low gas pressure, high backgrounds, and communication failures within the instrument are described in this display. The Status drop-down menu should be the first step in any attempt to troubleshoot the PCM-2.

The operator may press the F2 key while in this display to clear the transaction buffer. When the Store Transactions variable in the instrument configuration screen is set to “Yes,” all measurement results are saved in the non-volatile memory of the unit’s front panel board. If this data is not collected by a host computer, the buffer will eventually overflow and the PCM-2 will be removed from service. This condition will be corrected if a host computer polls out the accumulated transactions or if the buffer is forcibly cleared with the F2 key (all transaction data will be lost). The operator may also clear any Contaminated Detector alarms that may exist by pressing the F3 key. Contaminated Detector conditions are self-clearing but may be cleared manually if desired.

Detector Status

This screen presents an overview of the PCM-2 in the form of a detector map. Detectors that are operating normally are shown in green, while those that are unusable due to high background or sensitivity problems are colored blue. If both the alpha and beta channels of a detector have been deactivated (through the Detector Parameter Edit screen), that detector will be depicted in gray.

The keyboard arrow keys may be used to move a cursor around the map to select one detector at a time. Background count rates, alarm levels and status information are displayed for the highlighted detector.

The F3 key may be used while in this screen to clear the Contaminated Detector alarm flag should it be set. Contaminated Detector conditions are self-clearing but may be cleared manually if desired.

Log File

If status logging is enabled (via Instrument Setup screen), the PCM-2 maintains a status log that is stored in two ASCII files named "NEWSTAT.TXT" and "OLDSTAT.TXT." If an abnormal status condition occurs, a time-stamped status line is stored in "NEWSTAT.TXT." If and when the condition clears, this is also noted in the file.

If "NEWSTAT.TXT" becomes full (MAX = 200 entries), its entire contents are transferred to "OLDSTAT.TXT," overwriting any older status information stored there. After this transfer, "NEWSTAT.TXT" is cleared and the status change that just occurred is stored there. Incoming status changes are always stored in "NEWSTAT.TXT," which therefore always contains the most recent information.

Both files may be viewed and printed if desired by selecting the Status Log menu item.

Chapter 7 Calibration

Overview

Adjustment of the unit's detectors high-voltage setting, beta threshold, and alpha threshold are all computer controlled in the PCM-2. Computer control of these settings means that the technician can perform a complete electronic set-up and calibration of the monitor through the computer keyboard and display, without the use of a screwdriver or other tools.

Calibration and maintenance utilities provided by the embedded PC controller permit the technician to perform automatic detector plateaus, view background count rates, perform efficiency determinations, perform beta–alpha crossover analysis and generate calibration reports.

PCM-2 - VERSION V 1.9

View Edit Status **Calibration** Utilities

- source Check
- Background Plateau
- Source Plateau
- Efficiencies
- sHield factors
- statistical Variance Test
- False Alarm Test
- calibration Report

Source Check

The instrument's ability to detect radiation may be checked by placing a source on one or more detectors and verifying that an alarm occurs. Source Check mode uses the same count times and parameters as normal counting mode; however, for convenience, it is not necessary to close the body position switches. Count cycles are run continuously until Check mode is exited, and all detectors that have alarmed are shown in red on the map display, simplifying the task of remembering which detectors have been successfully checked. Results are stored in "SOURCE.TXT" and can be viewed or printed at the conclusion of the test. The results are stored in a day file if the user has enabled this feature.

Background Plateau

Due to the large number of detectors in the PCM-2, plateauing each with a single source is a daunting proposition. An alternative is to use background radiation over a long period (i.e., overnight) to verify that all detectors exhibit similar responses. (See figs. 7-1 and 7-2.) This process takes the instrument out of service for several hours but runs without any operator intervention.

Background plateau results have three main uses:

1. **The data is subtracted from source plateaus to correct for background levels.**

2. **By paging through the background plateau graphs, it is possible to identify any detectors with unusual response characteristics or arcing problems.**

3. **The voltage range over which source plateaus must be run may be narrowed to a small region around the point at which alpha background counts begin to climb sharply.**

The user may scan the background plateau for each detector using a vertical cursor line. As the cursor is moved, information below the graph is updated. The information displayed includes the high-voltage setting and the alpha and beta counts at that setting. The operator may select the high voltage for the displayed detector by pressing F2 while the cursor is positioned on the voltage desired. The operator may also select high voltage via the override parameter or detector parameter edit displays.

The background plateau data can be displayed as actual data or normalized data (relative to the largest data point).

If the hand probe option is installed and the hand probe board is communicating properly, a background plateau may be obtained for the hand probe detector as well. Pressing F5 in the Select Detectors screen toggles the selection of the hand probe detector. If the hand probe option is installed but the board is not communicating, a message will appear in the Select Detectors screen informing the user that the hand probe is not communicating. Pressing F5 when choosing to view plateau data also selects the hand probe detector. Plateau data may be viewed even if the hand probe board has a communication failure.

Source Plateau

To determine the optimum detector voltage for a particular altitude, plateau one or more detectors with alpha and beta sources. Setting all detectors to the same voltage usually obtains satisfactory performance; however, the PCM-2 also allows for individual settings.

We recommend running source plateaus on at least two detectors to obtain reliable data.

If you use calibration sources with high activities, it should not be necessary to subtract out background rates because they will be much lower. For the best possible accuracy or if the sources used are of relatively low activities, background information acquired with the background plateau routine may be subtracted from source plateaus. In order to do this, the background plateau must include the voltage range of the source plateau and you must run it at the same voltage steps.

Source plateau graphs show four curves representing alpha and beta rates and crossover rates from alpha to beta and beta to alpha. To select the optimum high voltage setting for a detector while viewing its source plateau, first move the cursor line to that point where the beta as alpha counts begin to rise. Select a high-voltage setting just below that point, move the cursor there and press F2 to save that high voltage. If you want to set all other detectors to the same high voltage, use the Override Edit display.

As with background plateau data, source plateau data can also be displayed as actual or normalized data. The alpha and beta source plateaus are normalized for each source type; the two curves that result from the beta source are normalized to the maximum value in that data. The curves generated by the alpha source are normalized in an analogous fashion. Thus, all four curves are displayed in comparable scale, a feature that is especially useful if the alpha and beta sources differ greatly in activity level.

If the hand probe option is installed and the hand probe board is communicating properly, a source plateau may be obtained for the hand probe detector as well. Pressing F5 in the Select Detectors screen toggles the selection of the hand probe detector. If the hand probe option is installed but the board is not communicating, a message will appear in the Select Detectors screen informing the user that the hand probe is not communicating. Pressing F5 when choosing to view plateau data also selects the hand probe detector. Plateau data is viewable even when the hand probe board has a communication failure.

Special Considerations

The modular detector boards' (MDB) operating voltages have been preset at 1550 Vdc during the initial unit testing and checkout at Thermo Electron's Santa Fe, New Mexico, manufacturing facility. The MDBs have an upper operating voltage limit of 1750 Vdc, and the PCM-2 software does not allow the user to set operating voltages above this high limit—a feature that prevents detector high-voltage arcing failure potential due to over-volting at sea level.

CAUTION The potential for over-volting exists at altitudes above sea level. The general rule for adjusting the MDB's operating voltage is to increase it by 30 Vdc for each 1000 ft. of elevation decrease below the initial 6480 ft. set-up elevation (Santa Fe). To avoid this destructive over-voltage arcing potential, users should try to minimize their MDB operating voltages to the extent possible. ▲

Once a high-voltage discharge arc path is established in a detector, a minute amount of carbon is deposited at the point of discharge on the detector chamber. This carbon deposit then becomes a point of decreased resistance in the probe chamber for subsequent arc potential. If arcing is allowed to continue by further over-volting the detector, additional carbon deposits will occur due to arcing, and the detector's performance will begin to deteriorate at an increasing rate.

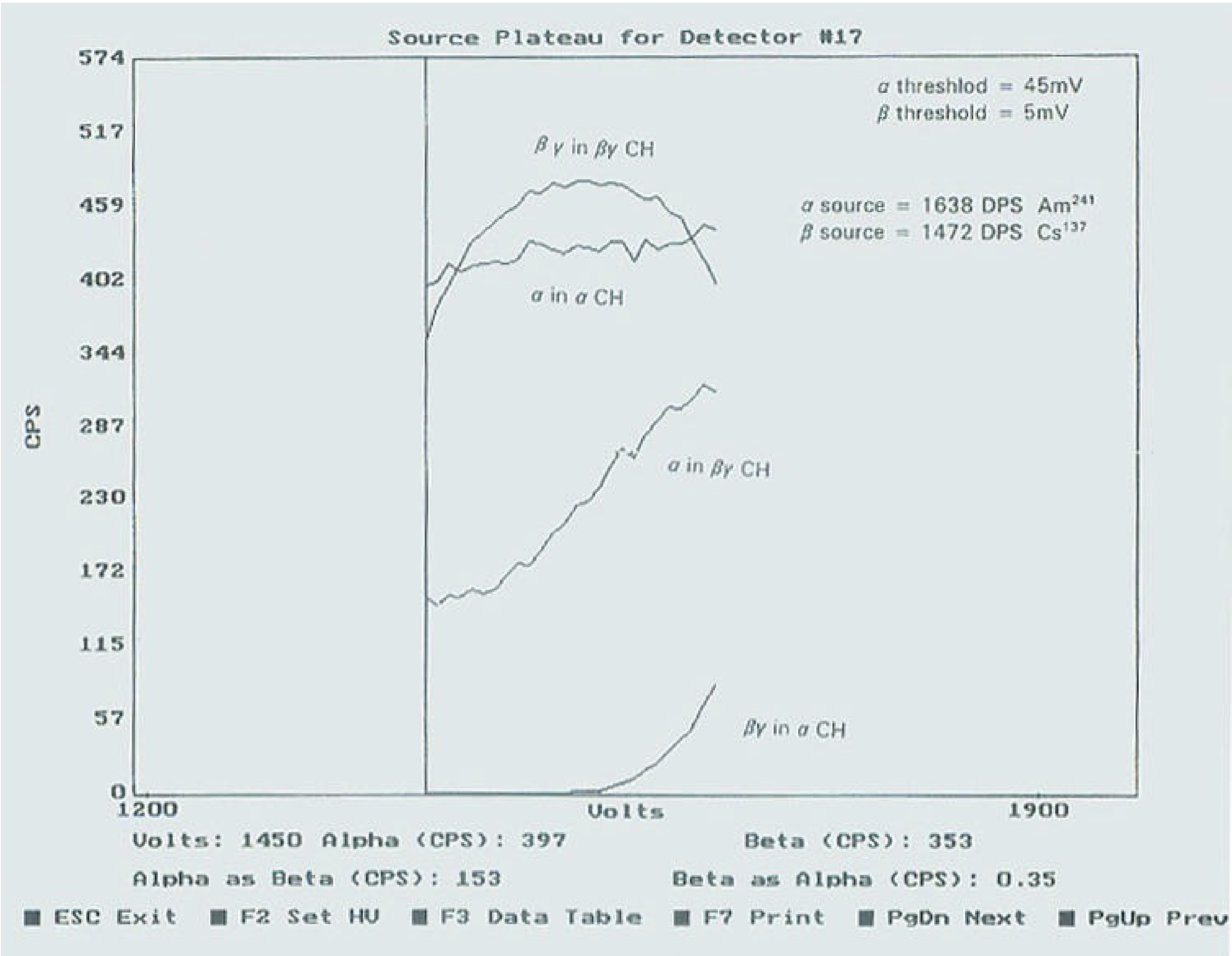

Figure 7-1. Typical source plateau curves. (A larger version of this graph is located in Chapter 22.)

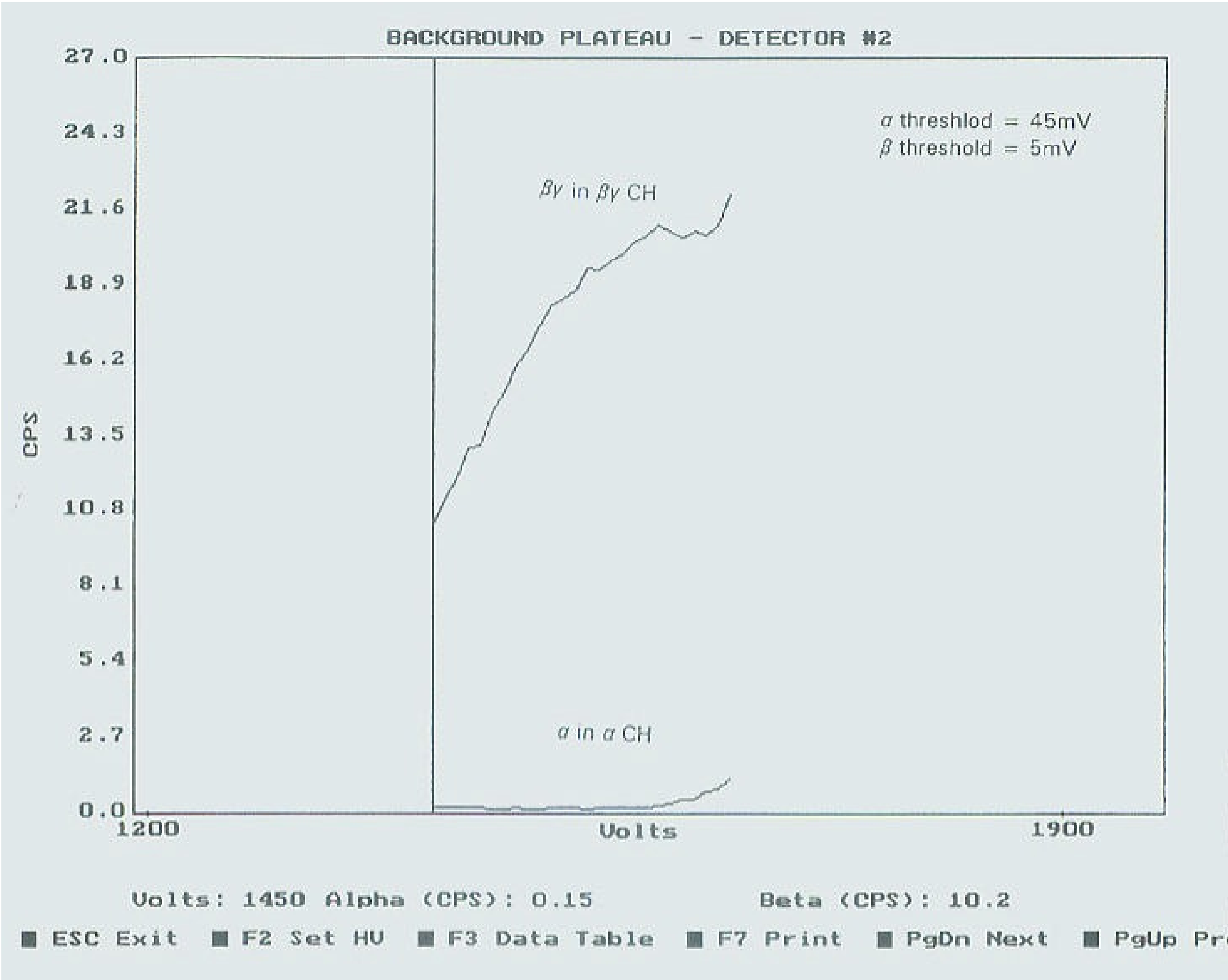

Figure 7-2. Typical background plateau curves. (A larger version of this graph is located in Chapter 22.)

Efficiencies

Detector efficiencies are determined by measuring calibrated sources and then dividing the measured count rates by the known activities of the sources. When the efficiency calculation function is selected, the user is asked to enter activities for one alpha and one beta source, and then select a detector and channel to calibrate. The selected detector will acquire counts in the specified channel for the count time selected. When the count cycle is completed, a new detector efficiency will be calculated and displayed on the Measured Efficiency line. The operator must press the F2 key to store the new efficiency. It is not automatically saved. The count cycle may be repeated by pressing Enter. Efficiency values may also be directly edited via the detector-parameter display.

If the hand probe option is installed and the hand probe board is communicating properly, an efficiency test may be run for the hand probe detector as well. As for the plateaus, pressing F5 selects the hand probe detector and starts the test. If the hand probe option is installed but not communicating, a message will appear in the Select Detectors screen informing the user that the hand probe is not communicating. To view the test results, press F5 to select the hand probe detector. Efficiency data may be viewed even if the hand probe board has a communication failure.

Shield Factors

Two count cycles are initiated, the first with the unit unoccupied and the second with a representative (average size) user in the counting position. Shield factors are calculated for all detectors simultaneously and may be saved either individually or as a set. Since the background count rates used to calculate shield factors are low, we recommend using count times of at least 100 seconds (and preferably more) for accuracy.

Statistical Variance Test

This test acquires counts from all active channels for N count cycles where N is selected by the operator. Each count cycle is T seconds long where T is the selected or calculated count time currently used for measurements. After completing N cycles, the instrument will calculate the mean, the variance and the variance divided by the mean for every active channel. These results will then be presented in tabular form and may be printed if desired. If the variance divided by the mean for any channel falls outside the range of 0.67 to 1.50, the channel is probably noisy.

False Alarm Test

This test performs N measurements where N is selected by the operator. Each measurement is performed just as if a person were in the monitor. At the conclusion of each cycle, the instrument checks for alarms and increments a counter if one or more channels have alarmed. At the conclusion of this test, the number of alarms divided by N will determine the unit's false alarm rate.

Calibration Report

Selecting this item causes the PCM-2 to generate a calibration report. If the user has not entered a serial number for the instrument other than “0000” (default value), an editing screen for the serial number will appear. The user may edit the serial number if desired. The report will then be generated using the new serial number if one was entered. If a printer is available, the report may be printed for a permanent record.

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Chapter 8 Utilities

PCM-2 - VERSION V 1.9

View Edit Status Calibration **Utilities**

- Detector Download
- Front Panel Test
- Communications Check
- Voice Annun. Test
- Remote Annun. Test
- Badge Reader Test
- Access Gate Check
- Set PCM-2 Clock
- Edit Colors
- Transfer Files
- Delete Files
- eXit to DOS

Detector Download

If one or more modular detector boards (MDBs) are installed or replaced while the PCM-2 is operating, they must be initialized with high voltage and detector threshold values. This utility provides a means to download parameters to one or more detector boards without resetting the entire instrument.

Front Panel Test

The front panel board of the PCM-2 provides an interface between the main computer and the instrument's various sensors and indicators. If the unit is connected to a host computer, this board also buffers test results until the host accepts them. This status screen may be used to test the operation of the front panel keypad, all of the switches used to detect a user's body position and the two gas pressure sensors.

Communications Check

This diagnostic utility verifies that all microprocessor-based boards within the instrument respond correctly. In addition, it displays the software version numbers for all boards. If more than one version of the modular detector board software is in use in the PCM-2, the communications check result for the MDBs will read "Multiple Versions." If all the software versions are the same, the software version number will be displayed.

Voice Annunciator Test

If the voice annunciator option is installed, this test may be used to verify that the voice board is functioning properly. This test cycles through every message in voice board memory. A potentiometer (R14) on the voice board may be used to adjust volume.

Remote Annunciator Test

The PCM-2 supports a bank of four remote annunciators; an alarm light, a ready light, a recount light and a horn. If remote annunciators are used, this test verifies that they are functioning properly.

Badge Reader Test

This test waits for an entry from the badge reader and then echoes the number received on the screen. If a badge reader is not installed or if it doesn't seem to be working properly, the operator must enter a number via the keypad to exit this test.

Access Gate Check

Displays the current status (locked or unlocked) of the entrance and exit gates (if any).

Note The Access Control Gate Check feature supports PCM-2's Access Control Gate option ("OPT5 and OPT5A, Access Control" on page 19-24). ▲

Set Clock

Time and date information are included in all reports produced by the PCM-2. This utility function resets the clock to a time specified by the user.

Edit Colors

The Edit Colors utility function permits changes to the display color schemes. This may be done as a matter of personal preference or to coordinate the PCM-2's display with those of other instruments. The use of this screen is self-explanatory.

Caution If the same color is ever used for both foreground and background on a single Edit Colors screen, the information displayed will not be seen and the operator **cannot** edit the status colors (i.e., those colors used to depict normal, alarmed, inactive or failed detectors). ▲

Mask User ID

The Mask User ID function is used to hide the person's ID number during the card reader input. This is typically used at facilities which use the social security number as the person's ID number.

Transfer Files

The File Transfer utility allows the user to copy files without exiting the PCM-2 program. The user is prompted to enter a source file string and a destination file string (wildcards are allowed in both strings). If the file already exists in the destination file directory, the user will be prompted to choose to overwrite the file or quit. In addition, if there is not enough space on the destination drive, an "Insufficient Disk Space" message will be posted. For example, to copy all the files in directory C:\PCM2 to a floppy disk in drive A, enter the string "C:\PCM2*.*" for the source string and "A:*.*" or "A:\" for the destination string.

Delete Files

The Delete Files utility allows the user to delete files without exiting the PCM-2 program. The user is prompted to enter the name of the files to be deleted (wildcards are allowed in the string). If the file does not exist, the user will be notified to press the Escape key.

If a filename string of "*.*" is entered, you will be asked if you really want to delete all the files in that directory. If "Yes" is selected, all the files in the specified directory will be deleted; if "No" is selected, no files will be deleted.

Note Exercise care when deleting files. The following files should **never** be deleted:

PCM2.EXE	HIMEM.SYS
PCM2.OVR	TRIP.CHR
AUTOEXEC.BAT	COMMAND.COM
CONFIG.SYS	EGAVGA.BGI

Any file with the extension ".IMG". ▲

Exit to DOS

Control of the main computer is returned to the disk operating system. Access to DOS is provided for maintenance of the system hardware and software.

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Chapter 9 Maintenance

Preventative Maintenance

Routine Maintenance

The PCM-2 instrument should be kept clean and dry. Dust should not be allowed to accumulate on printed circuit boards or other electrical components within the unit's internal electronics enclosures. Dust accumulations can result in noise problems or high-voltage power supply arcing. It is therefore important that the electronics enclosure, LCD enclosure and ceiling cover panels be replaced and securely fastened after servicing or system setup.

Replace the P-10 counting gas supply when the supply cylinder's pressure is unable to provide at least 5 psi at the regulated low-pressure output. If the instrument is supported with an optional gas bottle enclosure, routine gas pressure checks can be made by viewing the pressure gages on the supply cylinders through the enclosure's clear Lexan window. A single size 1A (1.54 ft^3) gas cylinder will support a standard PCM-2 instrument in good condition (i.e., no punctured detectors) and with a normal operational gas flow rate for approximately 32 days at a nominal gas flow rate of 200 cc / min. The same instrument equipped with an optional gas manager will consume only approximately 10–20% of the counting gas of a standard, continuously flowing system, thereby operating for approximately 160 days on a Size 1A cylinder at the same 200 cc / min nominal gas flow rate. The gas supply plumbing harness for the instrument incorporates an in-line filter for gross particulate and moisture removal from the gas prior to entering the detectors. Although this filter, located in the lower electronics enclosure, is not likely to become clogged in normal usage, it should be replaced if gas flows become inhibited or if you suspect a bad or dirty supply of gas.

The reusable / disposable protective cardboard and polyethylene film covers for the foot probe (of which spares are located in the internal pocket on the side door of the unit) should be routinely cleaned or replaced to avoid accumulations of particulate contamination on the probe face. If the optional protective film dispenser is installed, this routine procedure is to advance a fresh width of film over the detector face from the supply roll. This procedure may need to be performed as often as twice daily (depending on the frequency of usage and the relative cleanliness of users' shoes) to avoid increased measurement count times or foot detector face punctures.

Switches

Optical Position Switches

The PCM-2 uses optical position switches for the foot, side of the hip, and the side of the foot. These switches ensure the proper placement of the user during a measurement. Maintenance for these switches includes making sure they are aligned correctly. You can test their alignment using PCM-2 diagnostic routines.

Mechanical Position Switches

The position switch adjustment is initially made during manufacture of the instrument and is intended to be permanent under normal usage. The position switch adjustment may, however, change in time as a function of normal instrument usage. In this case, readjustment may be performed by loosening the switch mounting hardware and repositioning the switch relative to is actuator or by simply bending the switch's integrated actuator. Readjustment should yield very sensitive settings where the switch trips even under very slight detector panel movement.

Weight Switch

The weight switch is located beneath the slotted grille foot platform in the base of the PCM-2 unit. Its function is to interrupt background measurement updating by sensing when a user has stepped up onto the unit.

1. **On newer PCM-2 units. you can gain access to the switch by removing the screw-mounted access panel on the rear base trim. On older units that do not have this switch access panel, access is gained only by tipping the unit back on an incline dolly to expose the switch from the underside of the unit.**

2. **Remove the switch by loosening its mounting screws. Retain the screws, nut plate and switch actuator assembly. Unsolder the switch from its electrical leads and extract the switch and wiring from the mounting bracket.**

3. **Noting the positions of the switch leads on the switch contacts, resolder the switch leads to the contacts of the new switch.**

4. **Install the new switch to the switch-mounting bracket in reverse order of removal.**

5. **Adjust the switch within its mounting slots or slightly bend the switch actuator arm so that the switch makes contact upon a slight deflection of the footplate grille (as occurs with the weight of a user) but does not make contact when the footplate grille is in place by itself.**

6. **When the proper switch adjustment has been made, remount the access panel cover plate or return the unit to the upright position.**

There are no other standard mechanical or electrical components in the PCM-2 that require scheduled repair or replacement.

Decontamination Cleaning

The PCM-2 has been designed to allow relative ease of decontamination by providing user interface surfaces and detector panels made of either stainless steel or powder-coated steel. The material selection enables the use of water, detergents, and even mild solvents or abrasives in the decontamination process without damaging or reducing the working life of the detector panels' surfaces.

Note Use of a pressurized flow of water or other cleaning agents is not recommended when cleaning the external surfaces of the instrument for decontamination. Liquids under pressure can migrate into the internal electronics enclosures through seams and gaps at sheet metal part interfaces and cause potential damage. ▲

Detector Maintenance

The PCM-2 detectors do not require any specific periodic maintenance but because of the delicate nature of their thin Mylar®-covered faces, often do require face puncture/tear repair. The recommended approach to instrument servicing in the event of a detector becoming punctured or otherwise dysfunctional, is to remove the subject detector and replace it with a spare purged detector of the same configuration. This approach renders the unit out of service for only the short time interval required for detector swapping, enabling the maintenance technician to repair the damaged probe without further impacting the unit's operation. (See Chapter 16: "Detectors" and Appendix B: "Procedures" for detailed instructions regarding PCM-2 detector assembly repair and servicing.

Quick-Purge Line

PCM-2 units are equipped with a quick-purge line for the purpose of purging detectors quickly whenever the need arises. This feature is simply a 14-ft length of 1/8" inner diam red PVC gas supply tubing which has a sealing quick-disconnect plug fitting at its end and joins with the gas supply plumbing harness at a T junction positioned approximately 6" downstream of the flow meters. The quick-purge line is labeled and resides in back of the flow meter and gas manager brackets, where it normally hangs in a 10" diam coil. A Velcro Rip-Tie strap that is permanently attached to the line holds the coil up and out of the way for storage when the line is not in use. The quick-purge line coil is accessible through the back door and when uncoiled for use will reach any detector in the instrument.

Because the PCM-2’s gas supply plumbing harness is outfitted with 0.005" diam orifices at the inlet of each detector and because the quick purge line does not include an orifice, system counting gas effectively bypasses the unit’s detectors when the quick purge line is in use. This arrangement allows a maintenance technician to quickly purge any singular detector in the unit or on a nearby bench with fresh counting gas without disrupting any other plumbing fittings or tubing and without introducing any ambient air into the detectors’ counting gas supply lines.

Usage of this quick-purge feature is as simple as unplugging the gas supply line fitting from the subject detector and plugging in the quick-purge line’s fitting, which immediately causes gas to flow through the detector into the system gas exhaust plumbing harness at the rate prescribed by the PCM-2’s flow meters.

Note Exercise care when setting the gas supply adjustments. Excessive gas pressures or gas flow rates can cause the purging detector’s fragile Mylar® face to burst. If possible, visually monitor the rate and degree of detector face swelling during the purging operation so as to avoid detector damage. ▲

When the detector is adequately purged (as determined by the gas pressure and flow rate), remove the quick purge line and reinstall the normal gas supply harness line in its place. Since the fitting at the end of the quick purge line is self-sealing like the others on the PCM-2, system counting gas will once again flow normally and equally through the gas supply harness and metering orifices into all of the detectors.

Troubleshooting

The following subsections list some of the problems that may occur with the PCM-2 and presents probable causes.

High / Low Sensitivity Fail

With every background update, a detector sensitivity analysis is performed on each channel. A sensitivity failure is posted when a detector's sensitivity falls outside of defined limits of sensitivity. The analysis is performed as follows:

- Detector average background count rates are normalized to a reference detector size by applying that detector's geometry factor. For example, a small detector's geometry factor will be greater than 1. Its background count rate is scaled up by its geometry factor so that the corrected count rate can be compared to all other detector channel on an equal count rate / unit area basis.

- The corrected background count rates of all active detectors are averaged to provide a reference count rate for comparison. Separate averages are computed for the alpha and beta channels.

- A tolerance band is established about the mean count rates computed in the previous steps. The tolerance band upper limit is determined by dividing the average count rate by the alpha or beta sensitivity factor (the sensitivity factors are less than 1). The lower limit of the tolerance band is derived by multiplying the average count rates by the appropriate sensitivity factors.

- Detector channels whose corrected average background count rate falls within the tolerance band are considered to be normal. If a detector's alpha or beta average background count rate exceeds the upper limit of the tolerance band, that detector is flagged with a Hi Sensitivity Failure. A Low Sensitivity Failure occurs whenever a detector channel falls below the lower limit.

The environment that a PCM-2 operates in can cause sensitivity failures even though all detectors can be operating properly. For that reason, the first recommended step is to analyze the geometry factors and sensitivity factors and make changes to those parameters as necessary.

- Default geometry factors are set in inverse proportion to the detectors area, using detector #0's area as the benchmark. Factors other than a detector's size can contribute to its count rate (e.g., a streaming background or a shield that affects only part of the instrument). If changing geometry factors is warranted, observe the background averages in the View menu (ensure that the Correction is toggled off) and assess relative values of count rates to establish appropriate geometry factor values. Geometry factors are edited on the Detector Parameter screen under the Edit menu.

- Default sensitivity factors are "0.50" for the beta channels and "0.10" for the alpha channels. While these values will work for many installations, an environment that involves wide fluctuations of background accompanied by directional characteristics may warrant lowering the sensitivity factors. Sensitivity factors are established in the System Parameters screen under the Edit menu.

If count rates are high or low enough to indicate a true sensitivity failure, the following steps are suggested:

- A low-sensitivity failure may also be caused by counting gas starvation. Verify positive gas supply, correct pressure and flow rate settings and search out any leaks or kinked hoses that may be present. Once corrected, allow sufficient purge time before placing the channel back into service.

- Other possible problems will be narrowed down to a failed detector assembly or its complimentary modular detector board (MDB). By exchanging the MDB with that of a known good channel, it is possible to isolate the problem to either the board or the detector. The faulty assembly should be replaced.

Note Whenever a MDB is replaced, the Detector Download routine must be invoked to restore the correct parameters to the affected detector. ▲

High-Voltage Fail

Verify that the high-voltage failure message was not induced by some transient condition by first executing the Detector Download routine from the Utility menu. If this does not restore the affected channel, the high-voltage circuit of that MDB is likely to be malfunctioning. High-voltage failures are commonly caused by a broken anode wire in the detector that is short-circuited to ground. Before replacing the MDB, use a continuity meter to test the anode-to-ground conductance. If a conductive path exists, rewire or replace the detector prior to attaching a new MDB to that detector. Refer to Chapter 13: "Modular Detector Board" for more information on MDBs and detectors.

Note Whenever an MDB is replaced, the Detector Download routine must be invoked to restore the correct parameters to the affected detector. ▲

Comm Fail

Communications failures can frequently be overcome by forcing communications to be re-established through the Detector Download routine under the Utility menu. If this does not correct the problem, inspect the connection of the wiring harness to the affected MDB. If the connection is secure, the failure is likely to be a faulty RS-485 transceiver IC on the MDB. Replacing the MDB is the fastest way to put the instrument back into service.

Note Whenever an MDB is replaced, the Detector Download routine must be invoked to restore the correct parameters to the affected detector. ▲

High Background Fail

A high-background failure is most often caused by improper setup of the instrument. If all detector channels are counting properly, the condition is caused by too restrictive a count time for the statistical constraints applied to the measurement exercise. In Preset All and Fixed Count Time modes, this condition is overcome by increasing the length of the count time interval. In Minimum Count Time mode, the maximum count time must be extended to correct the condition.

Hardware-induced high-background failures exhibit the symptom of a noisy channel evidenced by excessive count rates. The count rates can be observed in the View Background Averages or View Gross Count Rates selections in the Test mode menu. If high count rates exist in only the alpha or beta channel but not in both channels, the problem is almost certainly on the MDB, which should be replaced. Otherwise the problem could also be caused by a poor high-voltage connection resulting from the MDB not being properly seated onto the detector or by the detector's anode wire arcing to ground. If the latter is the cause, the detector must be rebuilt.

Note Whenever an MDB is replaced, the Detector Download routine must be invoked to restore the correct parameters to the affected detector. ▲

High & Low Count Fail

Verify that the Hi Fail and Lo Fail limits provide adequate margin for normal fluctuations in background count rate to remain between the two values. These two parameters are found in the Detector Parameters and Override Parameters screens under the Edit menu selection.

Hardware-induced high-count failures exhibit the symptom of a noisy channel evidenced by excessive count rates. The count rates can be observed in the View Background Averages or View Gross Count Rates selections in the Test mode menu. If high count rates exist in only the alpha or beta channel but not in both channels, the problem is almost certainly on the MDB, which should be replaced. Otherwise the problem could also be caused by a poor high-voltage connection resulting from the MDB not being properly seated onto the detector or by the detector's anode wire arcing to ground. If the latter is the cause, the detector must be rebuilt.

Low count failures can be caused by insufficient flow of counting gas. If adequate pressure and flow exist, a leak in the plumbing circuit or a rupture in the Mylar® window of the detector could cause loss of counting gas. Other causes of low-count failure include broken anode wires in the detector or component failure on the MDB. By swapping the MDB with one from a good detector zone, the problem can be segregated to either the MDB if it follows the board to the other zone or to the detector if it remains with that zone.

Note Whenever an MDB is replaced, the Detector Download routine must be invoked to restore the correct parameters to the affected detector. ▲

Contaminated Detector

A Contaminated Detector condition can only be flagged in the first background update interval following a personnel contamination measurement. Two conditions must exist before the condition will be flagged: (1) the detector must post an alarm during the contamination measurement; and (2) that detector's background count rate must be elevated above its previous average background by a factor determined by the background sigma factor.

When a contaminated detector condition is posted, the possibility of a statistical anomaly causing the condition can be investigated by observing the background count rates in the View menu selection. If high count rates exist, the presence of contamination can be verified with an independent counter. Short-half-life isotopes may be allowed to decay in situ or contamination can be removed using proper health physics procedures. The instrument can be restored to service by clearing the condition in the Detector Status screen of the Status menu selection.

Chapter 10 Hardware Complement Sheet

This chapter provides a means of listing detailed information regarding each printed circuit board assembly (PCBA) configuration used in the PCM-2 and how each printed circuit board differs from its standardized base board configuration.

This chapter also provides a convenient means of including additional configuration information in the event future of changes to these PCBAs. Board configuration specifics including configuration revisions are contained in chapters 11 through 15.

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Chapter 11 Front Panel Board

General Description

Designed to be a general-purpose control panel, this board provides many commonly used functions required for control of typical instruments. A variety of input, output and communications ports are included, along with memory and computing capabilities. The PCM-2 front panel board is a slave to the instrument's main computer. It performs the following functions:

- Input of all switches such as the body position sensors, gas pressure switches and front panel keypad.
- Control of the countdown clocks, body position indicators and LED traffic lights.
- Control of the optional badge reader.
- Serial communications to and from an optional host computer.
- Nonvolatile storage of instrument setup parameters.
- Nonvolatile storage of measurement results, if enabled, for transfer to the host computer.

While it is beyond the scope of this document to provide step-by-step troubleshooting procedures for this board, the following information should be of use in diagnosing and localizing failures. A basic familiarity with microprocessor circuits is assumed.

Circuit Description

Processor

An 80C51 supported by 64 kB of program storage and 32 kB of working RAM provides control and computational abilities. Three additional 32 kB banks of RAM are installed to provide a large buffer for history data. By using RAM sockets that contain lithium batteries, backup power may be supplied for data retention during power outages.

The front panel board is based on an Intel 80C51 microprocessor. This device can support up to 64 kB of external RAM and 64 kB of ROM. All I/O devices are also mapped into external memory space. A bi-directional data bus is present on pins 32–39 of the processor. These pins are also used to output the eight low-order address bits at the beginning of each external memory cycle; the 74HC373 at A18 is used to latch this portion of the address under control of the Address Latch Enable (ALE) output on pin 30 of the processor chip. The eight high-order address bits are sourced directly from pins 21-28.

Instruction and data fetches from the EPROM (A4) are performed when the processor's PSEN output (pin 29) is active (low). A logical high on this pin indicates that a RAM or I/O access is in process. RAM in the low 32 kB of address space always corresponds to memory chip A5. Addresses from 8000-FFFF (hexadecimal) may be mapped to any of the three remaining RAM chips (A6, A7 or A8) or to the I/O devices. This selection is made by parallel output pins 14 and 15 of the microprocessor chip.

Serial Ports

Four serial ports are available. The first, which uses the CPU's internal UART, is buffered to/from RS-485 levels on pins 1 and 2 of P1 by A14. These pins are connected to the PCM-2's main internal data bus and provide communications between the front panel and main computer. Three other serial ports are implemented by A15, A16, and A17, which are Intel 82510 communications controller chips. All baud rates are generated from the microprocessor's crystal oscillator. By installing appropriate interface driver/receiver chips or jumpers, each may be configured for either TTL or RS-232 levels and supports DSR/DTR hand-shaking. One of the three may also be configured as a second RS-485 port.

A15 is buffered by A26 to RS-232 levels on connector P2. This port is used for the badge reader options and, in addition to the serial data and handshaking lines, includes two parallel inputs on pins 1 and 9 which may be jumpered low to indicate the presence and type of badge reader in use. Power and ground for the reader are also provided. By installing a set of jumpers in place of A26, this port may optionally be configured for TTL levels rather than RS-232; this is required by some readers.

A16 is buffered to and from RS-232 levels on connector P4 by A28. This is currently a spare I/O port. A17 is used for communications with a host computer via P3 and may be configured for either RS-232 or RS-485 levels by installing A27 or A29, respectively. Only one of these two buffers may be present at a time.

Parallel Ports

Eight switch inputs are provided; each pulled up to +5 V. Seven additional inputs (with pull-ups, but without protection) are distributed across two parallel I/O connectors and the badge reader interface. Twenty channels of parallel output are available on three connectors. Each is capable of sinking 0.5 amp to approximately 1 V; however, some limits exist as to how much total power the outputs can drive at any one time.

Parallel inputs are buffered onto the processor bus by 74HC373s at locations A23, A24 and A25. All off-board inputs are provided with pull-up resistors; however, only those on P8 and P9 have resistors and capacitors which offer some protection against voltage transients.

Parallel outputs are latched into 74HC374s at locations A19 through A22. Nine logic-level outputs are connected directly to P12; four of these are used to send data and clock signals to the two countdown clock boards. All other off-board outputs are buffered through ULN2003A chips at locations A32, A33 and A34. These are open-collector output devices capable of sinking to 250 mA and withstanding up to 50 V. Because these are Darlington configuration outputs, an On state output of 1.0–1.5 V is normal under heavy loads.

Two 4 x 5 matrix keypads may be connected to P10 and P11 (P11 is not used in the PCM-2). Only one row of keys is pulled low at a time by the outputs of A12 (a 74HC138 one-of-eight decoder), while the five column inputs are scanned as parallel inputs to A24.

Voltage Regulators

Three voltage regulators are used: A11, A13 and A31. A11 provides +5 V to most of the front panel board, while A31 powers the RS-232 and RS-485 buffers and the badge reader if required. The output of A13 is used by the two clock display boards. These are low-voltage-drop regulators that will operate from inputs of 6–12 Vdc applied to P1.

Other Features

Interrupts may be generated by the three communications chips under software control. All three are combined into a single interrupt input at pin 13 of the microprocessor and may also be read as parallel inputs to determine which chips are requesting service.

I/O Connector Assignments

The following is a detailed list of the front panel I/O pins. Input and output addresses are specified in hexadecimal. "+V" refers to the nominal 12 V supply. Connector pin numbers read clockwise around the board.

Connector P1: Power input and main serial data bus

Pinout:
01 RS-485 + (CPU internal UART)
02 RS-485 - (CPU internal UART)
03 Ground
04 +V
05 +V
06 Ground
07 Ground

Connector P2: Serial data to/from optional badge reader

Pinout:
01 Reader type sense: L = ICI barcode
02 RxD (from reader)
03 TxD (to reader)
04 DTR (to reader)
05 Ground
06 DSR (from reader)
07 +5 volts (to reader)
08 +V
09 Reader type sense: L = Xico magstripe

Note This UART's address is C008. ▲

Note Pins 1 and 9 pulled low for computer identics reader. ▲

Connector P3: Host computer port

Pinout: 01 RS-485 +

02 RxD (from host)

03 TxD (to host)

04 DTR (to host, RS-232 only)

05 Ground

06 DSR (from host, RS-232 only)

07 N/C

08 N/C

09 RS-485 -

Note This UART's address is C010. ▲

Note Port may be configured for either RS-232 or RS-485. ▲

Connector P4: Not currently used

Pinout: 01 N/C

02 RxD (from external device)

03 TxD (to external device)

04 DTR (to external device)

05 Ground

06 DSR (from external device)

07 N/C

08 N/C

09 N/C

Note This UART's address is C018. ▲

Connector P5: Traffic light outputs

Pinout:	01 Output bit 0 @ A001	Traffic light #1 red
	02 Output bit 1 @ A001	Traffic light #1 green
	03 Output bit 2 @ A001	Traffic light #2 red
	04 Output bit 3 @ A001	Traffic light #2 green
	05 Output bit 4 @ A001	
	06 Output bit 5 @ A001	
	07 Output bit 3 @ A002	
	08 Output bit 4 @ A002	
	09 Output bit 5 @ A002	
	10 Output bit 6 @ A002	
	11 +V	
	12 +V	Power to traffic lights

Connector P6: Remote status annunciator port

Pinout:	01 Output bit 0 @ A000
	02 Output bit 1 @ A000
	03 Output bit 2 @ A000
	04 Output bit 3 @ A000
	05 N/C
	06 Input bit 4 @ A003
	07 Input bit 3 @ A003
	08 Input bit 2 @ A003
	09 Ground
	10 +5 V
	11 +V
	12 +V

Connector P7: Gas source control and access control option

Pinout:		
	01 Output bit 4 @ A000	Gas source solenoid valve relay
	02 Output bit 5 @ A000	Access control exit unlock
	03 Output bit 6 @ A000	Access control entrance lock
	04 Output bit 7 @ A000	Access control aux. output
	05 Output bit 6 @ A001	Gas pressure #1 sense drive
	06 Output bit 7 @ A001	Gas pressure #2 sense drive
	07 Input bit 1 @ A003	Gas pressure sense input
	08 Input bit 0 @ A003	Access control doors open input
	09 Ground	Ground to access control switch
	10 +5 Volts	
	11 +V	Power to gas solenoid relay
	12 +V	Power to access control

Connector P8: Body position sensors

Pinout:		
	01 Ground	
	02 Ground	
	03 Input bit 7 @ A001	
	04 Input bit 6 @ A001	Platform weight sensor switch
	05 Input bit 5 @ A001	Left foot position switch
	06 Input bit 4 @ A001	Right foot position switch

Connector P9: Body position sensors

Pinout:		
	01 Ground	
	02 Ground	
	03 Input bit 0 @ A001	Hand position switch
	04 Input bit 1 @ A001	Hip position switch
	05 Input bit 2 @ A001	
	06 Input bit 3 @ A001	

Connector P10: Front panel keypad

Pinout: 01 Row 6 drive
02 Column 5 sense
03 Column 4 sense
04 Row 4 drive
05 Column 3 sense
06 Column 2 sense
07 Column 1 sense
08 Row 5 drive
09 Row 7 drive

Connector P11: Spare keypad inputs

Pinout: 01 Row 2 drive
02 Column 5 sense
03 Column 4 sense
04 Row 0 drive
05 Column 3 sense
06 Column 2 sense
07 Column 1 sense
08 Row 1 drive
09 Row 3 drive

Connector P12: Clock display power and data

Pinout:	01 Input bit 7 @ A002	
	02 Output bit 7 @ A002	
	03 Output bit 7 @ A003	
	04 Output bit 6 @ A003	
	05 Output bit 5 @ A003	
	06 Output bit 4 @ A003	
	07 Output bit 3 @ A003	Display 2 clock
	08 Output bit 2 @ A003	Display 2 data
	09 Output bit 1 @ A003	Display 1 clock
	10 Output bit 0 @ A003	Display 1 data
	11 +5 Volts to displays 12 Ground	

Connector P13:Spare keypad inputs

Pinout: 01 Row 3 drive
02 Row 2 drive
03 Column 1 sense
04 Row 1 drive
05 Row 0 drive

Keyboard Inputs

A matrix-encoded keypad of up to 20 keys may be connected to the front panel board at connector P10.

Host Communications Port Configuration

The SP24 series front panel boards (based on PCB P/N 11526) provide three serial communications ports, one of which is normally used for communications with a site host computer. When the host provides one port per instrument, RS-232 levels are normally used. If multiple instruments are connected in party line network, it is necessary to use RS-485 levels.

Host communications are supported through connector P3 on the SP24 board, a 9-pin female D connector. In the RS-232 configuration, IC A27 provides serial data output on pin 3 of this connector and receives input data on pin 2. DTR out is present on pin 4 and DSR in is present on pin 6. When the SP24 is configured for RS-485, IC A29 is used. P3 pin 1 is the positive I/O line and pin 9 is negative. Connector pin 5 is ground.

Reconfiguration Procedure

To convert an RS-232 board to RS-485, remove the IC from location A27 and install an RS-485 transceiver chip in the socket at A29. The preferred chip for this application is Thermo Electron P/N ICCMA485.

Converting an RS-485 board to RS-232 is the opposite; remove IC A29 and install Thermo Electron P/N ICXXMAX2323 at A27.

CAUTION Do not simultaneously install A27 and A29. ▲

Table 11-1 lists the items incorporated in the front panel board and should contain all parts necessary for normal repair.

Table 11-1. Front Panel Board Electronic Parts List

Ref. Desig.	Drawing No.	Part Name	Description	Part No.
A1	11526-D03	IC	Microprocessor	ICCMAC51FA
A2	11526-D03	IC	Triple 3-Input NOR	ICHCA7427
A3, 9, 10, 12, 30	11526-D03	IC	3-to-8 Line Decoder	ICCMAHC138
A4	11526-D11	IC	64K x 8 CMOS EPROM	Consult Thermo
A5, 6*, 7*, 8	11526-D03 11526-D11*	IC	32K x 8 Static CMOS RAM	ICCM43C256
A11, 13, 31	11526-D03	IC	Voltage Reg., +5 Low Drop	ICAVAL4941
A14, 29**	11526-D03	IC	RS-485 Transceiver	ICCMA485
A15-17	11526-D03	IC	CMOS UART	ICCMA82510
A18, 23-25	11526-D03	IC	Octal Buffer	ICHCA74373
A19-22	11526-D03	IC	Octal Latch	ICHCA74374
A26, 27**, 28	11526-D11	IC	CMOS to RS-232 interface	ICXXMAX233
A32*, 33*, 34*	11526-D11	IC	7-Channel Power Buffer	ICXX30
C1	11526-D03	Capacitor	22 pF	CPCE220P3R
C2	11526-D03	Capacitor	33 pF	CPCE330P3P
C3-5, 7-9,10,12-15,17-28, 38-41	11526-D03	Capacitor	0.1 µF	CPCE104P3N
C6	11526-D03	Capacitor	10 µF	CPTA100M4X
C11, 16, 37, 42	11526-D03	Capacitor	22 µF	CPTA220M4H
C29-36	11526-D03	Capacitor	0.01 µF	CPCE103P3N
DS1	11526-D03	LED	Internal Resister, Green, 5-Volt	OPLP25
HSA13	11526-D03	Heat sink	High Power, TO-220	MEHS22
HSA11, 31	11526-D03	Heat sink	Med. Power, TO-220	MEHS20
P1	11526-D03	Connector	7 x 0.100" Header	COMR107
P2-4	11526-D03	Connector	DB-9 Female, R/A PCB	COMR1209
P5-7, 12*	11526-D03 11526-D11*	Connector	12 x 0.100", Header	COMR112
P8, 9	11526-D03	Connector	6 x 0.100", Header	COMR706
P10, 11	11526-D03	Connector	9 x 0.100", Header	COMR809
P13	11526-D03	Connector	5 x 0.100", R/A Header	COMR1205
R1-3	11526-D03	Resistor	8.2K, 1/4W, 5%	RECC822B22
RP1-5	11526-D03	Resistor	4 x 1K SIP Network	REAR102B21
RP3, 6	11526-D03	Resistor	9 x 10K SIP, Network	REAR103B21

S1-8	11526-D11	DIP Switch	8-Position	SWMI5
S9	11526-D03	Push Button Switch	PC Mount R/A	SWPB27
X1	11526-D03	Crystal	11.0592 MHz	CYOS18
XXA5, 6*, 7*	11526-D03 11526-D11	Socket	28-Pin “Smart” with battery	ICXX27
XXA8	11526-D03	Socket	28-Pin “Smart” with battery and clock	ICXX26

* Item is specific to the PCM-2 board configuration.

**Either A27 or A29 may be used; see “Serial Ports” on page 11-2.

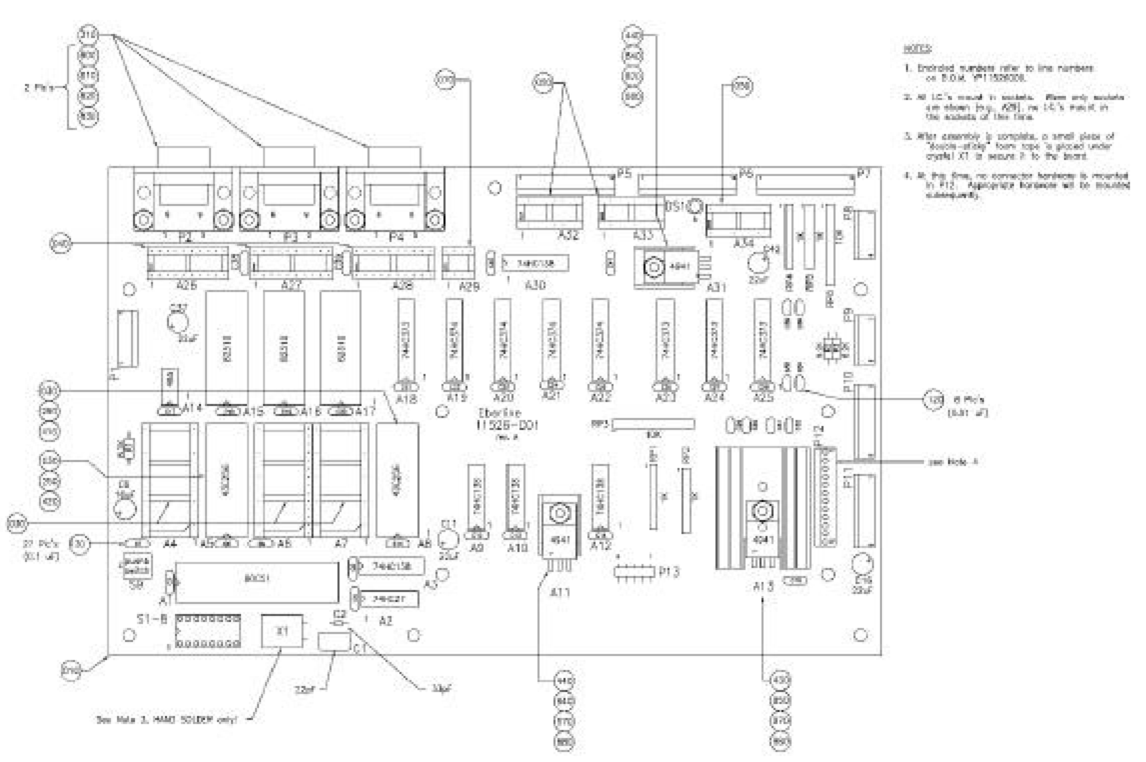

Figure 11-1. 11526-003, Front panel board SP24 basic component assembly. (A larger version of this drawing is located in Chapter 22.)

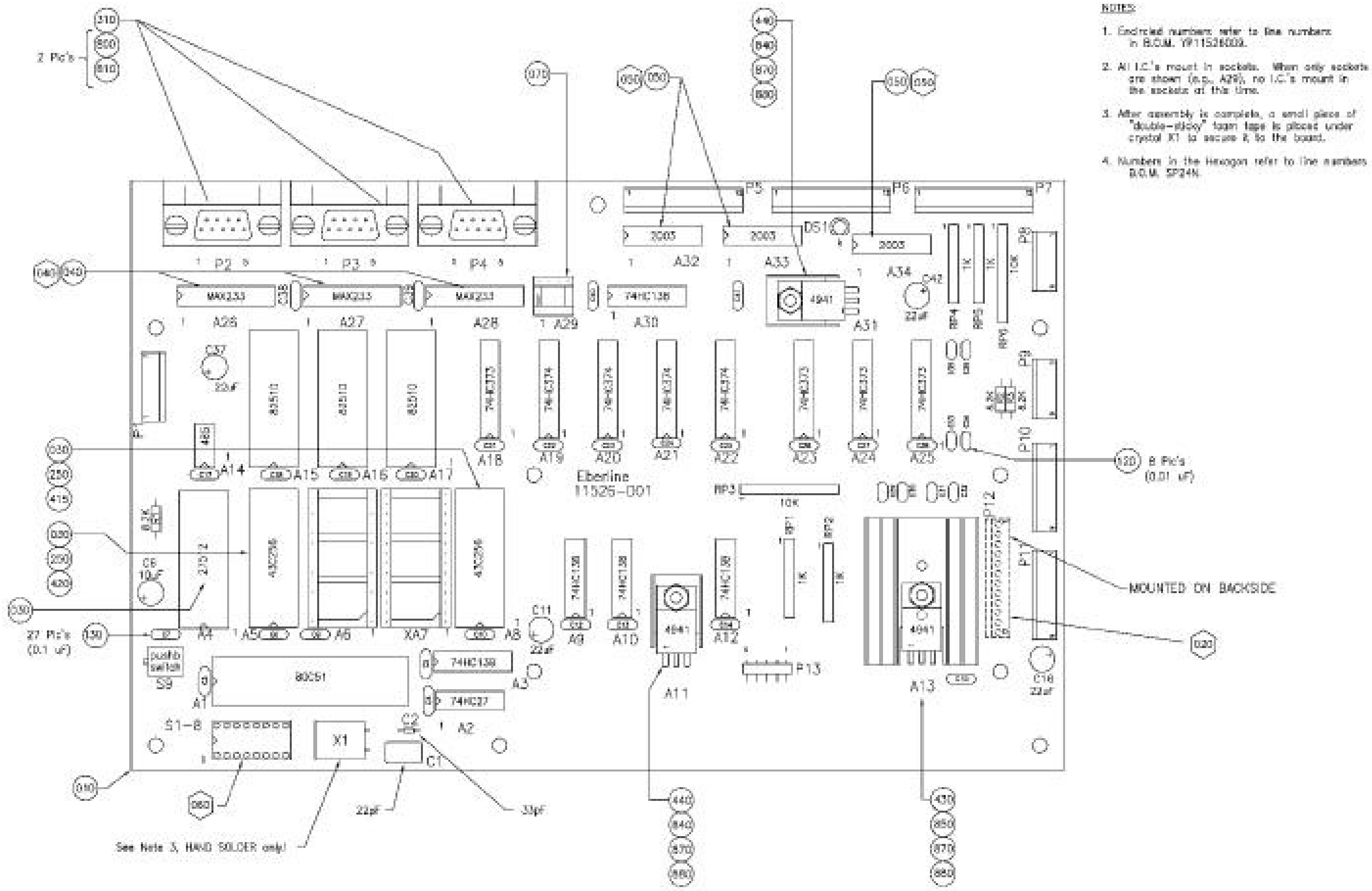

Figure 11-2. 11526-009, Front panel board components. (A larger version of this drawing is located in Chapter 22.)

Chapter 12 RS-232 to RS-485 Interface

General Description

This printed circuit board provides conversion of an RS-232 interface to an RS-485 interface. It supports bidirectional half-duplex communication.

Theory of Operation

The RS-232 transmit signal is input at J2 pin 2 and converted to TTL by (A100) MAX233 chip. This signal is then converted to RS-485 levels by A102 (DS3695). The RS-485 communication protocol requires that if a device is not transmitting, the transmitter must be turned off. This is accomplished by a comparator (A101 TLC372C) used as a one shot. Each time a high-level character bit is sent by the transmitter, the one shot will turn on the transmitter for the duration required to send one character. The baud rate must be selected by SW1-SW4 resistors R2 to R7 in conjunction with C4 provide the time constant during which the transmitter is turned on. (See Table 12-1.) The same comparator that enables the transmitter also disables the receiver.

Table 12-1. Baud Rate Selection SW1-4

SW1-4	Closed*	Baud Rate
1	X	4,800
2	X	9,600
3**	X	19,200
4	X	38,400

*All others open. **PCM-2 setting.

Special Functions

The RS-485 transmitter and receiver chip (A102) is protected by spark gaps GT-1 and GT-2 and surge suppressor CR1-CR4. High voltage on either of the RS-485 communication lines initially is clamped by CR1 to CR4 and current limited by R12 & R13. GT-1 and GT-2 provide protection after voltage breakdown has occurred. A grounding lug is provided on the chassis of units that use this board. For best operation of the protection circuit, this lug should be connected to a good earth ground by a 14-gauge copper wire.

If this board is to be used with an unregulated supply as in the PCM-2, regulator A103 and C1 may be added and jumper JP-1 cut.

The RS-485 communication protocol defines only voltage levels of transmission and electrical characteristic of the transmitters and receivers. The character protocol, baud rate, number character bits, stop bits, and parity must be selected to match for both transmitters and receivers.

RS-232 to RS-485 Interface Parts List

Table 12-2 lists the items incorporated in the RS-232 to RS-485 interface board and should contain all parts necessary for normal repair.

Table 12-2. Interface Parts List

Ref. Desig.	Drawing No.	Part Name	Description	Part No.
A100	11451-C02	I.C.	RS-232 to TTL converter	ICXXMAX233
A101	11451-C02	I.C.	Dual comparator	ICACA372
A102	11451-C02	I.C.	RS-485 Transceiver	ICXXAS3695
A103	11451-C02	I.C.	Voltage regulator, 5V	ICAVA2950C
C1	11451-C02	Capacitor	0.047 µF, 50V, 20%	CPCE473P4N
C2	11451-C02	Capacitor	33 µF, 10V, 10%	CPXX12
C3	11451-C02	Capacitor	100 pF, 500V, 5%	CPMI101P3X
C4	11451-C02	Capacitor	0.015 µF, 2.5%, 33V	CPPF153P1K
C5	11451-C02	Capacitor	0.1 µF, 50V, 10%	CPCE104P3N
CR1-4	11451-C02	Transient Suppressor		CRXXLCE65
GT-1, GT-2	11451-C02	Surge Arrestor	Spark gap	VETU2
J1	11451-C02	Connector	2 pin, 0.156"	COMR1502
J2	11451-C02	Connector	9 pin, 0.100"	COMR809
J3	11451-C02	Connector	12 pin, 0.100"	COMR112
R1	11451-C02	Resistor	27K, 1/4W, 5%	RECC273B22
R2, 3, 8, 9, 11	11451-C02	Resistor	48.7K, 1/4W, 1%	RECE483B12
R4	11451-C02	Resistor	200K, 1/4W, 1%	RECE204B12

Ref. Desig.	Drawing No.	Part Name	Description	Part No.
R5	11451-C02	Resistor	100K, 1/4W, 1%	RECE104B12
R6	11451-C02	Resistor	51.1K, 1/4W, 1%	RECE513B12
R7	11451-C02	Resistor	24.9K, 1/4W, 1%	RECE253B12
R10	11451-C02	Resistor	249K, 1/4W, 1%	RECE244B12
R12, 13	11451-C02	Resistor	4 , 3W, 5%	REWW040B16
R14	11451-C02	Resistor	100 , 3W, 5%	REWW101B16
SW1-4	11451-C02	Switch	DIP, SPST, 4 position	SWMI47

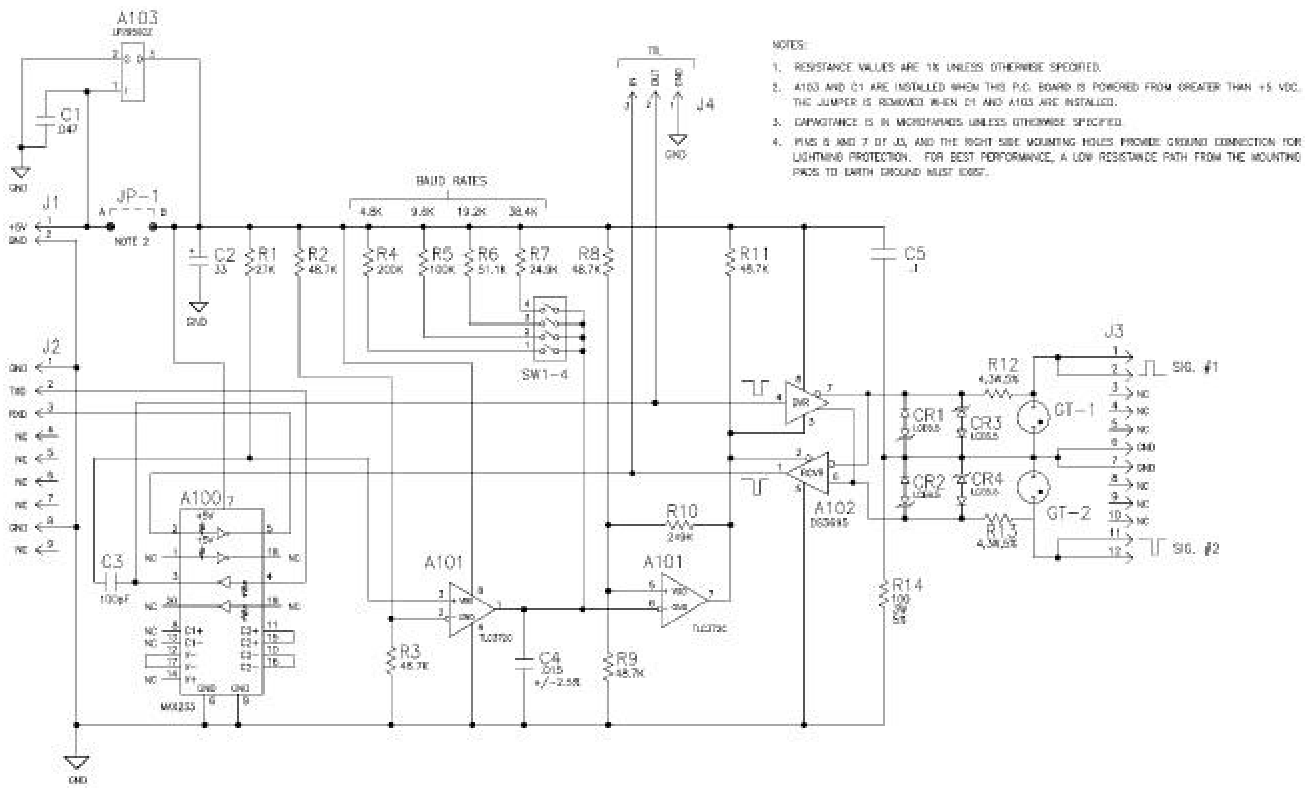

Figure 12-1. 11451-003, RS-232 to RS-485 interface. (A larger version of this drawing is located in Chapter 22.)

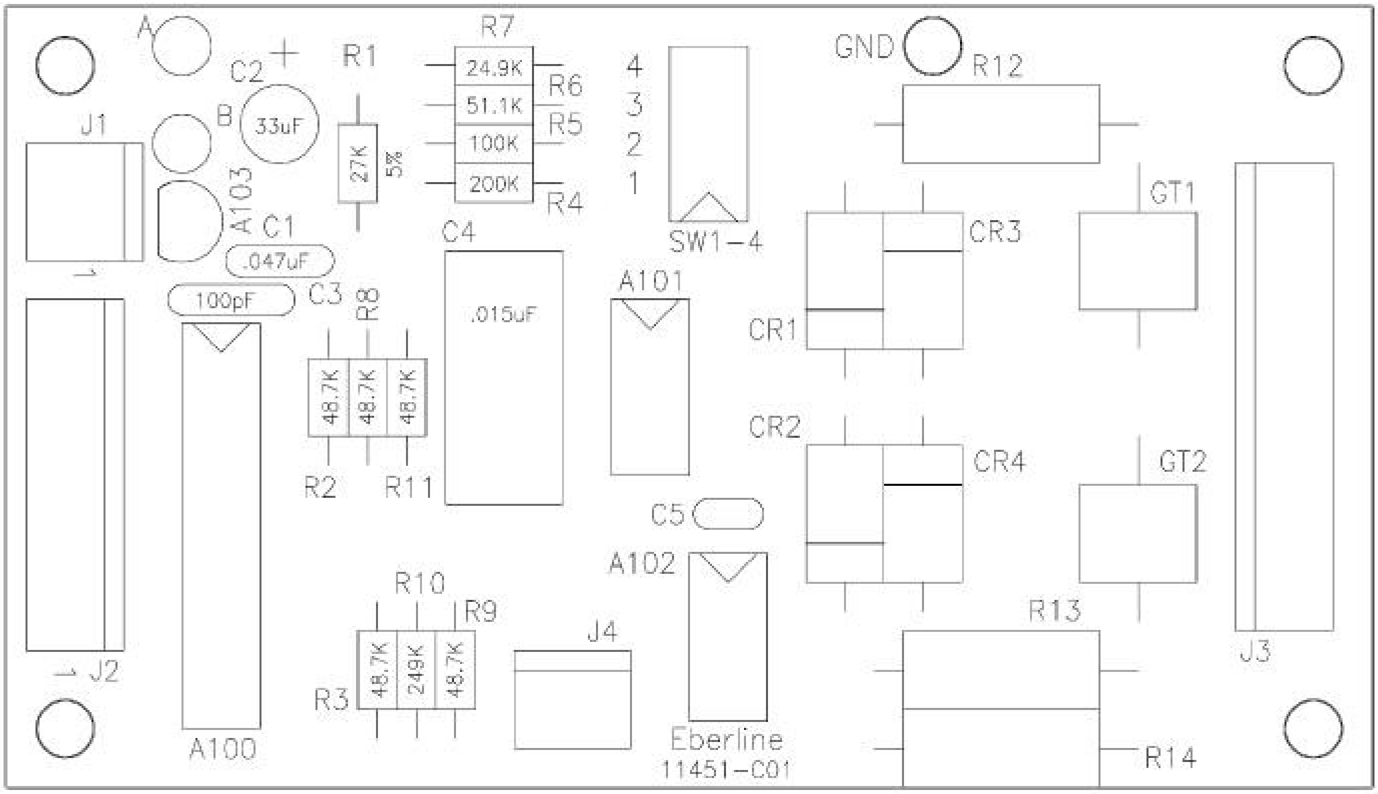

Figure 12-2. 11451-004, RS-232 to RS-485 interface components. (A larger version of this drawing is located in Chapter 22.)

Chapter 13 Modular Detector Board

General Description

Each detector in the PCM-2 is served by an independent circuit board that combines the functions of high-voltage power supply, signal amplifier, pulse height discriminator, and dual channel counter. By mounting these boards directly to the rear of the detector chambers, the need for high-voltage cables and expensive coax connectors has been eliminated and the effects of any single failure isolated to one detector.

All functions of the modular detector boards (MDB) are controlled by a single-chip microprocessor. In addition to the control logic, this device contains program ROM and working random access memory. The processor, an Intel 83C51FA, is capable of outputting pulse-width modulated signals which are filtered to provide DC levels which control the high-voltage supply and determine alpha and beta pulse height thresholds. Communications with the main computer of the PCM-2 are implemented through the processor's internal serial port.

External Connections

The MDB is normally connected to its detector by a banana plug on the detector body that plugs into a jack mounted on the circuit board. Grounding is provided via the board's grounding jumper wire/lug that directly contacts the back of the detector over the MDB mounting stud. When used with a remote detector such as the PCM-2's optional hand probe, a coaxial cable assembly is terminated directly to the board.

Low-voltage power and serial data enter through a twelve-pin header (J1) at the front edge of the detector board. Pins 1, 2 and 12 of this header are DC ground; a supply of 8–15 Vdc at approximately 50mA is required on pin 2. As configured for use in the PCM-2, pins 4 and 5 are bidirectional serial data at RS-485 levels that are buffered to and from the processor chip by IC A5. The remaining pins of J1 are jumpered to ground as necessary to define the network address of each board, eliminating the need to manually set address switches when replacing a board because that information is wired into the chassis harness connector.

A four-pin header, J3, is used only when the MDB is part of the hand probe option. This connector contains power, ground and signals for a clicker board used with the hand probe. J2 is connected to the switch that enables clicking when the hand probe is removed from its holder.

Circuit Description

Amplifier and Discriminator Circuits

Pulses from the detector are coupled into a low-impedance amplifier through a DC-blocking capacitor. Two stages of amplification are used. The first stage inverts negative-going detector pulses and feeds the alpha pulse threshold comparator. The second stage, which is non-inverting, provides sufficient gain for detection of beta pulses.

Each amplifier output is AC coupled into its respective threshold comparator. The thresholds' voltages are obtained by filtering two pulse-width modulated outputs from the microprocessor. One-shot multivibrators condition the comparator outputs into logic-level signals with constant pulse widths. Anti-coincidence logic may be enabled under software control to prevent alpha pulses from also being included in the beta count or disabled for test purposes. When a MDB is used in the hand probe option, alpha and beta outputs are combined using a logic OR gate to produce click pulses.

CAUTION The high-voltage section of this board produces potentials of up to 2500 V which may remain present for several minutes after power is removed. Exercise care when working on this module. Discharge the input jack to chassis ground with an insulated screwdriver before removing the circuit board from its housing. ▲

High-Voltage Supply

Accelerating potential for the detector is produced by an inverter and voltage-multiplying ladder circuit. The output voltage is divided by a 1000:1 resistor network and compared to a reference voltage generated by filtering a pulse-width modulated output from the microprocessor. This feedback loop controls the frequency of the inverter oscillator. Two additional comparators are used which interrupt the processor chip if the high-voltage output goes out of tolerance.

High voltage is adjustable in 255 steps of slightly less than 10 V per step. An adjustment potentiometer is provided for more precise calibration of the (nominally) 1000:1 voltage divider.

Setup and Calibration

A 2 x 6 pin header located directly behind J1 configures the MDB for operation or calibration. Placing a shorting jumper in position #1 (the left-most pair of pins) instructs the microprocessor to operate as a normal detector board, while position #2 designates a hand probe board. Removing the jumper entirely selects high-voltage calibration mode, and jumpering position #6 disables the high-voltage power supply entirely. Positions 3, 4 and 5 should not be jumpered. Jumper settings are read only when power is first applied to the board.

If the board is powered up with no jumper installed, the power supply will be set for 1250 V. The actual output may be adjusted to this nominal value by potentiometer R10; this is the only calibration required. Use a high-impedance voltage divider probe to measure the output voltage, since the supply has an impedance of one megohm.

Operation of the two amplifier stages may be monitored at test points 5 and 6 respectively. DC levels at both of these points should be between 0.5 and 1.5 V. Alpha and beta one-shot outputs are present on pins 2 and 3 of J2. If a pulse generator is connected to the detector input, note that the input impedance of the amplifier is low and may load the generator output significantly. As mentioned above, placing a jumper in position #6 will disable the high-voltage supply for technician safety.

Threshold Values

Alpha and beta pulse-height discriminator thresholds default to values of 45% and 4.8% respectively. These levels may be changed via the detector parameter menu; however, this capability should be used only after careful evaluation. The MDB can be used with several types of radiation detectors; its full adjustment range is not intended for any one type.

Increasing the beta threshold will rapidly reduce detector response to low-energy (beta and gamma) particles, both from contamination sources and background. This will result in decreased beta/gamma detection efficiency; however, background count rates may actually decrease faster than those from contamination.

The default alpha threshold was selected to almost eliminate alpha counts due to beta particles. Lowering this value will increase alpha particle detection efficiency; however, false alpha-channel alarms may be caused by higher energy sources. Raising the alpha threshold will slightly reduce the number of beta particles incorrectly counted as alphas; however, the opposite error (counting alphas as betas) will increase rapidly.

Before changing these thresholds, it is strongly recommended that representative calibration sources be used. Ideally, samples of the actual isotopes to be detected should be used to measure the changes in response to both contamination sources and background. If thresholds are changed, detector efficiencies should also be rechecked.

Modular Detector Board Parts List

Table 13-1 lists the items incorporated in the MDB and contains all parts necessary for normal repair.

Table 13-1. Modular Detector Board Parts List

Ref. Desig.	Drawing No.	Part Name	Part Description	Part No.	Ref. Desig.
None		11543-005	Circuit Board	Modular Detector	ZP11543002
A1	80	11543-005	Microprocessor	83C51 Mask ROM	Consult Factory
A2	30	11543-005	I.C.	Quad NOR gate	ICHCA00002
A3	40	11543-005	I.C.	+5 V Regulator	ICAV7805
A4	50	11543-005	I.C.	+5 V Regulator	ICAVA2950C
A5	60	11543-005	I.C.	RS-485 Xcvr.	ICCMA485
A7		11543-005	Hybrid	Custom Hybrid	VEBD14
XA1	70	11543-005	I.C. Socket	40-Pin DIP	SOIC140
XA2	80	11543-005	I.C. Socket	14-Pin DIP	SOIC114
XA5	90	11543-005	I.C. Socket	08-Pin DIP	SOIC308
C1	100	11543-005	Capacitor	10 µF, 16V	CPTA100M4X
C2, 3, 21	110	11543-005	Capacitor	33 pF, Ceramic	CPCE330P3P
C4, 8-11	120	11543-005	Capacitor	0.1 µF, 50V	CPCE104P3N
C12, 16, 20	130	11543-005	Capacitor	0.01 µF, 3000V	CPCE103P4Y
C13	140	11543-005	Capacitor	0.047 µF, 4000V	CPPF503PXY
C14	150	11543-005	Capacitor	220 pF, 3000V	CPCE221P3Y
C15	160	11543-005	Capacitor	0.001 µF, 3000V	CPCE102P3Y
C17	170	11543-005	Capacitor	0.01 µF, 80V	CPPF103P3O
C18	180	11543-005	Capacitor	0.27 µF, 50V	CPCE274P4N
C5,7,19	190	11543-005	Capacitor	33 µF, 10V	CPXX12
R1-5	200	11543-005	Resistor	10K Ohm 1/4W 5%	RECC103B22
R6	220	11543-005	Resistor	220 Ohm 1/4W 5%	RECC221B22
R7, 11	230	11543-005	Resistor	10M Ohm 1/4W 5%	RECC106B22
R8	240	11543-005	Resistor	1 M Ohm 1/4W 5%	RECC105B22
R9	250	11543-005	Resistor	270 Ohm 1/4W 5%	RECC271B22
R10	370	11543-005	Potentiometer	100K Ohm trim	PTCE104B83
T1	260	11543-005	Transformer	High Voltage	TFHV5
CR1	270	11543-005	LED, T-1	Red superbright	OPLP57
CR2-4	280	11543-005	Rectifier	High Voltage	CRSIVA0025
CR5	290	11543-005	Diode	Small signal	CRSI1N4148
Q1,3	300	11543-005	Transistor	N-Channel FET	TRMN2N7000
Q2		11543-005	Transistor	PNP medium power	TRSP2N4234
X1	320	11543-005	Crystal	7.3728 MHz	CYOS12
J1	330	11543-005	Header	12-Pin x 0.156"	COMR612

J2	390	11543-005	Header	9-Pin x 0.1"	COMR809
J3	340	11543-005	Header	4-Pin x 0.1"	COMR1104
J4	400	11543-005	Banana Jack	Uninsulated	COMI14
JP1-6	350	11543-005	Header	2x6-Pin x 0.1"	COMR1312
XJP1	360	11543-005	Jumper	2-Pin x 0.1"	COHD121
MDB	20	11543-006	Ground Wire	MDB-to-Detector	ZP11534541
	30	11543-006	Washer	Wave Washer 10	SCMW59

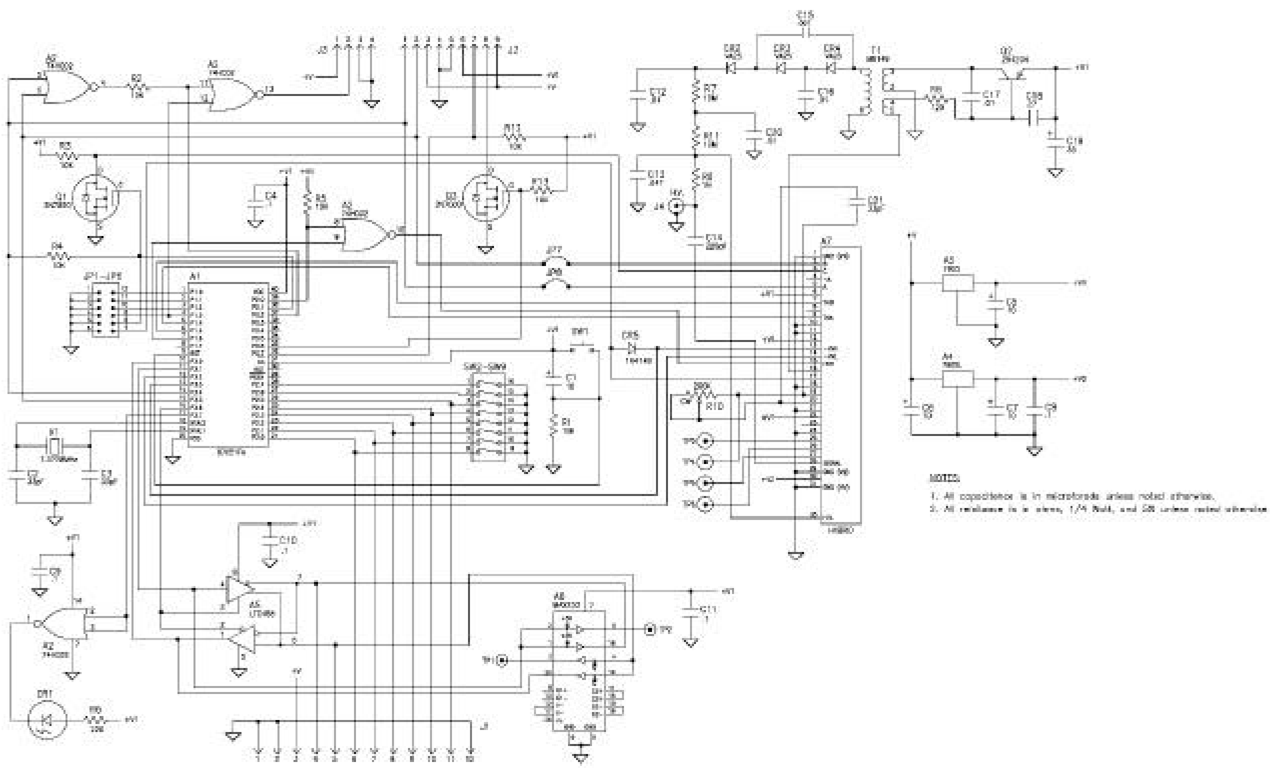

Figure 13-1. 11543-001, Modular detector board. (A larger version of this drawing is located in Chapter 22.)

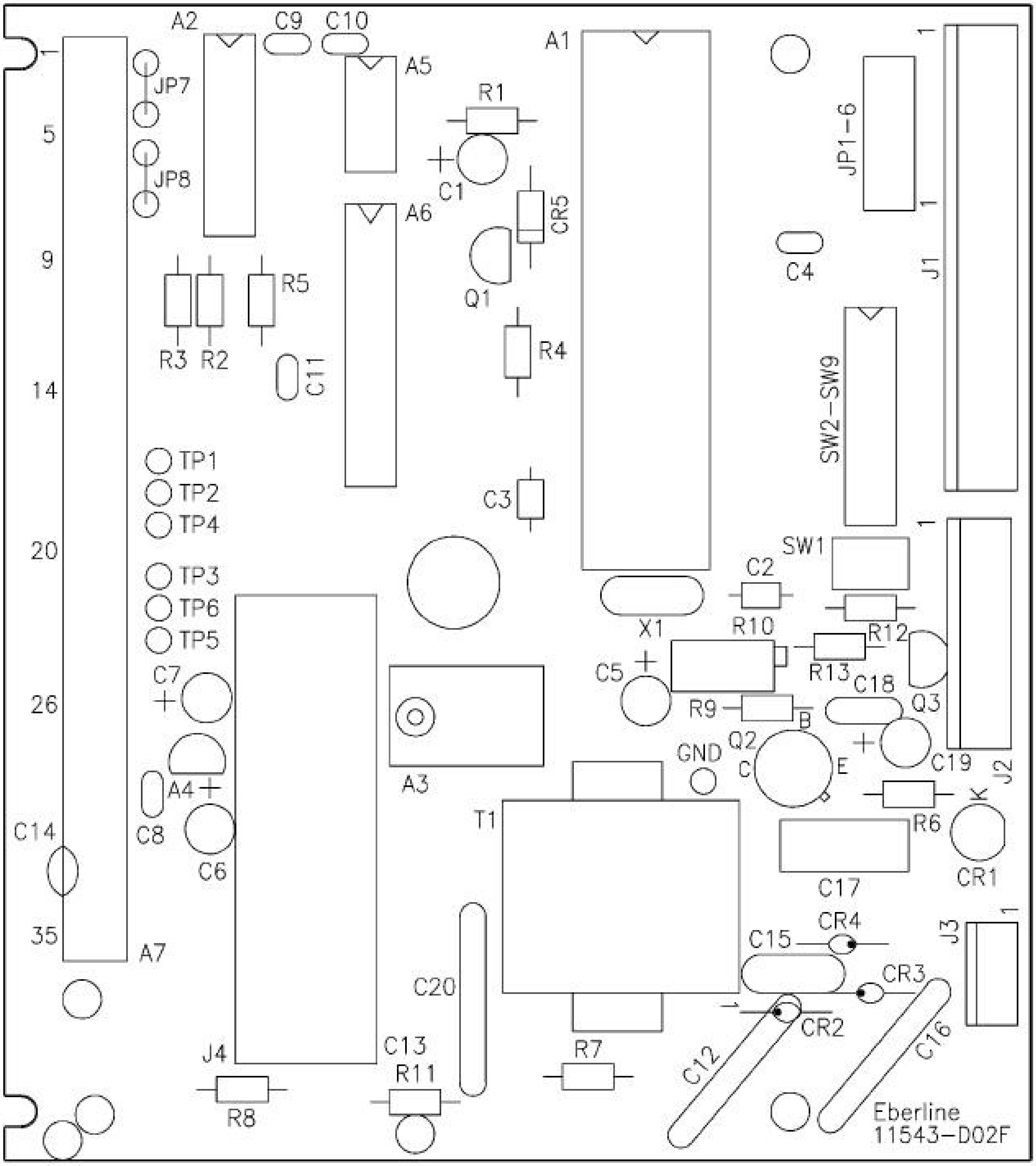

Figure 13-2. 11543-005, Modular detector board components. (A larger version of this drawing is located in Chapter 22.)

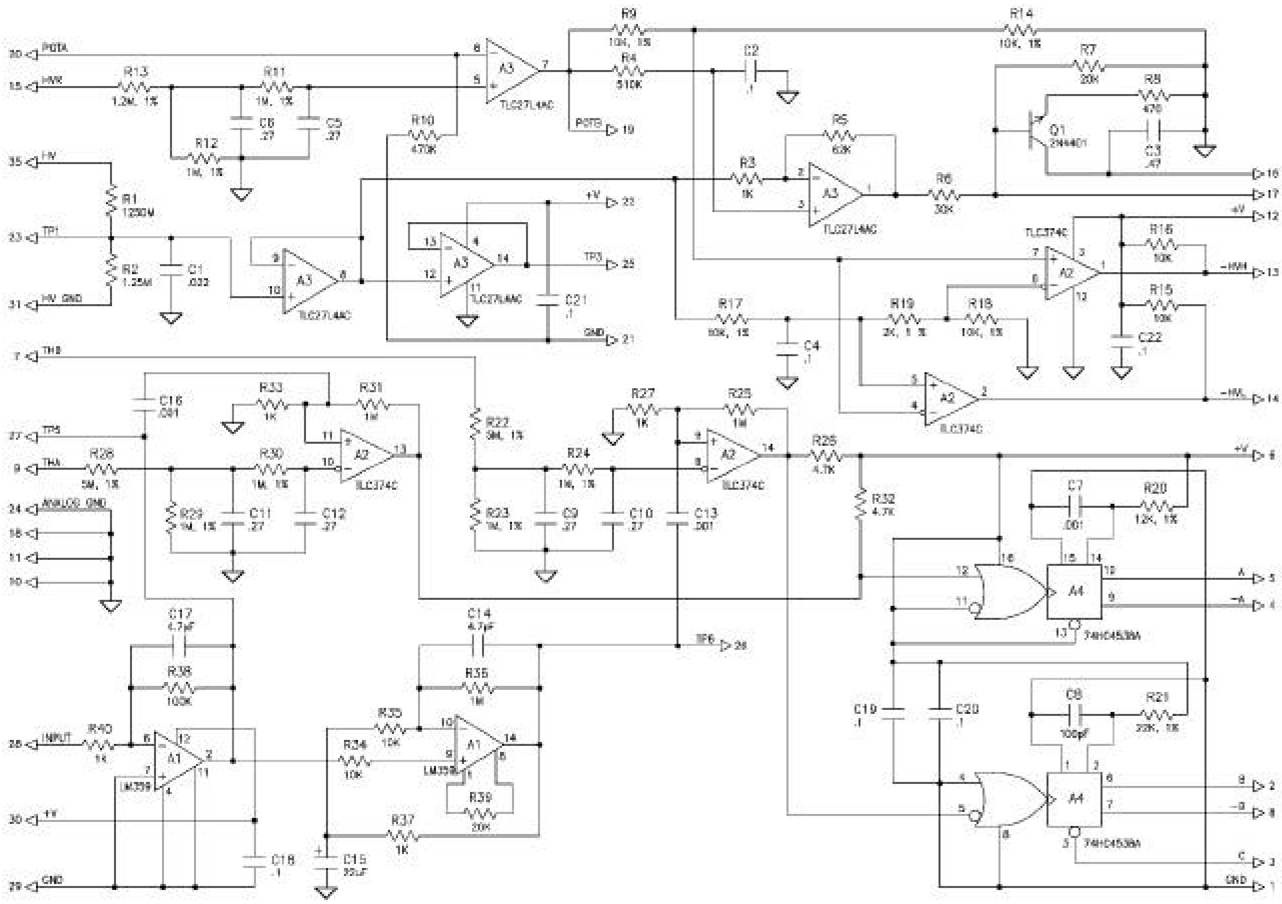

Figure 13-3. 11543-008, Modular detector board, hybrid schematic. (A larger version of this drawing is located in Chapter 22.)

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Chapter 14 Clock Display Board

General Description

Two of these boards are used in each PCM-2. In addition to the clock itself, which shows count time remaining, several red LEDs prompt users to correct their body position if any of the sensor switches are not being actuated. The two circuit boards are identical; however, a different graphic overlay is used in each location.

The heart of this board is the two-digit numeric display chip which is capable of accepting serial data from the front panel board and using that information to light the appropriate LED digit segments. Additional bits from the display's internal shift register are brought out to a driver chip which in turn controls the red LEDs behind the body position displays.

Clock Display Board Configuration

Proper operation of the traffic light displays requires setting S1-8 according to Table 14-1.

Table 14-1. S1-8 Switch Settings

Position	Open	Closed
1	CDB#1, Rev 0.I.	CDB#1, Rev A
2	CDB#2, Rev 0.I	CDB#2, Rev A
3 - 8	Not used	Not used

Clock Display Board Parts List

Table 14-2 lists the items incorporated in the clock display board and contains all parts necessary for normal repair.

Table 14-2. Clock Display Board Parts List

Ref. Desig.	Drawing No.	Part Name	Part Description	Part No.
(None)	11534-C151	Circuit Board	Clock Display	ZP11534149
P1, P2	11534-C151	Header	12-Pin x 0.1"	COMR912
C1, C2	11534-C151	Capacitor	0.1:F, 50V	CPCE104P3N
CR1-3	11534-C151	Diode	1 Amp 50V	CRSI1N4002
R1-7	11534-C151	Resistor	100 Ohm 1/4W 5%	RECC101B22
R8, R9	11534-C151	Resistor	1K Ohm 1/4W 5%	RECC102B22
A2	11534-C151	I.C.	7-Channel Buffer	ICXX30
DS1-7	11534-C151	LED, T-1	Red superbright	OPLP57
RP1	11534-C151	Resistor Array	9 x 4.7K Ohm	REAR472B21
A1	11534-C151	Numeric display	2-digit green	OPDS32
A3	11534-C151	I.C.	Display Driver	ICXX5480

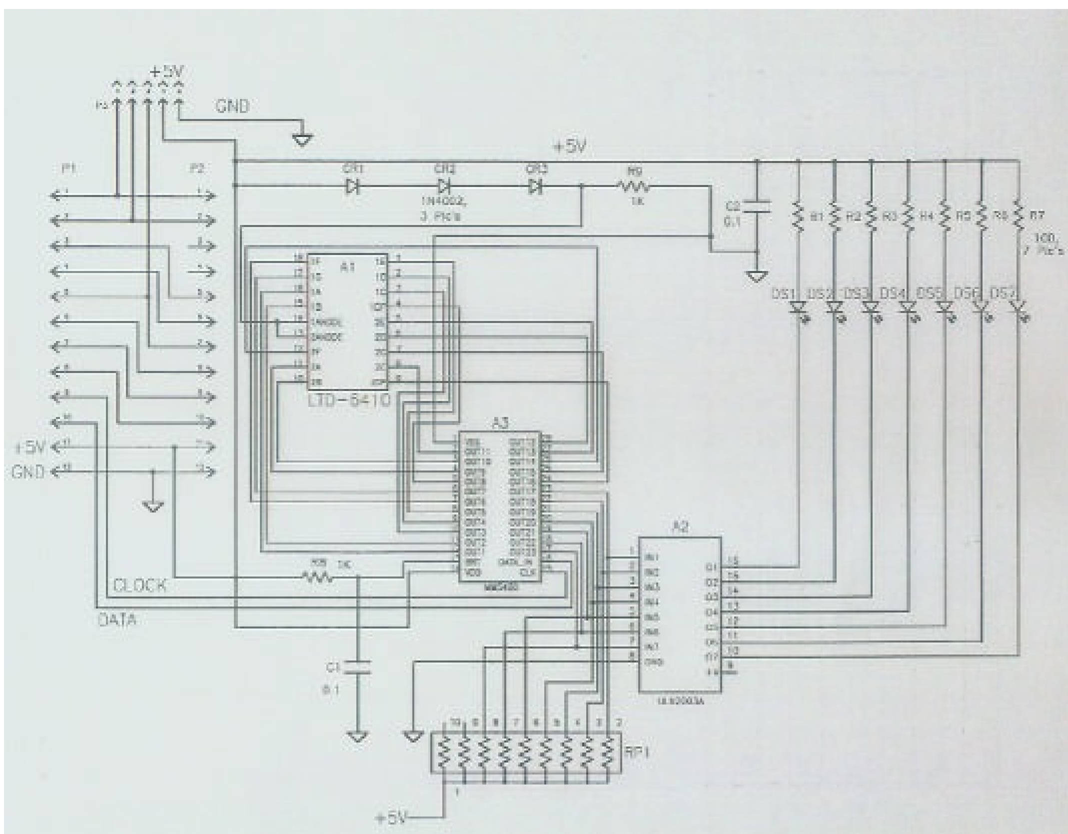

Figure 14-1. Clock display board, 11534-150. (A larger version of this drawing is located in Chapter 22.)

