Section 11: Devtronics CMA2-D Servo Advanced Concept Scanners (ACS)

(Work Procedure 8)

Train Control Engineering
Defect Detector Work Procedure
Number 8

Equipment: Devtronics CMA-2D
Servo ACS Scanners

Purpose: Weekly, Monthly, Quarterly Tests as per Rule 27.0

WEEKLY

Test Equipment Needed: (See Figure 11-1)
Simpson 260
Fluke 27, 87, or equivalent
Soldering iron

Figure 11-1: Fluke meter, Simpson 260, and soldering iron

1. Give the entire detector location a good visual inspection. Check, tighten, and/or replace any loose bolts and broken parts on the transducers, scanner bases, deflector blocks, and dragger. Inspect the ground rods and connections, and replace or repair them to the CSX standard. (Refer to the *Signal Construction and Maintenance Standards* manual as shown in Figure 11-2.) Replace any badly damaged paddles on the dragger. Remove any debris or obstructions from the dragger. Check the dragger switch gasket to ensure that water is not getting into the switch contact.

Figure 11-2: Signal Construction and Maintenance Standards *manual*

Figure 11-3: Inspecting the ground rods and connections

2. Remove the scanner covers and clean out the inside of each scanner base using a soft brush. Clean the scanner lenses and mirrors by carefully washing off any dirt and grime using a spray bottle with clean water. Then finish cleaning them with a soft cloth. Do **NOT** clean with an ammonia-based product because it will damage the lenses. Check the proper operation of the scanner cover heaters and the shutter mechanisms. Replace the scanner covers and clean them with a cleaning solution. If the scanner covers are still dingy or dull, paint them aluminum to help reflect heat away from the scanner.

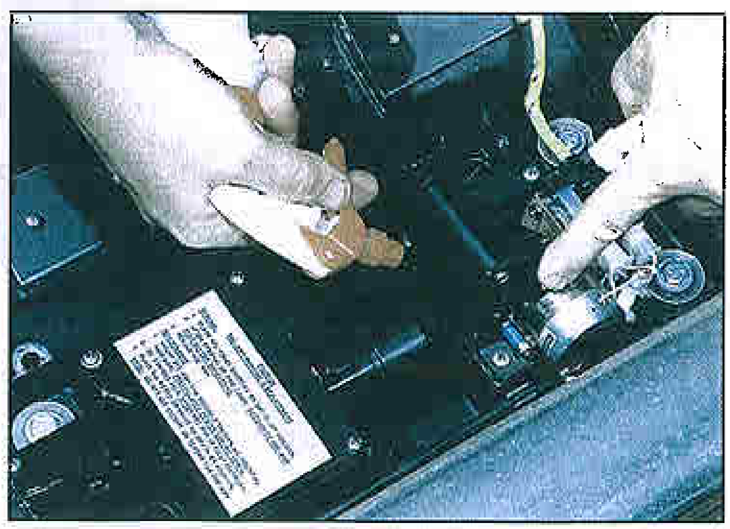


Figure 11-4: Cleaning the scanner lenses

3. On the CMA2-D, enter Train Data mode by doing the following:

   a. Press the CLEAR button. "Train Data" appears on the display.

   b. Press the ENTER button. "Print Trains" appears on the display.

   c. Press the SCROLL button. "Chart Trains" appears on the display.

   d. Press the ENTER button. The display gives the date and time of the trains in memory. Scroll through the trains and select one to plot on the data plotter.

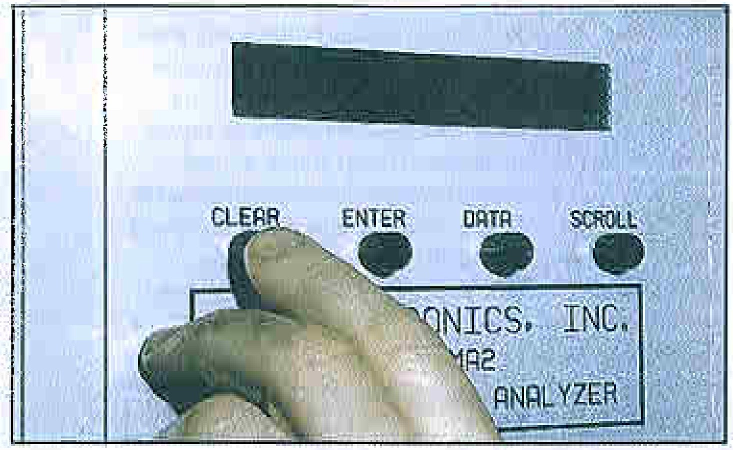


Figure 11-5: Charting the data

   e. Press the ENTER button for the selected train. The processor obtains the data from the RAM (random access memory) card to obtain the data for charting the train. Obtaining the data can take up to a minute before the plotting begins.

   f. Repeat this procedure for several trains.

4. Check the graph for proper gating, missing wheels, back gating, and normal heat levels of 5 to 6 mms. Check the pre-calibration and post-calibration heat levels as printed on the end of the tape for these trains. The minimum level for the pre-calibration is 60 counts; 150 counts is the minimum for the post-calibration.

   NOTE: Pre-cal and post-cal described in the video refer to pre-calibration and post-calibration.

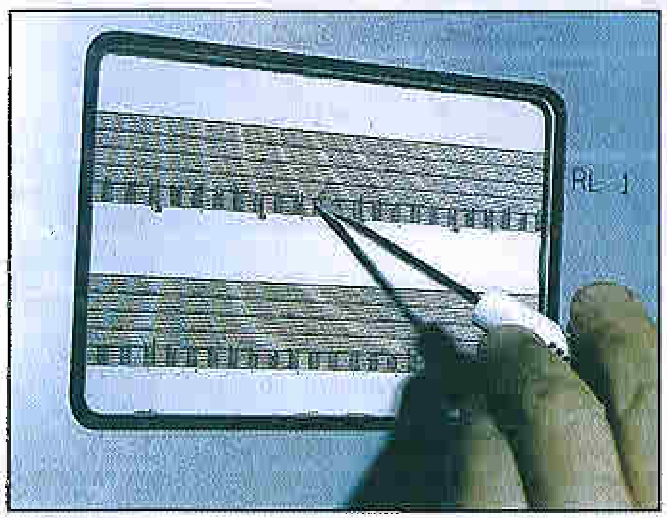


Figure 11-6: Checking the graph

5. Check the printer for proper operation. Replace the ribbon if necessary to make a good readable printout and check the paper supply. Date and initial the printouts and keep them for 30 days. Inspect the header information to be sure that it is correct, including the alarm levels. Look for maintenance notes and correct any problems indicated.

6. With the Simpson 260, the Fluke 27/87, or the equivalent, check and record in the log book the following voltages:

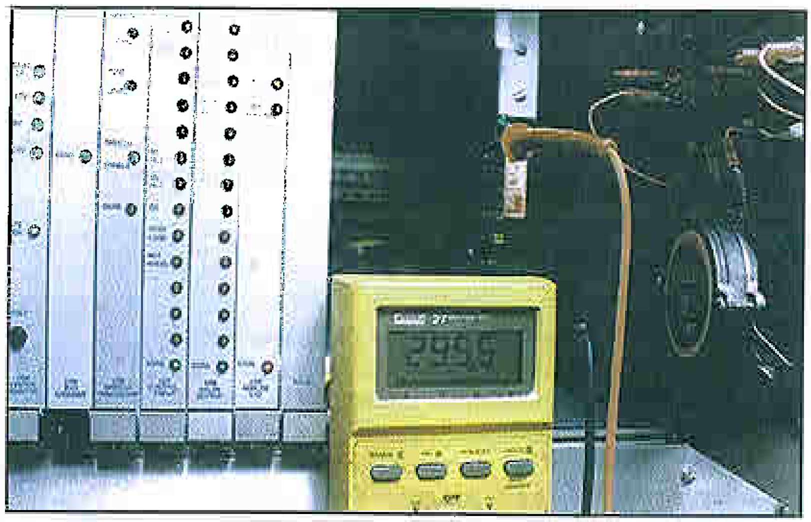


Figure 11-7: 1A17 power supply card

Module/System	Terminal	Voltage	Allowable Range
Unreg AC	LPC	115VAC	110V - 125VAC
Reg AC		115AC	115V-118VAC

Note: Turn off the AC power for the next test.

12V DC battery	battery		12V - 13.5VDC

NOTE: Restore the AC power.

1A17 power supply card	TP 1 (red)	+300VDC	295V - 305VDC
	TP 2 (blue)	-300VDC	-295V to -305VDC
	TP 3 (red)	+170VDC	165VDC - 175VDC
	TP 4 (red)	+200VDC	198VDC - 202VDC
	TP 5 (blue)	-200VDC	-198V to -202VDC
	TP 6 (red)	+15VDC	14.4V - 15.6VDC
	TP 7 (yel)	+6VDC	5.9V - 6.1VDC
	TP 8 (grn)	-6VDC	-5.9V to -6.1VDC
	Common (black)	Reference to the above voltages.	

7. Run a continuous roller bearing test using the test set and apply heat to each scanner using a heated soldering iron. Activate the dragging equipment device. The detector must announce correct locations of all detections, with proper graph and printer outputs. Be sure the correct side is announced.

8. Run a short test train using the test set and listen to the voice transmission on the vehicle radio to be sure that it is clear (not distorted) and has proper amplitude.

9. Put the test switches on the test set to 00 and turn the test set off. Be sure that the radio is on, sweep the floor, and lock the location.

MONTHLY

Additional Test Equipment Needed: Servo function simulator/generator
Thermometer

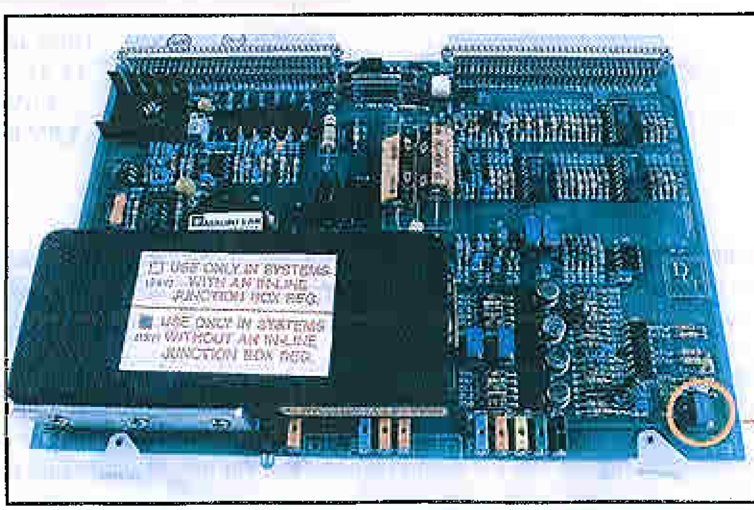
1. Perform the weekly tests.

2. Place the function simulator/generator outside in the shade for about 15 minutes to be sure that the reference chopper wheel is at ambient temperature. Determine the ambient temperature using a thermometer placed in the shade near the detector bungalow. Set the simulator/generator to 130 degrees above ambient and allow the simulator 5 minutes to stabilize and for the light to go out. (The generator will take about 15 minutes.) You now have about 15 minutes to do the calibration. If the calibration takes longer than 15 minutes, the simulator/generator must be turned off, placed in the shade, and allowed to cool before using it again.

Figure 11-8: Placing the function simulator/ generator in the shade

NOTE: The 200VDC bolometer bias voltage will vary with changes in ambient temperature surrounding the rail mounted scanners. Prior to calibrating, check and if neccessary, adjust this bias voltage to 200 ± 2V by adjusting R75 on 1A17 power supply. The power supply is located behind the CMA02 speaker panel.

Figure 11-9: Scanner 1A17 power supply module showing R75



R75

3. On the CMA2-D, enter Heat Calibration mode by doing the following:

    a. Press the CLEAR button. "Train Data" appears on the display.

    b. Press the SCROLL button. "Setup" appears on the display.

    c. Press the ENTER button. "Heat Cal to Display" appears on the display.

    d. Place the function simulator on the scanner cover saddle, rail 1.

    e. Press the ENTER button on the CMA2-D and turn the simulator/generator gate switch on.

    f. Calibrate RL1 to 130 counts at the low end of the function simulator cycle. "RL1 130" should appear on the display.

Calibration Pots

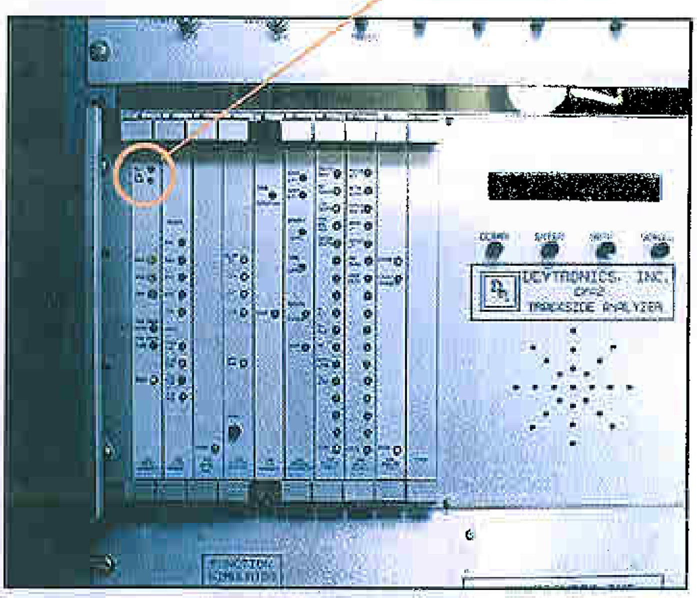


Figure 11-10: Rail 1 and Rail 2 calibration pots.

    g. Repeat this procedure for rail 2.

    h. Adjust the RL1 and RL2 potentiometers located on the 1A1 card, if necessary.

    i. Turn off the function simulator power and the gate switch. Unplug the simulator cable. Be sure to *press the RESET button on the 1A4 monitor board.*

    j. Run a continuous roller bearing test using the test set and apply heat to each scanner using a heated soldering iron. Activate the dragging equipment device. The detector must announce correct locations of all detections with proper graph and printer outputs.

QUARTERLY

Additional Tools Needed:
(See Figure 11-10)

Tape line
Servo alignment fixture 200099-81-X
Mirror cap
Appropriate hand tools

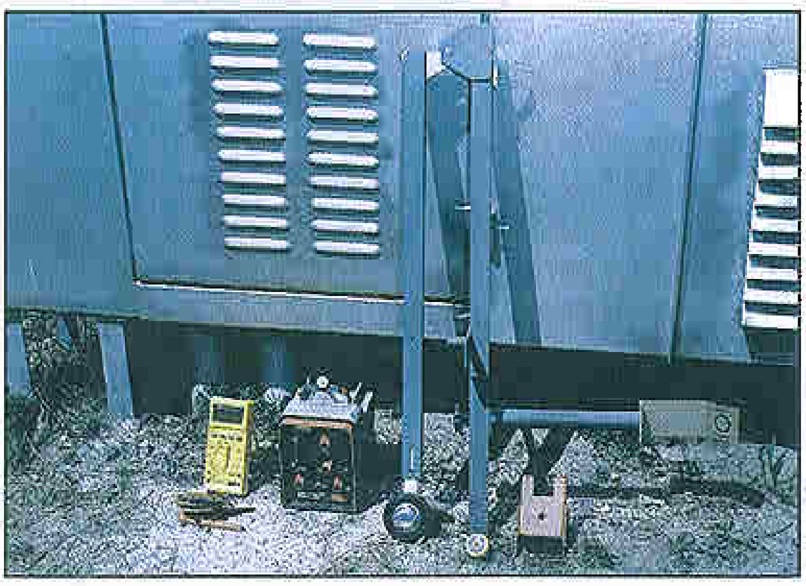


Figure 11-11: Meter, function simulator, alignment fixture, tape line, and mirror cap

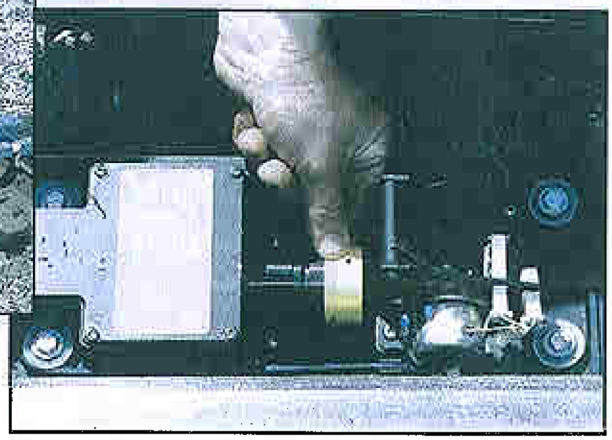
1. Perform the weekly and monthly tests.