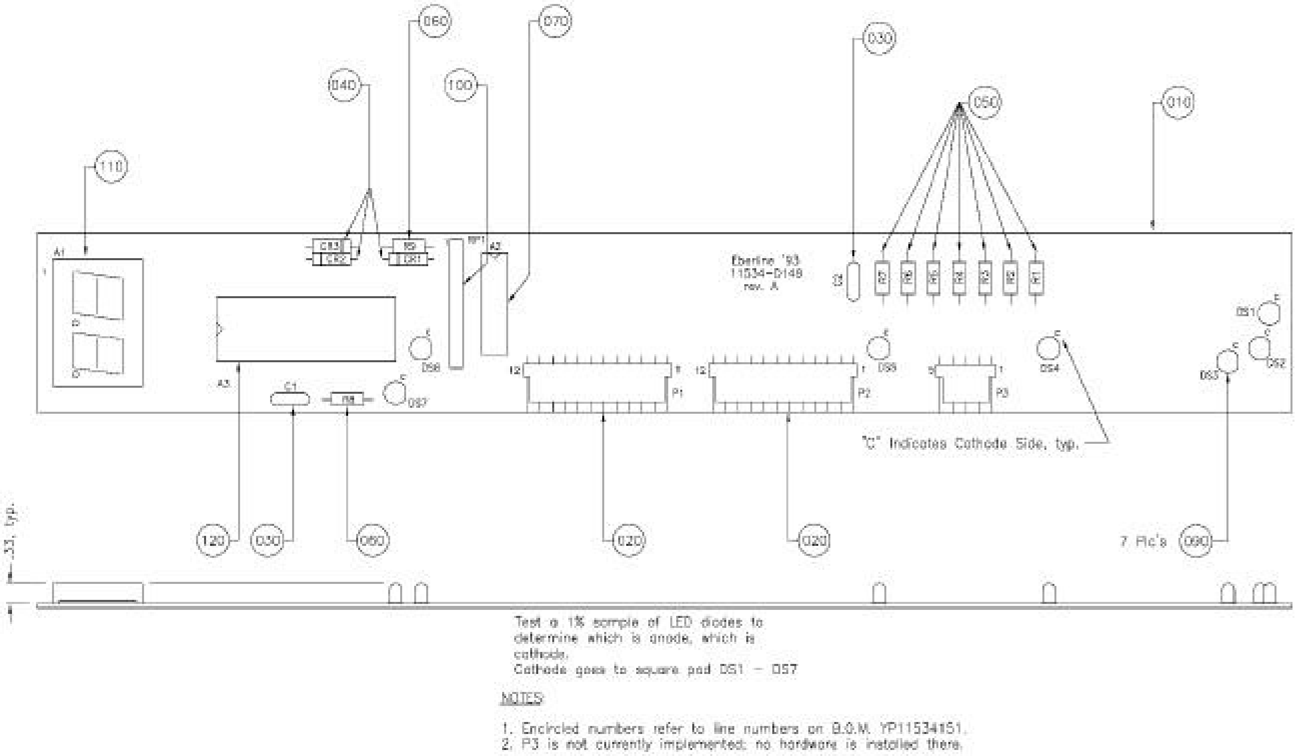

Figure 14-2. 11534-151, Clock display board components. (A larger version of this drawing is located in Chapter 22.)

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Chapter 15 Traffic Light Board

General Description

The traffic light board consists of six series LED lights (3 red and 3 green) and six limiting resistor pairs which are controlled by the PCM-2 front panel board.

Switch to ground at Pin 4 on J1 turns on the 3 green lights and switch to ground at Pin 5 on J1 turns on the 3 red lights. Two traffic light PCBAs are mounted in the ceiling of the PCM-2 behind the two coincident oblong cutout sets in the ceiling trim at the front and left sides of the unit. The red lights are illuminated whenever the instrument is in its “Test” mode or is experiencing a failure in its “Operational” mode (i.e., out of gas, high background fail, sensitivity fail, etc.) and thereby serve as a visual prompt that the unit is not ready for measurement. Conversely, the green lights are illuminated whenever the unit is ready for measurement.

Traffic Light Board Parts List

The following table lists the items incorporated in the traffic light board and contain parts necessary for normal repair.

Table 15-1. Traffic Light Board Parts List

Ref. Desig.	Drawing No.	Part Name	Part Description	Part No.
(None)	11534-C148	Circuit Board	Traffic Light	ZP11534147
P1	11534-C148	Header	5-Pin x 0.1"	COMR1205
R1, 3, 5	11534-C148	Resistor	150 Ohm 1/4W 5%	RECC151B22
R2, 4, 6, 7, 9, 11	11534-C148	Resistor	220 Ohm 1/4W 5%	RECC221B22
R8, 10, 12	11534-C148	Resistor	270 Ohm 1/4W 5%	RECC271B22
A1, 2, 3	11534-C148	LED Bar	Yellow 6 x 29 mm	OPLP56
A4, 5, 6	11534-C148	LED Bar	Red 6 x 29 mm	OPLP55

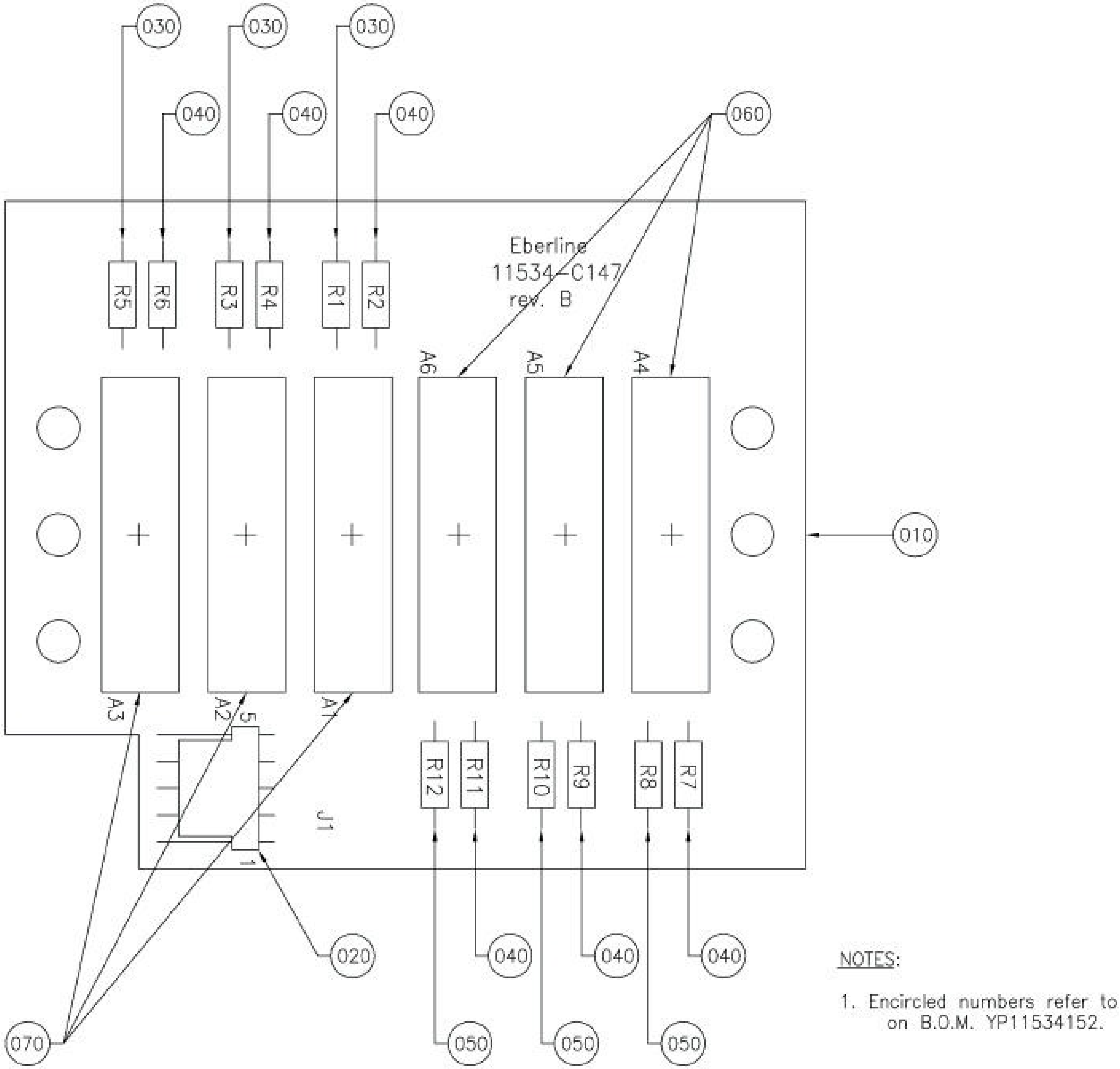

Figure 15-1. Traffic light board components, 11534-152. (A larger version of this drawing is located in Chapter 22.)

Chapter 16 Detectors

General Description

The PCM-2 uses gas-flow proportional detectors (also referred to as *probes*) operating on P-10 counting gas. The standard unit supports connection to an external counting gas supply. Detector pulses resulting from ionization of the counting gas are amplified and discriminated by pulse height in separate alpha and beta counting channels for each detector zone.

Nine large, four medium and three small detectors are used in the standard PCM-2 unit, for a total of 34 detector channels (the large detectors have 3 individual channels each). A 0.85 mg/cm^2 aluminized Mylar® is used for the face window of the detectors, providing high sensitivity to low-energy beta particles. The PCM-2 detectors have the following physical and operational characteristics:

Large	212 in^2 (1368 cm^2) window area
Medium	113 in^2 (728 cm^2) window area
Small	50 in^2 (325 cm^2) window area
Beta Efficiency (4B)	25%–30% (contact efficiency to Tc^{99}).
Alpha Efficiency (4B)	20% (contact efficiency to typical alpha emitters such as Pu^{239}, Am^{241} and Th^{230}).

Note The overall efficiency of the bottom foot detector in the base of the unit can be considerably less, depending on the spacing of the detector's face away from the bottom of the foot of the user, the open area of the footplate which has been provided with the unit, and the thickness of any protective polyethylene or Mylar® film used on the detector. ▲

Each of the three sizes of detector assemblies has been designed for internal attachments of anode wires as close as possible to the detector chamber walls. This design feature minimizes the insensitive regions which commonly exist at the sides or ends of detectors of this type and reduces the overall dead area of the entire instrument when the detectors are placed closely together as in the PCM-2.

Another design feature of the PCM-2 detectors is a chamber faceplate that presses onto the detector pan and secures the Mylar® window to the detector without screws. A silicone rubber gasket provides the gas seal between the inner pan and Mylar® window/faceplate. Reusable quick-release clips mount the faceplate to the detector body. This design, using gaskets and no screws, also eliminates any face-mounting flanges so that separation between adjacent detectors is further minimized and allows for quick and easy rebuilding of detectors with damaged Mylar® windows without the need for any disposable assembly materials such as double sticky tape.

A rugged plated steel screen with 66% open area protects each detector in the standard PCM-2 unit, with the exception of the bottom foot detector.

Optional thin high-sensitivity etched (0.010" thick, stainless steel, 83% open area) detector screens are also available. These optional screens, being physically thinner and having a 20% greater open area, provide a proportionate decrease in typical measurement count times and are thereby recommended for use in monitoring environments where maximum sensitivity (such as alpha measurement) is desired.

The bottom foot detector rests on height adjustable brackets beneath a rugged stainless steel slotted base plate with 74% open area. Because this standard slotted base plate design maximizes open area of detection, it supports users with relatively broad and flat-soled shoes only. An optional perforated grid stainless steel base plate with 1/4" diam. holes (58% open area) is available in support of users with high-heeled shoes.

See Chapter 19: “Options” for more detailed information on these and other options.

Design Configuration

PCM-2 detector assemblies have undergone design revision since the instrument first went into production. The original detector design was based on a universal internal anode wire support system requiring individual dielectric standoffs and soldered wire supports. This design, although quite functional when built and tested, has proven to be problematic from a mass production assembly standpoint. It has therefore been replaced by a more readily producible design requiring fewer internal components and assembly considerations.

Both detector assembly configurations feature identical detection capabilities and performances and are indistinguishable in their fully assembled conditions. Identification of these original and revised detector assemblies is possible by PCM-2 unit serialization as shown in Table 16-1 below.

Table 16-1. Detector Configuration

Detector Part No.	Detector Description	PCM-2 Serial No.
YP11534245	Detector Assembly, Long	Serial nos. 001 through 150.
YP11534246	Detector Assembly, Medium	
YP11534247	Detector Assembly, Small	
YP11534560	Revised Detector Assembly, Long	Serial nos. 151 and subsequent.
YP11534561	Revised Detector Assembly, Medium	
YP11534562	Revised Detector Assembly, Small	

Maintenance

While in normal use in typical monitoring environments, gas proportional detectors such as those used in PCM-2 require little maintenance other than keeping them reasonably clean and supplied with counting gas. A detector with a clean, contaminate-free Mylar® window will experience reduced background and will therefore have a greater sensitivity to measured radiation within a given count time. Since minimization of count times for measurement is of concern to almost all users, and because “dirty” often equates to “contaminated” in radiation-monitoring environments, PCM-2’s detectors should be kept clean for maximally efficient radiation measurements.

Cleaning

Particulates which settle on the Mylar® window of a detector can be blown away with a clean (i.e., filtered), dry compressed air or gas source. Avoid using pressures or nozzles that may puncture the detector’s Mylar® face. Detectors that have contaminated faces as a result of liquid or oil stains or residues should be removed from the unit and carefully wiped clean with a soft wiper and alcohol. Again, avoid any cleaning agent or practice that may puncture the delicate Mylar® face of the detector.

Protection

The medium-sized probe located in the base of the PCM-2 is especially subject to contamination from particulates released from the shoes of its users. For this reason, special thin polyethylene film probe protectors are provided with the standard PCM-2 unit. Ten of these cardboard framed protectors are supplied in a holder located in the unit’s side door. They are installed over the foot detector and have bend tabs for keeping them aligned atop the foot detector. They can easily be removed, cleaned or discarded, and replaced.

Usage of these foot detector protectors will preclude most detector punctures due to dirt or pebbles from shoes and will greatly facilitate routine cleaning of the foot detector. An optional Mylar® film dispenser roll is also available for the same protection and cleaning purposes, offering an even greater degree of convenience for foot detector servicing. Replacement film rolls and cardboard/film protectors are available (see chapters 20, 21 and 22).

The remaining detectors in the instrument are each protected by a thin etched stainless steel screen. These screens serve to prevent detector face punctures potentially caused by physical user interface with the detector panels (i.e., sharp or protruding clothing, pens, pencils, badges, jewelry, etc.). If any detector becomes punctured or otherwise damaged to the point of failure, it can easily be removed and replaced with a spare detector.

Replacement

The PCM-2 has been designed for quick and easy removal and replacement of its detectors. Velcro® cinch straps retain the detectors in their respective panels in the instrument, and quick-connect self-sealing fittings attach their gas plumbing harnesses. Therefore, no tools are required for detector removal and installation. A spare purged (air evacuated / P-10 gas filled) probe can thereby replace a damaged detector in minutes, preventing lengthy instrument downtime while a detector is repaired. An optional set of spare continuously purging internally mounted detectors is available to support such detector replacement requirements. (See Chapter 19: “Options”.)

Special Considerations

PCM-2 detectors are quite sensitive to contamination due to out-gassing of various substances that can come in contact with internal surfaces of the probe chamber or those of its gas delivery components. When this happens the subject detectors can experience a notable decrease in efficiency characterized by low beta background values. This poisoning of the detector chamber can be caused by its exposure to any organic solvents that are present in substances such as (but not limited to) adhesives, sealants and lubricants. This is especially true of RTV (silicone) adhesives. Avoid using these types of substances in areas or on components that are in direct contact with or carry counting gas to the internal surfaces of the detector assemblies.

Rebuilding

PCM-2 detectors have been designed to be field repairable. Often during the course of normal instrument usage, one or more detectors may go out of service due to Mylar® face punctures, anode wire breakage or other internal electrical failures. In the event of detector failure, repair becomes necessary. Thermo Electron has developed specific processes for the repair or complete rebuild and testing of PCM-2 probes which vary depending on the configuration of detector assembly involved. Identification of the type of detector assembly to be rebuilt is of primary consideration in the rebuilding effort. (See Table 16-1 above.)

Appendix D: "PCM-2 Revised Detector Assembly Procedure" defines the detailed process steps for the complete assembly manufacture of the revised design detectors. Appendix E: "PCM-2 Detector High Voltage and Leak Test Procedure" defines those processes required to properly test the probes when assembled. This procedure appears in Appendix B: "Procedures" and supplements detector assembly drawings 11534-560 (see Fig. 16-1, Fig. 22-14); 11534-561 (see Fig. 22-16); and 11534-562 (see Fig. 22-18) for the revised probes.

Detector Assembly Parts List

Table 16-2 lists the electronic items incorporated in the detector and should contain all parts necessary for normal repair.

Table 16-2. Detector Assembly Parts List

Item Ref. No.	Drawing Ref. No.*	Part Name	Description	P/N
030	11534-560 11534-561 11534-562	Turret post	Teflon	ZP11534557
035		Turret spindle	Brass	ZP11534556
040		Turret cap	Teflon	ZP11534558
045		Wire spring	Anode wire	ZP11534559
050		Insulator washer	Outer	ZP11534165
060		Insulator washer	Inner	ZP11534360
070		Banana plug	Uninsulated	COMI13
080		Flat washer	Stainless steel	SCMW50
110		Copper tape	Conductive, double sticky	HDTA83
140		Teflon coated wire	22 AWG	WRTF99922
150		1/8" quick coupling	Modified	ZP11534346
160		Ring clip	Probe chamber	ZP11534030
170		Aluminized Mylar® sheet	0.0025" thick	MMMY3
180		Anode wire	0.001" diam. stainless steel	MEWI3
200		Teflon tape dot	1/2" diam.	HDTA88
010	11534-560	Probe chamber	Long, revised	ZP11534551
020	11534-560	Chamber ring	Long	ZP11534332
190	11534-560	Probe gasket	Long	ZP11534372
210	11534-560	1/8" street elbow	Modified	ZP11534538
220	11534-560	1/8" quick coupling	Socket	FGPL19
010	11534-561	Probe chamber	Medium, revised	ZP11534552

020	11534-561	Chamber ring	Medium	ZP11534339
190	11534-561	Probe gasket	Medium	ZP11534373
220	11534-561	1/8" street elbow	Modified	ZP11534538
230	11534-561	1/8" quick coupling	Socket	FGPL19
010	11534-562	Probe chamber	Small, revised	ZP11534553
020	11534-562	Chamber ring	Small	ZP11534337
190	11534-562	Probe gasket	Small	ZP11534374

*Drawing reference number.

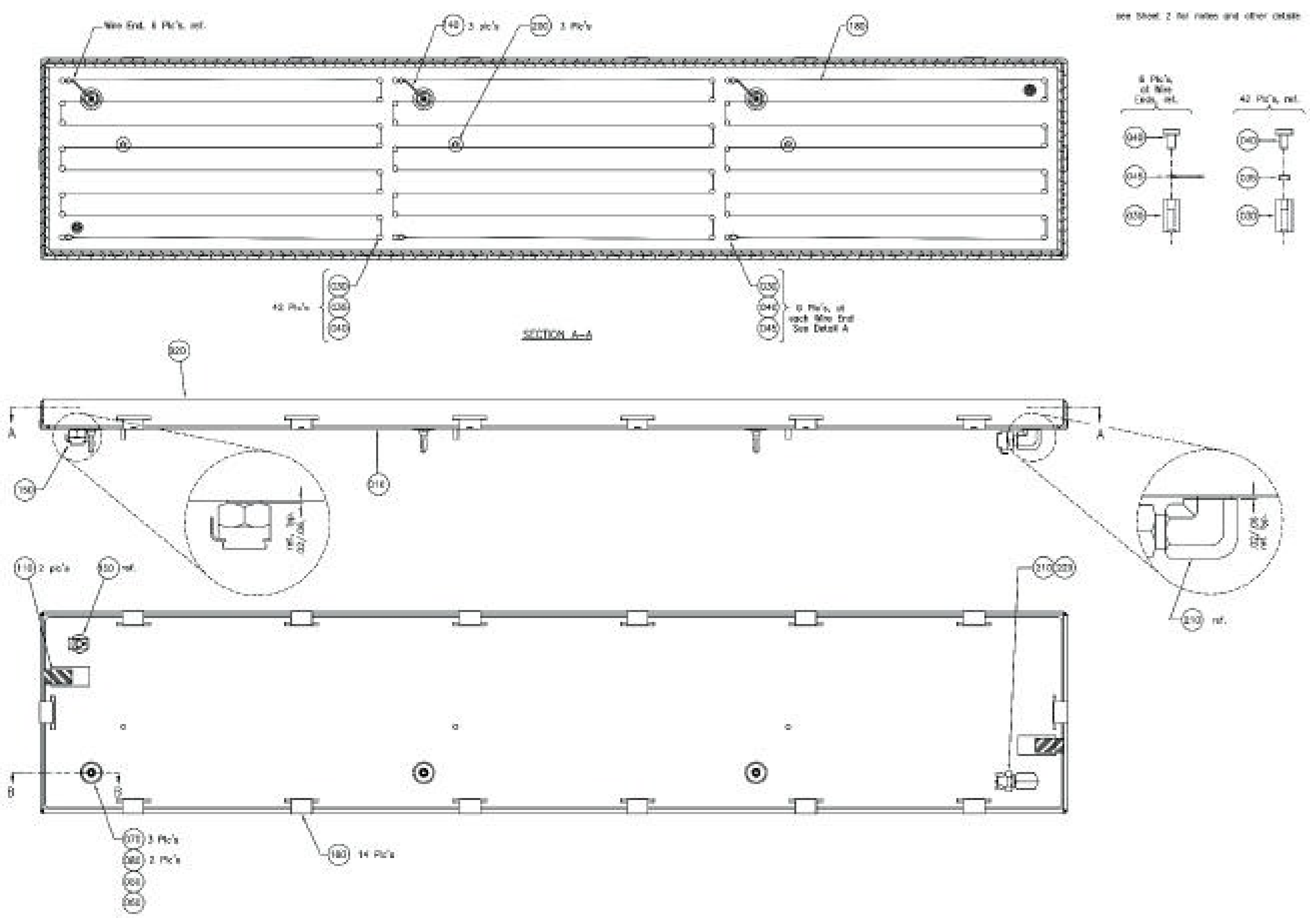

Figure 16-1. 11534-560, Revised detector assembly, long, drawing 1 of 2. (A larger version of this drawing is located in Chapter 22.)

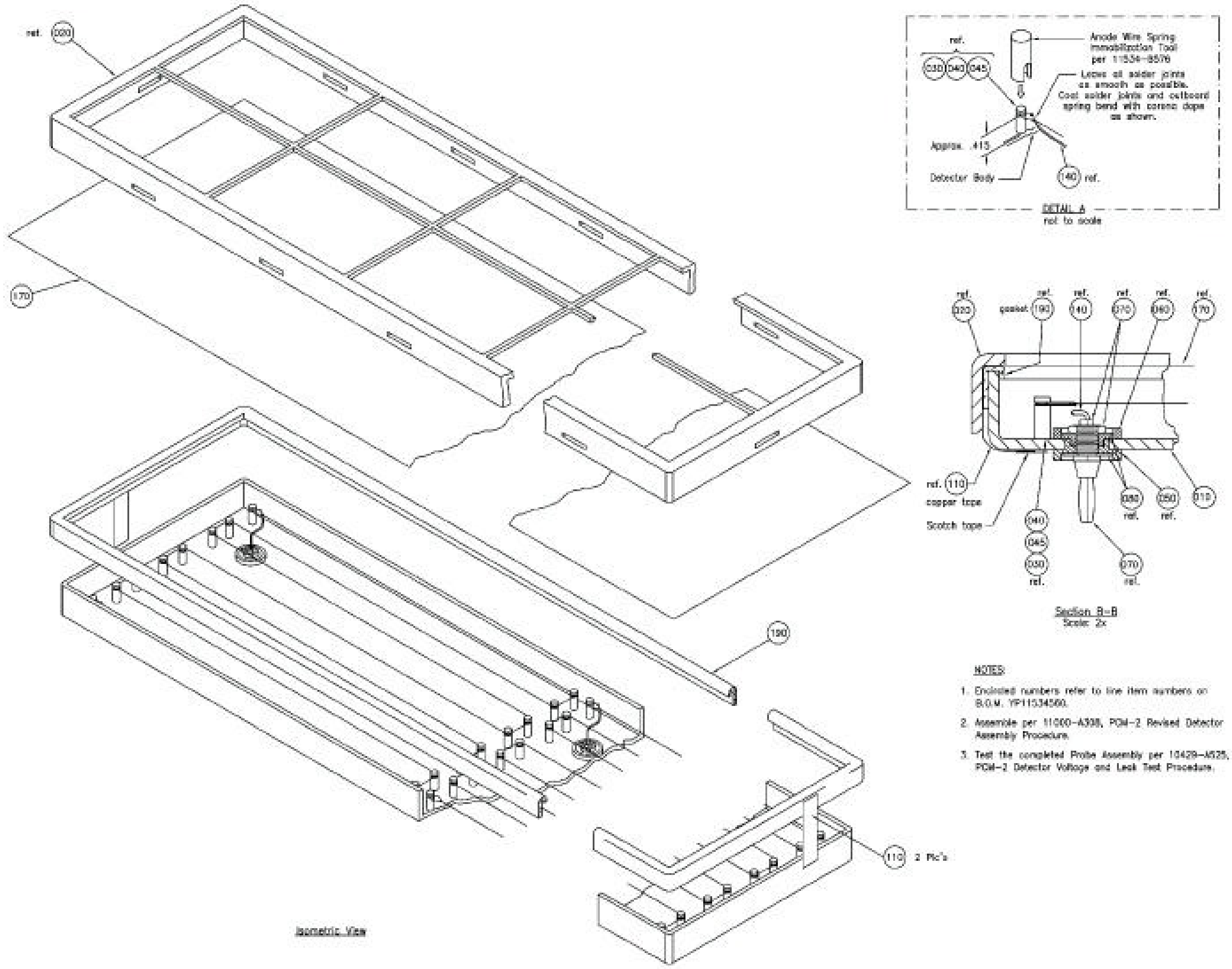

Figure 16-2. 11534-560, Revised detector assembly, long, drawing 2 of 2. (A larger version of this drawing is located in Chapter 22.)

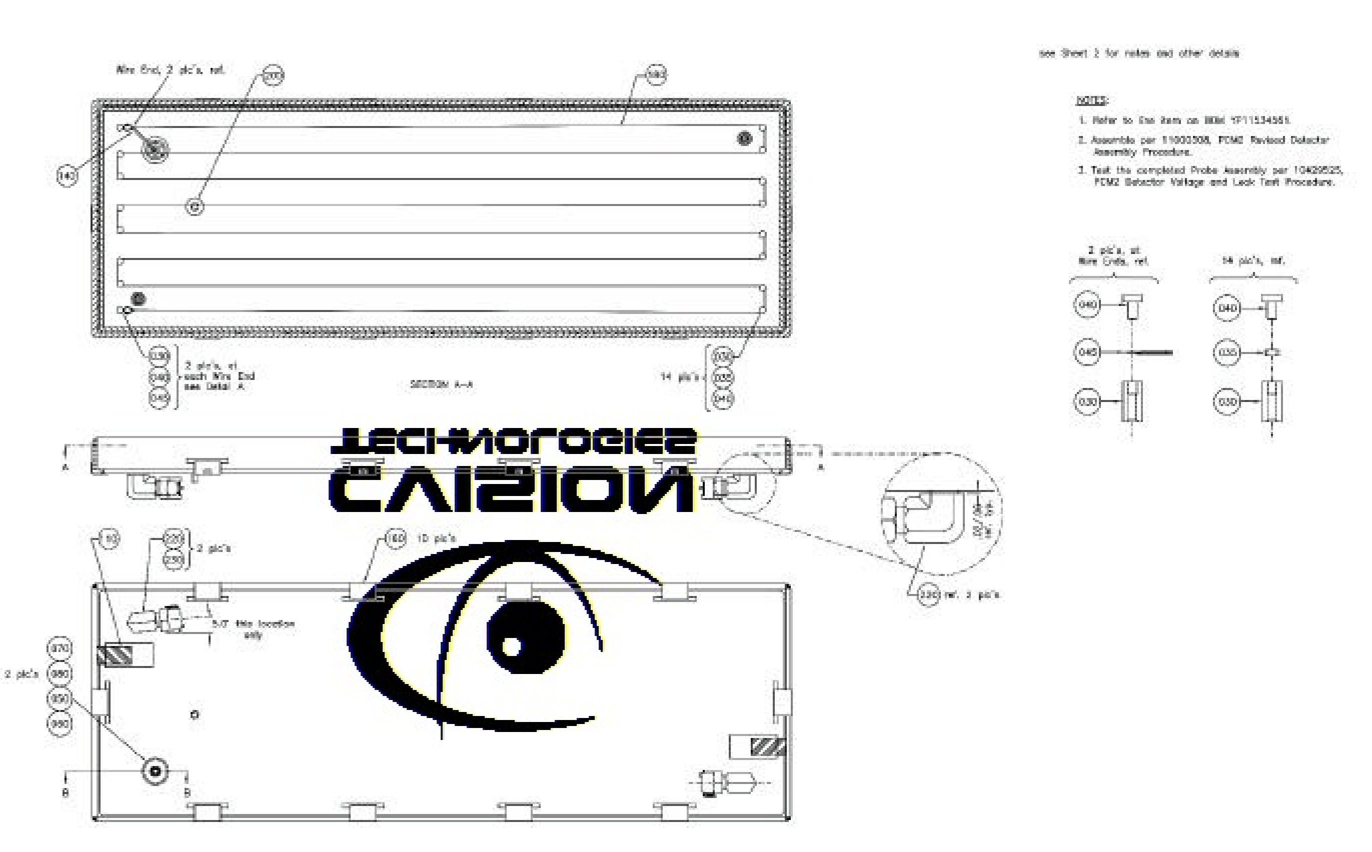

Figure 16-3. 11534-561, Revised detector assembly, medium, drawing 1 of 2. (A larger version of this drawing is located in Chapter 22.)

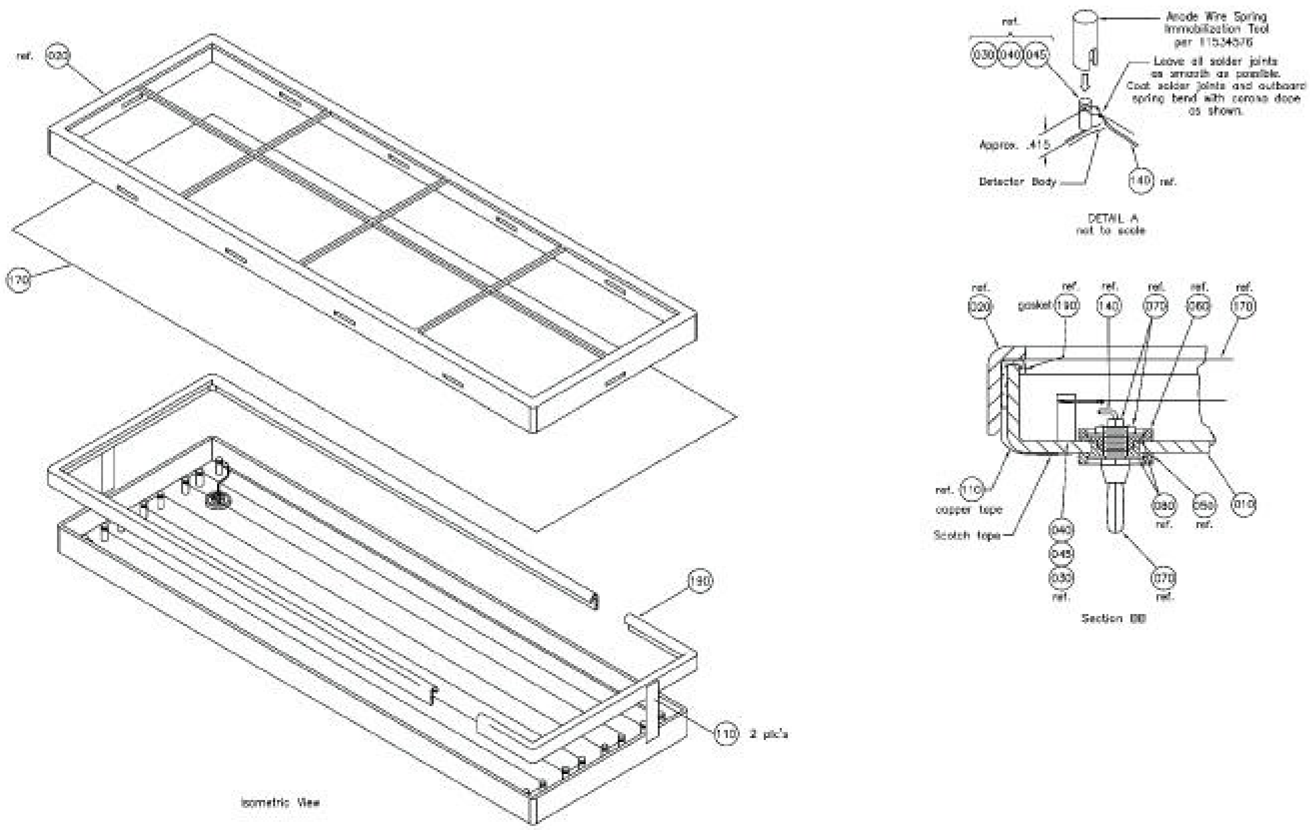

Figure 16-4. 11534-561, Revised detector assembly, medium, drawing 2 of 2. (A larger version of this drawing is located in Chapter 22.)

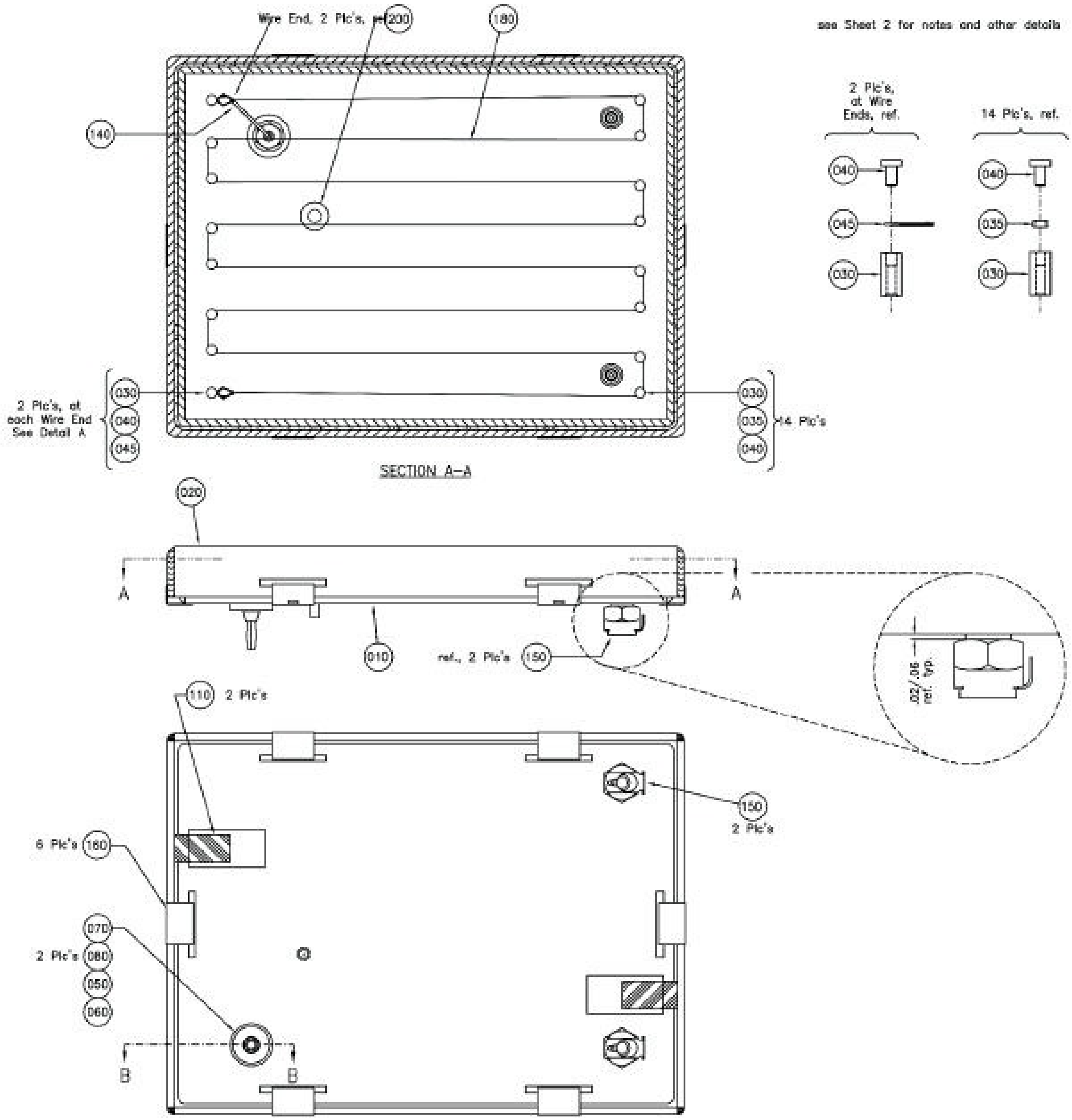

Figure 16-5. 11534-562, Revised detector assembly, small, drawing 1 of 2.

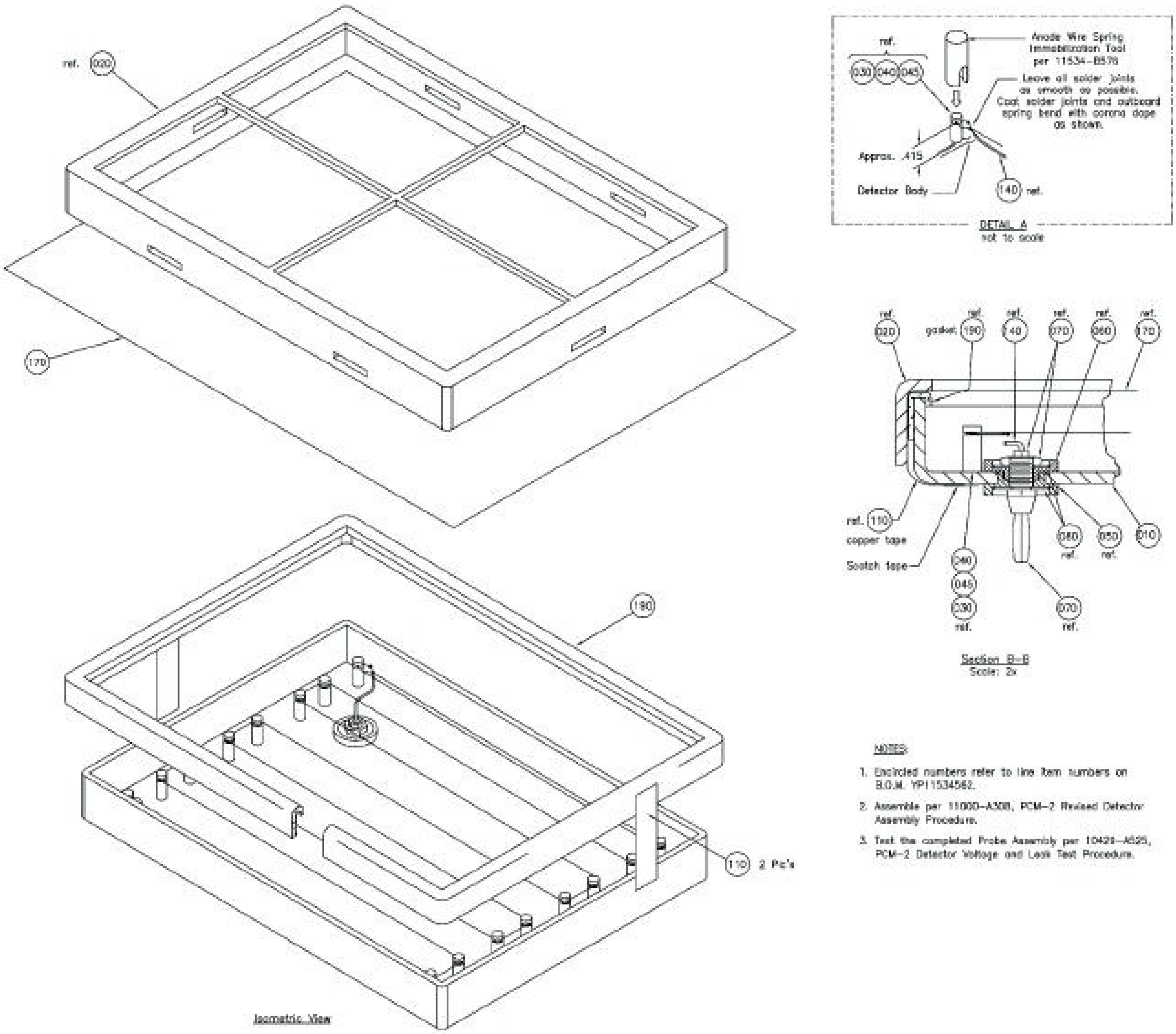

Figure 16-6. 11534-562, Revised detector assembly, small, drawing 2 of 2. (A larger version of this drawing is located in Chapter 22.)

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Chapter 17 Hard Disk Drive

Hard Disk Drive

This option is a 2 GB (or larger) hard disk drive for the PCM-2 instrument. It mounts in the lower electronics enclosure adjacent to the power supply mounting bracket. Addition of this option significantly enlarges the PCM-2's data storage capabilities for transaction files, calibration reports, status log files, source check routine results, etc. It also significantly enhances the unit's overall speed with respect to instrument startup, calibration and troubleshooting.

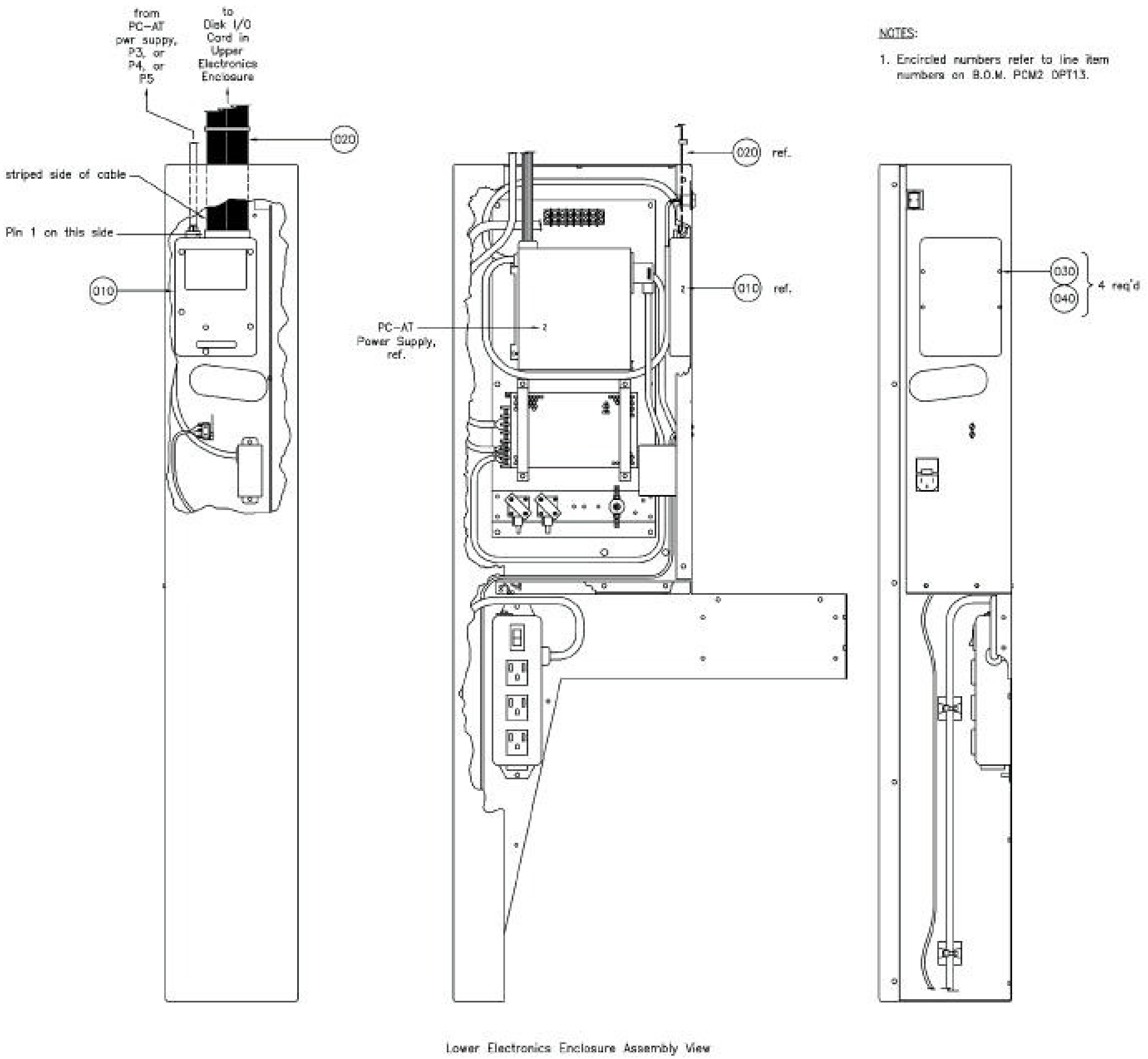

Figure 17-1. 11534-563, Hard disk drive assembly. (A larger version of this drawing is located in Chapter 22.)

Hard Disk Drive Parts List

Table 17-1 lists the electronic items incorporated in the hard drive and contains parts necessary for normal repair.

Table 17-1. Hard Disk Drive Parts List

Item Ref No.	Drawing No.	Part Name	Description	Part No.
010	11534-D563	Hard Disk Drive	2 GB	VEIN49
020	11534-D563	Cable Assembly	Hard Drive, 24" long	VEMI107

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Chapter 18 Swiveling Casters

The PCM-2's swiveling casters consist of two sets: two fixed and two swiveling casters, mounted in the rear and front corners of the unit's base to provide the user with an easily movable instrument platform.

Two independently actuated rubberized machine levelers are also mounted in the unit's base adjacent to the swiveling casters. These spring-loaded levelers are manually actuated through holes located in the sides of the base into a down position with an actuation lever, to stabilize the instrument in a fixed location of operation. Actuating the levelers up enables the user to wheel the unit away from a wall, gas bottle enclosure, or another adjacent instrument for access to its rear or side doors or for decontamination of the unit. The actuation lever stores on a mounting clip in the side door of the instrument.

Note The swiveling casters are designed to provide mobility of the PCM-2 instrument over hard, level and smooth surfaces only. Due to the low clearance design of the leveler mechanisms, usage of the casters for moving the unit over irregular, soft, or inclined surfaces is not recommended. Damage to the caster's leveler mechanisms and the PCM-2 unit itself can occur if movement of the equipped unit is not limited to the approved surface types. ▲

Swiveling Casters Parts List

Table 18-1 lists the items incorporated in the swiveling casters and should contain all parts necessary for normal repair.

Table 18-1. Swiveling Casters Parts List

Item Ref No.	Drawing No.	Part Name	Description	Part No.
010	11534-D340	Swiveling Caster Bracket	Right Front	ZP11534279
012	11534-D340	Swiveling Caster Bracket	Left Front	ZP11534368
020	11534-D340	Fixed Caster Bracket	Rear	ZP11534280
030	11534-D340	Glide Tube	Leveler Actuator	ZP11534276
040	11534-D340	Modified Glide Handle	Leveler Actuator	ZP11534278
050	11534-D340	Glide Cam Shaft	Leveler Actuator	ZP11534275
060	11534-D340	Lift Ring	Leveler Actuator	ZP11534277
070	11534-D340	Glide Bracket	Leveler Actuator	ZP11534274
075	11534-D340	Cam Spacer	Leveler Actuator	ZP11534532

077	11534-D340	Warning Label	Caster Option	ZP11534534
080	11534-D340	Swiveling Caster	Medium Load, 2 Wheel	MMCA20
090	11534-D340	Fixed Caster	Medium Load, 2 Wheel	MMCA21
100	11534-D340	Compression Clip	Actuator Handle	MMCL14
110	11534-D340	Machine Glide	Light, Screw	HDMI172
120	11534-D340	Compression Spring	Leveler Actuator	SGC031
130	11534-D340	Ring Clip	Shaft Retaining	HDRR30
140	11534-D340	Roll Pin	3/16" diameter x 3/4", S.S.	HDMI29
180	11534-D340	Cap Screw	#10-32 x 1/4" Socket Head	SCSH1004
185	11534-D340	Cap Screw	#10-32 x 5/8" Socket Head	SCSH1010
220	11534-D340	Jam Nut	1/2-13 Hex	SCMN20
230	11534-D340	Lock washer	#10, Internal Tooth, S.S.	SCIT0010

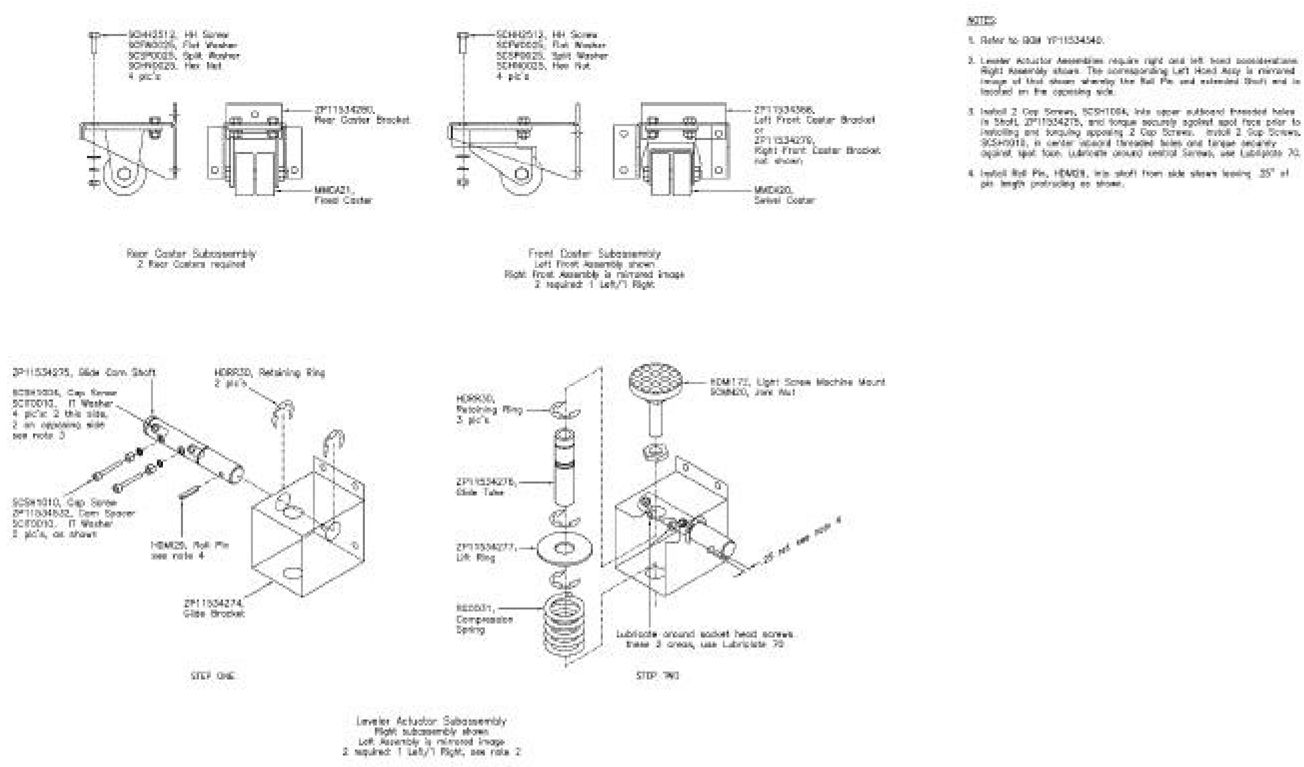

Figure 18-1. 11534-340, Swiveling casters assembly. (A larger version of this drawing is located in Chapter 22.)

Chapter 19 Options

Hand Probe Option

OPT1, Hand Probe

This option for the PCM-2 includes an HP-100C, 100 cm^2 hand-held frisking detector with a detector holder mounted on the left side of the instrument. Also included are a modified modular detector board (MDB, SP28B) and an audible clicker board that clicks proportional to the net count rate of the combined alpha and beta particles being detected. The modified MDB is mounted inside the unit on the left-hand side of the main frame. and the clicker board resides in the ceiling adjacent to the PC speaker-mounting bracket.

PCM-2 units equipped with this option include a display of the hand probe's background and alarm status whenever the probe is removed from its holder. If the hand probe is removed from its cradle during background update or after the results of a measurement are posted, the hand probe readings and the new alarm set points are displayed on the screen for both alpha and beta channels. If the alarm set points are nonzero, the hand probe readings are compared to the alarm set points. If either alarm set point is exceeded, the instrument begins to beep and will continue to do so until the hand probe is replaced in its cradle or until the probe reading falls below the alarm set point. Setting the alarm set point to "0" disables the alarm checking for that channel. The hand probe display automatically disappears when the probe is returned to its holder.

See Chapter 13: "Modular Detector Board" for detailed information regarding the modified configuration of the standard MDB used for the hand probe option.

Hand Probe Parts List

Table 19-1 lists the items incorporated in the hand probe and should contain all parts necessary for normal repair.

Table 19-1. Hand Probe Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
030	11534-D307	Hand Probe Holder	HP-100B/C	ZP11530122
040	11534-D307	Adapter Assembly	HV-to-P10	YP11417019
050	11534-D307	Cable Assembly	Clicker Board	YP11534522
*060	11534-D307	PCBA*	Clicker Board	*YP11532000 or *YP11585000
070	11534-D307	Cable Assembly	Hand Probe Switch	YP11534528
080	11534-D307	Modular Detector Board Assembly	Chassis Mounted	SP28B
090	11534-D307	Hand probe	100 cm2	HP100C
100	11534-D307	Cable Assembly	72" MHV-MHV	CA-85-72
180	11534-D307	1/8" ID Tubing	Black PVC	MMTU68
190	11534-D307	Flow meter	10-100 cc/min	MTFM80
200	11534-D307	Hose “T”	1/8" Hose Barbs	FGPL7
210	11534-D307	Hose Barb	1/8 x 1/8 MPT, Brass	FGBR53
220	11534-D307	Needle Valve	Flow Adjustment	FGMI51

* See “Clicker Board Configuration” on page 19-3 for the clicker PCBA applicable to your PCM-2 unit.

Hand Probe Clicker Board

General Description

The PCM-2 clicker board is used in conjunction with monitors that have the hand probe option installed. The purpose of this board is to output audible clicking tones that are proportional to the combined net count rate (background subtracted) of the alpha and beta hand probe channels. Clicking tones, which emanate from the perforated section of the ceiling, are produced only when the hand probe is removed from its holder on the side of the instrument.

Theory of Operation

The modified modular detector board (SP28B) is connected to the clicker board by the cable YP11534522. The SP28B provides unregulated 10–12 Vdc power and ground to the clicker board. The signal that drives the clicker circuit, provided by the MDB, is fed to the input of integrated circuit A1. A1 provides pulses of constant width and timing, regardless of the duration or spacing of its inputs. The pulses are applied to the transistors Q1 and Q2. The outputs of Q1 and Q2 are connected to the primary side of the transformer T1. The two pulses generated by A1 act in a push–pull fashion to increase the voltage swing across the primary side of the transformer. The transformer steps up this voltage and then applies the voltage across the speakers SK1 and SK2. The volumes of the speakers' outputs are adjusted by potentiometer R4.

Clicker Board Configuration

PCM-2 units with serial numbers 101 through 171, if equipped with the hand probe option, are furnished with the original clicker PCBA (YP11532000). PCM-2 units with serial numbers 172 and subsequent are equipped with the revised clicker PCBA (YP11585000). The original clicker board can be easily distinguished from the revised counterpart by its speaker arrangement. The original board included two piezoelectric sounders and a transformer; the new revised board has no transformer and uses only one speaker mounted face down on the board.

Original Clicker Board Parts List

Table 19-2 lists the items incorporated in the original clicker board and should contain all parts necessary for normal repair.

Table 19-2. Original Clicker Board Parts List

Item Reference No.	Drawing No.	Part Name	Description	Part No.
010	11532-003	PC Board	Clicker	YP11532002
A1	11532-003	I.C.	Dual Monostable Multivibrator	ICHCA4538
C1-4	11532-003	Capacitor	0.01 µF, 50V, 20%	CPCE103P3N
J1	11532-003	Connector	4 pin, 0.10"	COMR1104
Q1-3	11532-003	MOSFET	N-Channel	TRMN2N7000
R1-3, 8, 9	11532-003	Resistor	47K, 1/4W, 5%	RECC473B22
R4	11532-003	Potentiometer	200S, 1/4W, 10%	PTCE201B03
R5	11532-003	Resistor	47S, 1/4W, 5%	RECC470B22
R6, 7	11532-003	Resistor	470K, 1/4W, 5%	RECC474B22
SK1, 2	11532-003	Speaker	Piezoelectric Sound Transducer	ADSP6
T1	11532-003	Transformer	Dual Primary	TFPO38

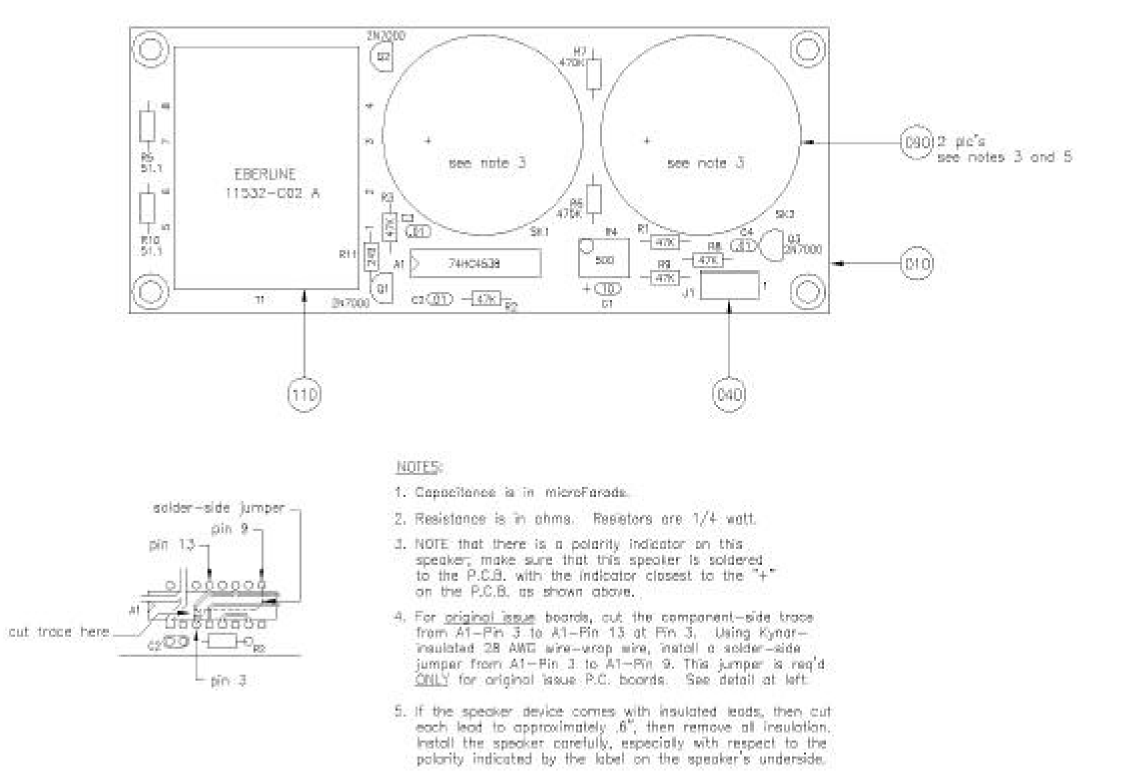

Figure 19-1. 11532-003, Clicker Board II components. (A larger version of this drawing is located in Chapter 22.)

Clicker Board II Parts List

Table 19-3 lists the items incorporated in Clicker Board II and should contain all parts necessary for normal repair.

Table 19-3. Clicker Board II Parts List

Item Ref No.	Drawing No.	Part Name	Description	Part No.
A1	11585-C03	I.C.	Dual Monostable	ICCMA4538B
C2-4	11585-C03	Capacitor	0.01 :F, 50V, 20%	CPCE103P3N
J1	11585-C03	Connector	4 pin, 0.10"	COMR1104
Q1-3	11585-C03	MOSFET	N-Channel	TRMN2N7000
R2, R3	11585-C03	Resistor	27K, 1/4W, 5%	RECC273B22
R1, R8 , R9	11585-C03	Resistor	47K, 1/4W, 5%	RECC473B22
R5, R10	11585-C03	Resistor	5.1S, 1/2W, 10%	RECC511N23
R11	11585-C03	Resistor	249KS,1/4W, 1%	RECE251B12
R4	11585-C03	Potentiometer	500S, 3299W, vert., top adj.	PTCE501B33
SK1	11585-C03	Speaker	11/16 dp, 8S	ADSP3
XA1	11585-C03	IC Socket	16 Pin Dip	SOIC116
C1	11585-C03	Capacitor	10:F, 35V, 10%	CPTA100M3L
140	11585-C03	Retainer	Speaker	ZP10534009
010	11585-C03	PC Board	Clicker Board II	ZP11585002

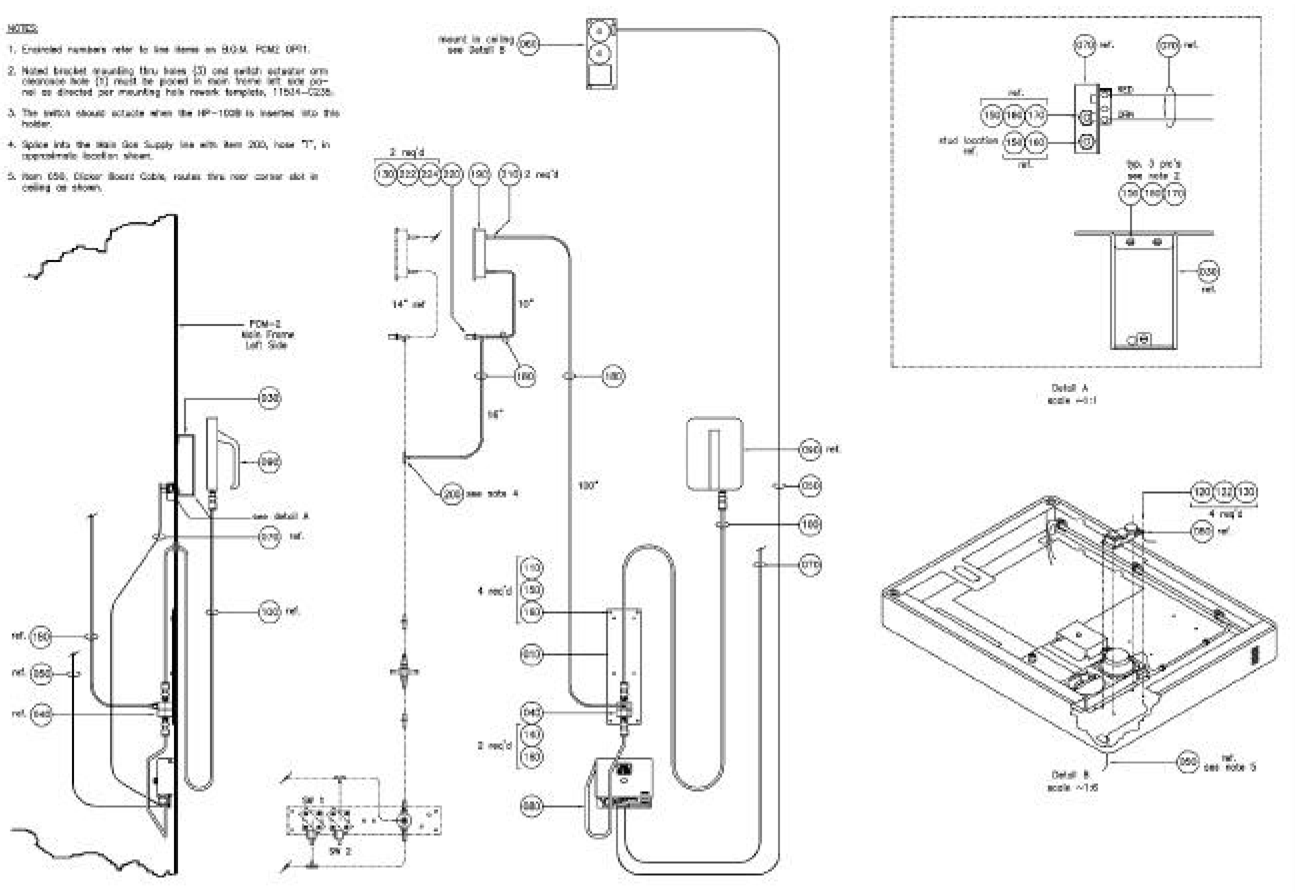

Figure 19-2. 11534-307, Hand probe assembly. (A larger version of this drawing is located in Chapter 22.)

Voice Annunciator

OPT2A, Voice Annunciator

Installation and Use of 16-bit Sound Card

“Sound Card Voice Annunciator” on page 19-7 explains the changes between the voice annunciator (PCM2 OPT2) and PCM-2 OPT2A (PCM2 OPT2A). This version of PCM2 OPT2A uses an IBM 16-bit sound card in place of the voice annunciator board (YP11513000). The sound card is wired to the speaker via its Out port. In the Sound Card Voice Annunciator Option, the voice annunciator board (YP11513000) is not used; instead, a new sound card which supplies the required sound interface is mounted in the onboard computer (see Figure 19-3). New autoexec.bat and config.sys files are loaded. Software for the sound card resides in a new subdirectory (IBMII) on the root directory.

Sound Card Voice Annunciator

OPT2A, Sound Card Voice Annunciator

This option includes a PC sound card, sound card software, and a cable assembly with audio speaker. The voice annunciator speaks phrases which prompt the user for proper body positioning for measurement, announce monitor status, and prompt data input requirements. The sound card voice annunciator uses standard wave files that are easily created on any Windows computer with a sound card and microphone. This allows the user to create custom messages or to provide voice prompting in any language. Wave files with standard PCM-2 messages in English are provided with this option.

The sound card is mounted in an expansion slot on the PCM-2 PC mother board, and its audio speaker mounts adjacent to the PC speaker in a bracket in the ceiling of the unit. (See Figure 19-3.)

The PCM-2 software plays wave files stored on the disk. For example, when someone steps into the PCM-2 and does not begin entering an ID number within 5 seconds (the delay time can be adjusted) the program will look for a file named "ENTERID.WAV" on the disk and play that file if it is located. Wave files are stored in the same directory as the PCM-2=s program (pcm2.exe). This is the PCM2 subdirectory on the hard drive in most installations.

Selecting Voice Annunciator Test on the Utilities menu can test the sound card. This test cycles through all the available wave files. Pressing the F3 key on the Instrument Configuration Parameters menu also tests it by playing the "Voice Annunciator is Active" message (ANNTEST.WAV).

Wave files can be recorded and used to replace the wave files in the instrument. Create the appropriate wave files using a Windows computer equipped with a sound card and microphone.

For best results, use the settings PCM 11,025 Hz, 8 Bit, and Mono when recording the wave files. Name the files as indicated below. Replace the files on the hard disk drive in the PCM-2, using the DOS Copy command. This file is not played during normal use and is convenient for testing new recordings.

The sound card port can be selected and the voice speed can be set on the Instrument Configuration Parameters menu. You may select ports 220, 240, 260 and 280 (hex). The default setting "220" is unlikely to cause a conflict with other hardware. The voice playback speed can be affected by settings used during recording and by processor speed. The voice speed can be adjusted between "1" and "9999" to get the desired voice quality.

To replace a wave file,

1. **Select the Exit to DOS function from the Utilities menu.**

2. **Insert a floppy disk containing the new file.**

3. **Type 'copy a:/FileName.WAV d:\pcm2' (followed by Enter).**

4. **Replace FileName with the appropriate file name such as 'ANNTEST'. (The file should already exist on the hard disk.)**

5. **The system will prompt you with "Overwrite c:\anntest (Yes/No/All)? Respond by entering 'y' and press Enter.**

A standard PCM-2 uses the following wave files:

Aborted.wav	{Measurement cancelled}
Alarm.wav	{Contamination detected}
AnnTest.wav	{Voice annunciator is active, for testing}
ArMout.wav	{Arm out of position}
BkgUpd.wav	{Updating background, please wait}
CNTDONE.wav	{Count complete, please exit.
CNTPOS1.WAV	{Counting position one}
CNTPOS2.WAV	{Counting position two}
DONTEXET.WAV	{Contamination detected, do not exit area or use another Beta Max, Call RadCom}
EIGHT.WAVE	{Eight}
EnterID.wav	{Enter ID number}
EnterRWP.wav	{Enter RWP number}
ENTPOS1.WAV	{Enter position one}

ENTPOS2.WAV	{Enter position two}
FACERT.WAVE	{Face right}
FaceIn.wav	{Face in, turn head right}
FaceOut.wav	{Face out, turn head right}
FAILURE.WAV	{Instrument failure}
FIVE.WAV	{Five}
FOUR.WAV	{Four}
HPROBE.WAV	{Hand probe in use}
IDERROR.WAV	{ID entry error, please re-enter}
IDOK.wav	{ID Entry OK}
INSHANDS.WAV	{Insert hands}
JOBNUM.WAV	{Enter job number}
LFoot.wav	{Move left foot closer}
LFTFTOUT.WAV	{Left foot out of position}
LHand.wav	{Insert left hand}
Lhip.wav	{Move left hip closer}
LSHOULDR.WAV	{Move left shoulder closer}
NINE.WAV	{Nine}
ONE.WAV	{One}
OutOFSRV.WAV	{Instrument out of service}
Password.wav	{Enter password}
PSTION1.WAV	{Assume position one}
PSTION2.WAV	{Assume position two}

RECOUNT.WAV	{Recount required}
RFoot.wav	{Move right foot closer}
RHand.wav	{Insert right hand}
Rhip.wav	{Move right hip closer}
RSHOULDR.WAV	{Move right shoulder closer}
RTFTOUT.WAV	{Right foot out of position}
SEVEN.WAV	{Seven}
SIX.WAV	{Six}
StepDn.wav	{Please step down}
STEPUP.WAV	{Please step up}
TEN.WAV	{Ten}
THREE.WAV	{Three}
TURNARND.WAV	{Turnaround}
TWO.WAV	{Two}

Basic Installation

1. **Mount the speaker as shown in Figure 19-3.**

2. **Mount the sound card in a socket on the PC motherboard and insert the cable jack from the speaker in its Out port.**

3. **Insert the installation disk in the PCM-2 floppy drive and type "A:\INSTALL".**

4. **Press Enter at the DOS prompt.**

The installation disk

- Creates a new directory labeled “C:\IBMII” and installs the following files in the new directory:

  CWBAUDIO.BIN

  CWBAUDIO.INI

  CWBINIT.EXE

  CWBMIX.EXE

- Replaces the autoexec.bat file with an autoexec.bat containing the following lines:

```
PATH C:\PCM2;C:\IBMII;
REM Set sound card
REM *************************
C:\IBMII\CWBMIX /M=15,15 /W=15,15 /L=15,15 /X=1 F=15,15 /C=1,1
/I=L
SET BLASTER=A220 I5 D1 T4
REM Start PCM2 program
REM ************************************
CD PCM2
PCM2 SS
```

- Replaces the config.sys file with a configuration file that contains

```
REM Set Sound Card
DEVICE=c:\ibmii\cwbinit.exe /0
```

Troubleshooting

If the sound annunciation stops,

1. **Remove the RF shield covering the PC motherboard and confirm that the sound card's speaker cable is still connected and that the card is seated in the expansion slot. If any of the above are not secure, connect or reseat accordingly.**

2. **After turning off the power to the PCM-2, install a known operational VEBD52A card in the slot, connect the speaker cable, and verify that the board test works.**

3. **If the above steps do not solve the problem, reinstall the speaker software and the autoexec.bat and config.sys files from the installation disk.**

Voice Annunciator Parts List

Table 19-4 lists the items incorporated in the voice annunciator and should contain all parts necessary for normal repair.

Table 19-4. Voice Annunciator Parts List

Ref. No.	Part Name	Description	Part No.
	Sound Card	Voice Annunciator	VEBD52A
	PGMVEBD52A	Sound Card Software	PGMPCM2VEBD52A
30	Cable Assembly	Speaker and Cable	YP11534645

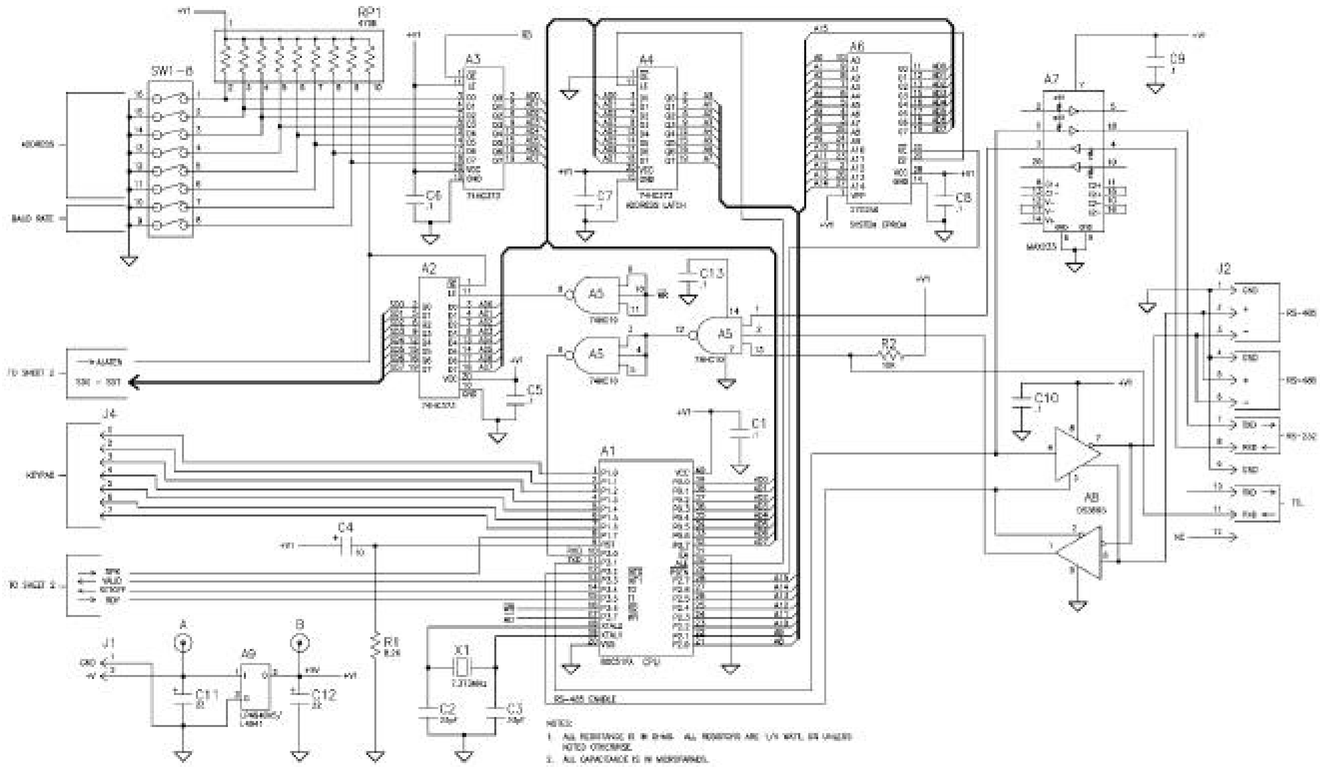

Figure 19-3. 11513-002, Voice annunciator, drawing 1 of 2. (A larger version of this drawing is located in Chapter 22.)

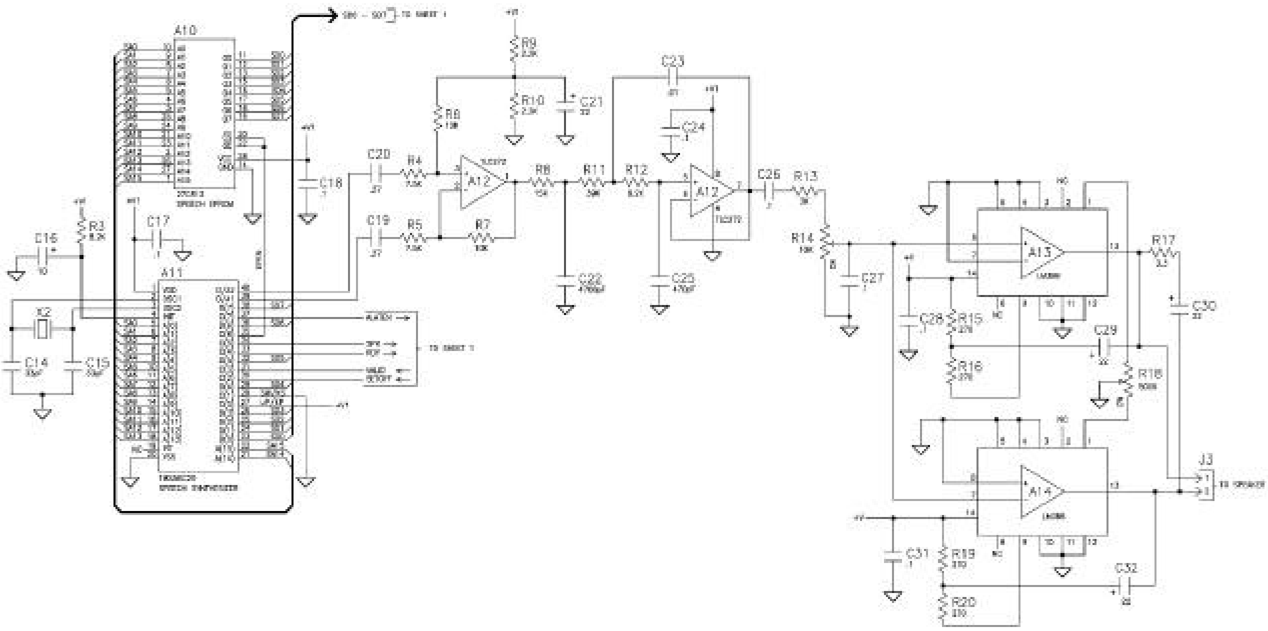

Figure 19-4. 11513-002, Voice annunciator layout, drawing 2 of 2. (A larger version of this drawing is located in Chapter 22.)

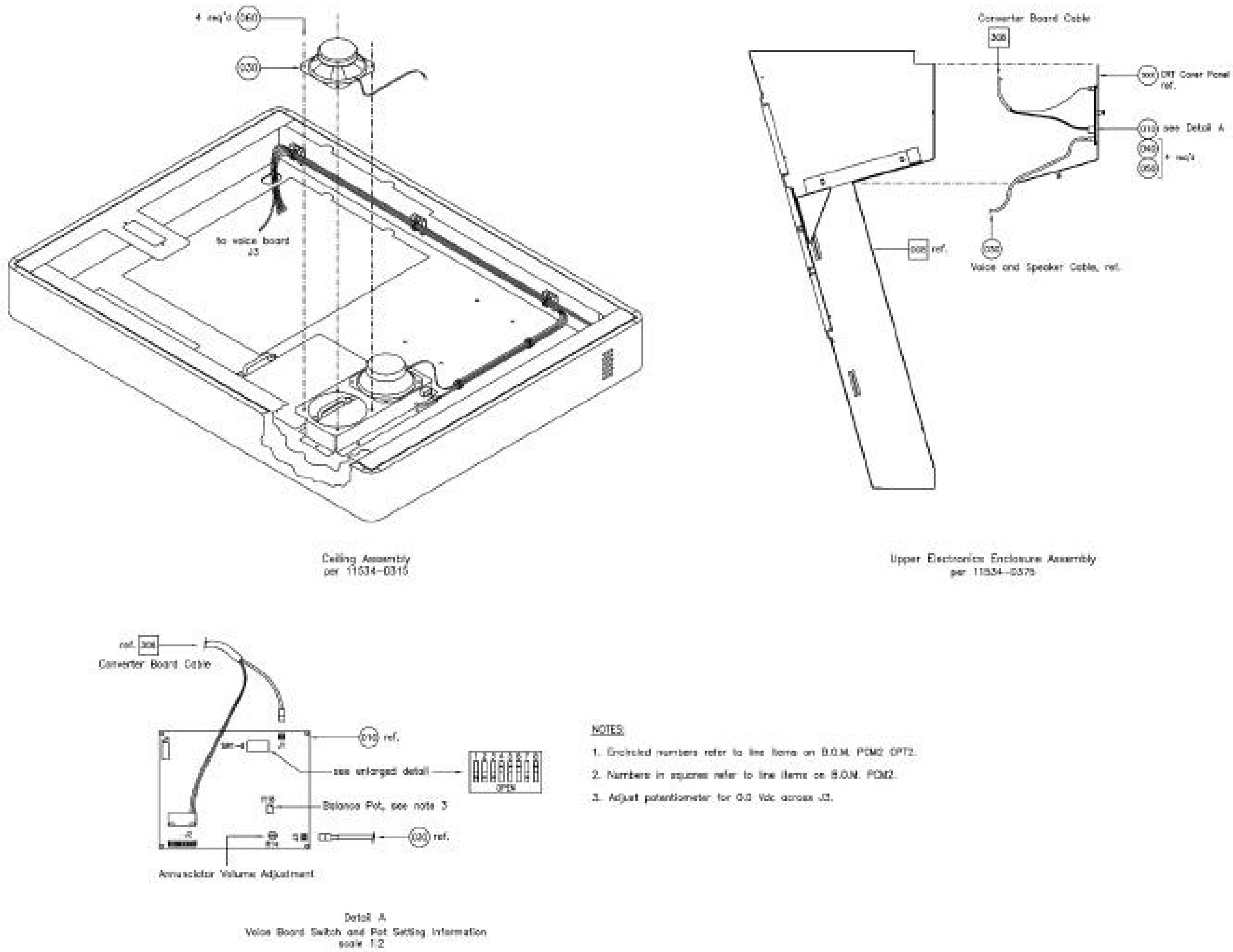

Figure 19-5. 11534-313, Voice annunciator assembly. (A larger version of this drawing is located in Chapter 22.)

Printer Option

OPT3, Printer

The PCM-2 Printer Option enables the user to quickly and easily generate hard copy of various measurement and calibration data such as calibration reports, transaction files, status log reports and source check routines. This option consists of a 9" dot matrix RS-232C compatible printer, and technical manual. The printer sits on a special shelf that is mounted to the side door on the right-hand side of the instrument (as you face the PCM-2).

The PCM-2 interfaces with the printer via a parallel port on the PC. The printer cable is routed internally out of the electronics enclosure, through the cabinet, and externally through a strain relief at the lower right-hand side and rear of the instrument.

Refer to the printer's technical manual for printer mode select switch settings and other configuration information.

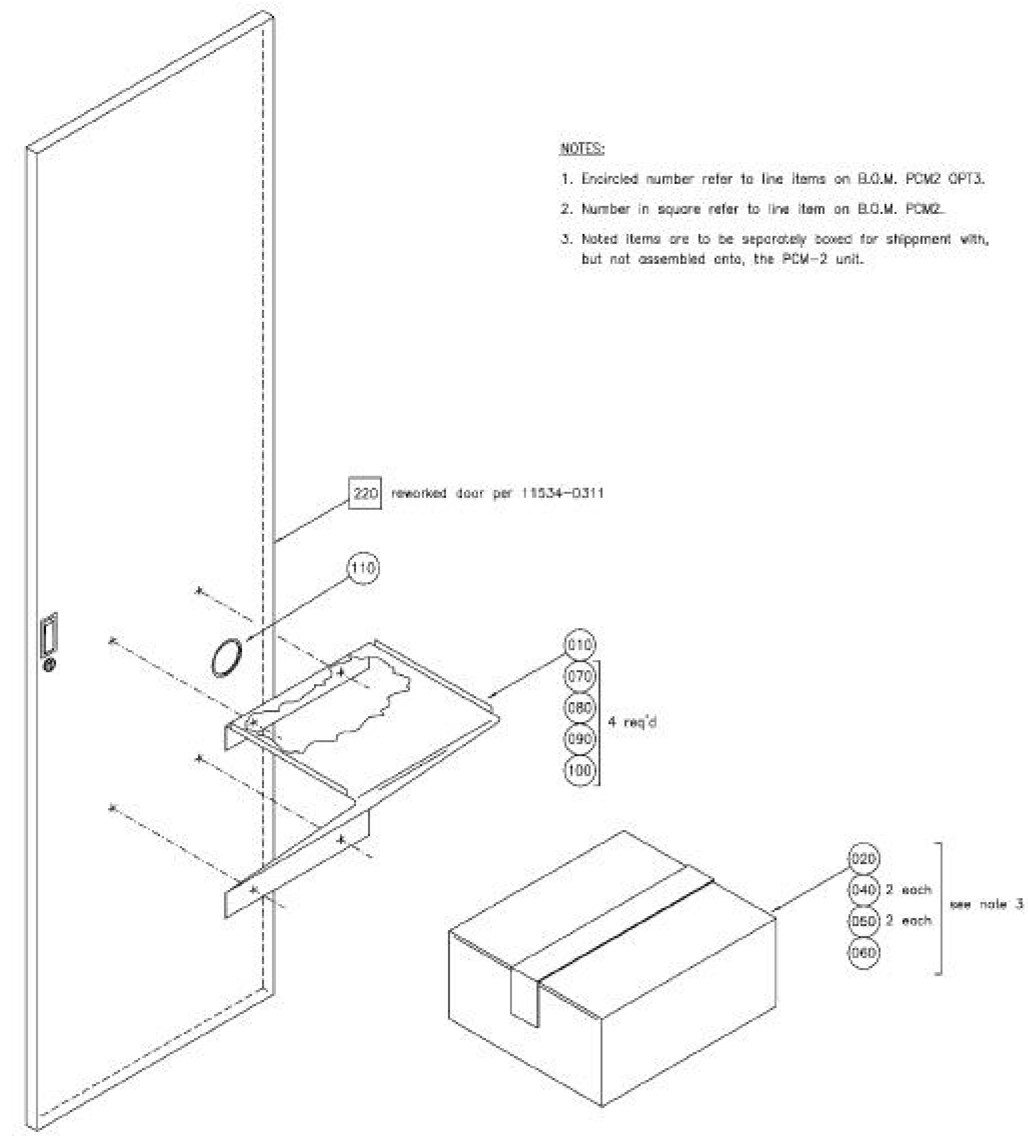

Figure 19-6. 1534-312, Printer assembly. (A larger version of this drawing is located in Chapter 22.)

Printer Parts List

Table 19-5 lists the items incorporated in the printer and should contain all parts necessary for normal repair.

Table 19-5. Printer Parts List

Item Ref No.	Drawing No.	Part Name	Description	Part No.
010	11534-D312	Mounting Shelf	Printer	ZX11351109
020	11534-D312	Printer	Printer, 9" Dot Matrix, Serial Interface	VEMI254
040	11534-D312	Cable Tie	Ty-wrap	HDMI102
050	11534-D312	Ty-wrap Clamp	Adhesive Backed	MMCL44
060	11534-D312	Cable Assembly	Parallel Printer	CA-92-15FT
110	11534-D312	Strain Relief	Printer Cable	WRSR14

Remote Annunciator

OPT4, Remote Annunciator

The remote annunciator option consists of a module with Contamination (Alarm), Counting/Ready, and Recount lights. The panel has an alarm horn and an Alarm Acknowledge (Alarm Ack) switch. When an alarm occurs during a measure cycle, the Contaminated light and the alarm horn turn on. Pressing Alarm Ack silences the remote annunciator's alarm horn but not the instrument's horn.

A steady Ready light indicates the PCM-2 is ready to perform a measurement. A flashing Ready light indicates a measurement in progress. The Recount light indicates the user has exited the PCM-2 before the measure cycle is complete. This option includes the cable CA-89-xxFT (xx denotes cable length in feet), which connects the PCM-2 to the remote annunciator. When ordering this option, the user must specify the length of this cable. Maximum cable length is 200 ft.

Remote Annunciator Board Electronic Parts

Table 19-6 lists the electronic items incorporated in the remote annunciator board and should contain all parts necessary for normal repair.

Table 19-6. Remote Annunciator Board Electronic Parts

Item Ref No.	Drawing No.	Part Name	Description	Part No.
None	11549-C01 S3	Circuit Board	Remote Annunciator	ZP11549001
J1	11549-C01 S3	Connector	15-Pin "D", Male	COMR1315
J1	11549-C01 S3	Jackscrews	0.560" Long Screw	COHD75
SW1	11549-C01 S3	Switch	Momentary Push Button	SWPB14
SW1	11549-C01 S3	Switch Cap	Black	SWHD6
None	11549-C01 S3	Spacer	0.25" x #4 Clearance	SPRB4404

SK1	11549-C01 S3	Buzzer	Piezoelectric Transducer	ADSS6
DS1, 3	11549-C01 S3	LED Bar	Red 6 x 29 mm	OPLP55
DS2	11549-C01 S3	LED Bar	Yellow 6 x 29 mm	OPLP56
R1, 4, 5	11549-C01 S3	Resistor	220 Ohm 1/4W	RECC221B22
R2, 6	11549-C01 S3	Resistor	270 Ohm 1/4W	RECC271B22
R3	11549-C01 S3	Resistor	150 Ohm 1/4W	RECC151B22

The remote annunciator accessory is designed for use with products that incorporate Thermo Electron computer boards in the SP24 series. When connected to P6 of the computer board, the following signals are used:

```
SP24"D" Conn. Signal
P6-Pin #
-------------------------------------------
0101"Alarm" LED drive (active low)
0209"Ready" LED drive (active low)
0302"Recount" LED drive (active low)
0410Buzzer drive (active low)
0503No signal
0611Alarm acknowledge switch (active low)
0704(Unused input, active low)
0812(Unused input, active low)
0905Ground
1013+5 Volt supply
1106+12 Volt supply
1214+12 Volt supply
--07,08,15No connection
```

This connection is typically made in two stages. A short cable internal to the instrument runs from P6 of the computer board to a 15-pin D connector. The signals are then brought to the remote annunciator via an extension cable that is of a length appropriate to the specific installation sit. This cable extends pins 1, 2, 5, 6, 9, 10, 11, 13 and 14 of the D connector from the instrument to the annunciator.

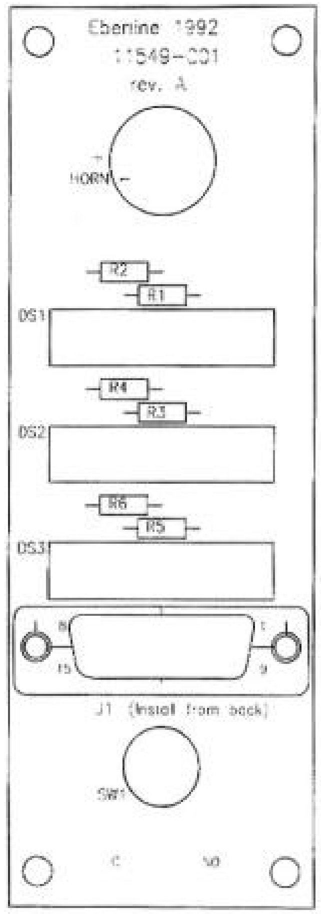

Figure 19-7. 11549-001, Remote annunciator component layout. (A larger version of this drawing is located in Chapter 22.)

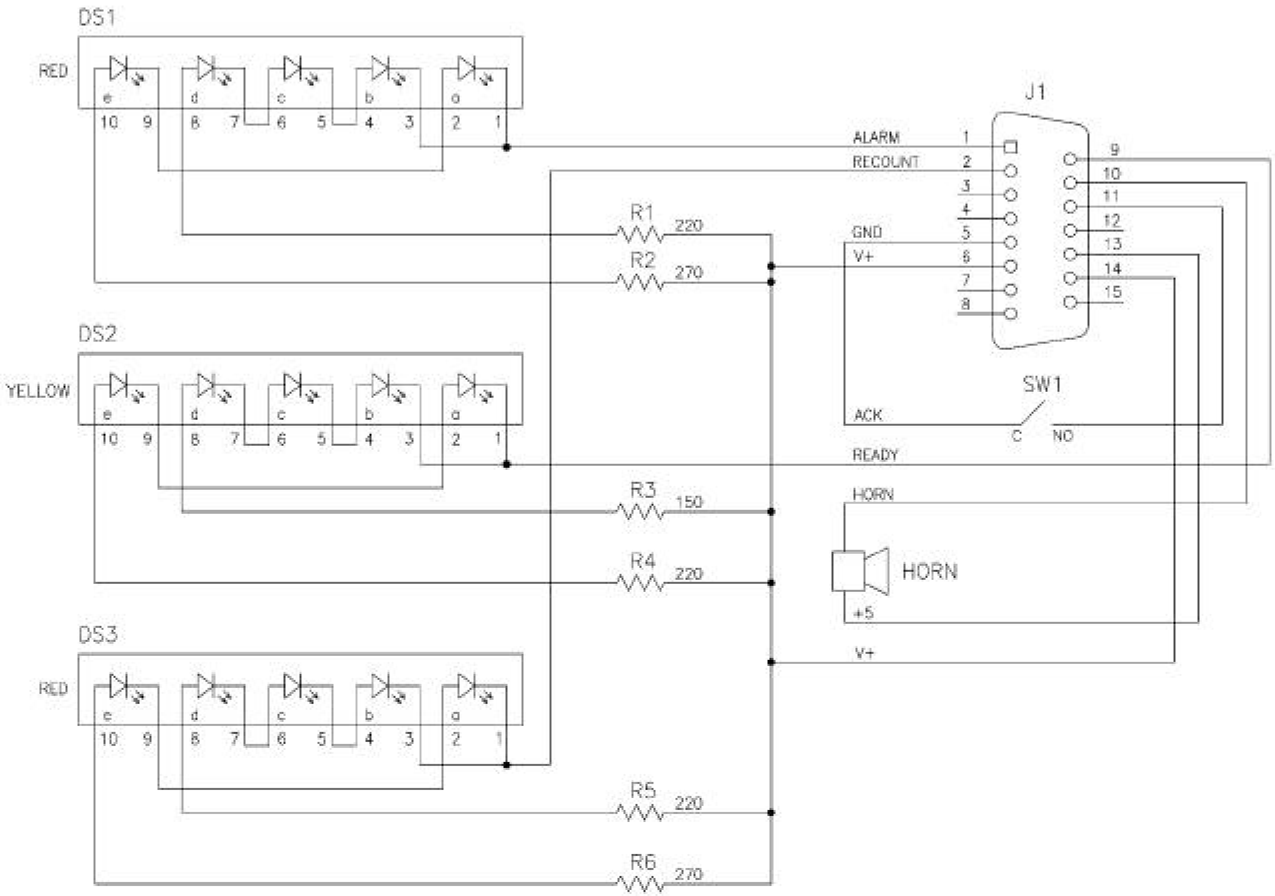

Figure 19-8. 11549-002, Remote annunciator. (A larger version of this drawing is located in Chapter 22.)