2. Using a triangulation procedure, check to be sure the scanners are located squarely across from each other.

Figure 11-12: A maintainer using triangulation to ensure squaring of the scanners

3. Place the alignment fixture across the rails, approximately centered between the A and B transducers. Be sure that the alignment fixture is square with the rails. Remove the scanner cover and place a mirror cap on the scanner lens. Be sure that the cap is **squarely** seated against the end of the lens barrel.

Figure 11-14: Setting up the alignment fixture and lens cap



CAUTION: A small error here can cause a large alignment error.

4. Look through the peep hole in the target plate toward the scanner, and move the upright post left or right on the fixture bar as necessary to center the red dot in the circle. To lower the dot, move the fixture closer to the scanner. To raise the dot, move the fixture away from the scanner. After centering the red dot in the circle, observe where the index mark on the upright post is on the scale on the fixture bar. This dimension should be 7 inches plus or minus 1/4 inch. Change the scanner cant nuts, if necessary, to achieve this dimension. When you are finished, the fixture should be at the center of the A and B transducers, plus or minus 1 inch. Repeat for the other side. When you are finished, be sure to remove the mirror cap from the scanner lens.

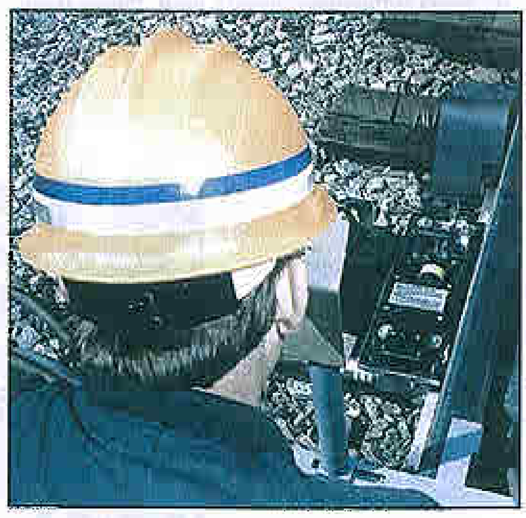


Figure 11-15: Looking through the peep hole to check the alignment

Figure 11-16: Adjusting to 7 inches ± 1/4 inch

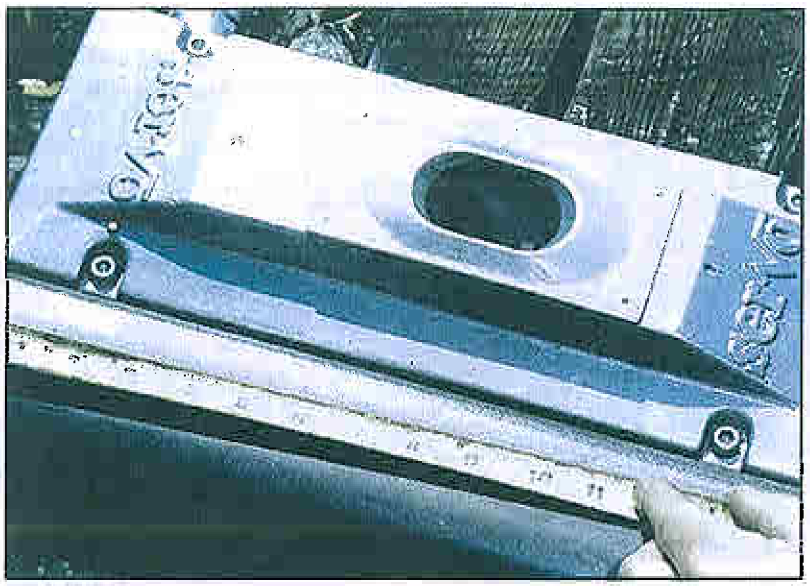


Figure 11-17: Measuring 8 inches from the center of the A transducer to the center of the scanner aperture

5. As a result of the previous step, the alignment fixture should now be centered between the A and B transducers. Measure from the center of the alignment fixture to the center of the A and B transducers. This dimension should be 12 inches, plus or minus one inch. If the transducers must be moved, the center of the A transducer should be 8 inches from the center of the scanner aperture. The center of the B transducer should be 24 inches from the center of the A transducer.

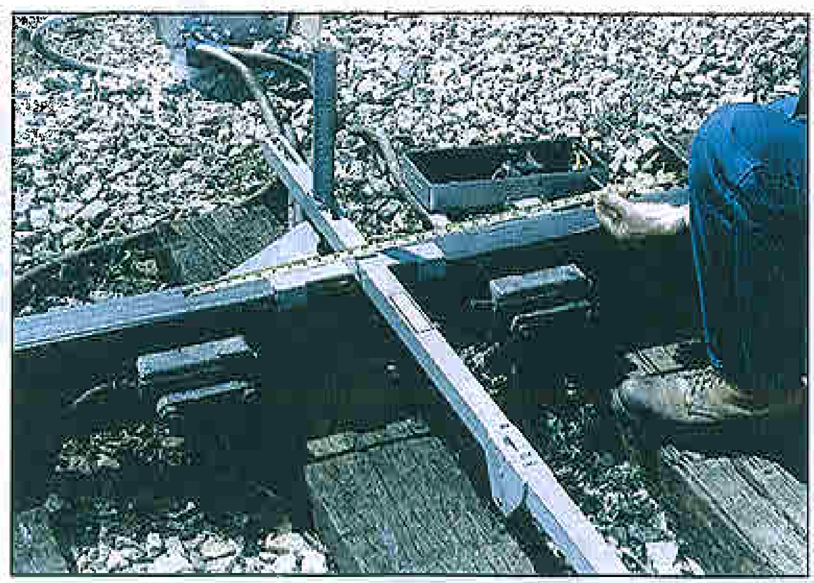


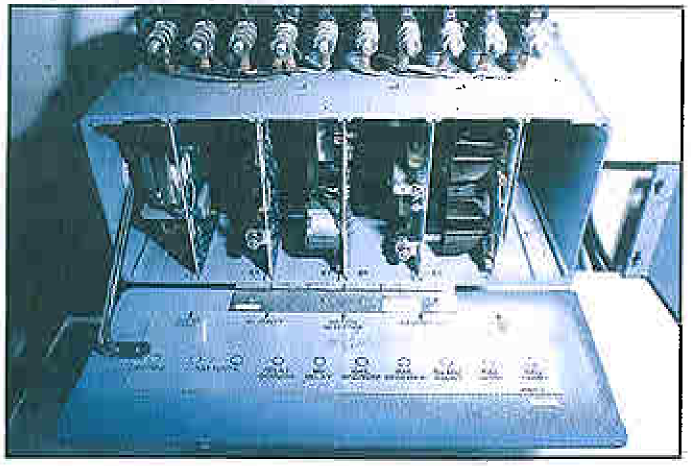
Figure 11-18: Measuring 24 unches between the A and B transducers

6. Check the Harmon 1140B Motion Detector by doing the following:

   a. Using the Simpson 260, Fluke 27/87, or equivalent, insert the positive lead into the red test jack on the motion detector module.

   b. Insert the black lead into the black test jack on the power amplifier card. The meter should read 200VDC ± 5VDC. Adjust the potentiometer on the transmitter board, if necessary, to obtain this reading.

   c. Set the island adjustment by placing a .06 ohm shunt 3 feet outside the receive track leads.



Firgure 11-19: Harmon 1140B Motion Detector front cover lowered

   d. Monitor the voltage across the island relay and adjust the receiver sensitivity potentiometer full clockwise. Voltage across the relay should read ± 1VDC of the battery supply voltage.

   e. Reduce the potentiometer slowly counterclockwise until the relay voltage drops to 0 volts.

   f. Tighten the lock nut.

   g. Remove the shunt and the relay should energize ± 1VDC of the battery supply voltage.

   h. Reset the CMA2-D by pushing the reset button on the 1A4 monitor board on the CMA2 front panel.

7. Measure the track gauge and check the surface of the track by observing the passing of a train. Notify proper authorities if the track conditions do not meet CSX standards.

Figure 11-20: A maintainer observing the surface of the track as a train passes and checking track gauge.

Devtronics CMA2-D
General Description

1.1 Introduction

The CMA2-D is a stand-alone microprocessor-based system designed to interface with existing trackside scanners and transducers. The CMA2 system performs heat analysis on the axle bearing temperatures of rolling stock.

In addition to heat analysis, the CMA2-D can be equipped to detect other trackside alarms and associates them with the closest axle to the alarm occurrence. These alarms can be applied singularly or in combination, depending on railroad specificatons.

Alarms include:
- Hot wheel
- High load
- Wide load
- Dragging equipment
- AC power off
- Outside air temperature sensing

1.2 Capabilities

The CMA2-D output includes:

- Data communication to a local data collection station
- Voice communication via radio to the train crew
- Digital data out to a local data/plotter recorder
- Printout to a local printer

When a train is on site, the CMA2-D system does the following:

- If a train arrives on site and there is a fatal system error pending, the system error voice message is sent.
- If an alarm is detected during train time, a warning tone is sounded.

After a train has departed from a site, the CMA2-D system does the following:

1. Voice communication begins.
   a. The site location is given by milepost.
   b. All defects are identified by axle count from either the head or the rear of the train.
   c. An analyzer failure voice message is sent for any major system error that occurs during train processing.

NOTE: See Appendix A of the CMA2-D manual for a detailed voice format.

2. Data/plotter chart recorder output begins.

   a. A data chart, using 25mm full scale, traces the digitized analog heat outputs. Tracings are reproduced that are proportional to the instantaneous speed of the train throughout train processing. If the peak heat for an axle is below a preselected pedestal mark, a pedestal is generated for chart tracing purposes.

   b. An event mark is provided for each defect that occurs, such as hot bearing, dragging equipment, and so on.

3. The following data is stored on the communication manager card:

   a. A summary of alarms or a "no defect" summary. Both summaries include:

      - Time and date the train entered the site
      - System errors detected
      - Length of the train
      - Number of axles counted

   b. For each car and engine (or engines) on the train:

      - Distance in inches between the center of the axles
      - Wheel gate duration (the elapsed time between Wheel Gate On to Wheel Gate Off)
      - Peak heat value of the scanned profile on each bearing

   c. A time and date stamp that includes all switch settings and parameters used in the processing of the train.

NOTE: If another train passes the site before the previous train's data is sent to the local data collection station, the previous train's data is stored in the extended RAM card. Train processing data for up to 150 trains can be stored in this card. This data is available to a local or central data collection station.

1.3 Configuration

The CMA2-D trackside analyzer is comprised of four principal units:

Unit 1	Mainframe
Unit 2	Rail panel interface
Unit 3	Rack-mounted test set
Unit 4	Data/plotter recorder

A. Unit 1

This unit contains all of the microprocessor buss-oriented subassemblies (printed circuit boards). It contains the basic processor mainframe (processor host motherboard); the +12V, -12V, and +5V, (1A12) processor power supplies; the + and - 200V bolometer bias supply, and the scanner pre-amp power supplies of +170V or (1A17 module), +24 (unit 6).

The motherboard hosts the following circuit boards:

Card	DWG Number	Description
1A1	CMA02-0634-11	Transducer/scanner interface card
1A2	CMA02-0695-11	Communication manager card
1A3	CMA02-0574-11	Extended RAM train storage
1A4	CMA02-0442-11A	System monitor card
1A5	CMA02-0450-11B	Input/output manager card
1A6	CMA02-0439-11	Speech processor card
1A7	CMA02-0451-11A	Digital input card
1A8	CMA02-0438-11A	Relay output card
1A9	CMA02-0696-11	Analog I/O card
1A10	Blank spare	Future assignment

The following assemblies are mainframe-mounted:

1A11	CMA02-0453-11	Display/speaker panel
1A12	CMA02-0444-11B	System power supply
1A13	CMA02-0443-11	Lightning protection board
1A14	CMA02-0456-11A	P2 motherboard
1A15	CMA02-0458-11B	Scanner lighting protection card with 6DB amps
1A16	CMA02-0462-11A	Relay control board
1A17	CMA02-0473-11C	Scanner power supply
1A18	CMA02-0460-11	Power supply P2 motherboard
1A19	CMA02-0461-11	Power supply P1 motherboard
1A20	CMA02-0560-11	Display panel I/O motherboard
1A21	CMA02-0565-11	Display panel TB/switch assembly

B. Unit 2

This unit contains the rail side interface and connection terminals. EDCO lightning protection devices for all transducers and external event monitor lines direct from rail side are protected by these devices.

C. Unit 3

This unit is a self-contained rack-mounted test set. It provides an independent external system approach to equipment testing. The unit is microprocessor-based and provides simulated train testing for extensive system performance checks and testing.

D. Unit 4

This unit is a digital data/plotter type recorder that is used to display analog heat pulses and annotate alphanumeric data directly onto the same chart paper.

1.4 Specifications

Operating environment:
-25 to +70 degrees Centigrade
5 to 95 percent relative humidity without condensation

Power consumption:
15 watts max at 24VDC
115V AC 60 Hz ± 5 percent

1.5 Module Descriptions

A. Scanner Interface Module - 1A1 Card

Function: Serves as a direct interface to trackside scanners, wheel pickup transducers, and approach track circuit or approach transducers. Provides analog heat signal conditioning and processing. Converts analog heat signals to digital, and then the digital signal processes heat signals for alarm conditions. Outputs processed train data for both digital transmission to a central location and for storage in the extended RAM storage buffer.

Scope: Provides an interface to Servo Models 7621/7707, 8808/8909, and ACS.

Transducers: Provides true "zero crossing" detection for Servo, GRS, and Harmon/GE wheel pickup transducers with direct interface. Minimum threshold detection is 500 millivolts with a 20,000 amp surge input lightning protection.

Heat Signal: Receives an input voltage level from scanner output for 130 degrees over ambient:

Minimum level	100 millivolts
Maximum level	300 millivolts
Impedance loading	3.9 megohms / 100 Pfd.

B. Communication Manager Module - 1A2 Card

Function: Manages digital communications between the field unit and a central data link, digital communications to a local page printer, and digital communications to a local smart terminal, such as a laptop PC. Invokes all communication protocols and maintains an error detecting link with central for block recall in the event of block error fault reception at central, or other error conditions.

Scope: Provides three RS232C serial interface ports on the mainframe for communication as described above.

Output: Meets RS232C specifications for serial communication ports.

C. Extended RAM Module - 1A3 Card

Function: Provides a mass storage buffer for extended train data. Operates in a rotating buffer fashion so that when it is full, the current train overwrites the oldest train. The buffer provides storage so that when the central communication link is inoperative, trackside train processing proceeds normally while storing current train data. Subsequent restoration of the communication link will provide automatic download from the field unit to the central for all buffered trains not held in the central directory.

Scope: Interfaces to the internal processor buss to handle the mass storage of train data.

Capacity: 1 megabyte of CMOS static RAM (onboard battery backed). Can store 100 trains that have 980 axles per train.

Output: Outputs formatted train data storage through the communication manager module and the appropriate RS232 serial port.

D. System Monitor Module - 1A4 Card

Function: Monitors the system power supply voltages. Contains a global watchdog timer and provides a front panel system reset function. If the 12 volt supplies drift out of tolerance by ± 10 percent, a system integrity failure is reported to central. If the program path is disrupted by some inadvertent disturbance, the global watchdog timer performs an automatic system reset after a predetermined time delay to force the equipment into the correct operations configuration.

Scope: Monitors the relay 12 volts, analog + and - 12 volts, and system logic +5 volt supplies. Provides a manual or an automatic system reset function.

Output: Generates a system Power Failure error if the 12 volt supplies are out of tolerance. Reports the power failure to central and initiates a system Integrity Failure message via voice output to the train crew over a local radio link.

E. I/O Manager Module - 1A5 Card

Function:	Manages vocal enunciation and discrete inputs, such as dragging equipment, high load, wide load, hot wheel, loose wheel, and so on. Manages analog input/output functions and controls all relay output functions. Also manages the front panel display for all setup functions, as well as the normal date and time display.
Scope:	Provides for the adjustment of all selectable parameters, such as heat processing alarm levels, transducer spacing for speed calibration, and so on. Provides a setup menu for field calibration with the heat function simulator and other equipment. Provides control of all output relays. Provides management of speech operation and vocalization to train crews by radio. Provides management of all external alarm inputs from dragging equipment, high load, wide load, hot wheel, loose wheel, and AC power loss alarm inputs. Provides all analog input management, such as the external ambient temperature sensing probe. Provides digital-to-analog function management for analog chart reproduction output.
Output:	Generates output via the internal buss to appropriate functions.

F. Speech Processor Module - 1A6 Card

Function:	Provides EPROM storage of digitized voice vocabulary. Provides speech processing for the vocal recovery of stored vocabulary.	
Scope:	Provides speech output for the local monitor speaker, an audio drive for radio input, and an output for a dispatcher's phone line. Also provides an alarm warning tone.	
Output:	Audio output to local speaker	8 ohms
	Audio output to radio	0 to 1 volt adjustable into 600 ohms
	Audio output to dispatcher	0 to 1 volt adjustable into 600 ohms

G. Discrete Input Module - 1A7 Card

Function:	Accepts discrete input functions, such as dry relay or switch contacts. May also be configured to accept voltage inputs ranging from 6 to 24VDC.
Scope:	Accepts alarm inputs from dragging equipment switch contacts, high load, wide load, loose wheel, and AC power monitor relay contacts. Accepts a radio busy input from the radio squelch circuit relay contact. Accepts a power monitor input from the system monitor and the bolometer bias power supply functions.
Input:	Dry relay, switch contacts, or voltage level 6 to 24VDC.
Capacity:	Provides for 16 discrete input functions. Approximately 8 are in normal usage.

H. Relay Output Module - 1A8 Card

Function:	Provides dry relay contacts to control external devices and equipment.
Scope:	Provides radio keying, chart recorder or external equipment start-up, radio request for double-track radio handshaking, post integrity check initiation, pre-integrity check initiation, and external defect light and/or external site integrity light.
Output:	Dry relay contacts rated at 2 amps at 250VAC maximum.
Capacity:	Provides for 16 control relay contacts. Approximately 8 are in normal usage.

I. Analog I/O Module - 1A9 Card

Function:	Accepts analog input functions to be digitized and processes the digitized data. Provides analog output functions recovered from a digitized database.
Scope:	Accepts a temperature probe input for outside air temperature monitoring. May be set up to accept other environmental sensor inputs such as wind direction, speed, precipitation, and so on. Provides an analog trace output for axle bearing heats for rail 1 and rail 2 outputs for the external chart recorder.
Inputs:	Analog input functions adjustable from 0 to 50V input levels.
Output:	Analog output levels 0 to 5V maximum.
Capacity:	Accepts 8 analog inputs and provides for 4 analog outputs.

CMA2 -D

Parts Identification

Test Set Panel

Trackside Analyzer

Function Simulator Input Panel

AAR Term I/O to Railside Cables

Strip Chart Recorder

Printer and Printer Shelf

12 VDC to 115 VAC Converter

Figure 11-21: CMA2-D system layout

CMA2 -D

Parts Identification

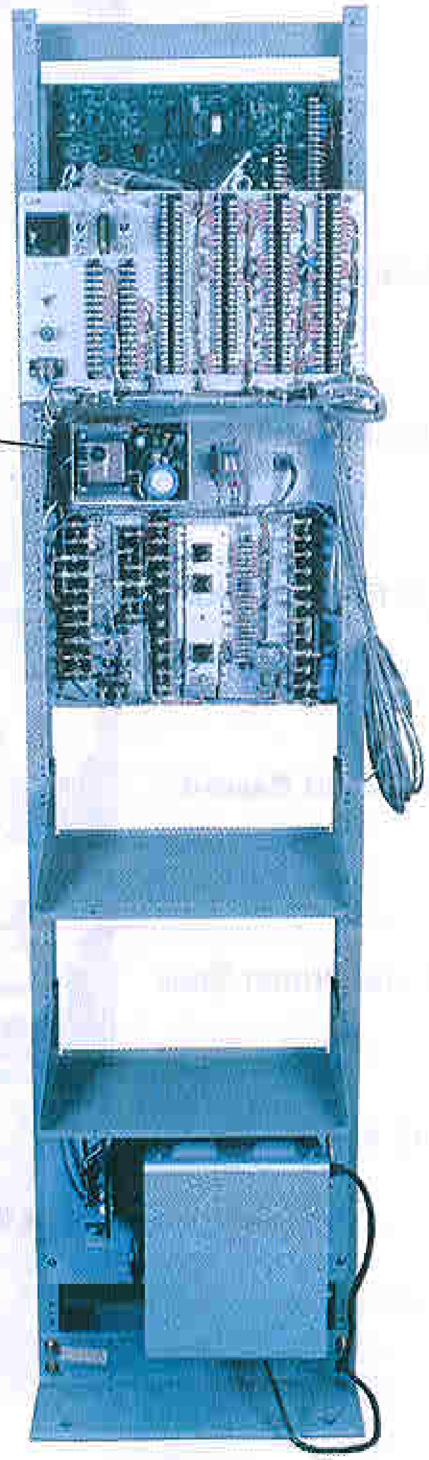
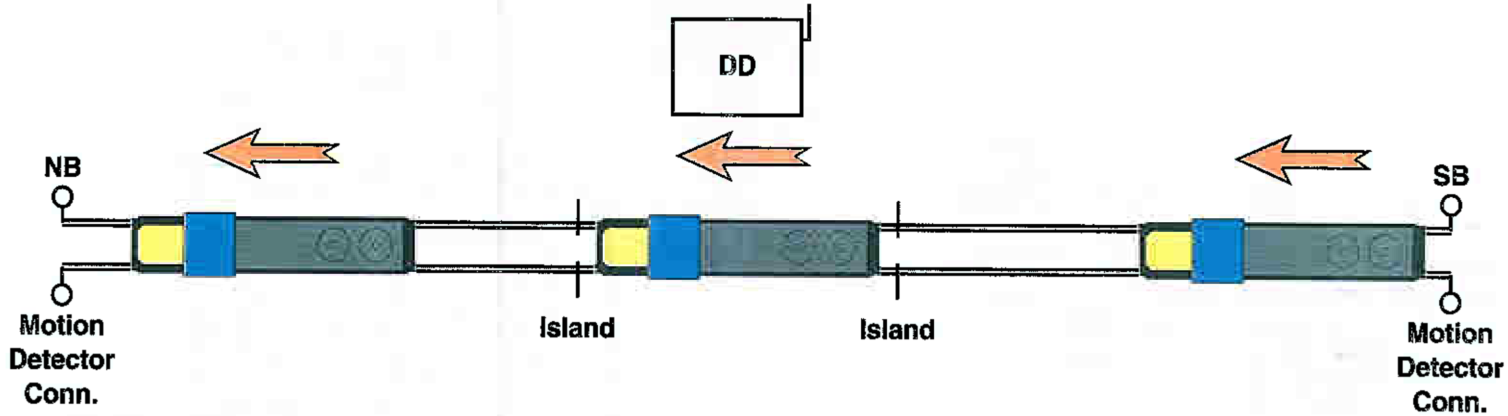


Figure 11-22: CMA2-D rear view

CMA2 Basic Operation/Train Movement Chart



OFFSITE

Island relay picks post integrity test

Scanner shutter closes

Motion detector picks

CPU processing completed

Annunciation of data to the train via radio and to local speaker (No defects, defects, site, speed, axles, etc.)
Stores data
Prints data
Graphs data

ISLAND

Island relay drops

Scanner shutter opens

Train occupies first wheelgate transducer establish direction

HEAT information gated to CPU

CPU processing of data

Stores and computes data for output

APPROACH

Motion detector activated

White light illuminates

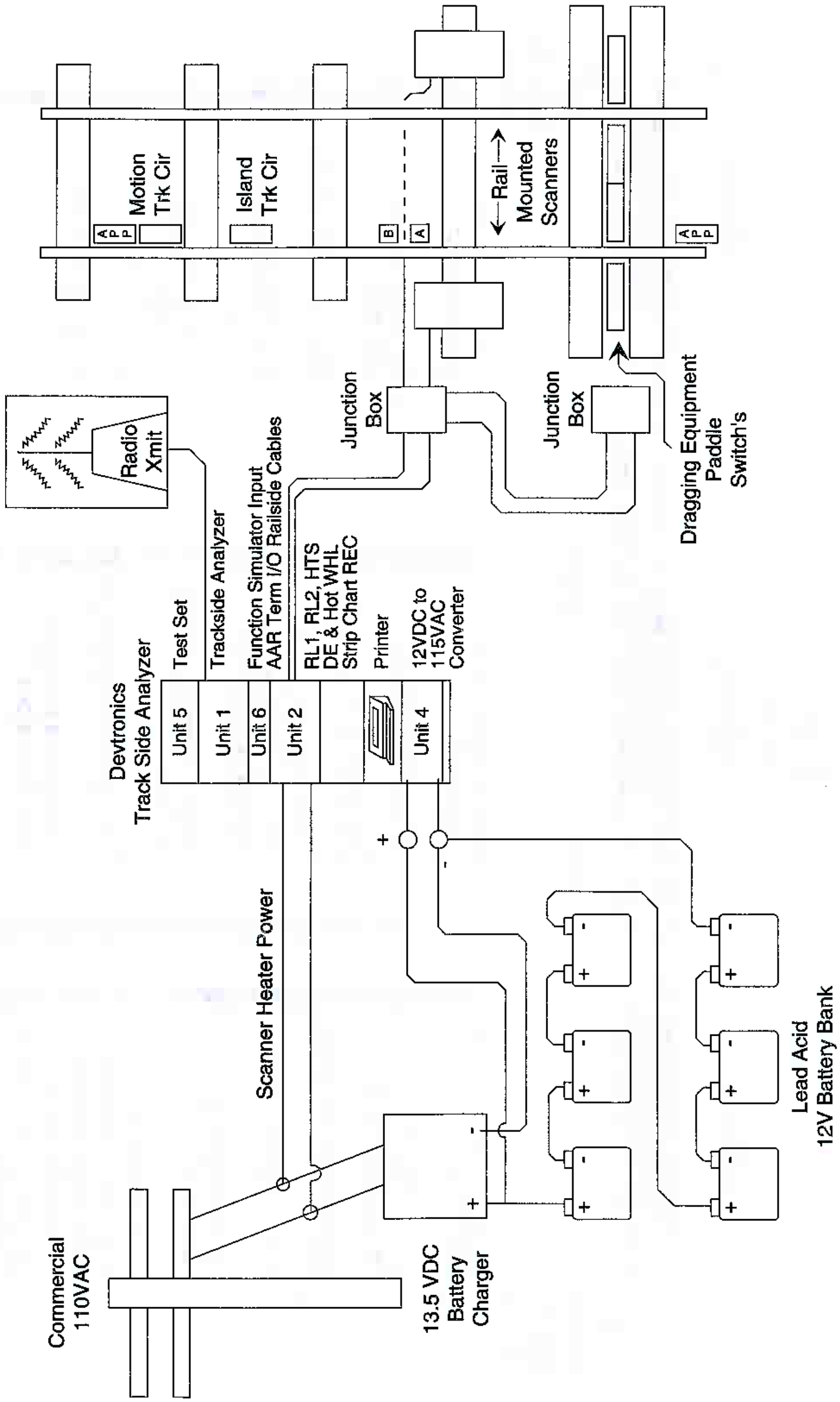
Greeting message begins

(CSX equipment defect detector mile post ___.)

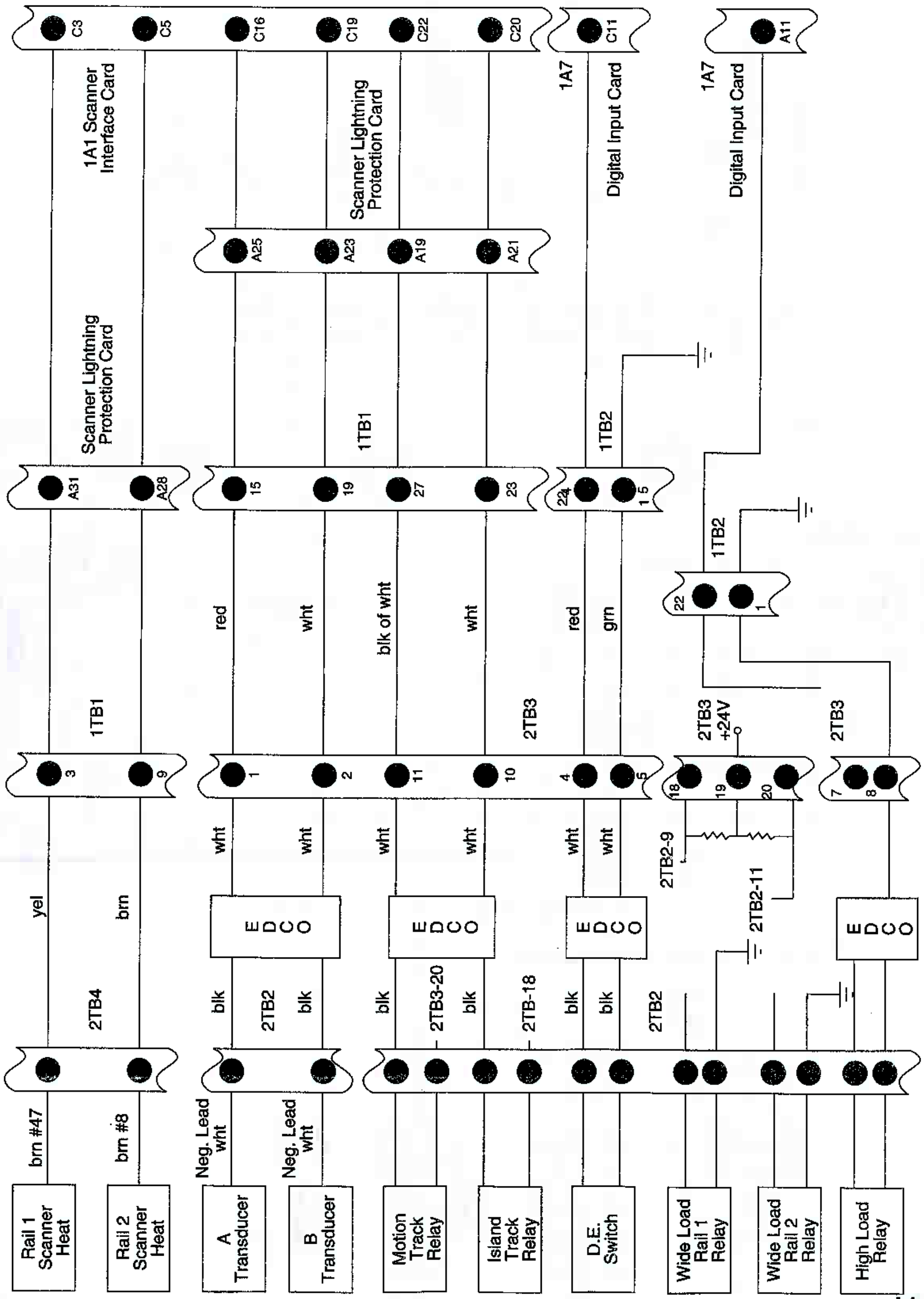
Pre integrity test

NOTE: Motion detector circuitry allows train stop and start on site.
If the motion detector is not functional, the system will operate with island only, but without pre integrity and stop and start feature.