Wall Mount Remote Annunciator

OPT14, Wall Mount Remote Annunciator

This option is comprised of a kit which allows the user to wall mount up to four remote annunciator modules in one location.

Remote Annunciator and Wall Mount Remote Annunciator Parts List

Table 19-6 lists the items incorporated in the remote annunciator board and wall mount and should contain all parts necessary for normal repair.

Table 19-7. Remote Annunciator and Wall Mount Remote Annunciator Parts List

Item Ref.No.	Drawing No.	Part Name	Description	Part No.
100	11534-D529	PCBA	Remote Annunciator	YP11549000
110	11534-D529	Wall Mounting Bracket	Remote Annunciator	ZP11534158
120	11534-D531	Wall Bracket Cover	Remote Annunciator	ZP11534195
140	11534-D529	Annunciator Panel	Remote Annunciator	ZP11534157
160	11534-D529	Rubber Foot	Press On	MMRU72
N/A	11534-D531	Cable	Interconnect	CA-89-XXFT

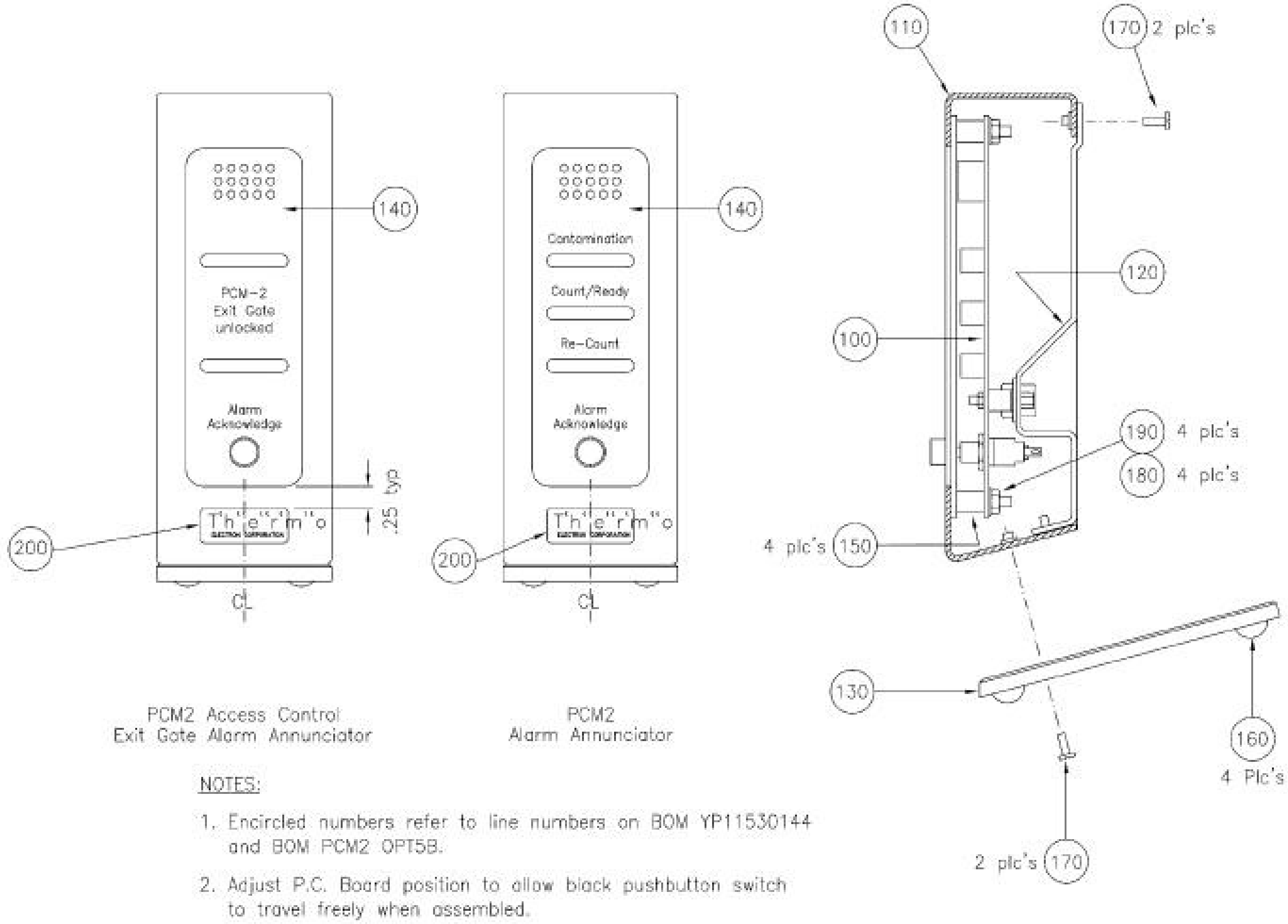

Figure 19-9. 11534-529, Remote annunciator assembly. (A larger version of this drawing is located in Chapter 22.)

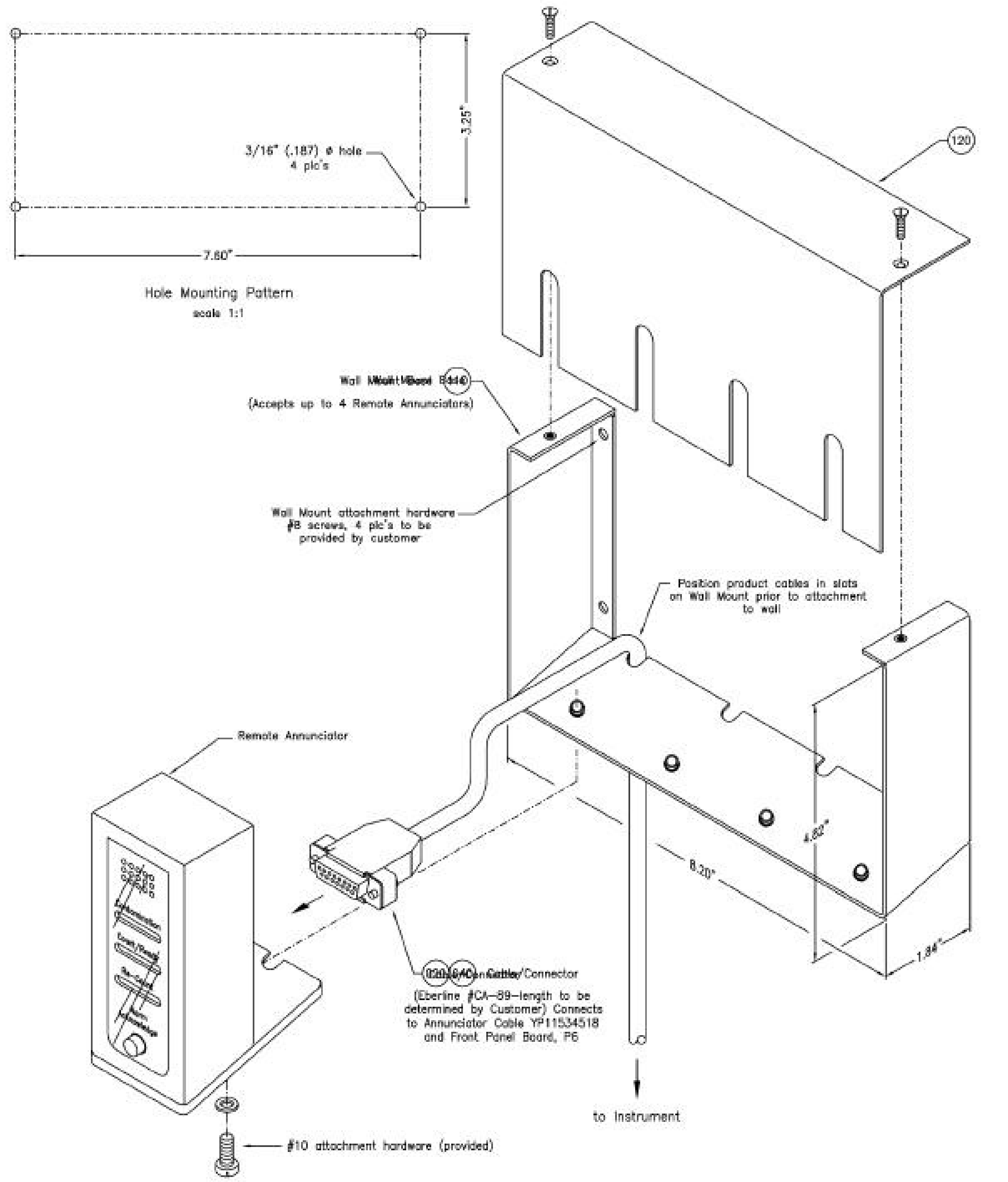

Figure 19-10. 11534-531, Wall-mount/remote annunciator assembly. (A larger version of this drawing is located in Chapter 22.)

Access Control

OPT5 and OPT5A, Access Control

The access control option is a modular system of two (entry and exit, OPT5) or one (exit only, OPT5A) hinged and locking gates that are mechanically and electronically integrated into the PCM-2 to control personnel egress from or ingress into the monitor. The system consists of the exit or entry gates supported by a rugged frame with ceiling and base assemblies which match and mount directly to the front of the PCM-2 unit.

Standard system features include 500-lb electromagnetic gate locks, thrust bearing supported swinging tubular steel and powder coated gates, dampened gas cylinder gate return springs, emergency exit gate lock override switch bar, audible emergency exit gate lock override alarm and custom programmable relock/alarm time delay relay.

Optional features include

- Audible / visual remote exit gate lock override alarm.
- Roof-mounted local exit gate lock override alarm strobe beacon.
- Remote pull station for centrally unlocking the exit gates of one or multiple PCM-2 access control units.

System Operation

Personnel access through the unit is controlled by the PCM-2's main computer by continuously monitoring contamination measurement status and assigning gate lock commands accordingly. For example, a user enters the PCM-2 from the left-hand side of the unit in its ready-to-measure condition through a normally unlocked entry gate (exiting the unit to the right by a normally locked exit gate is prohibited). The user undergoes the normal measurement cycle in both face-in and face-out body positions. If the PCM-2 posts a contamination alarm for either of the measurements the entry and exit gates will remain unlocked and locked respectively, allowing the user to go back to the left through the entry gate only for frisking and decontamination procedures.

Conversely, if the PCM-2 posts the All Clear, OK to Exit display after the measurement cycle, the entry and exit gates are simultaneously locked and unlocked respectively and the user can then exit the unit through the exit gate to leave the facility. In the All Clear scenario, the entry gate is locked in order to disallow potential tail-gaters (i.e., those users who might try to slip through the unit unmeasured on the heels of the previous uncontaminated user). For access control units configured with exit gates only (OPT5A), this automatic tail-gating safeguard can obviously not be realized.

The PCM-2 commands the exit gate lock to be energized (locked) continuously while the unit is turned on and operational in any mode other than when posting the All Clear instrument status. The exit gate is unlocked whenever the instrument is intentionally turned off or whenever electrical power is otherwise interrupted (i.e., in the case of a power outage). The entry gate is only locked during the brief All Clear instrument status periods when in use.

Note The gate locks used on the PCM-2 access control unit are electromagnets which when energized with the gates open can erase or scramble data stored on magnetic media (e.g., computer floppy disks, audio and video tape, magnetic ID badges and credit and bank cards). Therefore, users and maintenance personnel should avoid bringing magnetic media in close proximity with the magnetic exit gate latch when the exit gate will be open for longer than 5 seconds. ▲

System Adjustments

The unit's entry and exit gates are each equipped with a gas cylinder return spring and air dashpot dampener which interact to smoothly return the exit gate back to the fully closed and locked position. The gates' dampeners have been adjusted at Thermo Electron during system assembly to sufficiently deacelerate the returning gate from any open position. Due to variances between the air dashpot components themselves, each access control unit's dashpots have been uniquely adjusted to achieve consistent entry and exit gate return actions. Some initial break-in wearing of the gates' axis bearings and return mechanism components is likely to occur within the first year of operation which may necessitate subsequent readjustment of the air dashpots to maintain appropriate gate return rates and smooth gate closure actions.

If either dashpot requires adjustment, first remove the upper cover panel from atop the PCM-2. The large cylindrical dashpot components are located directly above the gas return springs in the ceiling assembly of the access control module (see Figure 19-13). The dashpots are equipped with an adjustable orifice knob at the rear mounting bracket end of the cylinder that allows infinite adjustability within its dampening range. To adjust the degree of dampening, simply rotate the adjustment knob slightly in the direction needed. If more dampening is needed to keep the gate from slamming shut, rotate the adjustment knob clockwise. If the gate is returning too slowly or is not fully closing against its magnetic lock strike, rotate the adjustment knob counter-clockwise. A proper adjusted dashpot should dampen the return of a fully open and released gate and not take an excessive amount of time for the gate to close completely against the lock strike on the PCM-2 cabinet. This is the extent of the mechanical adjustments that the access control unit may require. However, there are also possible electrical adjustments that can be made.

The access control electric circuitry includes a time delay relay that controls the duration that the exit gate remains unlocked (and the entry gate remains locked) after the PCM-2 has performed a successful clean measurement. This relay has 16 possible time delay ranges defined by switch settings that allow between 0.1 seconds to 120 minutes of time delay. An additional rotary knob on the top of the relay body allows adjustment between the minimum and maximum delay intervals within each possible setting.

Access control units are preset with a time delay of approximately 10 seconds by Thermo Electron during manufacture. This 10-second default interval has been determined to be effective for providing sufficient time to allow the user to exit the unit without allowing potential tail-gating of other users behind the first. It allows the exit gate to lock relatively quickly after the user has exited the unit.

The time delay can be adjusted by the customer to support the potential for specific exit gate unlock time intervals other than the noted factory setting. The table of the time delay intervals and the corresponding switch settings, printed on the side of the relay module itself is shown in Figure 19-11. Power to the access control unit should be turned off prior to resetting the time delay relay.

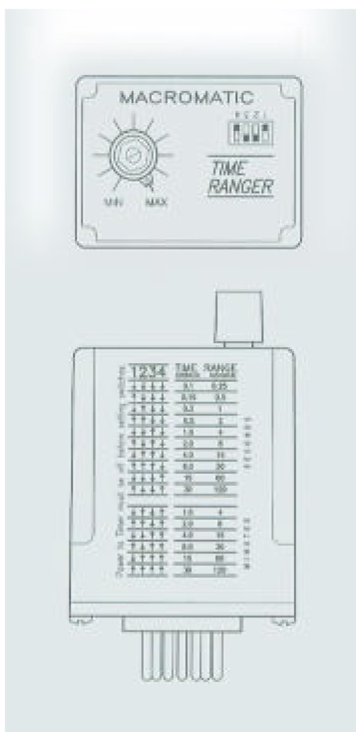

Figure 19-11. Time delay relay switch settings. (A larger version of this drawing is located in Chapter 22.)

Optional Features

The following three optional features may be added to the PCM-2 access control unit:

Remote Alarm Annunciator

This option consists of a small remote module which visually displays a red light and emits an audible tone to communicate alarms for either an unauthorized exit from or an emergency exit gate lock override condition at an access control equipped PCM-2 unit. The remote alarm module features a push-button Alarm Acknowledge switch to manually interrupt the audible alarm tone and visual alarm light. The typical application for this remote alarm annunciator module is for installation in a guard station where remote monitoring of personnel egress from a single PCM-2 or from multiple PCM-2s is desirable. This option includes the interconnecting cable CA-109-XXFT (XX denotes cable length in feet) The length of this cable, up to a 200-ft. maximum, must be specified by the user when ordering this option. The remote alarm modules can simply set upright on any horizontal surface or up to four modules can be wall mounted with the use of an optional wall-mounting fixture (see "Wall Mount Remote Annunciator" on page 19-21).

Local Alarm Beacon

This accessory is simply a red strobe light which illuminates when the access control unit is in an emergency gate lock override status. The alarm beacon is mounted atop the access control unit on the upper cover panel providing maximum visibility to Health Safety personnel that may be monitoring the system nearby. This option is recommended for customers who intend to operate multiple PCM-2s with access control adjacent to one another in the same area so as to provide the capability of instant visual identification of a single alarmed unit. This option can be easily retrofitted to any access control unit in the field.

Remote Pull Station

Marked with the familiar Pull in Case of Fire lettering and equipped with a key lock reset, this remote switch is intended for installation in a guard station where remote override of one or multiple exit gate locks is necessary in the event of fire or other emergency situations which require immediate personnel egress. This option includes only the pull station switch itself, which can be interwired with any number of PCM-2s. Since each facility will likely have its own unique wiring requirements for this remote switch, no interconnecting cable is provided with the option. Thermo Electron Customer Service and Engineering groups are available to provide design recommendations and services for installation and wiring of this safety-related option.

Detector Parts List

Table 19-8 lists the electronic items incorporated in the detector and should contain all parts necessary for normal repair. This table does not include parts references for the remote alarm annunciator wall mount bracket. For wall mount parts listings, refer to Table 19-7.

Table 19-8. Detector Parts List

Item Ref No.	Drawing No.	Part Name	Description	Part No.
100	11534-C529	PCBA	Remote Alarm Annunciator	YP11549000
140	11534-C529	Annunciator Panel	Remote Alarm Annunciator	ZP11534595
160	11534-C529	Rubber Foot	Press On	MMRU72
N/A	11534-C529	Interconnect Cable	Remote Alarm Annunciator	CA109XXFT
N/A	11534-C529	Fire Alarm Pull Station	Remote Gate Unlock Switch	MEVE184
N/A	11534-C529	Cable Assembly	Local Alarm Beacon	YP11534594
N/A	11534-C529	Red Strobe Beacon	Alarm	LPAS32

Access Control Parts List

Table 19-9 lists the electronic items incorporated in the detector and should contain all parts necessary for normal repair.

Table 19-9. Access Control Parts List

Item Ref No.	Drawing No.	Part Name	Description	Part No.
180	11534-D477	Bearing Support	Lower	ZP11534430
300	11534-D477	Thrust Bearing	Lower Gate Shaft	MMBG15
320	11534-D477	Flanged Bearing	Lower Gate Shaft	MMBG17
322	11534-D477	Hole Plug	Entry Gate Shaft	MMBZ27
360	11534-D477	Furniture Glide	Base Support	HDMI12
180	11534-D477	Bearing Support	Lower	ZP11534430
080	11534-D478	Cable Assembly	AC Power	YP11534469
090	11534-D478	Cable Assembly	Gate Position Switch	YP11534470
130	11534-D478	Cable Assembly	Relays	YP11534481
N/A	11534-D478	Cable Assembly	PCM-2 Interface	YP11534472
170	11534-D478	Bearing Support	Upper	ZP11534429
210	11534-D478	Switch Mounting Bracket	Exit Gate	ZP11534458
220	11534-D478	Switch Mounting Bracket	Entry Gate	ZX11534458
230	11534-D478	Mounting Bracket	Gas Spring & Dashpot	ZP11534457
310	11534-D478	Flanged Bearing	Upper Gate Shaft	MMBG16
322	11534-D478	Hole Plug	Entry Gate Shaft	MMBZ27
340	11534-D478	Rubber Grommet	1" id x 1 3/4 od x 3/32"	MMRU99
390	11534-D478	Rubber Bumper	Gate Stop	MMRU6
410	11534-D478	Power Supply	12v, 1.3 a	MEVE168
420	11534-D478	Terminal Strip		COTB41
430	11534-D478	Marker Strip		COHD39
470	11534-D478	Relay	Remote Gate Unlock	RLGP13
480	11534-D478	Relay Socket	Remote Gate Unlock	RLSO3
490	11534-D478	Relay	12v, Time Delay	RLTD01
500	11534-D478	Relay Socket	12v, Time Delay	RLSO15
510	11534-D478	Cable Clamp	1/4" diameter	MMCL62
100	11534-D479	Cable Assembly	Magnetic Lock	YP11534471
N/A	11534-D479	Magnetic Lock and Strike Plate	Entry and Exit Gates	MEVE183
120	11534-D479	Cable Assembly	Emergency Exit Switch	YP11534475
N/A	11534-D479	Sensing Edge Switch	Emergency Exit	SWMI61
250	11534-D479	Mounting Plate	Gate Handle	ZP11534465
260	11534-D479	Mounting Plate	Emergency Exit Switch	ZP11534466
330	11534-D479	Holder Channel	Sensing Edge	MMMI170
332	11534-D479	Panel Grommet	Rubber	MMRU56

370	11534-D479	Handle	Gates	HDHA24
100	11534-D480	Cable Assembly	Magnetic Lock	YP11534471
132	11534-D480	Modified Rod End	Dashpot	YP11534605
140	11534-D480	Retaining Plate	Base	ZP11534436
150	11534-D480	Retaining Plate	Ceiling	YP11534437
190	11534-D480	Stop Arm Bell Crank	Gates	ZP11534431
200	11534-D480	Key	Upper Gate Shafts	ZP11534444
240	11534-D480	Lock Housing	Exit Gate	ZP11534459
332	11534-D480	Panel Grommet	Rubber	MMRU56
350	11534-D480	Knurled Thumb Screw	#10-32 x 3/4' long x 3/4 diam.	SCTS17
380	11534-D480	Panel Grommet	Rubber	MMRU6
392	11534-D480	Air Dashpot	Gate Return Dampening	MMMI172
400	11534-D480	Gas Compression Spring	Gates Return	MMMI165
520	11534-D480	Flexible Conduit	Wire routing	MMTU41
730	11534-D480	Set Screw	1/4-20 x 1/4" long	SCSS2504

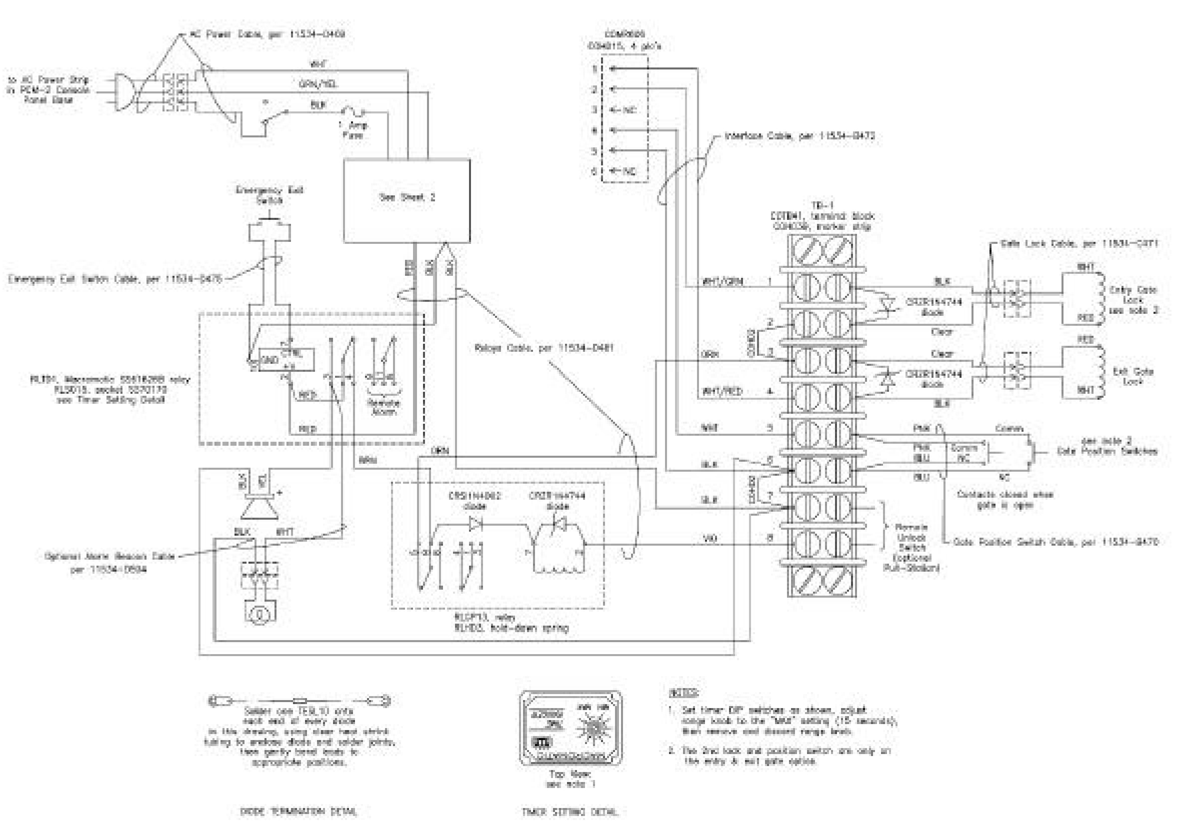

Figure 19-12. Access control, base assembly, 11534-477. (A larger version of this drawing is located in Chapter 22.)

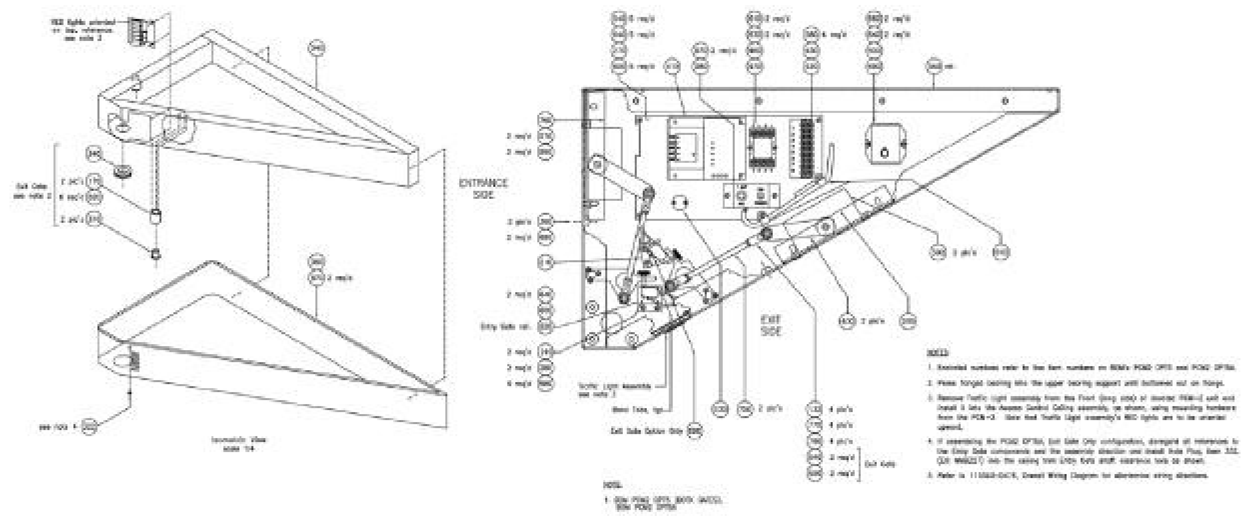

Figure 19-13. 11534-478, Access control, ceiling assembly. (A larger version of this drawing is located in Chapter 22.)

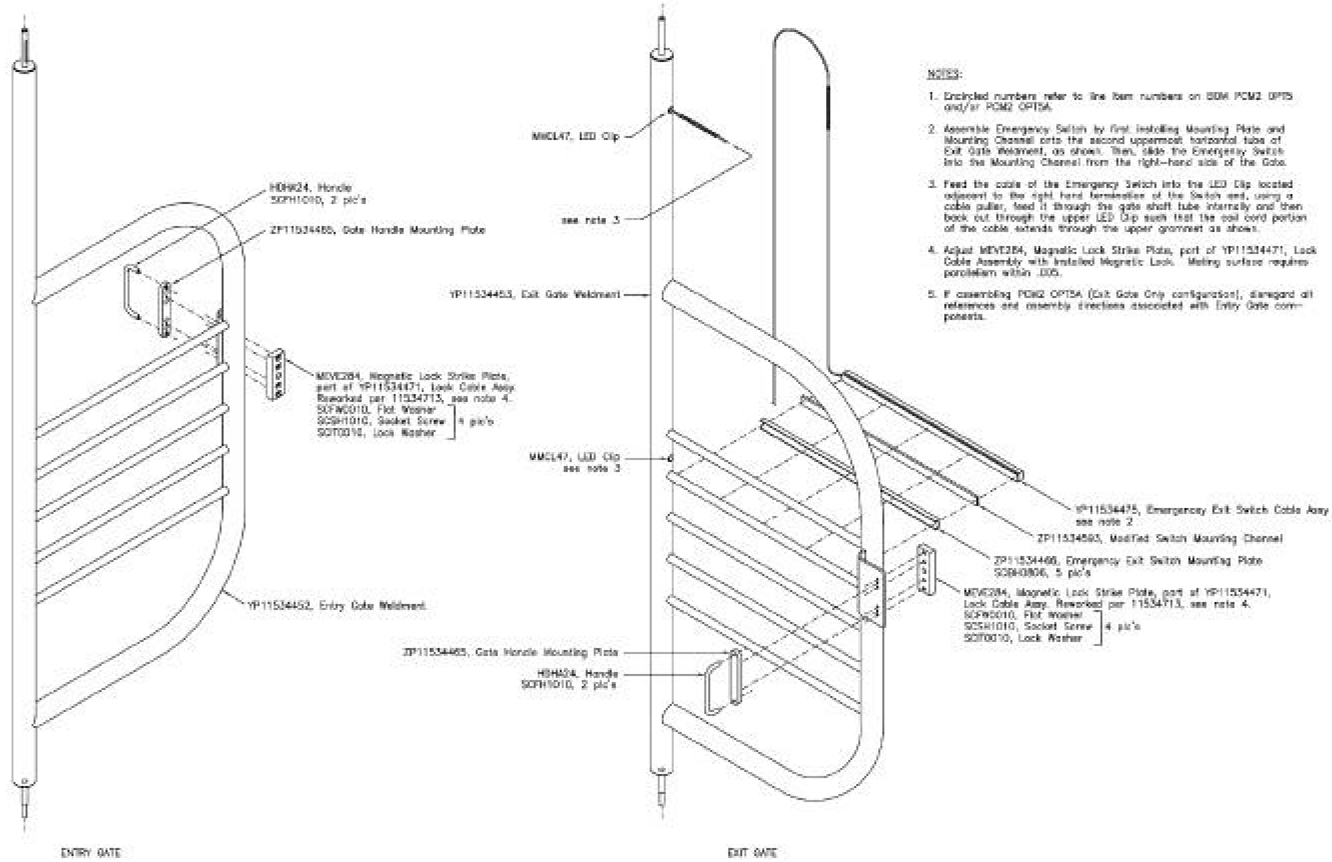

Figure 19-14. 11534-479, Access control, gates assembly. (A larger version of this drawing is located in Chapter 22.)

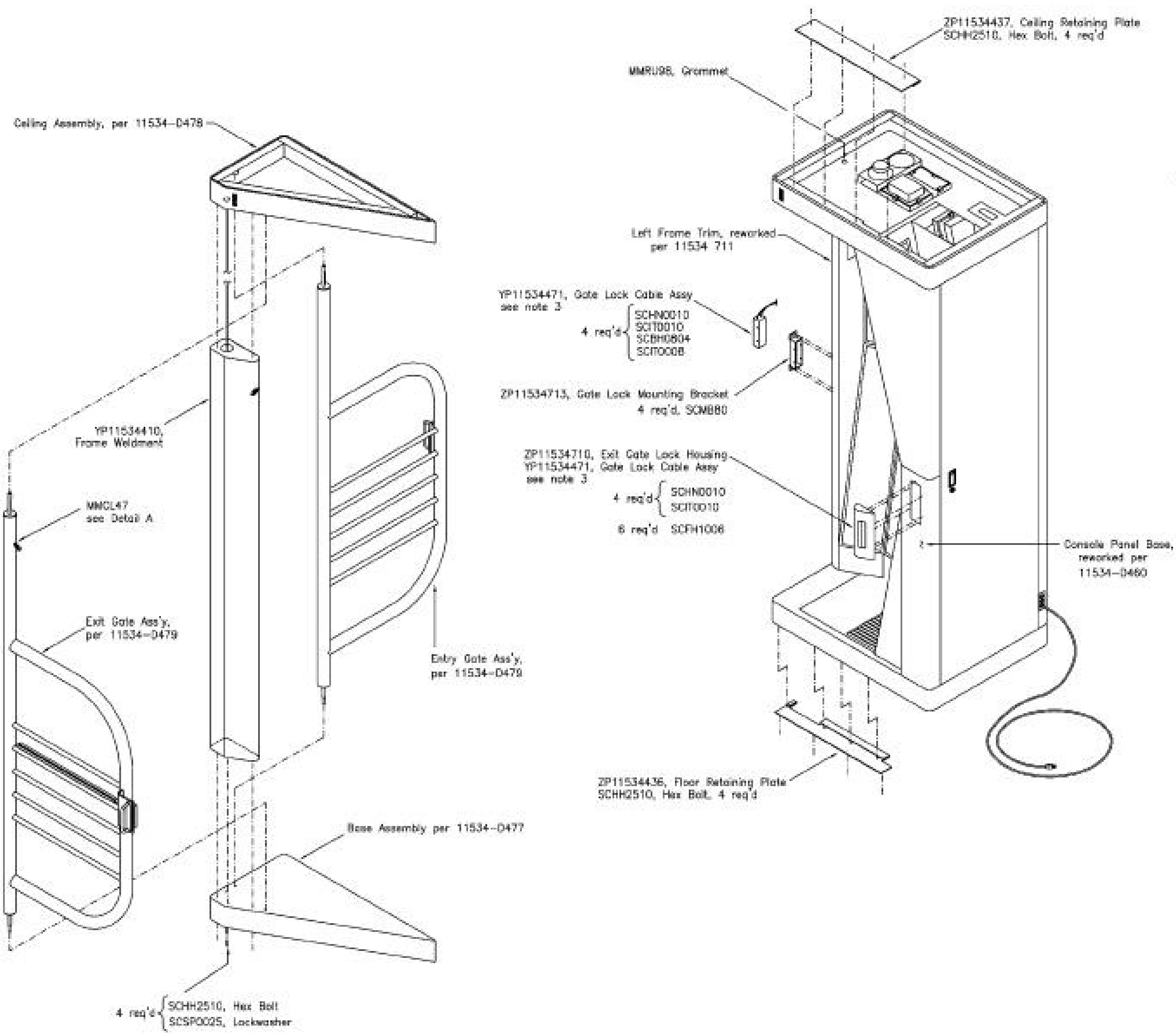

Figure 19-15. 11534-480, Access control, overall assembly, drawing 1 of 3. (A larger version of this drawing is located in Chapter 22.)

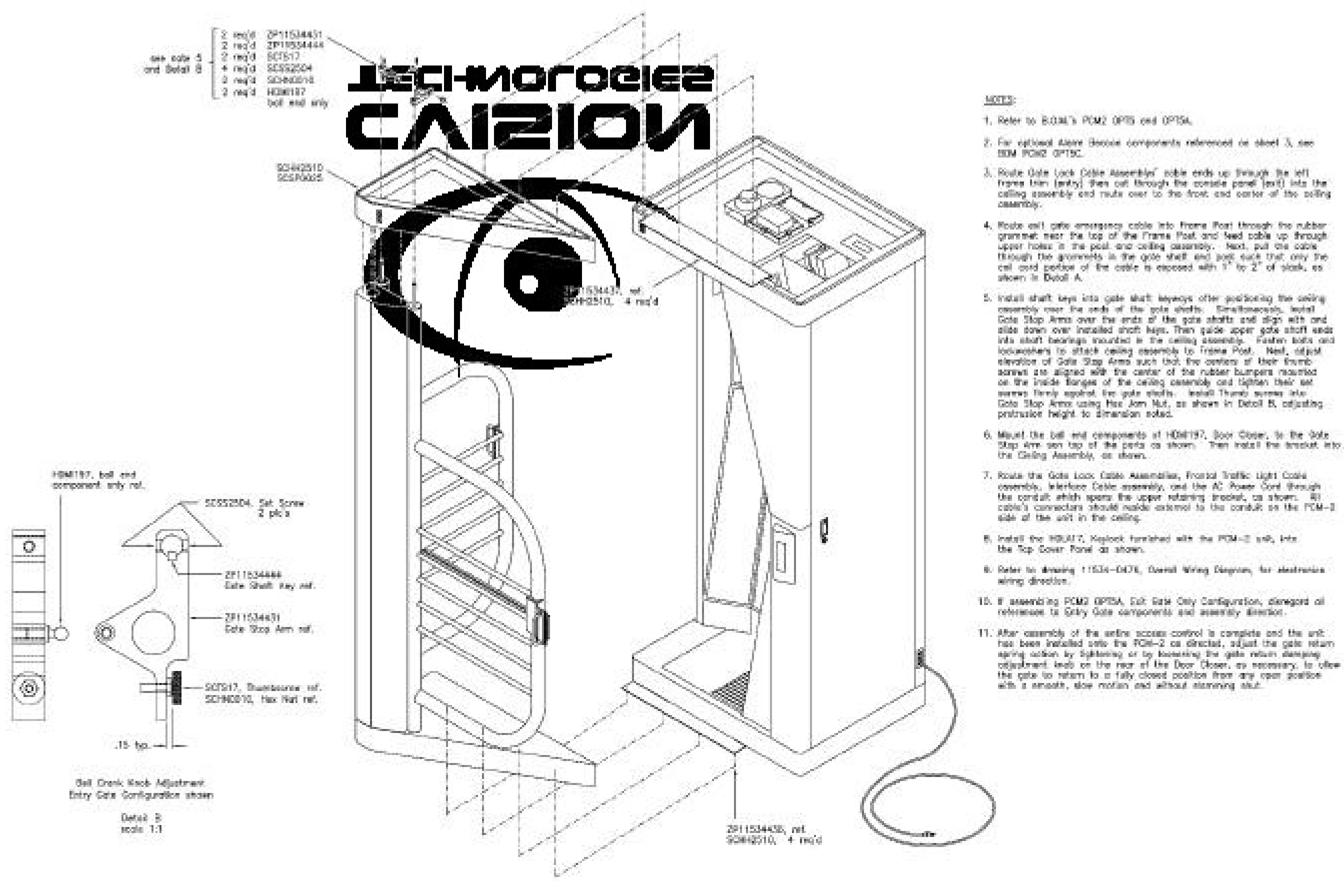

Figure 19-16. 11534-480, Access control, overall assembly, drawing 2 of 3. (A larger version of this drawing is located in Chapter 22.)

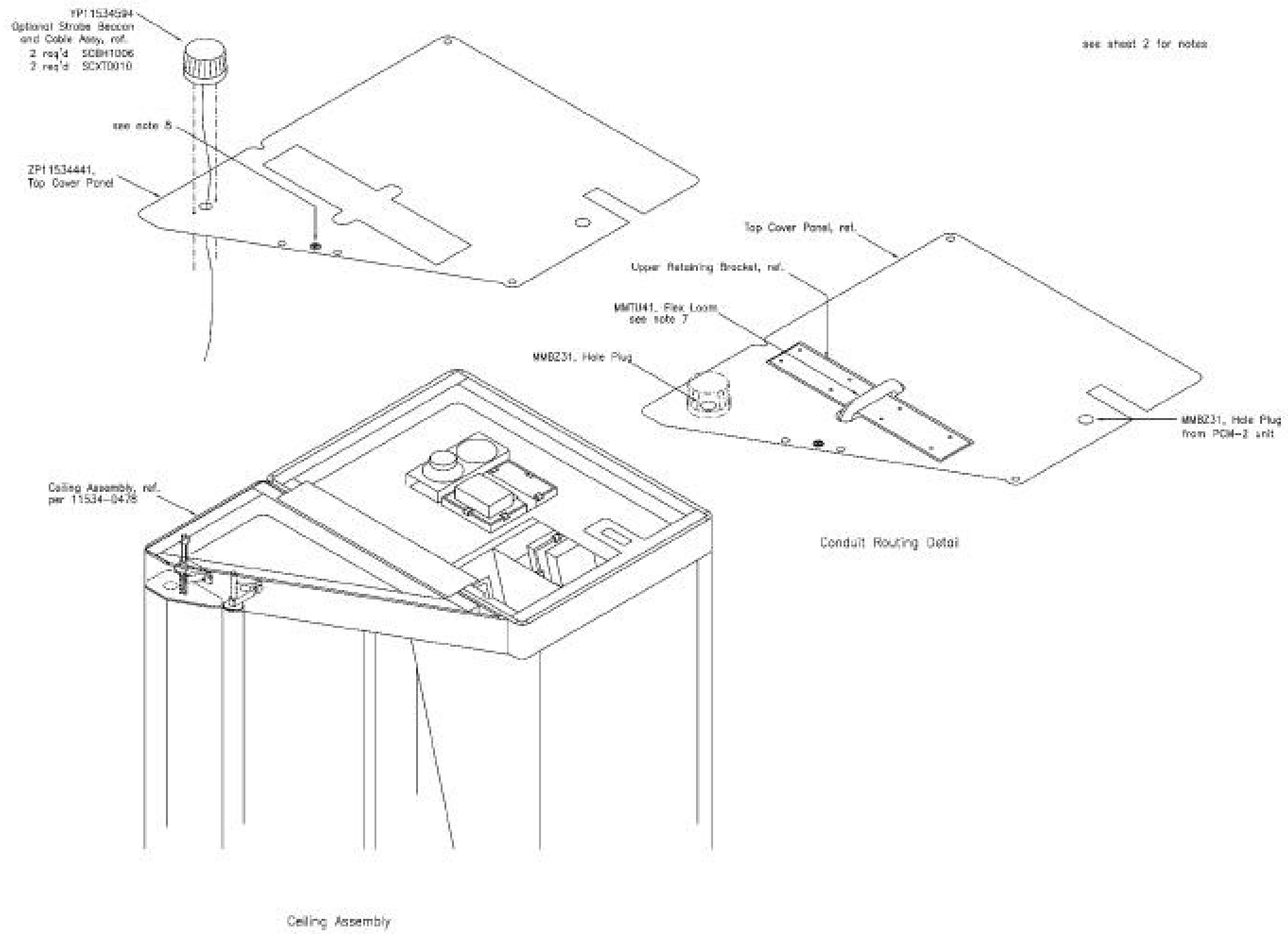

Figure 19-17. 11534-480, Access control overall assembly, drawing 3 of 3. (A larger version of this drawing is located in Chapter 22.)

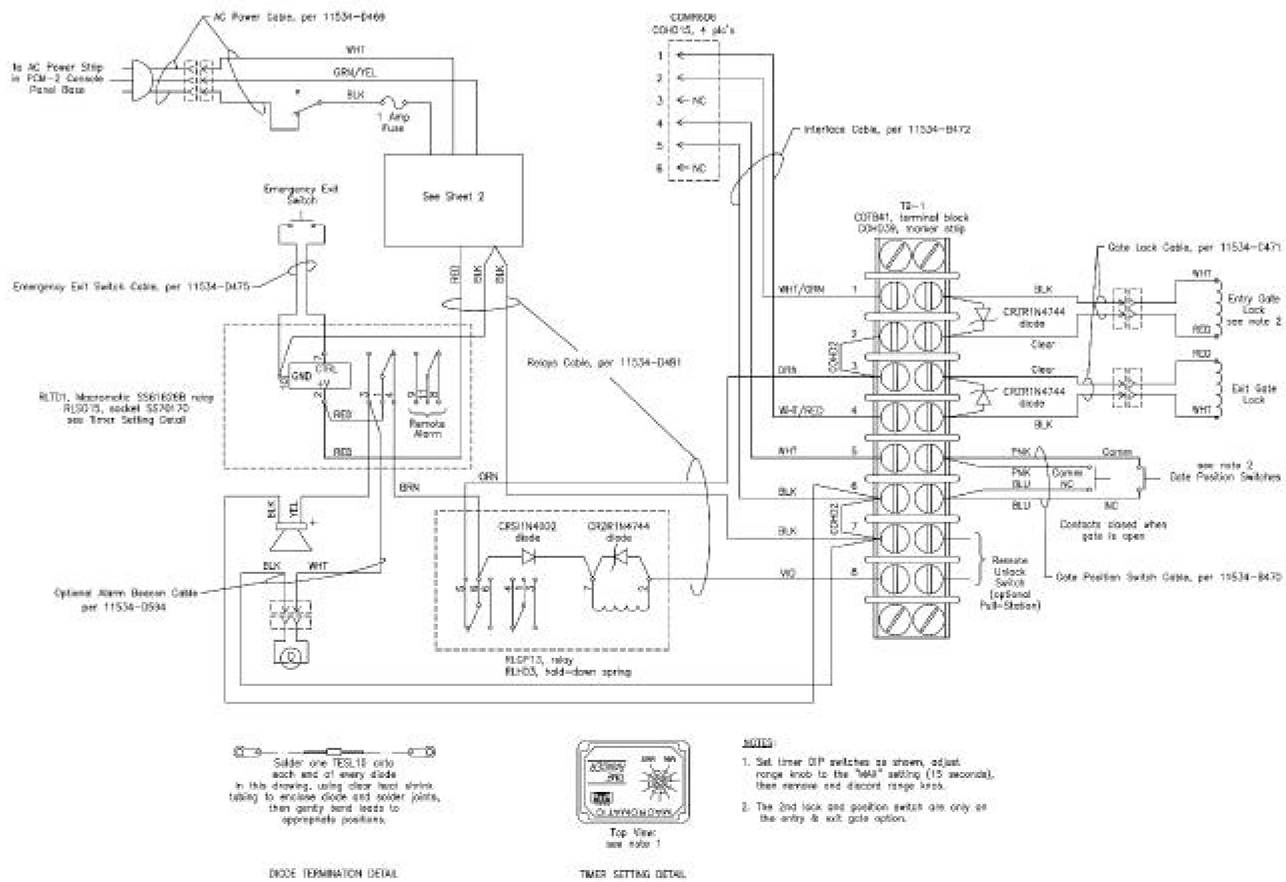

Figure 19-18. 11534-476, Access control, overall wiring. (A larger version of this drawing is located in Chapter 22.)

ICI Insert Card Reader

OPT7A, ICI Insert Cart Reader

The barcode reader provides a convenient means of entering a User ID number. This card reader is an insert reader in that it requires the user to insert a card with a bar code on it into the card guide. The barcode reader will read bar codes over the speed range of 3–30 inches per second (ips) at the recommended density of the encoded bar. A nonread is indicated by illuminating both the red and green LEDs. A good read is indicated by illuminating the green LED only. The reader is mounted in the lower cutout in the console panel's display panel beneath the CRT.

The reader is capable of reading either visible bar codes or bar codes hidden behind a special black filter. The reader is optimized to read bar codes whose narrow bar is greater than 0.013 inch. However, bar codes with a narrow bar width of 0.010" can be read with some slight deterioration of the high speed scanning rate. The recommended distance from the edge of the card to the center of the bar code strip is 3/8" (0.375"). The recommended width of the bar code strip is 1/2" (0.50").

The ICI bar code reader is a low-cost unit capable of reading only the codes shown in Table 19-10.

Table 19-10. Codes Readable by ICI Bar Code Reader

Code Type	Recommended Density	Number of Digits
Code 3 of 9	5 Characters/Inch (cpi)	6 Numeric
Code 3 of 9	5 Characters/Inch (cpi)	1 to 12 Alphanumeric
Interleaved 2 of 5	9 Characters/Inch (cpi)	2 to 16 Numeric

Note Interleaved 2 of 5 must have an even number of digits. ▲

ICI Insert Card Reader Parts List

Table 19-11 lists the items incorporated in the ICI insert card reader and should contain all parts necessary for normal repair.

Table 19-11. ICI Insert Card Reader Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
010	11534-D323	Mounting Plate	ICI Card Reader	ZP11534261
020	11534-D323	Cable Assembly	ICI Card Reader	YP11534513
030	11534-D323	ICI Card Reader	Modified, Bar Code	ZP11468206

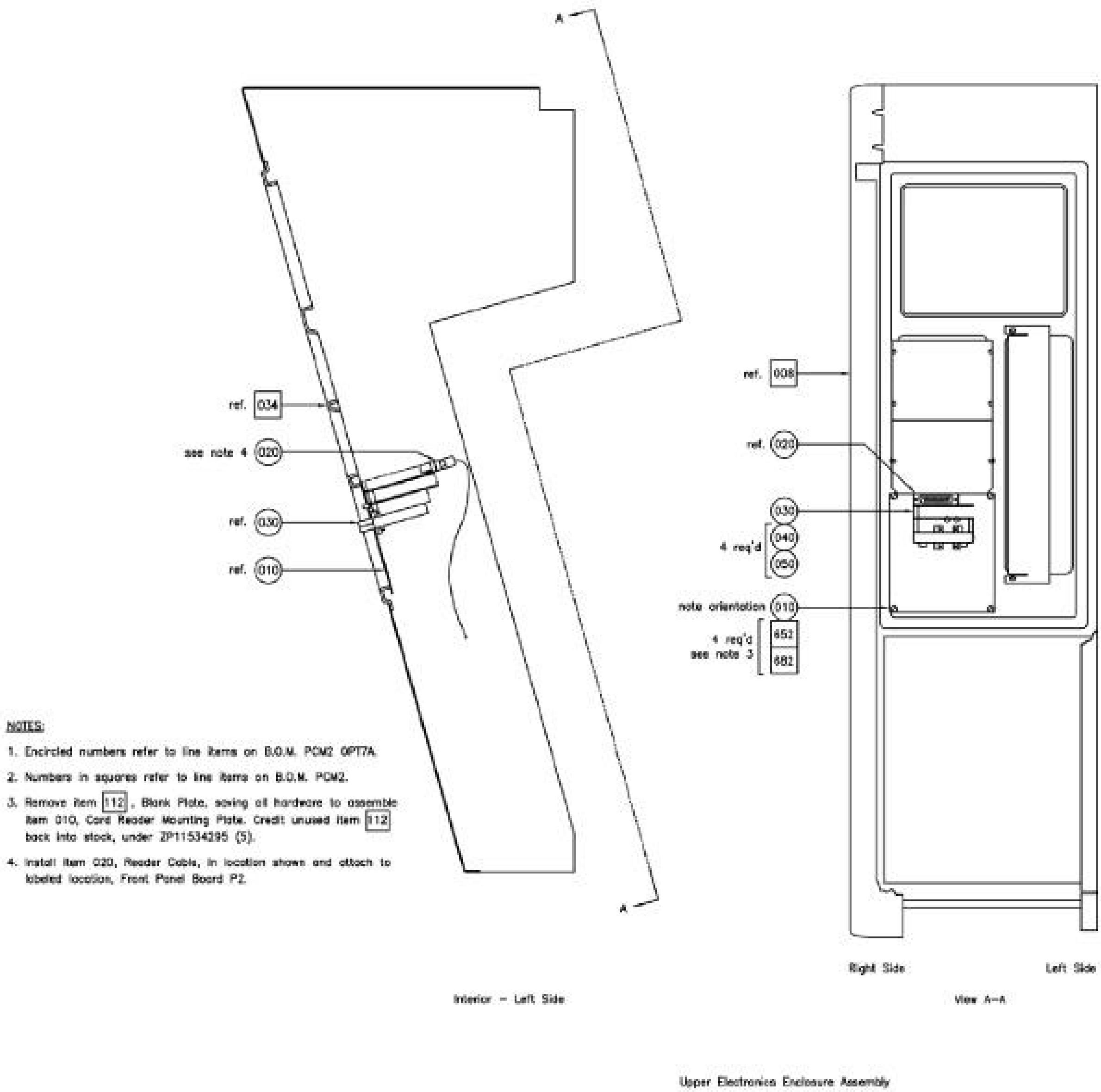

Figure 19-19. 11534-323, ICI insert card reader assembly. (A larger version of this drawing is located in Chapter 22.)

ICI Swipe Card Reader

OPT7B, ICI Swipe Card Reader

The bar code reader provides a convenient means of entering a User ID number. This card reader is a swipe reader in that it requires the user to pass a card with a bar code on it through the card guide. The bar code reader will read bar codes over the speed range of 3 to 30 inches per second (ips) at the recommended density of the encoded bar. A non-read is indicated by illuminating both the red and green LEDs. A good read is indicated by illuminating the green LED. The reader will read cards in either direction. The reader is mounted in the lower cutout of the console panel's display panel beneath the CRT.

The reader is capable of reading either visible bar codes or bar codes hidden behind a special black filter. The reader is optimized to read bar codes whose narrow bar is greater than 0.013 inches. However, bar codes with a narrow bar width of 0.010 inches can be read with some slight deterioration of the high speed scanning rate. The recommended distance from the edge of the card to the center of the bar code strip is 3/8" (0.375"). The recommended width of the bar code strip is 1/2" (0.50").

The ICI swipe bar code Rreader is a low-cost unit capable of reading only the same codes as does the ICI insert bar code reader.

ICI Swipe Card Reader Parts List

Table 19-12 lists the items incorporated in the ICI swipe card reader and should contain all parts necessary for normal repair.

Table 19-12. ICI Swipe Card Reader Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
010	11534-D324	Mounting Plate	ICI Swipe Reader	ZP11534262
020	11534-D324	Cable Assembly	ICI Swipe Reader	YP11354512
030	11534-D324	ICI Swipe Reader	Bar Code	VEIN43
040	11534-D324	Back Plate	ICI Swipe Reader	ZP11468191

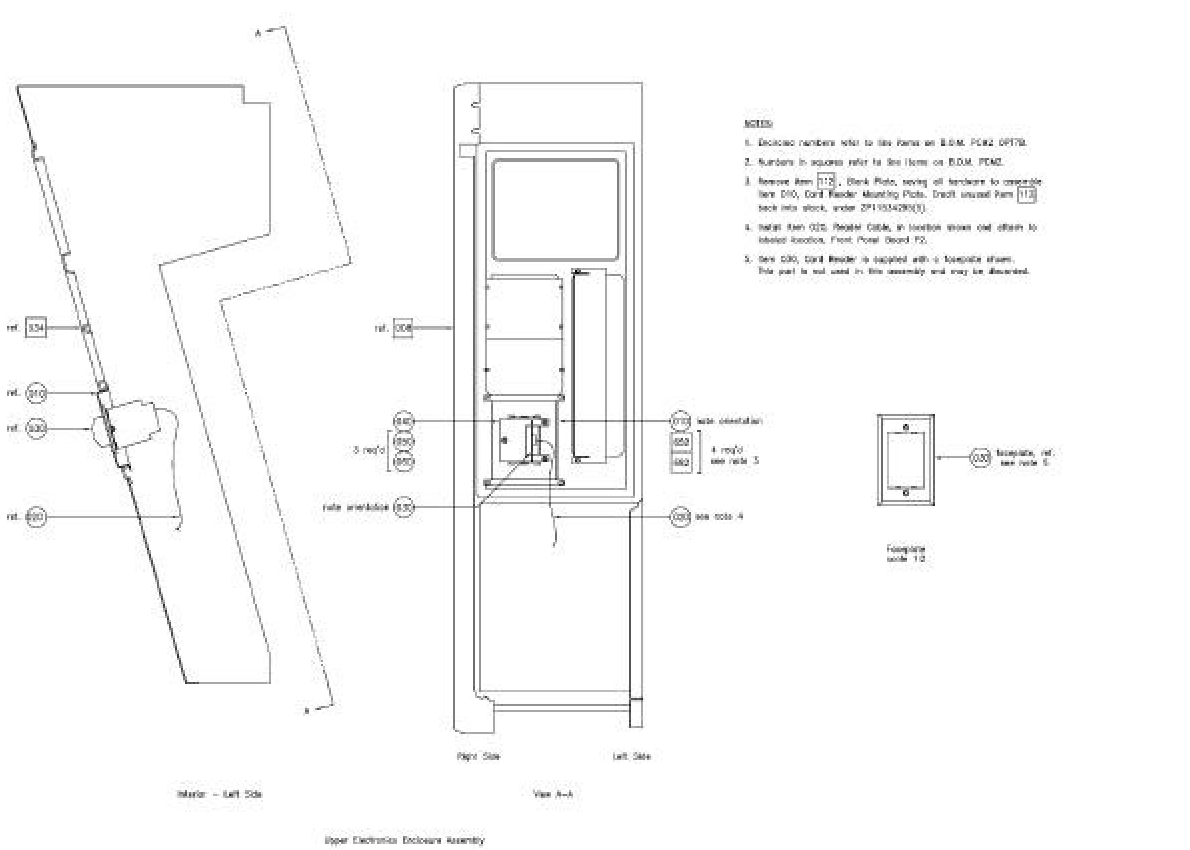

Figure 19-20. 11534-324, ICI swipe card reader assembly. (A larger version of this drawing is located in Chapter 22.)

XICO Insert Card Reader

OPT7C, XICO Insert Card Reader

The magnetic stripe card reader provides a fast and accurate alternative to keyboard entry of the User ID number. The magnetic stripe reader is a push–pull type that requires the user to insert a magnetic card into the card guide. The magnetic card reader is mounted in the lower cutout of the console panel's display panel beneath the CRT.

The recommended encoding for magnetic cards used in this reader is ANSI/ISO BCD with the data track located at ANSI Track #2 and the timing track at ANSI Track #3. The recommended density is 105 bits per inch (bpi). This will allow up to 39 data characters (PCM-2 allows 9 characters in the User ID and RWP# fields).

The center of magnetic strip should be located 7/16" (0.44") from the edge of the card. The recommended width of the magnetic card is 7/16" (0.44").

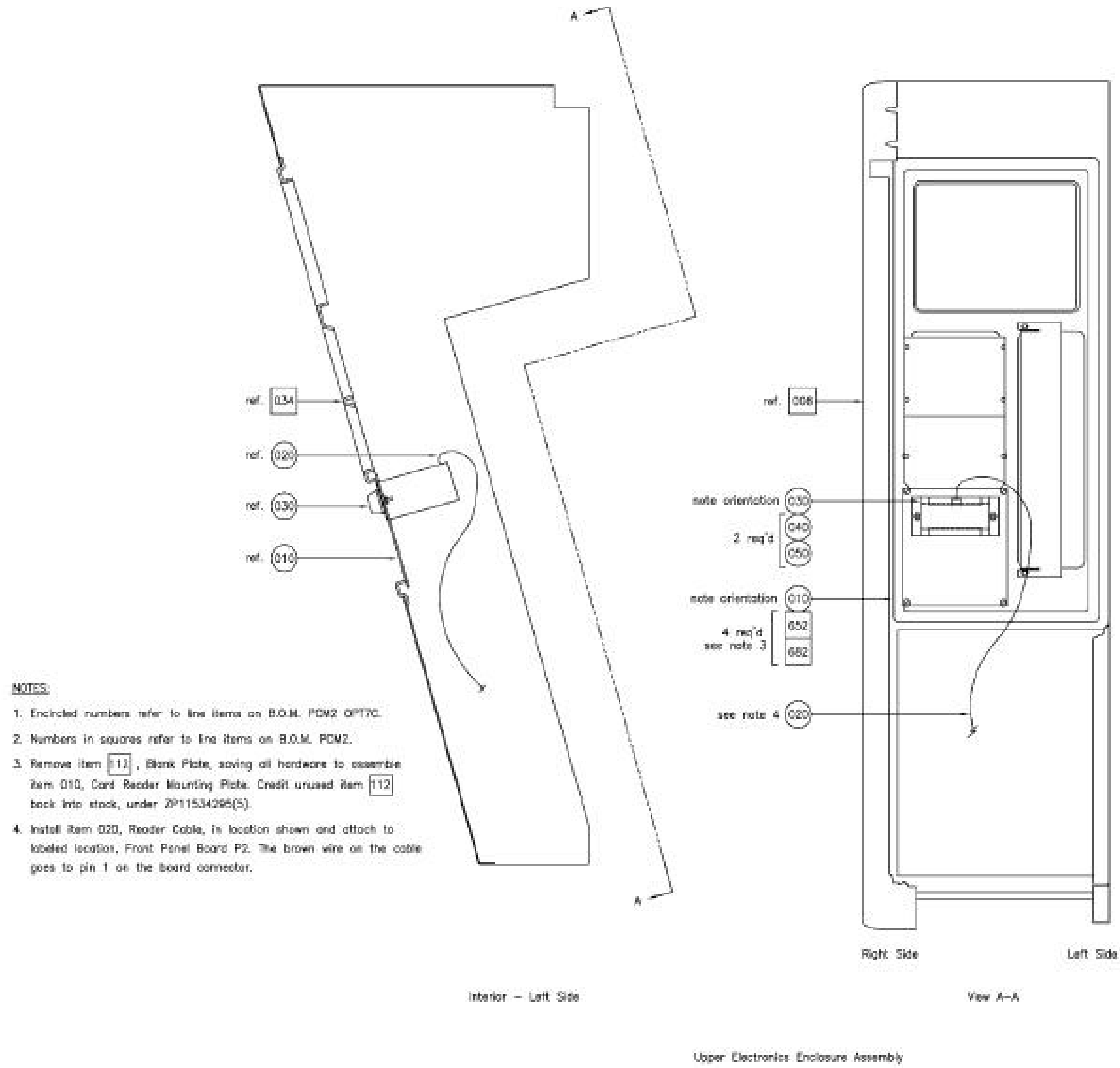

Figure 19-21. 11534-325, XICO insert card reader assembly. (A larger version of this drawing is located in Chapter 22.)

XICO Insert Card Reader Parts List

Table 19-13 lists the items incorporated in the XICO insert card reader and should contain all parts necessary for normal repair.

Table 19-13. XICO Insert Card Reader Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
010	11534-D325	Mounting Plate	XICO Card Reader	ZP11534141
020	11534-D325	Cable Assembly	XICO Card Reader	YP11534514
030	11534-D325	XICO Card Reader	Magnetic, Bar Code	VEMI69

ICI Swipe Card Reader

OPT7D1, ICI Swipe Card Reader

The Computer Identics is a high-quality bar code reader, capable of reading all standard bar codes and many non-standard codes. The bar code reader provides a convenient means of entering a User ID number. The card reader is a swipe reader in that it requires the user to pass a card with a bar code on it through the card guide. The recommended distance from the edge of the card to the center of the bar code strip is 3/8" (0.375"). The recommended width of the bar code strip is 1/2" (0.50"). The unit consists of an electronics package mounted in the ceiling of the PCM-2 and the reader itself is mounted in the lower cutout of the console panel’s display beneath the CRT.

Scanner Basics

The PCM-2 requires a scanner with a RS-232 interface, 9600 baud, no parity, eight data bits, one stop bit, and a carriage return terminator. The scanner’s interface has been setup per the following instructions. It will supply the proper RS-232 interface and the required codes for the bar code card. If the defaults were changed, then use the Reset bar code found in the separate manual provided with the instrument.

The scanner has been assembled according to 11534-706. The following setup and test were done for this type of scanner.

The scanner (VEMI89) has been connected to its cable (VECA93) which is then connected to the interface module’s (VEMI88A) port A.

The interface module’s other cable (YP11534705) has been connected to its RS-232 Modem port. The other end will be on the front panel’s (SP28B) port P2.

The interface module has the power jack attached which may be either from the wall plug unit (VEMI349) or the voltage tap (YP11534707) from the main power supply.

The following bar codes from the Scan Corporation's 2000 series programming guide were used:

Enter Program Mode	page 7
Exit Program Mode	page 7
Reset	page 7
Host	page 8
Postamble	page 9
Single Port Host / Single Port Aux	page 11

With the power on at the interface module (red LED is lit at the scanner), the following barcode scanning order was done:

1.	**Bar Code**	**Interface response**
2.	**Enter Program Mode**	**Three beeps**
3.	**Host**	**Two beeps**
4.	**Single Port Host / Single Port Aux C**	**Three beeps**
5.	**Postamble**	**Two beeps**
6.	**Single Port Host / Single Port Aux C**	**Three beeps**
7.	**Exit program**	**Two beeps, then three beeps.**

PCM-2 Setup

1. **Press Esc and then the password ("9999" is default) to access the Main menu.**

2. **Select the Utilities screen.**

3. **Access the card reader test and verify that the number is being read when the card is swiped through the scanner.**

If the test was successful, then secure the PCM-2. If the test was not successful, verify cable connections, scanner setup, etc.

Note Scan the **Reset bar code** to reset the scanner to factory defaults. The Reset bar code is located in the separate manual that has been provided with the PCM-2 instrument if the option is installed. ▲

Final Setup

1. **Return to Main menu.**
2. **Select Edit > Instrument Setup Parameters.**
3. **Find ID Entry Method and select Keypad / Aux.**
4. **If RWPs are used, it can also be enabled. The option of masking the barcode number also can be enabled.**
5. **If the number is to be masked, open the Utilities menu.**
6. **Select Mask User ID.**
7. **Select "Yes."**

Operation

1. **Press the Esc key until the main display returns. The PCM-2 will indicate that background is being taken, then it will display that it is ready for operation.**
2. **Step up into the PCM-2. It will request the User ID. Swipe the card and verify that the numbers appear at the bottom of the screen if the Mask feature has not been enabled. If the Mask feature was enabled, then only blocks will be shown.**

The PCM-2 will now allow the standard measurement sequence.

Repair

The following details a repair method for the barcode system of OPT7D1 (see "OPT7D1, ICI Swipe Card Reader" on page 19-42.)

Open the PCM-2's side door, turn off the unit, and carefully remove the electronics cover panel (ZP11534226, item 118) so that the floppy drive is not damaged. (See Figure 19-22.)

The card scanner is located on its mounting plate, ZP11534263. The interface module and its power supply are located on the upper section of the PCM-2.

Verify that the cables are connected properly. If the LED is on at the scanner, then scan the reset bar code (see "Note" on page 44) to set the scanner to factory defaults. If there was a response, then set up the scanner according to the listed barcode inputs.

If there is no response or if the LED is off, change out the scanner system with known good components.

When the system is repaired, reassemble and restart the PCM-2.

ICI Swipe Card Reader Parts List

Table 19-14 lists the items incorporated in the ICI swipe card reader and should contain all parts necessary for normal repair.

Table 19-14. ICI Swipe Card Reader Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
030	11534-B706	Scanner	Card Reader	VEMI89
040	11534-B706	Interface Module	Scanner interface	VEMI88A
020	11534-B706	Cable Assembly	Interface to Front Panel cable	YP11534705
090	11534-B706	AC Extension Cord	AC Extension Cord	WRAC20
	11534-B706	Scanner Interface cable	Adapter Cable	VECA93
	11534-B706	Power Supply	Wall Plug Power Supply	VEMI349
	11534-B706	Power Tap (in place of VEMI349)	Power Tap (Used instead of VEMI349)	YP11534707
010	11534-B706	Computer Identics Card Reader Mtg Plate		ZP11534263

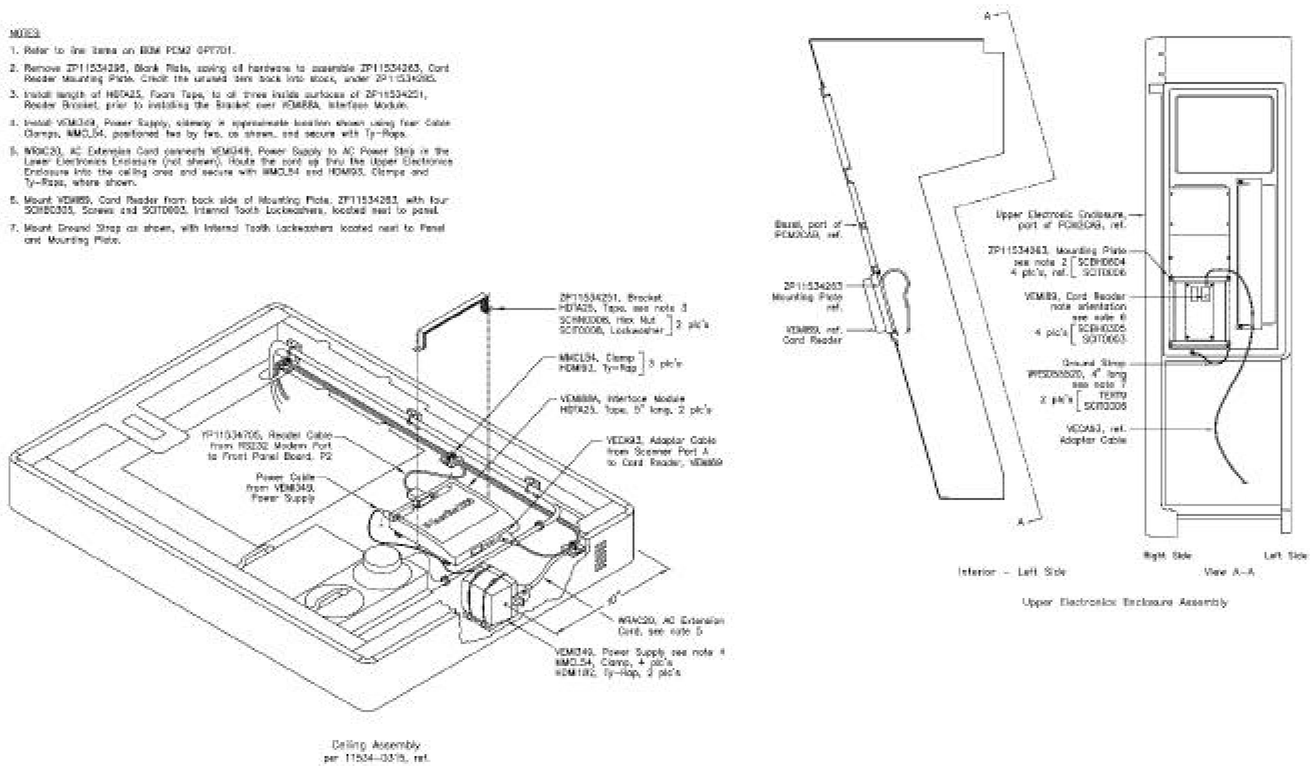

Figure 19-22. 11534-706, Computer identics swipe card reader assembly. (A larger version of this drawing is located in Chapter 22.)

Barcode Reader

OPT7F, Barcode Reader

This code reader option for the PCM-2 utilizes a compact programmable Intermec 2861 scanner/decoder module which uses high-speed spinning mirrors and sweeping laser beams to receive reflected light as analog waveforms from bar code labels which are then decoded and sent to the user as ASCII data. Timing and focus can be tuned to discern a variety of bar code widths. Interfacing with the PCM-2 is accomplished through an ADP-RS232 interface module.

The Intermec 2861 barcode reader features the following performance characteristics and code reading capabilities:

Power On LED Status Light	
Good Read LED Status Light	
Scanning Distance	2–10 in.

Scanning Width	1.5–9.75 in.
Scanning Speed	200 scans per sec.
Code Density	0.19 mm (0.0075 in.) to 1.27 mm (0.050 in.)
Code Discrimination	Code 39, Codabar, I 2 of 5, UPC / EAN, and Code 128.

The scanner module mounts in the upper electronics enclosure of the PCM-2, behind the console panel's display panel. The power supply mounts in the lower electronics enclosure on the lower vent panel and the ADP-232 interface module mounts to the floppy disk drive cover plate in the upper electronics enclosure. The custom badge insert interface panel is mounted in the display panel, beneath the CRT.

Note The scanner mounting hardware and display panel / badge interface hardware for this option has been designed around a specific set of code density and focus distance parameters. Thermo Electron can accommodate many other user specific code reading requirements with respect to these scanner mounting and code density / focus considerations. ▲

Caution The Intemec 2861 scanner emits a laser light beam which can be hazardous if viewed directly. Adequate precautions should be taken to avoid direct exposure of the beam to the eyes. ▲

Configuration

The Intermec Model 2681A01 scanner unit must be specially configured for use with Code 39. Its default parameters (9600 baud, 7 data bits, even parity and 1 stop bit) must be changed to 9600 baud, 8 data bits, no parity and 1 stop bit. In addition, the postamble variable must be set up as follows: POSTAMBLE = ENABLED = CR (carriage return). Refer to the *Model 2861A01 User's Manual* for the specific parameter settings for other barcode types.

Intermec Barcode Reader Parts List

Table 19-15 lists the items incorporated in the Intermec barcode reader and should contain all parts necessary for normal repair.

Table 19-15. Intermec Barcode Reader Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
010	11534D378	Foam Tape	Single Sticky	HDTA16
020	11534D378	Cable Assembly	Intermec Reader	YP1153438 6
030	11534D378	Intermec Reader	Bar Code	MEVE166
040	11534D378	Reader Power Supply	115VAC	MEVE167
042	11534D378	Reader Interface Box	ADP-232	MEVE190
044	11534D386	Reader Cable	Reader-to-ADP Box	MEVE191
050	11534D378	Mounting Bracket	Power Supply	ZP11534385
060	11534D378	Mounting Bracket	Reader	ZP11534384
070	11534D378	Hinge Bracket	Reader	ZP11534383
080	11534D378	Faceplate	Card/Badge Insertion	ZP11534382

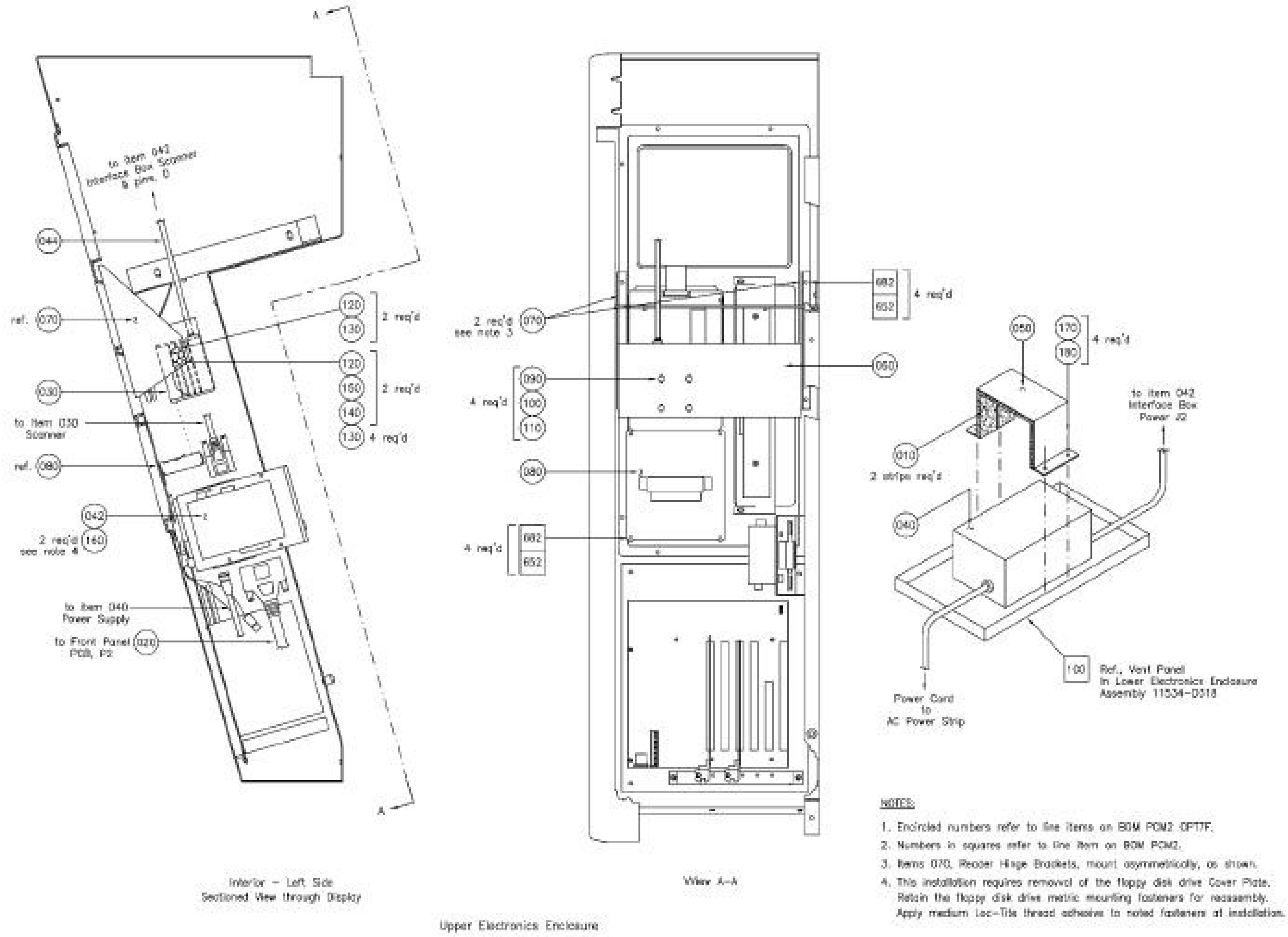

Figure 19-23. 11534-378, Intermec barcode reader assembly. (A larger version of this drawing is located in Chapter 22.)

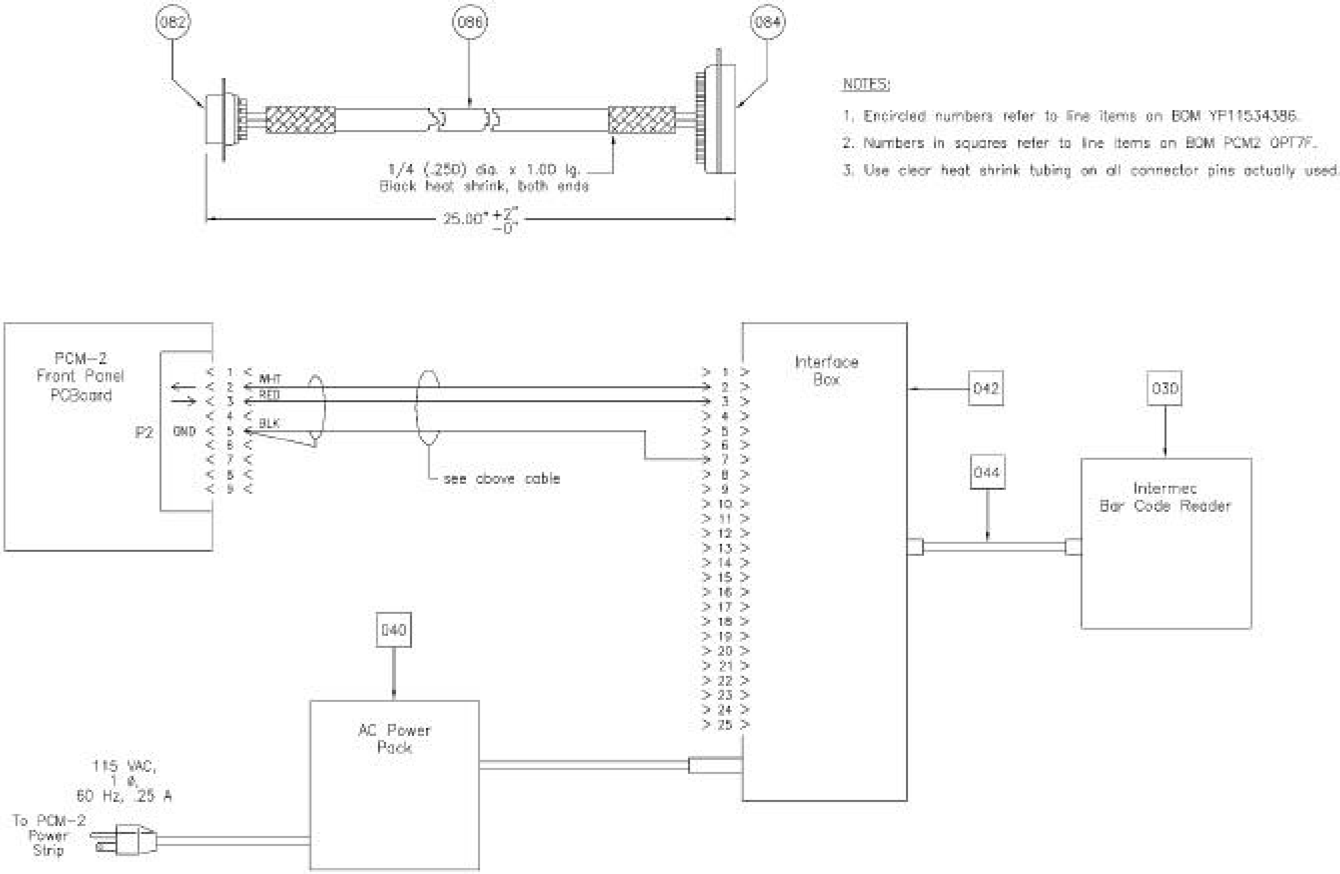

Figure 19-24. 11534-386, Intermec barcode reader wiring. (A larger version of this drawing is located in Chapter 22.)

Mylar®/Polyethylene Dispenser

OPT8, Polyethylene Dispenser

This option incorporates a thin Mylar® or polyethylene film supply and take-up roll system into the PCM-2's base to provide the user with a simple and easily accessable method of protecting the unit's foot detector from the frequent contamination caused by users shoes. The system has been designed to manually advance the thin film sheet over the foot detector and onto a blank take-up roll where the contaminated particles are trapped between film layers, to later be discarded along with the used protective film sheet.

The remaining blank supply roll core is used as the take-up roll when a new supply roll is installed. The film is manually advanced by inserting a hexagonal shaft driver into the take-up roll shaft center hex screw, through a small hole in the front of the PCM-2's base, and rotating the take-up roll 2 to 3 complete clockwise turns. A storage clip for the hex driver is located inside the PCM-2's side door.

As noted, two choices of protective film media are available with this option. The polyethylene material is 0.0005" thick. The Mylar® material is 0.00016" thick and is therefore better suited for alpha radiation monitoring. Both materials are furnished on cardboard cores in 200 ft. lengths.

This option offers the user a greater degree of foot detector maintenance than do the standard cardboard-framed 0.0005-in.-thick film protectors in that contaminated particulates released from users shoes are contained in the take-up roll when a fresh width of film is drawn over the detector. The thinner Mylar® material available with this option also decreases the impact to the overall sensitivity of the foot detector.

Mylar®/Polyethylene Dispenser Parts List

Table 19-16 lists the items incorporated in the Mylar®/Polyethylene dispenser and should contain all parts necessary for normal repair.

Table 19-16. Mylar®/ Polyethylene Dispenser Parts List

Item Ref No.	Drawing No.	Part Name	Description	Part No.
010	11534-D320	Roll Core	Film Dispenser	ZP11534301
020	11534-D320	Chassis	Film Dispenser	ZP11534299
030	11534-D320	Pan	Film Dispenser	ZP11534300
050	11534-D320	Clear Polyethylene Roll	0.0005 Thick. x 200 ft.	MMMI132
060	11534-D320	Cardboard Core	1 1/8 ID x 20"	MMMI133
070	11534-D320	Foam Tape	1/4" x 1/2"	HDTA7
080	11534-D320	Rubber Expansion Plug	11/16" diam.	MMRU104
090	11534-D320	Component Clip	Driver Retainer	MMCL14
110	11534-D320	Hex Socket Driver	3/16" hex	MMMI166
Opt.	11534-D320	Clear Mylar® Film Roll	0.00016 Thick x 200 Ft.	MMMI139

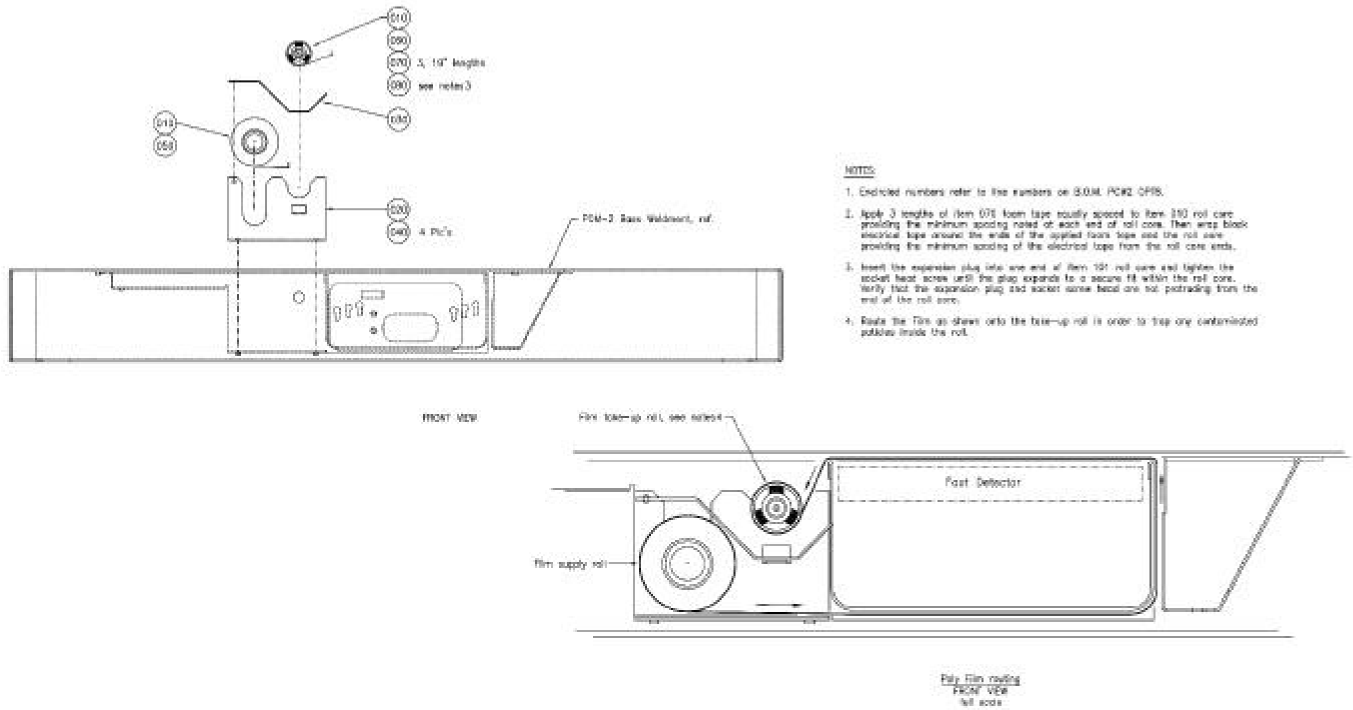

Figure 19-25. 11534-320, Polyethylene/Mylar® dispenser assembly, drawing 1 of 2. (A larger version of this drawing is located in Chapter 22.)

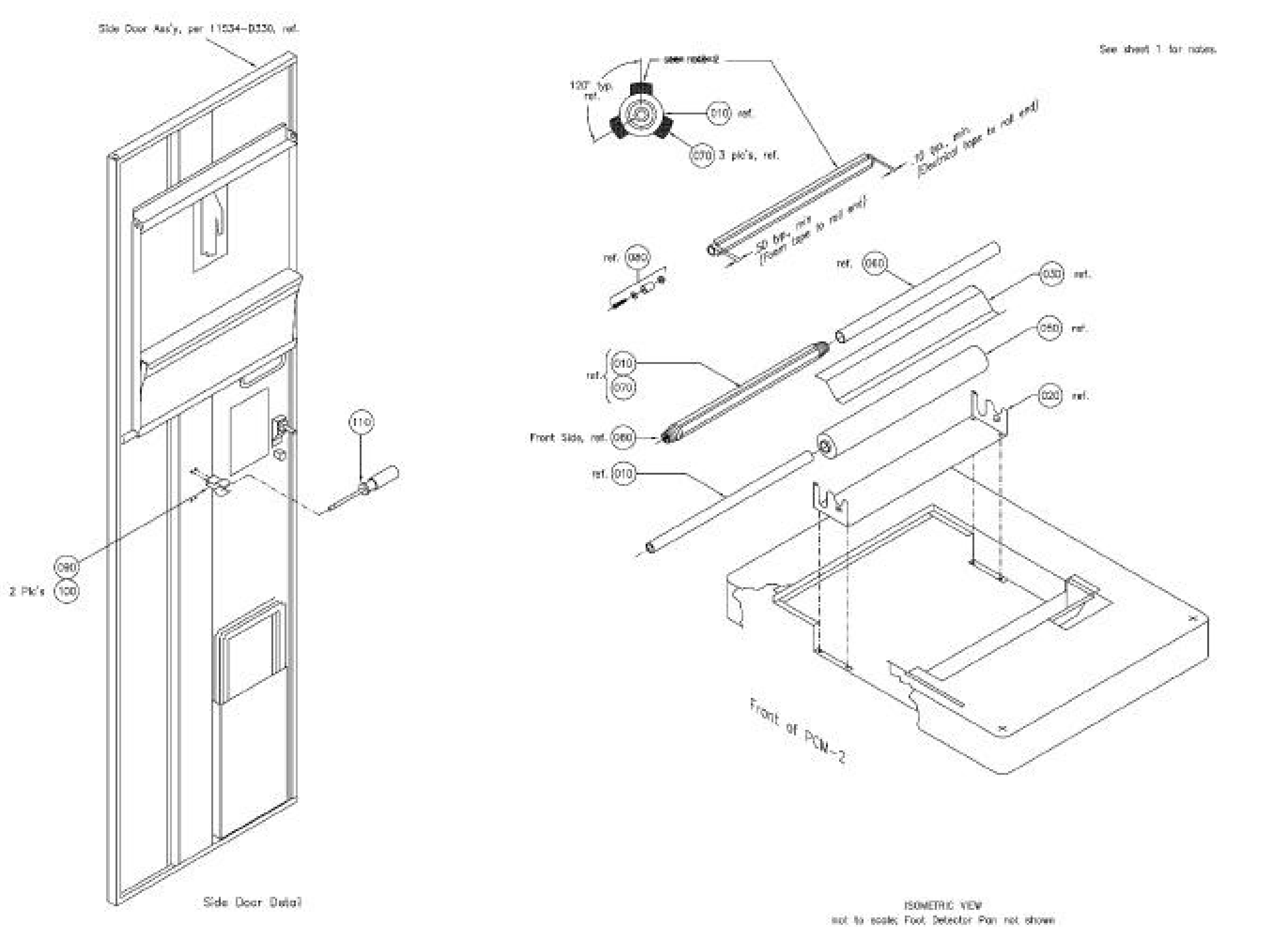

Figure 19-26. 11534-320, Polyethylene/Mylar® dispenser assembly, drawing 2 of 2. (A larger version of this drawing is located in Chapter 22.)

Gas Bottle Enclosure

OPT9, Gas Bottle Enclosure

This option for the PCM-2 is an independent sheet metal enclosure to support storage of two Size 1A counting gas cylinders either adjacent to a PCM-2 unit or at a remote location. It features a clear Plexiglas window in the locking door for monitoring the gas regulators' gages at a glance, internal bottle securing brackets/straps, a wall mounting bracket with quick release pin for DOT securing requirements and easy detachability, and hardware and paint finish which match that of the PCM-2 instrument. One additional two-stage gas bottle pressure regulator is also furnished with the option. See Figure 19-27 for unit dimensions.

Gas Bottle Enclosure Parts List

Table 19-17 lists the items incorporated in the gas bottle enclosure and should contain all parts necessary for normal repair.