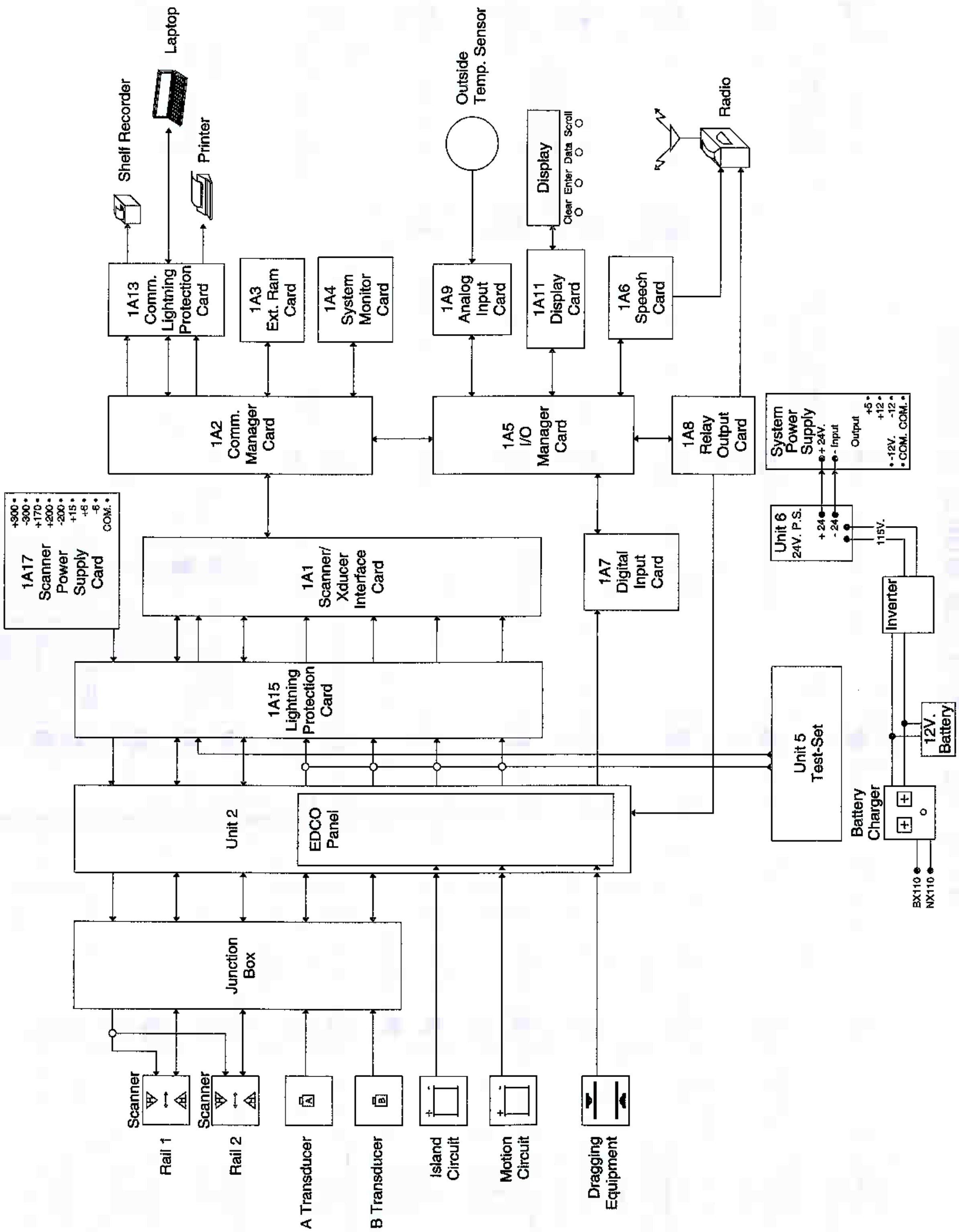
Devtronics CMA2 -D Block Diagram Overview



CMA02 Simplified Block Diagram

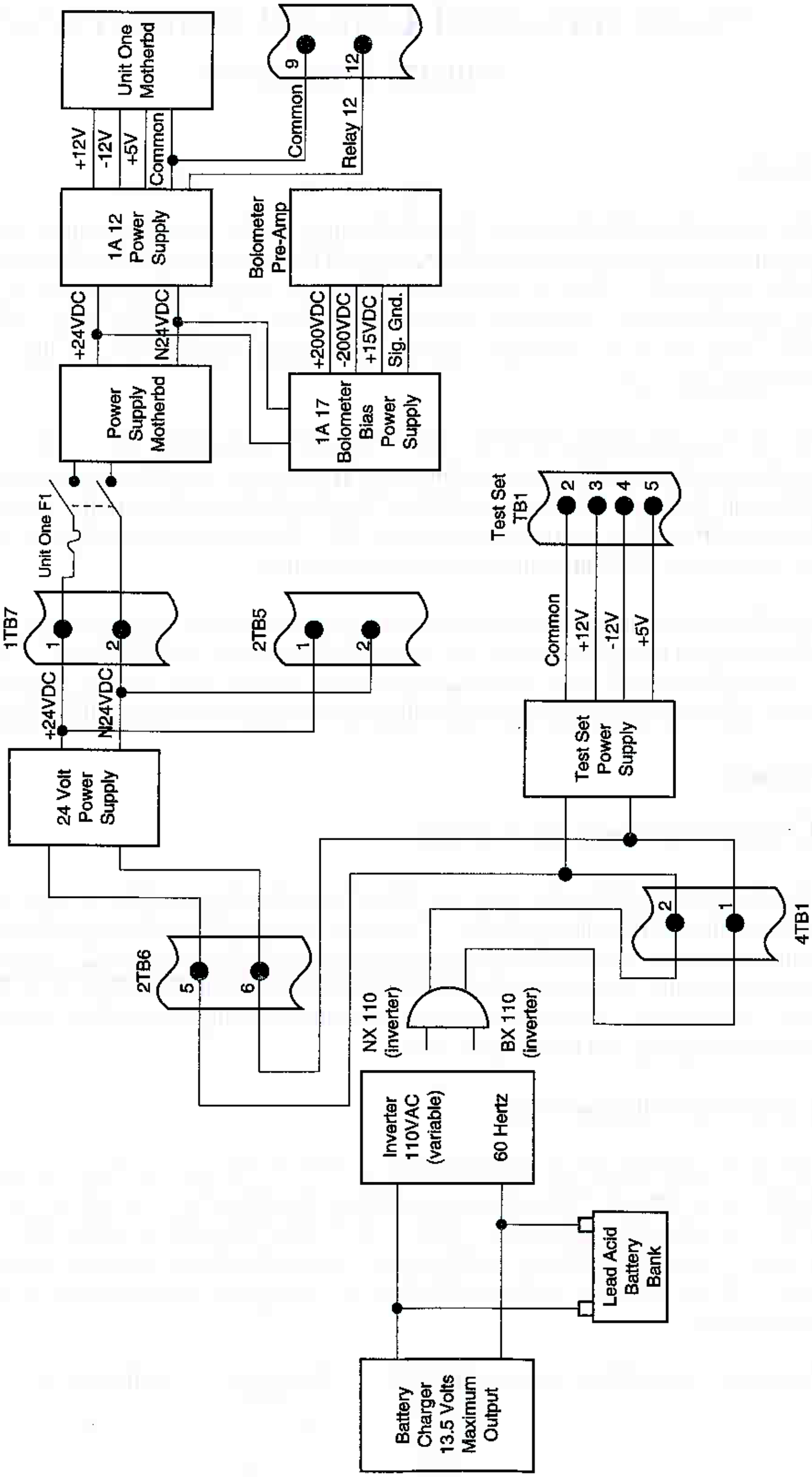


CMA2 Block Diagram at Defect Detector M.P.



Perry Power Supply Block Diagram

Servo Advanced Concept Scanner (ACS)



Servo Advanced Concept Scanner (ACS)
General Description

1.1 Scanner

The Servo (Phase II) Advanced Concept Scanner (ACS) is used in conjunction with trackside and wayside equipment for Hot Box Detector and Hot Box Detective Systems manufactured by the Servo Corporation. The ACS is a new lightweight, simplified, compact design scanner that is capable of viewing a variety of roller and plain bearing assemblies. Secured to the rail using the ISO-Clamp shock and vibration assembly, the scanner mounts closer to the rail for improved scanning performance.

The ACS can be configured with either a standard Germanium lens or a short focal length Germanium lens. Both lenses are functionally the same; the differences exist only in the lens mounting and in the lens target diagram. The standard lens has a target diameter of 1"; the short focal length lens has a target diameter of 1-1/2". Two scanners are required for each train inspection site. CSX presently uses the standard lens.

The Advanced Concept Scanner has fewer components than other scanners, which improves reliability and ease of maintenance. The ACS has the following features: a new Cant Cam clamp, a removable scanner cable with positive locking for the connector, an improved optic system with rotary lens focusing, a new aperture shutter mechanism, and replaceable cover heaters.

1.2 Features

A. ISO-Clamp/Cant Cam Assembly

The ACS mounts to the rail using the ISO-Clamp shock and vibration assembly, which allows for rapid rail-to-rail interchangeability. The newly designed Cant Cam simplifies rail cant angle adjustments; the 6-position Cant Cam offers accurate alignment in 1/2° increments. The ISO-Clamp assembly establishes a fixed relationship between the bearing target, the scanner, and the gating transducers. This assures increased scanning/gating accuracy by eliminating the effects of rail run, pumping, and foundation settling.

B. Removable Scanner Cable

The ACS cable allows for disconnections from the scanner in the field, without removing the scanner from the rail. The connector is tamper-resistant due to a positive locking feature that is accessible only when the scanner cover is removed. The cable can be replaced without unsoldering terminal connections. Scanner cable orientation can be changed easily for rail-to-rail interchange ability. Refer to the *Servo Phase II Advanced Concept Scanner Installation* instructions for more information.

The cable is available in standard 15', 35', and 65' lengths, as well as in customized lengths.

C. Optic System and Aperture Shutter Mechanism

A positive rotary lens focusing technique has been implemented, which allows optimum lens adjustment to be quickly achieved.

The aperture shutter mechanism features a fast flap-type self-locking unit that incorporates an integrity heater on the shutter flap. The mechanism is mounted directly on the scanner housing for ease of maintenance.

D. Scanner Cover Heaters

Removable scanner cover heaters minimize moisture accumulations and reduce the build-up of snow and ice on the scanner cover and around the aperture shutter mechanism. Each scanner cover heater uses 175 watts, for a total of 350 watts. The removable heaters are easily replaced, which minimizes maintenance time and costs. (The thermostat closes at 80° and opens at 100° F.)

Servo Advanced Concept Scanner (ACS)

Parts Identification

Figure 11-23: Scanner adjustment (cant nut)

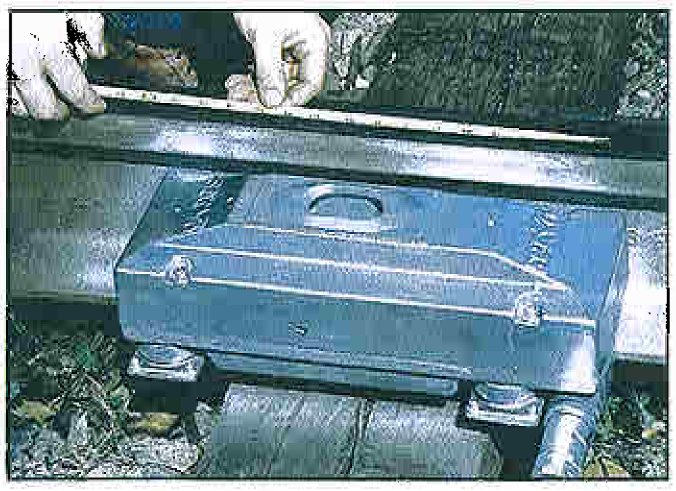


Figure 11-24: Servo Advanced Concept Scanner

Figure 11-25: Typical ACS track layout

Servo Advanced Concept Scanner (ACS)
Parts Identification

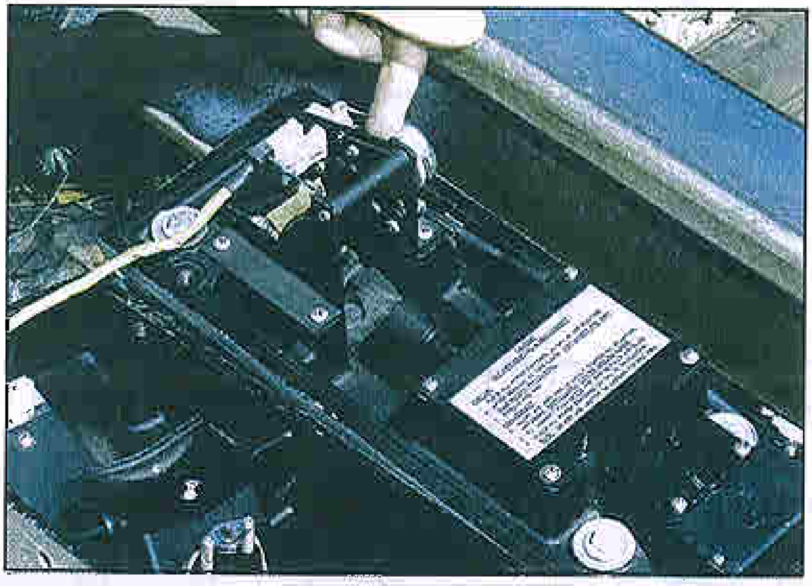


Figure 11-26: ACS scanner base

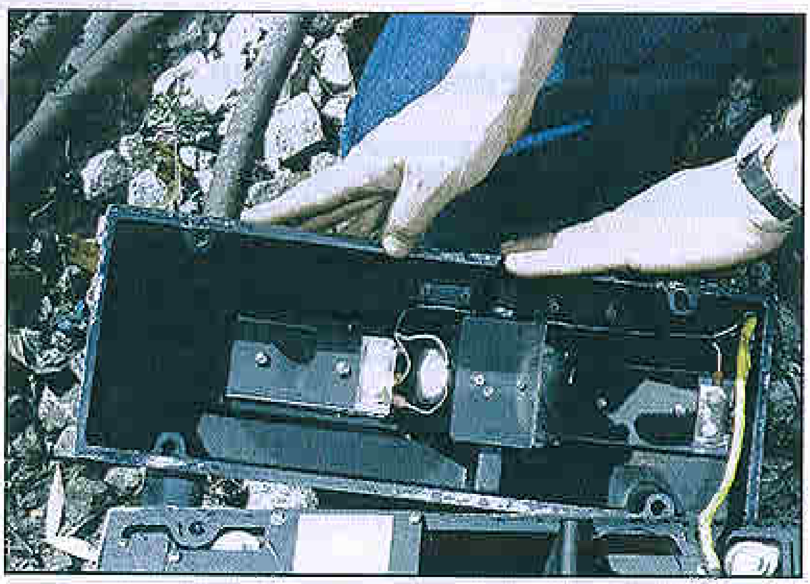


Figure 11-27: ACS scanner cover

Servo Advanced Concept Scanner (ACS)