Table 19-17. Gas Bottle Enclosure Parts List

Item Ref No.	Drawing No.	Part Name	Description	Part No.
040	11534D236	Window	Clear Lexan	ZP11534240
070	11534D236	Wall Bracket	Enclosure Stabilization	ZP11534243
080	11534D236	Rubber Grommet	7/8" x 1 1/8"	MMRU37
082	11534D236	Rubber Bumper	3/8" x 1/16" thick	MMRU90
090	11534D236	Hinge	Door	HDMI115
100	11534D236	Cylinder Holder	P10 Gas	MMMI48
110	11534D236	Furniture Glide	Enclosure	HDMI12
120	11534D236	Flush Latch	Door	HDLA16
196	11534D236	Hose Barb	1/4" MPT x 1/8 Barb, Brass	FGBR51
200	11534D236	Quick-Release Pin	Wall Bracket	HDMI166
210	11534D236	Gas Regulator	2 Stage, P10	PUHD38
220	11534D236	1/8" ID Tubing	Clear PVC	MMTU1

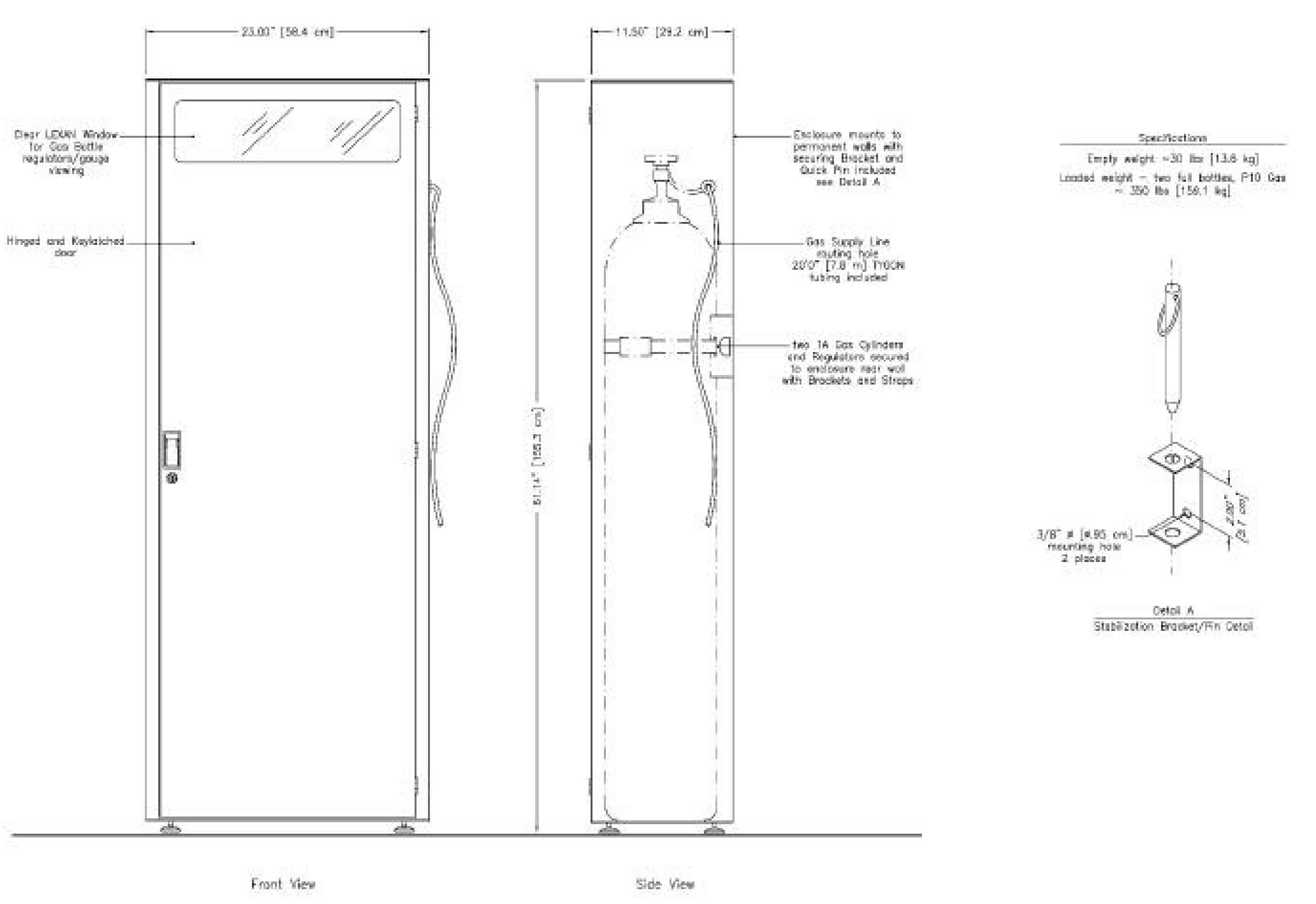

Figure 19-27. 11534-564, Gas bottle enclosure outline. (A larger version of this drawing is located in Chapter 22.)

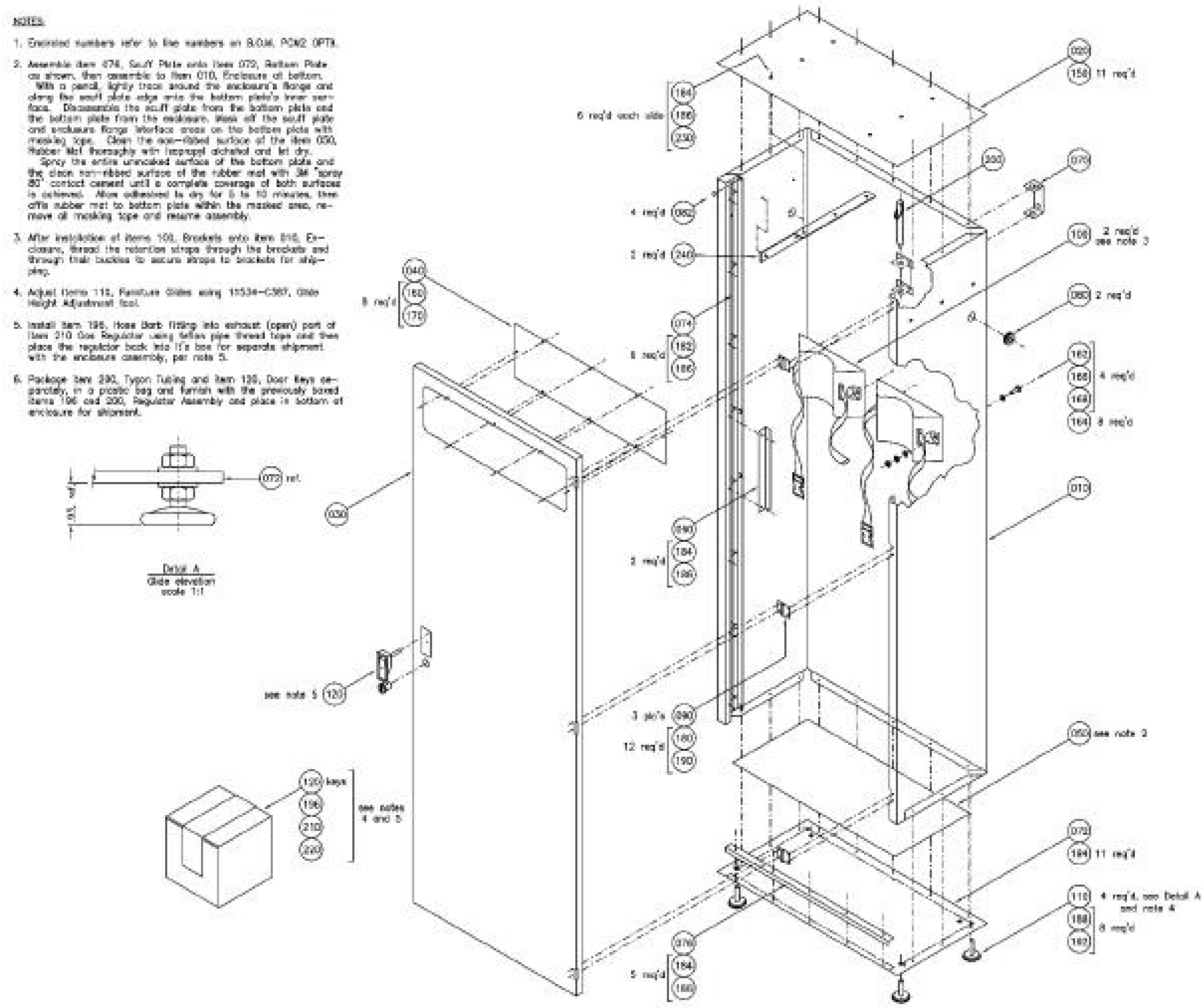

Figure 19-28. 11534-236, Gas bottle enclosure assembly. (A larger version of this drawing is located in Chapter 22.)

High-Heel Perforated Grid Base Plate

OPT11, High-Heel Perforated Grid Base Plate

The 1/4" diameter perforated grid base plate option serves as a simple substitute for the standard slotted base plate in support of users with high-heeled shoes. This perforated grid configuration reduces the open area over the foot detector to 58%

High-Heel Base Plate Parts List

Table 19-18 lists the items incorporated in the high-heel base plate and should contain all parts necessary for normal repair.

Table 19-18. High-Heel Base Plate Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
010	11534-D175	Footplate	Perforated Grid	YP11534175

Gas Management

OPT12, Gas Management

Theory of Operation

In concept, gas proportional detectors are very simple. In the real world, however, seals leak and materials come with random flaws. In practice, detectors require a constant flow of counting gas primarily to overcome the following:

- Loss of counting gas through pinholes in Mylar® detector faces and through imperfect seals elsewhere.
- Contamination with air (oxygen, water vapor, etc.) via the same routes.
- Organic vapors released from plastics, gaskets, foam seals, adhesives and other construction materials, particularly in newly built (or rebuilt) detectors.
- Gradual degradation of the counting gas itself, especially when exposed to high radiation fields.

The ideal solution is to provide each detector with a continuous flow of fresh counting gas to sweep out air and other contaminants as fast as they appear. In large multiple-detector instruments, this may not be economically or logistically feasible. Compromises may be made, such as plumbing several detector chambers in series, however the performance of each detector in such a chain becomes lower as gas purity decreases.

A corollary of this is that instruments should ideally be plumbed in a parallel manner, so that no detector receives the used gas from another. Unfortunately if each detector is operated at a normal flow rate of 200 cc/min, gas consumption in a large system is relatively high. In addition, each detector must be provided with its own flow meter and adjustment valve to insure that counting gas is evenly distributed among all of the detectors.

Finally, if the outlet of a detector is left open, chamber pressure will be very low and air will diffuse in relatively quickly. Flow rates must be adequate to maintain adequate working pressure and to prevent air from diffusing upstream from the gas outlet.

The PCM-2 Gas Manager System incorporates the following features to reduce the gas consumption rate of gas flow proportional detectors:

- Detectors are plumbed in parallel so that each receives fresh counting gas directly from the source.
- A flow restrictor is inserted in front of each detector to insure even distribution of gas to every chamber.
- Chamber outlets are connected together and exhausted through a flow restrictor to maintain uniform gas pressure within all detectors. A solenoid valve is used to bypass this restrictor during initial high rate purging of the detectors.
- Additional solenoid valves are used to meter gas into the intake manifold (upstream of the flow restrictors) as needed to maintain a constant working pressure. This pressure is measured at the outlet, and is therefore representative of all detectors in the system.

The overall gas consumption of such a system is determined by the pressure setting and the diameter of the outlet flow restrictor. In addition, enough gas must be supplied to compensate for leakage through detector faces and chamber seals.

Practical working pressures for typical detectors faced with thin Mylar® range from approximately 0.05 to 0.50" of water. Pressures above 0.5" may damage detector faces or seals; below 0.05" the Mylar® will not be adequately inflated and air will diffuse into the chambers more rapidly. A starting system pressure of 0.25" is recommended for the PCM-2.

In a parallel-plumbed system, maximum detector efficiency is typically obtained at a flow rate of approximately 10 cc/min per detector chamber. At 6 cc/min per detector chamber, a very slight decrease in efficiency may be observed, however operation will still be very satisfactory. Depending upon the size and number of leaks present, many detectors will operate well down to even 4 cc/min/chamber. Note that PCM-2 has three different sizes of detectors and that these are average values. Note also that new detectors may require slightly higher flow rates to remove organic vapors released by internal materials.

The absolute minimum useful flow rate for any given system must be determined by experiment and may therefore not be achieved in practice. It is quite easy, however, to operate instruments on only 15-20% of the gas which would be consumed without the gas manager. This equates to a gas usage rate of approximately one size #1A P-10 gas cylinder every 160 days for the PCM-2 unit under continuous normal operation at a system inlet pressure of 5 psi and flow rate of approximately 150 cc/min.

Operating Instructions

When operating normally, the gas manager displays three screens of data in rotation:

1. **System status (gas off, gas flowing, over pressure, etc.).**

2. **Current working pressure in inches of water.**

3. **Short- and long-term gas consumption.**

Gas use is expressed as the percentage of time the inlet valve has been opened in order to maintain pressure. The long-term value represents total consumption since the counter was last reset (or since the unit was powered on). Short term use covers the latest five minutes. If a gas leak occurs, the short term number will increase more rapidly than the long term value.

If the control knob is pressed, the display will prompt for entry of a password. This value is permanently set at “1287.” Rotate the knob until the first number “1” shows, then press the knob. Repeat this procedure for the other three digits.

If the knob is pressed and held for 3 to 4 seconds during normal operation, both gas use counters will be reset to zero. This should be done after purging the system to obtain steady-state gas consumption values. No password is required to reset the counters.

Once a correct password has been entered, the first screen displayed is pressure setpoint. Rotate the knob to increase or decrease this setting. To accept the displayed value, press the knob.

The second control screen offers to initiate an automatic purge. If the knob is rotated one click, “No” will be replaced by “Yes.”

1. **Press the knob to accept the displayed choice.**

2. **If "Yes" is accepted, another window will be displayed in which the desired purge time may be set. Rotate the knob until the correct value is displayed, then press to begin the purge cycle.**

3. **Another Yes–No screen will offer to reset the long-term gas use counter. Again, rotate the knob to make a selection, then press it to accept.**

Calibration

When initially setting up an instrument, initiate a detector purge and adjust the flow valve to approximately 800 cc/minute. Allow a minimum of 4 hours at this purge flow rate to completely purge all of the PCM-2's detectors. Reset the flow rate thereafter to approximately 150 cc/minute for normal operation.

Zero Pressure Reference Reset

This step should only be performed if the gas manager's pressure transducer is replaced or if nonzero pressures are displayed when the instrument is actually at zero pressure. Resetting the zero reference when there is actually pressure in the detectors will result in higher than desired operating pressures and may damage both the detectors and the pressure transducer.

1. **Before resetting the zero reference, disconnect the system exhaust hose from the gas manager. This will insure that the pressure transducer is actually at zero (i.e., atmospheric pressure).**

2. **Press the control knob to obtain a password prompt. Instead of the normal "1287" password, enter a value of "9999." The old and new zero values will be displayed, and the new value will be stored in nonvolatile memory.**

3. **Reconnect the exhaust hose and return the instrument to service. Make sure to readjust the operating pressure any time the pressure sensor zero has been set.**

Gas Manager Board Parts List

Table 19-19 lists the items incorporated in the gas manager board and contains parts necessary for normal repair.

Table 19-19. Gas Manager Board Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
A1	11582-D04	I.C.	Microprocessor	ICCMAC51FA
A2	11582-D04	I.C.	Octal Buffer	ICHCA74373
A3	11582-D04	I.C.	32K x 8 EPROM (programmed)	Consult Thermo Electron
A4	11582-D04	I.C.	32K x 8 RAM Static CMOS	ICCM43C256
A5	11582-D04	I.C.	3-to-8 Line Decoder	ICCMAHC138
A6	11582-D04	I.C.	2 Channel, 10 Bit A/D Converter	ICCM1091
A7	11582-D04	Encoder Switch	Rotary Shaft	SWMI50
A8	11582-D04	I.C.	Serial EEPROM 1K-bit CMOS	ICCMA93C46
A9	11582-D04	Transducer	0-5" H2O Pressure	MTFM36
A10	11582-D04	I.C.	RS-485 Transceiver	ICCMA485
A12	11582-D04	I.C.	Octal "D" Flip-Flop	ICHCA74374
A13	11582-D04	I.C.	7-Channel Power Buffer	ICXX30
A14	11582-D04	I.C.	+5 V Regulator	ICAV7805
A15	11582-D04	I.C.	Hex Schmidt Trigger	ICHCA14
A16	11582-D04	I.C.	+8 V Regulator	ICAV7808
A17	11582-D04	I.C.	+5 V Regulator	ICAVA2950C
C1, 11, 18, 19	11582-D04	Capacitor	10 µF, 16V	CPTA100M4X
C2-7, 10, 12-15, 17, 20, 21	11582-D04	Capacitor	0.1 µF, 50V	CPCE104P3N
C8, 9	11582-D04	Capacitor	33 pF, Ceramic	CPCE330P3P
C16	11582-D04	Capacitor	10 µF, 35V	CPTA100M4X
CR1	11582-D04	LED	Superbright Red	OPLP57
Display	11582-D04	LCD Alpha	2 x 16 Char.	OPDS19
J1	11582-D04	Header	12-Pin x 0.156"	COMR612
J3	11582-D04	Header	12-Pin x 0.100"	COMR112
J4	11582-D04	Power Jack	Circular	COMI16
R1, 3	11582-D04	Resistor	10K Ohm 1/4W	RECC103B22
R2, 4, 14	11582-D04	Resistor	3.3K Ohm 1/4W	RECC332B22
R5	11582-D04	Resistor	100 Ohm 1/4W	RECC101B22
R6	11582-D04	Resistor	330 Ohm 1/4W	RECC331B22
R7	11582-D04	Potentiometer	10K Ohm trim	PTCE103B33

X1	11582-D04	Crystal	7.3728 MHz	CYOS12
XA1	11582-D04	I.C. Socket	40-Pin DIP	SOIC140
XA2, 11, 12	11582-D04	I.C. Socket	20-Pin DIP	SOIC120
XA3, 4	11582-D04	I.C. Socket	28-Pin DIP	SOIC128
XA5, 13	11582-D04	I.C. Socket	16-Pin DIP	SOIC116
XA15	11582-D04	I.C. Socket	14-Pin DIP	SOIC114
XA6, 8, 10	11582-D04	I.C. Socket	08-Pin DIP	SOIC308
(None)	11582-D04	Jumper	Flat Cable	WRFC162603
(None)	11582-D04	Circuit Board	Gas Manager	ZP11582002

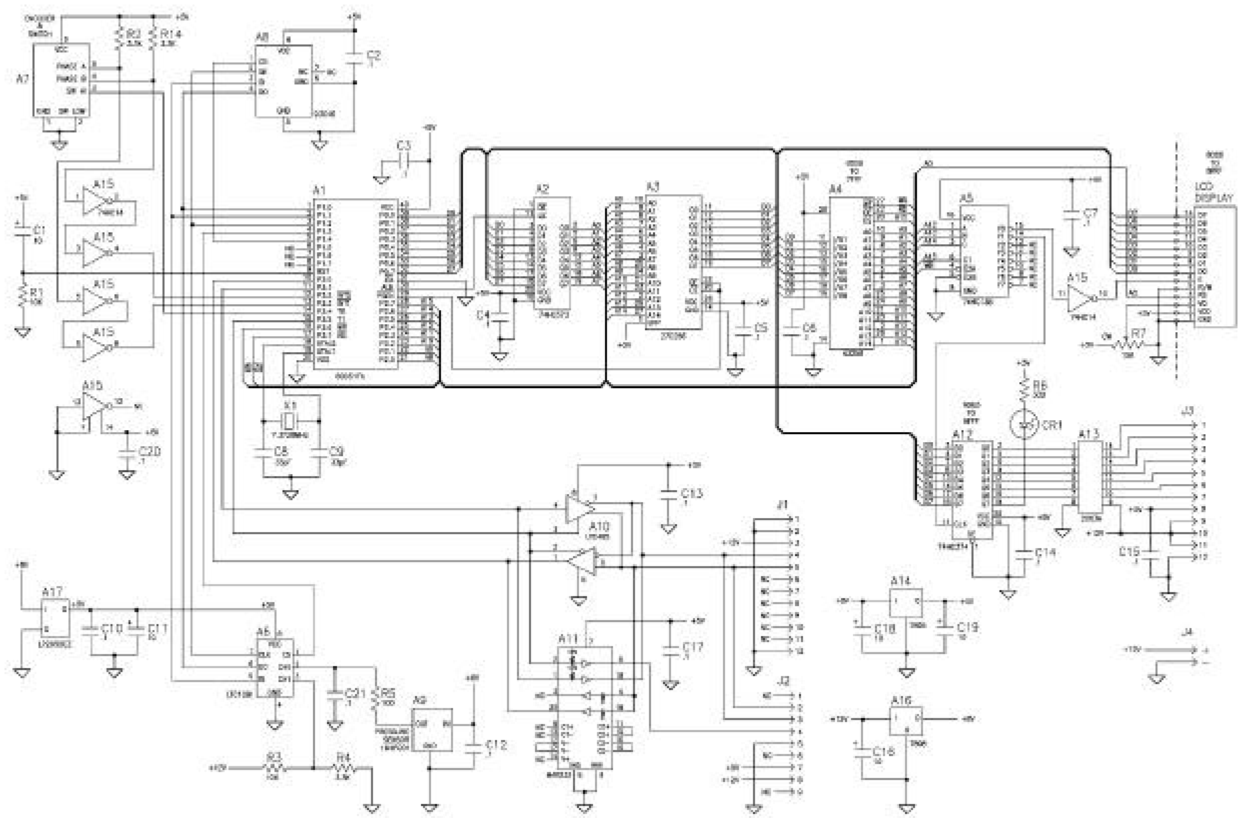

Figure 19-29. 11582-001, Gas manager board. (A larger version of this drawing is located in Chapter 22.)

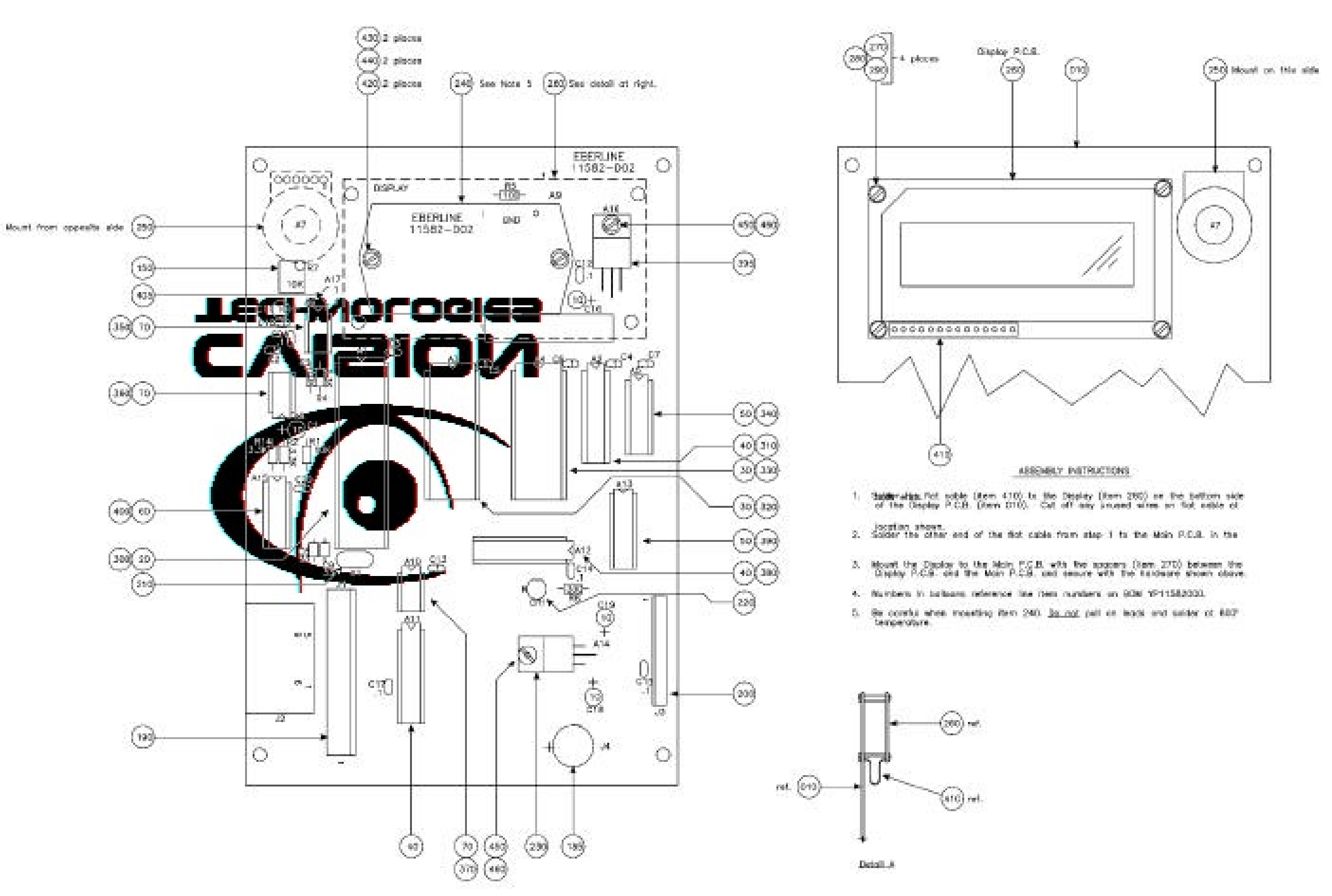

Figure 19-30. 11582-003, Gas manager board component. (A larger version of this drawing is located in Chapter 22.)

Gas Manager Parts List

Table 19-20 lists the electronic items incorporated in the gas manager and contains parts necessary for normal repair.

Table 19-20. Gas Manager Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
020	11534-D348	Mounting bracket	Gas Manager	ZP11534347
520	11534-D348	PCBA	Gas Manager	YP1157000 0
570	11534-D348	Metric Binder-Head Screw	M2.5 x 8.0	SCMB62
600	11534-D348	Knob	Gas Manager Control	HDKN2
620	11534-D348	Solenoid Valve	12 VDC	MEVE152

630	11534-D348	Solenoid Valve	3 Port, 12 VDC	MEVE 160
640	11534-D348	Plastic Hose Barb	#10-32 x 1/8 Hose	FGPL11
650	11534-D348	Brass Hose Barb	1/8 MPT x 1/8 Hose	FGBR53
660	11534-D348	Hose "T"	1/8 Hose Barbs	FGPL7
670	11534-D348	.016 Outlet Metering Orifice	#10-32 x 1/8 Hose	FGPL53
672	11534-D348	Plastic Reducer Fitting	1/8 MPT x #10-32	FGPL60
674	11534-D348	.012 Inlet Metering Orifice	#10-32 x 1/8 Hose	FGPL52
680	11534-D348	1/8" ID Tubing	Clear PVC	MMTU1
690	11534-D348	Seal Screw	#10-32 x 3/16 w/ o-ring	SCOR1003

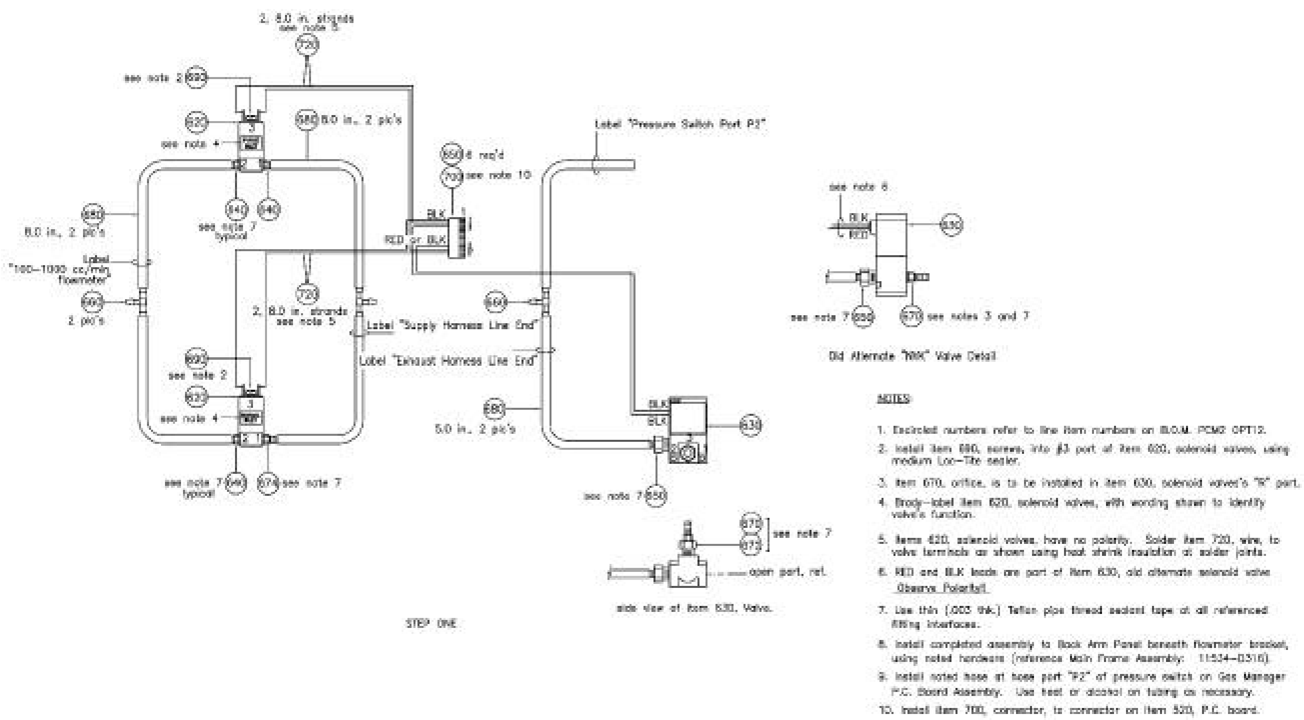

Figure 19-31. 11534-348, Gas manager assembly, drawing 1 of 2. (A larger version of this drawing is located in Chapter 22.)

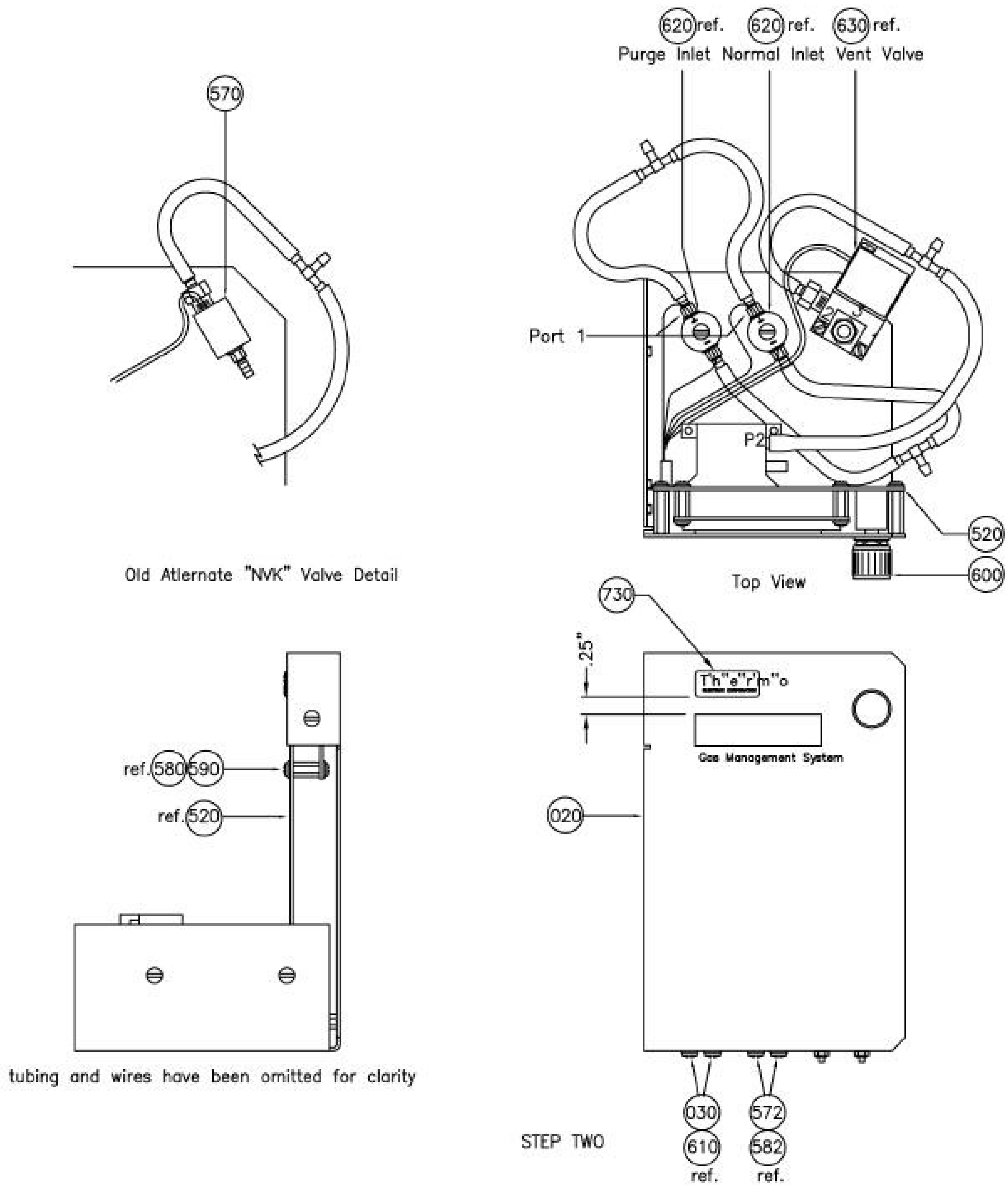

Figure 19-32. 11534-348, Gas manager assembly, drawing 2 of 2. (A larger version of this drawing is located in Chapter 22.)

Spare Purging Detectors

OPT15, Spare Purging Detectors

This option includes three standard spare detectors (one of each size) which are mounted internally to the unit on its rear door. The detectors are plumbed in parallel via gas supply and gas exhaust plumbing harnesses which flow the instrument's normal exhaust gas through them so that they continuously purge during normal instrument operation. This configuration provides the user with the capability of easy and immediate replacement of any damaged or otherwise failed detector without impacting the instrument's normal operation. Repair or replacement of the damaged detectors can then be pursued without incurring instrument downtime.

Spare Purging Detectors Parts List

Table 19-21 lists the items incorporated in the spare purging detectors and contains parts necessary for normal repair.

Table 19-21. Spare Purging Detectors Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
010	11534-D542	Detector Assembly	Long, 3 Channel	YP11534560
020	11534-D542	Detector Assembly	Medium, 1 Channel	YP11534561
030	11534-D542	Detector Assembly	Small, 1 Channel	YP11534562
040	11534-D542	Mounting Bracket	Spare Probe	ZP11534540
050	11534-D542	Velcro Cinching Strap	Probe Retaining	HDHA25
060	11534-D542	Strap Loop	2" Wide	HDHA27
070	11534-D542	1/4" Tubing	Blue PVC	MMTU62
080	11534-D542	Quick-Discount Coupling	1/4" Hose Barb	FGPL33
090	11534-D542	Hose "T"	1/4" Hose Barbs	FGPL2
100	11534-D542	Ty-wrap Clamp	Adhesive Backed	MMCL54
110	11534-D542	Cable Tie	Ty-wrap	HDMI93
140	11534-D542	1/4"ID Tubing	Red PVC	MMTU60
150	11534-D542	Reducer Fitting	1/4" tp 1/8" Hose Barbs	FGPL56
160	11534-D542	1/8" ID Tubing	Red PVC	MMTU70
170	11534-D542	Quick-disconnect In-Line Coupling	1/4" Hose Barb	FGPL43

Chapter 20 Standard Parts List

Table 20-1 lists the items used in the PCM-2 that are not specified in the subassembly or options sections of this manual. Each Drawing No. group below is keyed to an associated PCM-2 assembly drawing in Chapter 22: "Drawings" in which parts are keyed to numbers. The use of equivalent parts with the same operating characteristics is not restricted.

Table 20-1. Standard Parts List

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
078	11534-D304	Graphic Overlay	Keypad	ZP11534124
136	11534-D304	Back plate	Keypad	ZP11534125
137	11534-D304	Mylar® Insulator	Keypad	ZP11410021
320	11534-D304	Cable Assembly	Keypad	YP11534511
408	11534-D304	Keypad	20 Key Matrix	SWMI43
004	11534-D106	Back plate	Instructional Label # 1	ZP11534086
006	11534-D106	Back plate	Instructional Label # 2	ZP11534087
130	11534-D106	Instructional Label	Clock Display # 1	ZP11534084
132	11534-D106	Instructional Label	Clock Display # 2	ZP11534085
312	11534-D106	Cable Assembly	Clock Display # 1	YP11534507
314	11534-D106	Cable Assembly	Clock Display # 2	YP11534508
404	11534-D106	PCBA	Clock Display	YP11534151
222	11534-D308	Plumbing Harness	Gas Supply	YP11534369
225	11534-D308	Plumbing Harness	Gas Exhaust	YP11534371
554	11534-D308	Gas Filter	In-line	FIFH7
557	11534-D308	Tube Reducer	1/4" to 1/8" Hose Barbs	FGPL56
566	11534-D308	Flow meter	10-100 cc/min	MTFM80
568	11534-D308	Flow meter	100-1000 cc/min	MTFM81
570	11534-D308	Hose "T"	1/8" Hose Barbs	FGPL7
578	11534-D308	1/4" ID Tubing	Blue PVC	MMTU62
584	11534-D308	!/8" ID Tubing	Clear PVC	MMTU1
589	11534-D308	Needle Valve	Flow Adjustment	FGMI51
054	11534-D314	Mounting bracket	Glide	Switch Cable Assembly
088	11534-D314	Mounting Bracket	Foot Switch	ZP11534186
092	11534-D314	Actuator Bracket	Foot Switch	ZP11534302
135	11534-D314	Support Bumper	Footplate	ZP11534353

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
148	11534-D314	Nut plate	Foot Switch Mounting	ZP10741018
163	11534-D314	Cover Panel	Foot Switch Access	ZP10741572
318	11534-D314	Lower Cable Assembly	Foot Switch	YP11534510
508	11534-D314	Nylon Flange Bearing	Door Pivot	MMBU60
551	11534-D314	Furniture Glide	Base	HDMI12
601	11534-D314	Hole Plug	Base Trim	MMBZ24
602	11534-D314	Hole Plug	Base Trim	MMBZ26
618	11534-D314	Teflon Shoulder Washer	Foot switch Actuator	SCMW40
620	11534-D314	Actuator Spacer	# 8 x 3/16, Brass	SPRB8403
622	11534-D314	Spring Retaining Spacer	#4 x 3/16, Brass	SPRB4403
626	11534-D314	Compression Spring	Actuator Return	SGC048
679	11534-D314	Hex Jam Nut	Glide Adjustment	SCMN11
010	11534-D315	Mounting Bracket	Traffic Light	ZP11534105
022	11534-D315	Mounting Bracket	Speaker	ZP11534137
110	11534-D315	Cover Plate	Power Inlet	ZP11534281
134	11534-D315	Traffic Light Cover	Smoked Plastic	ZP11534103
244	11534-D315	Probe Chamber Assembly	Small, 9"x7"	YP11534562
310	11534-D315	Cable Assembly	Traffic Light	YP11534506
324	11534-D315	Cable Assembly	PC-AT Speaker	YP11534520
406	11534-D315	PCBA	Traffic Light	YP11534152
430	11534-D315	Modular Detector Board Assembly	Probe Mounted	SP28A
508	11534-D315	Nylon Flanged Bearing	Door Pivot	MMBU60
534	11534-D315	Velcro Cinching Strap	Probe Retaining	HDHA25
543	11534-D315	Ty-wrap Clamp	Adhesive Backed	MMCL54
560	11534-D315	Strap Loop	2" wide	HDHA27
587	11534-D315	Cable Tie	Ty-wrap	HDMI93
602	11534-D315	Hole Plug	Base Trim	MMBZ26
072	11534-D316	Support	Instep Detector	ZP11534220
110	11534-D316	Cover Plate	Instep Detector Panel	ZP11534281
152	11534-D316	Plate	Power Inlet	ZP11534342
154	11534-D316	Backing Plate	Power Inlet	ZP11534343
332	11534-D316	Power Cord	AC	WRAC4
418	11534-D316	LCD Assembly	10.4" Color	YP11534737

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
512	11534-D316	Rubber Bumper	3/8 diameter x 1/16	MMRU90
531	11534-D316	Foam Tape	Adhesive Backed	HDTA16
548	11534-D316	Conduit	Cable Routing	HDMI164
550	11534-D316	Conduit Cover	Cable Routing	HDMI165
604	11534-D316	Strain Relief	Power Cord	WRSR21
086	11534-D318	Mounting Bracket	Power Supply	ZP11534215
100	11534-D318	Vent Panel	Lower Elec. Enclosure	ZP11534228
108	11534-D318	Cover	Corcom	ZP11534264
148	11534-D318	Nut Strip	Switch Mounting	ZP10741018
302	11534-D318	Power Supply Assembly	Low Voltage	YP11534501
304	11534-D318	Gas Control Assembly	Switching & Sensing	YP11534502
316	11534-D318	Upper Cable Assembly	Hand Switch	YP11534509
330	11534-D318	AC Cable	Power Inlet	YP11534527
334	11534-D318	Power Strip	120 VAC	MEVE63
336	11534-D318	Terminal Strip	2 x 6	COTB15
426	11534-D318	Power Supply	PC-AT, 100 Watt	MEVE148
519	11534-D318	Caterpiller Grommet	Vent Panel	MMRU39
543	11534-D318	Ty-Wrap Clamp	Adhesive Backed	MMCL54
587	11534-D318	Cable Tie	Ty-Wrap	HDMI93
617	11534-D318	Foam Tape	1/2"W x 3/16" thick	HDTA25
010	11534-D321	Perforated Footplate	High Heel Option	YP11534175
098	11534-D321	Enclosure Cover	Lower Electronics	ZP11534225
118	11534-D321	Enclosure Cover	Upper Electronics	ZP11534226
120	11534-D321	Enclosure Cover	CRT	ZP11534227
124*	11534-D321	Perforated Grid, 1/8" square	Small Probe	ZP11534567
125*	11534-D321	Formed Perforated Grid, 1/8" square	Palm Detector	ZP11534573
126*	11534-D321	Perforated Grid, 1/8" square	Ankle Probe	ZP11534566
127*	11534-D321	Formed Perforated Grid, 1/8" square	Outer Hand Detector	ZP11534579
128*	11534-D321	Perforated Grid, 1/8" square	Long Probe	ZP11534565
138	11534-D321	Foot Probe Protector	Poly Film	ZP11534352
238	11534-D321	Slotted Footplate	Standard	YP11534328
240	11534-D321	Detector Assembly	Long, 3 Channel	YP11534560

242	11534-D321	Detector Assembly	Medium, 1 Channel	YP11534561
244	11534-D321	Detector Assembly	Small, 1 Channel	YP11534562
246	11534-D321	Adjustable Supports	Foot Probe	YP11534291
326	11534-D321	Cable (#1)	Detector	YP11534523
328	11534-D321	Cable (#2)	Detector	YP11534524
430	11534-D321	Modular Detector Board Assembly	Probe Mounted	SP28A
431	11534-D321	Foam Dust Shield	MDB to Detector	ZP11534578
432	11534-D321	Wave Washer	MDB Grounding	SCMW59
534	11534-D321	Velcro Cinching Strap	Probe Retaining	HDHA25
546	11534-D321	Handle	Electronics Cover	HDHA24
572	11534-D321	Fitting	1/4MPT x 1/8 Hose	FGBR51
590	11534-D321	Key latch	Upper Cover	HDLA17
594	11534-D321	Pressure Regulator	Counting Gas	PUHD38
601	11534-D321	Steel Hole Plug	1 1/2" diameter	MMBZ24
610	11534-D321	Eyebolts	Cabinet Lifting	SCMB24
610	11534-D321	Eyebolts	Cabinet Lifting	SCMB24
028	11534-D330	Track Pivot Plate	Keyboard Slider	ZP11534196
042	11534-D330	Track Spring Bar	Keyboard Slider	ZP11534211
044	11534-D330	Track Spring Pivot	Keyboard Slider	ZP11534212
046	11534-D330	Track Rear Bracket	Keyboard Slider	ZP11534200
048	11534-D330	Track Front Bracket	Keyboard Slider	ZP11534201
114	11534-D330	Pin	Door Pivot	ZP11534069
129	11534-D330	Pictoral Plate	Detectors Layout	ZP11534361
138	11534-D330	Detector Protector	Foot	ZP11534352
228	11534-D330	Modified Chassis Track	Keyboard Slider	ZP11534209
510	11534-D330	Compression Spring	Pivot Pin Return	SGG030
516	11534-D330	Nylon Shoulder Washer	Keyboard Pivot	SCMW52
526	11534-D330	Thumb Screw	# 8-32 x 1/2 S.S.	SCTS11
542	11534-D330	Extension Spring	Keyboard Return	SGEX20
588	11534-D330	Flush Latch	Door	HDLA16
616	11534-D330	Foam Tape	Double Sticky	HDTA31
630	11534-D330	Spacer	5/16" OD Aluminum	SPXX52
722	11534-D330	Spacer	#10 x 5/16 Aluminum	SPXX15

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
032	11534-D333	Holder Bracket	Keyboard	ZP11534198
052	11534-D333	Holder Bar	Keyboard	ZP11534199
129	11534-D333	Pictoral Plate	Detectors Layout	ZP11534361
428	11534-D333	PC-AT	Keyboard	VEIN47
514	11534-D333	Thumb Nut	#10-32, Brass	SCTS25
521	11534-D333	Panel Grommet	1 5/8 x 1 x 1/32	MMRU38
528	11534-D333	Rubber Bumper		MMRU24
530	11534-D333	Foam Tape	Single Sticky	HDTA12
544	11534-D333	Note Clip	Keyboard Plate	MMCL75
546	11534-D333	Round Handle	Keyboard Plate	HDHA24
592	11534-D333	Foam Grip	Keyboard Bar	MMRU92
616	11534-D333	Foam Tape	Double Sticky	HDTA31
632	11534-D333	Rubber Bumper	Keyboard Bottom	MMRU34
1	11534-D344	Front Panel Board	Cable Assembly	YP11534503
2	11534-D344	Clock Display #1	Cable Assembly	YP11534507
3	11534-D344	Clock Display #2	Cable Assembly	YP11534508
4	11534-D344	Traffic Light	Cable Assembly	YP11534506
5	11534-D344	Keypad	Cable Assembly	YP11534506
6	11534-D344	Upper Switch	Cable Assembly	YP11534509
7	11534-D344	Lower Switch	Cable Assembly	YP11534510
8	11534-D344	CRT Display	Cable Assembly	CA-91-72
9	11534-D344	Floppy Disc Drive	Cable Assembly	VEMI83
10	11534-D344	Converter Board	Cable Assembly	YP11534504
11	11534-D344	Serial Data	Cable Assembly	YP11534516
12	11534-D344	PC Speaker	Cable Assembly	YP11534520
13	11534-D344	Low Voltage Supply	Cable Assembly	YP11534501
14	11534-D344	Detector #1	Cable Assembly	YP11534523
15	11534-D344	Detector #2	Cable Assembly	YP11534524
16	11534-D344	6" Jumper	Cable Assembly	YP11534535
010	11534-D369	1/8 ID Tubing	Red PVC	MMTU70
020	11534-D369	.005 Orifice	1/8" Hose Barbs	FGMI50
030	11534-D369	Quick-Disconnect Coupling	1/8" Hose Barb x 1/8 Flow	FGPL31
040	11534-D369	90 degree Quick Disconnect	1/8" Hose Barb x 1/8 Flow	FGPL46
050	11534-D369	Hose “T”	1/8" Hose Barbs	FGPL7
010	11534-D371	1/4" ID Tubing	Blue PVC	MMTU62
020	11534-D371	Quick-Disconnect Coupling	1/4" Hose Barb x 1/8" Flow	FGPL33
030	11534-D371	!/8" ID Tubing	Blue PVC	MMTU71
040	11534-D371	Reducer Fitting	1/4" to 1/8 Hose Barbs	FGPL56
060	11534-D371	Hose “T”	1/4 Hose Barbs	FGPL2

Item Ref. No.	Drawing No.	Part Name	Description	Part No.
034	11534-D375	Display Panel	Molded Console	ZP11534214
106	11534-D375	Stiffener Bracket	Console Keypad	ZP11534248
112*	11534-D375	Blank Panel	Card Reader	ZP11534295
156	11534-D375	Spacer Bracket	Keypad	ZP11534367
322	11534-D375	Cable Assembly	PC Serial	YP11534516
324	11534-D375	Cable Assembly	PC Speaker	YP11534520
331	11534-D375	Jumper Cable	9 pin, 6"	YP11534535
340	11534-D375	Video Cable	6 ft., VGA	CA-91-72
345	11534-D375	Printer Cable	Parallel, 15 ft.	CA-92-15FT
402	11534-D375	PCBA	Front Panel	SP24B
410	11534-D375	SBC	Single Board Computer	YP11534741
412	11534-D375	Power Cable	Floppy Disk Drive	VECA92
414	11534-D375	PCBA	PC-AT, Disk & I/O	VEBD16
416	11534-D375	LCD	Flat panel display assembly	YP11534737
420	11534-D375	Floppy Disc Drive	1.4 Mbyte	VEMI78
422	11534-D375	Cable	Dual Floppy Disc	VEMI83
424	11534-D375	PCBA	RS232-RS485	YP11451000
426	11534-D375	Power Supply	PC-AT, 100W	MEVE148
428	11534-D375	Keyboard	PC-AT	VEIN47
529	11534-D375	Rubber Bumper	Keyboard	MMRU45
613	11534-D375	Hex Switch Nut	3/8-32, Thin	SCMN4
688	11534-D375	Lock washer	3/8" IT, SS	SCIT0037
110	11534-D502	Pressure Switch	Counting Gas	SWMI27
130	11534-D502	Solenoid Valve	12 VDC	MEVE152
140	11534-D502	Diode	Solenoid Valve	CRSI1N4005
150	11534-D502	Hose Barb	10-32 x 1/8 ID, Brass	FGBR57
160	11534-D502	Mounting Bracket	Auto Switches	ZP11171073
170	11534-D502	Strain Relief	Hose Barb	ZP11229057
230	11534-D502	Clear Tubing	1/8 x 1/4 PVC	MMTU1
270	11534-D502	Cable Tie	Ty-wrap	HDMI102

* See Chapter 19: "Options" for specific optional card reader mounting plate part number information.

* See Chapter 19: "Options" for optional high-sensitivity etched detector screens part numbers.

Chapter 21 Recommended Spare Parts

Table 21-1 is comprised of those spare parts recommended for one-year support of from one to five standard PCM-2 units in order to limit instrument down-times due to component failures. The quantities listed in the table should be doubled for support of six to 14 units and tripled for support of 15 or more units. Some failed modules such as printed circuit boards and detectors can be repaired and returned to stock for future use.

Spare parts to support PCM-2 options are listed in Chapter 19: "Options".

Table 21-1. Recommended Spare Parts List*

Part No.	Description	Quantity
SP28A	Modular Detector Board	2
YP11534560	Detector Assembly (Long)	2
YP11534561	Detector Assembly (Medium)	2
YP11534562	Detector Assembly (Short)	1
YP11451000	RS485 to RS232 Converter Board	1
SP24B	Front Panel Board	1
YP11582000	Gas Manager Board	1
MEVE152	Single Port Solenoid Valve	1
MEVE160	Three Port Solenoid Valve	1
VEIN82-300M	Single Board Computer	1
YP11534501	12 Vdc Power Supply	1
PSL09-0100	Computer Power Supply	1
SWMI105	Photocell Emitter/Receiver Pair	1
VEIN92	Flat Panel Display	1
MMMY3	Detector Mylar® (83 sq. ft. roll)	1
Special Tools		
ZP11534699	PCM-2 Detector Clip Installation Tool	1
PCM1B OPT23	Gas Leak Detector	1

* One PMC-2, one year.

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Chapter 22 Drawings

Overview

This chapter contains a compilation of drawings contained in this manual. For parts subject to replacement or failure, see Chapter 20: "Standard Parts List". Numbers encircled in a drawing refer to Bill of Materials (BOM) line items.

Description	Drawing No.	Figure No.
Access control, base assembly	11534-477	22-51
Access control, ceiling assembly	11534-478	22-52
Access control, gates assembly	11534-479	22-53
Access control, overall assembly	11534-480	22-54, 22-55, and 22-56
Access control, overall wiring	11534-476	22-57
Ceiling assembly	11534-315	22-21 and 22-22
Clicker Board II component layout	11532-002	22-36
Clicker Board II components	11532-004	22-42
Clicker PCB component assembly	11532-003	22-41
Clock display	11534-150	22-11
Clock display PCB component assembly	11534-151	22-12
Computer Identics swipe card reader assembly	11534-706	22-62
Detectors installation assembly	11534-321	22-74 and 22-75
Flat panel display assembly	11534-737	22-83
Front panel board components	11526-009	22-5
Front panel board SP24 basic component assembly	11526-003	22-4
Gas bottle enclosure assembly	11534-236	22-37
Gas bottle enclosure outline	11534-564	22-86
Gas control assembly	11534-502	22-30
Gas exhaust plumbing harness	11534-371	22-29
Gas manager assembly	11534-348	22-67 and 22-68
Gas manager board	11582-001	22-65
Gas manager board component	11582-003	22-66
Gas supply plumbing harness	11534-369	22-28
Hand probe assembly	11534-307	22-40
Hard disk drive assembly	11534-563	22-20

Description	Drawing No.	Figure No.
Head & shoulders switch assembly	11534-548	22-79 and 22-80
ICI insert card reader assembly	11534-323	22-59
ICI swipe card reader assembly	11534-324	22-60
Instructional label assemblies	11534-106	22-27
Instrument outline	11534-555	22-1
Intermec barcode reader assembly	11534-378	22-63
Intermec barcode reader wiring	11534-386	22-64
Island assembly	11534-317	22-24 and 22-25
Keyboard pivot plate assembly	11534-333	22-35
Keypad and backplate assembly	11534-304	22-26
Lower electronics enclosure assembly	11534-318	22-69
Main frame assembly	11534-316	22-72 and 22-73
Modular detector board	11543-001	22-8
Modular detector board components	11543-005	22-9
Modular detector board, hybrid	11534-008	22-10
Overall assembly access control	11534-480	22-76, 22-77 and 22-78
Plumbing	11534-371	22-87
Plumbing configuration	11534-308	22-31 and 22-32
Polyethylene dispenser assembly	11534-320	22-38 and 22-39
Power cable, single board PC	11534-740	22-85
Power cable, VEIN92	11534-739	22-84
Printer assembly	11534-312	22-46
Rear and side door assembly	11534-330	22-70 and 22-71
Rear hand detector panel assembly	11534-322	22-23
Remote annunciator	11549-002	22-88
Remote annunciator assembly	11534-529	22-47
Remote annunciator component assembly	11549-001	22-48
Revised detector assembly, long	11534-560	22-14 and 22-15
Revised detector assembly, medium	11534-561	22-16 and 22-17
Revised detector assembly, small	11534-562	22-18 and 22-19
Right/left foot switch assembly	11534-319	22-22
RS-232 to RS-435 interface	11451-003	22-6
RS-232 to RS-485 interface components	11451-004	22-7
Swiveling casters assembly	11534-340	22-58

Description	Drawing No.	Figure No.
System block	11534-344	22-33
Time delay relay switch settings	N/A	22-50
Traffic light PCB component assembly	11534-152	22-12
Typical background plateau curves	N/A	22-3
Typical source plateau curves	N/A	22-2
Upper electronics enclosure assembly, basic	11534-375	22-34
Voice annunciator assembly	11534-313	22-45
Voice annunciator layout	11513-002	22-43 and 22-44
Wall-mount/remote annunciator outline	11534-531	22-49
XICO insert card reader assembly	11534-325	22-61

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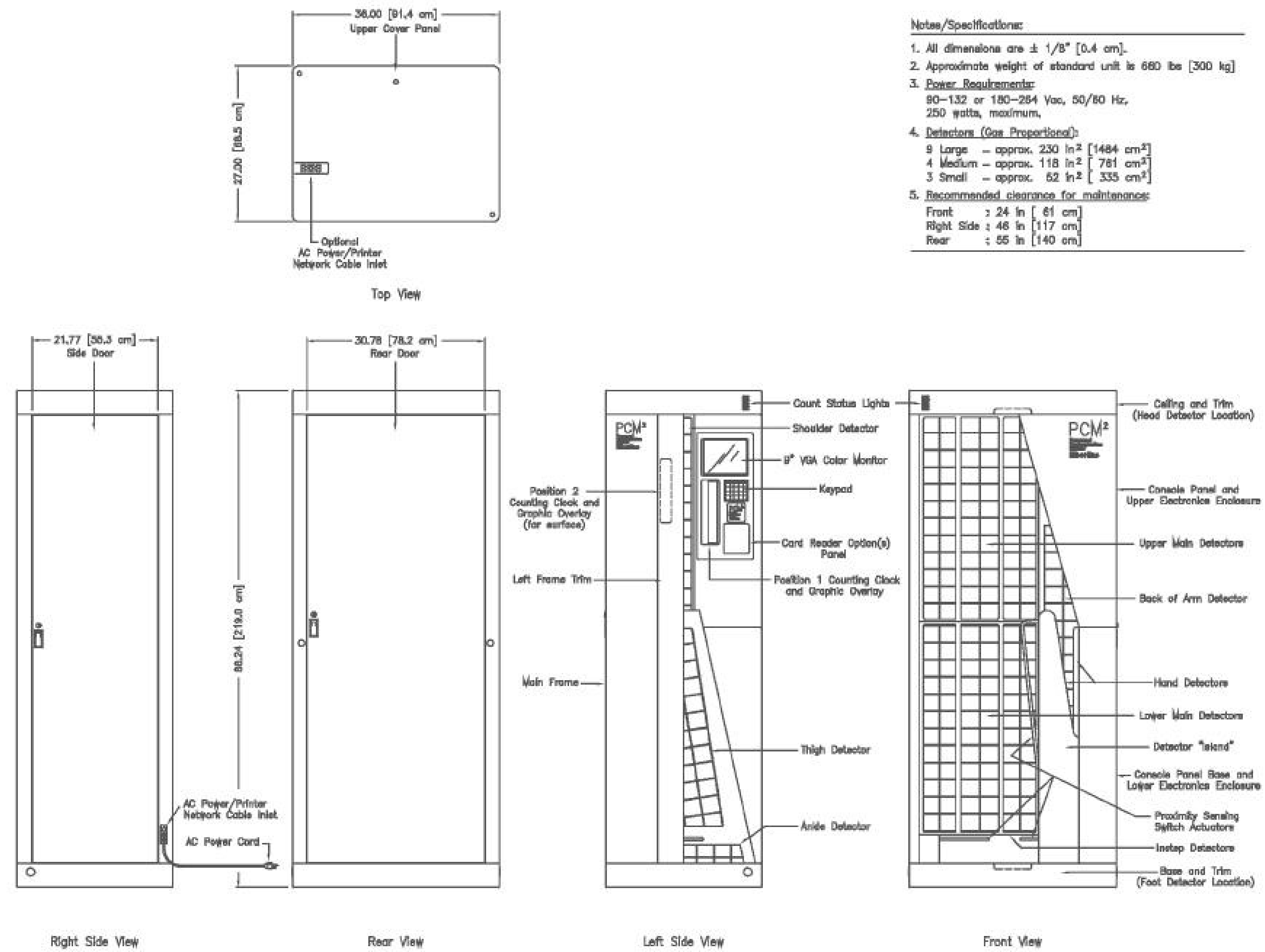


Figure 22-1. 11534-555, Instrument outline.

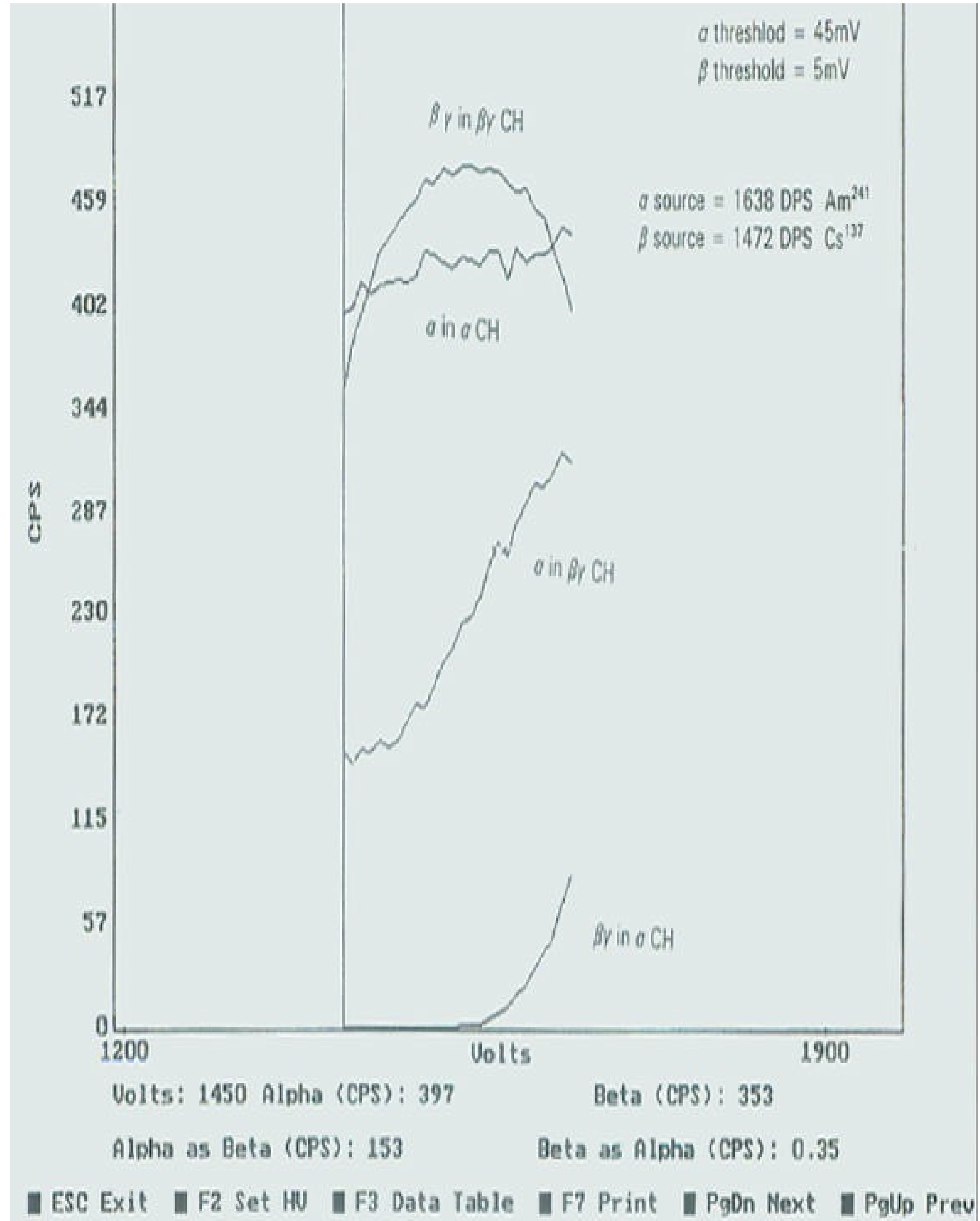


Figure 22-2. Typical source plateau curves.

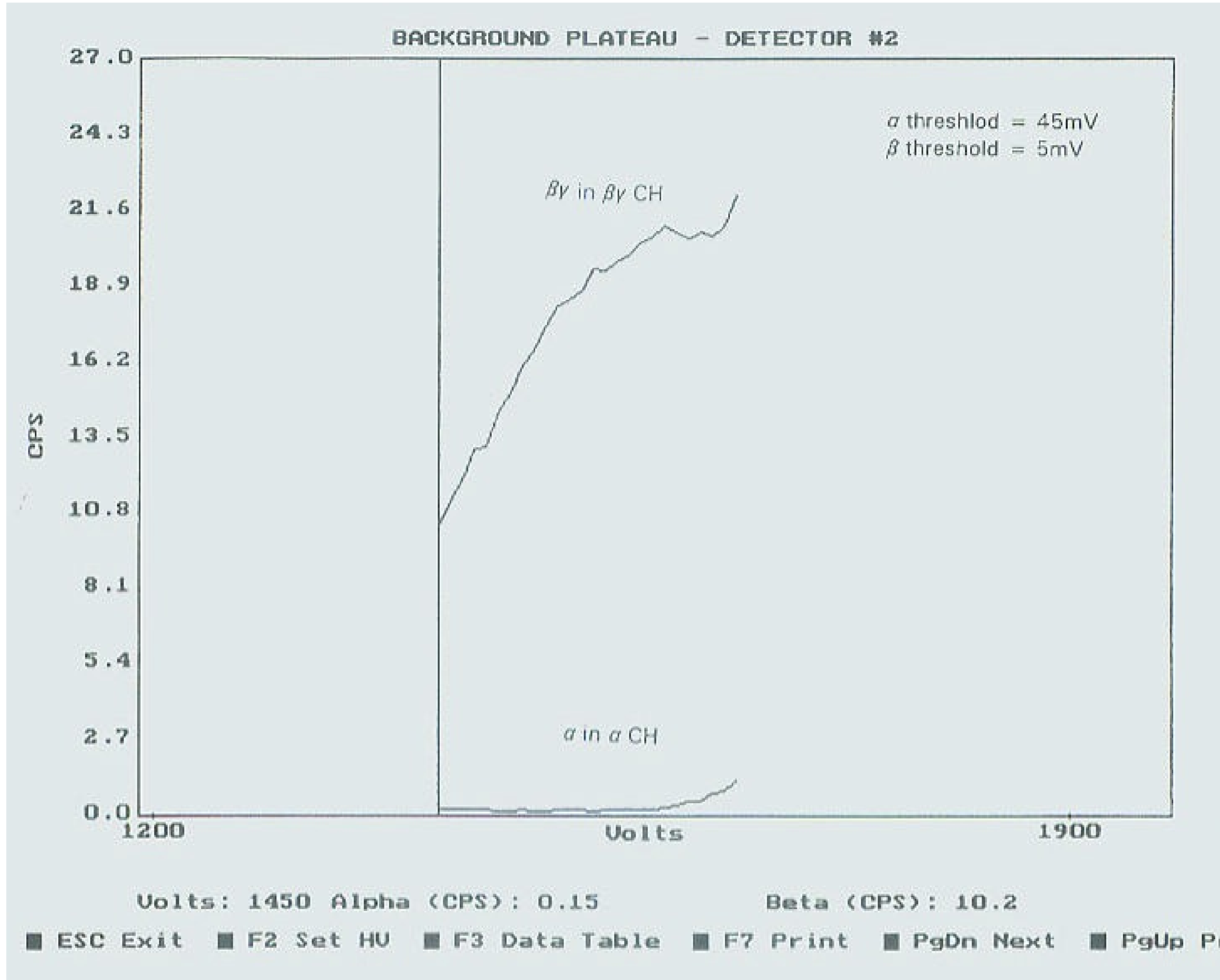
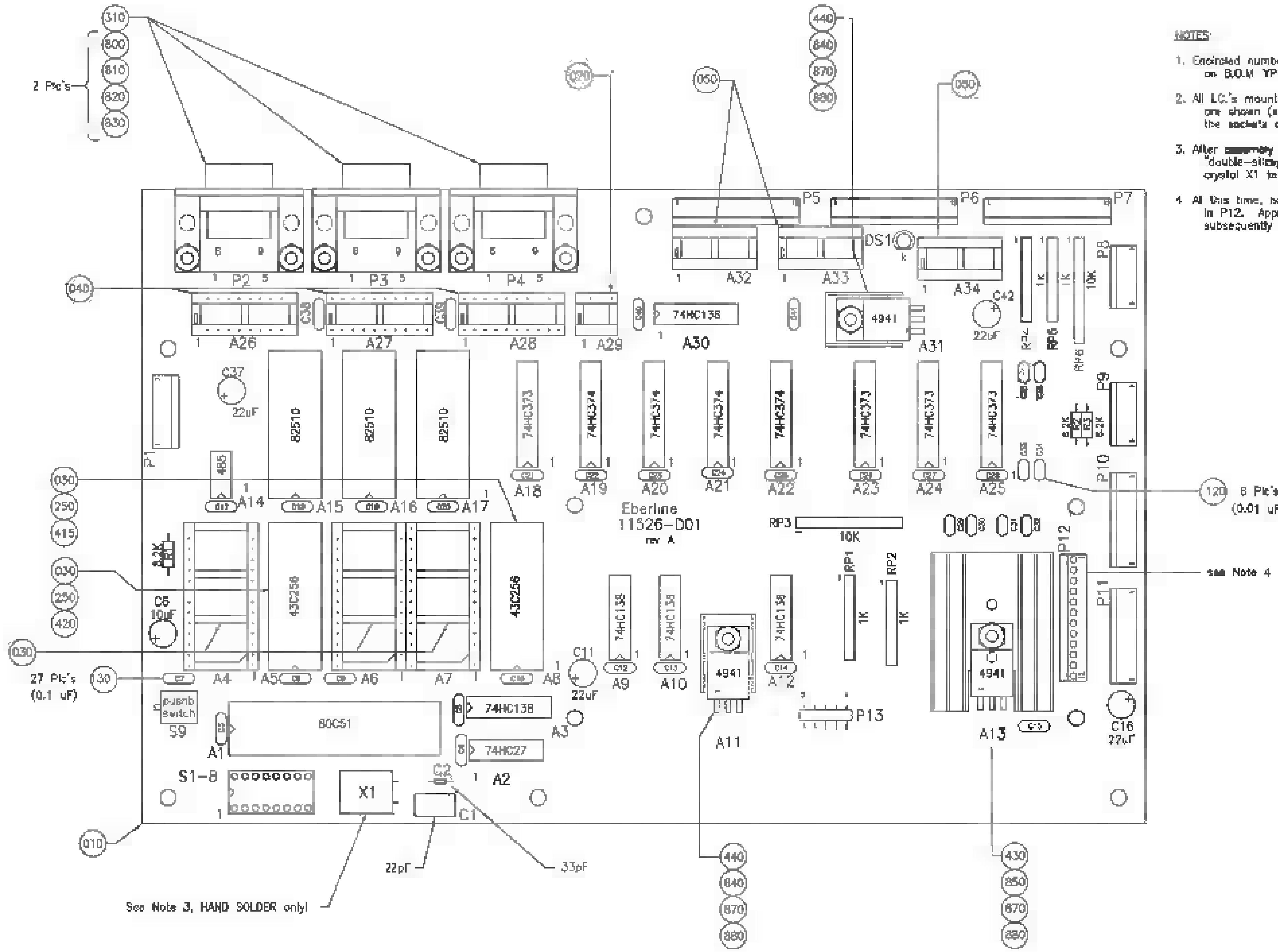


Figure 22-3. Typical background plateau curves.



NOTES:

1. Encircled numbers refer to ure numbers on B.O.M YP11526000
2. All I.C.'s mount in sockets. When only sockets are shown (e.g., A29), no I.C.'s mount in the sockets at this time.
3. After assembly is complete, a small piece of "double-sticky" foam tape is placed under crystal X1 to secure it to the board
4. At this time, no connector hardware is mounted in P12. Appropriate hardware will be mounted subsequently

Figure 22-4. 11526-003, Front panel board SP24 basic component assembly.

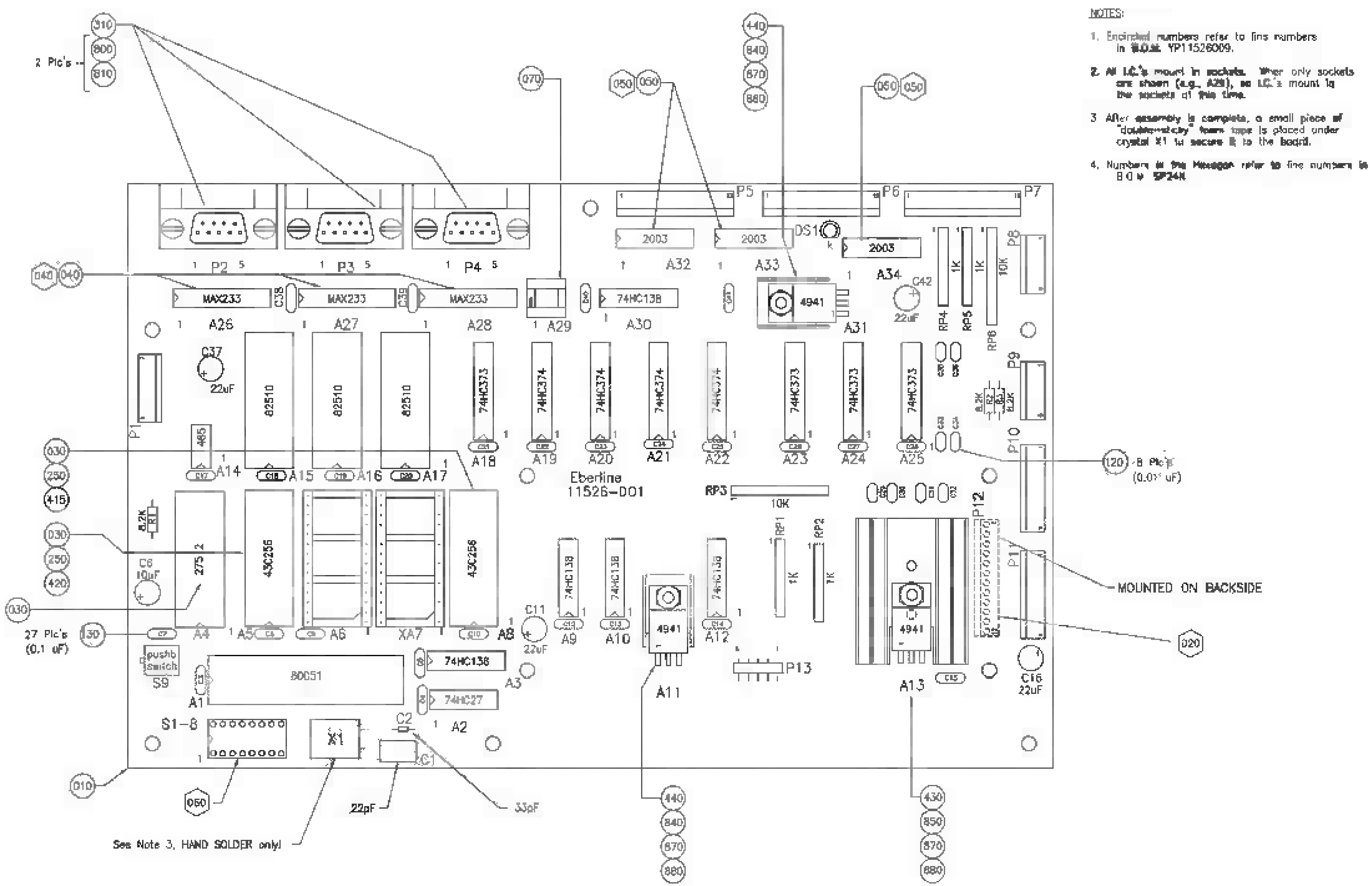
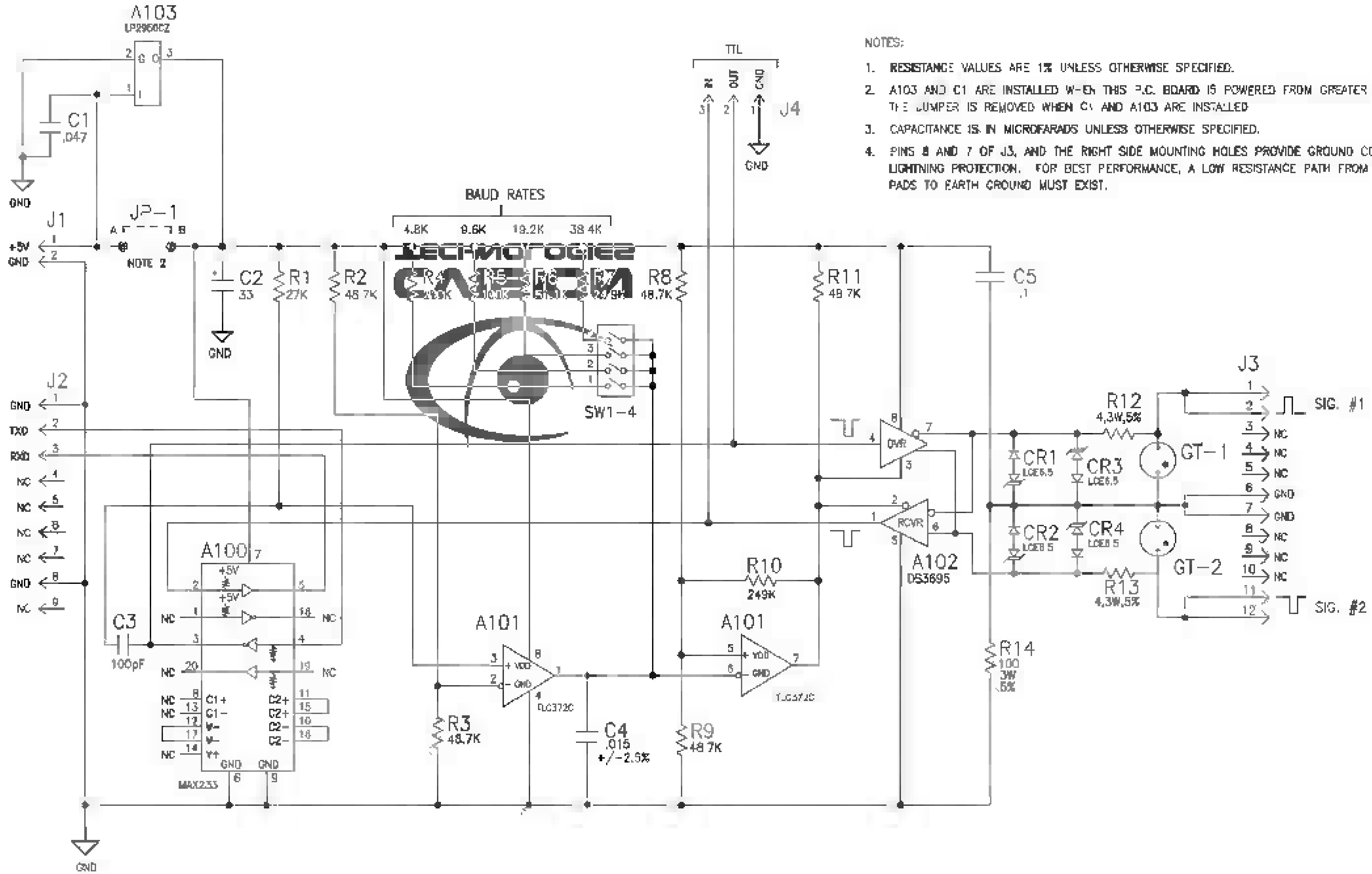


Figure 22-5. 11526-009, Front panel board components.



NOTES:

1. RESISTANCE VALUES ARE 1% UNLESS OTHERWISE SPECIFIED.
2. A103 AND C1 ARE INSTALLED WHEN THIS P.C. BOARD IS POWERED FROM GREATER THAN +5 VDC, THE JUMPER IS REMOVED WHEN C1 AND A103 ARE INSTALLED.
3. CAPACITANCE IS IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
4. PINS 6 AND 7 OF J3, AND THE RIGHT SIDE MOUNTING HOLES PROVIDE GROUND CONNECTION FOR LIGHTNING PROTECTION. FOR BEST PERFORMANCE, A LOW RESISTANCE PATH FROM THE MOUNTING PADS TO EARTH GROUND MUST EXIST.

Figure 22-6. 11451-003, RS-232 to RS-485 interface.

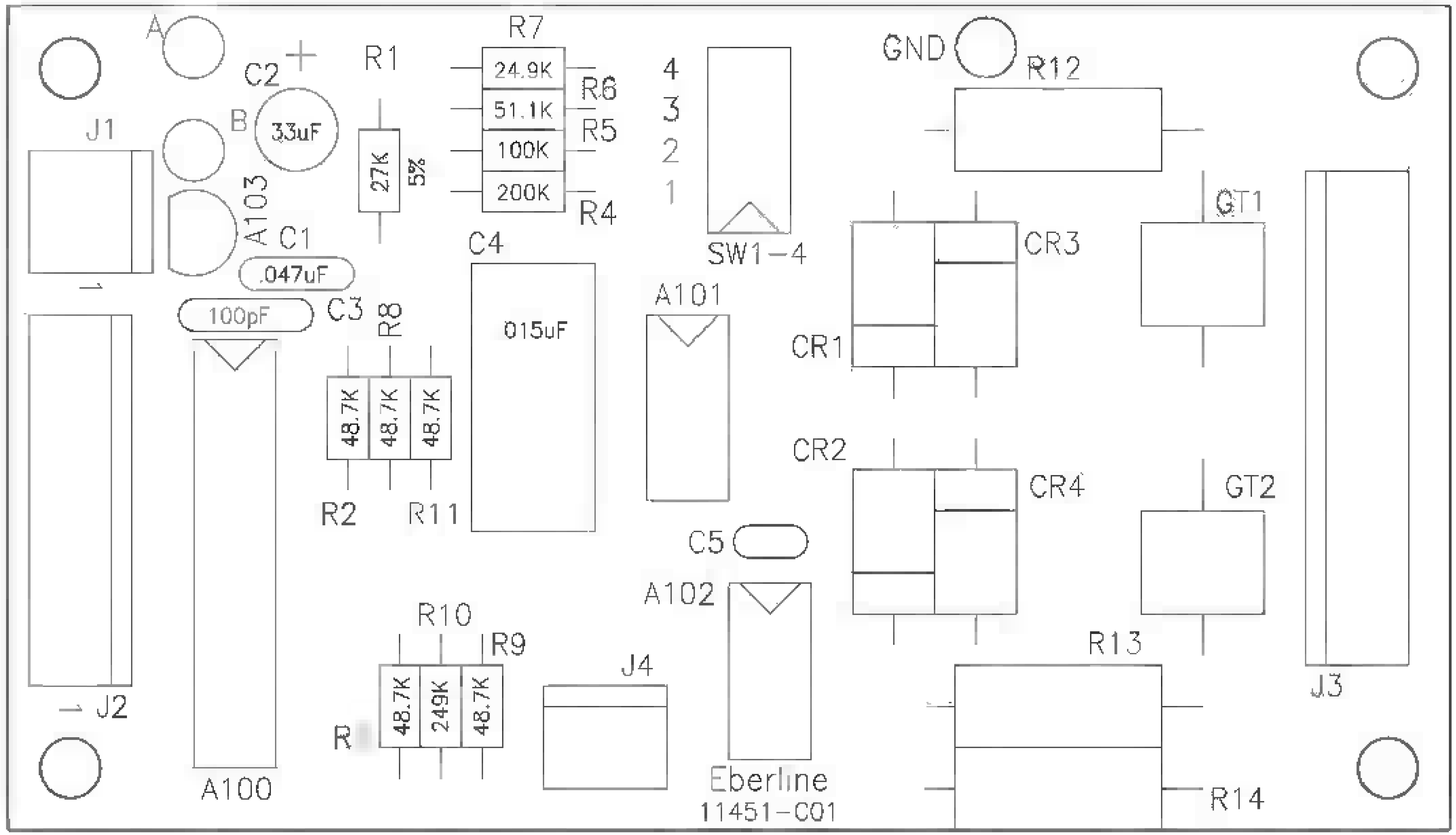


Figure 22-7. 11451-004, RS-232 to RS-485 interface components.

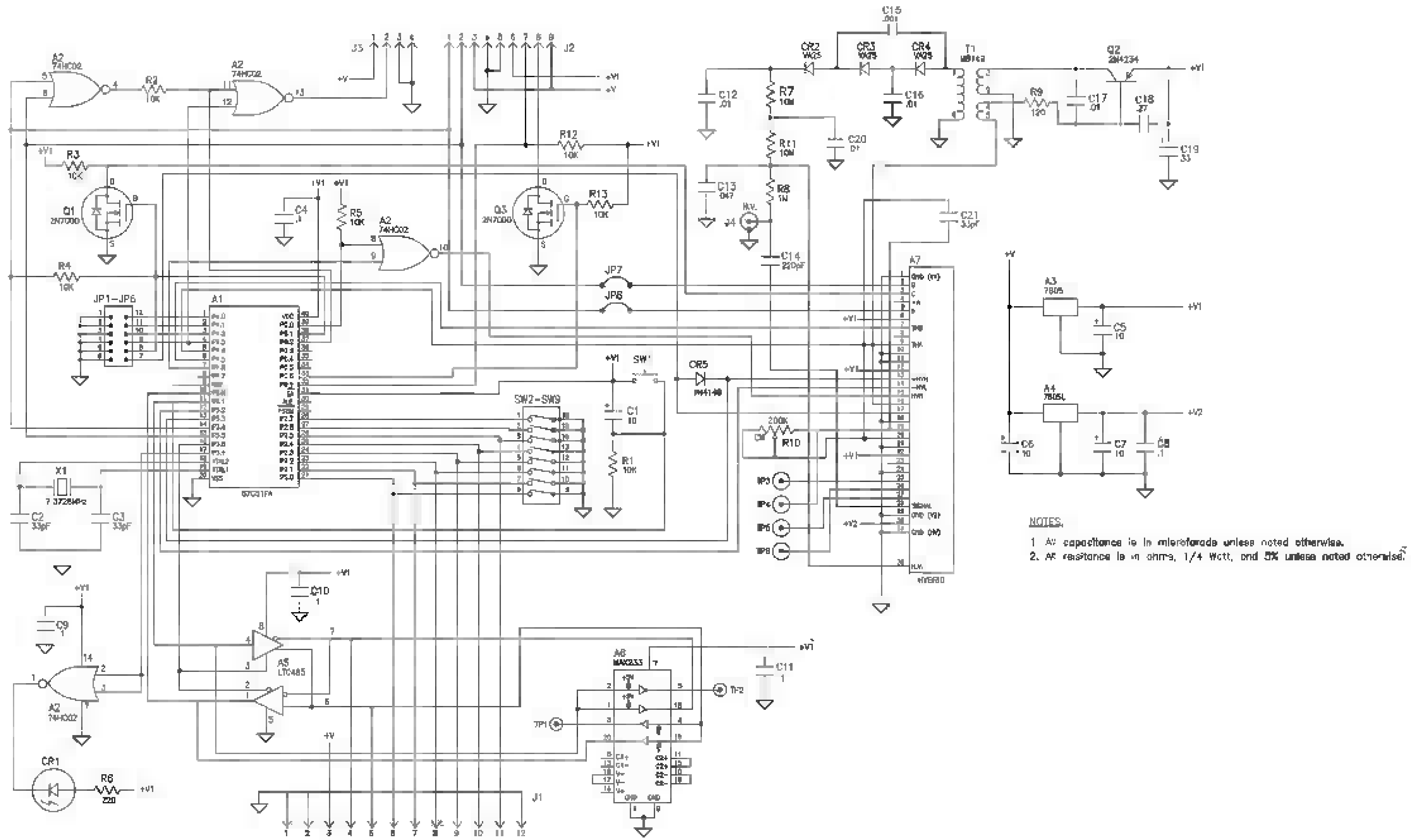


Figure 22-8. 11543-001, Modular detector board.

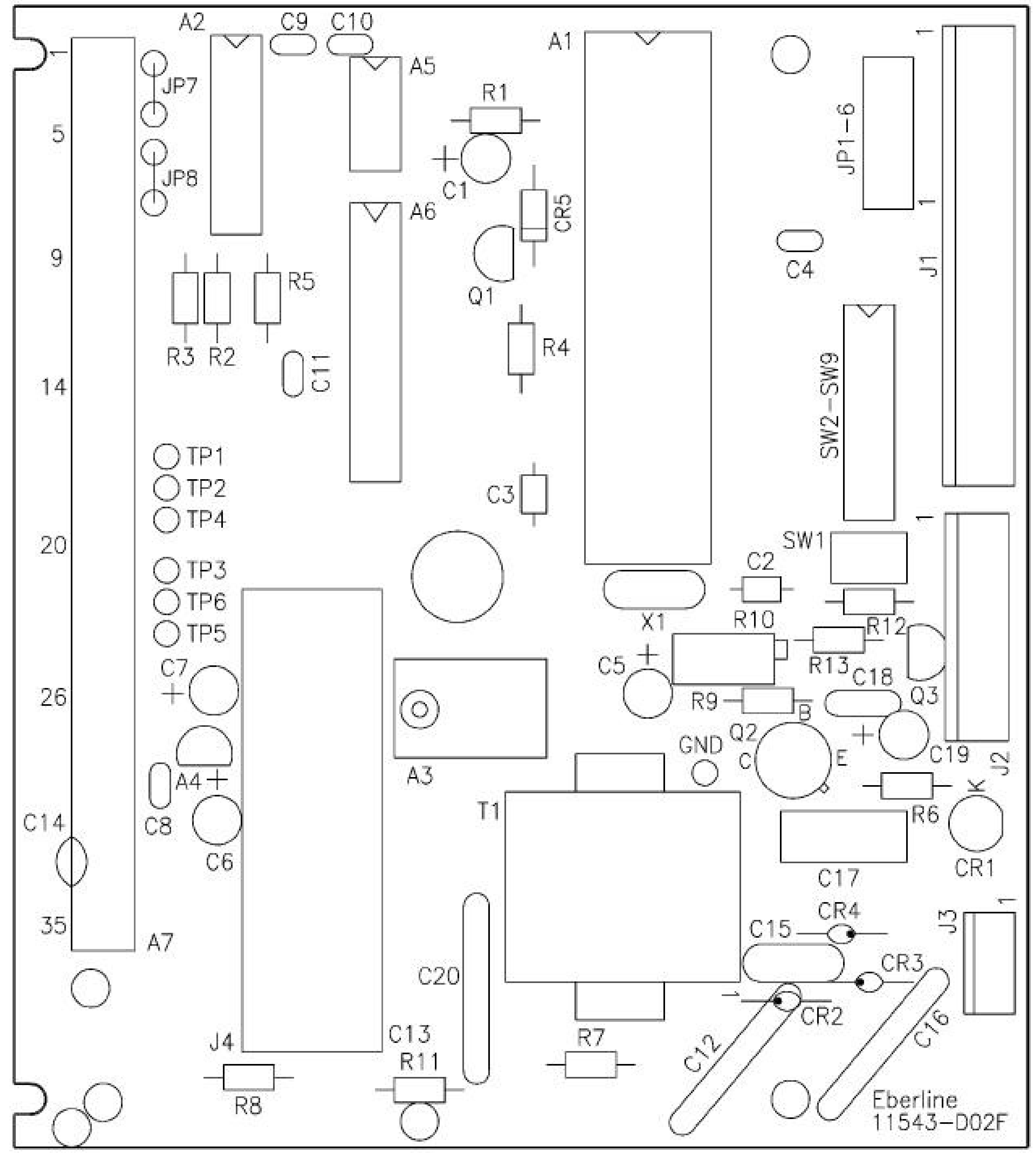


Figure 22-9. 11543-005, Modular detector board, components.

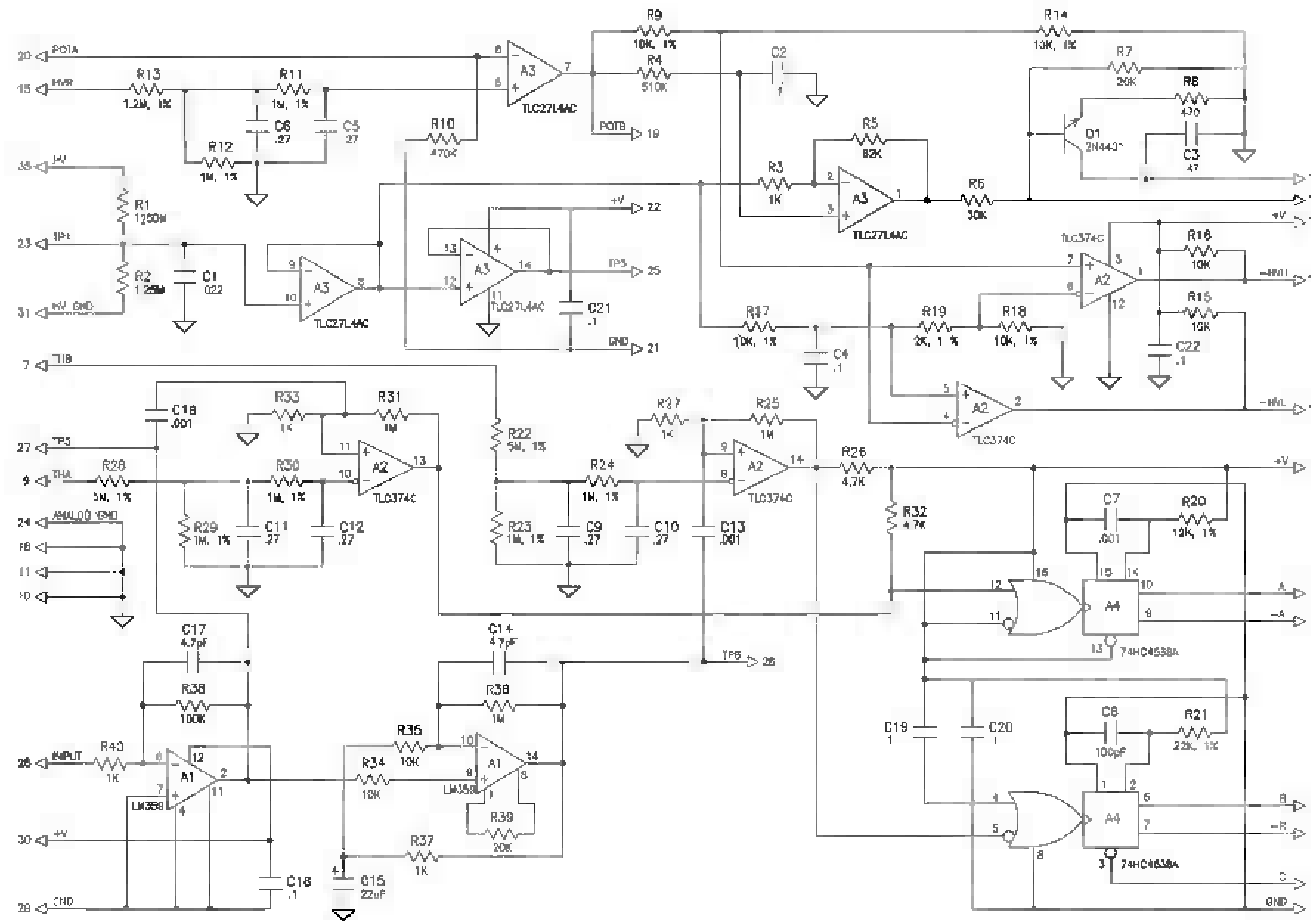


Figure 22-10. 11543-008, Modular detector board, hybrid schematic.