Scanner Adjustment

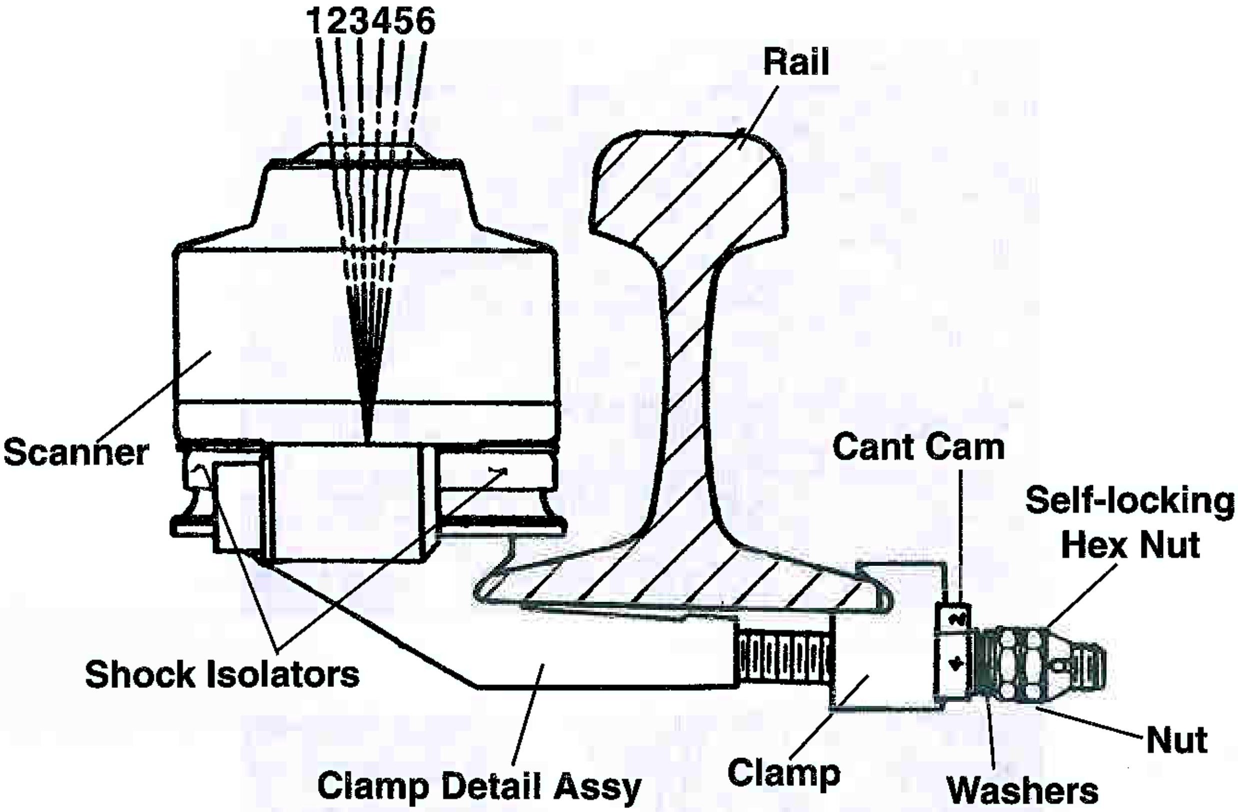
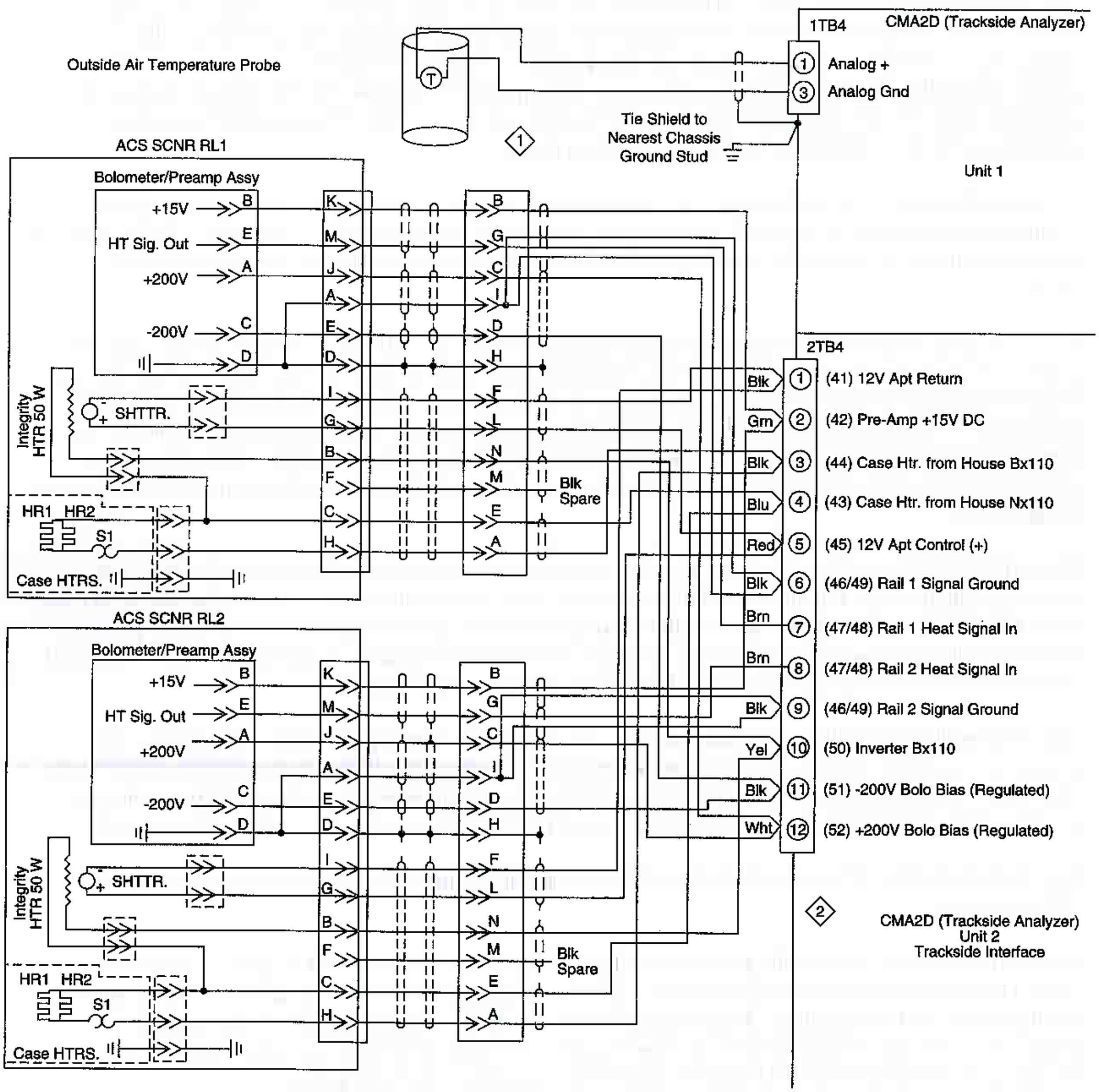


Table 1			
Rail		Cant Cam Nut Number	
	1/40 Cant	1/40 Cant	1/40 Cant
115 lb.	4	2	6
132 lb., 136 lb., 140 lb.	6	4	
155 lb.	6	4	

NOTE: Cant nut numbers given are to be used as a starting point only. Actual numbers after alignment will vary.

Servo Advanced Concept Scanner (ACS)

Schematic Rail 1 Scanner



Harmon Model 1140B/1141B Motion Detectors

General Description

1. The Harmon Model 1140B and 1141B Motion Detectors are designed for use as restart circuits in conjunction with Harmon AFTAC or existing track circuit systems in grade crossing protection applications. The device detects the decreasing level of its transmitted signal in the rail caused by the circuit shortening effect of the approaching train. The motion detector is sensitive enough to provide detection when the rate of signal level decrease reaches .1 db per second. Therefore, the detection distance of the motion detector is a function of train speed.

   Detection distance is relatively stable over a wide range of varying ballast conditions, but it will be reduced in instances of very poor ballast resistance and other heavy track load conditions. Under nominal conditions, the motion detector should provide 25 seconds or more warning time at train speeds to 35 m.p.h.

   Channels are provided in the frequency spectrum from .5 KHz to 10.2KHz. Detection distances under good track conditions may be expected to 2,500 feet up to 4 KHz for fast-moving trains. Slow-moving trains will be provided about 25 seconds warning time, but an appropriately shorter detection distance will result. Channels above 3.5 KHz are attenuated more and provide shorter detection distances. The higher frequencies may be employed when it is desired to limit the "look" distance of the unit. Since track conditions affect the distance capability, the chart in the specification section may be used only as a rough guide.

   Since the motion detector will not sense a slow-moving train until it is relatively close for 25 seconds warning time, time-out circuits should be planned for track circuits in which slow-moving trains may stop prior to initial detection. If the train continues to approach the motion detector at the reduced speed (or after a stop and subsequent acceleration), it will be "reacquired" by the motion detector when its speed is such that the decreasing signal level rate reaches the pre-set sensitivity level.

2. The motion detector contains an island circuit that is adjustable from a point about 10 feet from the points of coupling to the rail to its maximum distance. The "ring-by" of the island circuit is about 5 feet. The motion detector also contains a positive island circuit, which, when employed, provides a failsafe island section. If the positive island circuit is used, two 1,000 ohm neutral relays must also be used.

3. The motion sensing circuit relay output is redundant and is fed in series through two mercury-wetted relay contacts.

4. The motion detector, beyond the established island circuit, does not have built-in protection against either an open rail or a shorted rail situation. To provide this safety feature, an AFTAC or other wrap around circuit is recommended. The circuit should be set up to withhold control of the crossing protection relays until the motion detector has acquired the train. (See the schematic drawing section in the *Harmon Model 1140B/1141B Motion Detector* manual for sample relay logic.)

5. The unit operates on any stable nominal 12VDC (10.5 to 14VDC) externally provided power source and contains internal regulation, a rectifier surge protection panel, and 230VDC gas gap discharge devices across connections to the rail for protection against external overvoltages to a front steepness of up to

5 KV per microsecond (5,000 amps over 20 microseconds). The unit draws approximately 1 amp (2 ohm load).

6. The relay output power provides about 12VDC to a 500 ohm relay if the battery source is 12VDC. If the battery source is less than 12VDC and the relay is less than 500 ohm (or two 1,000 ohm if the positive island circuit is used), then the relay output will be proportionately lower than 12 volts.

7. Both the transmitter section and receiver section connections to the rail must be made through railroad provided external lightning protection devices. (An equalizer and two heavy-duty arrestors for both sets of leads.)

   CAUTION: Polystyrene capacitors are used in the motion detector for frequency stability; therefore, it should not be subjected to temperatures over 160 degrees F.

8. When insulated joints exist within the desired track circuit, series-tuned coupling units are available for by-passing the insulated joints.

9. If the motion detector is connected to the rail employing the same leads as the battery of a DC track circuit, a reactor must be placed in series with one of the battery leads and rail (not between the motion detector and the rail). The reactor reluctance should be 10 ohms or higher at the motion detector frequency.

10. Typical circuit block diagrams appear in the schematic section of the *Harmon Model 1140B/1141B Motion Detector manual.*

11. When the motion detector is employed on a rusty rail, a time constant prevents the premature release of crossing protection that would be created by a train moving from shiny to rusty rail within the motion detector limits. It should be noted that this time constant also provides some false activation of crossing protection if transient shorts are experienced. The time constant is by-passed within the island circuit limits so that excessive "ring-by" does not occur. Unless otherwise specified, the time constant is approximately 15 ± 5 seconds. If it is desired to reduce the loss of shunt pickup delay, replace the 2mfd capacitor C8 on the motion detector (124B-1) module. Note that .68mfd provides about 8 seconds and .33mfd provides about 3 seconds. Due to inherent circuitry delays, a lower pickup delay cannot be obtained.

   NOTE: The motion detector contains mercury-wetted relays mounted on the surge panel; therefore, the cabinet should be mounted in a horizontal position.

12. Since the motion detector senses decreases in its own signal level strength in the rail, it is also sensitive to power source fluctuations and inductively induced spikes. Momentary power source drops exceeding .5V DC cause the motion detector to "drop out." For this reason, surge suppressors should be provided in any circuit that draws any appreciable load, and a suitable reactor/capacitor should be provided in DC power leads to the motion detector.

   The 1141A Motion Detector has a frequency modulated transmitter module (121A-7) for use as a transmitter with an FM AFTAC Receiver. The lowest modulating rate (Subtone A - 1OHz) cannot be used in the 1141A motion detector. Subtones B through F (16-84 Hz) may be utilized without detrimental effects.

INSTALLATION

1. Mount the cabinet in the physical location.

2. Attach the physical ground to the GND terminal.

3. Make rail connections (after lightning protection) to four rail terminals. (Two for the transmitter and two for the receiver). To effectively define the center of the crossing, connect the transmitter and receiver on opposite sides of the crossing.

   NOTE: If the same leads are used for the DC track circuit connections, a reactor unit must be in one of the battery leads so that the battery will not present a "short" to the motion detector. Connect the motion detector leads between the reactor and rail.

4. If the motion detector is to be used beyond the limits of existing insulating joints, by-pass coupling units must be installed between the insulated joint connections.

5. Observing polarity, connect the (-) and (+) terminals to the 12VDC power source. Internal regulating is provided in the motion detector, and proper operation may be obtained from any stable 10 to 14VDC external power. Power below 12VDC, of necessity, results in reduced transmitter output and/or receiver relay output.

6. To adjust the motion detector transmitter output power, insert a voltmeter (250V scale) positive lead in the red test jack on the motion detector module, and insert the negative lead in the black test jack on the power amplifier. Turn the transmitter potentiometer and adjust for 200VDC. This setting is the optimum transmitter output power and motion detecting sensing level. Lower levels may be used with slightly reduced sensitivity when the circuit is artificially shortened by a hardwire shunt. Tighten the lock nut. This should provide voltage on the test point of 200V ± 5V, and the voltage level on the rail will be 0db ± 5db.

7. Check the island circuit "ring-by" with a .06 ohm shunt. Under favorable ballast conditions, it should be 3 to 5 feet beyond the point of shunt connection during adjustment.

8. When the motion detector transmitter is used to activate a receiver at an adjacent location and additional power to the rails is required due to low ballast conditions, the following procedure may be used:

   a. Increase the transmitter output by turning the potentiometer R5 clockwise to the desired output level.

   b. Record this level for future adjustments. If a frequency selective voltmeter is not available, remove the track leads from the transmitter output, terminate the output with a 2 ohm load, and record the output level.

   c. Place a DC voltmeter across the 200V test point and ground on the motion detector module. Reduce the input by turning the potentiometer R1 counterclockwise until the meter reads 200VDC.

   NOTE: This procedure is applicable only on the Model 124B-1 Motion Detector module. The earlier versions do not have the input adjustment available.

Island Circuit Adjustment

1. Connect the voltmeter across the "relay" terminals, with the relay connected.

2. Connect an .06 ohm shunt across the rails at a point 3 feet beyond the desired island distance (i. e., for a 100 foot island circuit, 53 feet from the center of the crossing). Only a C clamp type rail connection should be used on the shunt. A poor shunt means a long island during train passage.

   NOTE: The island circuit should extend at least 3 feet beyond the motion detector rail connections.

   If the ballast conditions are low or questionable, connect the shunt across the rails ten feet beyond the desired island circuit distance. (This will result in somewhat longer "ring-by," i. e., 25 to 30 feet from island limit.) If the rails are rusty, it would be best to use an engine to set the island and monitor the rail with AC VTVM.

3. Observing the relay voltage on the meter, adjust the receiver sensitivity potentiometer (lower front section on the receiver printed circuit board) full clockwise (full turn of the pot to the right). The voltage across the relay should read battery supply voltage. Reduce the potentiometer slowly counterclockwise until the relay voltage drops to 0 volts. Tighten the lock nut.

4. Remove the shunt. The relay should energize ± lVDC of the battery supply voltage.

Harmon Model 1140B/1141B Motion Detectors

Parts Identification

Figure 11-28: Harmon 1140B Motion Detector

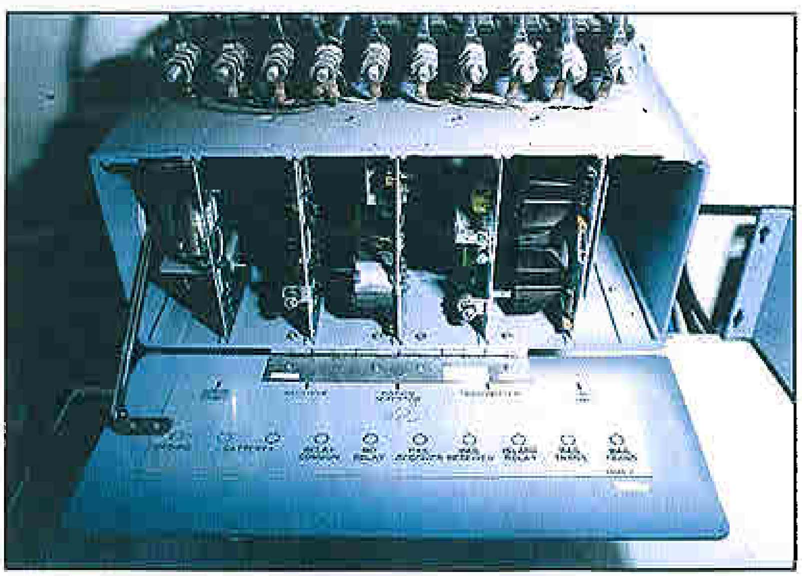


Figure 11-29: Harmon 1140B Motion Detector front cover lowered

CMA2-D Troubleshooting

1.1 General

This section helps localize some common problems that occur with the CMA2-D down to the sub-unit.

1.2 Preliminary Checks

1. Check the power supply voltages.

Locate the digital input card 1A7 (CMA02-0451-11). If the Power moniter LED is lit, all voltages are normal.

Further localization may be determined by the power supply status of the Relay 12V, +12V, -12V, and +5V power supplies. Locate the system monitor card 1A4 (CMA02-0442-11). Any front panel LED that is not lit indicates the respective power supply failure.

2. Check the fuses.

The CMA2-D main power fuse is located at the rear of unit 1 below the ON-OFF switch.

The scanner heater and shutter fuses are located on the lower right front panel of unit 2.

3. Verify the switch settings.

Refer to Section 2.3 of the CMA2-D manual for the switch settings.