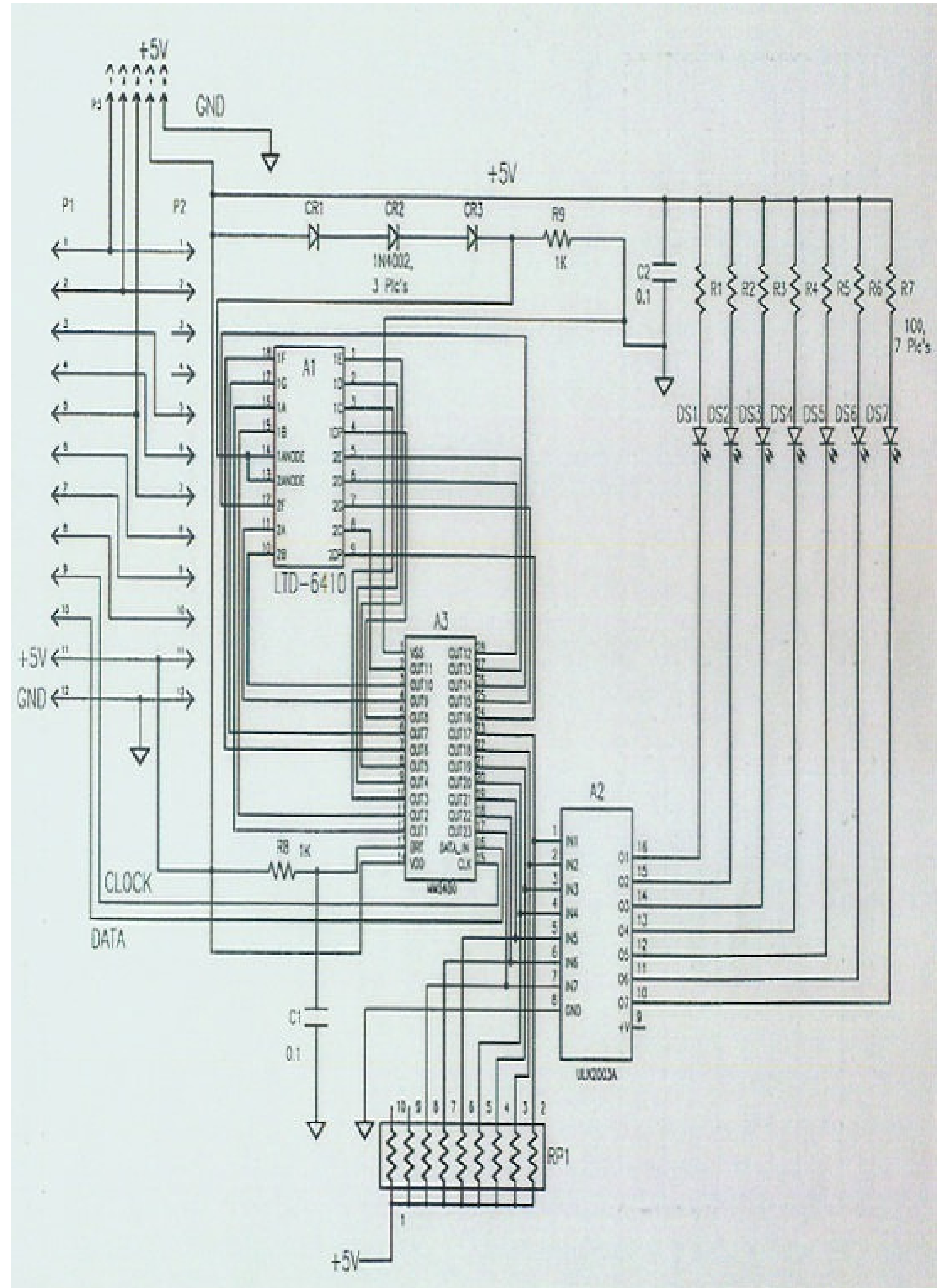


Figure 22-11. 11534-150, Clock display board.

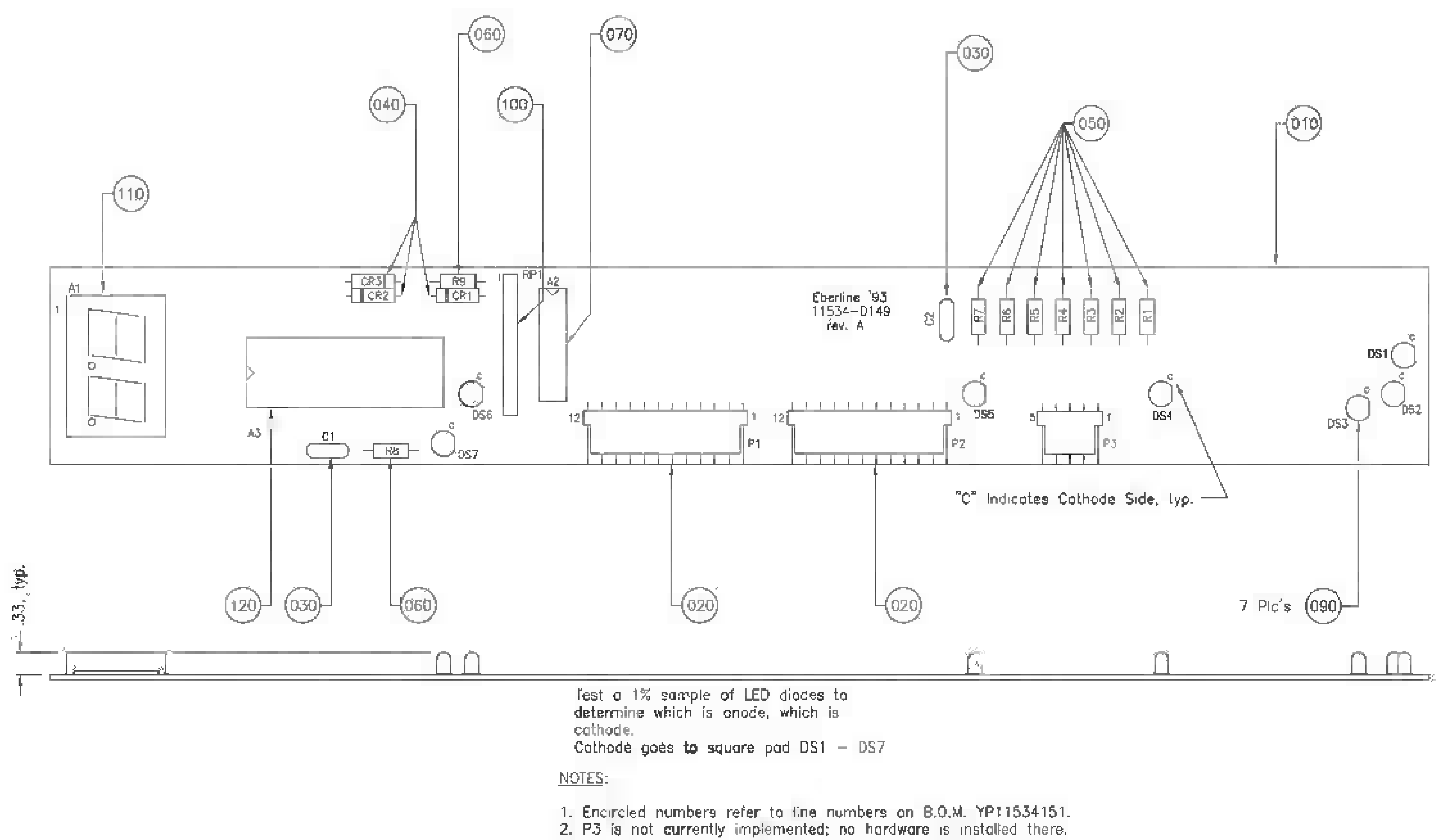
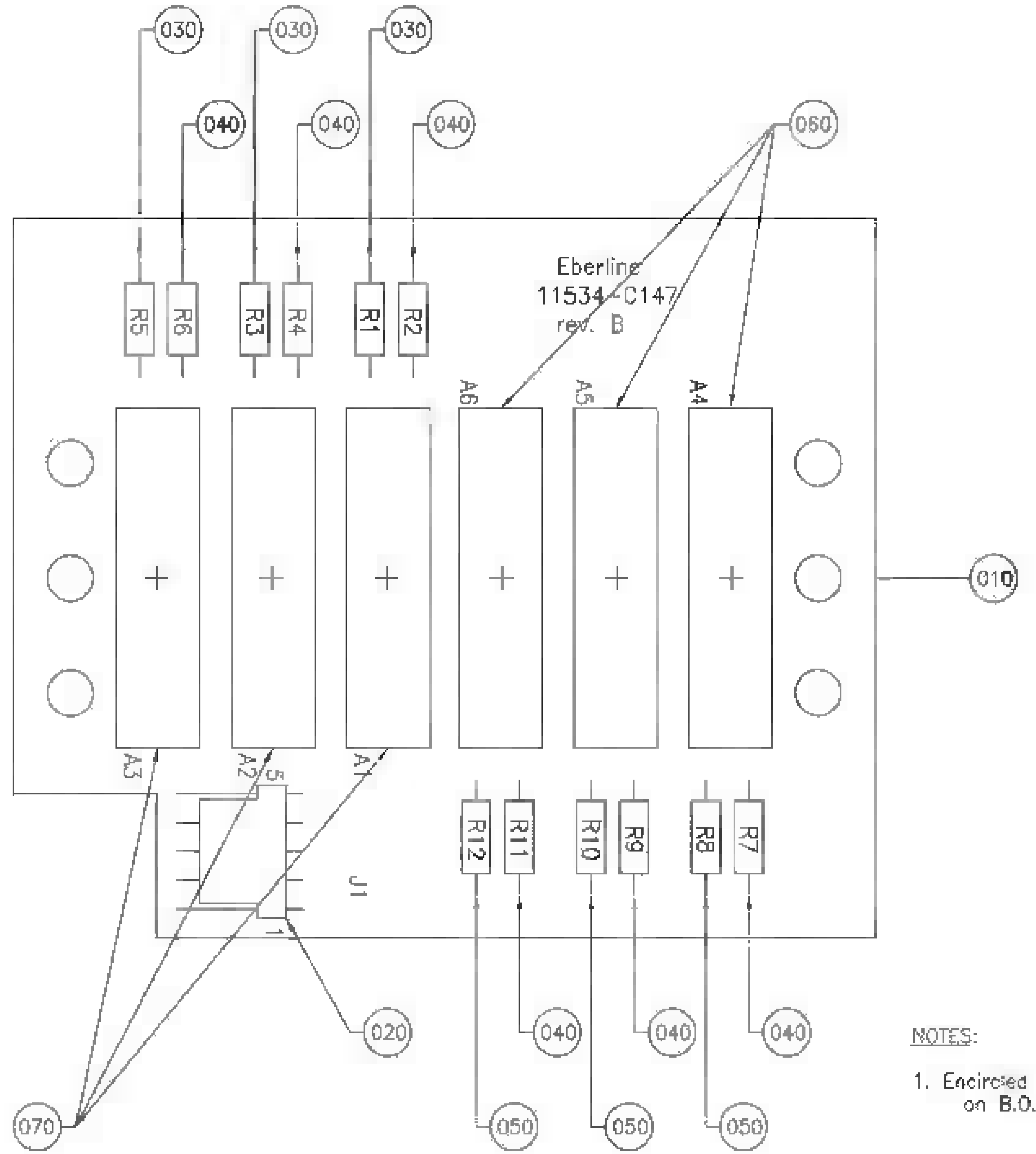


Figure 22-12. 11534-151, Clock display PCB component assembly.



NOTES:

1. Encircled numbers refer to line numbers. on B.O.M. YP11534152.

Figure 22-13. 11534-152, Traffic light PCB component assembly.

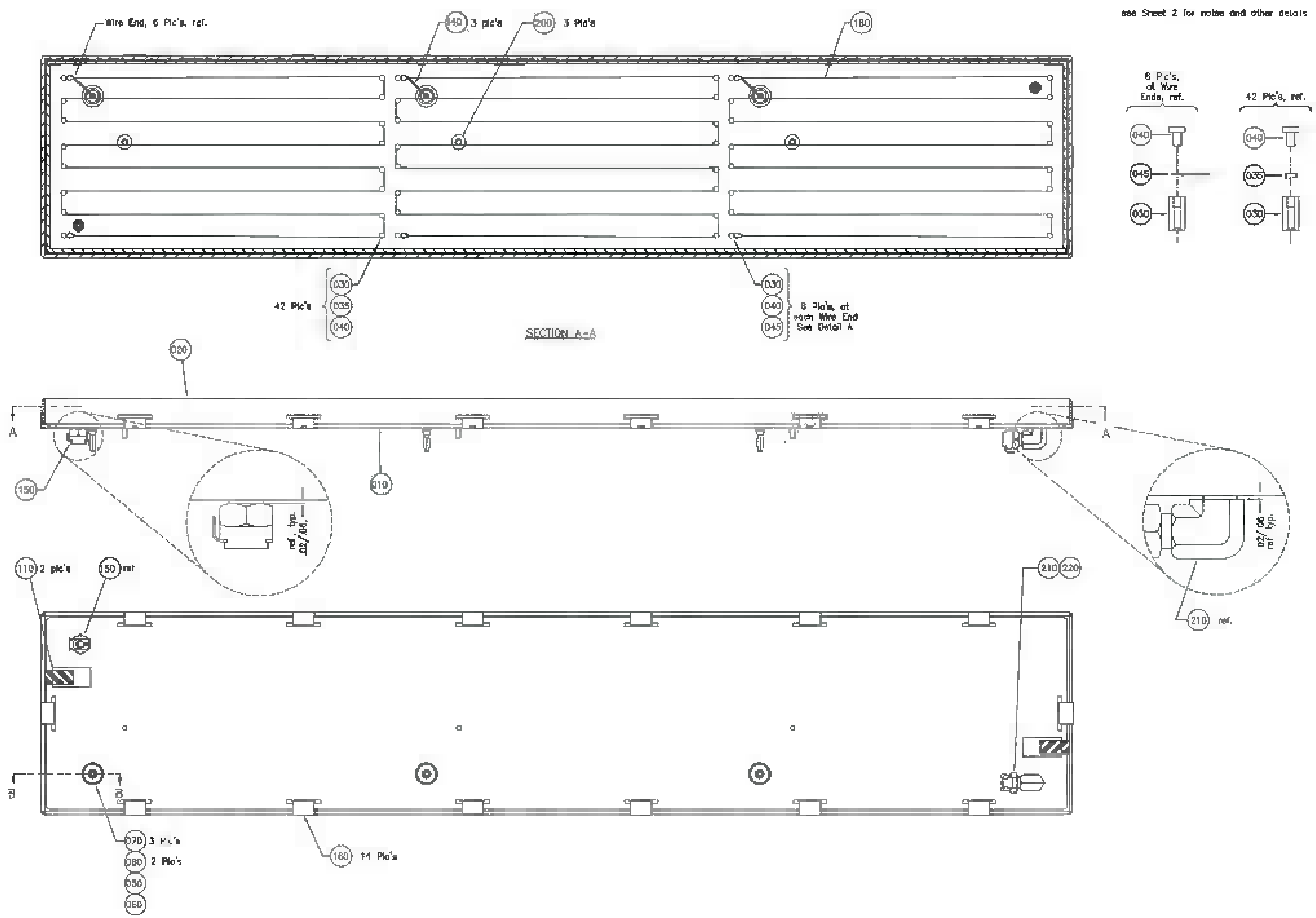


Figure 22-14. 11534-560, Revised detector assembly, long, 1 of 2.

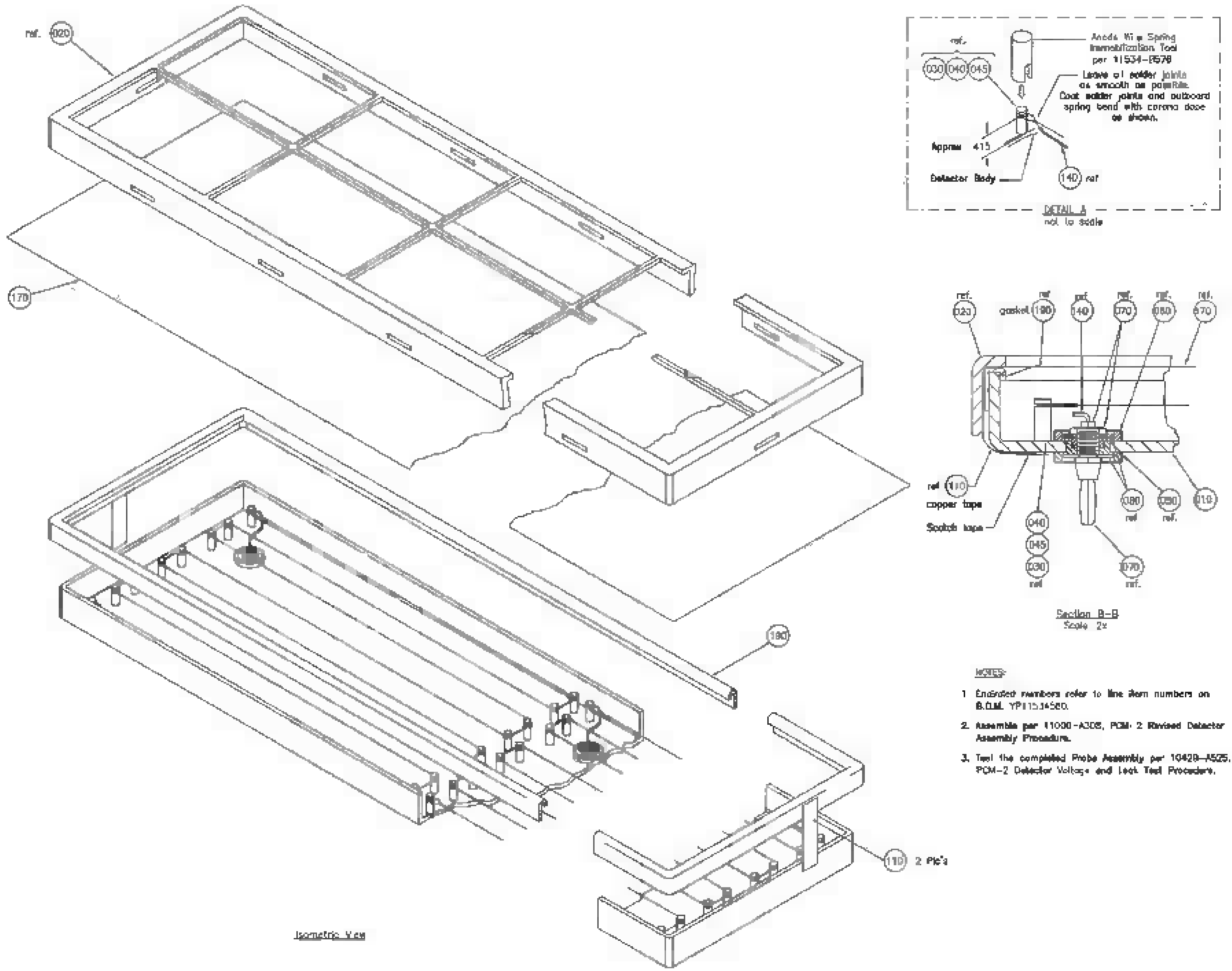


Figure 22-15. 11534-560, Revised detector assembly, long, 2 of 2.

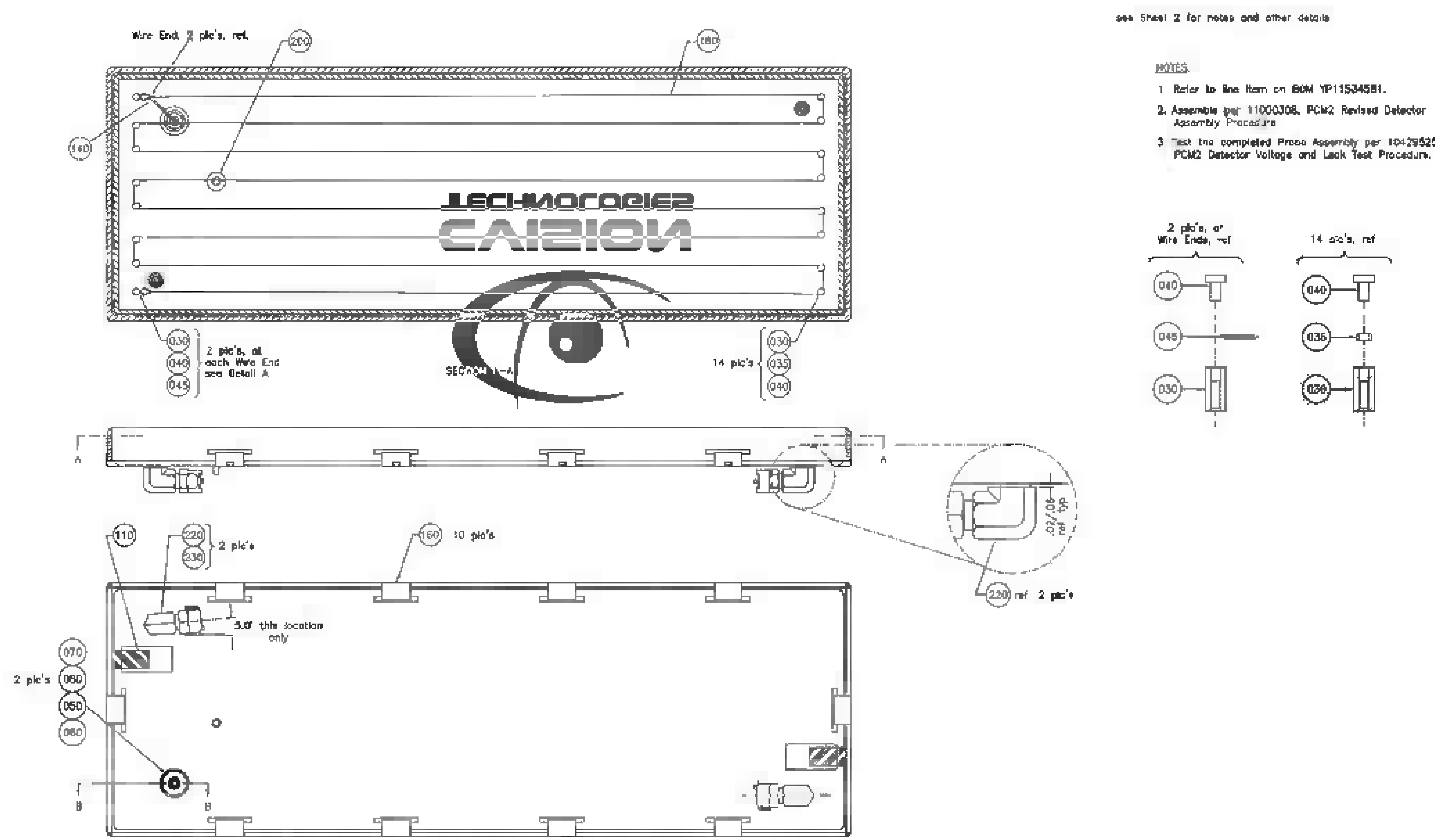


Figure 22-16. 11534-561, Revised detector assembly, medium, 1 of 2.

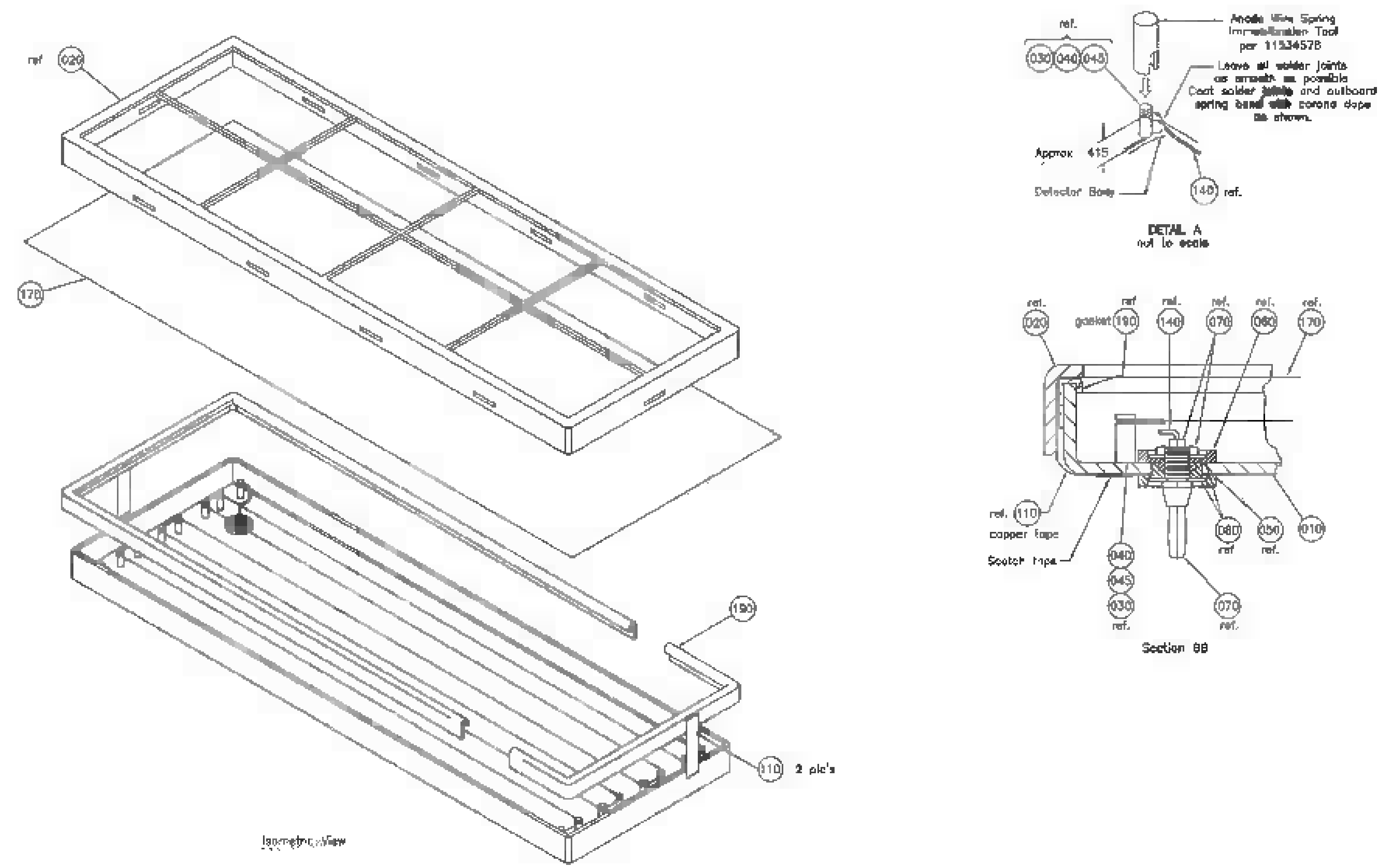


Figure 22-17. 11534-561, Revised detector assembly, medium, 2 of 2.

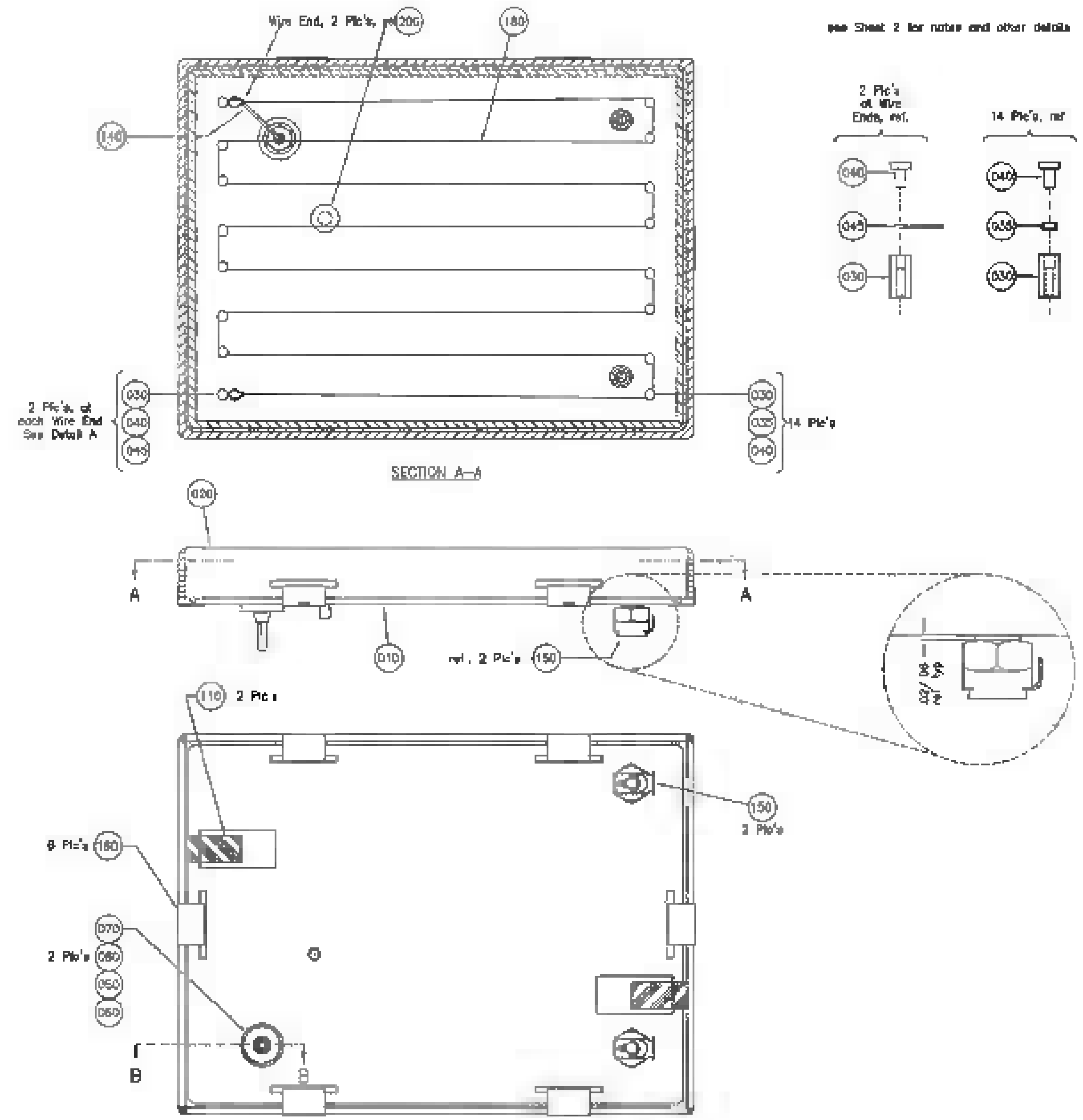


Figure 22-18. 11534-562, Revised detector assembly, small, 1 of 2.

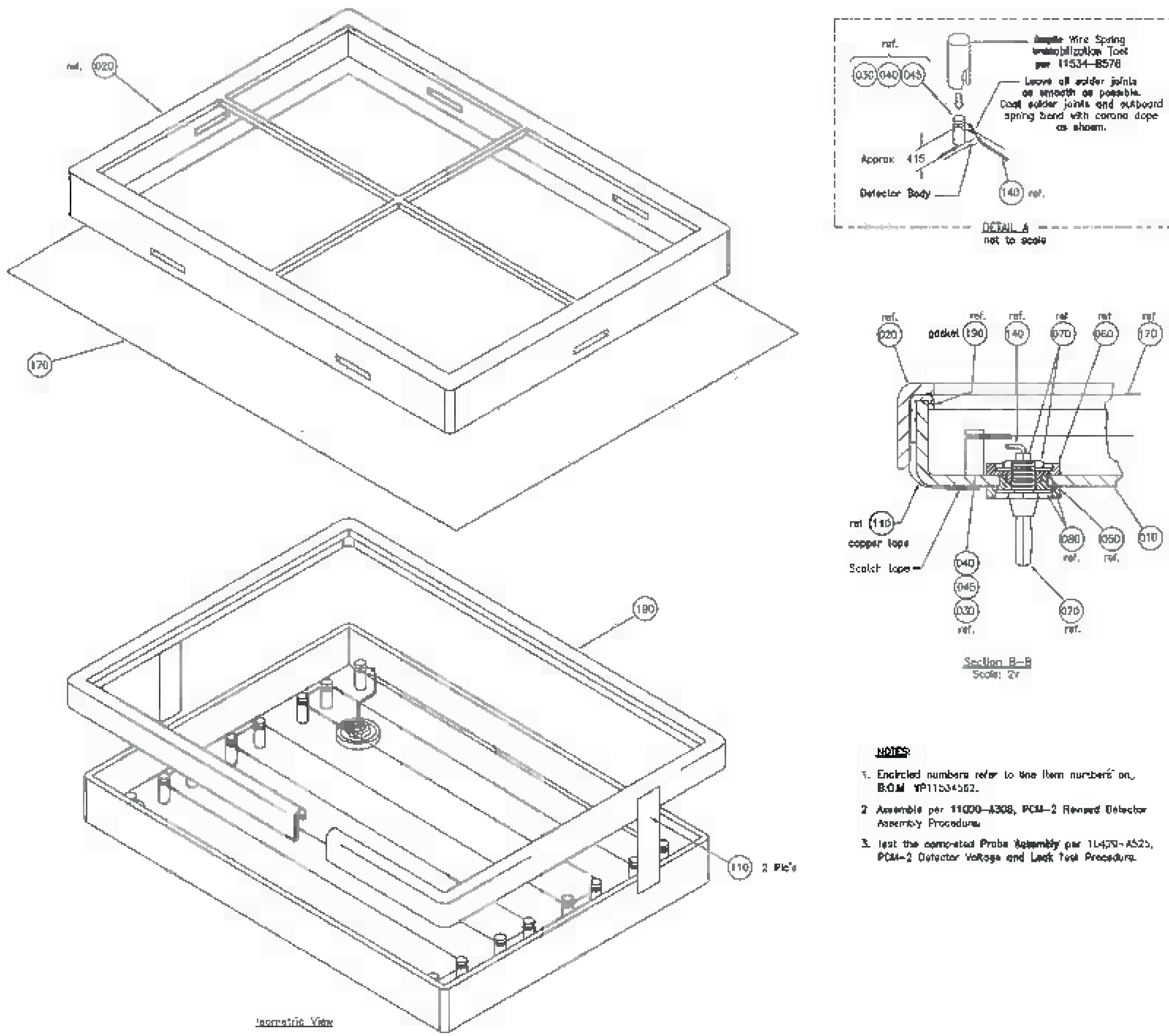


Figure 22-19. 11534-562, Revised detector assembly, small, 2 of 2.

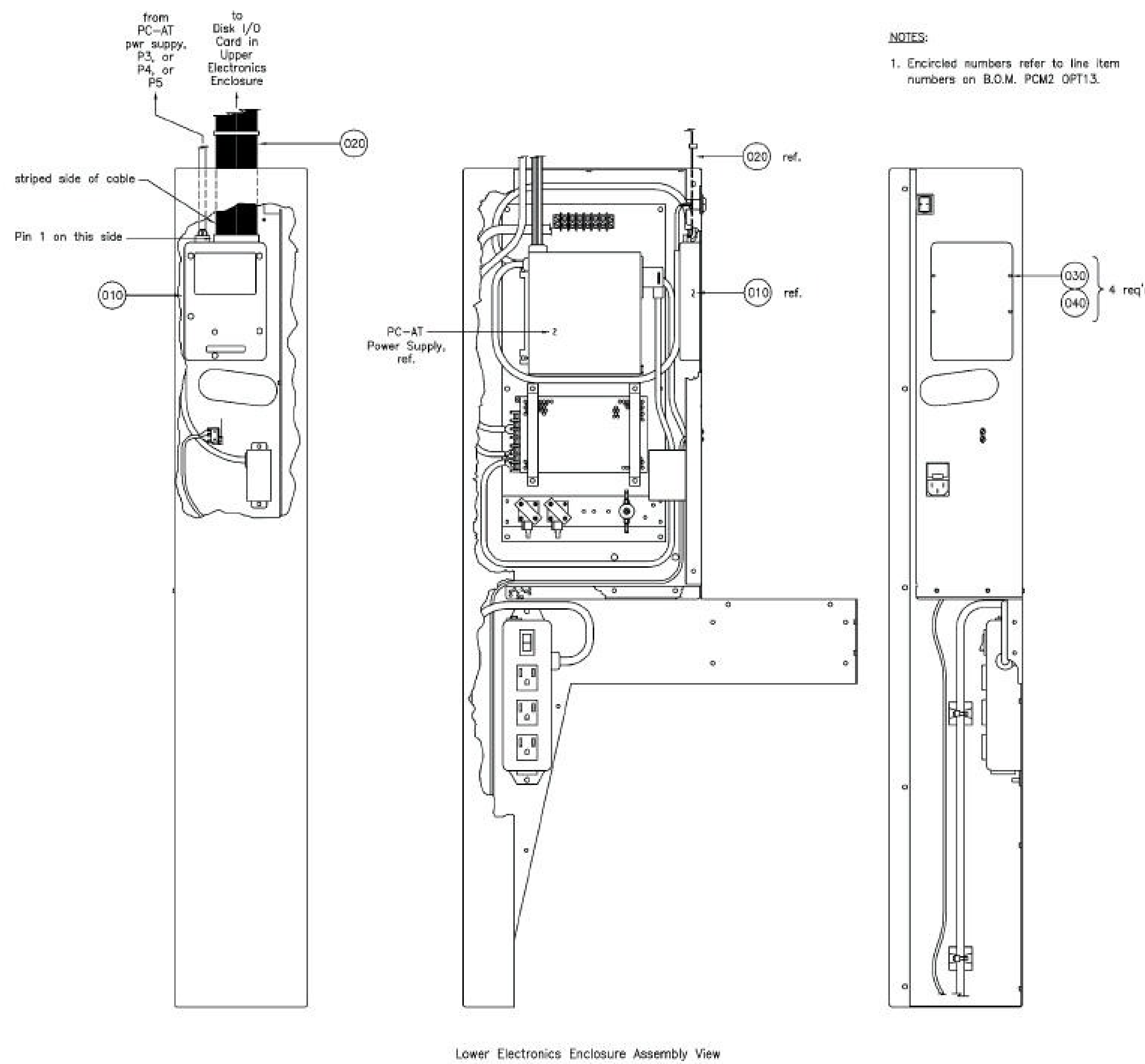


Figure 22-20. 11534-563, Hard disk drive assembly.

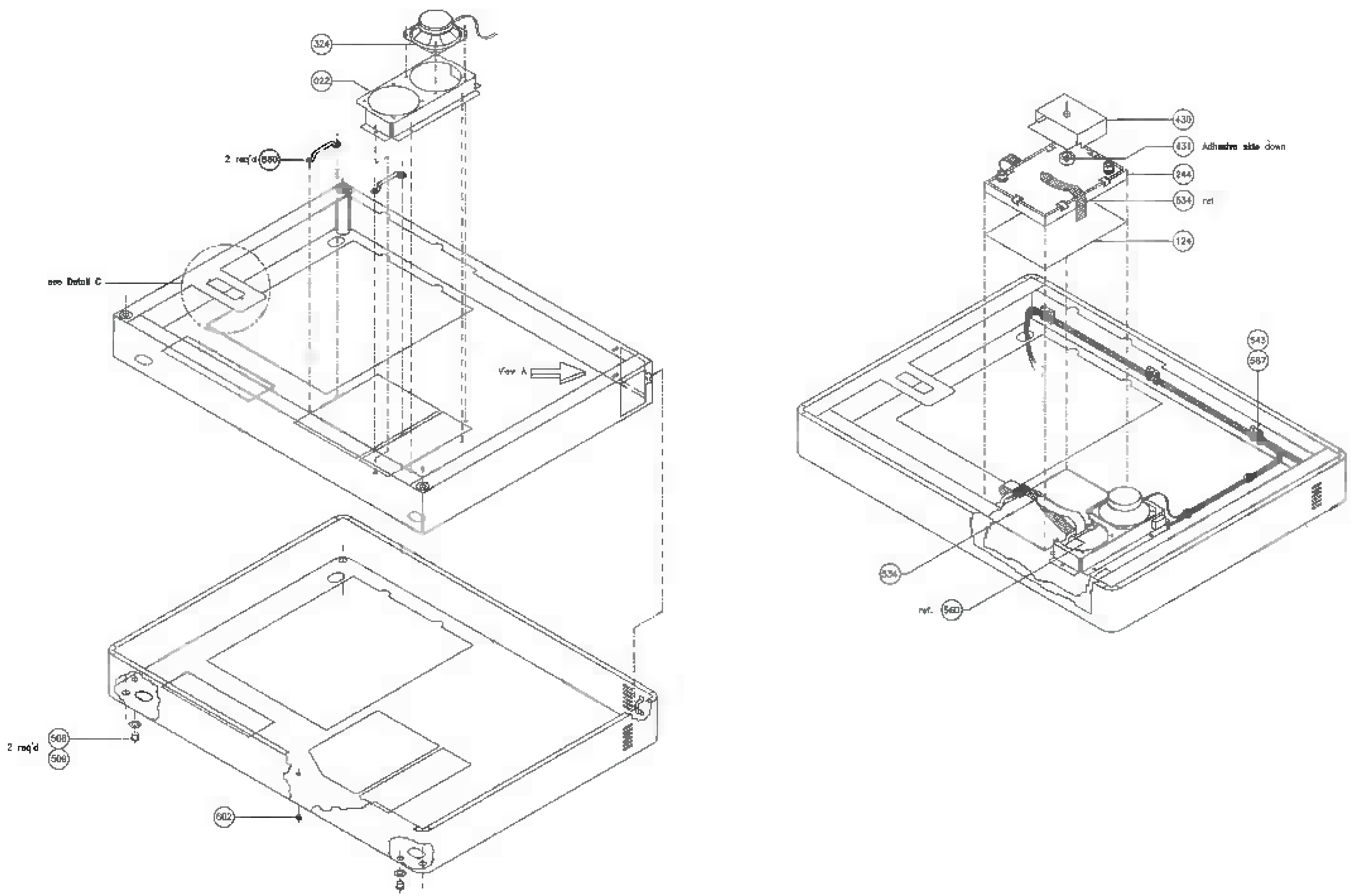
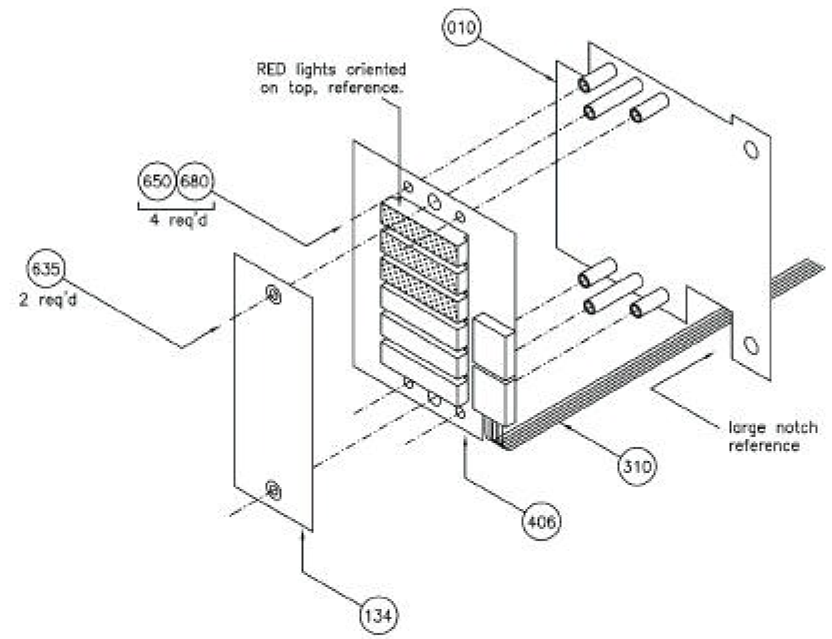
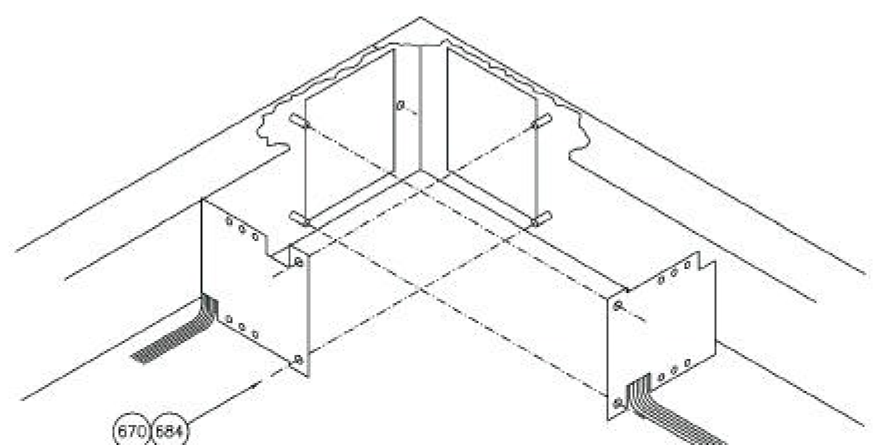
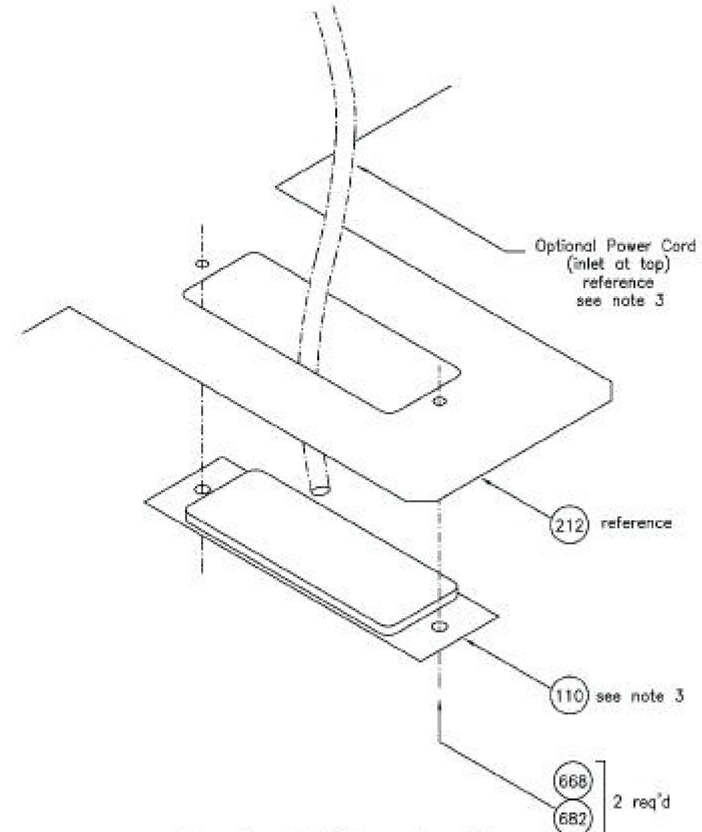


Figure 22-21. 11534-315, Ceiling assembly, 1 of 2.







NOTES:

1. Encircled numbers refer to line items on B.O.M. PCM2–Basic.
2. A "Front" and a "Side" traffic light assembly is required for each ceiling assembly. The Side assembly differs from the Front assembly shown in Detail A in that the item 010, bracket, must be rotated 180° such that it's large notch is facing upward. The PCBA is mounted to the bracket so that the band of red lights is always upward.
3. Item 110, Power Inlet Cover, is to be installed here as shown for standard power inlet configuration thru the Main Frame Assembly. The Power Inlet Cover is to be installed on the Main Frame Assembly, 11534–0316 only when power inlet requirements are specifically required thru the ceiling assembly, via direction from sales.
4. Route Speaker and Traffic Light Assembly cables along front inside of ceiling and secure with items 543, clamps, and 587, tywraps as shown. Then route cables down thru ceiling assembly into the electronics enclosure area thru noted oval slot.

Figure 22-22. 11534-315, Ceiling assembly, 2 of 2.

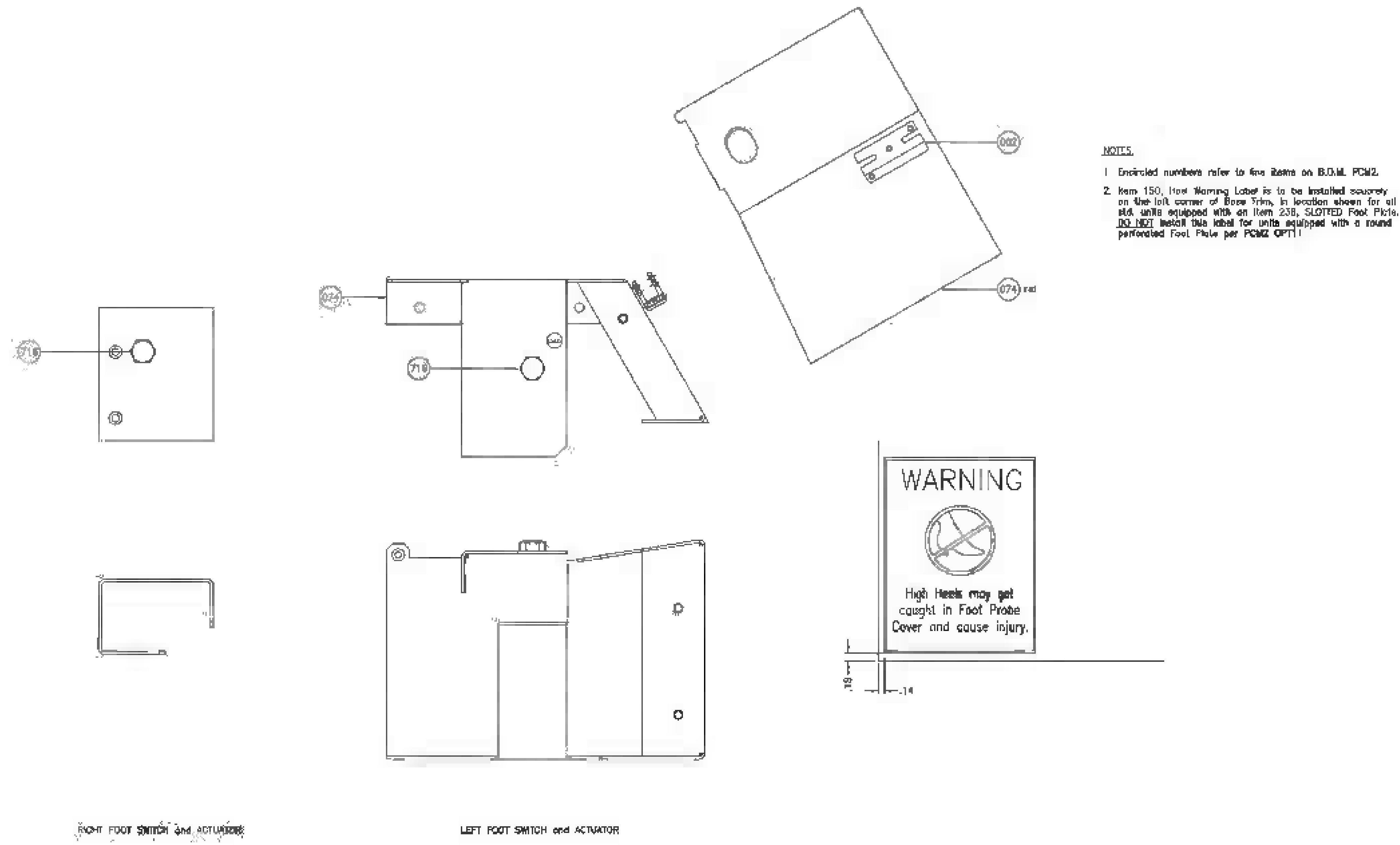
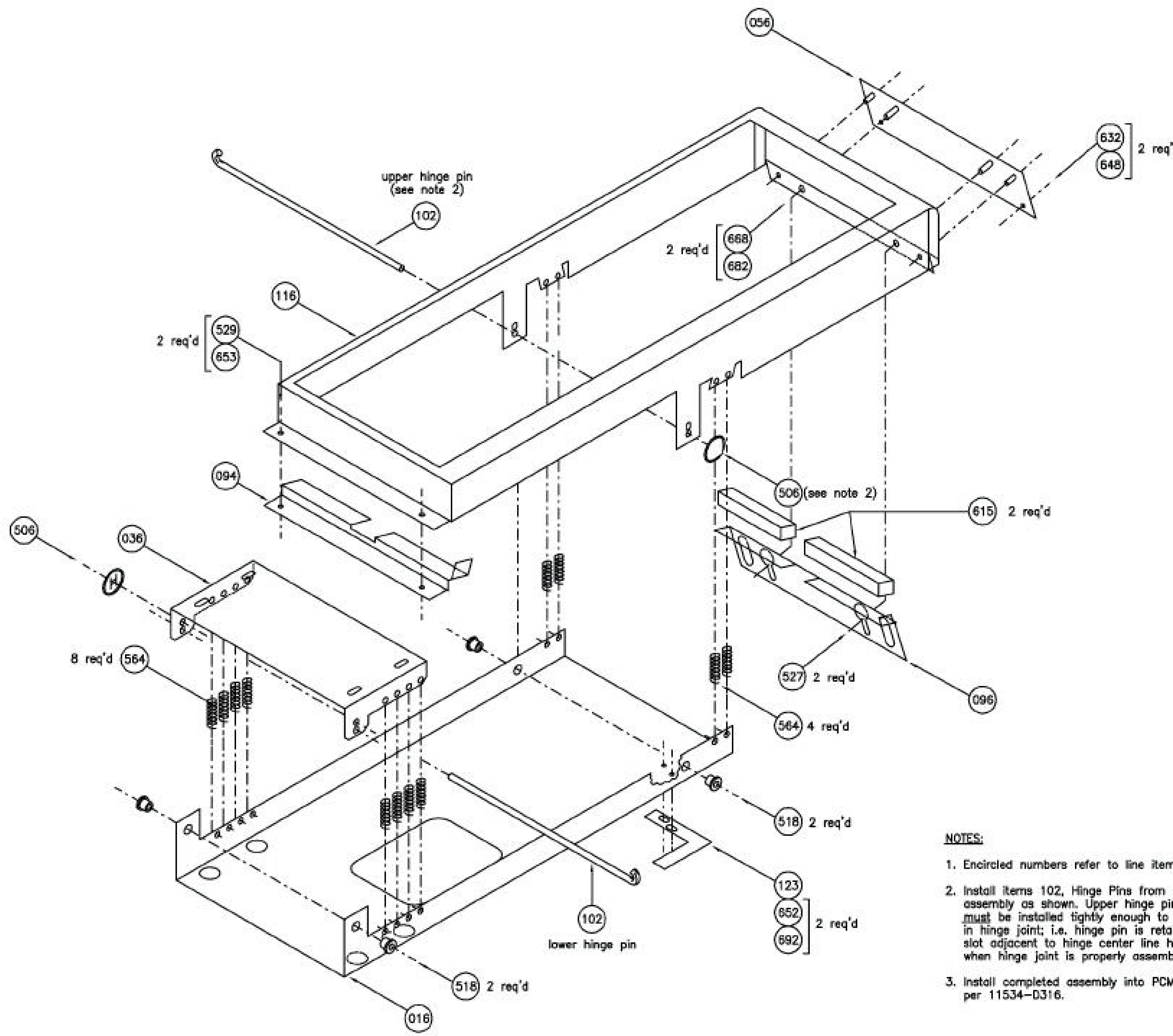


Figure 22-22. 11534-319, Right / left foot switch assembly.



NOTES:

1. Encircled numbers refer to line items on B.O.M. PCM2.
2. Install items 102, Hinge Pins from opposite side of the assembly as shown. Upper hinge pin speed nut, item 506, _must_ be installed tightly enough to eliminate _all_ axial play in hinge joint; i.e. hinge pin is retained by curved end in slot adjacent to hinge center line hole and can not rotate when hinge joint is properly assembled.
3. Install completed assembly into PCM–2 Main Frame assy per 11534–D316.

Figure 22-23. 11534-322, Rear hand detector panel assembly.

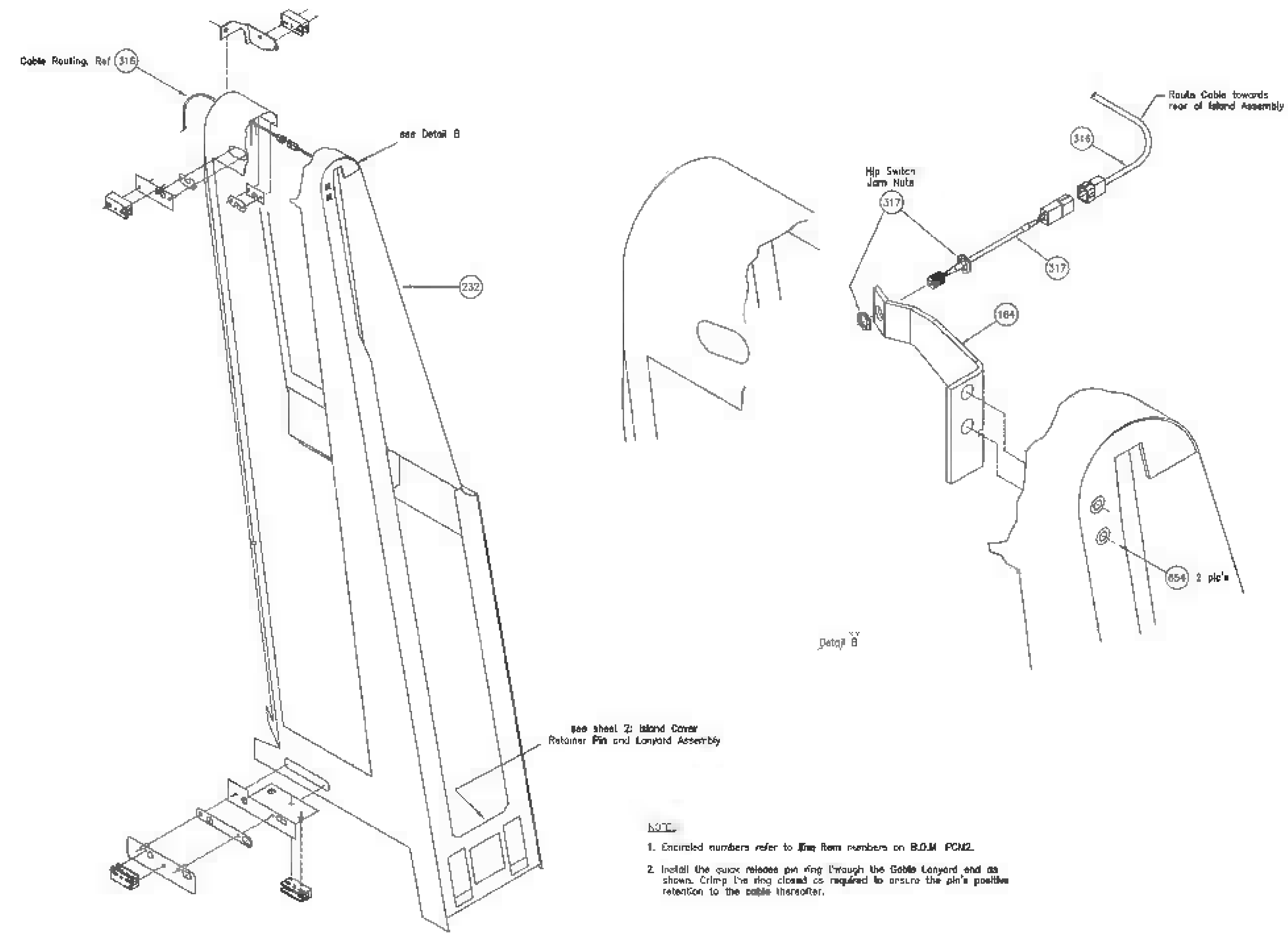


Figure 22-24. 11534-317, Island assembly, 1 of 2.

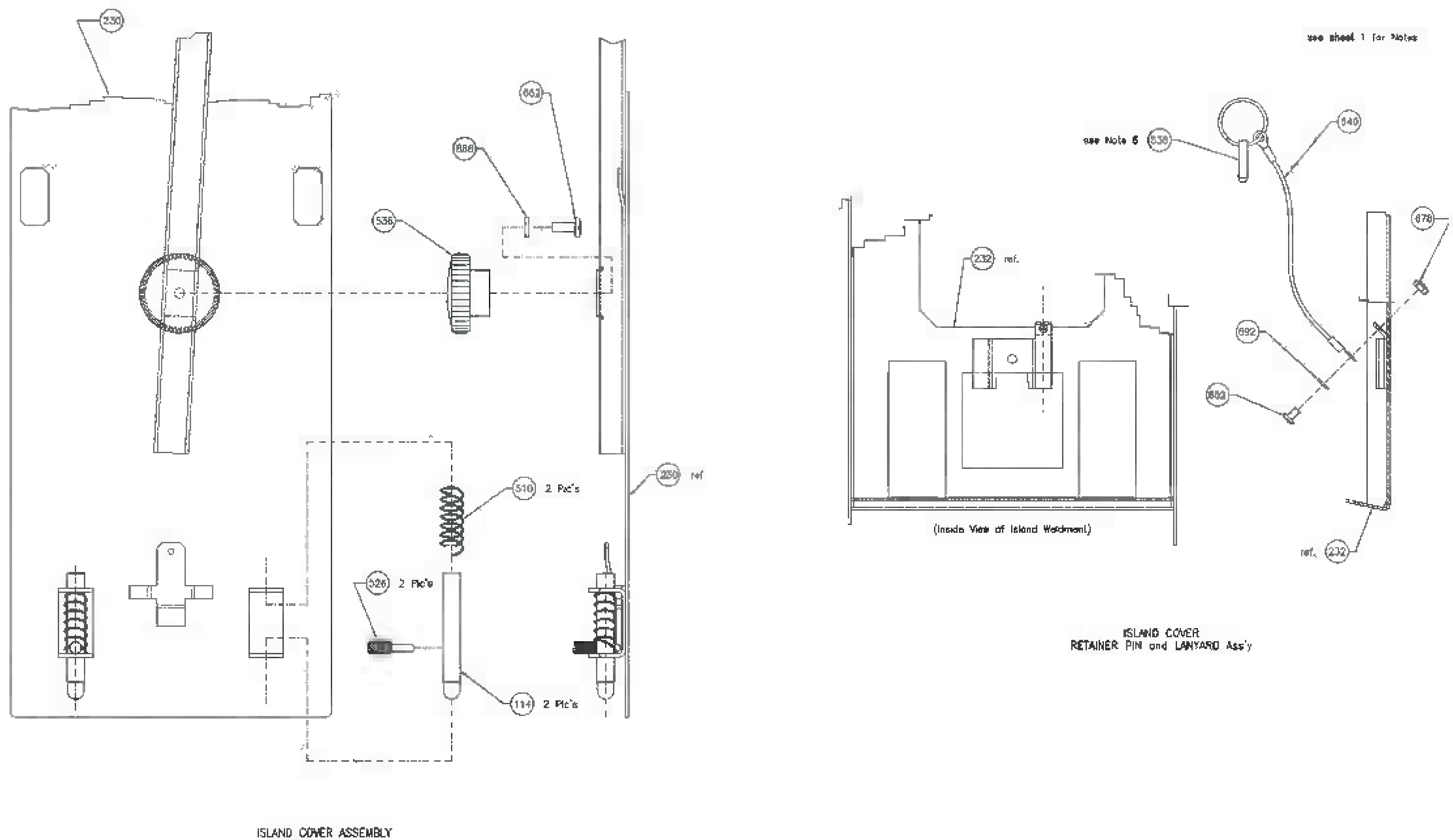
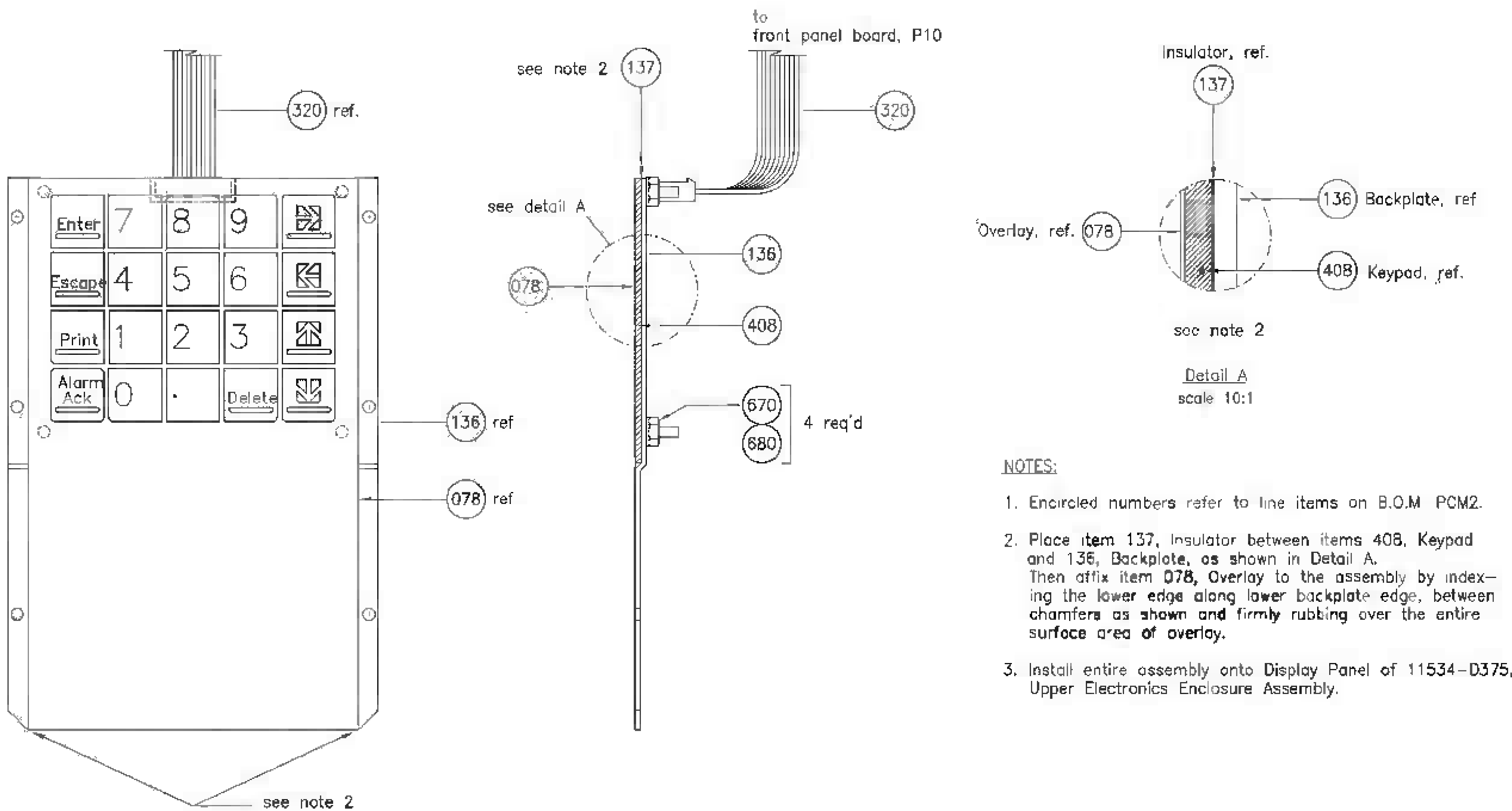


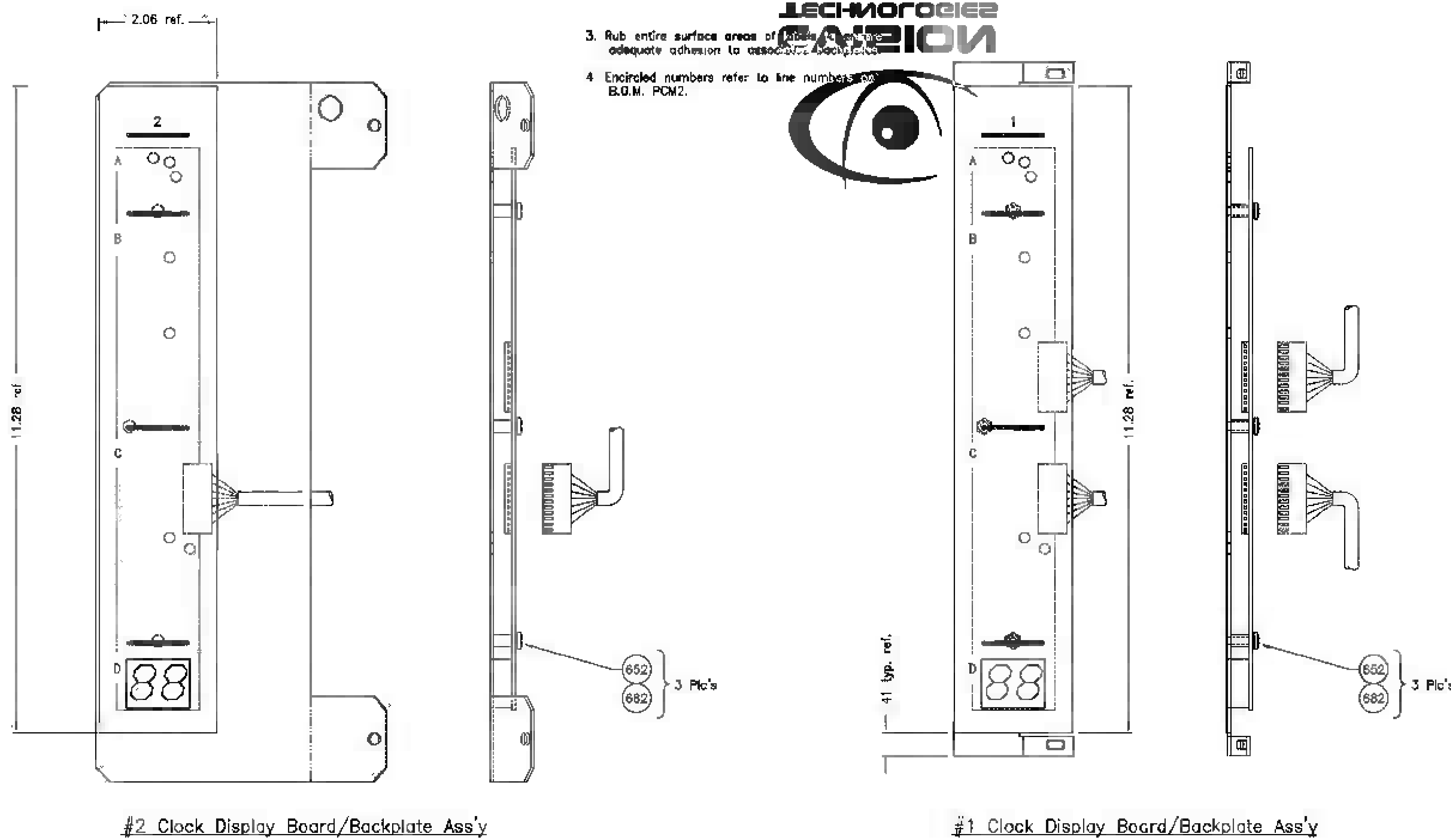
Figure 22-25. 11534-317, Island assembly, 2 of 2.



NOTES:

1. Encircled numbers refer to line items on B.O.M PCM2.
2. Place item 137, Insulator between items 408, Keypad and 136, Backplate, as shown in Detail A. Then affix item 078, Overlay to the assembly by indexing the lower edge along lower backplate edge, between chamfers as shown and firmly rubbing over the entire surface area of overlay.
3. Install entire assembly onto Display Panel of 11534-D375, Upper Electronics Enclosure Assembly.

Figure 22-26. 11534-304, Keypad and backplate assembly.



3. Rub entire surface areas of labels to ensure adequate adhesion to associated backplates.

4. Encircled numbers refer to line numbers on B.O.M. PCM2.

Figure 22-27. 11534-106, Instructional label assemblies.

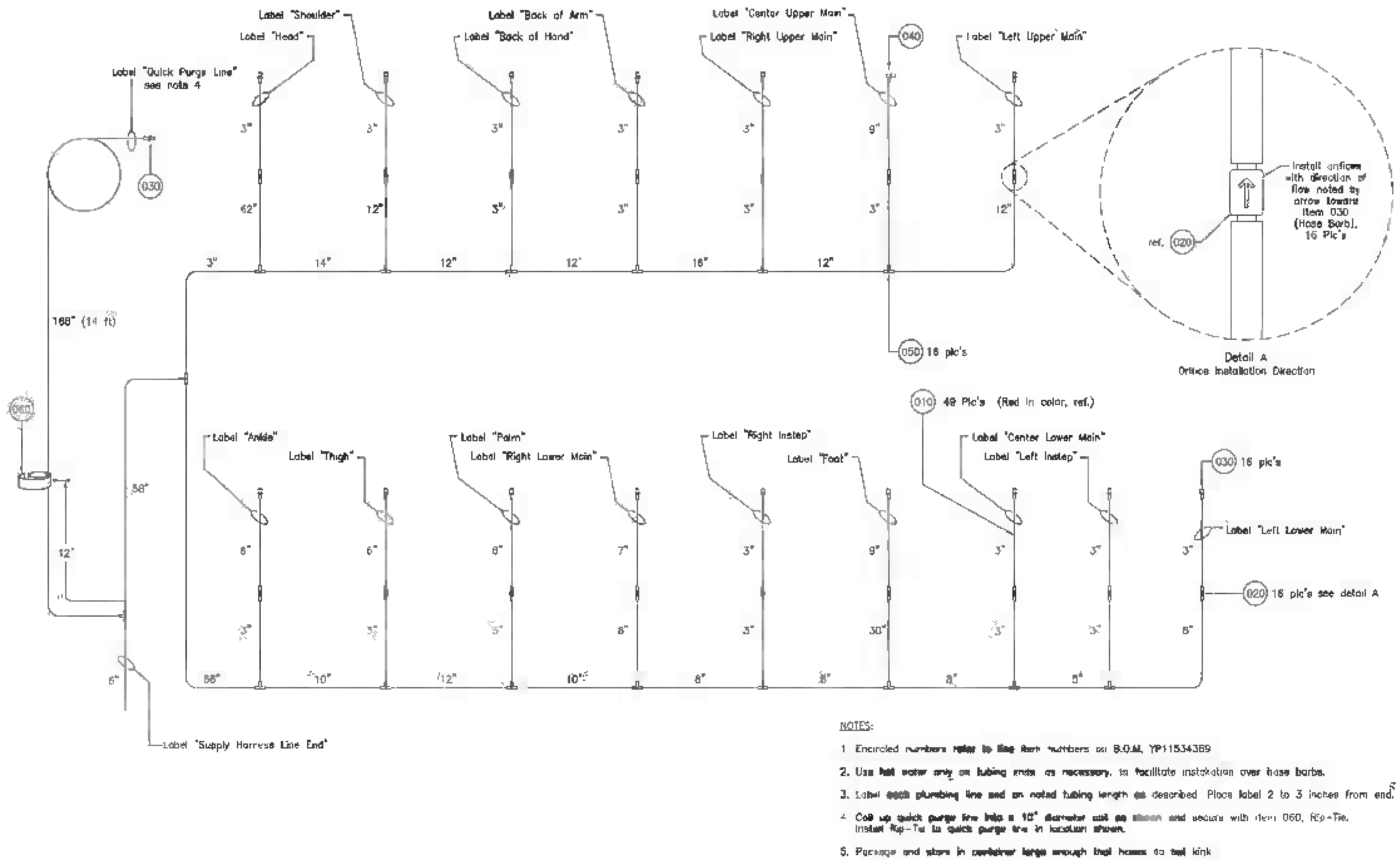


Figure 22-28. 11534-369, Gas supply plumbing harness.

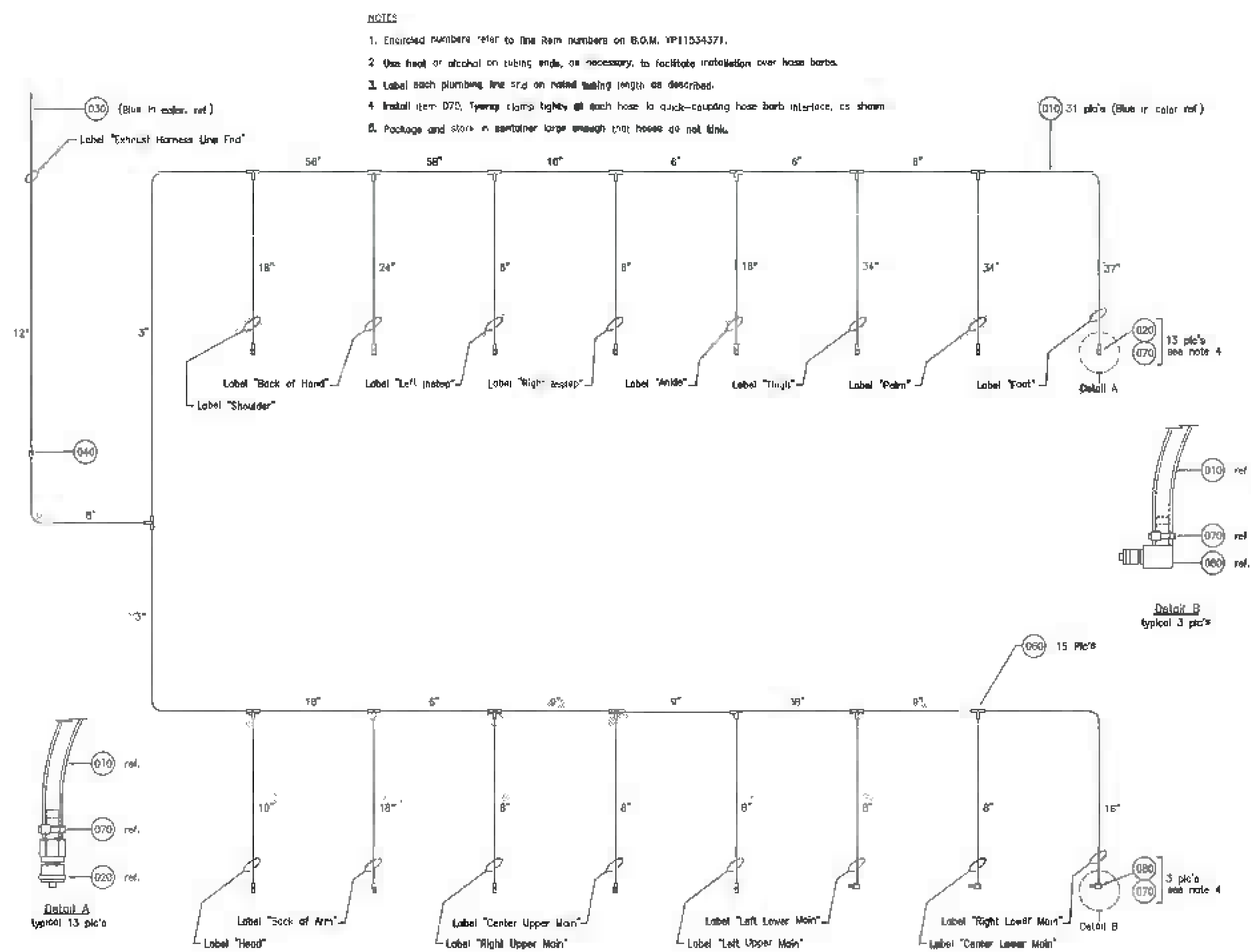


Figure 22-29. 11534-371, Gas exhaust plumbing harness.

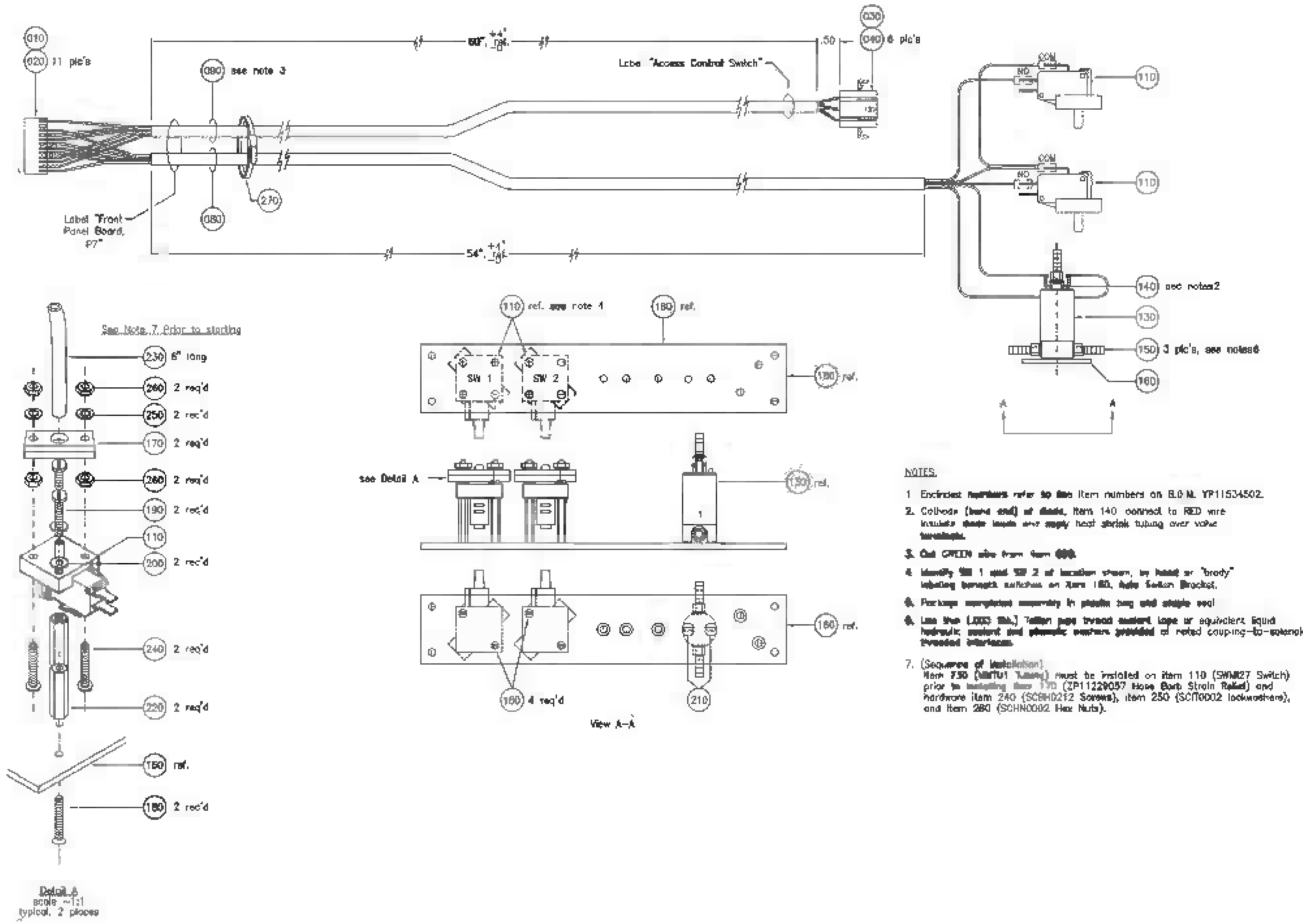
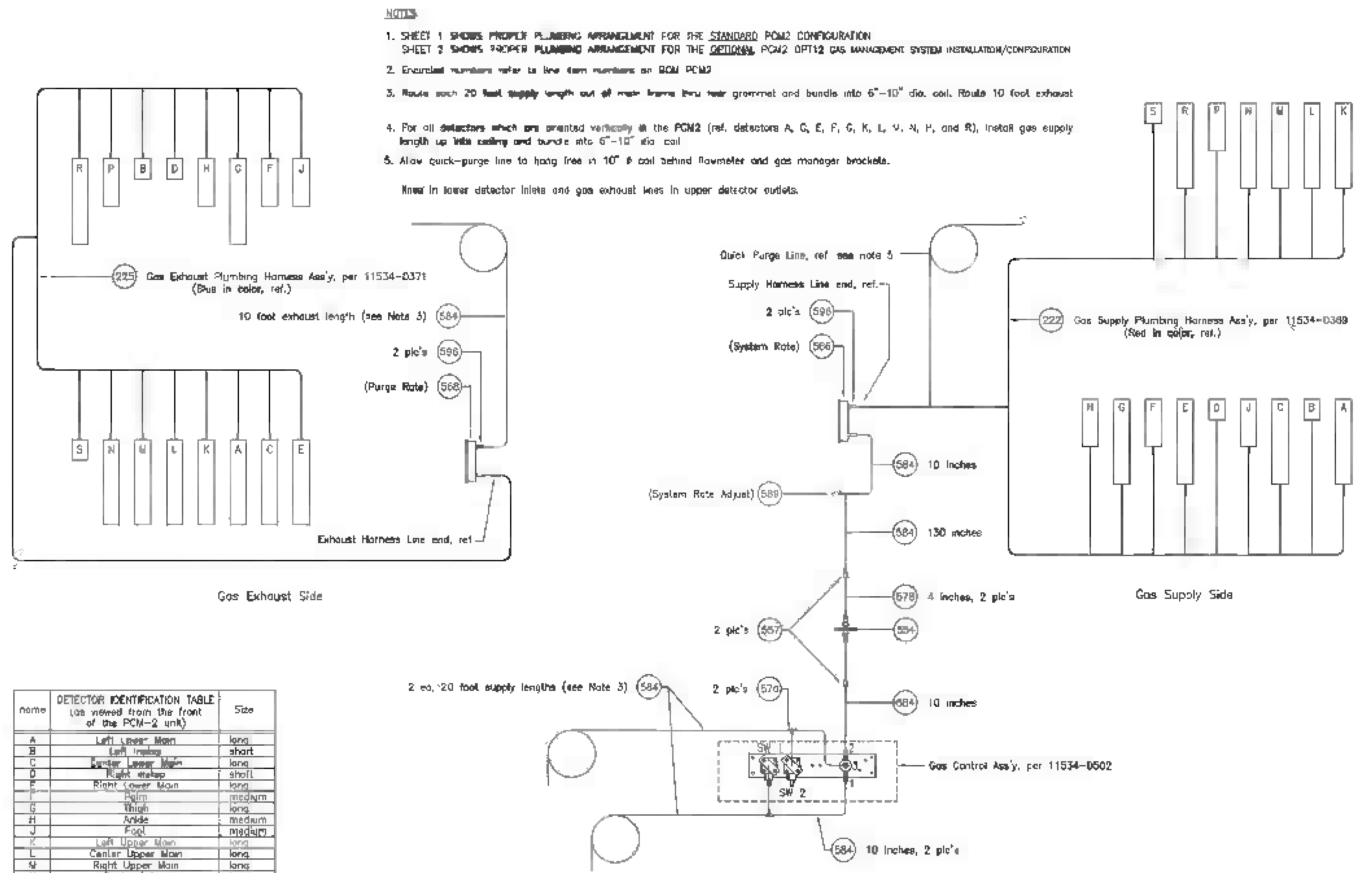


Figure 22-30. 11534-502, Gas control assembly.



name	DETECTOR IDENTIFICATION TABLE (as viewed from the front of the PCM-2 unit)	Size
A	Left Lower Main	long
B	Left Instep	short
C	Center Lower Main	long
D	Right Instep	short
E	Right Lower Main	long
F	Palm	medium
G	Thigh	long
H	Ankle	medium
J	Foot	medium
K	Left Upper Main	long
L	Center Upper Main	long
M	Right Upper Main	long
N	Back of Arm	long
P	Back of Hand	medium
R	Shoulder	long
S	Head	short

Figure 22-31. 11534-308, Plumbing configuration, standard, 1 of 2.

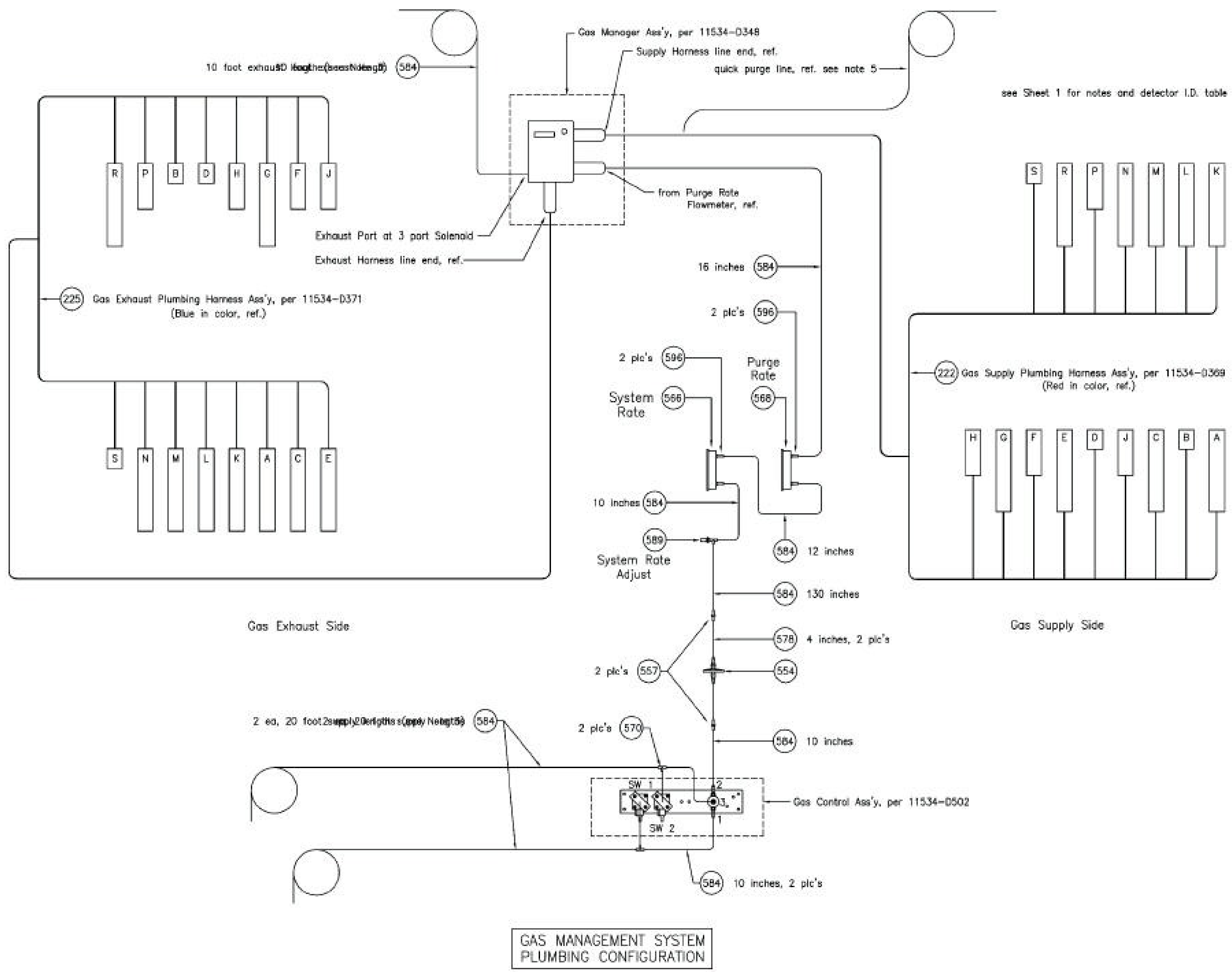


Figure 22-32. 11534-308, Plumbing configuration, gas management, 2 of 2.

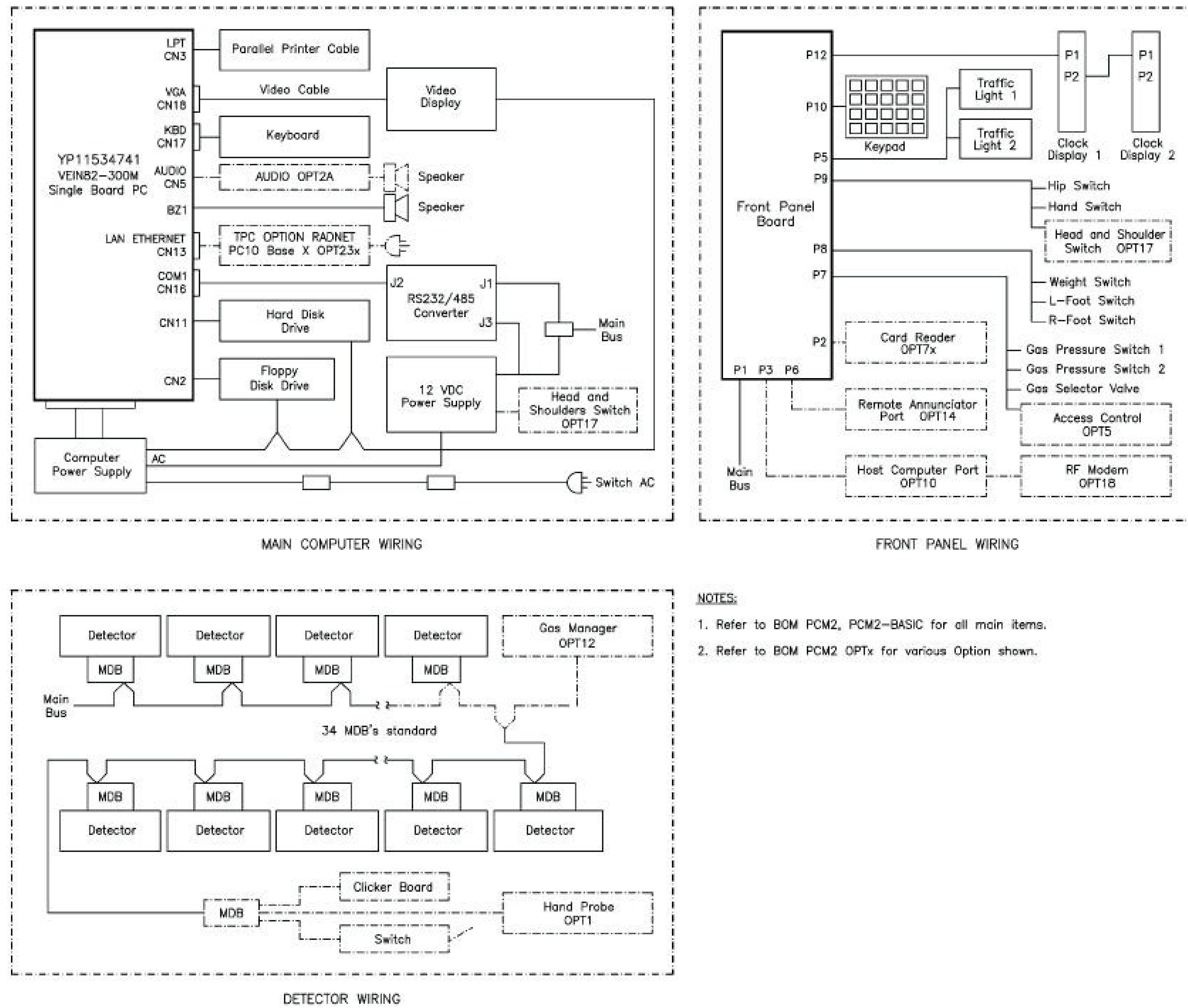


Figure 22-33. 11534-344, System block.

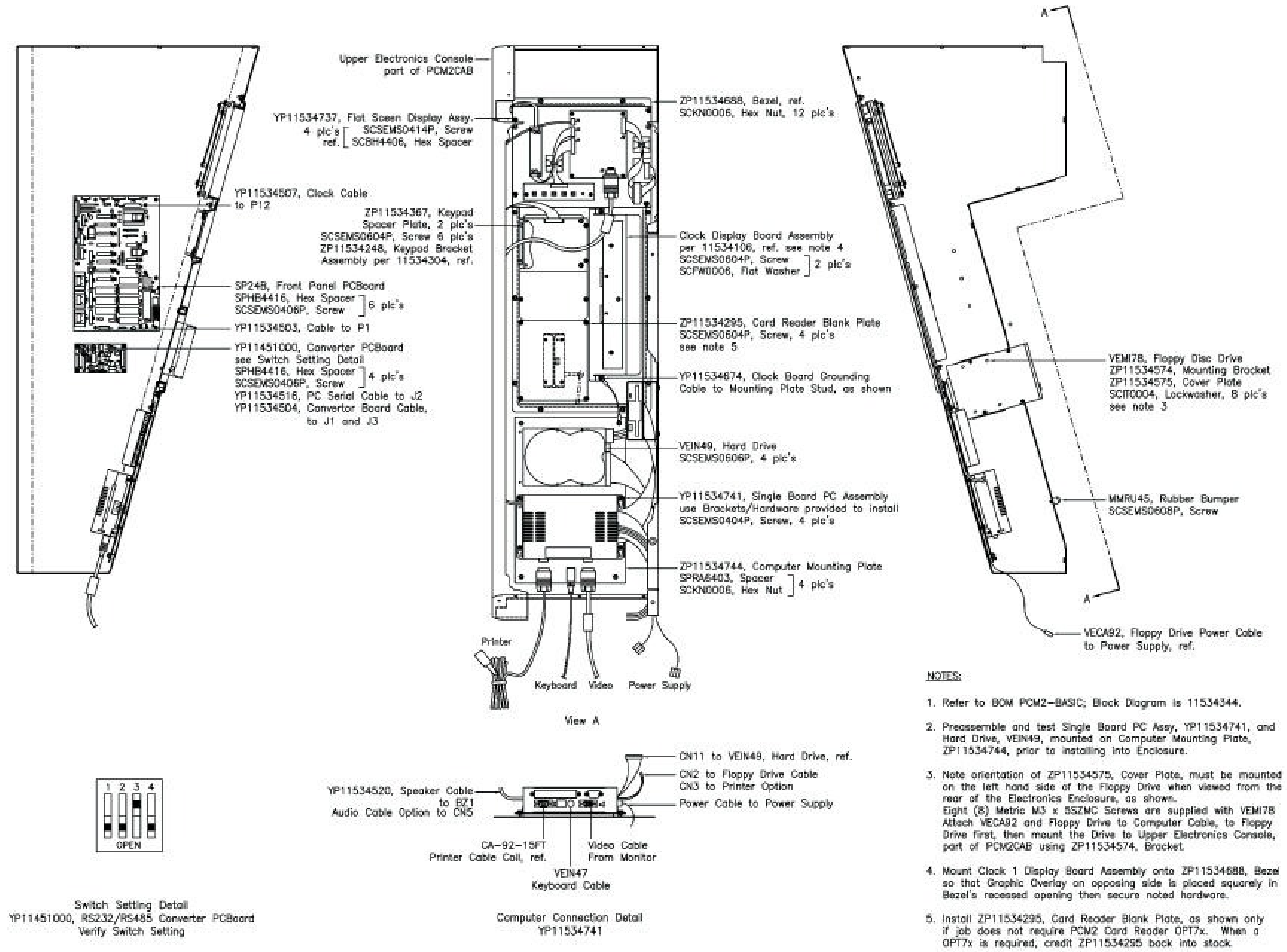


Figure 22-34. 11534-375, Upper electronics enclosure assembly, basic.

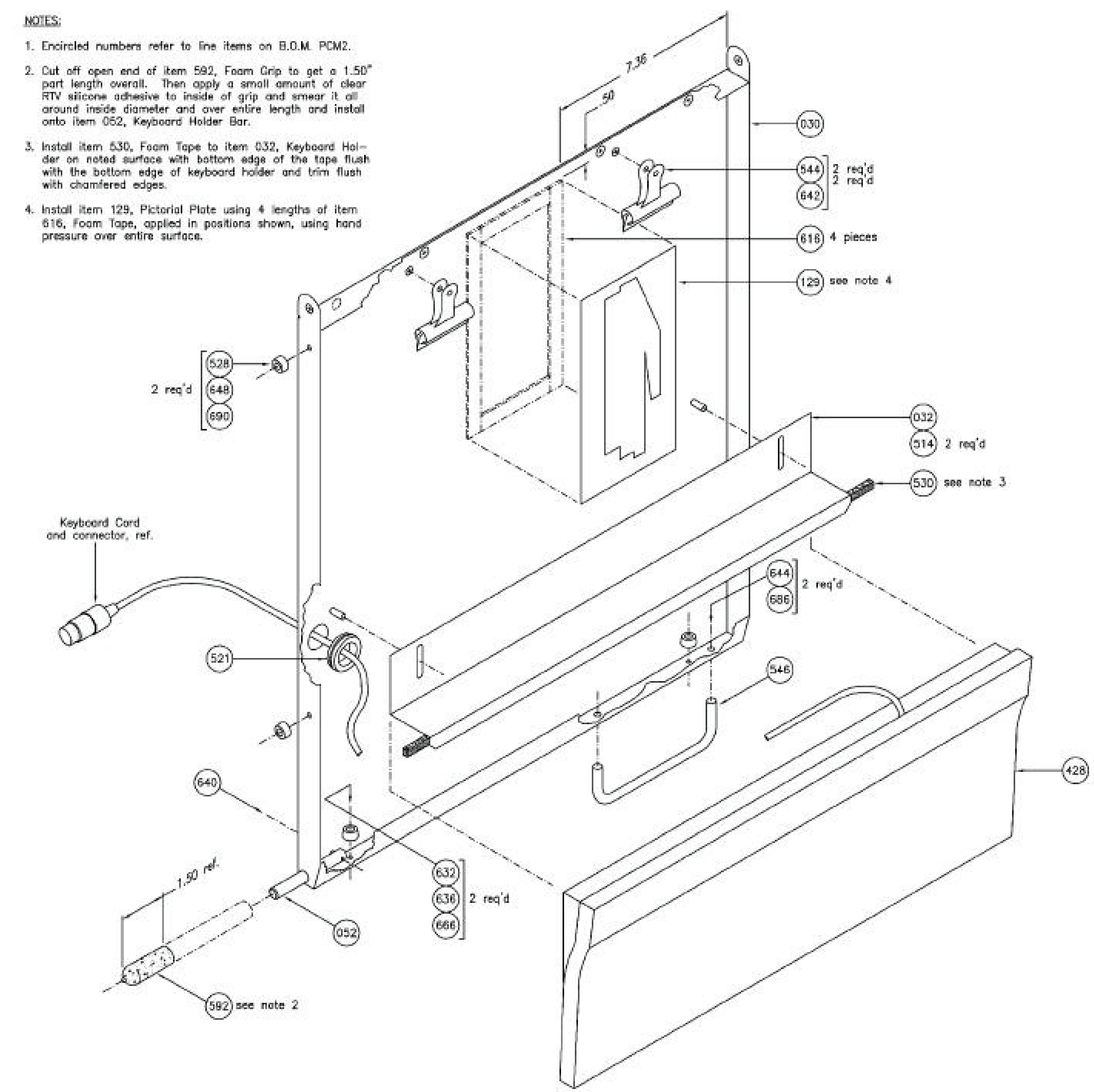
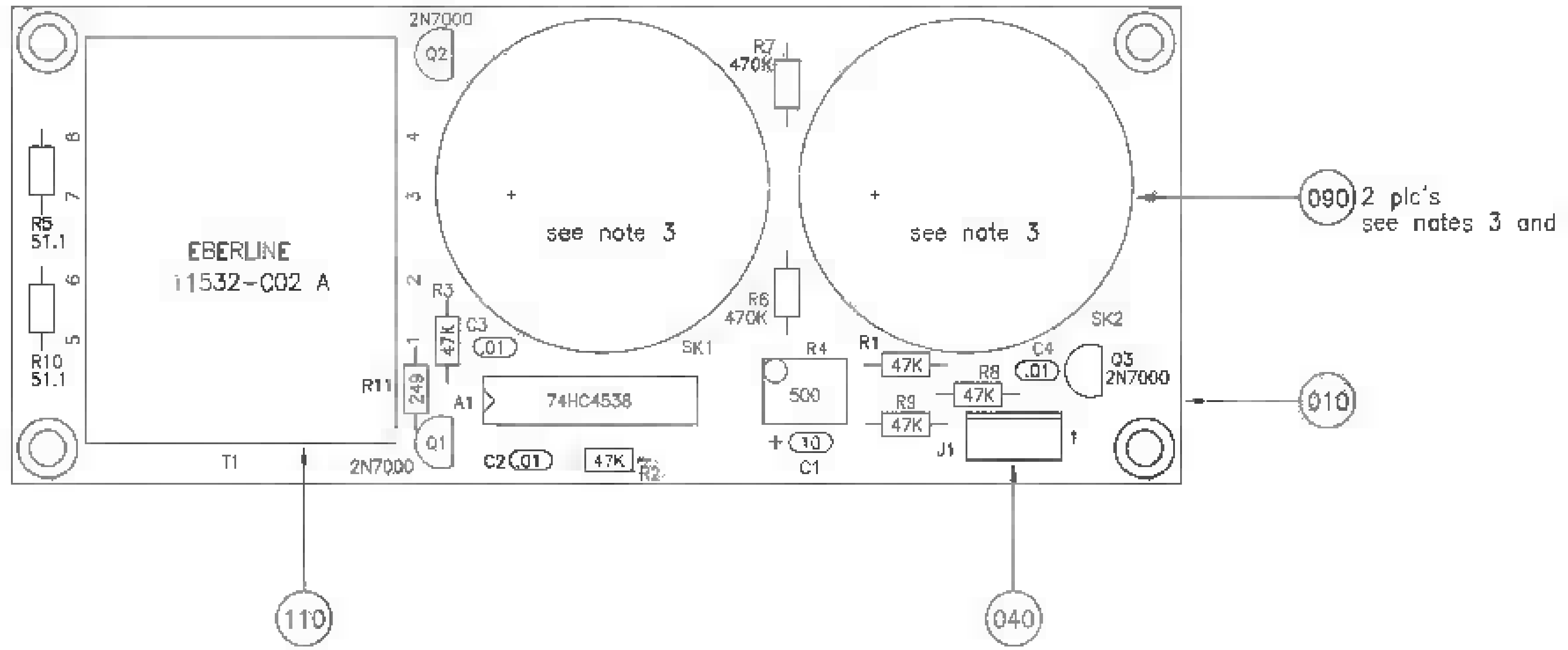
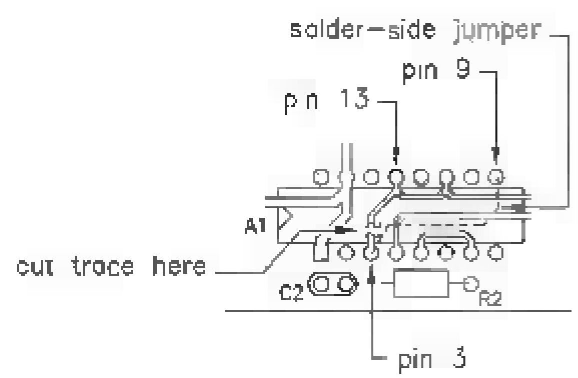


Figure 22-35. 11534-333, Keyboard pivot plate assembly.





NOTES:

1. Capacitance is in microFarads.
2. Resistance is in **ohms.** Resistors are 1/4 watt
3. NOTE that **there is a polarity** indicator on this **speaker; make sure** that this speaker is soldered **to the P.C.B. with the** indicator closest to **the** "+" on the P.C.B. as shown above.
4. For original issue boards, **cut the** component-side trace from A1-Pin 3 to A1-Pin 13 at Pin **3.** Using Kynar-insulated 28 AWG wire-wrap wire, install a solder-side jumper from A1-Pin 3 to A1-**Pin** 9 This jumper is req'd ONLY for original issue P.C. **boards** See detail at left.
5. If **the** speaker device comes with **insulated leads,** then cut each lead to approximately 6", then remove all insulation. Install the speaker carefully, especially with respect to the **polarity indicated by** the label on **the speaker's** underside

Figure 22-36. 11532-002, Clicker Board II component layout.

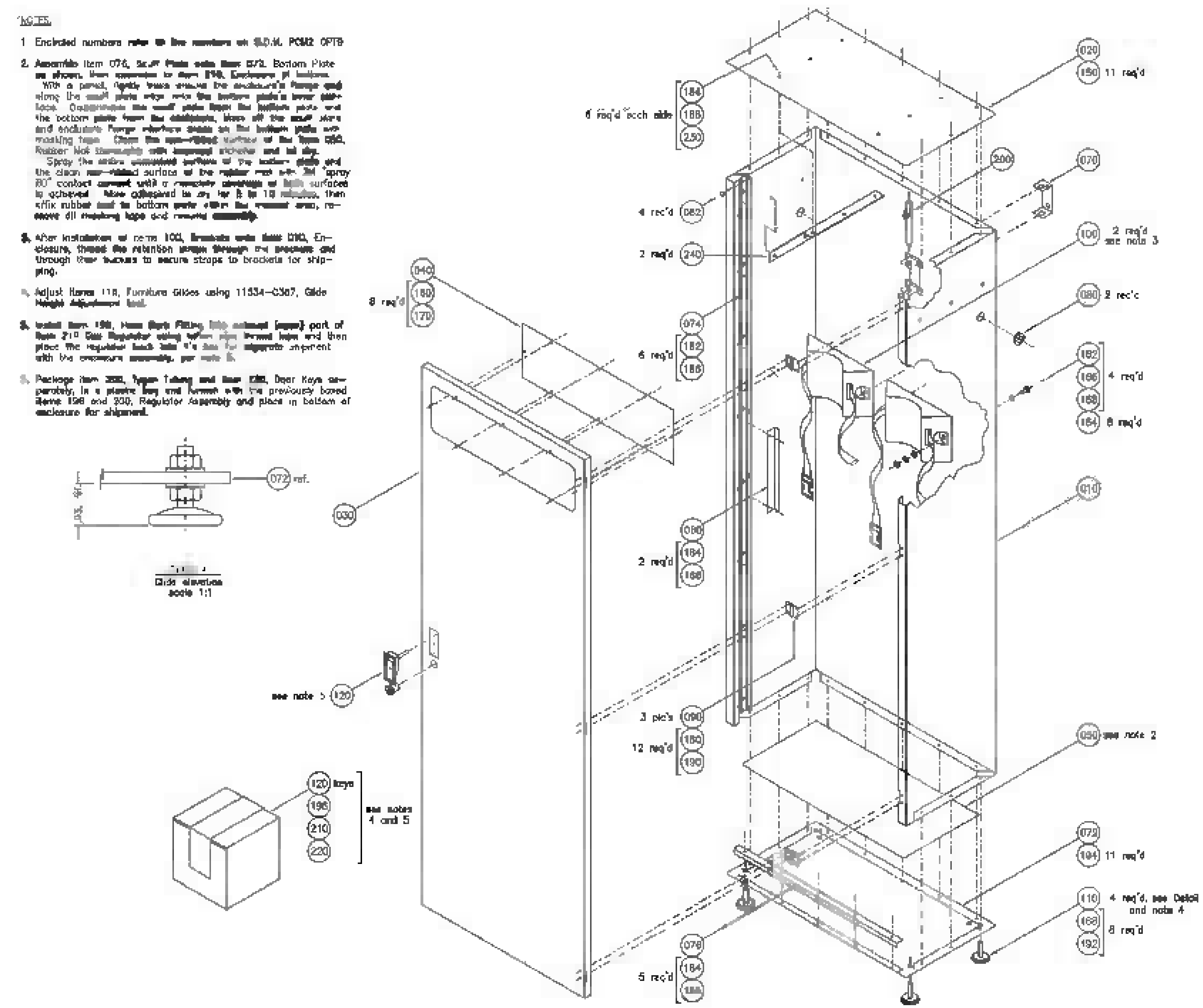
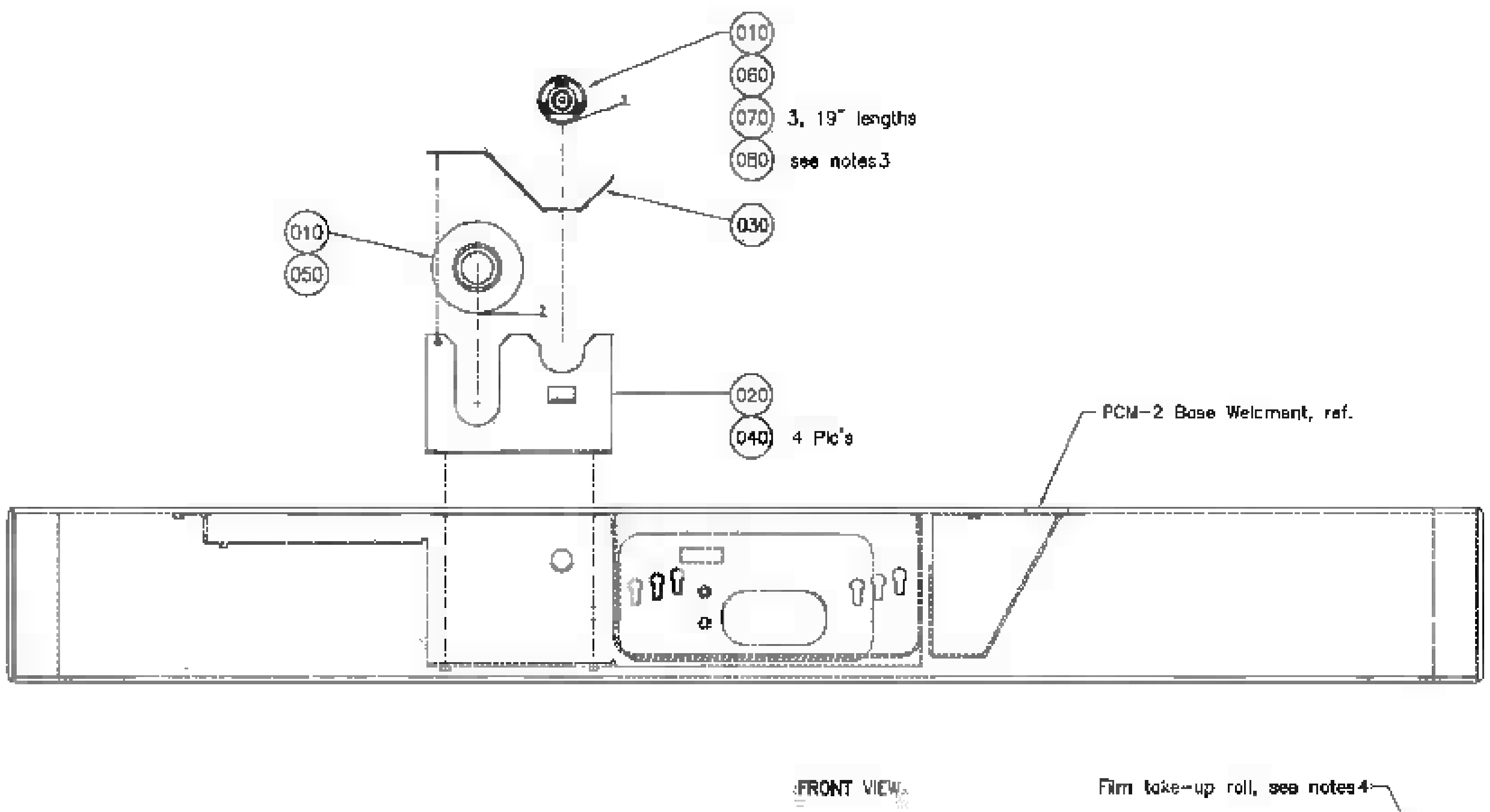


Figure 22-37. 11534-236, Gas bottle enclosure assembly.



NOTES:

1. Encircled numbers refer to line numbers on B.O.M. PCM2 OPT8
2. Apply 3 lengths of item 070 foam tape equally spaced to item 010 roll core providing the minimum spacing noted at each end of roll core. Then wrap black electrical tape around the ends of the applied foam tape and the roll core providing the minimum spacing of the electrical tape from the roll core ends.
3. Insert the expansion plug into one end of item 101 roll core and tighten the socket head screw until the plug expands to a secure fit within the roll core. Verify that the expansion plug and socket screw head are not protruding from the end of the roll core.
4. Route the Film as shown onto the take-up roll in order to trap any contaminated paticles inside the roll.

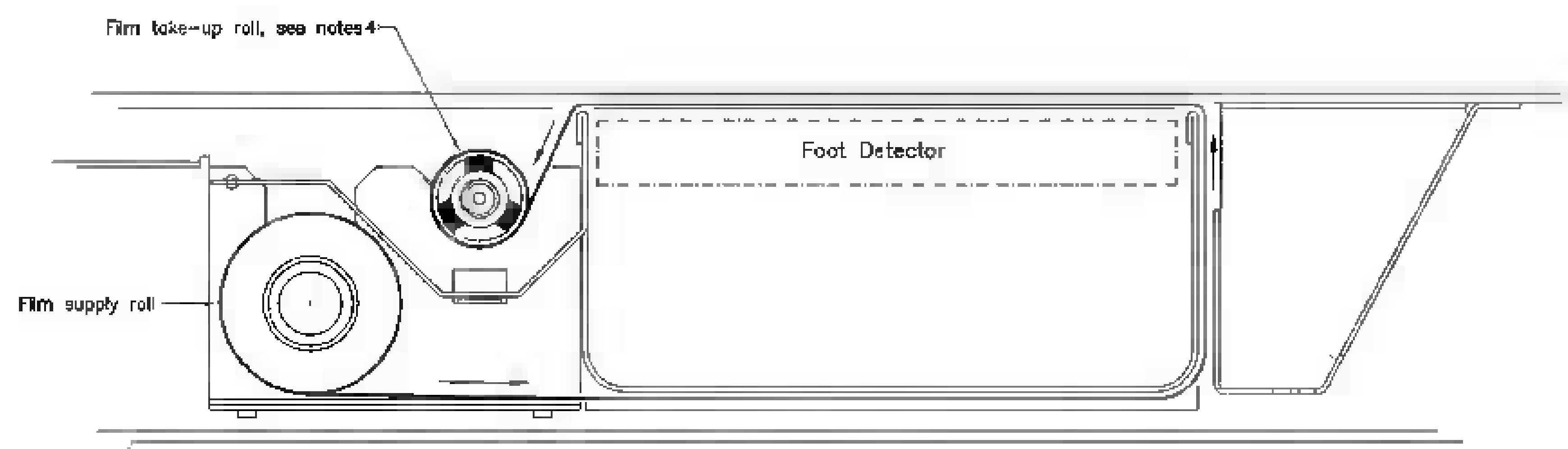


Figure 22-38. 11534-320, Polyethylene dispenser assembly, 1 of 2.

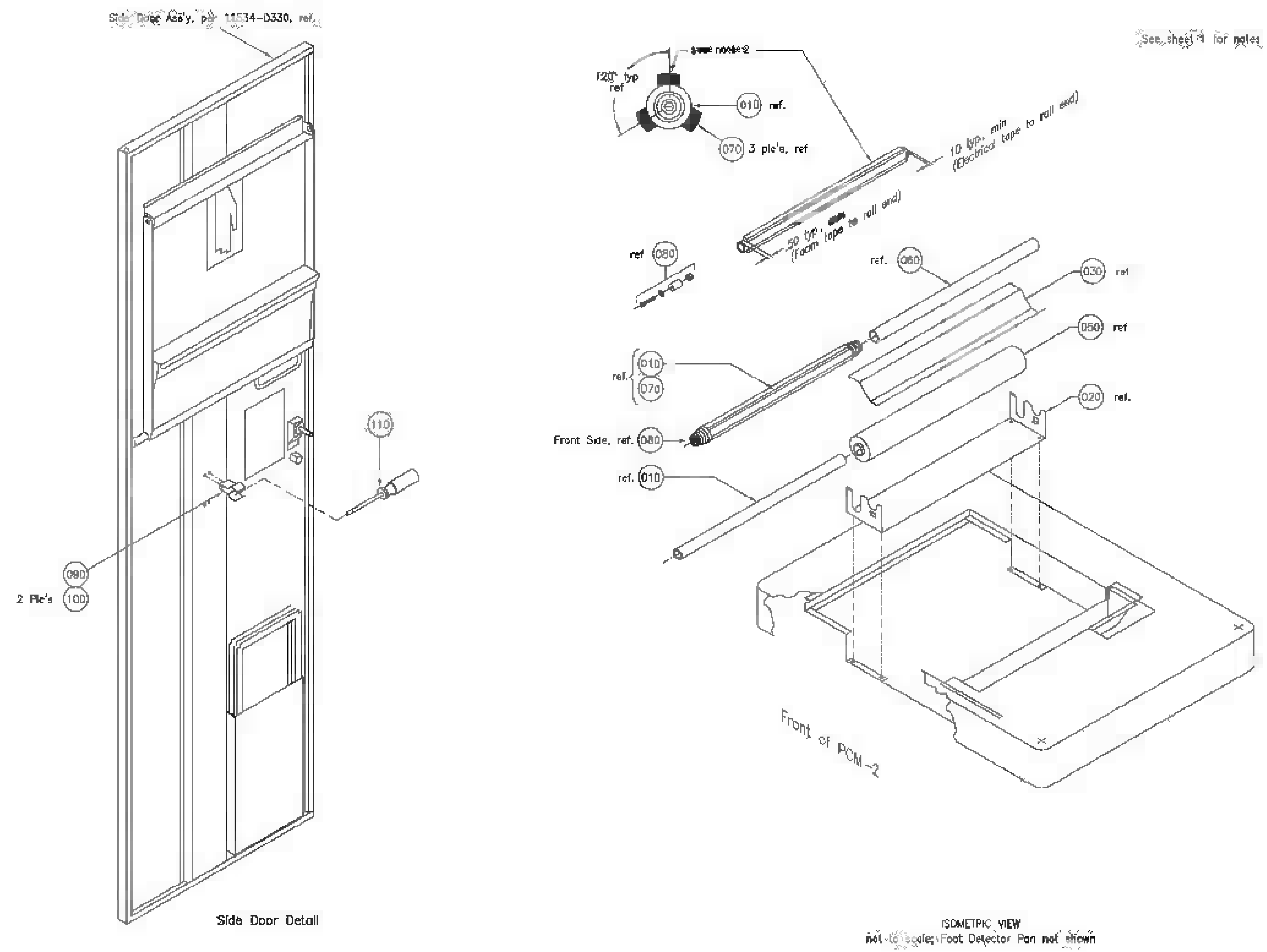


Figure 22-39. 11534-320, Polyethylene dispenser assembly, 2 of 2.

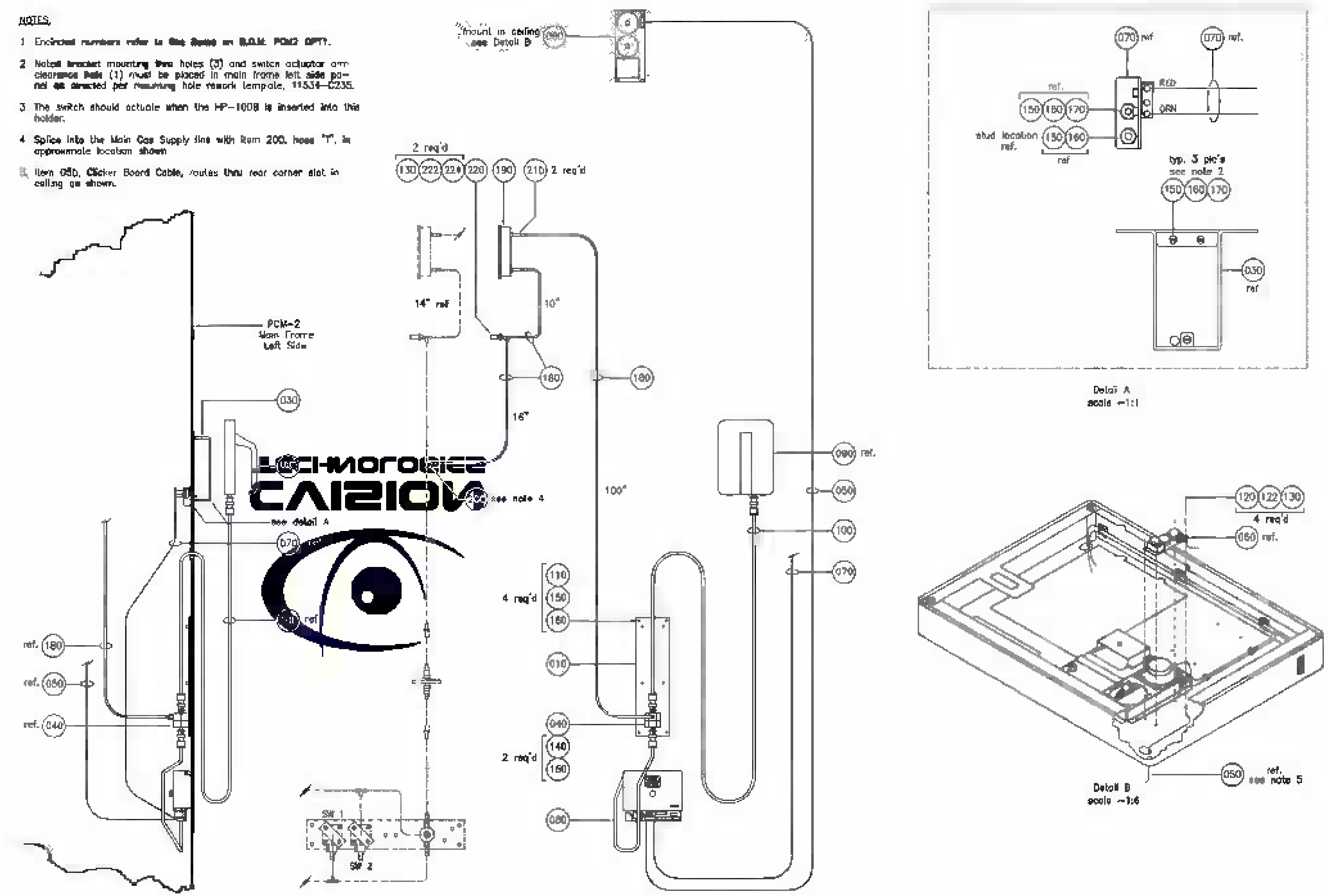


Figure 22-40. 11534-307, Hand probe assembly.

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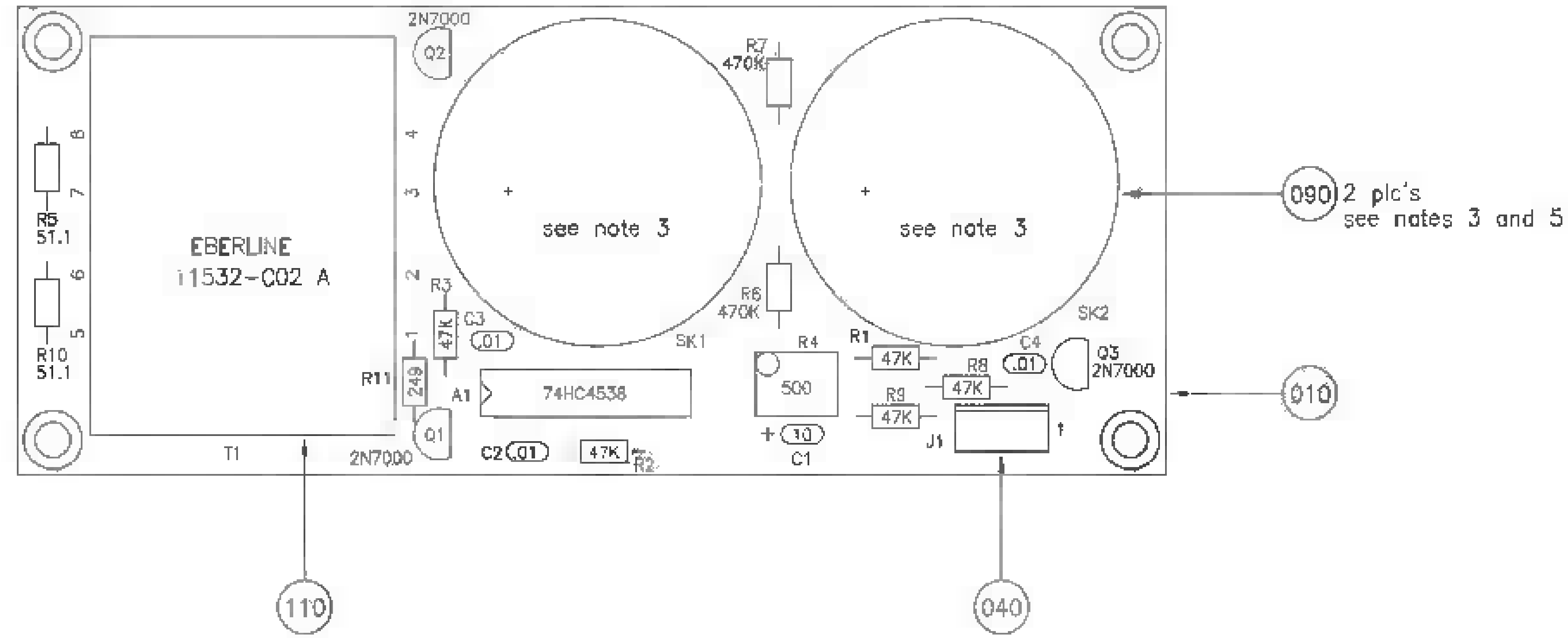
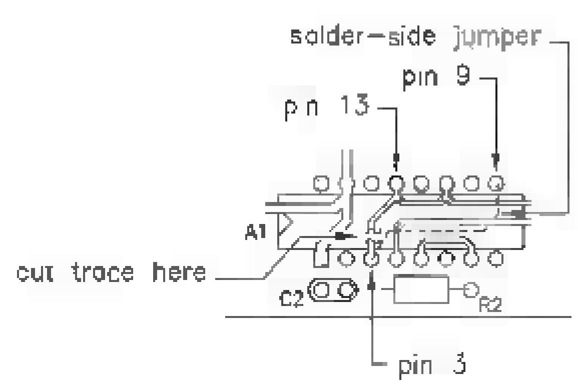
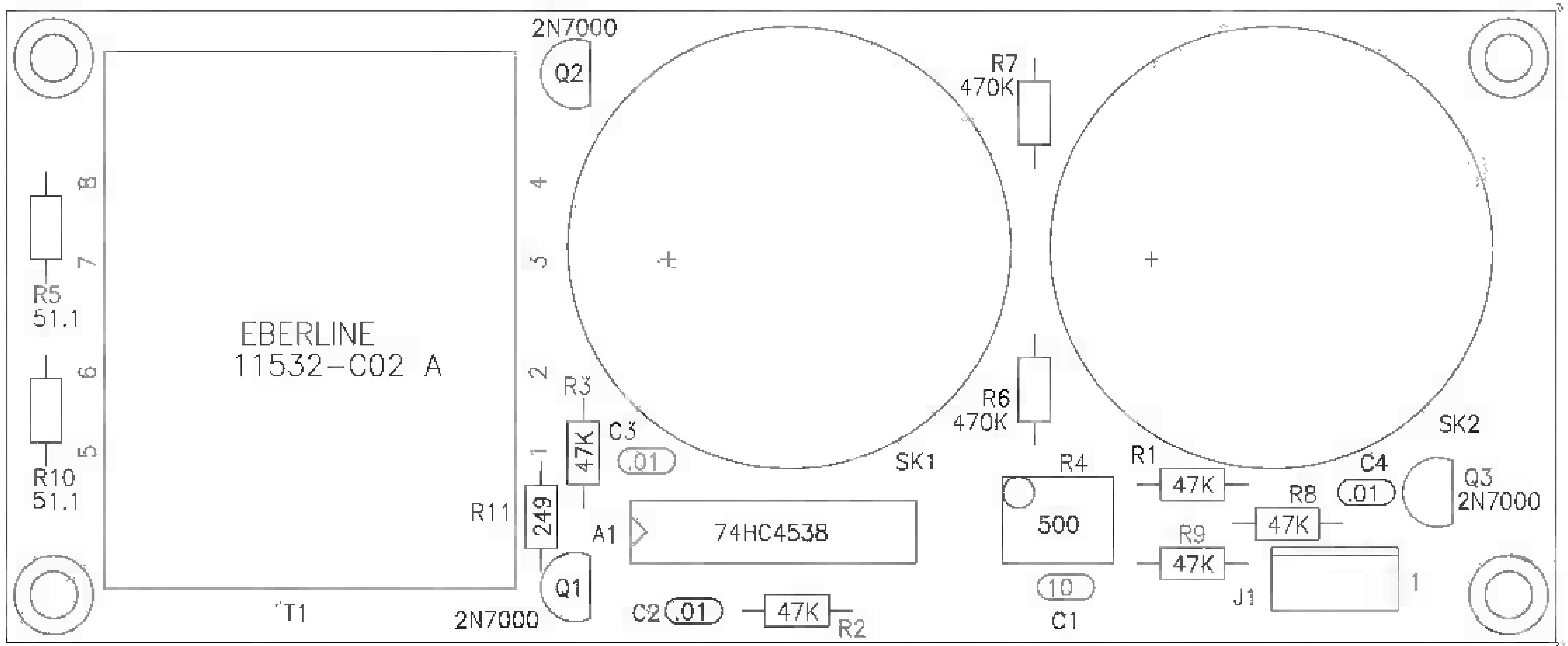




NOTES:

1. Capacitance is in microFarads.
2. Resistance is in **ohms.** Resistors are 1/4 watt
3. NOTE that there is a polarity indicator on this speaker; make sure that this speaker is soldered to the P.C.B. with the indicator closest to the "+" on the P.C.B. as shown above.
4. For original issue boards, cut the component-side trace from A1-Pin 3 to A1-Pin 13 at Pin 3. Using Kynar-insulated 28 AWG wire-wrap wire, install a solder-side jumper from A1-Pin 3 to A1-Pin 9. This jumper is req'd ONLY for original issue P.C. boards. See detail at left.
5. If the speaker device comes with insulated leads, then cut each lead to approximately 6", then remove all insulation. Install the speaker carefully, especially with respect to the polarity indicated by the label on the speaker's underside

Figure 22-41. 11532-003, Clicker PCB component assembly.



NOTES.

1. Capcitance is in microFarads.

2. Resistance is in ohms. Resistors are 1/4 watt.

Figure 22-42. 11532-004, Clicker Board II components.

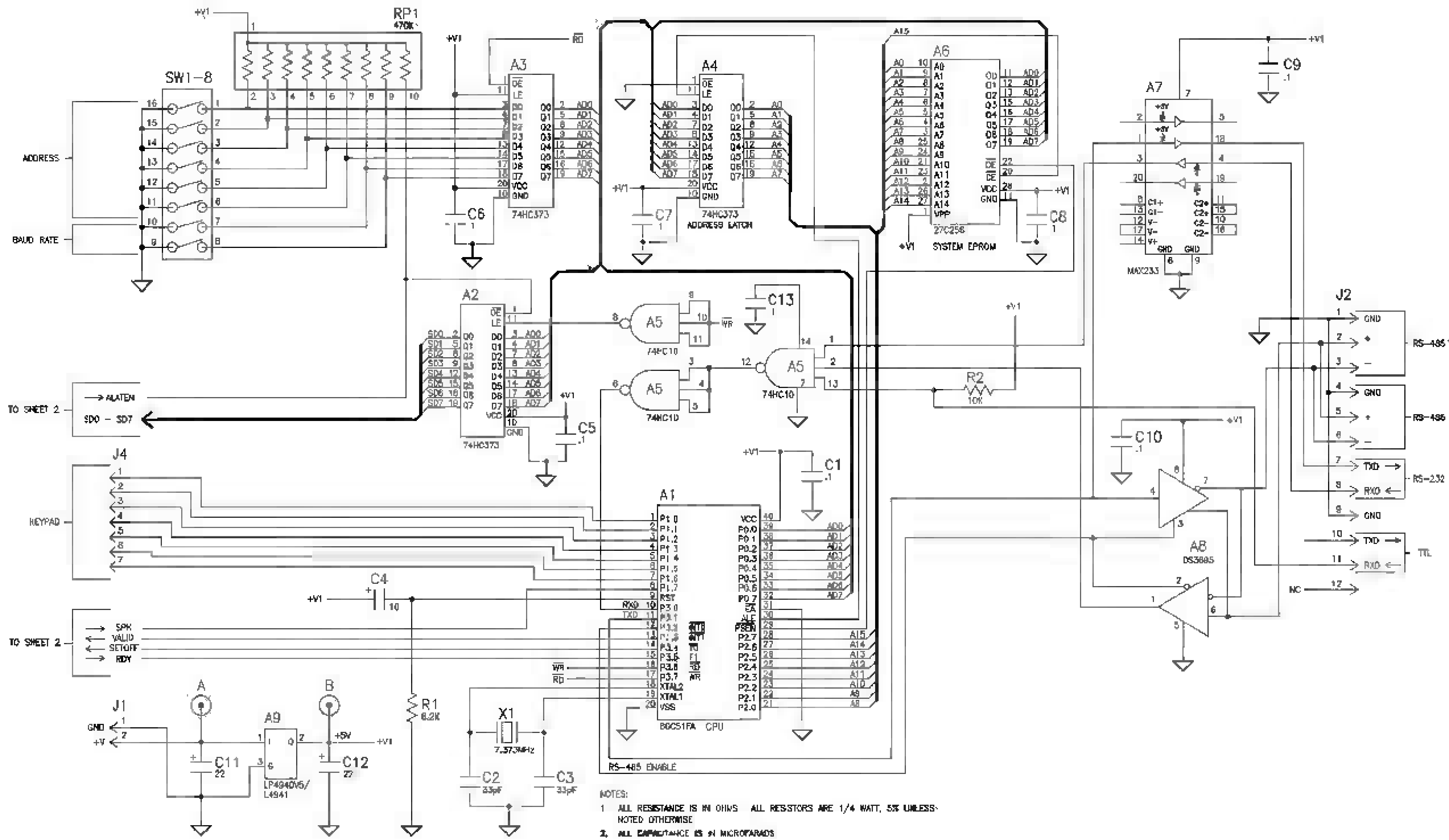


Figure 22-43. 11513-002, Voice annunciator, 1 of 2.

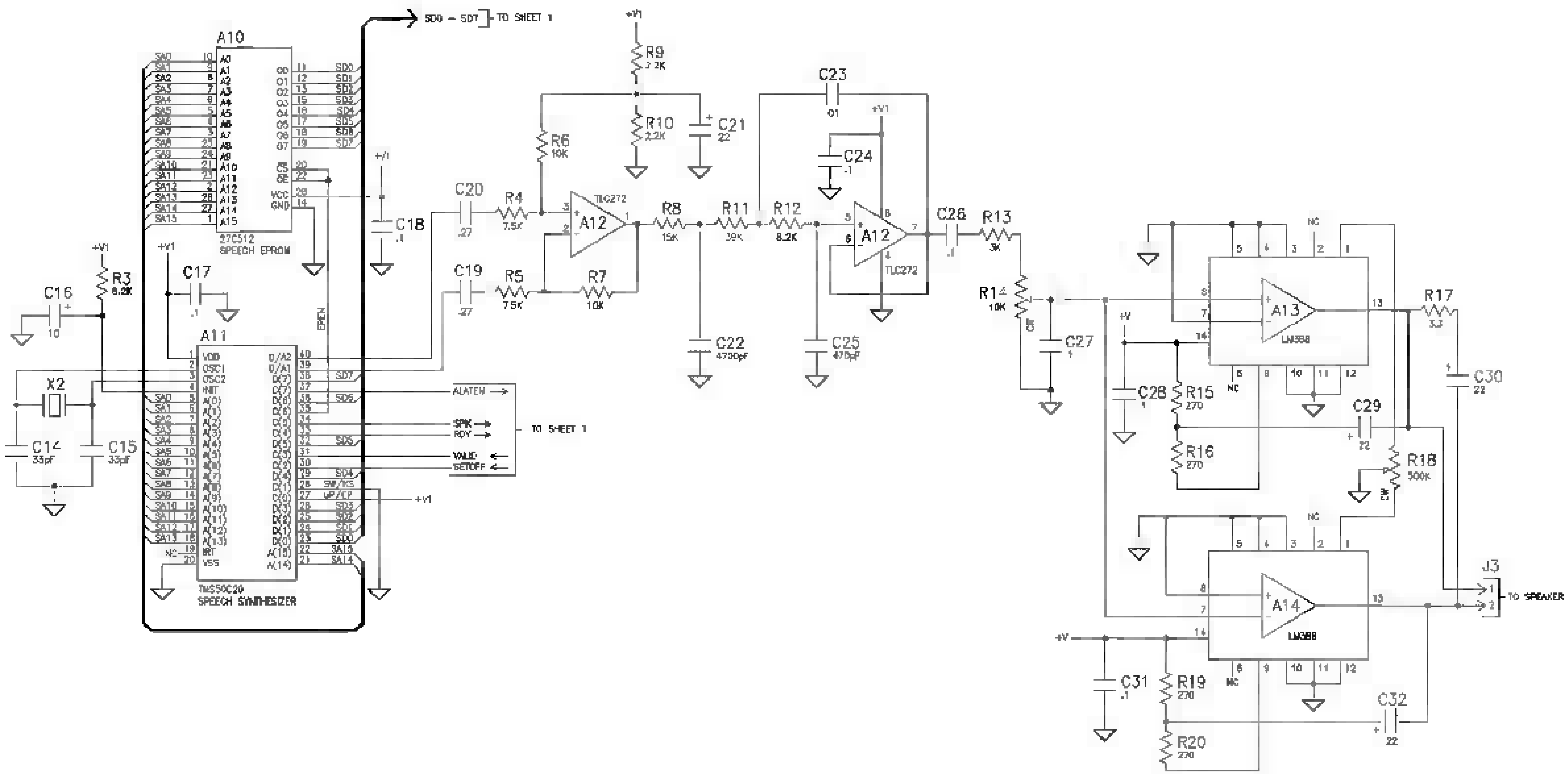


Figure 22-44. 11513-002, Voice annunciator layout, 2 of 2.

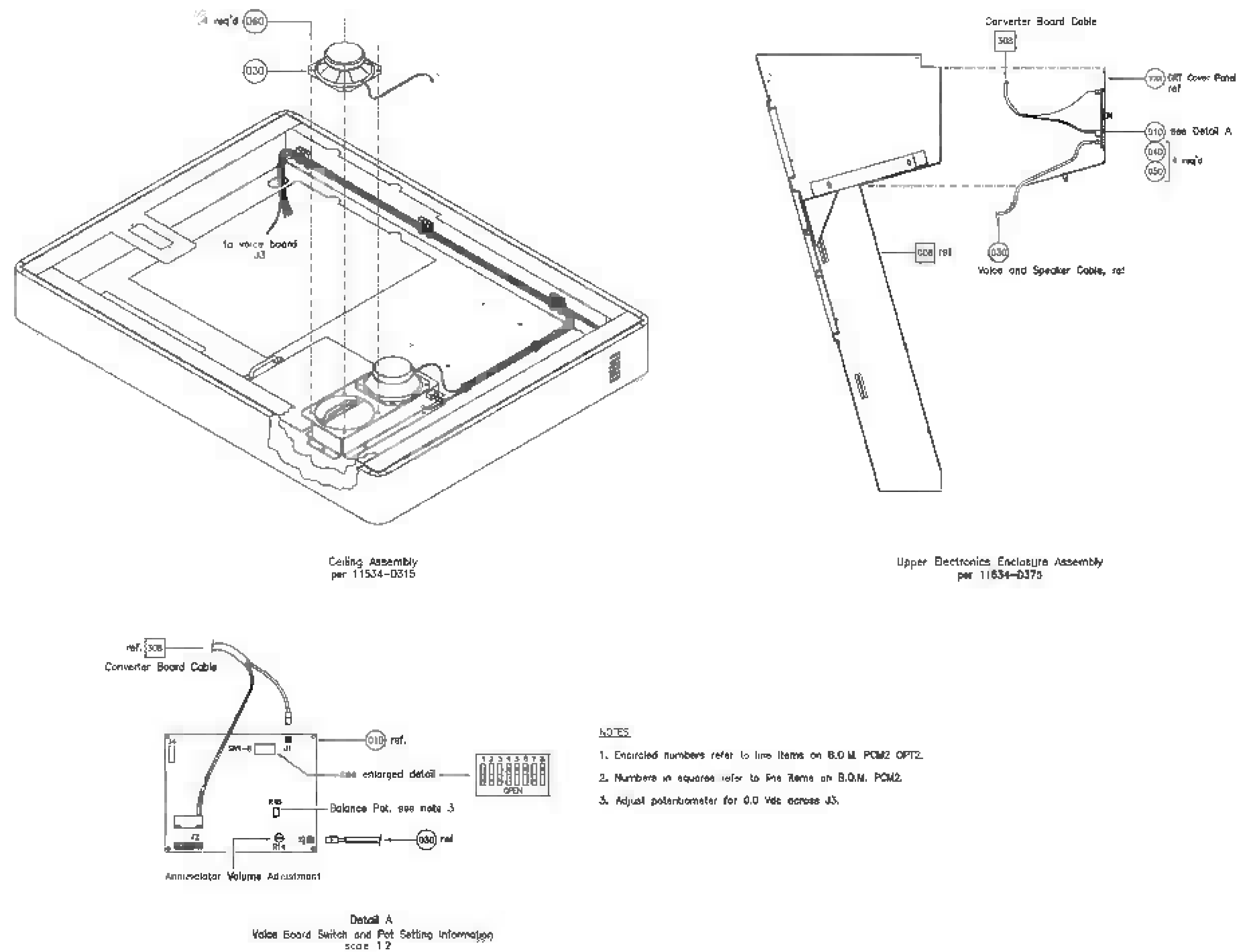


Figure 22-45. 11534-313, Voice annunciator assembly.

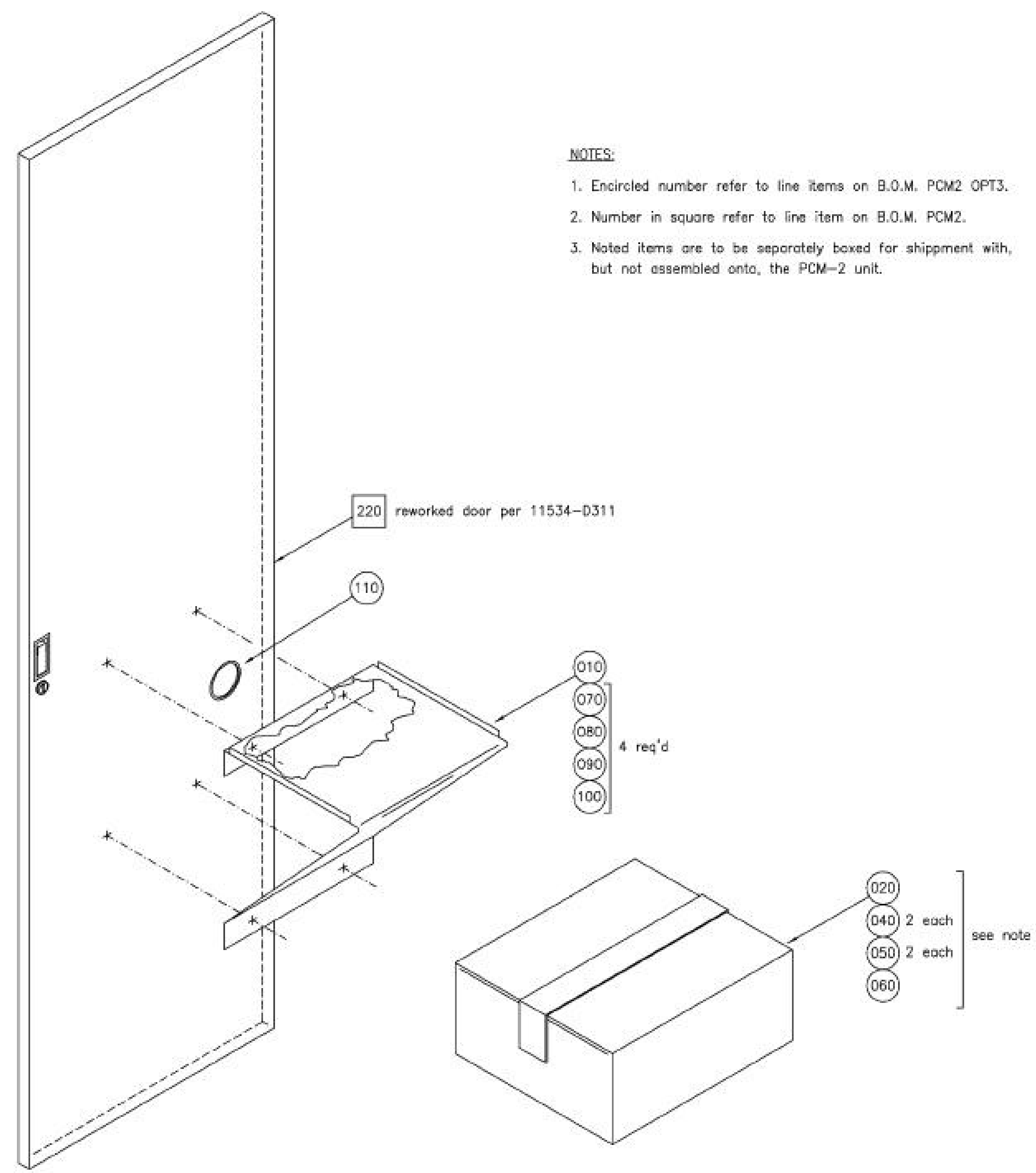
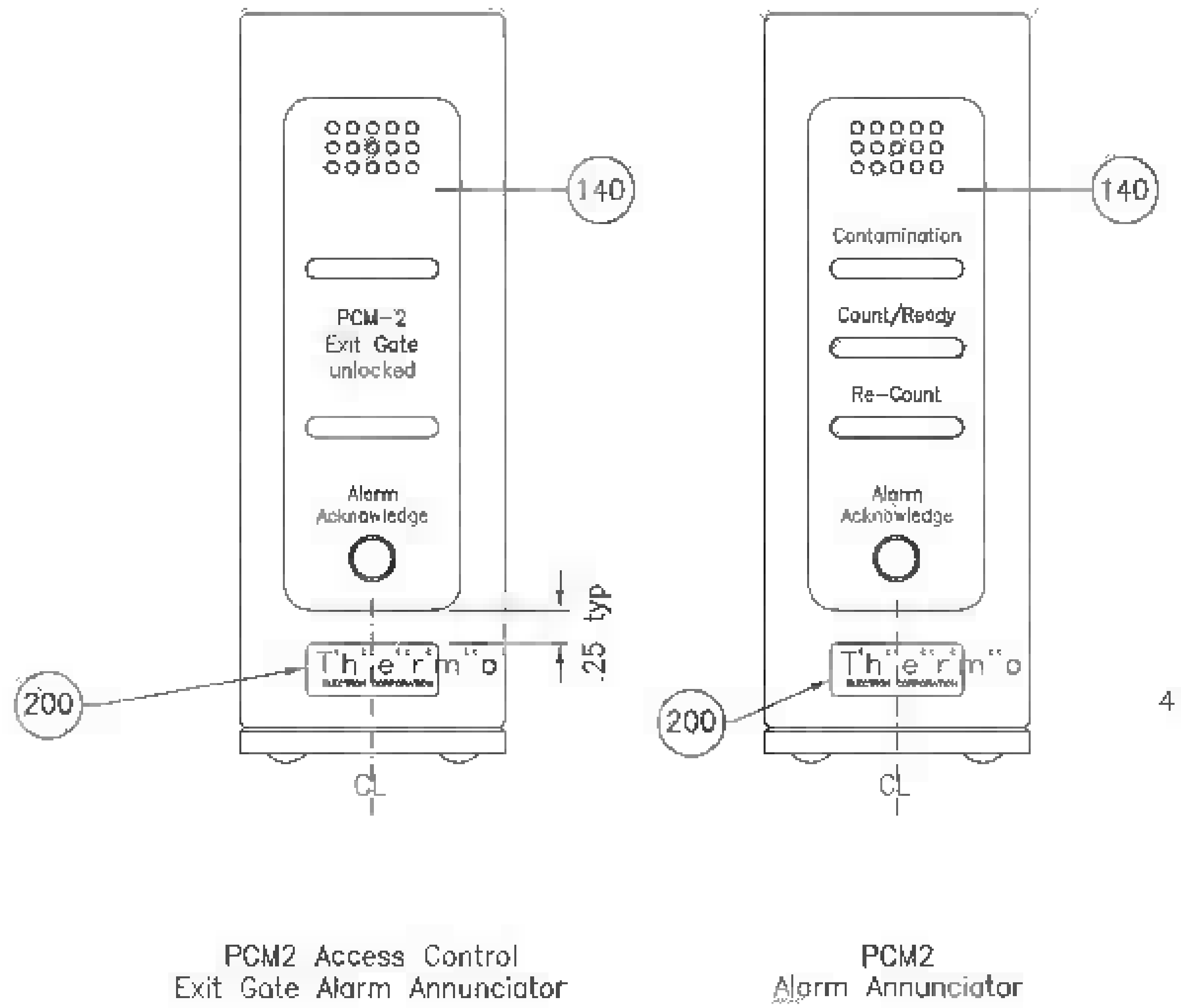
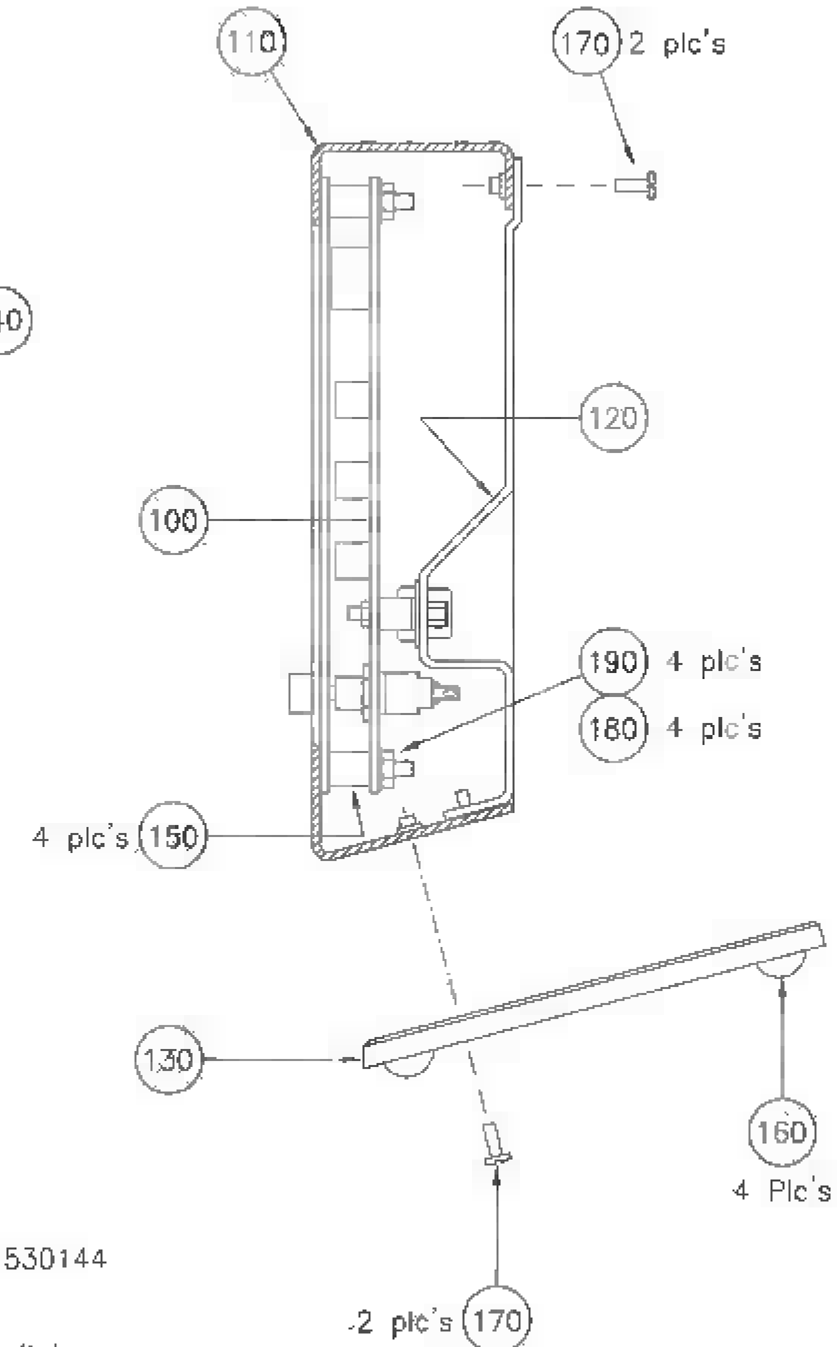


Figure 22-46. 11534-312, Printer assembly.





NOTES:

1. Encircled numbers refer to line numbers on BOM YP11530144 and BOM PCM2 OPT5B.
2. Adjust P.C Board position to allow black pushbutton switch to travel freely when assembled.

Figure 22-47. 11534-529, Remote annunciator assembly.

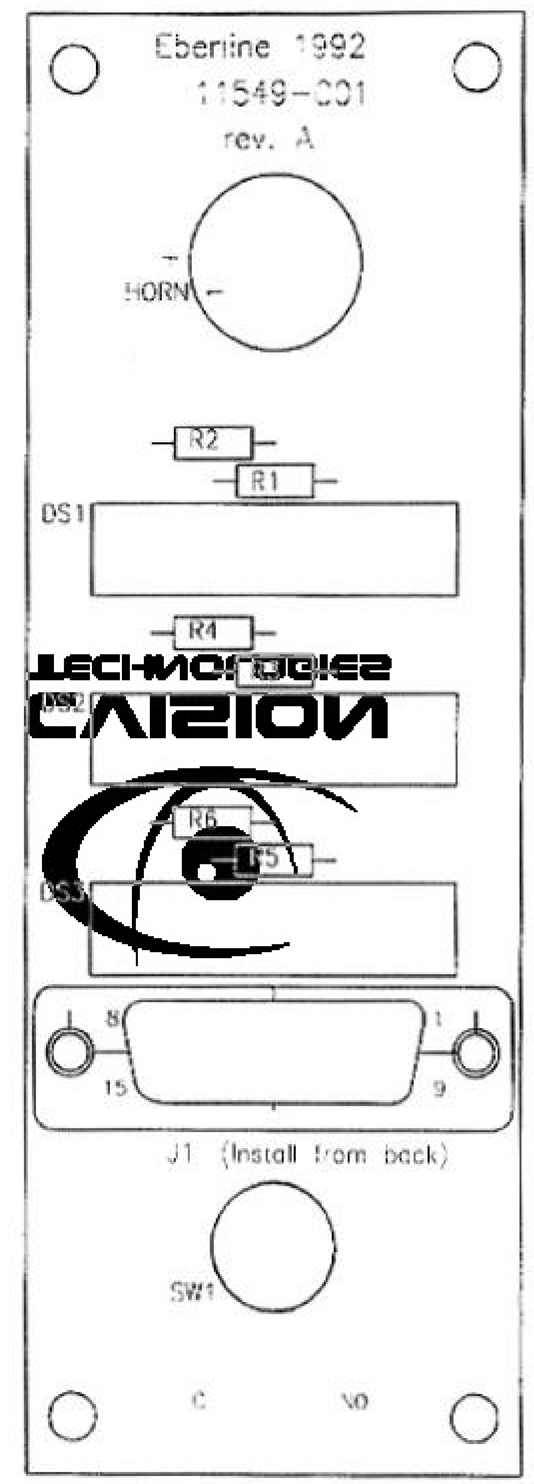


Figure 22-48. 11549-001, Remote annunciator component layout.

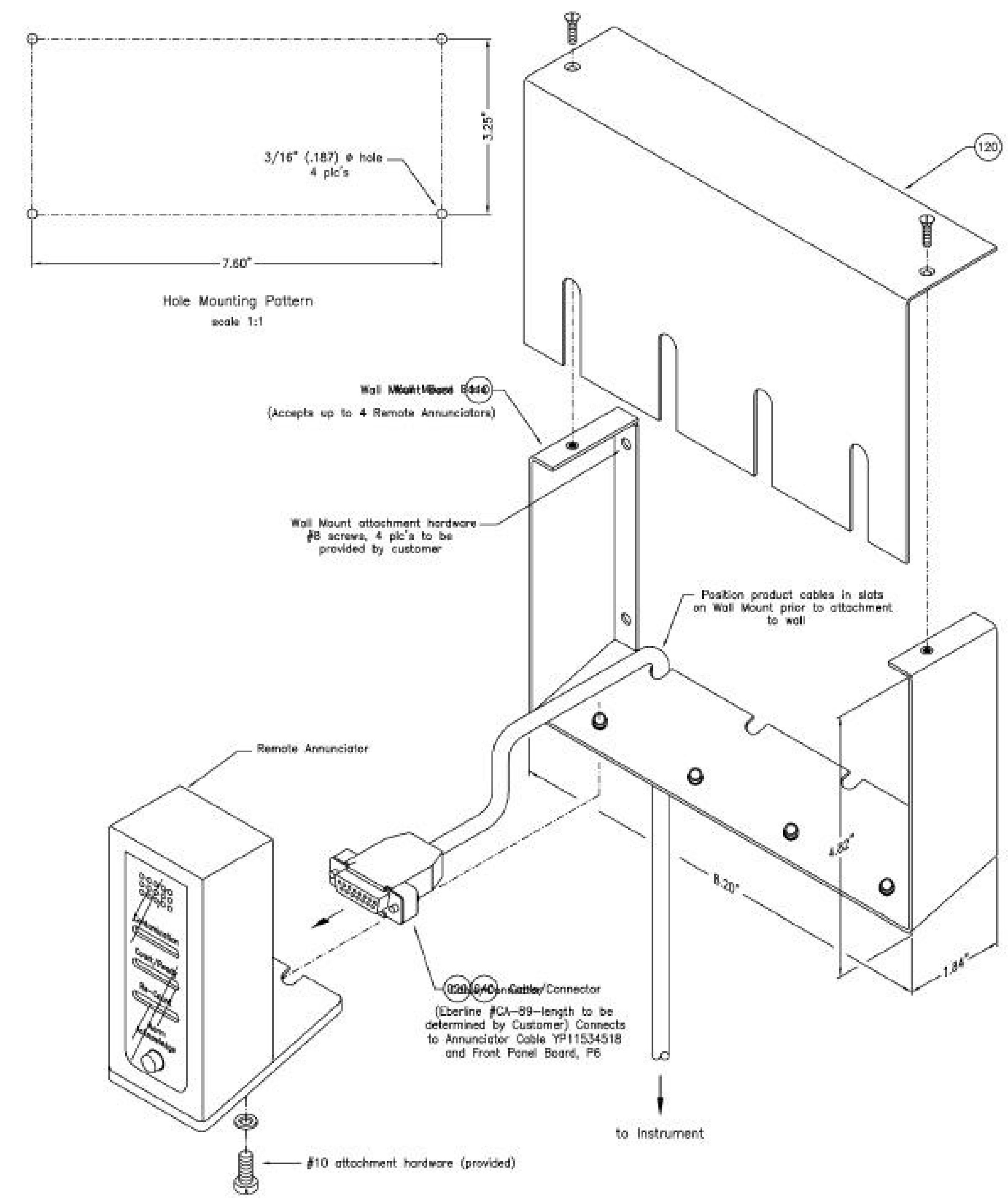


Figure 22-49. 11534-531, Wall-mount/remote annunciator outline.

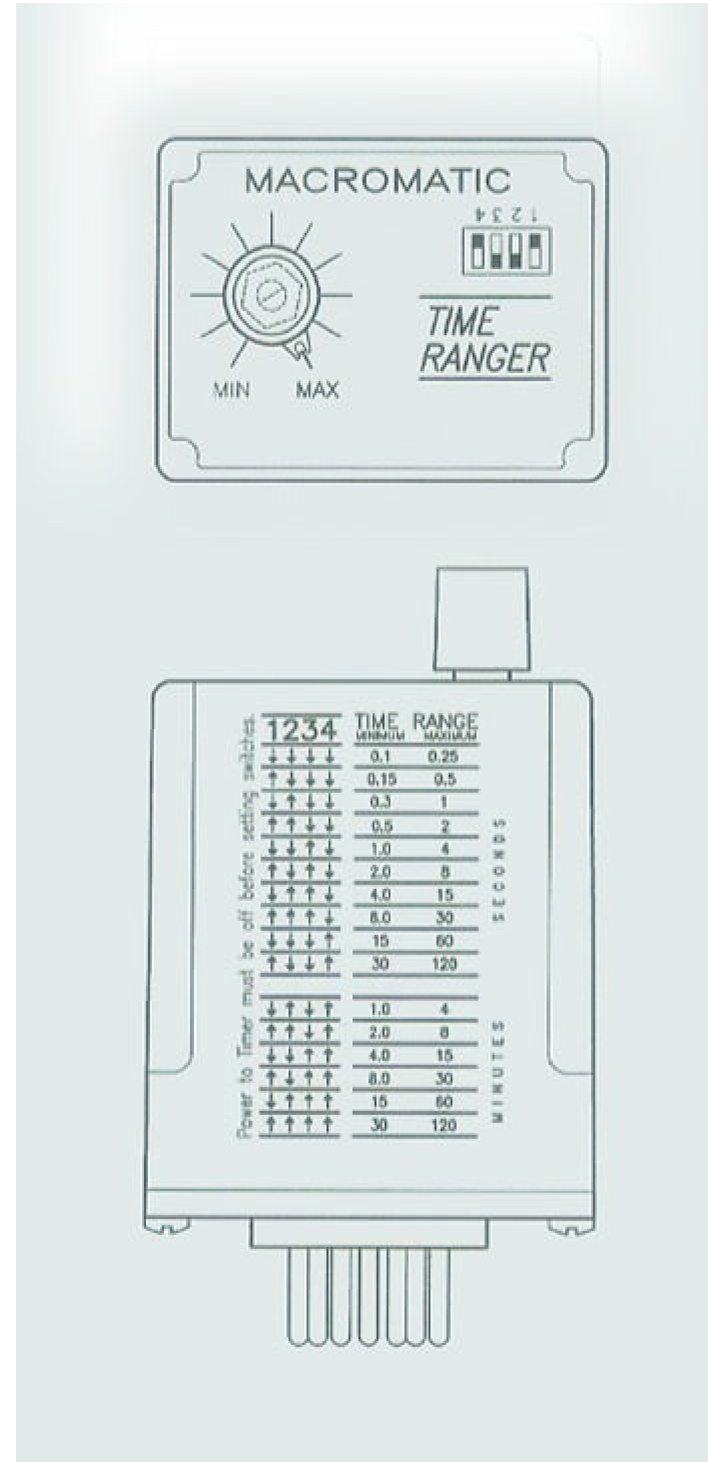


Figure 22-50. Time delay relay switch settings.

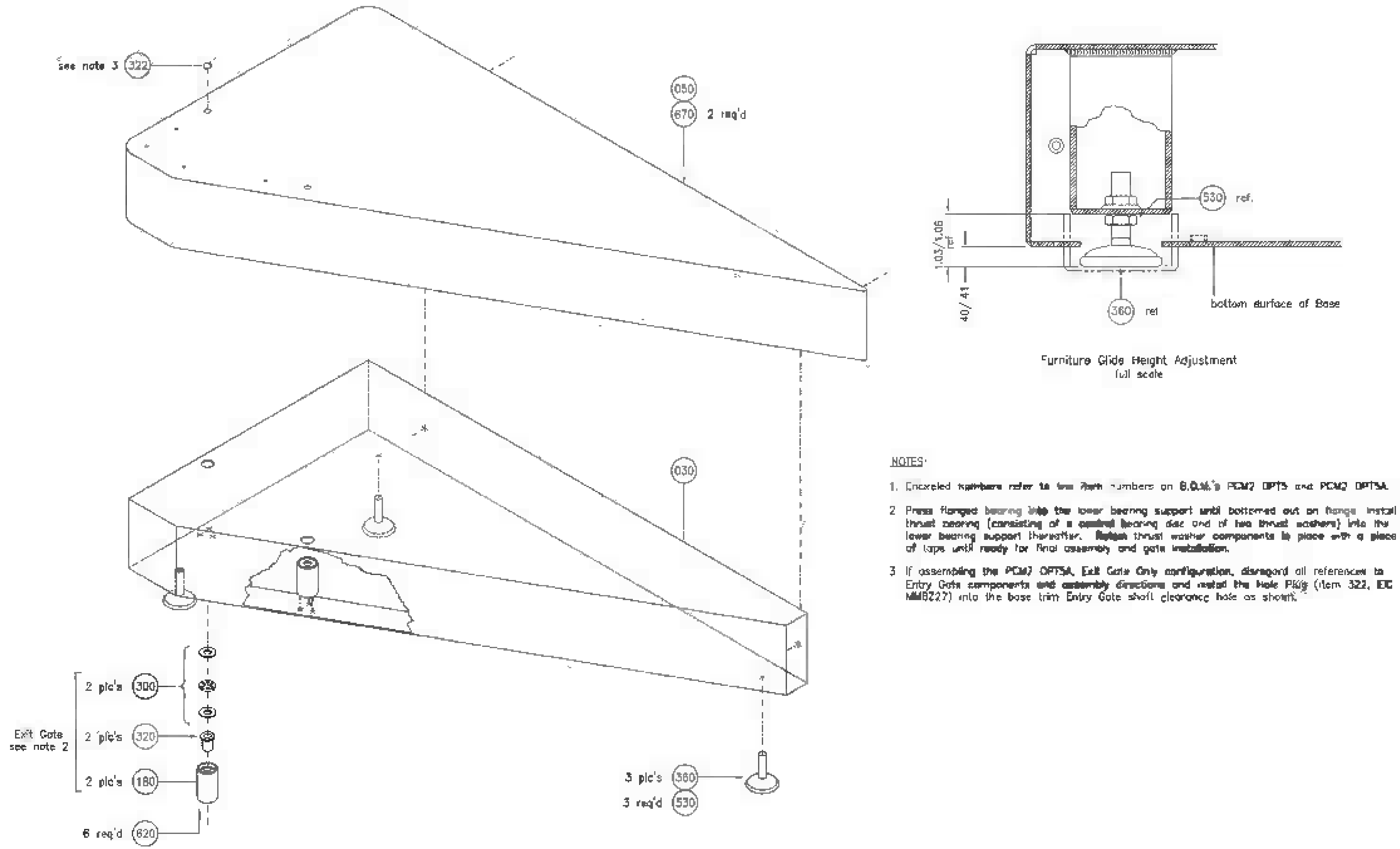


Figure 22-51. 11534-477, Access control, base assembly.

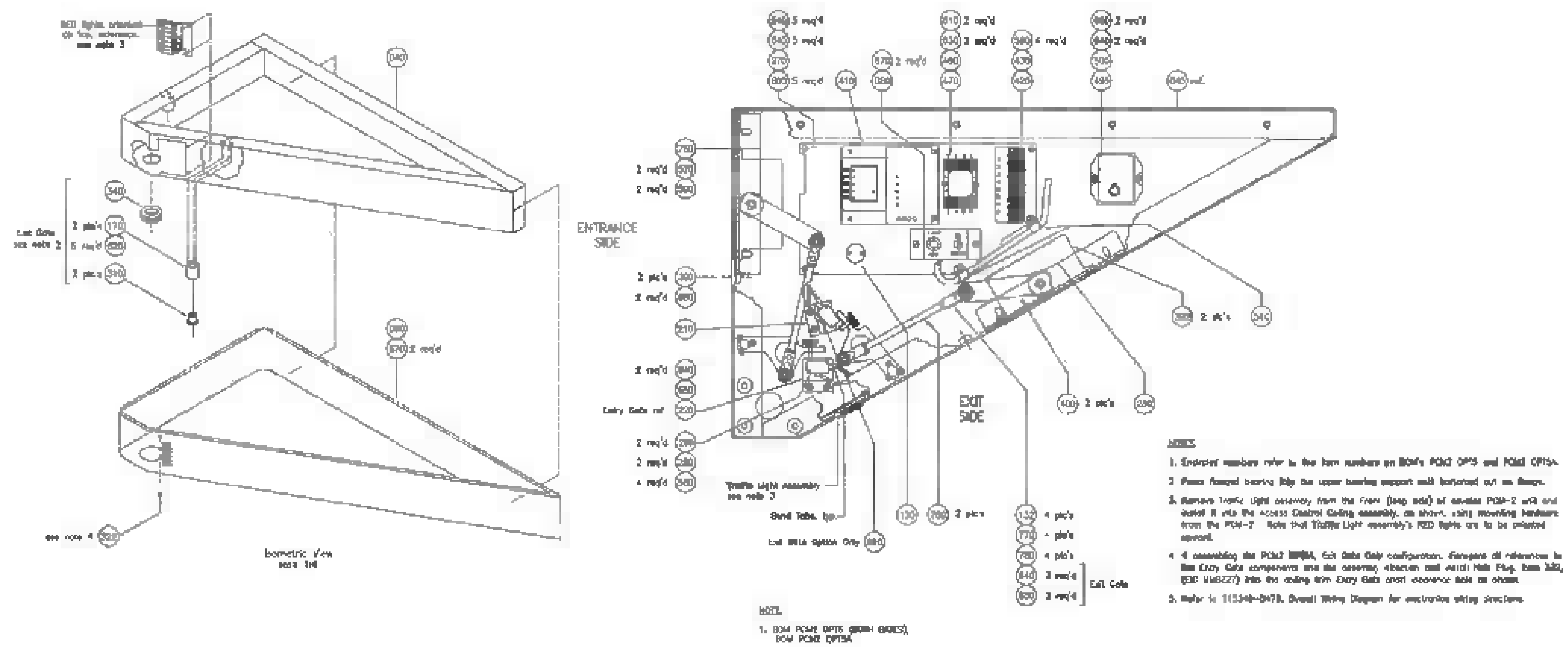


Figure 22-52. 11534-478, Access control, ceiling assembly.

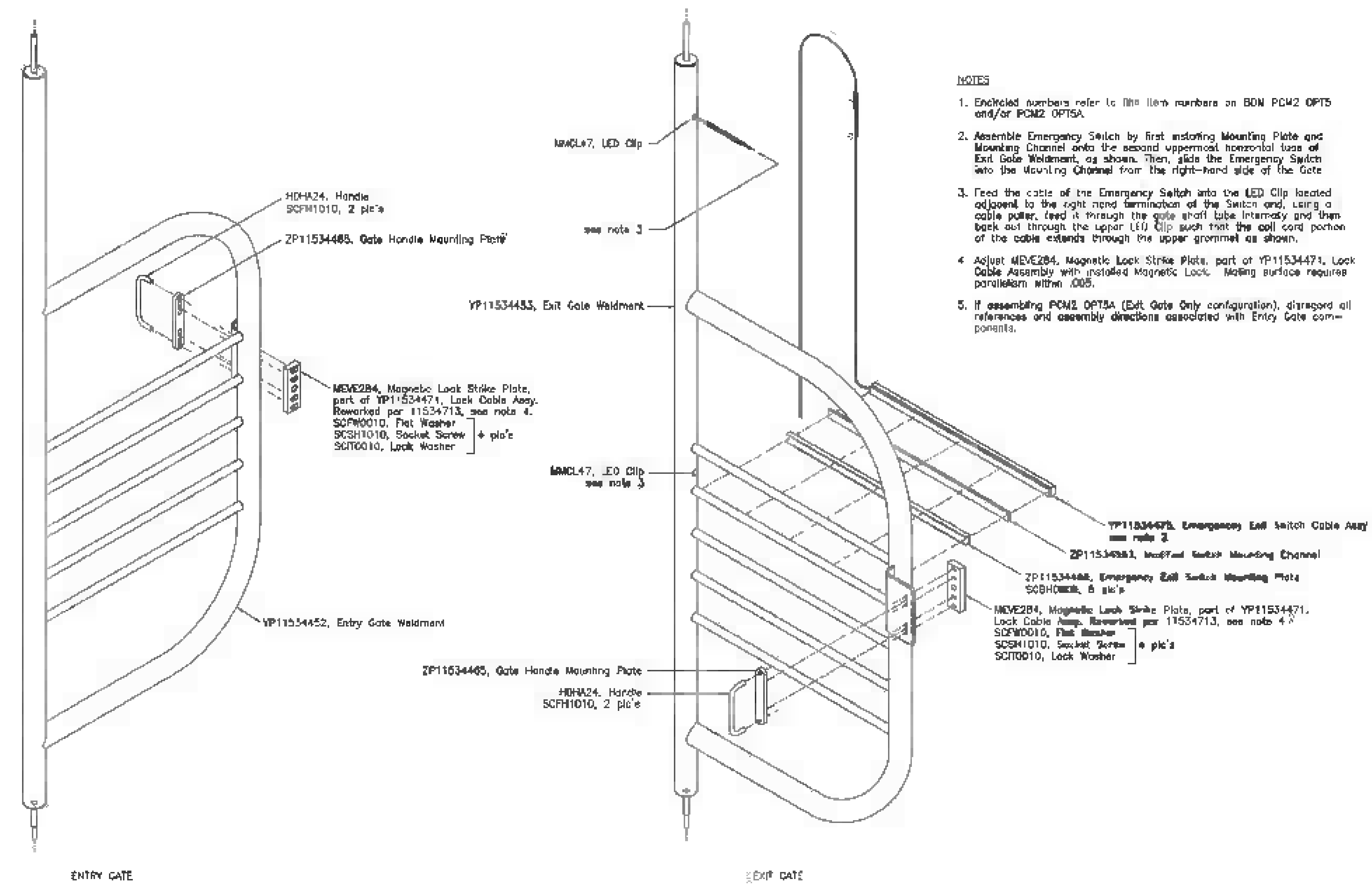


Figure 22-53. 11534-479, Access control, gates assembly.

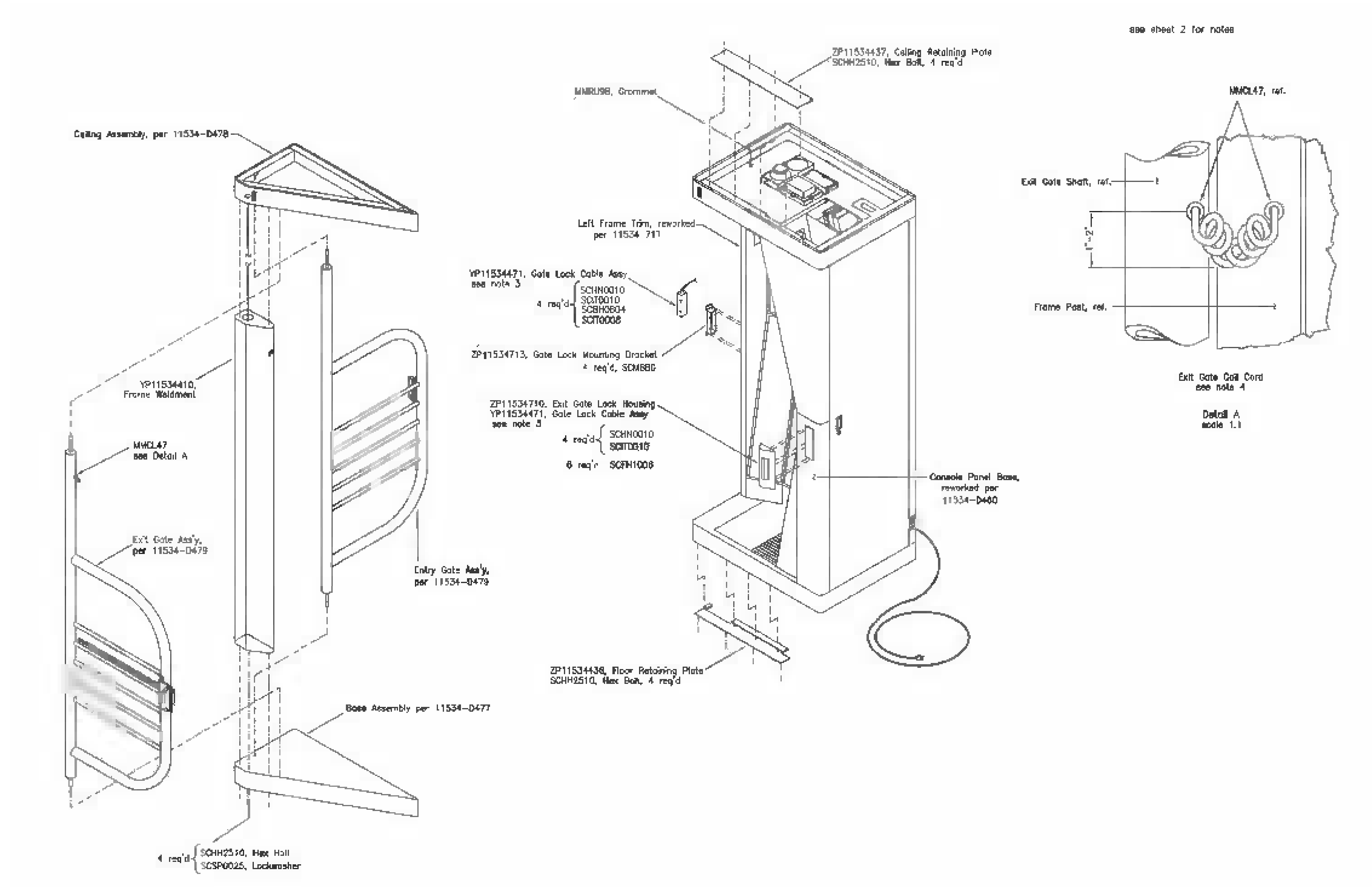
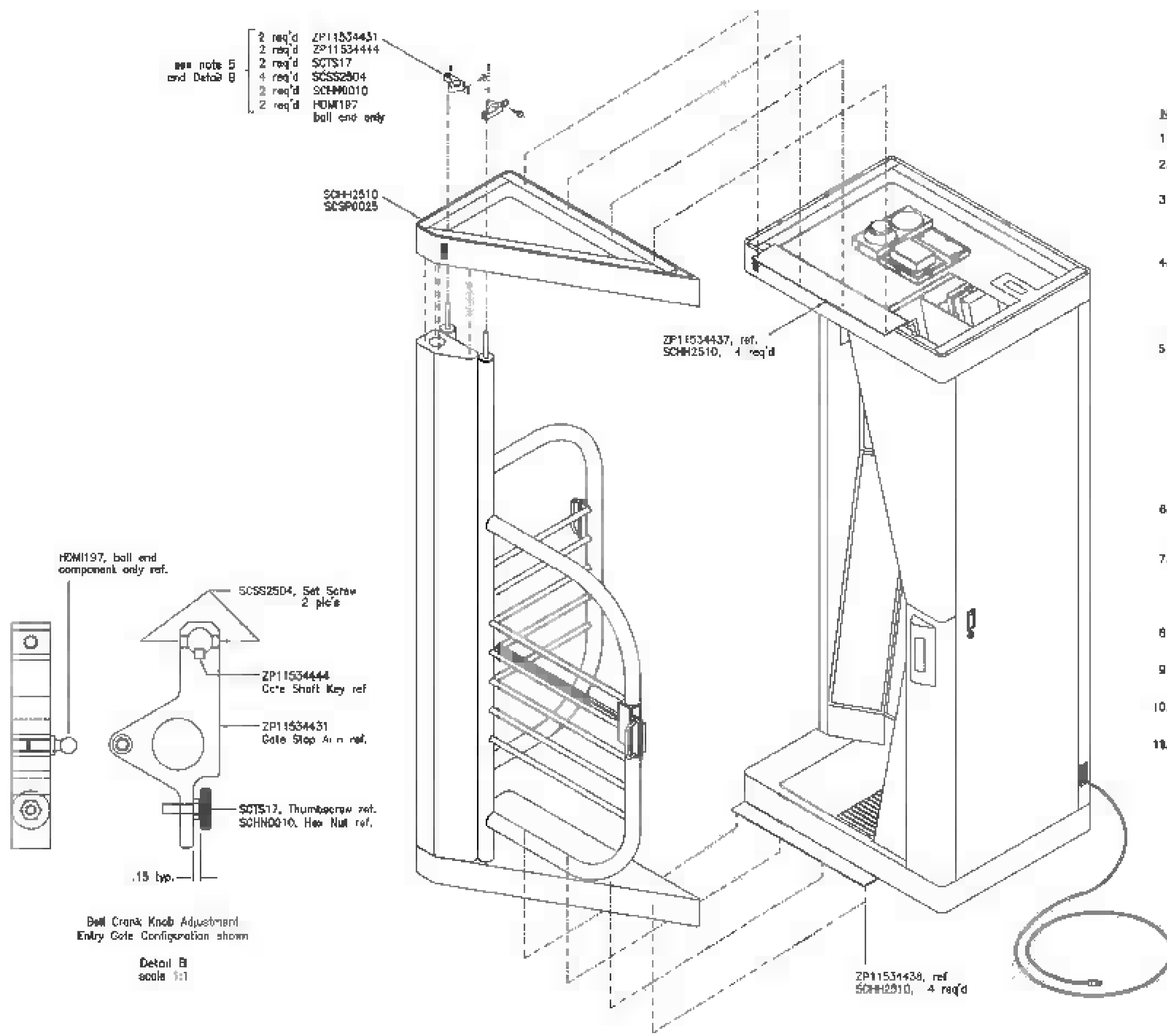


Figure 22-54. 11534-480, Access control, overall assembly, 1 of 3.



NOTES:

1 Refer to B.O.M.'s PCM2 OPT5 and OPT5A.

2. For [illegible] Beacon components referenced on sheet 3, see BOM PCM2 OPT5C.

3 Route Gate Lock Cable Assemblys' cable ends up through the left frame [illegible] (entry) then out through the console panel (exit) into the ceiling assembly and route over to the front and center of the ceiling assembly.

4. Route [illegible] gate emergency cable into Frame Post through the rubber grommet near the [illegible] of the Frame Post and feed cable up through upper holes in the post and ceiling assembly. Next, pull the cable through the grommets in the gate shaft and post such that only the [illegible] portion of the cable is exposed with 1" to 2" of slack, as shown in Detail A.

5 Install shaft keys into gate shaft keyways after positioning the ceiling assembly over the ends of the gate shafts. Simultaneously, install Gate Stop Arms over the ends of the gate shafts and align with and slide [illegible] over installed shaft keys. Then guide upper gate shaft ends into shaft bearings mounted in the ceiling assembly. Fasten bolts and lockwashers to attach ceiling assembly to Frame Post. Next, adjust elevation of Gate Stop Arms such that the centers of their thumb screws are aligned with the center of the rubber bumpers mounted on the inside [illegible] of the ceiling [illegible], and tighten their set screws firmly against the gate shafts. Install Thumb screws into Gate Stop Arms using Hex Jam Nut, as shown in Detail B, adjusting protrusion height to dimension noted.

6. Mount the ball end components of HDMI197, Door Closer, to the Gate Stop Arm [illegible] top of the parts as shown. Then install the bracket into the Ceiling Assembly as shown.

7. Route the Gate Lock Cable Assemblies, Frontier Traffic Light Cable assembly, Interface Cable assembly, and the AC Power Cord through the conduit which spans the upper retaining bracket as shown. All cable's connectors should remain external to the conduit on the PCM-2 side of the unit in the ceiling.

8 Install the HDLA17, Keylock furnished with the PCM-2 unit, into the Top Cover Panel as shown.

9 Refer to drawing 11534-D476, Overall Wiring Diagram, for electronics wiring direction.

10. If assembling PCM2 OPT5A, Exit Gate Only Configuration, disregard all references to Entry Gate components and assembly direction.

11. After assembly of the entire access control is complete and the unit has been installed onto the PCM-2 as directed, adjust the gate return spring action by tightening or by loosening the gate return damping adjustment knob on the rear of the Door Closer, as necessary, to allow the gate to return to a fully closed position from any open position with a smooth, slow motion and without slamming shut.

Figure 22-55. 11534-480, Access control, overall assembly, 2 of 3.