4. Verify that all inputs are present and correct.

1.3 Isolation Guide

Problems and possible causes are as shown in the following table:

PROBLEM	POSSIBLE CAUSE
Axle count errors	I/O manager board 1A5 (CMA02-0450-11) Transducer or connection Scanner/transducer interface board 1AI (CMA02-0437-11) Lighting protection board 1A15 Digital input board 1A7 (CMA02-0451-11)
Missing wheel gates	Scanner/transducer interface board IAI (CMA02-0437-11) Transducer or connection Lightning protection board IA15 (CMA02-0458-11)

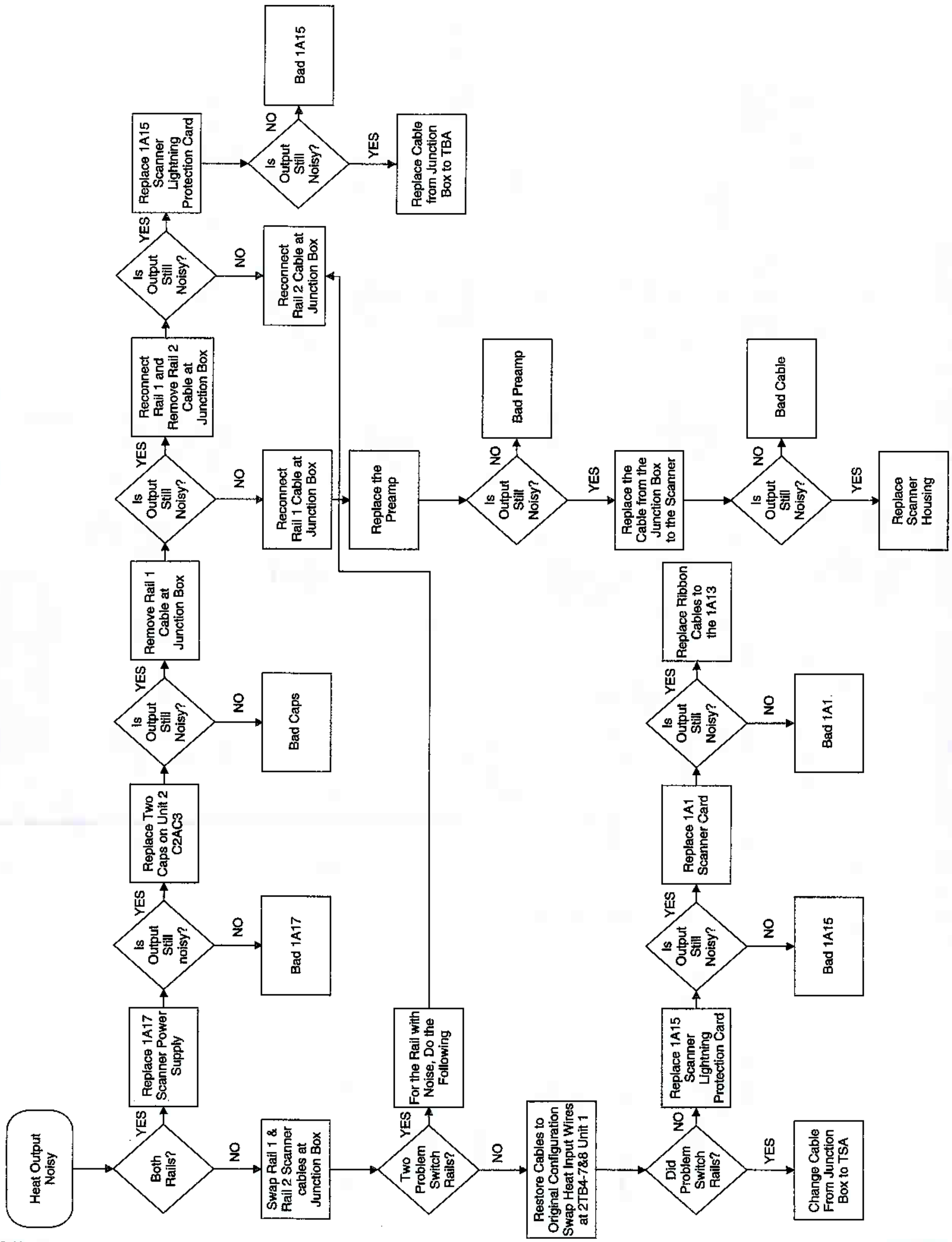
PROBLEM	POSSIBLE CAUSE
Missing wheel gates (continued)	Appropriate EDCO device on transducer unit
Reverse gating	Scanner/transducer interface board IAI (CMA02-0437-11) Transducer or connection Appropriate EDCO device on transducer unit Lightning protection board IA15 (CMA02-0458-11)
Wrong direction	Scanner/transducer interface board IAI (CMA02-0437-11) Program site description wrong Appropriate EDCO device on transducer unit Lightning protection board IA15 (CMA02-0458-11)
Constant hotboxes **Maximum heat**	Scanner/transducer interface board IAI (CMA02-0437-11) Spike or other foreign object under the scanner Lightning protection board IA15 (CMA02-0458-11) Bad feed thru capacitor Loose cable connections Bolometer bias filter caps Defective sensor/power supply 1A17
DE not detected **Constant DE**	Digital input board 1A7 (CMA02-0451-11) Relay minus 12 volt out of tolerance Grounded cable in DE junction box Appropriate EDCO device on transducer unit DE switch out of adjustment
Zero heats or equal heats	Scanner power supply board IA17 (CMA02-0473-11) Scanner/transducer interface board IAI (CMA02-0437-11) Bad sensor or cabling Broken or loose mirror Shutter assembly Heavy rain or snow Lightning protection board IA15 (CMA02-0458-11) Aperture relay control board IA16 (CMA02-0462-11) Aperture control relay K1 located inside the main frame of the CMA2-D at the top left. (Access it from the lower rear panel.)
Erroneous switch settings	System power supply 1A12 (CMA02-0444-11) Bad 1A5 or board battery I/O manager board IA5 (CMA02-0459-11) New 1A5 board installed, not properly set up

PROBLEM	POSSIBLE CAUSE
Speech failure	Local speaker, just in house, not fatal Volume control on rear of unit 1 Speech processor board 1A6 (CMA02-0439-11) I/O manager board 1A5 (CMA02-0450-11)
Radio failure	Relay output board 1A8 (CMA02-0438-11) Relay 12 volt power supply IA12 (CMA02-0444-11) Bad radio or connection Antenna
Garbled data transmission to the plotter printer output	Communication manager board 1A2 (CMA02-0440-11) or invertor output Local battery out of tolerance Lightning protection board IA13 (CMA02-0443-11)
Continuous alarm tone or No alarm tone	Speech processor board 1A6 (CMA02-0439-11) I/O manager board 1A5 (CMA02-0450-11)
Incorrect time	I/O manager board 1A5 (CMA02-0450-11) Battery on the board
Display inoperative	I/O manager board 1A5 (CMA02-0450-11) 1A12 power supply Display module
Incorrect temperature	Analog I/O board IA9 (CMA02-0452-11) Improper positioning of probe measuring ambient temperature Temperature sensor (TS001-0501-11)
Heat level high - one side	Scanner heater defective Scanner or associated cabling Scanner/transducer interface board IAI (CMA02-0634-N-11) improperly calibrated
Heat level high - both sides	Blown fuse--F1, F2 1A17 power supply Scanner/transducer interface board IAI (CMA02-0437-11) improperly calibrated
False alarms relative to heat (false firings)	Scanner caps and wiring (check all pertinent wiring) Improper calibration Loose cable connectors (check pertinent connnections)

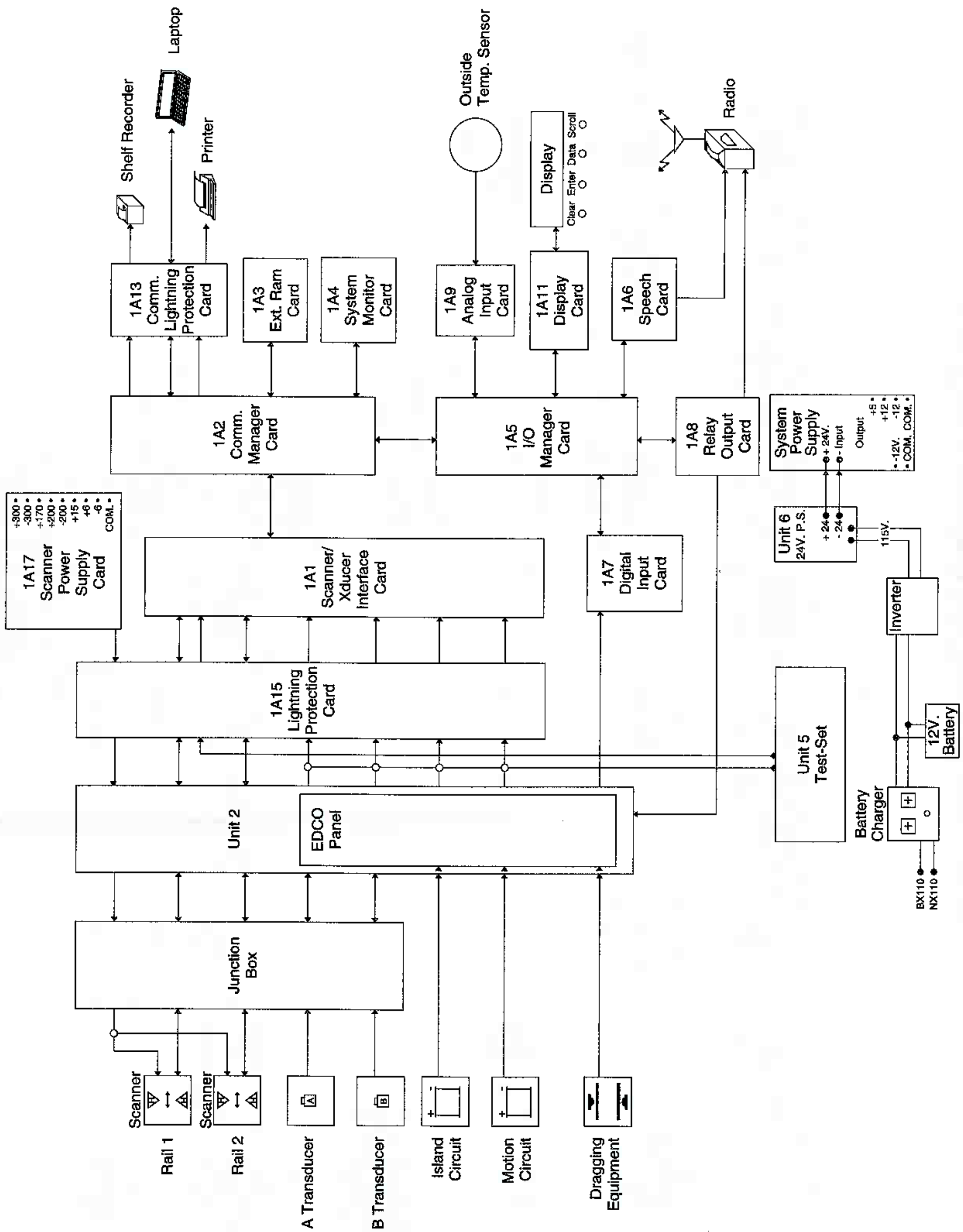
To check transducer problems, do the following:

1. Connect a voltmeter across the transducer terminals in the junction box.
2. Attach the positive lead to the black wire and the negative lead on the white wire.
3. Set the voltmeter on the low voltage scale.
4. Insert a metal object into the transducer's magnetic field. Insertion of the metal object should result in a positive meter movement. Retraction of the object should result in a negative deflection.
5. If no meter movement is indicated in the above test, check for an open transducer coil using an ohmmeter. The transducer should read approximately 600 ohm.

Noisy Heats Troubleshooting Diagram

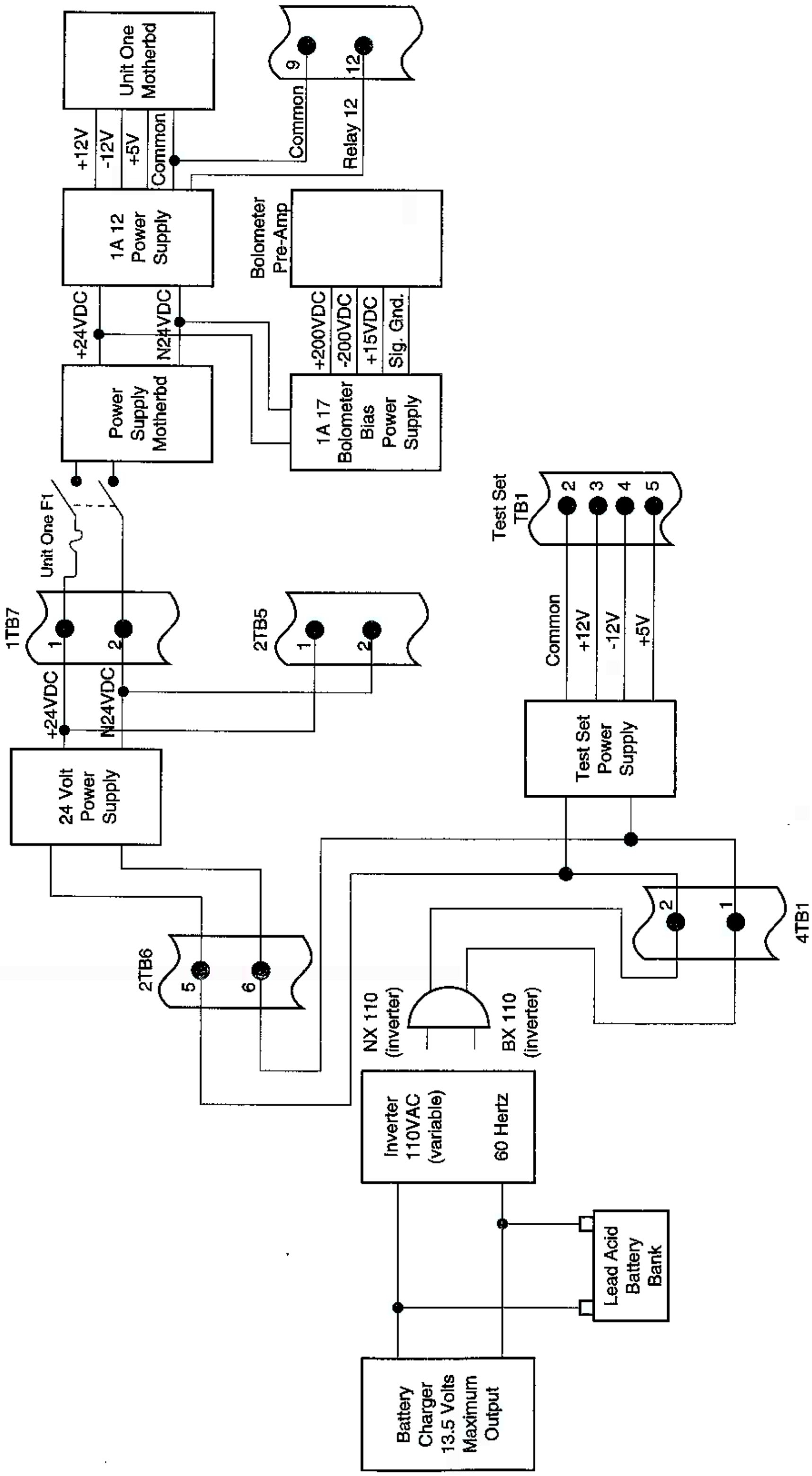


CMA2 Block Diagram at Defect Detector M.P.



Perry Power Supply Block Diagram

Servo Advanced Concept Scanner (ACS)



Technical Reference Section

HOT BOX Detector Handbook

Hot Box Detector Handbook

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The infrared heat sensing systems currently employed by the U. S. Railroads and Canada are relative heat sensing and indicating devices. In particular, these devices indicate the relative heat difference between an ambient temperature reference and the scanned journal housings, the protruding axle for roller bearings, and, in the case of the GRS detector, the wheel hub.

The ambient temperature reference for these detectors is a surface maintained at close to ambient temperature on which the sensing elements stabilize between axle scans of a passing train. During the axle scan, the temperature gives rise to a sensor output that is relative to the ambient temperature reference.

The later models of the GRS and Harmon detectors use a moveable shutter blade that is placed in the optical sensing path between wheel gate times so that the sensing element stabilizes to the temperature of the reference shutter surface. During axle scan time, the shutter blade is moved out of the optical path of the sensor vision and the wheel geometry is scanned, giving rise to an output relative to the reference shutter blade for the detector.

The Servo detectors, however, utilize the bottom surface of the rolling stock (car bottom reference) between axle scan times as the surface for the temperature reference. The car bottoms generally maintain a temperature close to ambient temperature, depending on emissivity and other factors. Therefore, during axle scan times the Servo bolometer bridge gives rise to an output that is relative to the temperature of the bottom of the cars scanned.

The outputs of the infrared sensors for general railroad use also have not been smoothed or linearized for a linear output indication versus rising temperature difference between reference and scan geometry. Therefore, the outputs used for the railroad industry today are relative and nonlinear indications of temperature differences between ambient temperature and the temperature of the scan geometry.

Historically, a method for indicating these relative temperature rises for scanned geometry was to use a millimeter-based scale for measuring deflection or heat rise for the Hot Box Detector output. Although this method of display has no direct absolute significance, by usage a great deal of dependence has been placed upon stopping criteria based upon chart interpretation of millimeters of deflection for relative temperature rise for axle bearings on rolling stock.

However, an alternative method has been employed by the Devtronics' Signal Processing equipment since 1978, and a more recent innovation was implemented in 1986. The 1986 methodology was developed in conjunction with work being done for the Norfolk Southern Corporation at that time and has since been in operational use in over 100 detectors for CSX Transportation and in as many detectors for Norfolk Southern.

Although the method to be described here is similar to and can be proportionally related to chart millimeters of deflection, the differences should be clearly understood. The new method should always be analyzed or reviewed based upon its given rules for performance and not necessarily equated to the millimeter scale for stopping criteria.

There are numerous devices and many ways to measure a physical parameter we call *temperature*. Look around the household for the different types of common ordinary "thermometers" or temperature-indicating devices. Some are slim cylinders of sealed glass with a column of mercury or red-colored alcohol (for the cheaper devices), whose column height indicates levels of temperature. Some devices have round dial faces with a moveable pointer or indicator to display levels of temperature. Some devices simply display a varying color to indicate ranges of temperature. Some devices (more expensive) have digital readouts to display temperature levels in numerical digits.

One may just as well display temperature levels on a meter reading volts or current, millimeters on a chart, or just simple numerical counts. The point here is that any mechanism capable of indicating a relative difference of amplitude is just as capable as any other means of indicating relative temperature differences. In particular, the point here is that there is nothing inherently absolute about displaying journal temperatures for hot box detectors in millimeters of deflection on an arbitrarily calibrated chart recorder, which is a device responding to a varying voltage input to deflect the chart pen motors to varying levels of amplitude representing varying levels of scanned journal heat from the passing train wheel sets.

Now, getting back to the ordinary household thermometer and in particular the liquid column display type, we have already agreed that the relative height of the indicating fluid indicates the relative degree or level of temperature. For a moment let's consider this notion. If we took the sealed glass column from its mounting, we now have a relative temperature indicating device. Why? Because we have lost the calibrated scale (on the backing from which we removed the cylinder), and we now measure a temperature with respect to some other temperature of known height. The column still indicates the same height as before we removed it; however, now we only know that one temperature is greater than another reference temperature because the column is higher by some uncalibrated distance or height than before when we looked at the reference temperature. Now we can better understand the term *relative temperature indicating device.*

Why is it relative? The readings are now *relative* because the new temperature is an indication that is greater by an amount related to our reference temperature, which was the height of the column before the new temperature rise occurred. Why is it not absolute read out? Because we don't have an absolute scale of calibration for each point on the thermometer at which we wish to read the new temperature indication. This is the category in which all present Hot Box Detectors used in this country and Canada now basically operate.

At this time don't assume that Hot Box Detectors are not calibrated, because indeed they are. It's a matter of how they are calibrated that makes the difference between absolute and relative temperature indicating devices. And it is your understanding of this difference that makes the difference in a better interpretation of what your Hot Box Detector is telling you. So let's investigate a basic calibration method for the CMA2G Hot Box Detector system and analogously relate the method to the uncalibrated thermometer cylinder.

Hot Box Detectors have historically been a single point of calibration device. That means that at only one specific arbitrarily selected point in the dynamic range of display (from zero to maximum) is a known temperature source used to adjust the output to a specific indication level of also arbitrary units of output indication, such as millimeters on a chart, a voltage level, etc.

Let's apply the single point calibration method to the uncalibrated thermometer cylinder and see how it works - because it is the same principle. For instance, let's put the thermometer cylinder into an oven calibrated and set to exactly 130 degrees F above the temperature outside the oven in the room for instance. If it is 75 degrees F in the room, we must set the oven to 75 + 130 = 205 degrees F. When the thermometer reached its indicating height, we mark that level and call it 13 units (not necessarily degrees). We now use the same units, which for convenience we will use actual millimeter markings down to "0" and up to "25" with "13" on the scale calibrated at 130 degrees F above ambient. What do we now have? We have an ordinary thermometer (household type) calibrated exactly the way we would calibrate a hot box detector.

Now what kind of data or information can we get from this type of indicating device? Let's think about it a little bit and see what we know about the situation:

1. We know that when the column reaches 13 on our arbitrary scale that the thermometer is at a temperature that is 130 degrees above ambient or room temperature. Since the room temperature was 75 degrees F, the actual or absolute temperature the thermometer experienced was 205 degrees F.

2. Now let's look at the thermometer when it's reading 15 on our new scale. What is the absolute temperature of the thermometer at this time? We do not know! Why? Because 15 on our arbitrary scale is not necessarily calibrated to an absolute calibration for the new point of indication on our scale. In other words 15 does not necessarily indicate 150 degrees above ambient just because 13 indicated 130 degrees above ambient at the point of calibration. The calibration sensitivity at the point of calibration is 130/13 = 10 degrees F per millimeter (above ambient), but only at the point of calibration. Why? Because 15 mm of column height on the thermometer may not be scaled to the column height required for 150 degrees F above ambient indication.

3. What do we know? We know that 15 mm is simply 2 units hotter than 13 mm. We know instinctively, however, that 15 mm is certainly much much hotter than 1 mm on our scale, etc. Hence, we should now have a much better understanding of the term *relative temperature indicating device.*

4. What good is this kind of device and how can we use it? There are three methods of protection from excessive temperatures in usage or application of this type of device. Absolute level, differential, and ratio criteria for alarm levels of detection.

ABSOLUTE LEVEL

Looking at our arbitrary scale we know that 15 mm is hotter than 13 mm by 2 more units and that 13 mm represents by (reverse calculation) and absolute temperature of 205 degrees F. 15 mm now represents a temperature hotter than 205 degrees F. Therefore, an empirically derived indication level can be selected so that if any indication reaches that established level, an alarm can be set regardless of any other consideration, simply because we know that the level is without question excessive. Hence, the term *absolute alarm level.* An absolute level can be selected such that any heat level equal to or greater than that level will give an alarm indication.

DIFFERENTIAL LEVEL

A method that has historically been applied in the use of Hot Box Detectors from its inception has been the differential heat level comparison technique. The heat level on a given axle on one side is compared to the heat level on the other side of the same axle. The lower level is subtracted from the higher level to get a relative indication of how much "hotter" the higher side is compared to the lower side. Again an empirically established difference level may be selected which says that if the hotter journal is hotter than the cooler one by the difference amount, an alarm should be set.

RATIO LEVEL

A newer method, employed in the earliest Devtronics' detectors since 1978, implements a premise that an adjacent journal heat level may be examined on a ratio basis, i.e., the hotter level divided by the cooler level equals a ratio that again can be empirically selected as a dangerous level for safe operation of rolling stock. In other words, if the "hotter" is 2 times, 3 times, 4 times, and so on hotter than the cooler, then we can make a determination based on the ratio of hot to cold.

EXAMPLE:

Let's say a cooler journal was indicating 4 mm on our thermometer and the adjacent journal is hotter by 3 times than the cooler journal, which puts the hotter journal at 12 mm (12/4 = 3 times hotter). This puts us close to our calibration point of 130 degrees over ambient (13 mm); therefore, intuitively and empirically we may select a ratio between 3 to 4 as being abnormal for the hotter compared to the cooler.

However, the ratio method is applied to the entire side of a car. With the advent of the microprocessor we could now detect car "geometry" (in other words tell which journals belonged to which car) so that we could establish an average heat level for each side of a car. Currently, the highest heat on the car side is extracted and all other journals on the side are mathematically averaged to establish a car side average (CSA). Then the hottest level is divided by the CSA to determine the car side ratio level. If this ratio exceeds selected level settings and if an absolute alarm has not been declared and if the differential alarm has not been declared, then the car side ratio will effect an alarm condition.

The order of precedence of alarm examination is as follows:

First	Absolute level is checked for alarm condition.
Second	Differential level is checked for alarm condition.
Third	Car side ratio level is checked for alarm condition.

Exceeding any of the above alarm criteria conditions will cause an alarm indication to be set.

Note that no existing remote infrared heat sensing and scanning device employed in the railroad industry today is capable of yielding an absolute calibrated temperature output for determining the exact temperature of the surface scanned in absolute units such as degrees F, degrees C, or degrees Kelvin. Therefore, such devices are rather a relative temperature indicating device so that the degree of protection is directly related to the skill of indirect techniques of analysis as alluded to earlier. For some number of years, we at Devtronics have observed for some number of years existing technology as applied to the railroad industry and have collaborated with many persons in the industry to arrive at an indirect method of analysis in our signal processing techniques that provides the most advanced approach in the railroad industry today to automated heat signal analysis for Hot Box Detectors.

To arrive at an absolute constantly calibrated Hot Box Detector, an absolute calibrated non-varying reference temperature chamber would need to be utilized such as a liquid nitrogen constant reference temperature chamber and constant sensor temperature chamber. This would be cost prohibitive in its commercial environment for the railroad industry. Therefore, it has been our goal to use the best knowledge available for indirect techniques for application to the hot box detector for the railroad industry. We shall constantly pursue that objective.

Before going into the more detailed and exact methodology of the CMA2G, please review the foregoing as needed to be the foundation for proceeding into the triple slope heat analysis discussion as applicable to the CMA2G.

CMA2G HEAT ANALYSIS METHODS

TRIPLE SLOPE ALARMING CRITERIA

In our previous discussion we said that Hot Box Detectors were single point calibrated and that we could just as easily use numerical counts to display relative journal heat temperature differences as well as any other indication means. So, let us now discuss exactly how we calibrate the CMA2G, its indication means, and the alarming mechanisms employed in monitoring wheel journals for unsafe operating temperature levels.

HEAT CALIBRATION

A calibrated heat function simulator is used to generate calibrated heat pulses simulating journal heat pulses similar to actual train operation. The simulator is set onto the rail mounted I R Scanner housing and aligned with the optical aperture (opening) in accordance with detailed alignment instructions in the technical manual. The calibrated thermostat dial is set to 130 degrees F above ambient (outside air temperature). The ambient outside air temperature can be read on the CMA2G front panel digital read out directly in degrees F. If the ambient is 90 degrees F, then set the simulator dial to 220 degrees F (90 + 130 = 220).

The CMA2G in its calibration mode (set as per technical manual) is set for a digital readout of 130 "counts" for both Rail 1 and Rail 2. This now sets the calibration point at a readout level of 130 counts and completes the calibration for the detector.

At this point what do we know?

1. We know that when the detector indicates 130 counts the sensor has sensed a surface at 130 degrees F above ambient. If the ambient temperature is 70 degrees F, then the surface scanned was 130 + 70 = 200 degrees F. Or if the ambient was 80 degrees F, then the surface scanned was 130 + 80 = 210 degrees F, and so on.

2. We also know that a surface at ambient temperature would represent "0" counts. Therefore, counts between "0" and "130" represent relative temperature indications between ambient (outside air) temperature and 130 degrees F above ambient.

3. We also know that counts above "130" indicate the temperature of a surface hotter than 130 degrees F above ambient.

One would be tempted to mentally or intuitively relate counts displayed for journal heats as degrees F above ambient, e. g., 130 = 130 degrees F. But, remember our single point of calibration does not correlate any of the other output counts to degrees and that correlation holds true only at the point of calibration.

However, as it turns out in actuality, one may not be too far in error by making such a correlation. But, there would be errors at any point other than the calibration point and the error would be greater the further away from the calibration point one makes a direct correlation. That is to say, at a reading of 135 counts if we interpreted this to mean 135 degrees F above ambient, our error would be small as compared to interpreting 220 counts as 220 degree F above ambient. Just for information purposes, let's see how far off one might be at the extremes of our indication scale from actual temperature:

CMA2G Counts	Actual Temperature	% Error
195	175 Degrees from ambient	11.4
170	160 Degrees from ambient	6.25
150	145 Degrees from ambient	3.25
130	130 Degrees from ambient	0.00

The full scale deflection for the CMA2 is 255 counts maximum. There is an expected error of about +15% at 255 counts which would correlate to an actual surface temperature (ignoring emissivity factor) of about 217 degrees F above ambient for full scale deflection. Therefore, if the outside air temperature is 90 degrees F and the defect detector readout indicates 255 counts, the scanned surface is at a temperature of approximately 90 + 217 = 307 degrees F, which is well beyond a journal surface temperature for safe operation.

CHART RECORDER OUTPUT SCALING

The CMA2G numerical display output maximum is 255 counts. These counts are scaled to millimeters of chart deflection by a dividing factor of 10 as follows:

Counts	Chart Deflection in mm
10	1.0 mm
20	2.0 mm
30	3.0 mm
40	4.0 mm
50	5.0 mm
60	6.0 mm
70	7.0 mm
80	8.0 mm
90	9.0 mm
100	10.0 mm
110	11.0 mm
120	12.0 mm
130	13.0 mm
140	14.0 mm
150	15.0 mm
160	16.0 mm
170	17.0 mm
180	18.0 mm
190	19.0 mm
200	20.0 mm
210	21.0 mm
220	22.0 mm
230	23.0 mm
240	24.0 mm
250	25.0 mm
255	25.5 mm

Therefore, any printout in counts divided by 10 = mm of chart deflection. We note then that the numerical read out resolution is 0.1 mm. This translates to the fact that the numerical display can be read to the 1/10 of a mm, which equates to about 5 times better resolution than trying to read a tape by eye, which at best would be accurate to only
± 1/2 mm.

Note that at the point of calibration "1 count" = 0.1 mm chart deflection, which correlates to 1 degree F for every 0.1 mm of chart deflection.

ALARM METHODS AND LEVELS

As discussed earlier, there are 3 methods of testing for alarm conditions:

Absolute level alarm testing

Differential level alarm testing

Car side ratio level alarm testing

We will consider each one in detail with specific and currently recommended settings for each of these alarm sets and describe exactly how they operate, e. g., invoked based on collected heat data samples from the train car wheel sets.

ABSOLUTE LEVEL ALARMS

As previously noted, we can select an absolute level of indication such that if any journal heat level indication is equal to or greater than the selected level an alarm for that journal (axle) is set and declared regardless of any other alarm criteria selected. The current settings are:

Roller bearing Absolute level setting = 195 (counts)

Friction bearing Absolute level setting = 90 (counts)

DIFFERENTIAL LEVEL ALARMS

As previously noted, we can select a "difference" level setting such that if a journal on one side exceeds the journal level on the other side of the same axle by the selected amount, an alarm is set and declared for the side with the higher heat level.

Roller bearing Differential level setting =104 (counts)

Friction bearing Differential level setting = 65 (counts)

RATIO LEVEL ALARMS

The ratio alarm method in this case is the comparison of the highest heat on the side of a car against the average of all remaining heats on the same side of the car. The following example illustrates this method:

Side: RL 1

Axle:	1	2	3	4
Heat Level:	10	20	15	85

Axle #4 with a heat level of 85 counts is the highest journal on the RL 1 side.

A Car Side Average (CSA) is taken by adding all other heats and dividing by the number of axles added together.

10 + 20 + 15 = 45
45 divided by 3 = 15 (counts)

If an alarm multiplier of 4 is used, the test for alarm condition of axle #4 follows:

CSA	X	Multiplier	=	Alarm point
15	X	4	=	60 (counts)

Therefore, axle #4 with an 85 count is in alarm, based on the given rules and settings in this example.

The purpose of the car side ratio method is to protect against a situation where a high heat level may be just below the absolute alarm level so that the absolute level protection was not alarmed. The heat on both ends of the same axle might be high so that the differential is not set or alarmed. However, when the high heat is compared to a car side average, a clearly dangerous level may exist. Therefore, the CSR (Car Side Ratio) can catch some of the sleepers that might get by absolute and differential alarm levels.

This method was added by Devtronics Inc. in 1978 and is in operation in over 600 detectors nationwide at this time.

In 1986 Devtronics, in conjunction with the Norfolk Western Railroad, added a new method to the, heretofore, single car side ratio multiplier setting. This new method has been referred to as the triple slope heat analysis routine.

TRIPLE SLOPE ALARM LEVELS

Instead of using a single ratio multiplier for CSA testing, 3 different ratio multipliers are used to test for a CSA alarm. Intuitively we can view the advantage of using 3 different alarm ratios in the following manner:

As the CSA elevates, the difference or ratio required for an alarm condition gets smaller. Therefore, by using smaller (lower) multipliers as the average heat for the side of the car increases, we are able to better protect the rolling stock safely as the CSA increases, while using a larger (higher) multiplier when the CSA is low.

Why? What is the advantage? By using a larger multiplier when the CSA is lower, we are less likely to falsely stop trains with cars having a low CSA. At the same time we can more quickly approach the alarm condition when the CSA is higher without letting a train get by with an unsafe journal temperature condition existing.

There are 3 different alarm ratios used when applying car side ratio analysis for roller type bearings. As well, there is another set of 3 different alarm ratios for friction type bearings. Keep in mind, in all cases, alarm settings are totally adjustable from either the equipment in the field or from the central monitor system at the Dispatcher's location.

Up to now we have alluded to a distinction between roller type bearings and friction type bearings in our analysis scheme, but we have not discussed the method of arriving at the bearing type classification that is inherent in the operation of the detector. Because the Servo type scanners have historically sensed different heat levels for the two basic type bearings in the rolling stock, the detector uses a method based on a car average heat level to classify cars being scanned into either roller or friction type bearings.