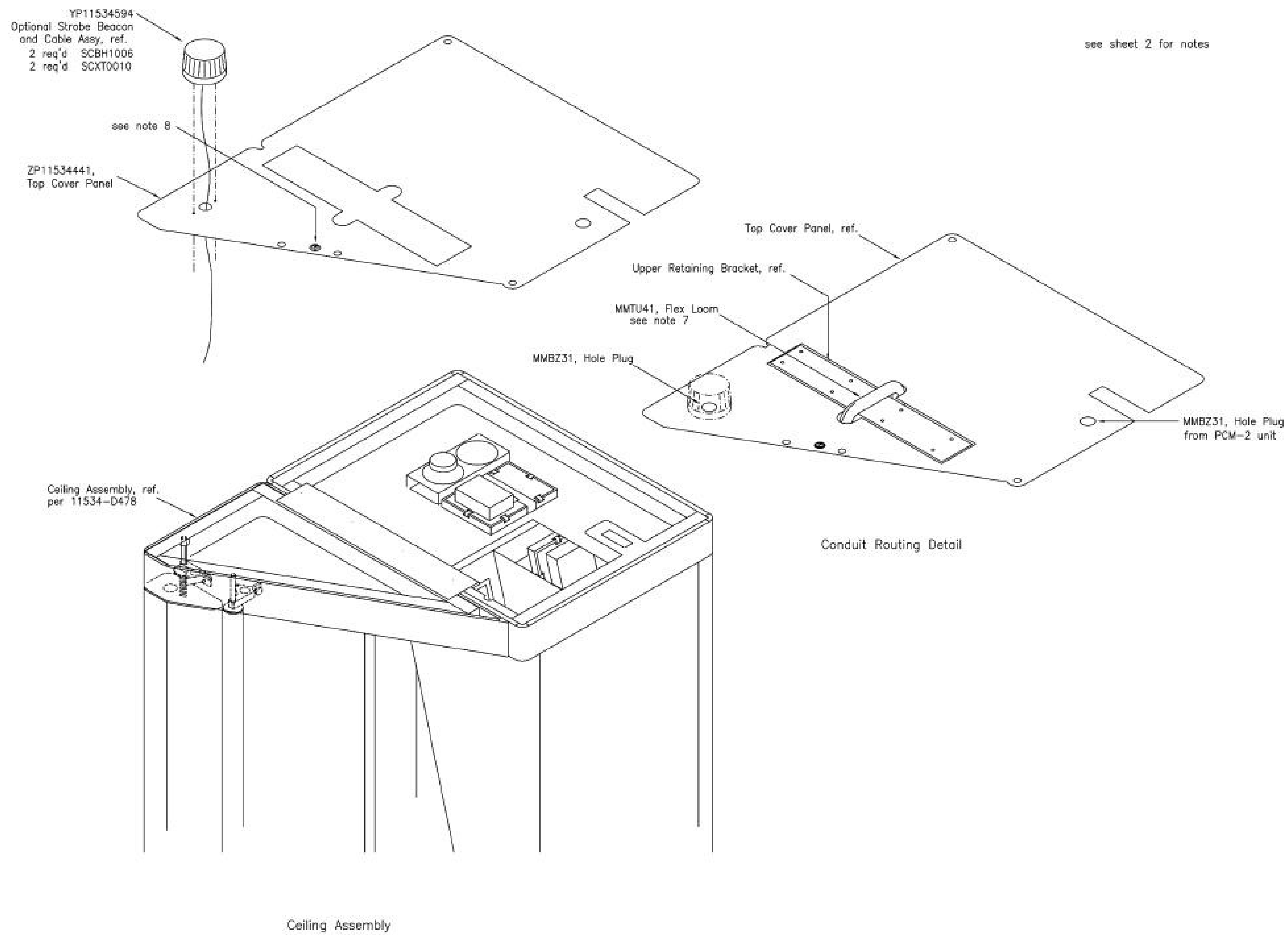


Figure 22-56. 11534-480, Access control, overall assembly, 3 of 3.

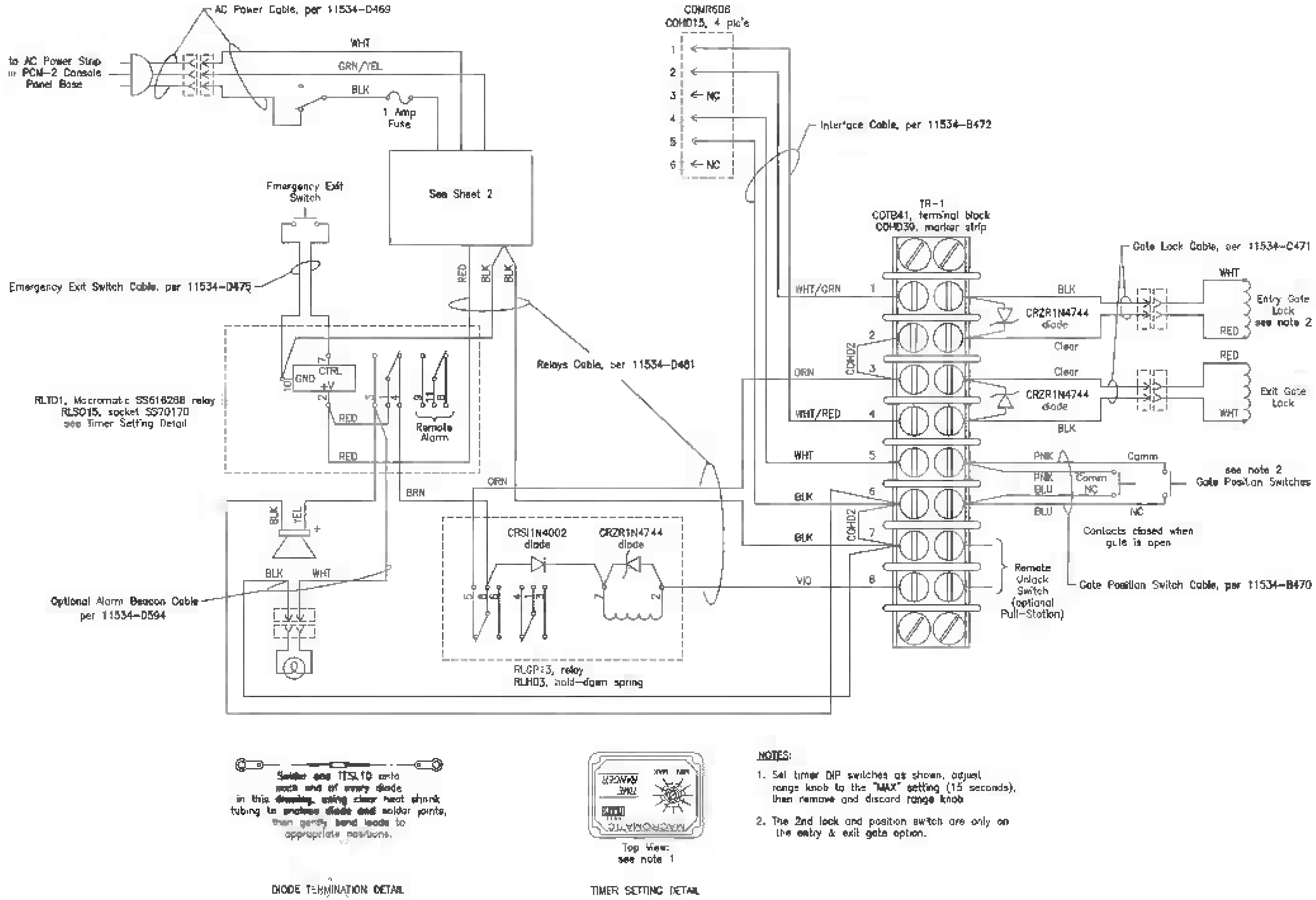
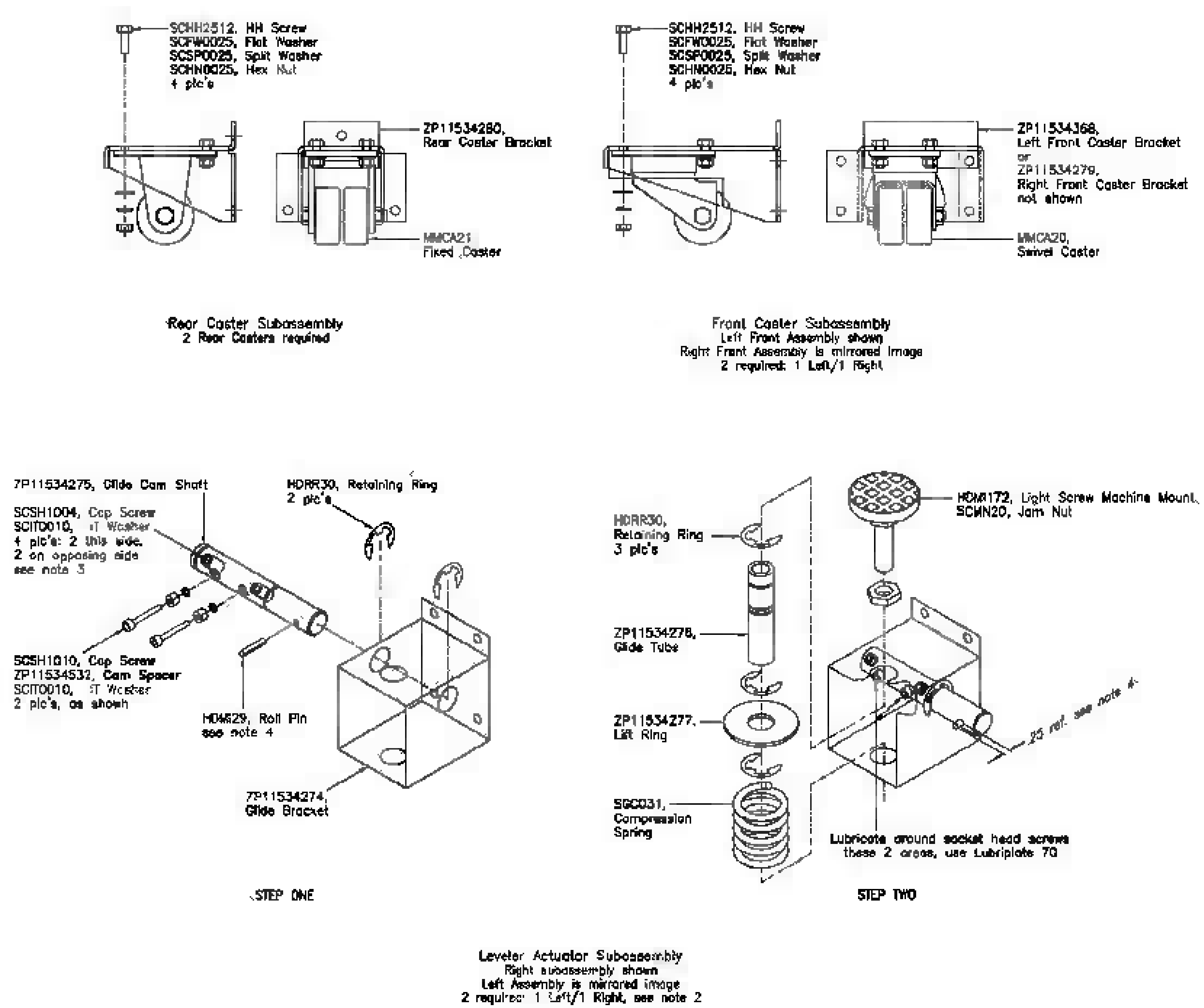


Figure 22-57. 11534-476, Access control, overall wiring.



NOTES:

1. Refer to BOM YP11534340.
2. Leveler Actuator Assemblies require right and left hand considerations. Right Assembly shown. The corresponding Left Hand Assy is mirrored image of that shown whereby the Roll Pin and extended Shaft end is located on the opposing side.
3. Install 2 Cap Screws, SCSH1004, into upper outboard threaded holes in Shaft, ZP11534275, and torque securely against spot face prior to installing and torquing opposing 2 Cap Screws. Install 2 Cap Screws, SCSH1010, in center inboard threaded holes and torque securely against spot face. Lubricate around central Screws, use Lubriplate 70.
4. Install Roll Pin, HDMI29, into shaft from side shown leaving .25" of pin length protruding as shown.

Figure 22-58. 11534-340, Swiveling casters assembly.

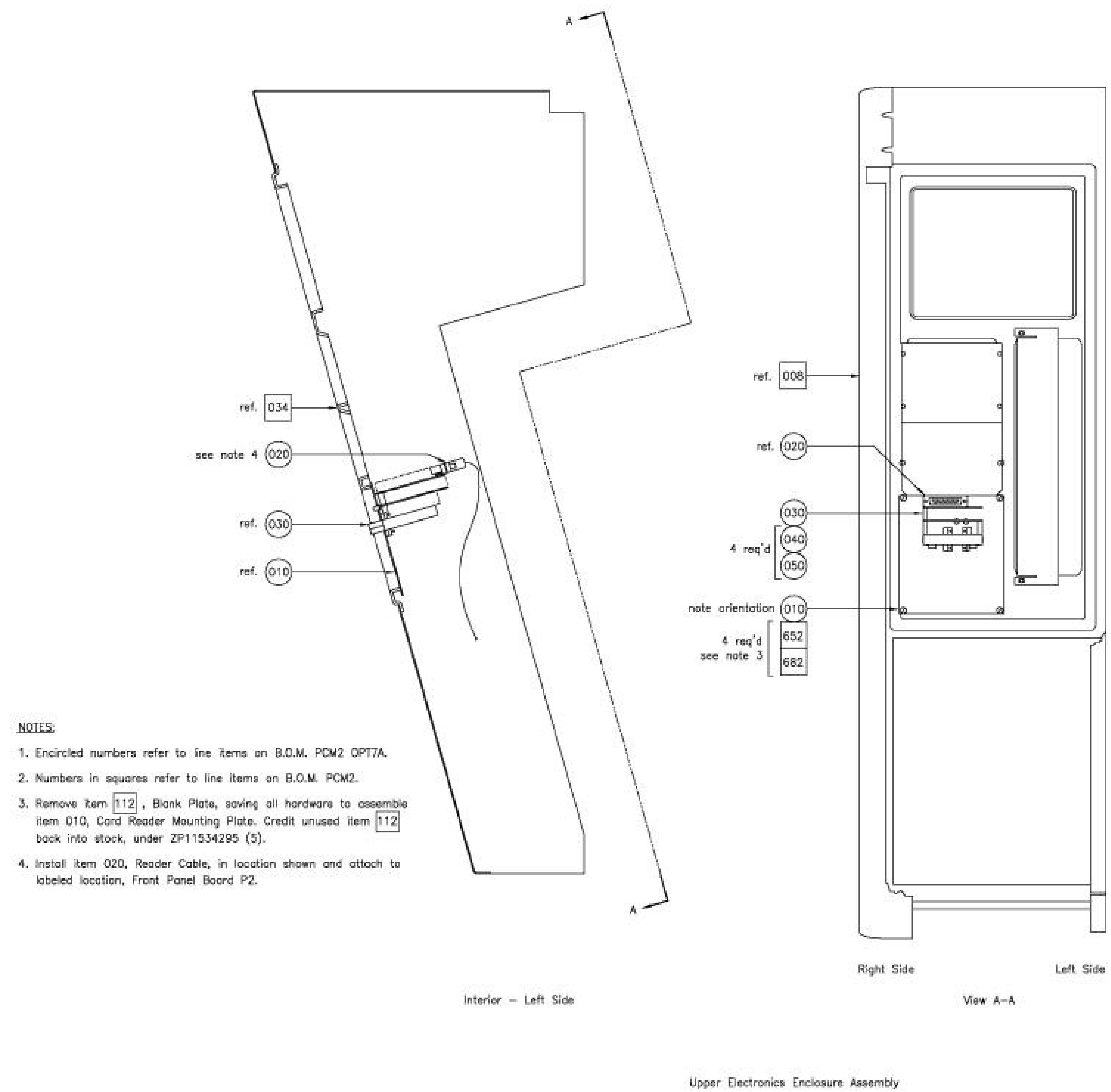


Figure 22-59. 11534-323, ICI insert card reader assembly.

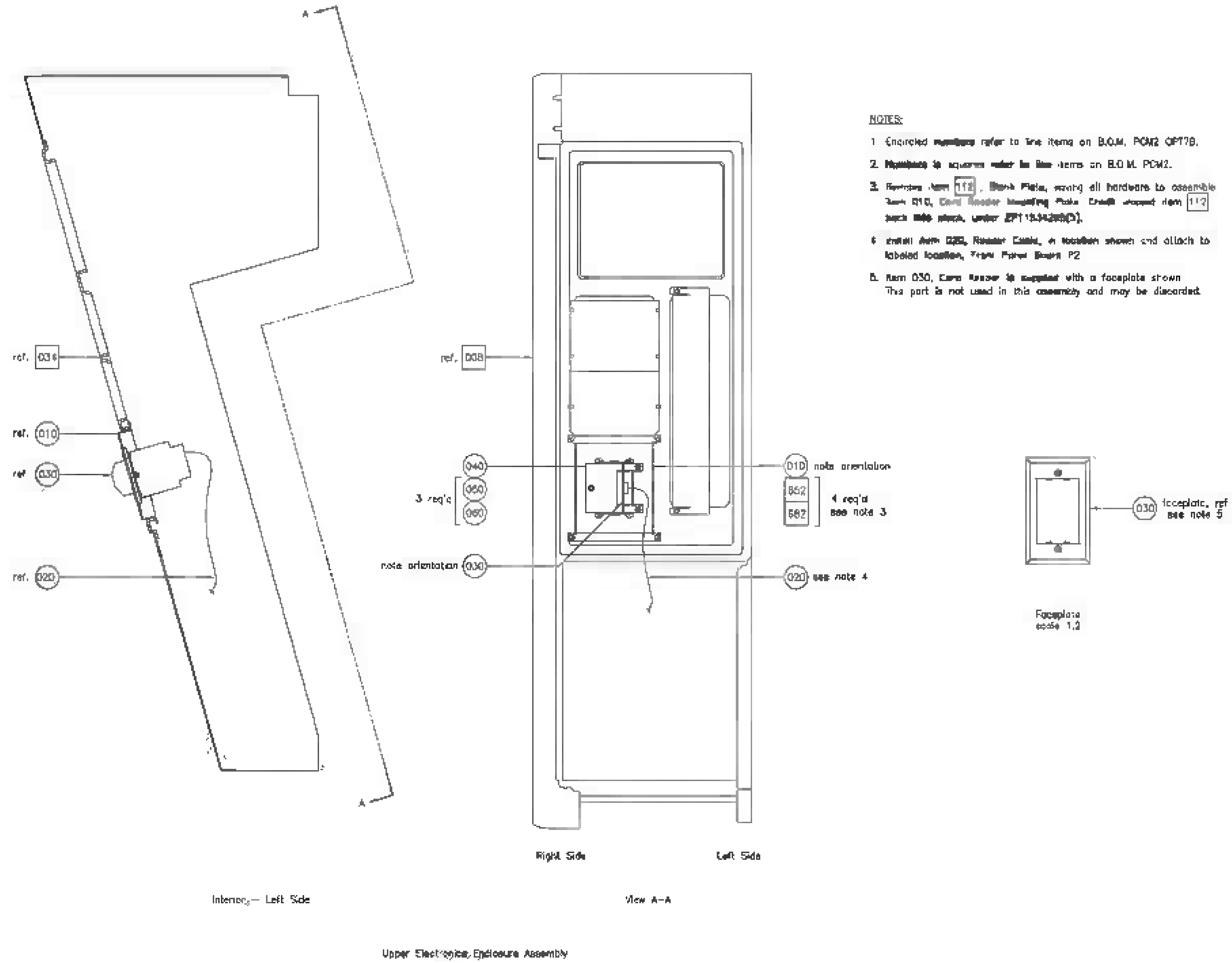
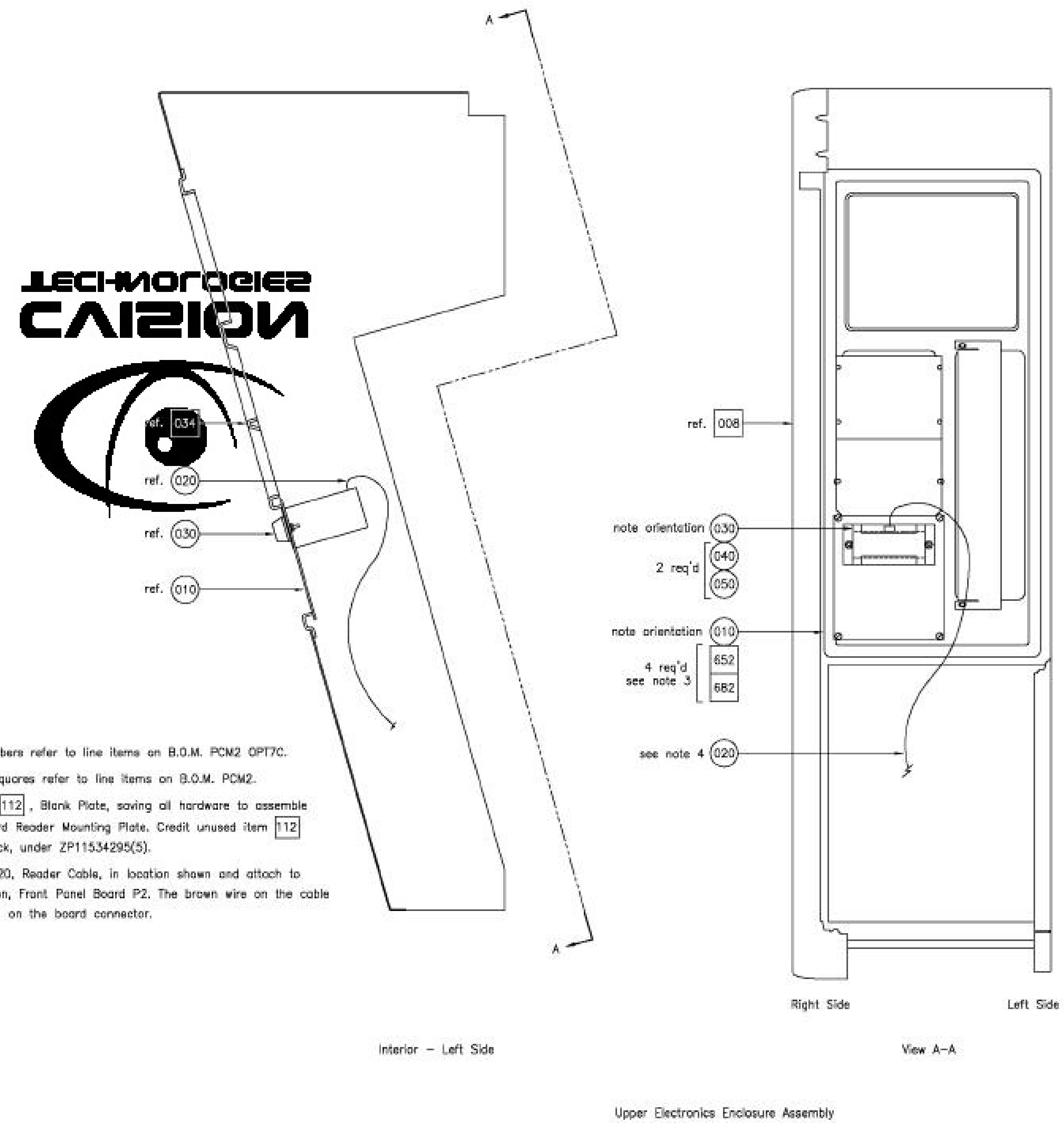


Figure 22-60. 11534-324, ICI swipe card reader assembly.



NOTES:

1. Encircled numbers refer to line items on B.O.M. PCM2 OPT7C.
2. Numbers in squares refer to line items on B.O.M. PCM2.
3. Remove item 112, Blank Plate, saving all hardware to assemble item 010, Card Reader Mounting Plate. Credit unused item 112 back into stock, under ZP11534295(5).
4. Install item 020, Reader Cable, in location shown and attach to labeled location, Front Panel Board P2. The brown wire on the cable goes to pin 1 on the board connector.

Figure 22-61. 11534-325, XICO insert card reader assembly.

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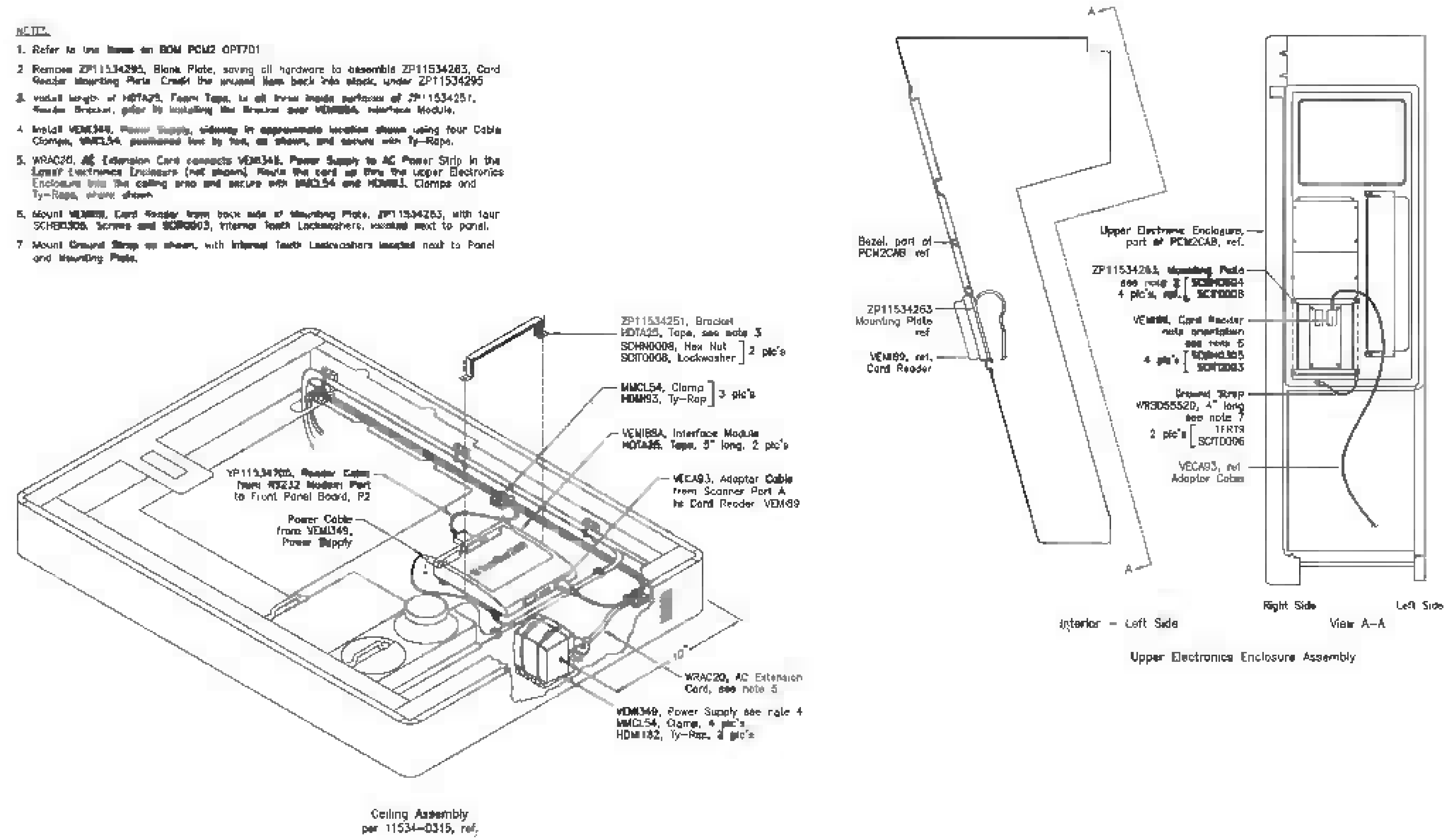


Figure 22-62. 11534-706, Computer Identics swipe card reader assembly.

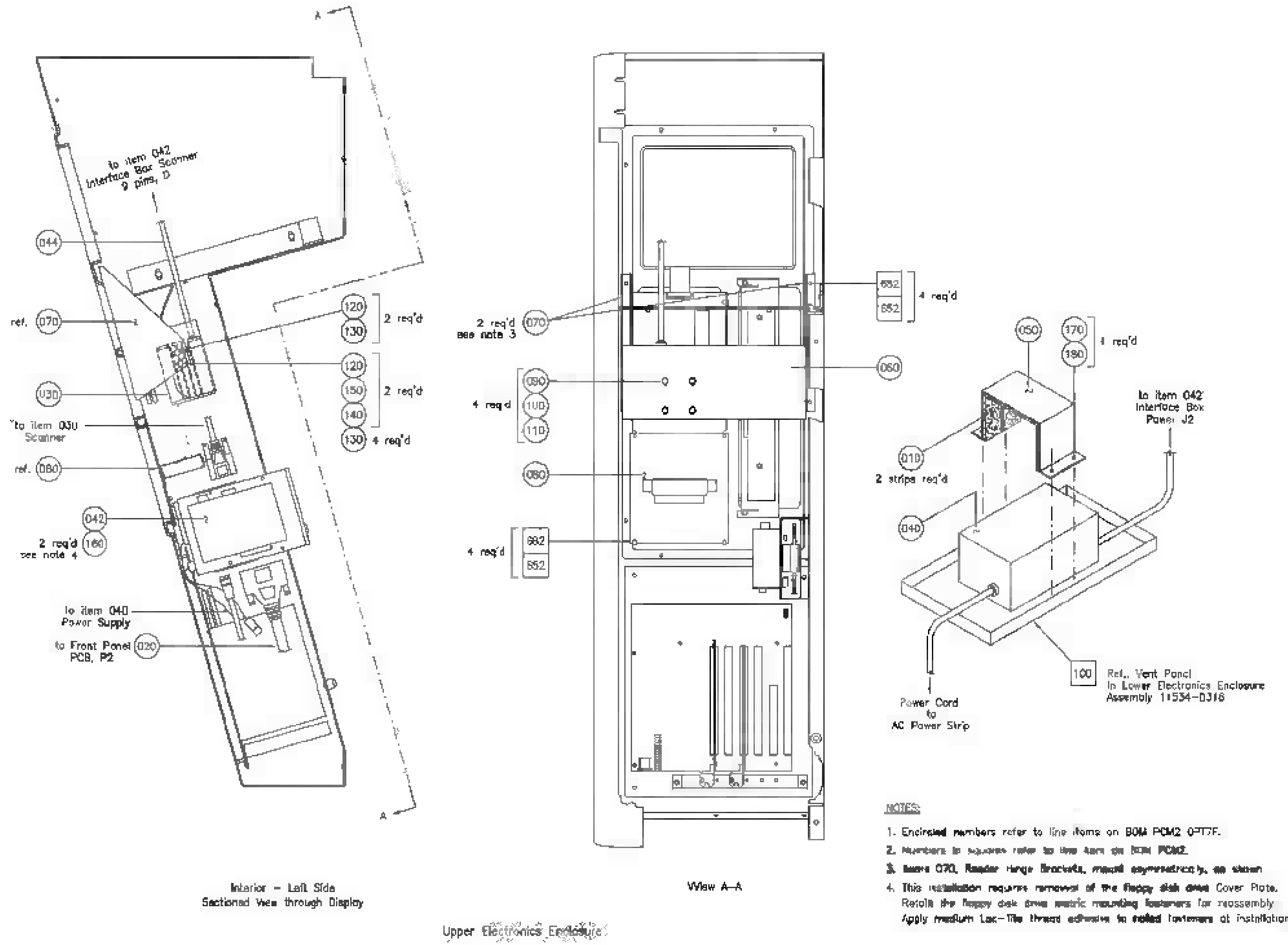


Figure 22-63. 11534-378, Intermec barcode reader assembly.

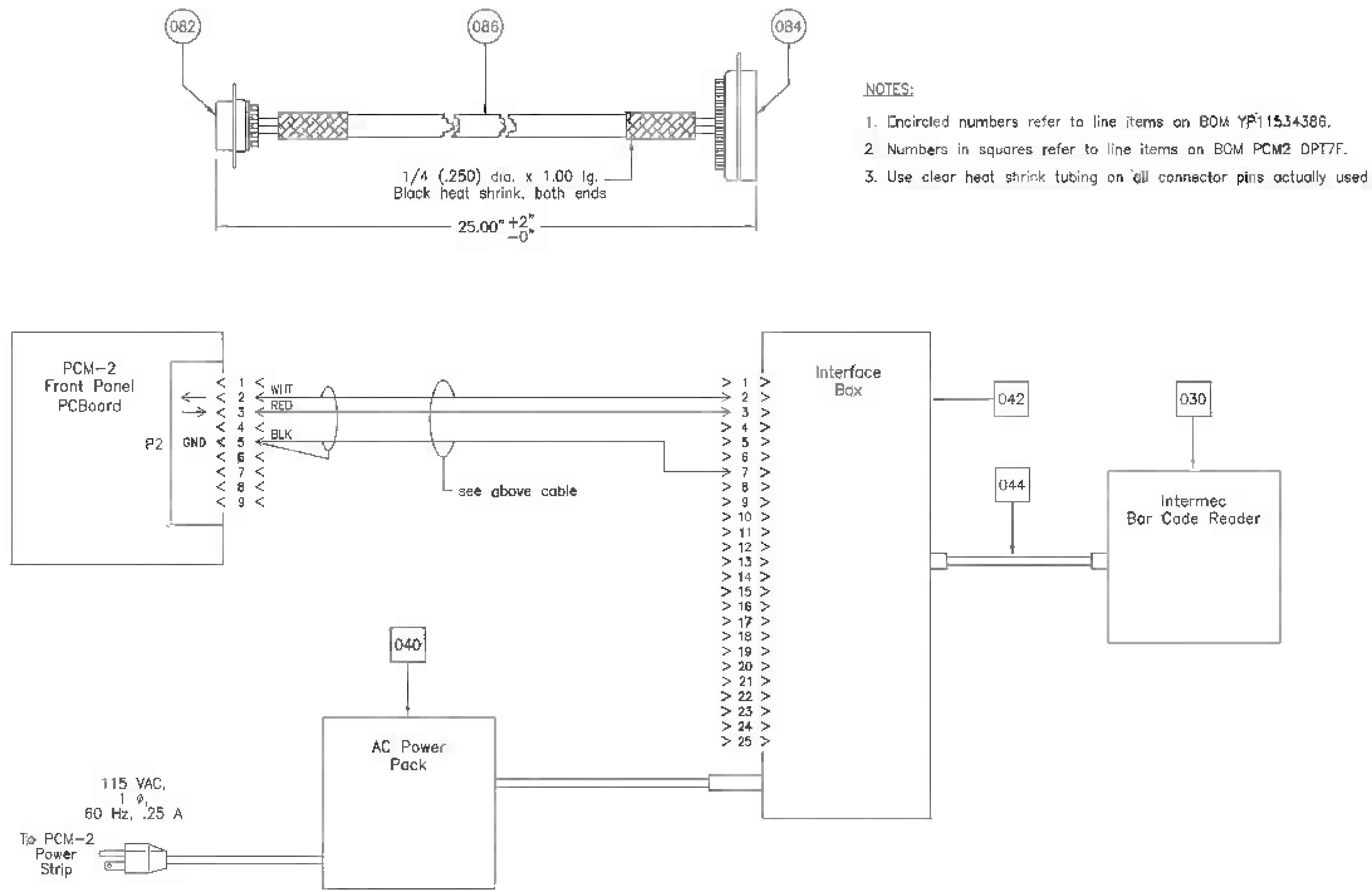


Figure 22-64. 11534-386, Intermec barcode reader wiring.

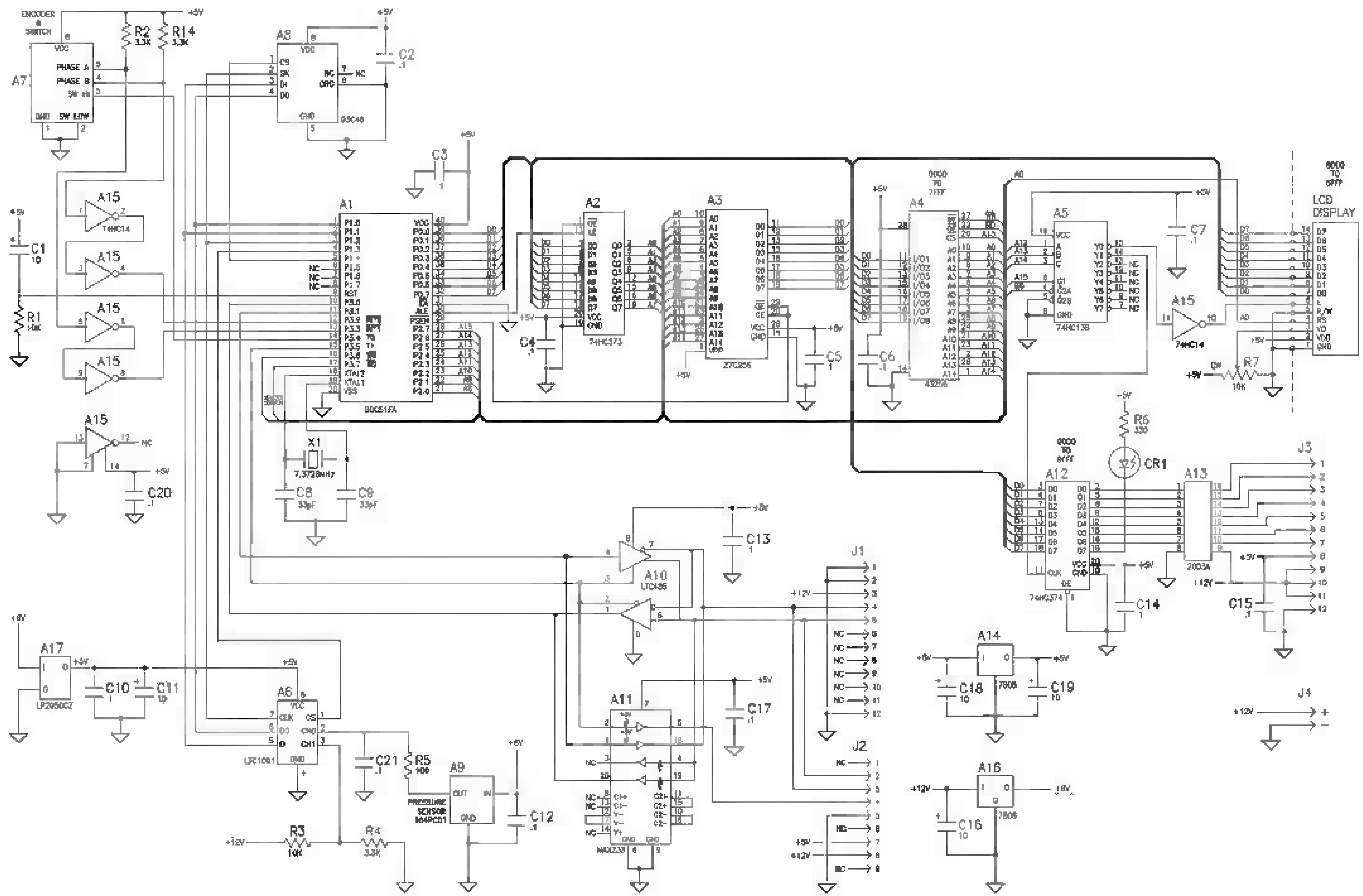


Figure 22-65. 11582-001, Gas manager board.

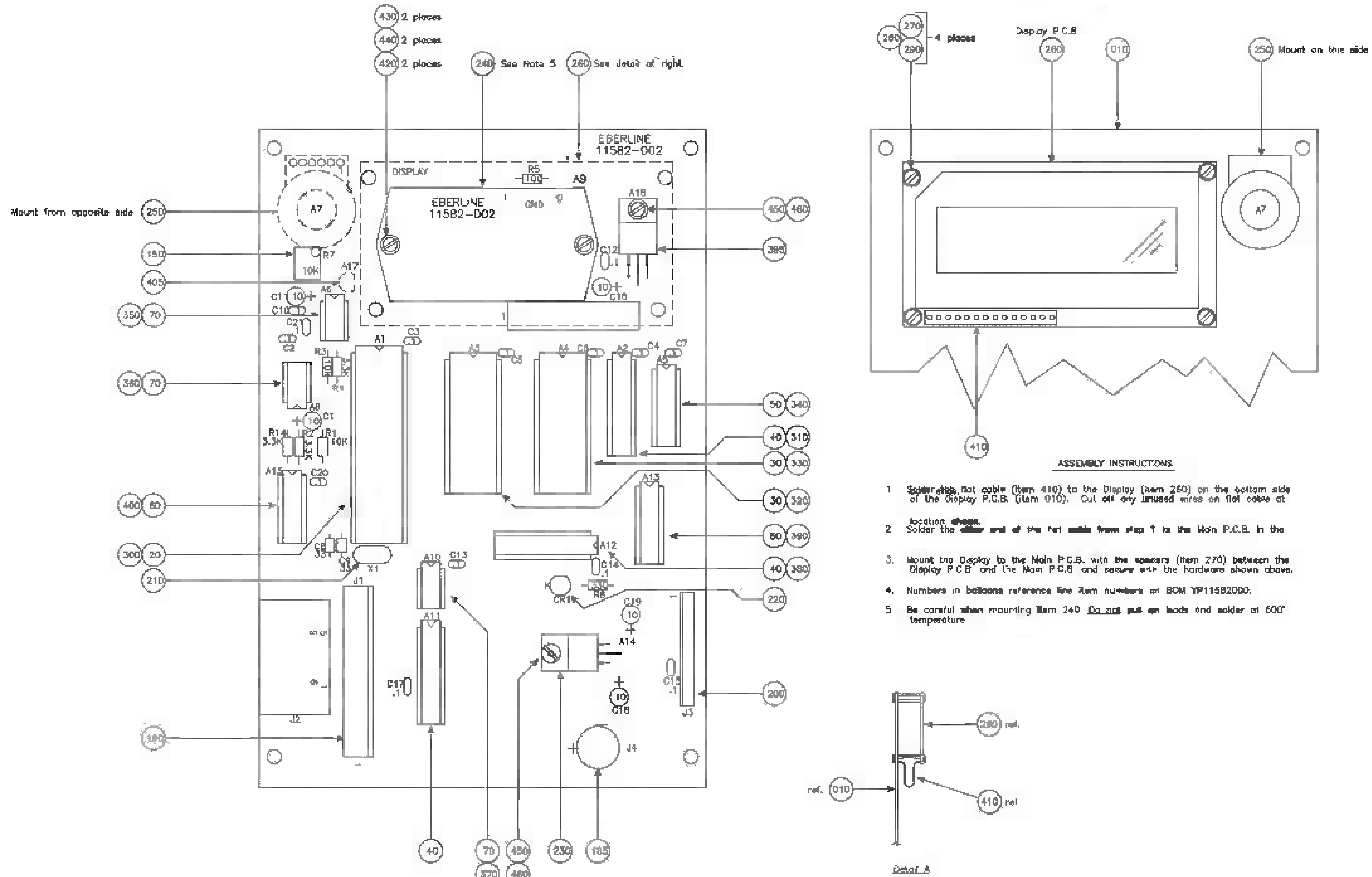
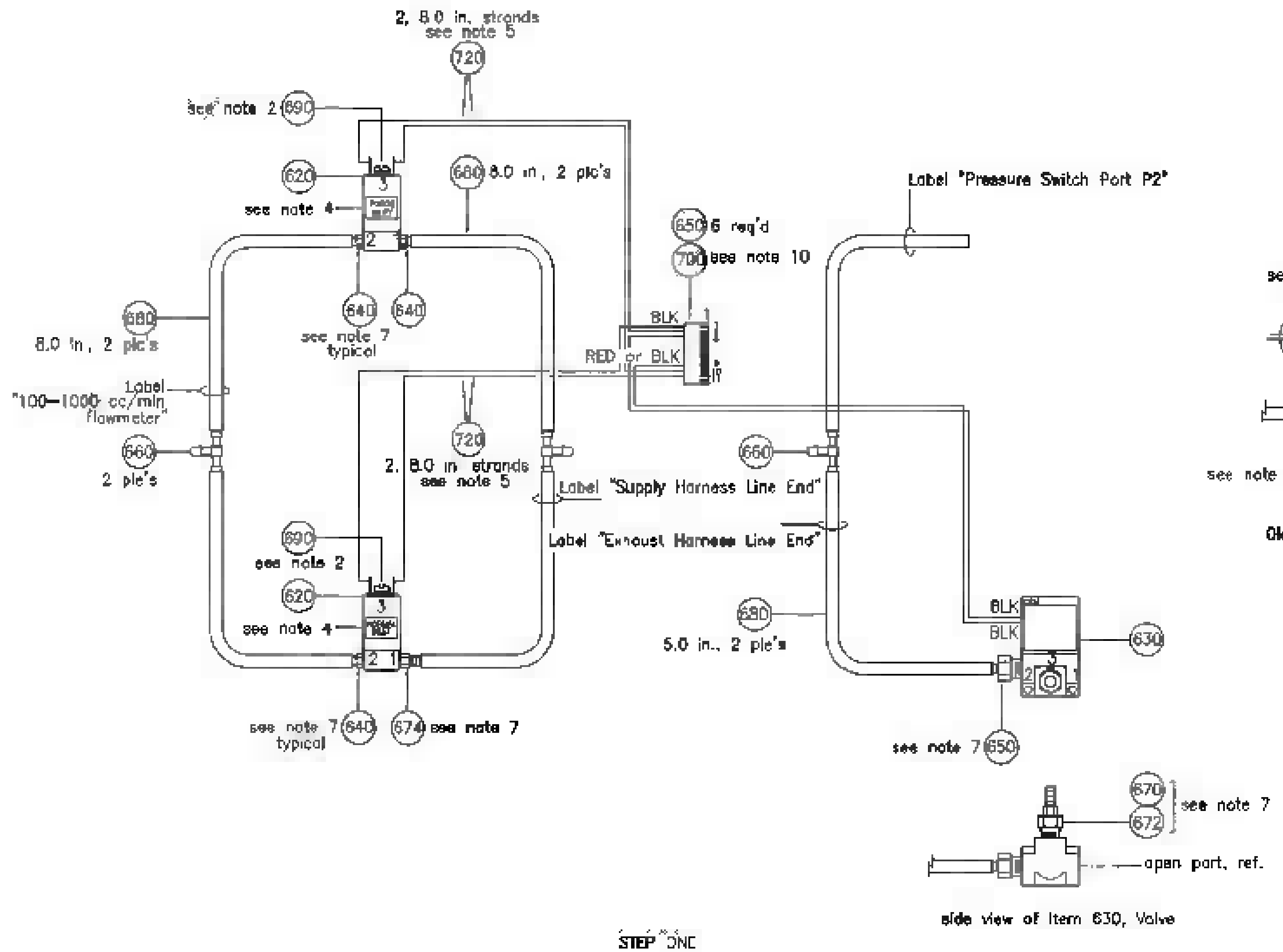
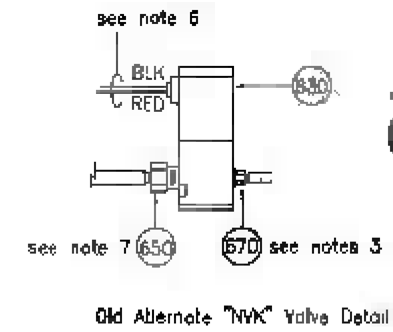


Figure 22-66. 11582-003, Gas manager board component.





NOTES.

1. Encircled numbers refer to line item numbers on B.O.M. PCM2 OPT12.
2. Install item 590, screws, into #3 port of item 620, solenoid valves, using medium Loc-Tite sealer.
3. Item 670, orifice, is to be installed in item 630, solenoid valve's "R" port.
4. Brady-label item 620, solenoid valves, with wording shown to identify valve's function.
5. Items 620, solenoid valves, have no polarity. Solder item 720, wire, to valve terminals as shown using heat shrink insulation at solder joints.
6. RED and BLK leads are part of item 630, old alternate solenoid valve. Observe Polarity!!
7. Use thin (.003 inx) Teflon pipe thread sealant tape at all referenced fitting interfaces.
8. Install completed assembly to Back Arm Panel beneath flowmeter bracket, using noted hardware (reference Main Frame Assembly 11534-0316)
9. Install noted hose at hose port "P2" of pressure switch on Gas Manager P.C. Board Assembly. Use heat or alcohol on tubing as necessary.
10. Install item 700, connector, to connector on item 520, P.C. board.

Figure 22-67. 11534-348, Gas Manager assembly, 1 of 2.

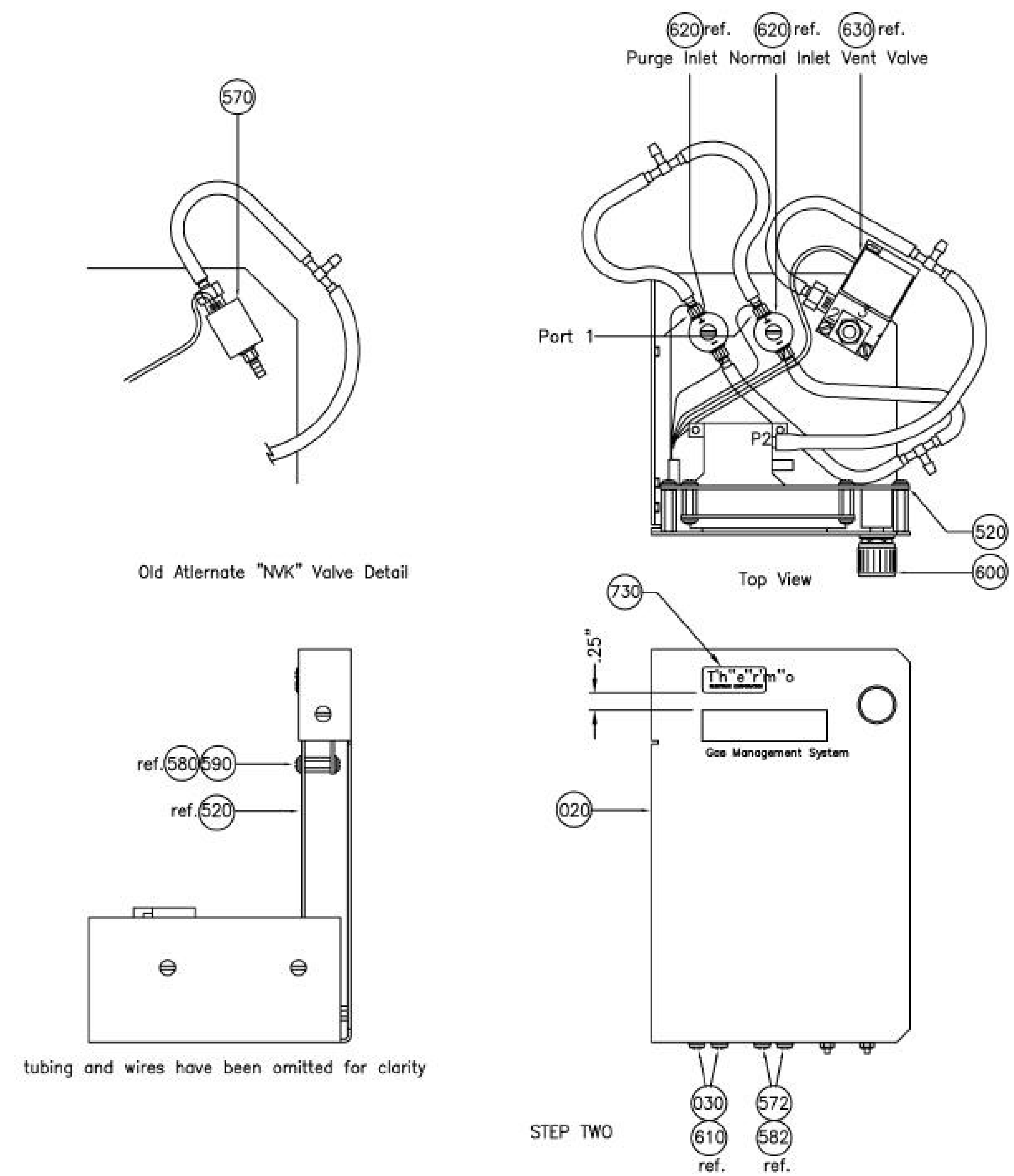


Figure 22-68. 11534-348, Gas Manager assembly, 2 of 2.

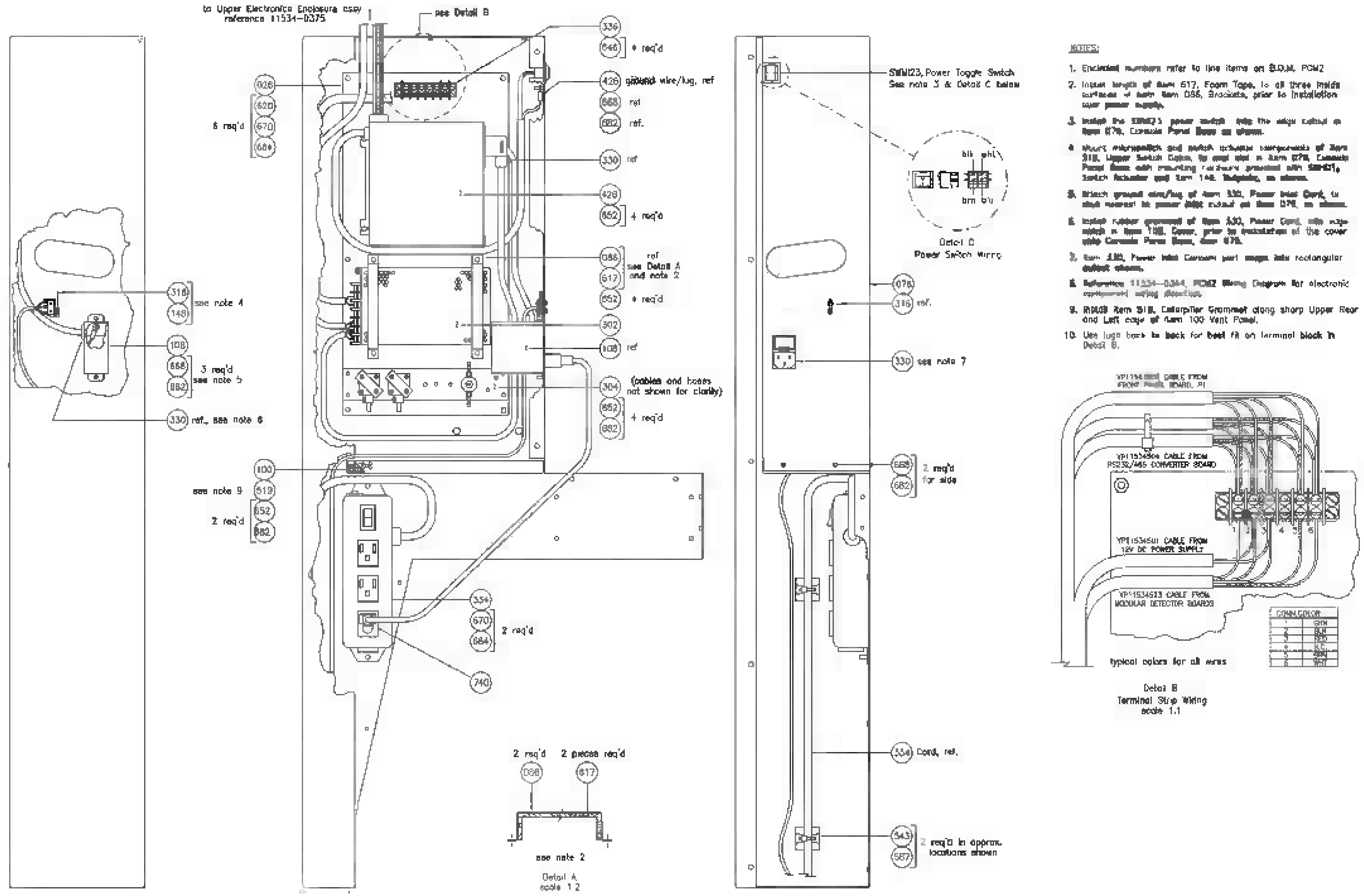


Figure 22-69. 11534-318, Lower electronics enclosure assembly.

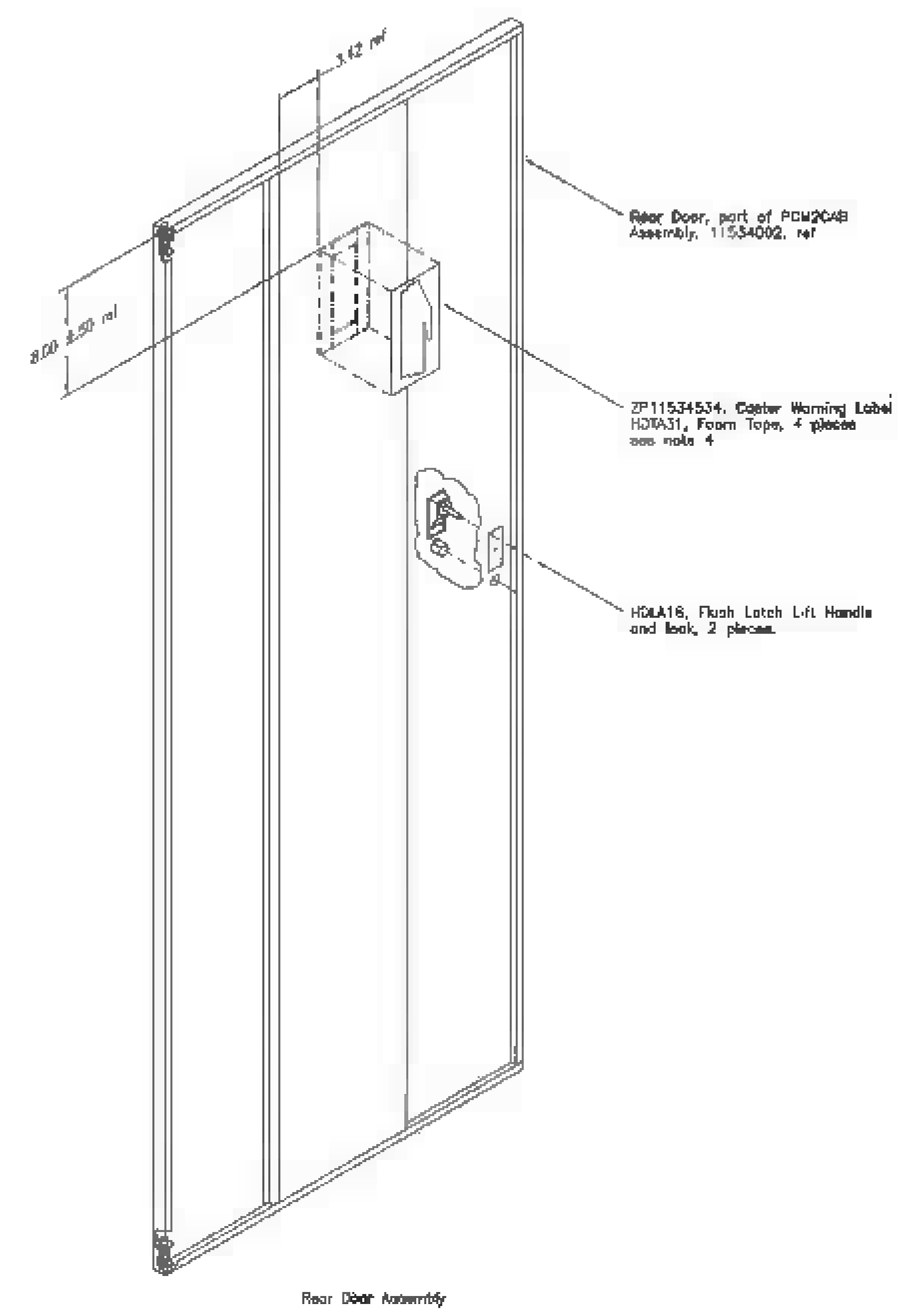


Figure 22-70. 11534-330, Rear and side door assembly, 1 of 2.

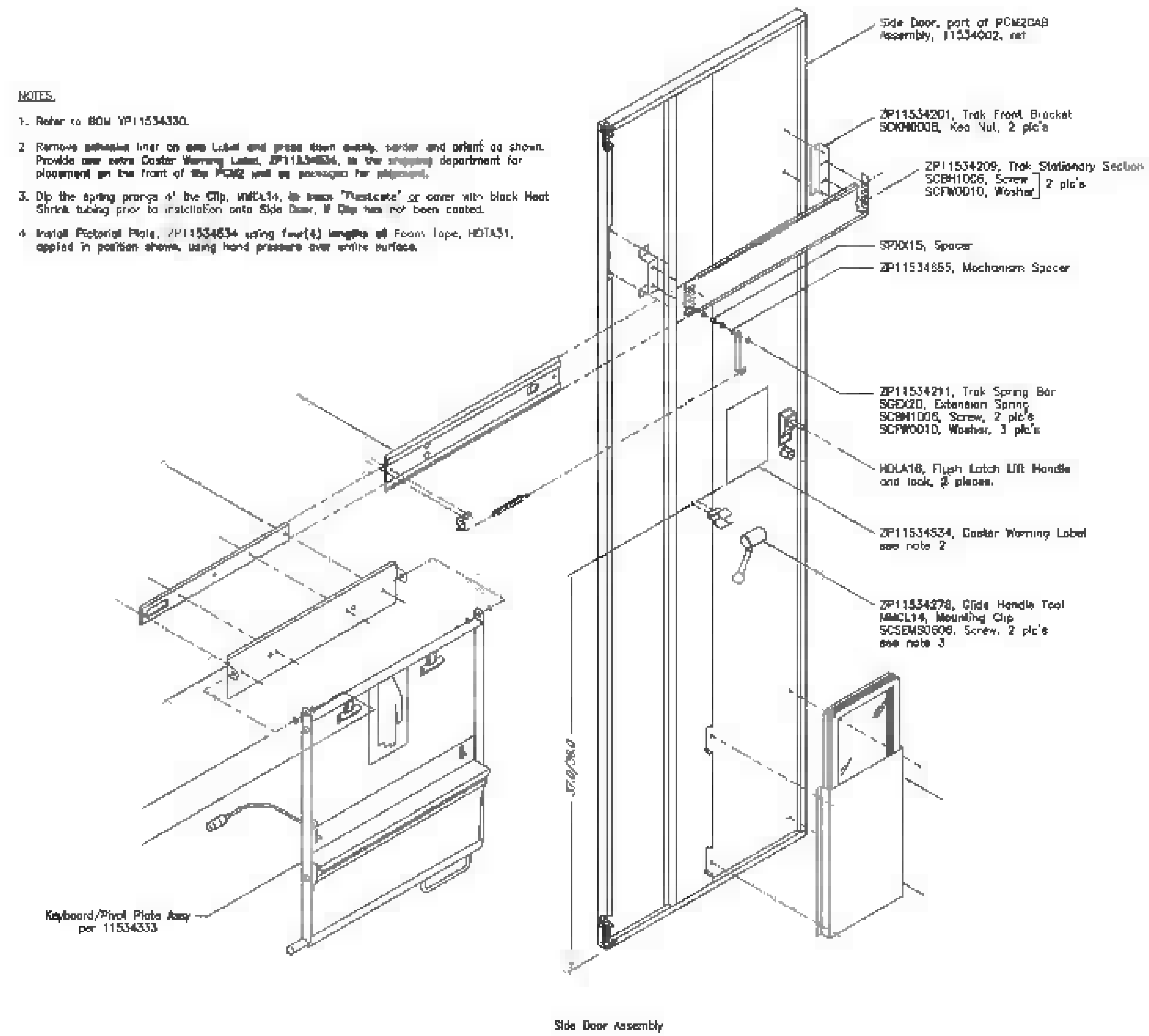


Figure 22-71. 11534-330, Rear and side door assembly, 2 of 2.

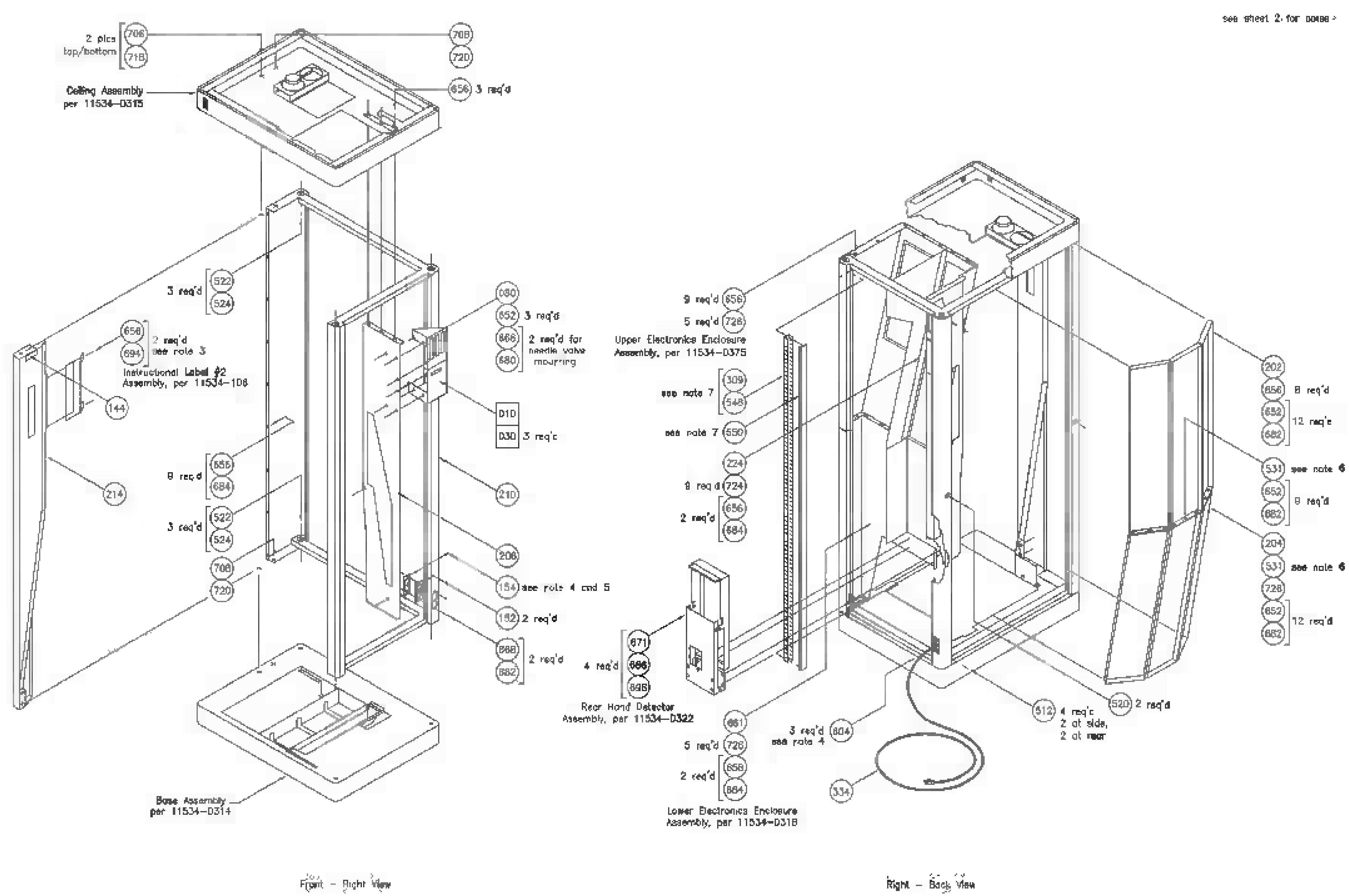


Figure 22-72. 11534-316, Main frame assembly, 1 of 2.

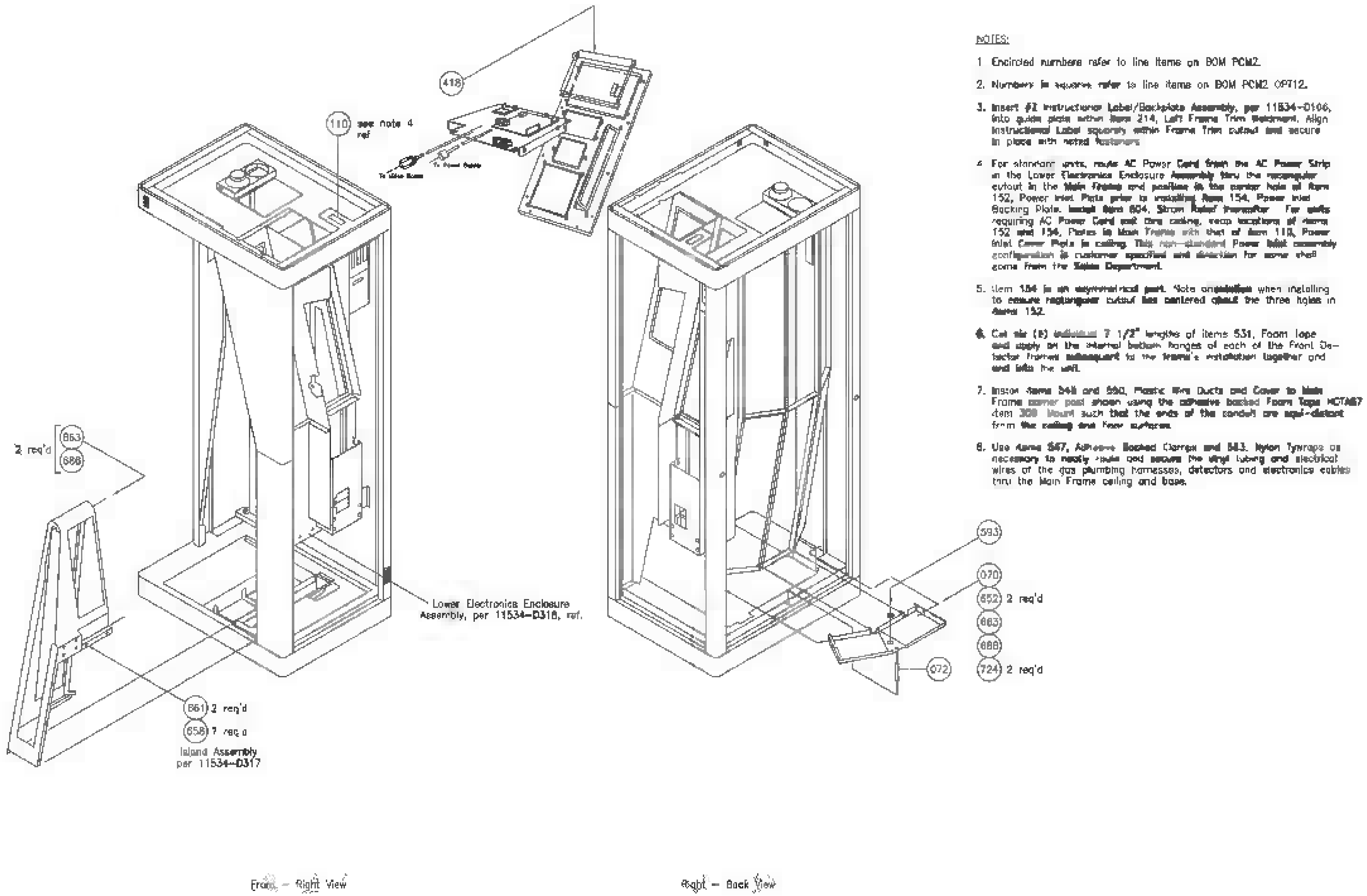


Figure 22-73. 11534-316, Main frame assembly, 2 of 2.

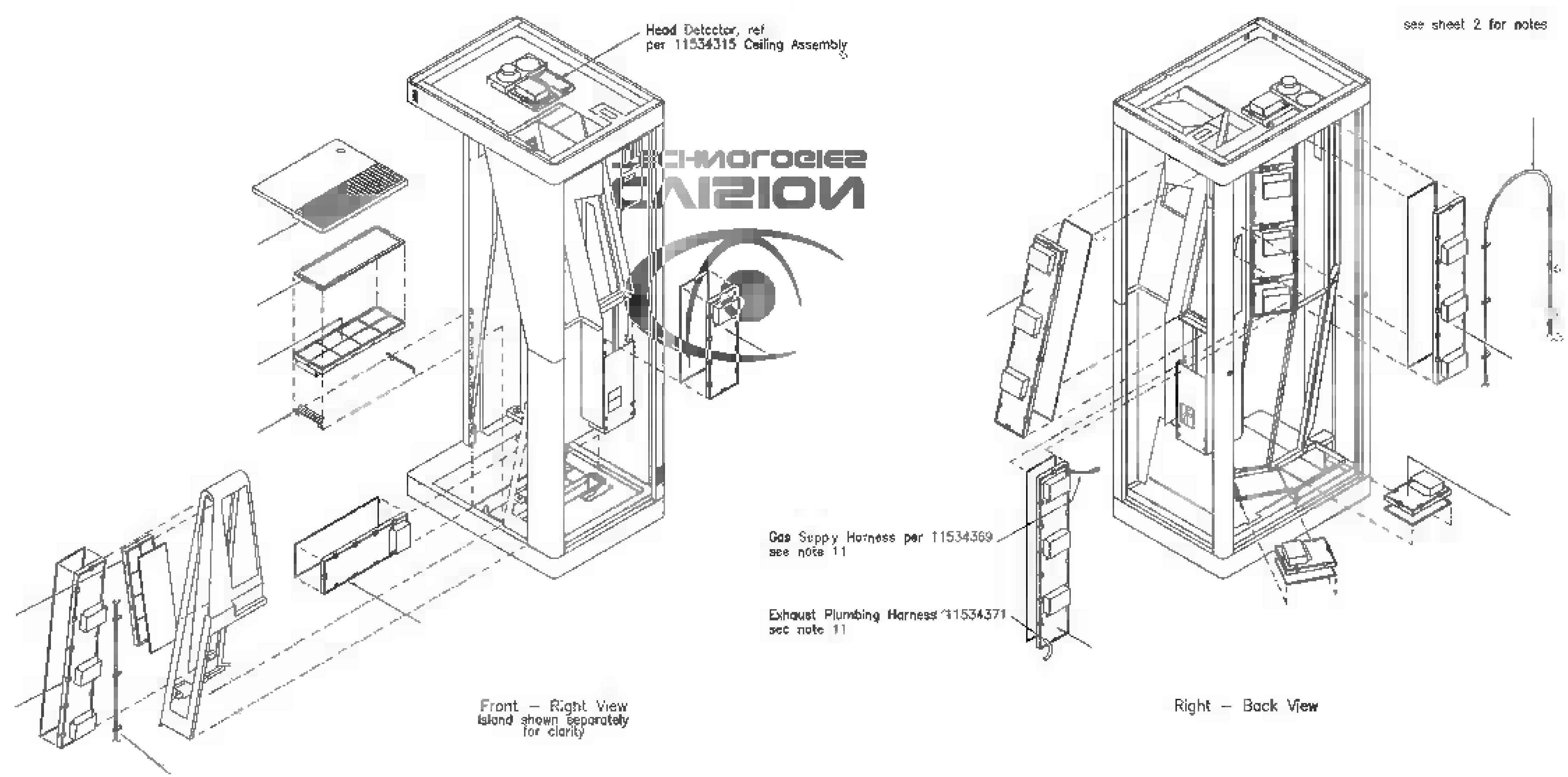
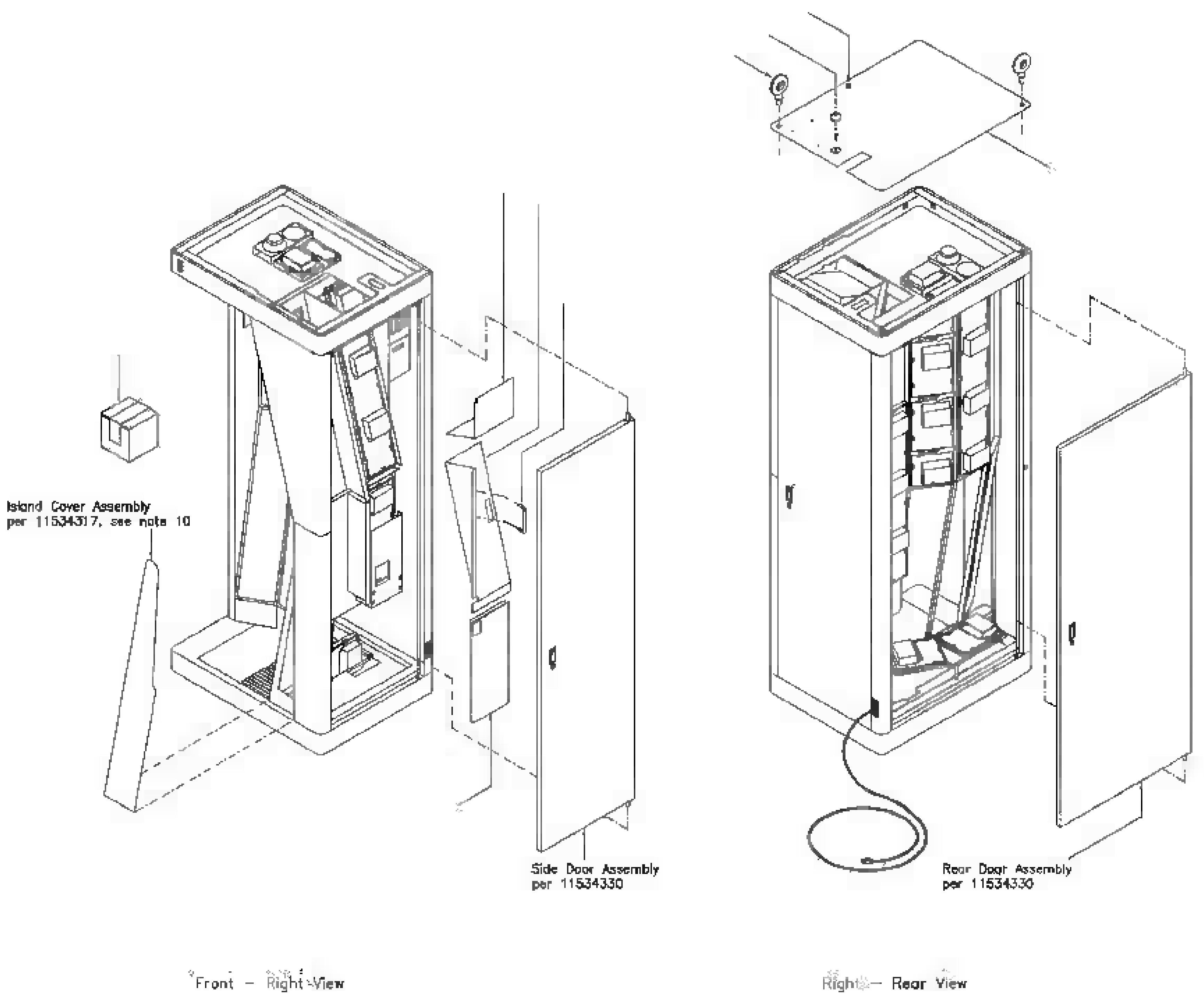


Figure 22-74. 11534-321, Detectors installation assembly, 1 of 2.



NOTES

1. Refer to BOM PCM2–BASIC.
3. Palm Detector and Grid slide into the Island Assembly as shown. Remove uppermost (end) clip from Palm Detector prior to installing into Island Panel.
4. Thigh and Shoulder Detectors are retained by two Cinch Straps (Item 534) at center and bottom strap cutout features only. Rear Arm Detector is retained by two Cinch Straps at center and top strap cutout features only.
5. Install Foot Detector Adjustment Brackets (Item 246) into Base Weldment detector pan in the center (midpoint adjustment) keyhole slot set prior to placing the detector. NOTE Avoid pinching foot detector gas supply and/or exhaust hoses.
6. Note orientation of all detectors with respect to their respective Modular Detector Board (Item 430) placements shown.
7. Detector Cables (Items 326 and 328) install onto their respective Modular Detector Boards as marked on each cable connector as keyed to the Detector Layout Plates (Item 129) located on the inside of the Rear Door Assembly. Detector cables are routed in series, from detector to detector, as defined by their number connector designators.
8. Install Electronics Enclosure Covers (Items 120, 118, and 098) from top to bottom using the captive hardware provided with the Main Frame Weldment and in the Electronics Enclosure Covers themselves.
9. Install Hose Barb Fitting (Item 572) into the exhaust (open) port of the Gas Regulator (Item 594) using Teflon pipe thread tape, then place the Regulator back into its box for separate shipment with the PCM–2.
10. Install the Island Cover Assembly onto the Island Assembly subsequent to installation of the Island's detectors, detector cables, and gas plumbing harnesses. The Cover installs by guiding its lower edge through the slot in the Base, then pushing downward and leaning the Cover in until it is flush against the Island's Front Backing Plate. Push the Cover up into place, engaging all retaining tabs in Island Backing Plate, then install the Retaining Pin, located on the Cable Lanyard, through the hole in the Backplate and Cover in order to lock the Cover in place. This final step is done from the inside of the Island Assembly, through the Side Door opening.
11. Install Gas Supply and Exhaust Plumbing Harnesses to detectors as directed per Plumbing Diagram 11534–D308. Route the gas hoses through the Base, Main Frame and Ceiling assemblies, and from detector to detector using Clamps and Ty–raps (Items 543 and 567) as necessary.
12. Apply Dust Shield (Item 431) around every "banana" plug on all detectors

Figure 22-75. 11534-321, Detectors installation assembly, 2 of 2.

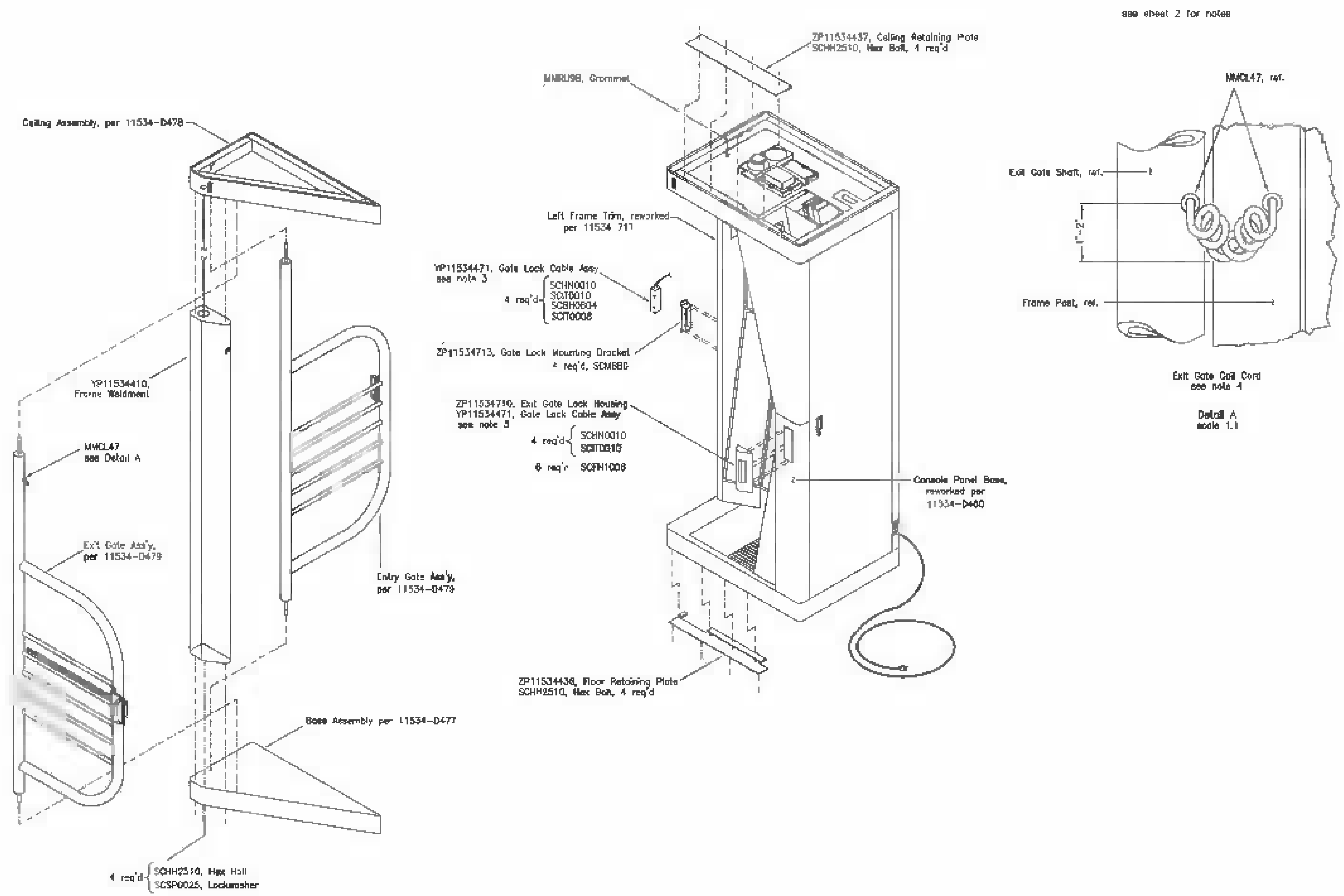


Figure 22-76. 11534-480, Overall assembly access control, 1 of 3.

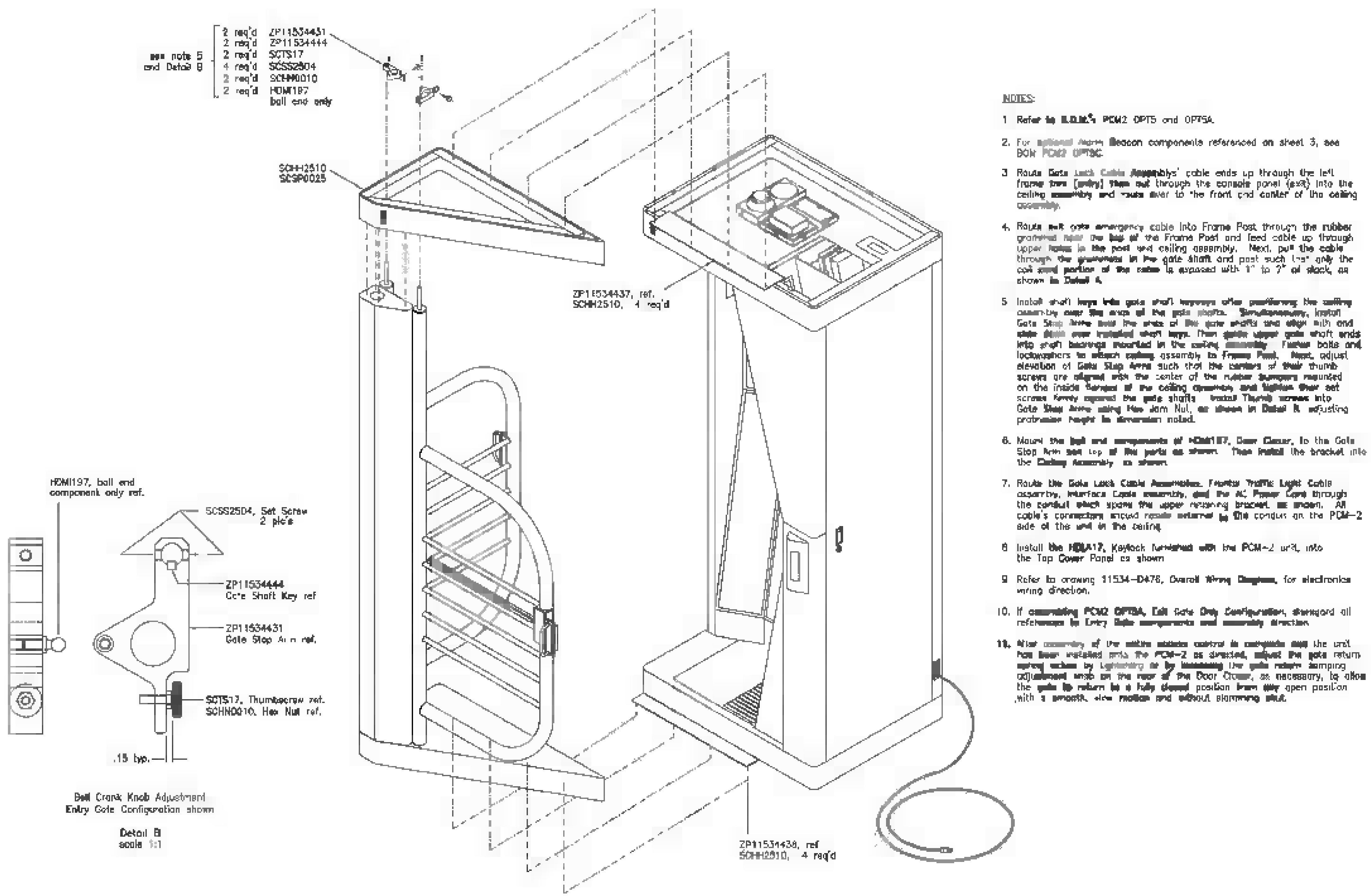


Figure 22-77. 11534-480, Overall assembly access control, 2 of 3.

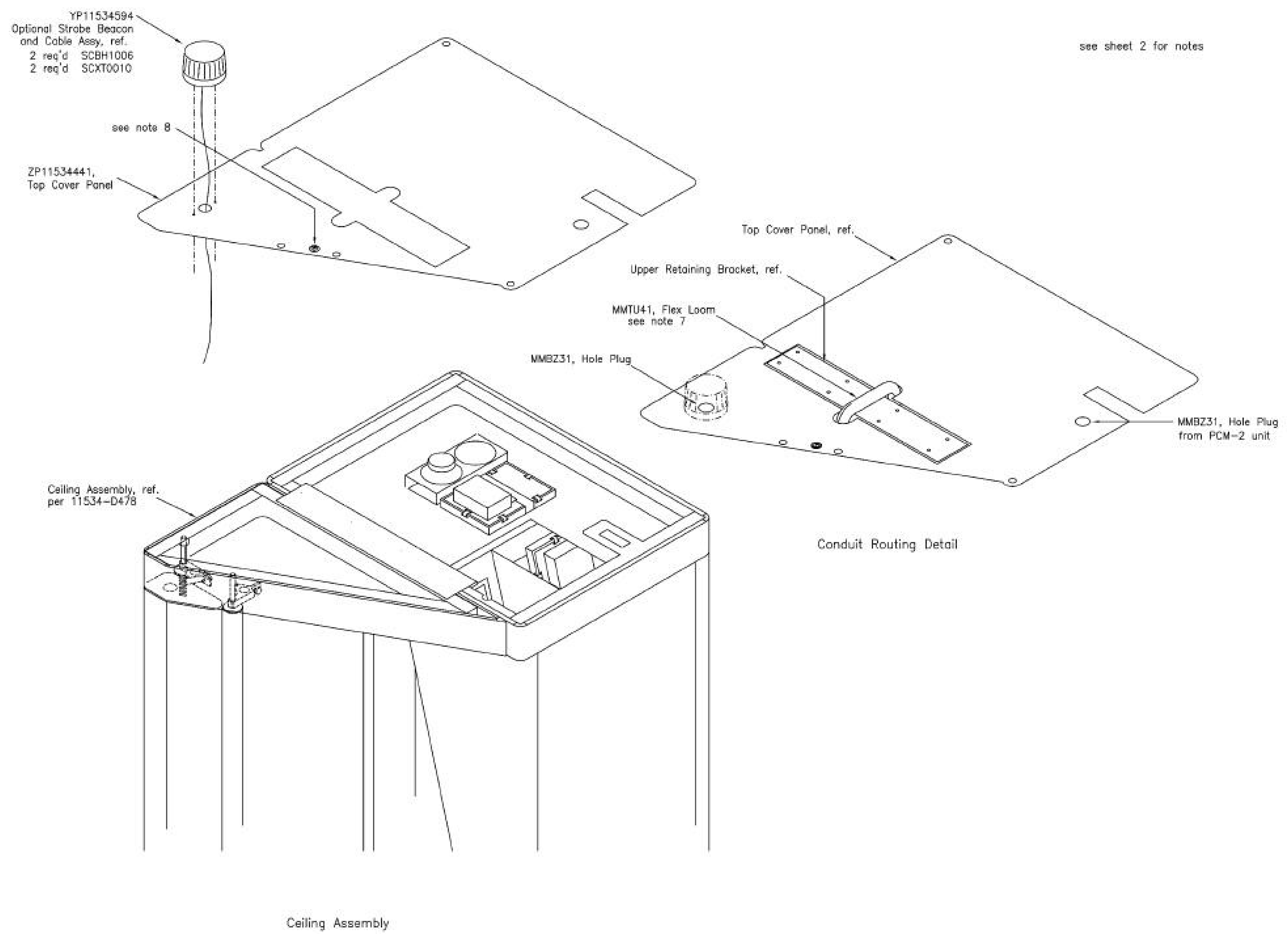


Figure 22-78. 11534-480, Overall assembly access control, 3 of 3.