Friction type bearings are somewhat recessed into the typical journal box housing and the Servo scan is across the journal housing during motion across the detector. In the CMA2 series equipment the surface temperature scanned is generally close to ambient temperature and the actual heat readings from the detector range from 0 to about 10 counts on the average, i. e., 0 to 1 mm on the chart. Whereas, in roller type bearings, the scan is across the protruding axle from the wheel, which tends to run on the average somewhat hotter than ambient temperature. Roller type bearings on the average generally run in excess of 10 counts and up to 40 to 60 counts for normal running heat levels.

This distinction in effective radiated heat differences between friction and roller type bearings can be detected and classified by the detector. A bearing type classification level setting is available for this process. It is currently set at 11 counts. Classification proceeds as follows:

Examples:

Axle:	1	2	3	4
RL 1 Heat:	2	5	0	2
RL 2 Heat:	0	1	8	10

A car average is taken by adding all the heats on both sides of the car, again excluding the highest, and dividing by the number of heats summed.

CAR AVERAGE = 2 + 5 + 0 + 2 + 0 + 1 + 8 = 18/7 = 2.57 rounded up = 3 counts

The classification level is set for 11; therefore, this car is classified as a friction bearing type car.

Axle:	1	2	3	4
RL 1 Heat:	8	15	20	30
RL 2 Heat:	18	25	50	40

Car Average = 8 + 15 + 20 + 30 + 18 + 25 + 40 = 22.28 rounded up = 23 counts

The classification level is set for 11; this car is classified as a roller bearing type.

SUMMARY: Any car having a car average equal to or greater than the classification level setting (in this case it is set to 11) will be classified as a roller bearing type car.

Any car having a car average below the classification level setting will be classified as a friction bearing type car.

Now let's consider the triple slope techniques and its application in the CMA2 series equipment. You may think of the 3 different alarm ratios in terms of slopes on a straight line graph representing the 3 different ratios. Hence, the name *triple slope*. Refer to the figures that follow. Figure 1 displays a straight line graph depicting the 3 slopes (alarm ratios) used for Roller bearing alarm analysis. You can think of each slope on the graph as controlling a zone of alarm conditions associated with that particular slope. Therefore, we have 3 zones for 3 different alarm ratios to be applied.

ZONE # 1 is determined by slope (ratio) # 1. ZONE # 2 is determined by slope (ratio) # 2. ZONE # 3 is determined by slope (ratio) # 3.

Let's examine the area protected by each zone:

ZONE # 1

This is the area encompassing all heat levels bounded by:

The X axis

The Y axis

The alarm line defined by $Y_1 = M_1X_1 + B_1$ and

The vertical line from the intersection of Line #1, Line #2, and the X axis

Where Y_1 is the alarm line defined by slope # 1
M_1 is the value of slope # 1 (alarm ratio # 1)
X_1 is the value of the car side average
B_1 is the value of the offset (y intercept of the alarm line)

ZONE # 2

This is the area encompassing all heat levels bounded by:

The X axis

The vertical line from the intersection of Line #1, Line #2, and the X axis

The alarm line defined by $Y_2 = M_2X_2 + B_2$ and

The vertical line from the intersection of Line #2, Line #3, and the X axis

Where Y_2 is the alarm line defined by slope # 2
M_2 is the value of slope # 2 (alarm ratio # 2)
X_2 is the value of the car side average
B_2 is the value of the offset (y intercept of the alarm line)

ZONE # 3

This is the area encompassing all heat levels bounded by:

The X axis

The vertical line from the intersection of Line #2, Line #3, the X axis, and

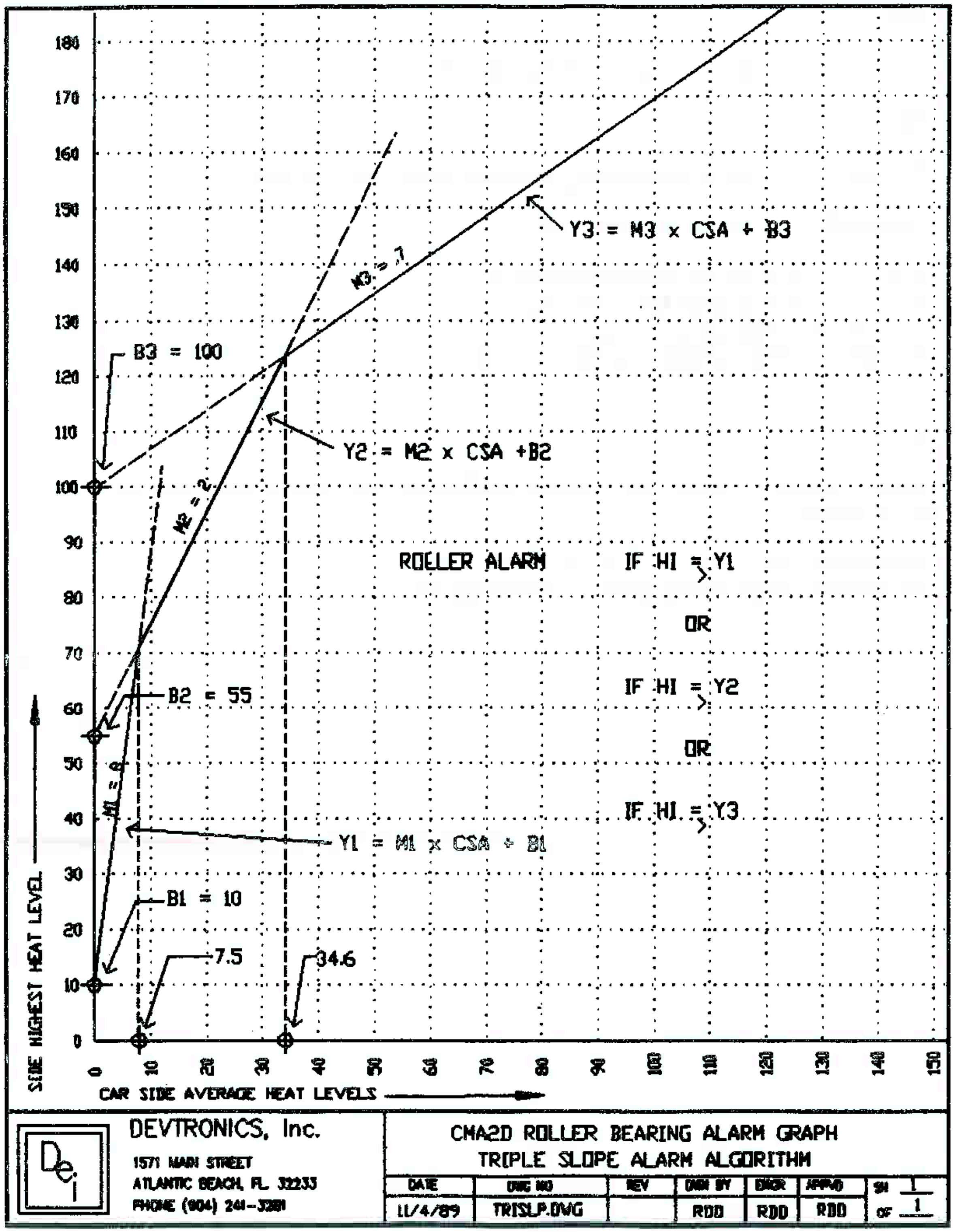
The alarm line defined by $Y_3 = M_3X_3 + B_3$

Where Y_3 is the alarm line defined by slope # 1
M_3 is the value of slope # 1 (alarm ratio # 1)
X_3 is the value of the car side average
B_3 is the value of the offset (y intercept of the alarm line)

SUMMARY:

An alarm condition, using car side averaging and the triple slope alarm methods is an alarm line defined by:

Alarm = Zone slope times CSA + Zone offset
This definition holds for all cases for car side averaging.



SIDE HIGHEST HEAT LEVEL
CAR SIDE AVERAGE HEAT LEVELS
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
Y3 = M3 x CSA + B3
M3 = .7
B3 = 100
Y2 = M2 x CSA +B2
M2 = 2
ROLLER ALARM
IF HI ≥ Y1
OR
IF HI ≥ Y2
OR
IF HI ≥ Y3
B2 = 55
M1 = 8
Y1 = M1 x CSA + B1
B1 = 10
7.5
34.6
DEVTRONICS, Inc.
1571 MAIN STREET
ATLANTIC BEACH, FL 32233
PHONE (904) 241-3281
CMA2D ROLLER BEARING ALARM GRAPH
TRIPLE SLOPE ALARM ALGORITHM
DATE
DWG NO
REV
DWN BY
CHKR
APPVD
SH 1
11/4/89
TRISLP.DWG
RDD
RDD
RDD
OF 1

Figure 11-30

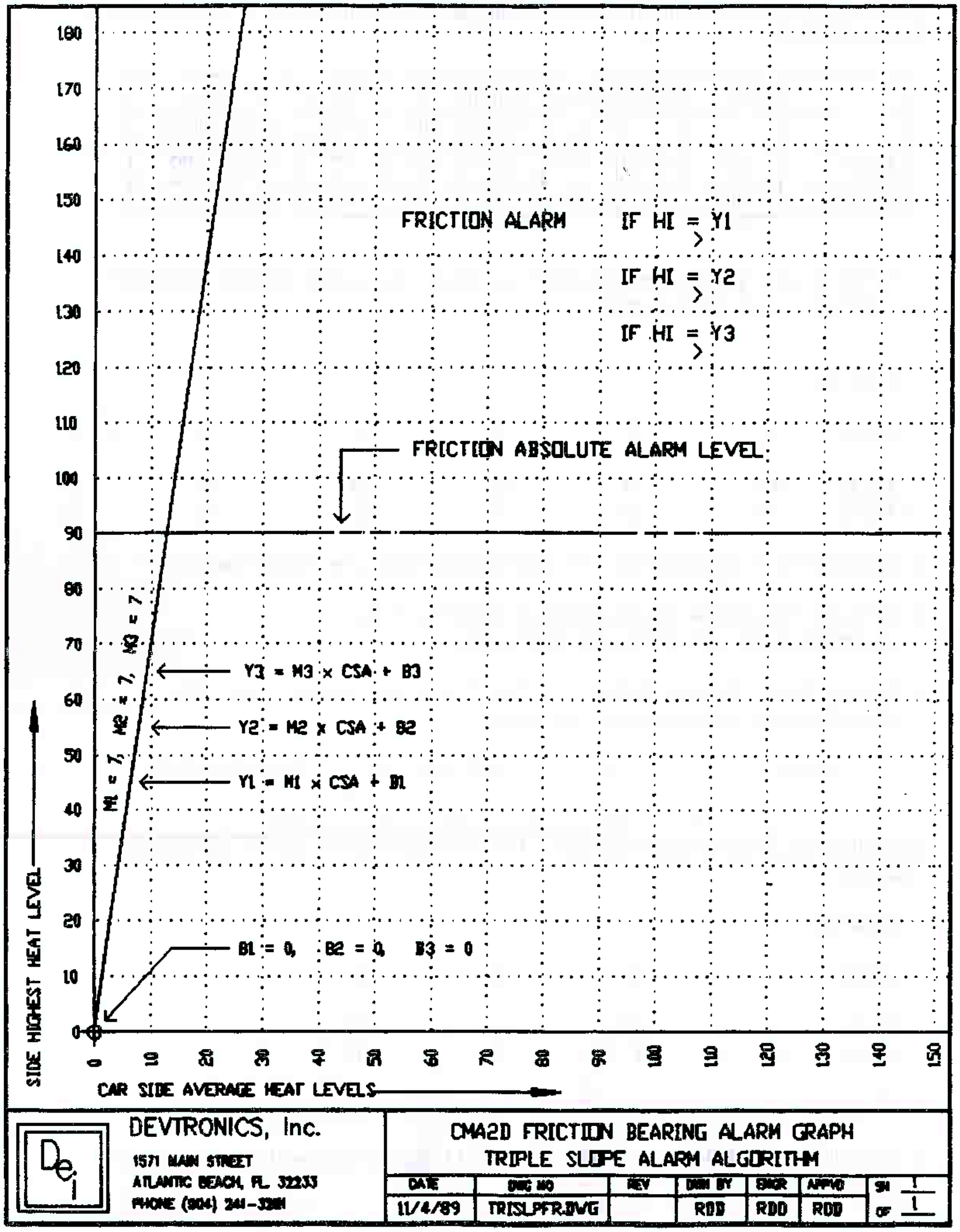

FRICTION ALARM
IF HI ≥ Y1
IF HI ≥ Y2
IF HI ≥ Y3
FRICTION ABSOLUTE ALARM LEVEL
M1 = 7, M2 = 7, M3 = 7
Y3 = M3 x CSA + B3
Y2 = M2 x CSA + B2
Y1 = M1 x CSA + B1
B1 = 0, B2 = 0, B3 = 0
SIDE HIGHEST HEAT LEVEL
CAR SIDE AVERAGE HEAT LEVELS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
DEVTRONICS, Inc.
1571 MAIN STREET
ATLANTIC BEACH, FL 32233
PHONE (904) 241-3381
CMA2D FRICTION BEARING ALARM GRAPH
TRIPLE SLOPE ALARM ALGORITHM
DATE
11/4/89
DWG NO
TRISLPFR.DWG
REV
DWN BY
RDD
ENGR
RDD
APPVD
RDD
SH 1
OF 1

Figure 11-31

The following is a table of recommended current settings defining all alarm settings available for the CMA2G:

	MHEAT	DIFF	CSA	Slope 1	CSA	Slope 2	CSA	Slope 3
			Mult	Offset	Mult	Offset	Mult	Offset
Roller	195	104	8.0	10	2.0	55	0.7	100
Friction	090	065	7.0	0	7.0	0	7.0	0

Let's look at some specific examples so that we can see how a alarm condition is declared using the CSA Triple Slope method:

CAR #1

Axle:	1	2	3	4	5	6
RL 1:	45	30	42	20	25	99
RL 2:	50	35	48	26	32	28

a. Classification is computed first = 35, which classifes the car as a roller type car.

b. Let's check RL 1 CSA...45+30+42+20+25 = 162/5 = 32.4;
the CSA rounded = 33 (3.3 mm on chart recorder).

c. Since a CSA of 33 lies on the X axis (refer to Fig. 11-xx) between 7.5 and 34.6, slope #2 (zone #2) is used for the calculation.

SLOPE	x	CSA	+	OFFSET	=	ALARM POINT
2	x	33	+	55	=	121

Since the alarm point for Rail 1 Car Side is 121, then axle #4 at 99 counts is not an alarm condition.

CAR #2

Axle:	1	2	3	4
RL 1:	55	60	58	145
RL 2:	50	35	48	26

a. Classification is computed first = 48, which classifies car #2 as a roller type car.

b. Let's check RL 1 CSA...55+60+58 = 173/3 = 57.6; the CSA rounded = 58 (5.8 mm on chart recorder).

c. Since a CSA of 58 lies on the X axis (refer to Figure 11-30) greater than 34.6 slope #3 (zone #3) is used for the calculation.

SLOPE	x	CSA	+	OFFSET	=	ALARM POINT
.7	x	58	+	100	=	140.6 rounded = 141

Therefore, axle #4 Rail #1 side of 145 counts is in alarm by 4 counts (.4 mm on chart over alarm point).

The above two examples show the method as applied to a car classified as a roller bearing type car. The method for a car classified as a friction bearing type car is exactly the same. However, in referring to Figure 11-31, you will note that the alarm line appears to be a single straight line. Even so, 3 alarm slopes have been set in having the same value and all the offsets have been set to 0; therefore, the graph looks like one straight line. However, it is indeed made up of 3 different segments having the same slope. What this means is the "narrow" CSA range for friction bearings requires basically a single slope to protect the friction operating zone. However, the capability is designed into the equipment to operate different slopes for frictions if operations dictated that requirement.

This document has been drafted with the intent to help the non-hot-box detector person to understand some basic alarm principles of operation of this device. This document in no way supersedes the applicable technical manual nor is its scope intended as such. However, if it helps one individual - technical or otherwise - then it is sufficient in its purpose.

NOTE:

The recommended alarm criteria settings given herein were not derived casually or carelessly. They have been correlated from data collected from many trains over an extended period of time. Actual set-outs were compared to the alarm levels selected and in no case since 1986 has any train been documented as having passed the detector, not alarmed and then within 10 miles from the detector have had a rung journal. That includes about 100 detectors in operation for Norfolk Southern and over 100 detectors for CSX Transportation.

Therefore, we issue an advisory of **caution** in changing and especially in increasing any alarm level setting without extensively correlated train data from many trains to substantiate new settings that are different from those recommended herein. Even so, the ultimate responsibility for correct alarm settings is that of the user railroad.