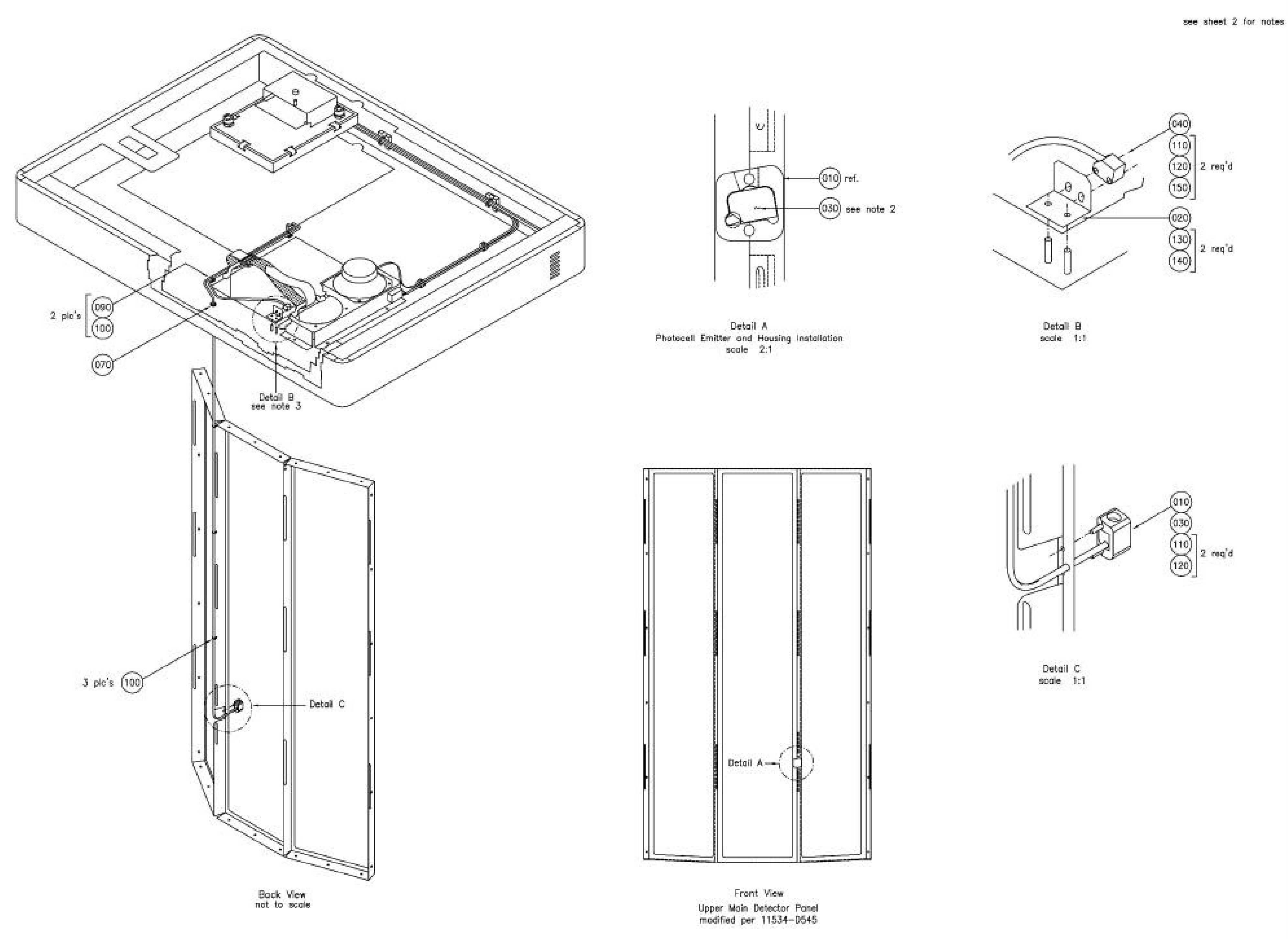
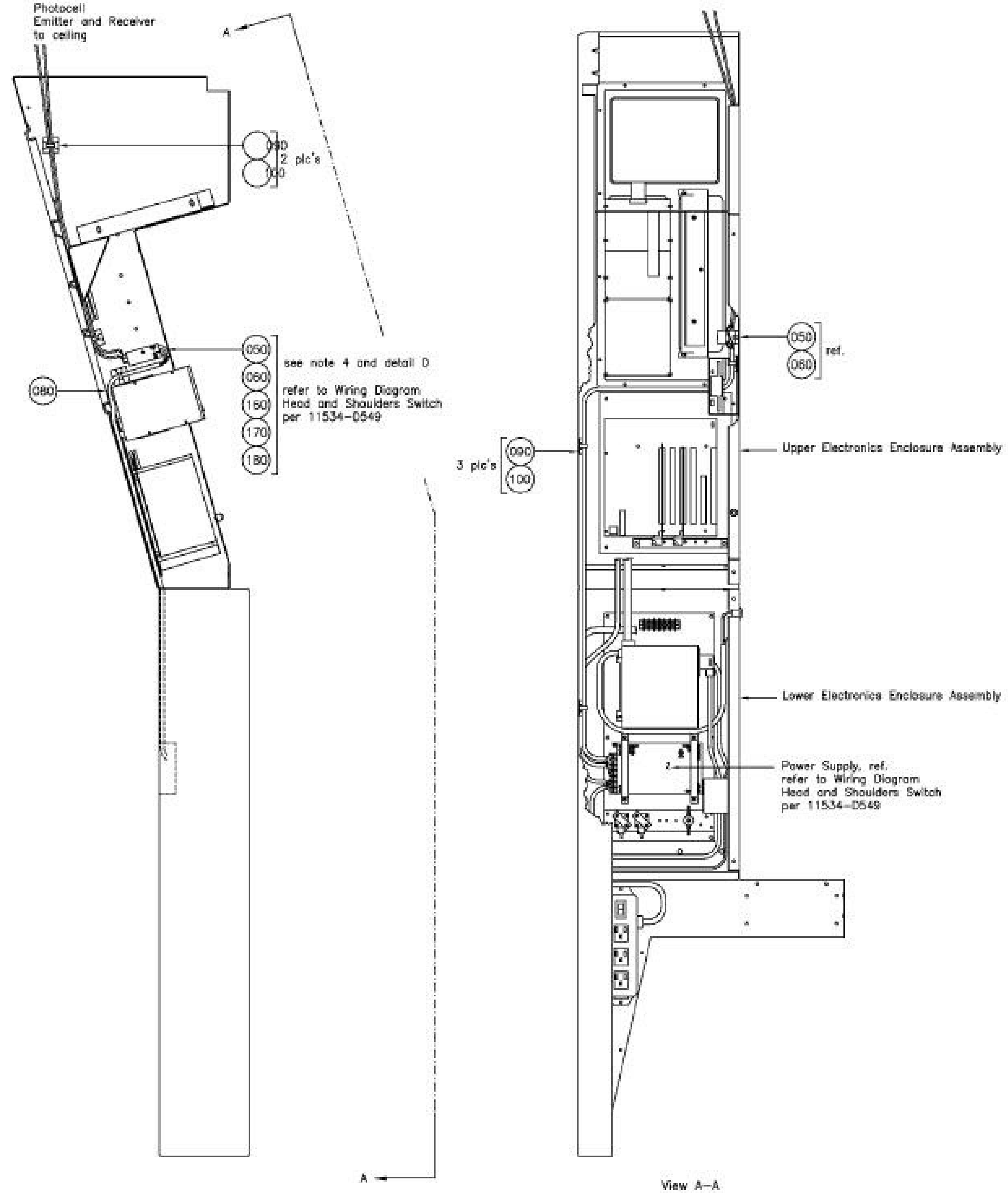
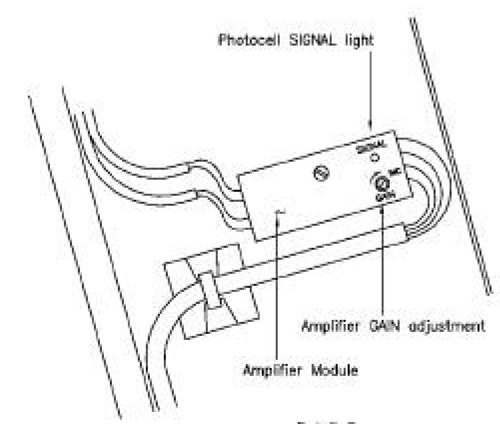


Figure 22-79. 11534-548, Head & shoulders switch assembly, 1 of 2.



NOTES:

1. Encircled numbers refer to line item on BOM PCM2 OPT17.
2. Install item 030, Photocell Emmiter into item 010, Housing as shown, carefully bending electrical cable into recess provided. Route the Cable thru the clearance hole in the reworked Front Panel and then secure Housing in place using two (2) each of item 110 and 120, Hex nuts and Lockwashers.
3. Attach item 020, Photocell Receiver Bracket, into Ceiling Assy at the two (2) press studs provided adjacent to the speaker bracket, using the hardware specified but DO NOT YET TIGHTEN. Attach item 040, Photocell Receiver to mounting bracket using mounting hardware specified but DO NOT YET TIGHTEN. Tighten bracket and photocell mounting hardware following photocell alignment and adjustment procedures per note 5.
4. Item 060, Amplifier Socket consists of two components; first, install plastic Socket Holder onto Upper Electronics Enclosure Panel as shown, then slide the Socket component into holder.
5. After mechanical assembly and electrical wiring of the entire option are completed, the Photocell Emitter and Receiver pair must be properly aligned.
   With electrical power applied to the Photocells, align Receiver in the ceiling so that the photocell Signal light on the Amplifier Module is illuminated. Continue to discretly adjust the angle and elevation of the Receiver until the Signal light's modulated pulse is minimized (most constant illumination possible) then tighten the mounting hardware at the Photocell receiver bracket. Ensure that the Signal light switches ON and OFF reliably when an object is placed between the Emitter and Receiver and then adjust Amplifier Module Gain screw clockwise to its maximum setting.



Detail D
Photocell Adjustments, see note 5
scale 1:1

Figure 22-80. 11534-548, Head & shoulders switch assembly, 2 of 2.

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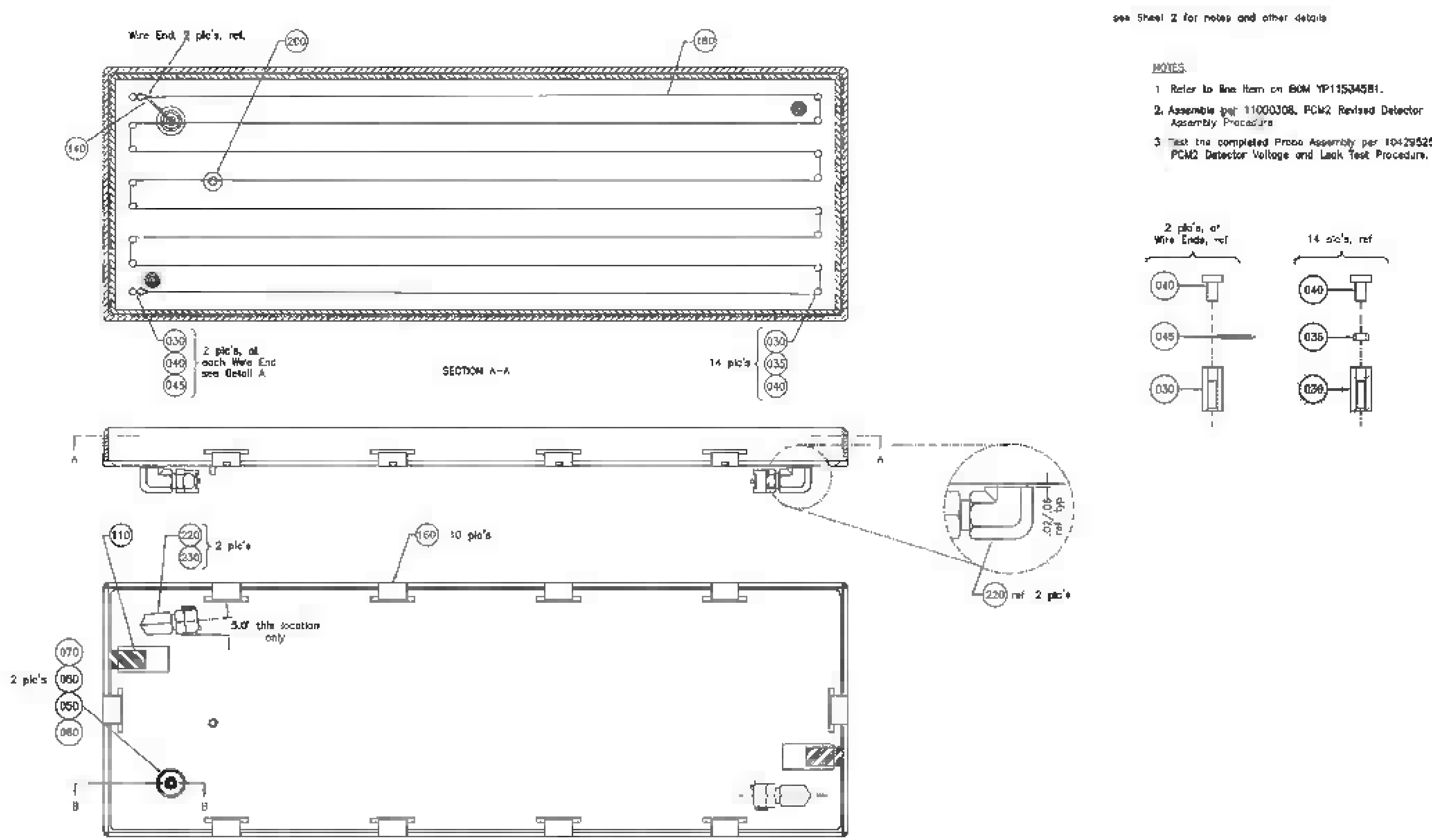

Figure 22-81. 11534-561, Revised detector assembly, medium, 1 of 2.

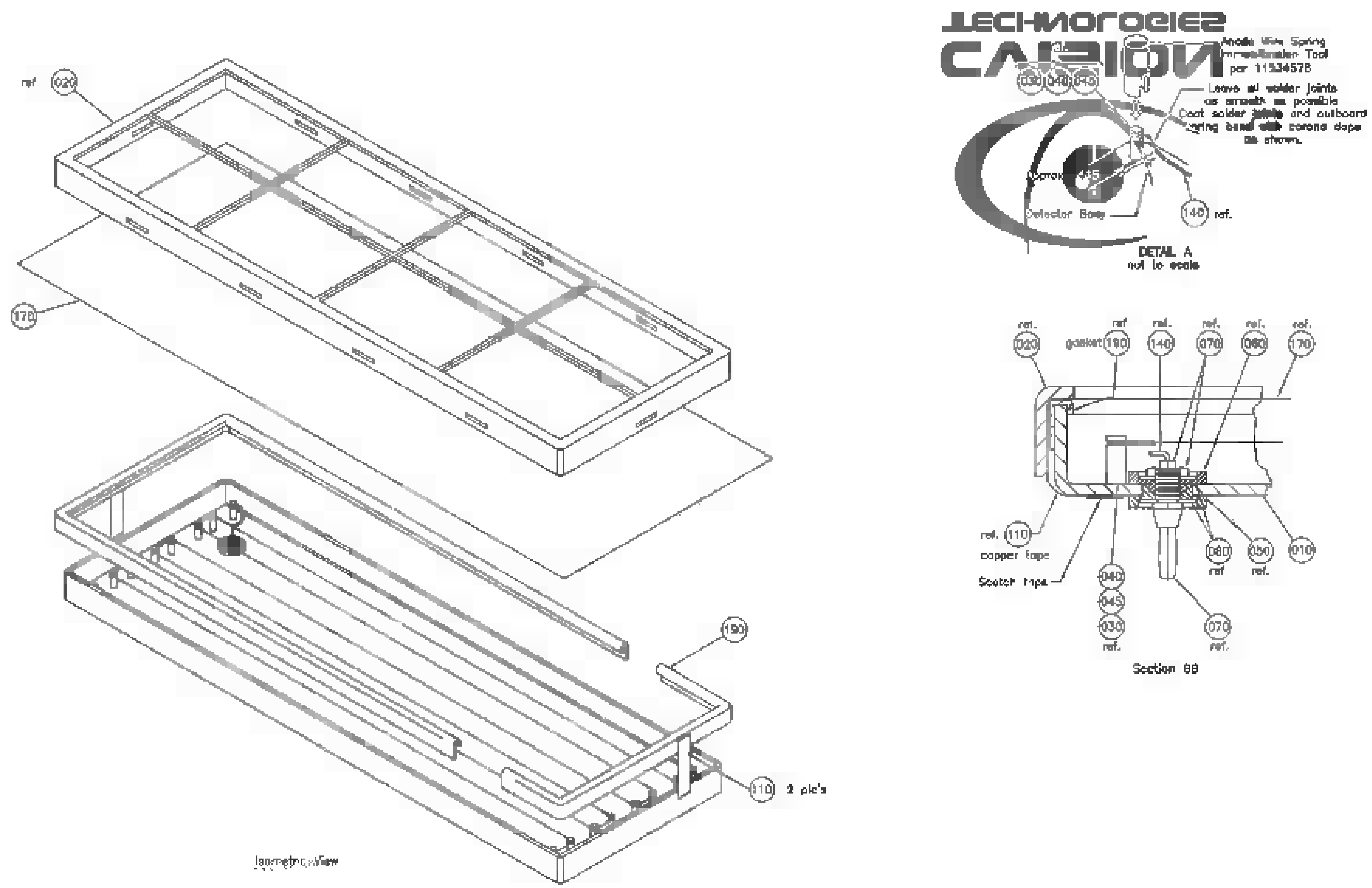

Figure 22-82. 11534-561, Revised detector assembly, medium, 2 of 2.

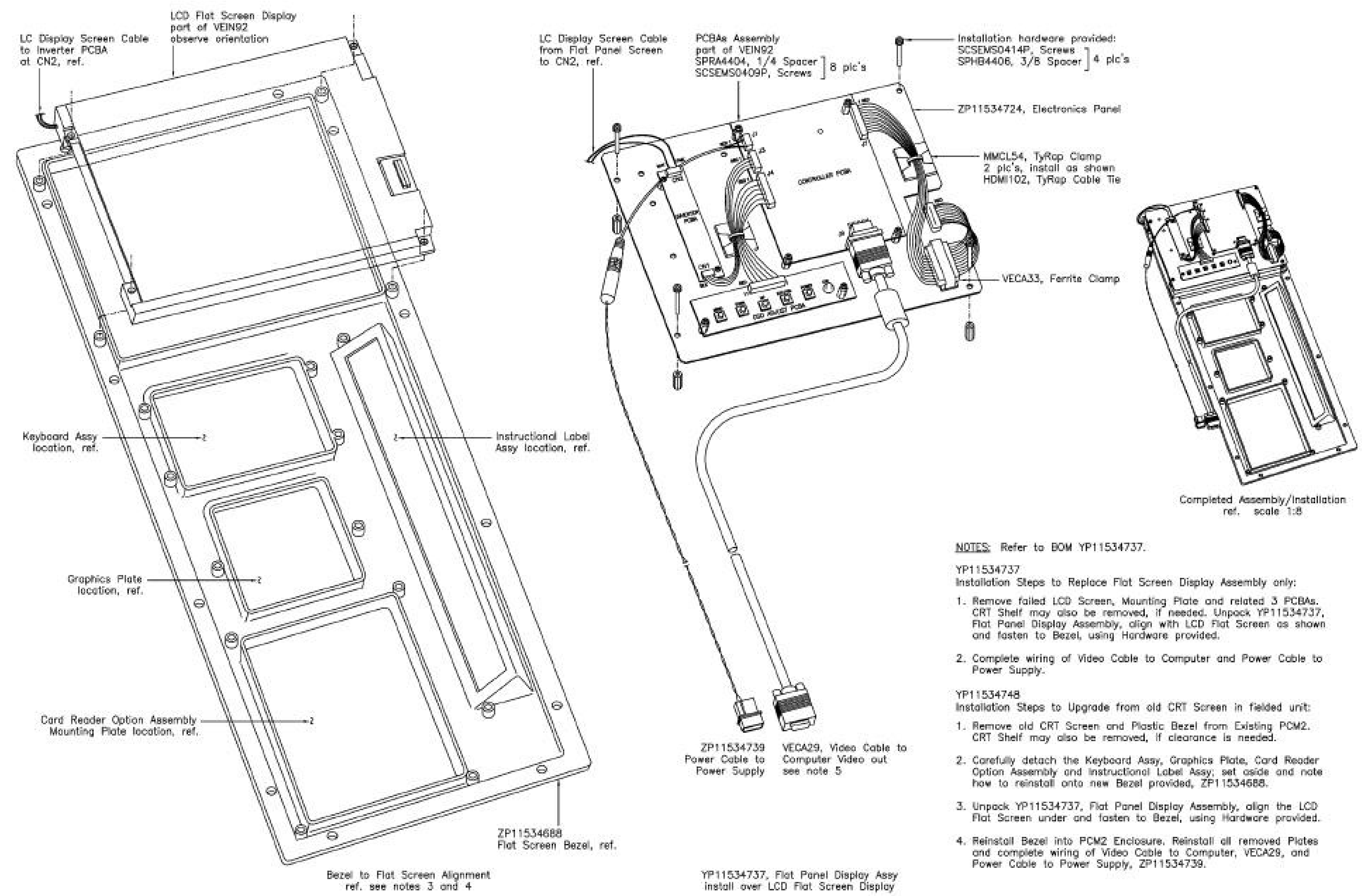

Figure 22-83. 11534-737, Flat panel display assembly.

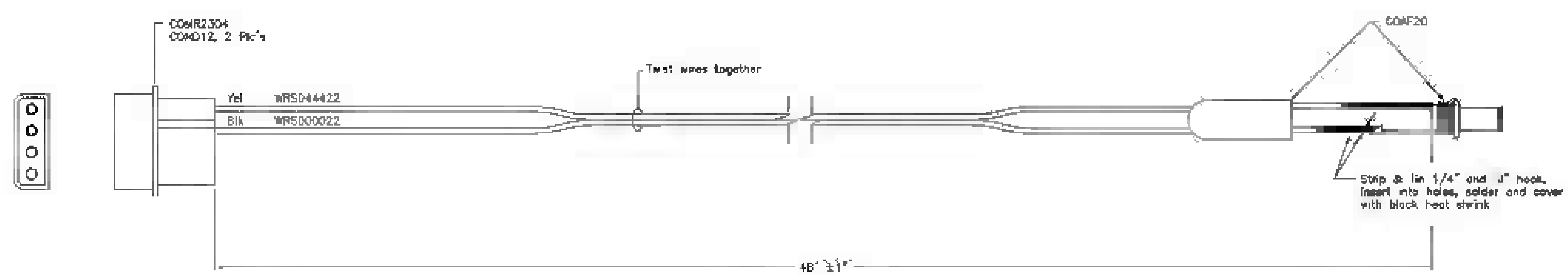

Figure 22-84. 11534-739, Power cable, VEIN92.

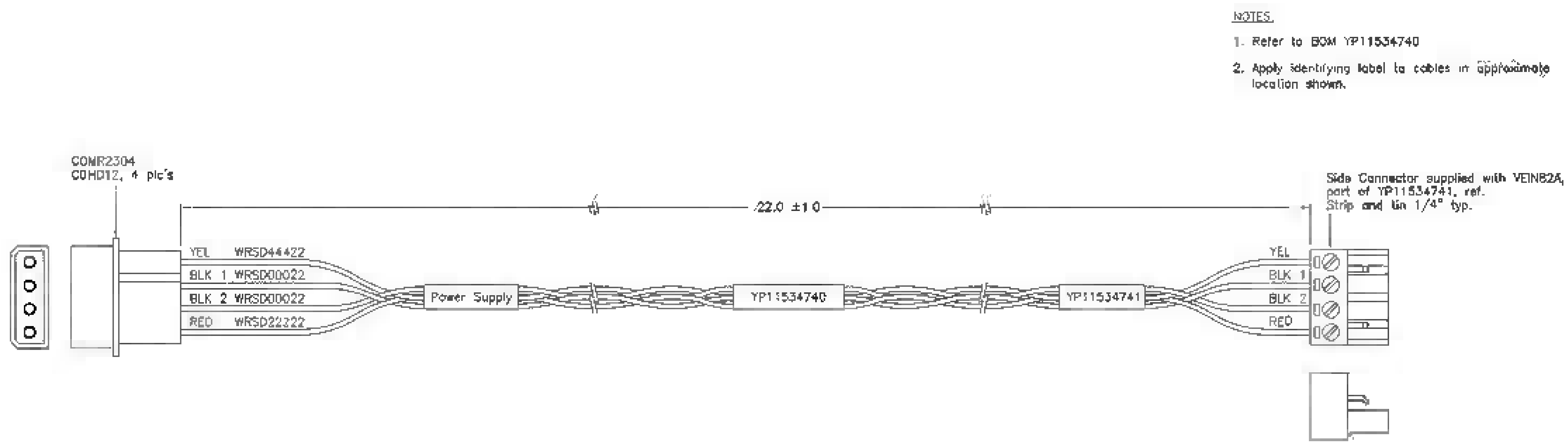

Figure 22-85. 11534-740, Power cable, single board PC.

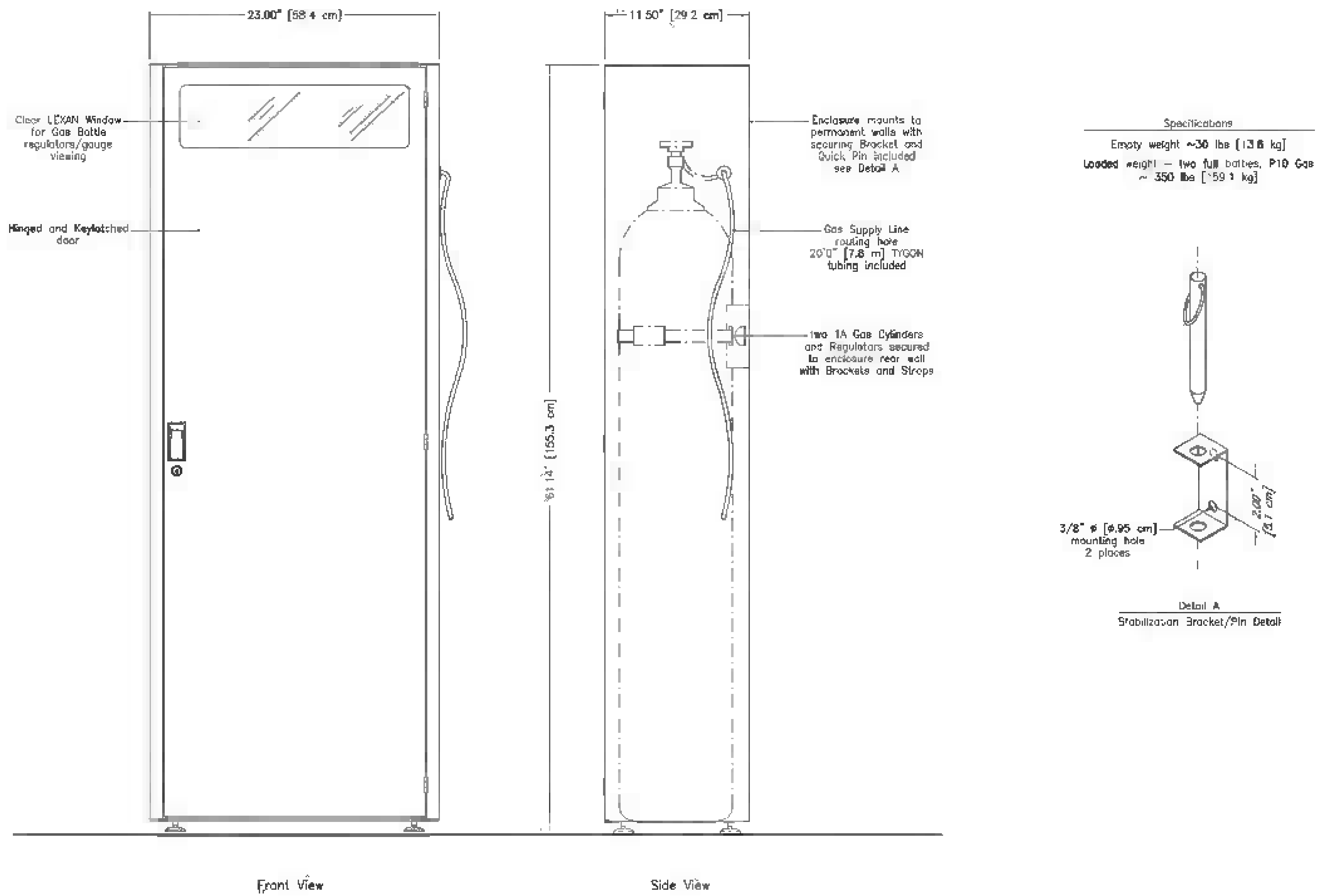

Figure 22-86. 11534-564, Gas bottle enclosure outline.

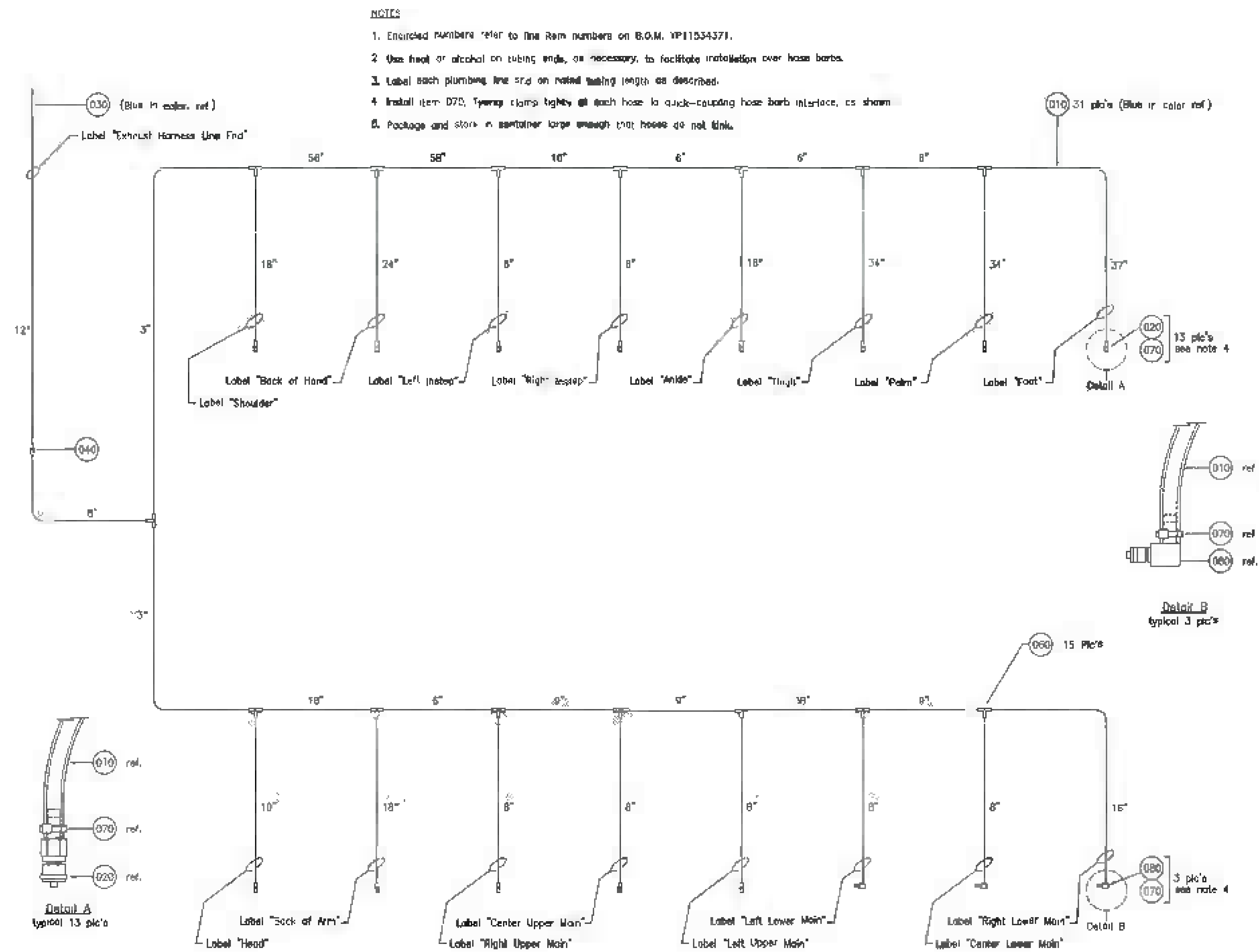

Figure 22-87. 11534-371, Plumbing.

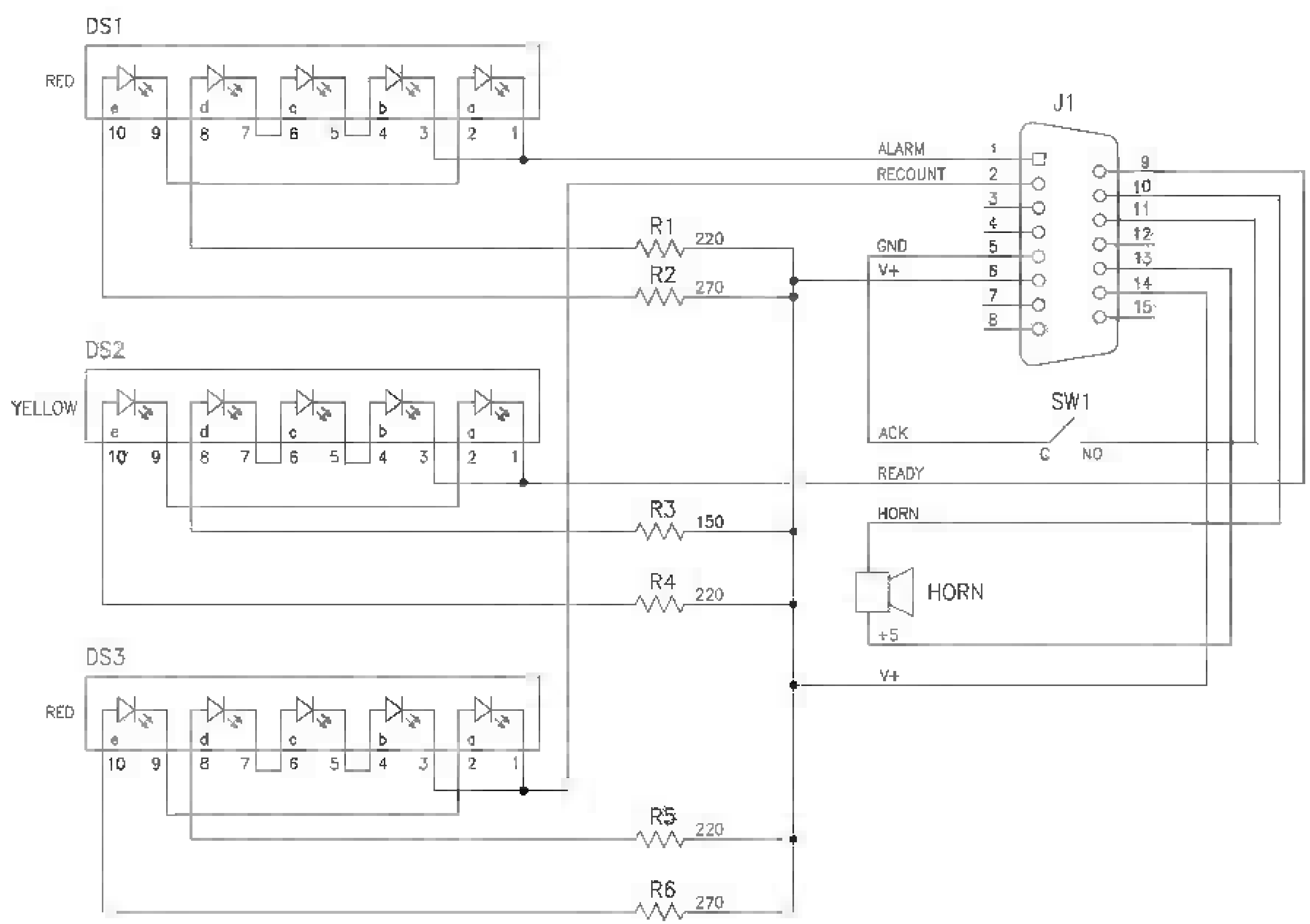

Figure 22-88. 11549-002, Remote annunciator.

Appendix A Statistical Control of Radiological Measurements

Introduction

Measurements that pertain to radioactive decay of isotopes involve uncertainties that are the result of the random nature of such decay. This randomness and the affect it has on measurements dictate that some statistical assessment of the results be made. Furthermore, there is involved with most measurements a signal that must be separated from background component (noise), with each component exhibiting its own statistical fluctuations. Classical statistical models, when properly applied, can provide a rich understanding of the events observed. By applying some fundamental rules to even the most sophisticated counting algorithms, use of the statistical models can be a straightforward exercise. This document attempts to illustrate what those rules are and how to apply them. The author attempts to speak to the nonstatistician and avoids complex derivations pertaining to pure statistical theory. Derivations are presented where they will help clarify a technique, and only as they apply to the subject of radiological measurements. Thus, this document is intended to be primarily a how-to discussion that the reader will refer to as an application guide.

Basic Measurement Parameters

Simple Measurements

As with any statistical population or sample, the two parameters that provide a reference point and a scale for observations and analysis are the *mean* or average and the *standard deviation* (which is frequently referred to as "sigma," deriving that name from the lower case Greek letter "F" used symbolically as a shorthand reference to standard deviation).

These two parameters when applied to raw counts of radiological events are quite simply determined. Generally, one is interested in the mean number of counts observed (post facto), or expected (implying future counts to be collected) in a specified counting interval. The mean can be determined from the results of a single measurement as well as the average of multiple measurements provided that the effect of differing counting intervals, if used, is properly accounted for. If a simple mean number of counts is known, the *theoretical* standard deviation is merely the square root of the mean where **N** represents the mean (Equation 1):

$$\sigma = \sqrt{N} \qquad \textbf{Eq. 1}$$

With the mean and standard deviation known, or predictable, for a set of measurements, the variation (or deviation) of measurements from the mean is likewise known or predictable with application of the appropriate distribution function.

Complex Measurements

As will be seen later, radiological measurements are rarely reported as merely the number of counts observed within a specific counting time interval. The values associated with the counts collected are usually manipulated algebraically so as to convert counts to count rates (counts per unit time), change units of measure, to apply sophisticated averaging techniques to a sequence of measurements, or to derive a value of interest from a complex relationship of variables as will be illustrated below.

Equation 2 is used to signify that a mean quantity Y is expressed as a function of n variables, x_i.

$$Y = f(x_1, x_2, x_3, ¼, x_n) \qquad \textbf{Eq. 2}$$

Statistical theory provides us with a general formula for deriving the standard deviation of N as illustrated by equations 3 and 4.

$$\sigma^2_Y = \sum_{i=1}^{n} \left[\frac{\delta Y}{\delta x_i}\right]^2 \sigma^2_{x_i} \qquad \textbf{Eq. 3}$$

$$\sigma_Y = \sqrt{\sum_{i=1}^{n} \left[\frac{dY}{dx_i}\right]^2 s^2_{x_i}} \qquad \textbf{Eq. 4}$$

Example To convert N counts collected in count time interval T to a count rate R, the counts are divided by the count time.

$$R = \frac{N}{T}$$ **Eq. 5**

$$\left[\frac{\delta R}{\delta N}\right]^2 = \frac{1}{T^2}$$ **Eq. 6**

$$\sigma_N^2 = (\sqrt{N})^2 = N$$ **Eq. 7**

Whereas T is a constant, the partial derivative of R with respect to T is zero.

Note An important assumption is made here: The length of the counting time interval is assumed to be precisely controllable or measurable so that there is no associated uncertainty and it can be treated as a constant.

Assembling the components equations 6 and 7 into Equation 4 yields Equation 8:

$$s_R = \sqrt{\frac{N}{T^2}} = \sqrt{\frac{R}{T}}$$ **Eq. 8**

Example An alpha CAM equipped with a multichannel analyzer is set up to monitor for plutonium contaminated particulates. Background counts (or count rates) are the result of the presence of radon and thoron which produce a spectral distribution as illustrated in Figure A-1.

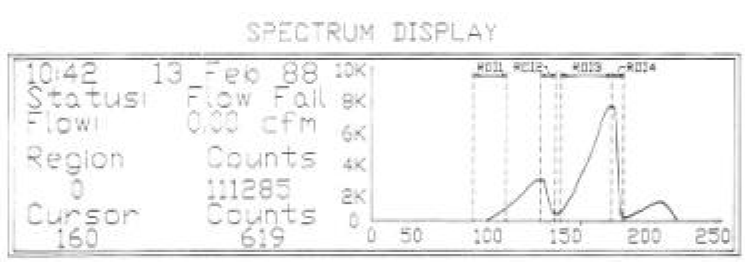

Figure A-1. Alpha CAM Spectrum

Empirical data shows that counts collected in four regions of interest (ROI) have a consistent relationship in the absence of plutonium. That relationship is expressed by Equation 9 where the four ROIs are identified as R_1 through R_4 and K is a constant.

$$\frac{R_1}{R_2} = K\frac{R_3}{R_4}$$ **Eq. 9**

Furthermore, when plutonium counts are present, they occur in R_1, so that in order to maintain the equality of Equation 9, the plutonium counts, Pu, must be subtracted from R_1. This leads to the derivation of the mean plutonium counts (or mean count rate), as expressed by equations 10 and 11:

Eq. 10

$$\frac{R_1 - Pu}{R_2} = K\frac{R_3}{R_4}$$

Eq. 11

$$Pu = R_1 - K\frac{R_3R_4}{R_4}$$

Equation 4 is applied to Equation 11 by first dissecting it into small, easily managed parts that are illustrated by Equation 12 through Equation 20 for the derivation of the Pu standard deviation. Equation 21 is the result of collecting all pertinent terms to solve for F_{Pu}.

$$\left[\frac{dPu}{dR_1}\right]^2 = 1$$ **Eq. 12**

$$s_{R_1}^{\ 2} = R_1$$ **Eq. 13**

$$\left[\frac{dPu}{dR_2}\right]^2 = \left[-K\frac{R_3}{R_4}\right]^2$$ **Eq. 14**

$$s_{R_1}^{\ 2} = R_2$$ **Eq. 15**

$$\left[\frac{dPu}{dR_3}\right]^2 = \left[-K\frac{R_2}{R_4}\right]^2$$ **Eq. 16**

$$s_{R_1}^{\ 2} = R_3$$ **Eq. 17**

$$\left[\frac{dPu}{dR_4}\right]^2 = \left[K\frac{R_2R_3}{R_4^{\ 2}}\right]^2$$ **Eq. 18**

$$s_{R_1}^{\ 2} = R_4$$ **Eq. 19**

$$\left[\frac{dPu}{dK}\right]^2 = s_K^{\ 2} = 0$$ **Eq. 20**

Note Equation 20 is superfluous because K is a constant, which excludes it from being a variable.

$$s_{Pu} = \sqrt{R_1 + K^2\frac{R_2R_3}{R_4^{\ 2}}\left[R_2 + R_3 + \frac{R_2R_3}{R_4}\right]}$$ **Eq. 21**

As overwhelming as Equation 21 may appear, the reader is encouraged to note the simplicity of equations 12 through 20 that make the derivation quite manageable.

Distribution Functions

Binomial Distribution

The binomial distribution is quite cumbersome to use. For that reason, it is rarely invoked for analysis of radiological counting exercises. It is worthy of mention because the popular Poisson and Gaussian functions are derived from it.

Poisson Distribution

This distribution function is an approximation of the binomial distribution function and is applicable when

1. **A large sample size is involved.**

2. **The probability of success associated with a single element or member of the sample population is very small.**

The above criteria is applicable to most radiological counting exercises. The sample size, in terms of number of atoms, usually will approach the order of magnitude of Avogadro's number. The probability that any one atom will disintegrate within time t is expressed by Equation 22.

$$p = 1 - e^{-l t}$$ **Eq. 22**

Where 8 is the decay constant for the isotope of interest. Since the half life of many common isotopes is very large when compared to typical count times, p is usually much less than 1.

The Poisson distribution function is best applied where fewer than 20 counts occur in a single count cycle and is appropriate for many alpha radiation counters where background count rates of less than 10 counts per minute (cpm) are frequently encountered. Efficiencies (detector counts/disintegration) of such instruments can be low since alpha particles are rapidly attenuated in air. Low efficiencies coupled with low levels of activity that are of regulatory concern result in the Less than 20 Counts rule of thumb being satisfied for the signal part of the measurement or counting exercise.

Note The classical definition of *measurement* makes the term inappropriate for radiological instrumentation that count pulses. However, popular use of the term deems its incorporation in this text as appropriate. ▲

The basic function of the Poisson distribution is expressed in Equation 23:

$$p(x) = \frac{e^{-l} l^{x}}{x!}$$ **Eq. 23**

where p(x) = the probability that exactly x events will occur, x = an integer, and

8 = the mean number of events that occurred or are expected to occur. Popular convention dictates use of the symbol 8, which is not to be confused with its use to symbolize *decay constant* (as in Equation 22).

x! = x (x-1) (x - 2) (x - 3) . . . 1.

0! is defines as equal to 1.

Of greater interest than probabilities associated with discreet integers is a cumulative distribution, a probability associated with x or more events. In this text, P is used to indicate a cumulative probability. Equation 24 illustrates the cumulative distribution P(x).

$$P(x) = \sum_{i = x}^{¥} px$$

Eq. 24

The Poisson distribution function is normalized, i.e., the sum of all probabilities is exactly 1. Therefore, anyone who would attempt the summation of Equation 24 would find relief in the identity of Equation 25.

$$P(x) = 1 - [p(0) + p(1) + p(2) + ¼ p(x-1)]$$

Eq. 25

Example A counter observes an average of 2.5 counts per interval. The probability distribution for this mean value follows (see eqs. 26 to 28):

Eq. 26

$$p(0) = \frac{e^{-2.5}2.5^0}{0!} = 0.082085$$

Eq. 27

$$p(1) = \frac{e^{-2.5}2.5^1}{1!} = 0.205212$$

$$p(0) = \frac{e^{-2.5}2.5^2}{2!} = 0.256516$$

Eq. 28

A convenient identity is

$$p(n) = p(n-1)\frac{\lambda}{n}$$ **Eq. 29**

The discrete and cumulative probability distribution is summarized in Table A-1 for values through x = 10. Figure A-2 is a histogram that graphically illustrates the distribution described by 8=2.5. Note that the histogram is skewed to the left. This is because the function's domain is nonnegative integers which precludes symmetry. The domain is intuitive in that neither negative counts nor fractional counts are realistic.

Table A-1. Poisson Distribution, Lambda = 2.5

x	p(x)	P(x)
0	0.082085	1
1	0.205212	0.917915
2	0.256516	0.712703
3	0.213763	0.456187
4	0.133602	0.242424
5	0.066801	0.108822
6	0.027834	0.042021
7	0.009941	0.014187
8	0.003106	0.004247
9	0.000863	0.00114
10	0.000216	0.000277

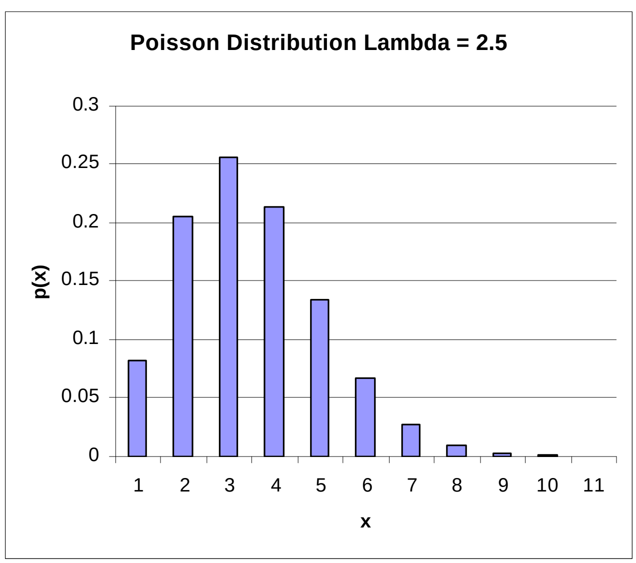

Figure A-2. Distribution described by 8=2.5.

Gaussian Distribution Function

An approximation can be applied to the Poisson distribution function when values of a function's mean (8 in the Poisson distribution function) become larger than about 20. This approximation, known as the Gaussian or normal distribution function is extensively used in radiological counting statistics. (See Figure A-3.) It is familiar to many as the bell curve defined by Equation 30 operating on x.

$$f(x) = \frac{e^{-\frac{x^2}{2}}}{\sqrt{2\pi}}$$ **Eq. 30**

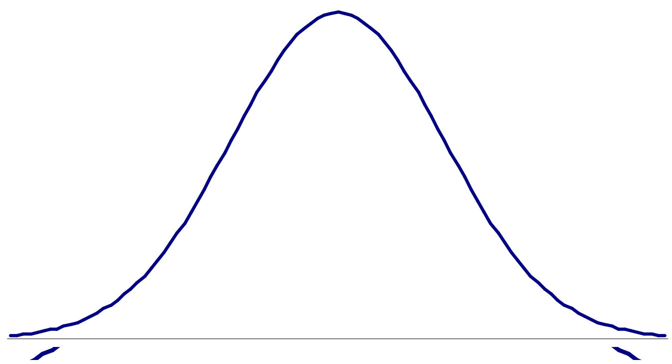

Figure A-3. Gaussian distribution function

The domain of this function is all real numbers. The function is centered about 0, whereas a sample's distribution is centered about its mean. Thus, the first step in applying the Gaussian distribution function to a sample is to subtract the sample's mean from each data point so as to center the data about zero. Second, the distribution of a sample is scaled to the independent variable x by its standard deviation. The cumulative Gaussian distribution function (Figure A-4) is normalized, i.e., the sum of all probabilities is 1, geometrically interpreted as the total area under the normal curve. The probability that x or less will be encountered within a sample is defined as the cumulative distribution from – 4 to x, as shown by Equation 31.

$$P(x) = \frac{1}{\sqrt{2p}} \int_{-¥}^{x} e^{\frac{-¡^2}{2}} d¡$$ **Eq. 31**

As illustrated by Figure A-4, Equation 31 is the area under the Gaussian distribution curve from 4 to x.

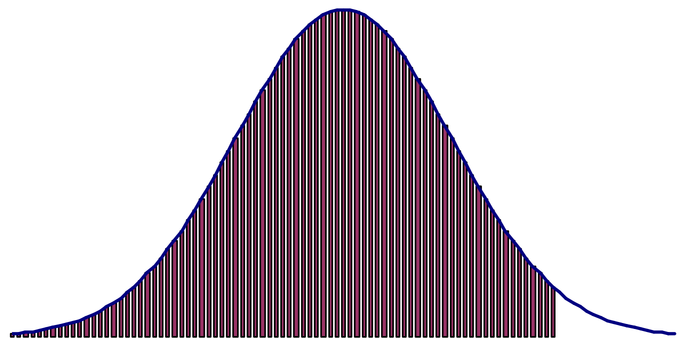

Figure A-4. Cumulative Gaussian distribution function

Much data related to statistical distribution functions is readily available in tabular form in math handbooks. Table A-2 presents values for the cumulative normal distribution operating on values of x from 0.00 through 5.00.

Table A-2. Cumulative Gaussian Distribution[1]

x	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.00	0.5000000	0.5039894	0.5079783	0.5119665	0.5159534	0.5199388	0.5239222	0.5279032	0.5318814	0.5358564
0.10	0.5398278	0.5437953	0.5477584	0.5517168	0.5556700	0.5596177	0.5635595	0.5674949	0.5714237	0.5753454
0.20	0.5792597	0.5831662	0.5870644	0.5909541	0.5948349	0.5987063	0.6025681	0.6064199	0.6102612	0.6140919
0.30	0.6179114	0.6217195	0.6255158	0.6293000	0.6330717	0.6368307	0.6405764	0.6443088	0.6480273	0.6517317
0.40	0.6554217	0.6590970	0.6627573	0.6664022	0.6700314	0.6736448	0.6772419	0.6808225	0.6843863	0.6879331
0.50	0.6914625	0.6949743	0.6984682	0.7019440	0.7054015	0.7088403	0.7122603	0.7156612	0.7190427	0.7224047
0.60	0.7257469	0.7290691	0.7323711	0.7356527	0.7389137	0.7421539	0.7453731	0.7485711	0.7517478	0.7549029
0.70	0.7580363	0.7611479	0.7642375	0.7673049	0.7703500	0.7733726	0.7763727	0.7793501	0.7823046	0.7852361
0.80	0.7881446	0.7910299	0.7938919	0.7967306	0.7995458	0.8023375	0.8051055	0.8078498	0.8105703	0.8132671
0.90	0.8159399	0.8185887	0.8212136	0.8238145	0.8263912	0.8289439	0.8314724	0.8339768	0.8364569	0.8389129
1.00	0.8413447	0.8437524	0.8461358	0.8484950	0.8508300	0.8531409	0.8554277	0.8576903	0.8599289	0.8621434
1.10	0.8643339	0.8665005	0.8686431	0.8707619	0.8728568	0.8749281	0.8769756	0.8789995	0.8809999	0.8829768
1.20	0.8849303	0.8868606	0.8887676	0.8906514	0.8925123	0.8943502	0.8961653	0.8979577	0.8997274	0.9014747
1.30	0.9031995	0.9049021	0.9065825	0.9082409	0.9098773	0.9114920	0.9130850	0.9146565	0.9162067	0.9177356
1.40	0.9192433	0.9207302	0.9221962	0.9236415	0.9250663	0.9264707	0.9278550	0.9292191	0.9305634	0.9318879
1.50	0.9331928	0.9344783	0.9357445	0.9369916	0.9382198	0.9394292	0.9406201	0.9417924	0.9429466	0.9440826
1.60	0.9452007	0.9463011	0.9473839	0.9484493	0.9494974	0.9505285	0.9515428	0.9525403	0.9535213	0.9544860
1.70	0.9554345	0.9563671	0.9572838	0.9581849	0.9590705	0.9599408	0.9607961	0.9616364	0.9624620	0.9632730
1.80	0.9640697	0.9648521	0.9656205	0.9663750	0.9671159	0.9678432	0.9685572	0.9692581	0.9699460	0.9706210
1.90	0.9712834	0.9719334	0.9725711	0.9731966	0.9738102	0.9744119	0.9750021	0.9755808	0.9761482	0.9767045
2.00	0.9772499	0.9777844	0.9783083	0.9788217	0.9793248	0.9798178	0.9803007	0.9807738	0.9812372	0.9816911
2.10	0.9821356	0.9825708	0.9829970	0.9834142	0.9838226	0.9842224	0.9846137	0.9849966	0.9853713	0.9857379
2.20	0.9860966	0.9864474	0.9867906	0.9871263	0.9874545	0.9877755	0.9880894	0.9883962	0.9886962	0.9889893
2.30	0.9892759	0.9895559	0.9898296	0.9900969	0.9903581	0.9906133	0.9908625	0.9911060	0.9913437	0.9915758
2.40	0.9918025	0.9920237	0.9922397	0.9924506	0.9926564	0.9928572	0.9930531	0.9932443	0.9934309	0.9936128
2.50	0.9937903	0.9939634	0.9941323	0.9942969	0.9944574	0.9946139	0.9947664	0.9949151	0.9950600	0.9952012
2.60	0.9953388	0.9954729	0.9956035	0.9957308	0.9958547	0.9959754	0.9960930	0.9962074	0.9963189	0.9964274
2.70	0.9965330	0.9966358	0.9967359	0.9968333	0.9969280	0.9970202	0.9971099	0.9971972	0.9972821	0.9973646
2.80	0.9974449	0.9975229	0.9975988	0.9976726	0.9977443	0.9978140	0.9978818	0.9979476	0.9980116	0.9980738
2.90	0.9981342	0.9981929	0.9982498	0.9983052	0.9983589	0.9984111	0.9984618	0.9985110	0.9985588	0.9986051
3.00	0.9986501	0.9986938	0.9987361	0.9987772	0.9988171	0.9988558	0.9988933	0.9989297	0.9989650	0.9989992
3.10	0.9990324	0.9990646	0.9990957	0.9991260	0.9991553	0.9991836	0.9992112	0.9992378	0.9992636	0.9992886
3.20	0.9993129	0.9993363	0.9993590	0.9993810	0.9994024	0.9994230	0.9994429	0.9994623	0.9994810	0.9994991
3.30	0.9995166	0.9995335	0.9995499	0.9995658	0.9995811	0.9995959	0.9996103	0.9996242	0.9996376	0.9996505
3.40	0.9996631	0.9996752	0.9996869	0.9996982	0.9997091	0.9997197	0.9997299	0.9997398	0.9997493	0.9997585
3.50	0.9997674	0.9997759	0.9997842	0.9997922	0.9997999	0.9998074	0.9998146	0.9998215	0.9998282	0.9998347
3.60	0.9998409	0.9998469	0.9998527	0.9998583	0.9998637	0.9998689	0.9998739	0.9998787	0.9998834	0.9998879
3.70	0.9998922	0.9998964	0.9999004	0.9999043	0.9999080	0.9999116	0.9999150	0.9999184	0.9999216	0.9999247
3.80	0.9999277	0.9999305	0.9999333	0.9999359	0.9999385	0.9999409	0.9999433	0.9999456	0.9999478	0.9999499
3.90	0.9999519	0.9999539	0.9999557	0.9999575	0.9999593	0.9999609	0.9999625	0.9999641	0.9999655	0.9999670
4.00	0.9999683	0.9999696	0.9999709	0.9999721	0.9999733	0.9999744	0.9999755	0.9999765	0.9999775	0.9999784
4.10	0.9999793	0.9999802	0.9999811	0.9999819	0.9999826	0.9999834	0.9999841	0.9999848	0.9999854	0.9999861
4.20	0.9999867	0.9999872	0.9999878	0.9999883	0.9999888	0.9999893	0.9999898	0.9999902	0.9999907	0.9999911
4.30	0.9999915	0.9999918	0.9999922	0.9999925	0.9999929	0.9999932	0.9999935	0.9999938	0.9999941	0.9999943
4.40	0.9999946	0.9999948	0.9999951	0.9999953	0.9999955	0.9999957	0.9999959	0.9999961	0.9999963	0.9999964
4.50	0.9999966	0.9999968	0.9999969	0.9999971	0.9999972	0.9999973	0.9999974	0.9999976	0.9999977	0.9999978
4.60	0.9999979	0.9999980	0.9999981	0.9999982	0.9999983	0.9999983	0.9999984	0.9999985	0.9999986	0.9999986
4.70	0.9999987	0.9999988	0.9999988	0.9999989	0.9999989	0.9999990	0.9999990	0.9999991	0.9999991	0.9999992
4.80	0.9999992	0.9999992	0.9999993	0.9999993	0.9999994	0.9999994	0.9999994	0.9999994	0.9999995	0.9999995
4.90	0.9999995	0.9999995	0.9999996	0.9999996	0.9999996	0.9999996	0.9999996	0.9999997	0.9999997	0.9999997
5.00	0.9999997	0.9999997	0.9999997	0.9999998	0.9999998	0.9999998	0.9999998	0.9999998	0.9999998	0.9999998

[1]Where x equals the number on the side plus the number on top.

Chi-Squared Distribution Function

The Chi-squared distribution function is applied post facto to counting experiments to evaluate goodness-of-fit of the data to a theoretical distribution. Stated otherwise, observed results are compared to expected (theoretical) results and a determination is made as to whether or not the difference is reasonable. A poor fit would suggest instrument malfunction indicated by spurious counts. Chi-squared is calculated as indicated by Equation 32.

Eq. 32

$$x^2 = \frac{1}{x_e}\sum_{i = 1}^{n}(x_i - x_e)^2$$

where

x_e = the experimental mean, or average value of the counts collected in N measurements,

N = the number of counting intervals involved, and

x_i = the count data collected in the i^{th} counting interval.

As the number counting intervals that are evaluated increases, the goodness-of-fit is expected to improve. Therefore, to be useful, the Chi-squared value must be considered along with the number of data points. The parameter $P^2/<$, known as “Reduced Chi-squared,” is used to enter a plot such as Figure A-5 or a table such as Table A-3 of Chi-squared values. The value $<$ is (n - 1) or the number of degrees of freedom in the experiment.

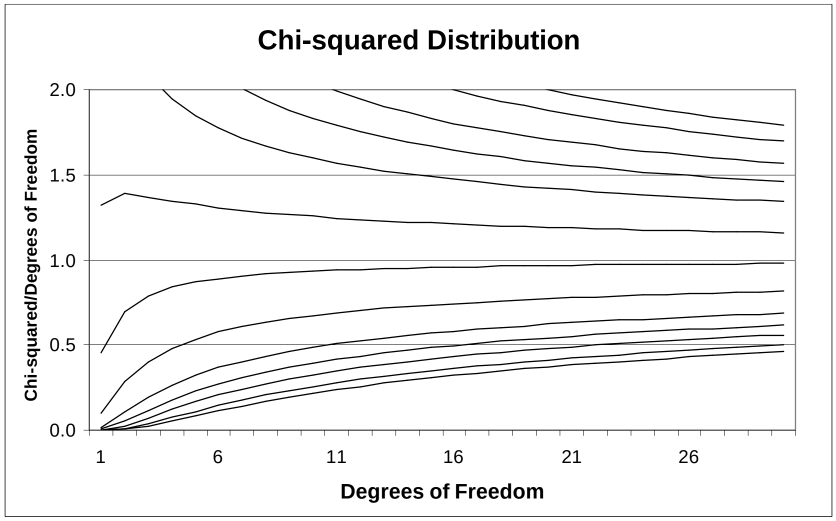

Figure A-5. Chi-squared distribution.

Table A-3 is entered at the row that corresponds to the number of degrees of freedom (n–1). Associated with the closest P^2/< found in that row is a probability listed at the top of the column. That value is the probability that P^2/< would be less than or equal to the number found in the table. Very large or very small probabilities indicate poor fit. When considered in terms of observed results divided by expected results, intuitively, an ideal experiment would produce a ratio of 1. A 50% probability is equivalent to saying that in a random sampling P^2/< is just as likely to be above as below the number indicated, and therefore indicative of a good fit of real data to ideal.

Note The fact that the degrees of freedom is one less than the number of data points can cause some consternation to students of statistics. To clarify the relationship between n and <, take the case of n = 2, the smallest value of n from which an average can be computed. Knowing the average and the value of only one of the two data points, it is possible to derive the second data point. Also, the two data points are equidistant from their average. In like fashion, if the average of n data points is known, then the value of any one of those data points can be derived from the values of the remaining (n–1) data points. Any value could be assigned to any of the (n–1) points, but the n^{the} can only assume a single value, determined by the first (n–1) points, hence, zero degrees of freedom exist for the n^{the} data point. ▲

Table A-3. Chi-squared Distribution

	0.005	0.010	0.025	0.050	0.100	0.250	0.500	0.750	0.900	0.950	0.975	0.990	0.995
1	0.000039	0.000157	0.000982	0.0039	0.0158	0.102	0.455	1.32	2.71	3.84	5.02	6.63	7.88
2	0.005013	0.0101	0.0253	0.051	0.105	0.288	0.693	1.39	2.30	3.00	3.69	4.61	5.30
3	0.0239	0.0383	0.0719	0.117	0.195	0.404	0.789	1.37	2.08	2.60	3.12	3.78	4.28
4	0.0517	0.0743	0.1211	0.178	0.266	0.481	0.839	1.35	1.94	2.37	2.79	3.32	3.72
5	0.0823	0.1109	0.1662	0.229	0.322	0.535	0.870	1.33	1.85	2.21	2.57	3.02	3.35
6	0.113	0.145	0.206	0.273	0.367	0.576	0.891	1.31	1.77	2.10	2.41	2.80	3.09
7	0.141	0.177	0.241	0.310	0.405	0.608	0.907	1.29	1.72	2.01	2.29	2.64	2.90
8	0.168	0.206	0.272	0.342	0.436	0.634	0.918	1.28	1.67	1.94	2.19	2.51	2.74
9	0.193	0.232	0.300	0.369	0.463	0.655	0.927	1.27	1.63	1.88	2.11	2.41	2.62
10	0.216	0.256	0.325	0.394	0.487	0.674	0.934	1.25	1.60	1.83	2.05	2.32	2.52
11	0.237	0.278	0.347	0.416	0.507	0.689	0.940	1.25	1.57	1.79	1.99	2.25	2.43
12	0.256	0.298	0.367	0.436	0.525	0.703	0.945	1.24	1.55	1.75	1.94	2.18	2.36
13	0.274	0.316	0.385	0.453	0.542	0.715	0.949	1.23	1.52	1.72	1.90	2.13	2.29
14	0.291	0.333	0.402	0.469	0.556	0.726	0.953	1.22	1.50	1.69	1.87	2.08	2.24
15	0.307	0.349	0.417	0.484	0.570	0.736	0.956	1.22	1.49	1.67	1.83	2.04	2.19
16	0.321	0.363	0.432	0.498	0.582	0.745	0.959	1.21	1.47	1.64	1.80	2.00	2.14
17	0.335	0.377	0.445	0.510	0.593	0.752	0.961	1.21	1.46	1.62	1.78	1.97	2.10
18	0.348	0.390	0.457	0.522	0.604	0.760	0.963	1.20	1.44	1.60	1.75	1.93	2.06
19	0.360	0.402	0.469	0.532	0.613	0.766	0.965	1.20	1.43	1.59	1.73	1.90	2.03
20	0.372	0.413	0.480	0.543	0.622	0.773	0.967	1.19	1.42	1.57	1.71	1.88	2.00
21	0.383	0.424	0.490	0.552	0.630	0.778	0.968	1.19	1.41	1.56	1.69	1.85	1.97
22	0.393	0.434	0.499	0.561	0.638	0.784	0.970	1.18	1.40	1.54	1.67	1.83	1.95
23	0.403	0.443	0.508	0.569	0.646	0.789	0.971	1.18	1.39	1.53	1.66	1.81	1.92
24	0.412	0.452	0.517	0.577	0.652	0.793	0.972	1.18	1.38	1.52	1.64	1.79	1.90
25	0.421	0.461	0.525	0.584	0.659	0.798	0.973	1.17	1.38	1.51	1.63	1.77	1.88
26	0.429	0.469	0.532	0.592	0.665	0.802	0.974	1.17	1.37	1.50	1.61	1.76	1.86
27	0.437	0.477	0.540	0.598	0.671	0.806	0.975	1.17	1.36	1.49	1.60	1.74	1.84
28	0.445	0.484	0.547	0.605	0.676	0.809	0.976	1.17	1.35	1.48	1.59	1.72	1.82
29	0.452	0.492	0.553	0.611	0.682	0.813	0.977	1.16	1.35	1.47	1.58	1.71	1.80
30	0.460	0.498	0.560	0.616	0.687	0.816	0.978	1.16	1.34	1.46	1.57	1.70	1.79

Qualitative Measurements

A typical qualitative measurement in a radiation monitoring system is a go–no go determination. For such a measurement an instrument is set up to alarm when a predetermined count rate is exceeded. Two primary constraints control the appropriate count rate on which to alarm. The first of these is the background count rate and what is deemed an associated false alarm rate, or probability that background alone will randomly exceed the alarm set point. This determines the lower limit for an alarm set point. The second constraint is the upper limit on the alarm set point which ultimately, determines the minimum activity (above background) that will cause an alarm with an associated probability or confidence level. Each constraint will be considered individually and then in combination with each other.

Controlling False Alarm Rates

What will be called a Type I false alarm herein is an alarm caused by background alone. Because the background count rate is random, during any one counting interval the background count rate could assume any non-negative value. Thus, even with a high alarm set point, there will exist a finite probability that a Type I false alarm will occur. Accepting that false alarms will not be entirely eliminated, the first step is to establish an acceptable probability of false alarm. For a single measurement, that small probability will be labelled p. For multiple measurements, be they sequential or simultaneous by way of multiple detector channels operating simultaneously, the overall false alarm probability of false alarm for N measurements (P_N) is defined by Equation 33.

$$P_N = 1 - (1 - p)^N \qquad \textbf{Eq. 33}$$

Once an overall false alarm rate is established, the false alarm rate per individual channel or measurement is derived from Equation 33 as illustrated by Equation 34.

$$p = 1 - \sqrt[N]{1 - P_N} \qquad \textbf{Eq. 34}$$

1. Low Count Rates and Short Counting Intervals

Counting exercises whose product of count rate and count time result in 20 or less counts per interval (average), as stated earlier, are appropriately modelled by the Poisson distribution function. By using the numbers from the example on page A-7, Table A-1 can be invoked for an example of false alarm rate control. In that example, 2.5 counts was the average expected number of counts per count interval. If a false alarm rate of 0.001 or less is desired, it is noted from Table A-1 that, based on 8 = 2.5, P(10) = 0.000277 satisfies the requirement whereas P(9) = 0.00114 exceeds the maximum acceptable false alarm rate. Thus, an alarm setpoint of 10 counts per count time interval, including background, would be selected. The total count rate on which to alarm is derived by dividing 10 counts by the length of the count time interval.

The Poisson distribution function can be cumbersome to use because the p(x) and P(x) values are not directly obtained by a single calculation. Rather, chains of calculations or the use of a look-up table are required.

2. High Count Rates and Long Counting Intervals

When 20 or more background counts are expected per count cycle, the Gaussian distribution function can be invoked with acceptable results. In terms of count rate, background will be annotated with the symbol R_B, R representing a count rate and B signifying background. The data must be first standardized, then normalized to the function as follows:

Because the function is standardized, i.e., centered about zero, so average background is subtracted from the data so as to reference to zero instead of average background. Thus, the alarm set point is expressed as a net count rate or count rate above background.

Regardless of the level of R_B, it is normalized, or scaled to the Gaussian function, by its standard deviation. Because Table A-2 operates on F (standard deviation) the entire distribution of R_B is known in terms of its F. An alarm setpoint would then be selected as being an appropriate number of F above the average background count rate for a given false alarm rate. An appropriate name for the constant that would multiply F is sigma factor (SF).

Equation 35 illustrates how simply the alarm setpoint is selected where $R_{A(MIN)}$ symbolizes the net count rate on which to alarm. Note that the alarm set point is expressed as a minimum since lower count rates would result in higher false alarm probabilities. Higher values are permissible since they would serve to reduce the false alarm rate. Figure A-6 is a graphic interpretation of Equation 35.

$$R_{A(MIN)} = SF\sqrt{\frac{R_B}{T}} \qquad \textbf{Eq. 35}$$

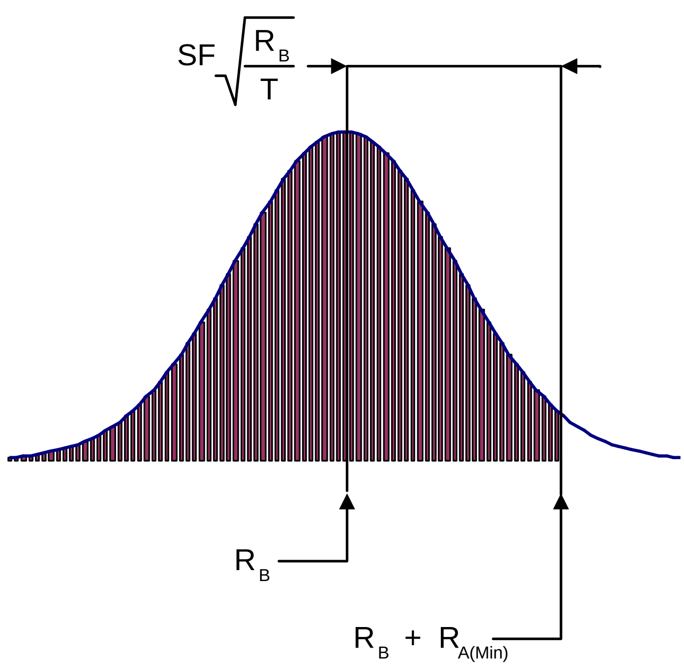

Figure A-6. Graphic interpretation of Equation 35.

In Figure A-6, the shaded area corresponds to the Gaussian cumulative distribution operating on SF, mathematically equal to Equation 31. The distribution represents the probability that the background count rate will be less than $R_{A(MIN)}$, so the false alarm rate is determined by Equation 36 where F(SF) is shorthand notation for the Gaussian cumulative distribution function operating on SF.

$$p = 1 - F(SF)$$ **Eq. 36**

Example In light of earlier comments, the false alarm rate is controlled entirely by SF, and is independent of R_B. (If Table A-2 is invoked, the independent variable ". . . x" is substituted for "SF." If SF is equal to 3.09, the table indicates F(SF) is equal to 0.9989991 and $p = 1 - F(SF) = 0.0010009$.

Consistent with Equation 33, in the case of N channels or N measurements, the overall false alarm probability is indicated by Equation 37.

$$p = 1 - F(SF)^N$$ **Eq. 37**

Because F(SF) is always less than 1, raising it to a power greater than 1 will reduce the value and increase the overall false alarm probability. This suggests that with an increasing number of channels, larger sigma factors are required to maintain an acceptable false alarm rate. Larger sigma factors decrease sensitivity as will be discussed later in this writing, so some compromise is always in order.

Table A-2 can be used in inverse fashion by entering its field with p and extracting SF (the more logical approach to using the table). Equation 38 expresses this technique mathematically where F^{-1} is notation for the inverse function of F.

$$SF = F^{-1}[\sqrt[N]{1 - P}]$$ **Eq. 38**

The process of invoking Equation 38 and entering Table A-2 with the results is greatly simplified by using the Sigma Factor Nomograph illustrated by Figure A-7. To use the nomograph, extend a straight line from the tick mark on the left-hand column that corresponds to the number of channels in use through the desired false alarm probability in the middle column until it intersects the right-hand column. The required sigma factor will be indicated. In analogous fashion, any of the three variables can become the dependent variable.

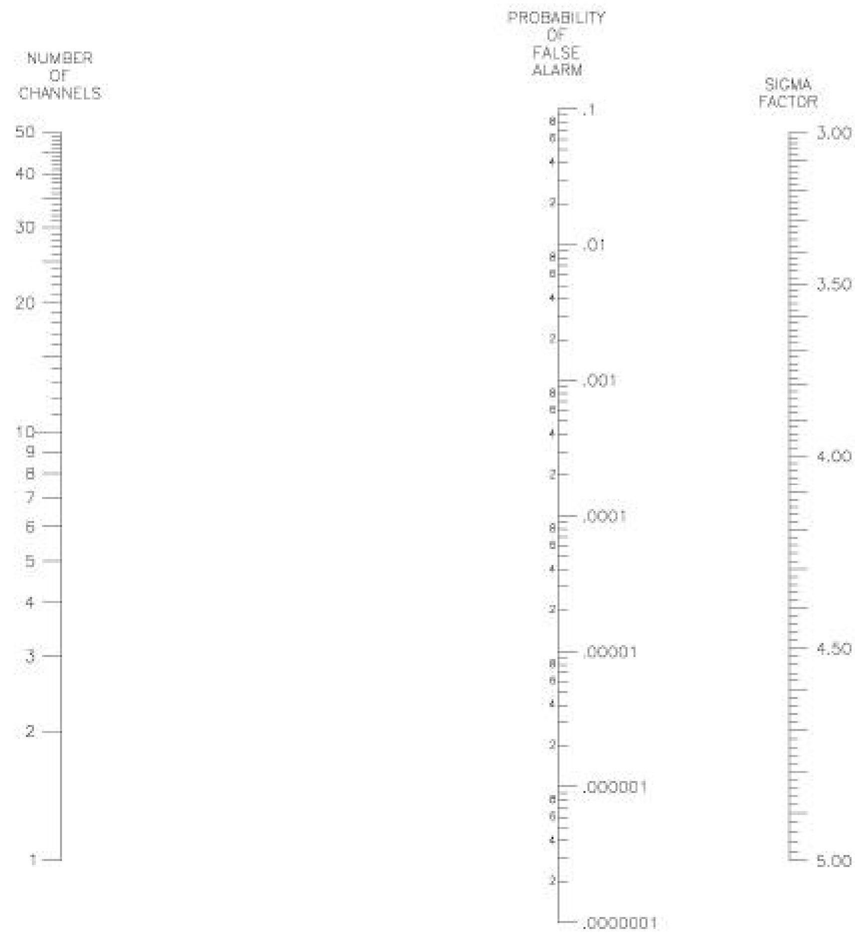

Figure A-7. Sigma factor nomograph.

Controlling Sensitivity

Qualitative counting exercises frequently seek to alarm with high reliability on some predetermined level of activity. The activity of interest is labelled *reliably detectable activity* (RDA). In a detector channel, the average count rate produced by RDA in the presence of background is RDA x Eff + R_B where Eff is the detector 4B efficiency, counts/disintegration. The net count rate produced by the source (RDA), and identified as R_S, is expressed in Equation 39.

$$R_S = [RDA \times Eff + R_B] - R_B$$ **Eq. 39**

The obvious redundance of R_B in Equation 39 is stated for a purpose that will be developed here. The term inside the square brackets represents $R_S + R_B$ which is measured in an interval which will be identified as T_{S+B}. From the resultant count rate, R_B, the assumed background count rate average, is subtracted to produce R_S. R_B, being previously determined, has a different time base identified as T_B. The standard deviation of R_S, determined by invoking Equation 4, is shown in Equation 40.

Eq. 40

$$s_S = \sqrt{\frac{RDA \times Eff + R_B}{T_{S+B}} + \frac{R_B}{T_B}}$$

Common practice is to maintain a long-term background average such that T_B is much greater than T_{S+B}. The result of this is that the right hand term under the radical becomes negligibly small compared to the left hand term and is usually ignored as will be the case throughout the rest of this discussion. The reader is cautioned, however, that in a counting exercise where T_B is approximately equal to T_{S+B} (or worse, less than the composite count time), the identity of Equation 40 should be used instead of Equation 41. In Equation 41, the S + B subscript is dropped since the need to differentiate between two counting intervals goes away.

Eq. 41

$$s_S \approx \sqrt{\frac{RDA \times Eff + R_B}{T}}$$

If an alarm set point is made equal to R_S, there would be a 50% likelihood that RDA would cause an alarm since R_S is its associated average count rate. Being an average, it is expected to exceed its average half of the time and be less than that value the remaining half of the time. By inspecting Figure A-8, the reader can envision that for significant (>> 0.50) probabilities of detection, the alarm setpoint must be lower than R_S. In a manner analogous to selecting $R_{A(MIN)}$, a maximum permissible alarm set point is expressed in terms of F_S. The multiplier of F_S is called "z" in this document. The desired probability of detection (also called *Confidence Level*) determines the value of z which is selected from Table A-2. A 90% confidence level (probability of RDA producing an alarm) is accomplished with z = 1.28 and a 95% confidence level results from z = 1.65.

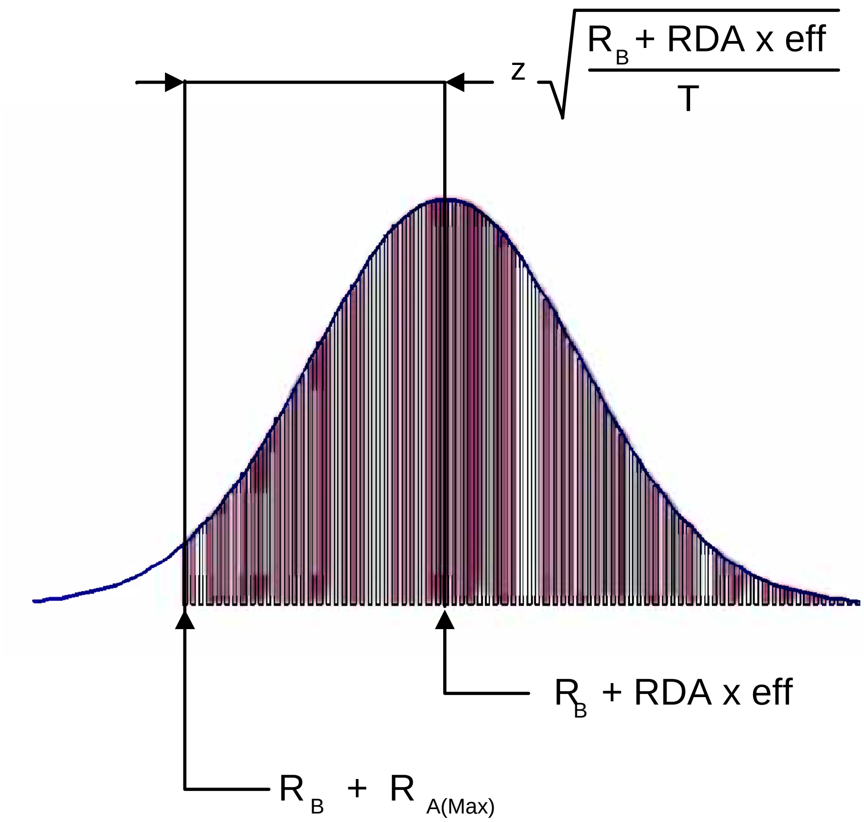

Figure A-8. Applying RDA in setting up a counting exercise for optimal performance.

Equation 42 expresses the computation of $R_{A(MAX)}$.

$$R_{A(MAX)} = RDA \times Eff - z\sqrt{\frac{RDA \times Eff + R_B}{T}} \qquad \textbf{Eq. 42}$$

Optimization Figure A-9 will be used as the basis of discussing how a counting exercise can be set up so as to maximize its desired performance. Figure A-9 illustrates the relationship of $R_{A(MIN)}$ and $R_{A(MAX)}$ on a single number line whose domain is non-negative count rates. First of all, it is important that $R_{A(MIN)}$ be kept less than or equal to $R_{A(MAX)}$. Whereas the spread of the distribution curve is determined by the standard deviation associated with it, adjusting F will adjust the breadth of its curve and, along with it, the position of R_A relative to the curves peak. Studying the expressions for F_B and F_S (the radical terms in equations 35 and 42), it should be apparent that the parameter most likely to be controlled by the operator of a radiation monitor is the length of the counting interval, T. Because T is in the denominator, larger values of T will reduce F. There can be several interpretations of how a counting exercise can be optimized. Each is discussed separately.

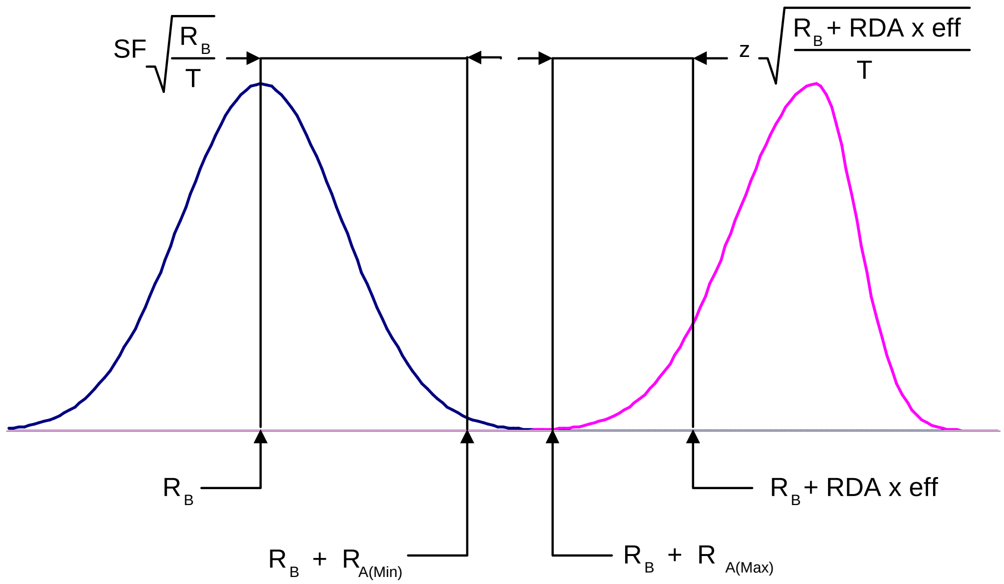

Figure A-9. Basis for maximizing counting exercise performance.

1. Minimum Count time

Since adjusting count time also adjusts F and therefore the associated alarm setpoints, it is possible to set $R_{A(MIN)}$ equal to $R_{B(MAX)}$. This is done in Equation 43 by equating the right hand sides of Equation 35 and Equation 36 and then solving for T. Since any lesser value of T would violate the requirement that $R_{B(MIN)} \leq R_{B(MAX)}$, the MIN subscript is appended to T to indicate that it is, in fact, the minimum count time that can be used without sacrificing one of the constraining parameters of the measurement.

$$T_{MIN} = \left[\frac{SF\sqrt{R_B} + z\sqrt{RDA \times Eff + R_B}}{RDA \times Eff}\right]^2 \qquad \textbf{Eq. 43}$$

2. Fixed Count Time

Obviously, using $R_{A(MIN)}$ for the alarm setpoint allows the instrument to operate as close to background as possible given the limitation of the count time selected. Assuming that the count time is as long as reasonably allowed, the sensitivity is maximized. Referring to Figure A-9, it can be shown that at the lower alarm set point, RDA has a greater probability of detection than would be determined by the maximum alarm setpoint. Thus, in fixed count time mode, the user-selected RDA becomes a maximum permissible RDA (no less than the selected confidence level should apply to the selected RDA), and at the confidence level selected, a lower RDA exists. This lower RDA is computed by Equation 44.

$$RDA = \frac{SF\sqrt{\frac{R_B}{T}} + z\sqrt{\frac{RDA \times Eff + R_B}{T}}}{Eff} \qquad \textbf{Eq. 44}$$

To solve Equation 44 as it is presented requires several iterative steps. Virtually any starting value for RDA can be placed in the right hand side. When the equation is solved, it returns a new value for RDA which is reentered in the right hand side. The process repeats until no change in RDA occurs. A closed form solution is indicated by Equation 45. The former method is usually preferred.

$$RDA = \frac{SF\sqrt{R_B T} + \frac{z^2}{2} + \sqrt{\frac{Z^4}{4} + z^2 SF\sqrt{R_B T} + R_B z^2 T}}{Eff} \qquad \textbf{Eq. 45}$$

3. Minimum Type II False Alarms

A Type II false alarm is defined as an alarm produced by activity (in addition to background) that is below RDA. Illustrated in Figure A-9 is the distribution of probabilities for varying activity levels under two different count times, all other parameters being held constant. In both instances, the 90% confidence level exists for the selected RDA of 110 Bq. Also, in both cases, diminishing probabilities of an alarm occurring are associated with diminishing levels of activity. However, the longer count time causes the performance of the instrument to more closely approximate the Step Function that an ideal instrument would exhibit wherein zero probability of an alarm exists below RDA = 110 Bq and a probability of 1.00 exists above that value. What is suggested by Figure A-9 is that Type II alarms are minimized by operating a radiation monitor to alarm at $R_{A(MAX)}$ (fixed RDA) with the maximum reasonable count time.

The term F_S is derived using the methods discussed earlier. In any event, Equation 4, the Error Propagation formula, should be invoked and applied to all applicable variables.

Summary

As stated earlier, this document is primarily a presentation of methods of applying what has been derived before in the area of statistical theory. The methods explained here are intended to be used as tools for simplifying the task of performing radiological counting exercises. While this is far from an all-inclusive discourse on the subject, it is hoped that this discussion covers most of the aspects of radiation counting statistics that one is likely to encounter.

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Appendix B Procedures

General Notes

Due to the complexity of the PCM-2, it is not practical to describe each individual keystroke in this document. Refer to this manual before and during checkout for more specific instructions, particularly regarding the computer interface.

If checkout is to be performed at any location other than the Thermo Electron factory in Santa Fe, it will be necessary to adjust the detector voltage to something other than 1550 V. At altitudes lower than 6480 ft above sea level (ASL), a higher voltage potential is required.

Required Equipment

In order to perform this checkout, calibrated sources of alpha and beta radiation are required. These are to be large 100 cm^2 sources. The alpha source is to be Am^{241} and the beta source is to be Cs^{137}. Select an alpha source with 1.5–2.5 times the activity of the beta source.

Note The sources used at the end-use facility should be representative of the isotopes to be monitored.

- **A digital voltmeter with HV probe.**
- **100 cm^2 alpha and beta sources.**
- **Inspection mirror.**
- **Formatted 3½" floppy.**

Setup

Electrical Power

1. **Verify that the instrument is configured appropriately for local line voltage. If there is any question, remove the lower electronics enclosure cover and verify the switch setting on the computer power supply. The inspection mirror is required for this check.**

2. **Using the ohms section of the voltmeter, check for any shorts between +12 V and ground.**

3. **Turn on the instrument and verify that the PCM-2 main display is displayed on the LCD within 3–4 minutes.**

4. **Set up the computer configuration in CMOS memory as follows:**

   Drive A = 3½" 1.44 M floppy.

   Primary Master = Auto

   61,952 kB Extended Memory.

   Num Lock off.

5. **Using the digital voltmeter, verify that the 12-V power supply is between 11.5 and 12.5 V. This measurement should be taken between pins 1 and 3 on any modular detector board connector. If the connector is removed from the detector board to make the measurement, the parameters must again be downloaded to that detector after reconnecting.**

Counting Gas Supply

1. **If only one P-10 gas bottle is available, use a C " gas T fitting to connect both counting gas inputs to the regulator.**

2. **With the gas pressure set at 5 psi, adjust the needle valve to obtain a flow rate of approximately 800 ml / minute.**

3. **Pinch off either inlet hose and verify that the flow rate (if it changes at all) returns to the same value.**

4. **Release this hose, then pinch off the other inlet hose.**

5. **Verify that the flow returns to approximately 800 ml/minute after releasing the hose.**

6. **Purge the instrument for approximately 6 hours at 800 cc/min.**

7. **Reduce the flow rate to 200 ml/minute for the remainder of this checkout.**

Note If the instrument is configured with a gas manager, refer to the instructions for that option. Initiate an automatic purge for 360 minutes and then operate the instrument at 0.25" of water. ▲

Allowing the unit to purge overnight is a common practice which enables the remainder of the check out and calibration to be started early the next morning.

Set Computer Clock

Initialize the PCM-2's computer clock to the current date and time. The date and time are included in the final calibration report and then again in the data collected when the monitor is used.

Background Checks

After purging the detectors, edit the system override parameters to obtain an operating voltage of 1550 V (or the closest available increment). All other parameters should be left at their default settings.

Display the background averages screen and verify that none of the detectors are indicating high voltage or communications failures. Permit the instrument to accumulate background data for at least 15 minutes. After this time, there should be no channel failures of any sort indicated., indicating that there are no problems or defects in the modular detector boards, gas supply or detectors.

Source Plateaus

Select any two (or more) detectors. Generate source plateaus on each of the detectors from 1450–1750 V and verify that the plateaus are normal. Count times of 30 seconds per step should be used, The sources used are to be of an emission rate that 30 seconds is a reasonable time. Background subtraction should be selected using the data taken with the background plateaus. Select the high voltage appropriate for the elevation and download that high voltage to all channels.

Statistical Variance Test

Initiate a statistical variance test of 100 count cycles. Print the test results and verify that the variance / mean value for each detector is between 0.66 and 1.50. If any detectors are outside this range, repeat this test twice more (2 x 100 count cycles). Any detector which is out of range all three times is unacceptable and must be repaired or replaced.

Retain the variance test results as part of the checkout record for the instrument.

Optional

Storing the Calibration on a Floppy Disk

1. **Exit the PCM-2 program.**

2. **Insert the formatted floppy into Drive A.**

3. **At the "c:\pcm2" prompt, copy the all of the ".dat" files to the formatted floppy.**

4. **Check and verify the following files have been copied to the diskette:**

   PCM2CAL.DAT

   PCM2DET.DAT

   PCM2MESG.DAT

   PCM2SYS.DAT

   PCM2UTL.DAT

   PCM2ZONE.DAT.

Efficiencies and Shield Factors

Calibrate all detectors for alpha and beta efficiencies and shield factors per the following procedures. All alpha channels should have an efficiency of at least 12% 4 pi and all beta channels should have an efficiency of 16% 4 pi with the exception of the detectors in Table B-1. As each detector is calibrated, store the efficiency values.

Table B-1. Alpha and Beta Efficiency and Shield Factor Calibration Procedures for Detectors

Detector	Alpha	Alpha with the Rugged Foot Plate	Beta	Beta with the Rugged Foot Plate
29	12% 4pi	8%	14% 4 pi	10%
30	12% 4pi		14% 4 pi	

Efficiency Test

Detector efficiencies are determined by measuring calibrated sources and then dividing the measured count rates by the known activities of the sources.

1. **Select the efficiency calculation function.**

2. **Enter activities for the alpha and beta calibration sources.**

3. **Select a detector and channel to calibrate. The selected detector will acquire counts in the specified channel for the count time selected. When the count cycle is completed a new efficiency will be calculated and displayed on the Measured Efficiency line.**

4. **Press the F2 key to store the new efficiency. It is not automatically saved.**

5. **If desired, repeat the count cycle by pressing Enter.**

Shield Factors

Two count cycles must be performed. The first count cycle is performed with the unit unoccupied. The second count cycle is performed with a person in the unit in counting position. Shield factors are determined for all detectors simultaneously. Save them as a set. A count time of a minimum of 100 seconds will be used for this measurement.

Access Gate Test

If the access gate option is installed, perform two measurement cycles, one with a source, and one without a source.

The access gate should be locked during Background Update mode, Test mode, and at the beginning of a measurement cycle.

At the end of a clean measurement cycle, the access gate unlocks and the Exit screen is displayed. This condition remains until the user opens the gate and exits the unit. As soon as the gate closes, it locks and the unit resumes counting background.

At the end of a contaminated measurement cycle, the alarms are displayed. After the user presses Alarm Ack the unit resumes normal operation. The access gate never unlocks.

Test the emergency exit. Pressing the strip on the gate should unlock the gate, causing the alarm to sound.

Appendix C Sigma Factor and RDA Calculators

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Appendix D PCM-2 Revised Detector Assembly Procedure

P/N 11000A308

The insert which follows was the most recent version available at the time this manual was compiled. It is included in this manual as an example. Please check with your Thermo Electron customer service representative to see if a more recent version is available.

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Appendix E PCM-2 Detector High Voltage and Leak Test Procedure

P/N 10429A525

The insert which follows was the most recent version available at the time this manual was compiled. It is included in this manual as an example. Please check with your Thermo Electron customer service representative to see if a more recent version is available.

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