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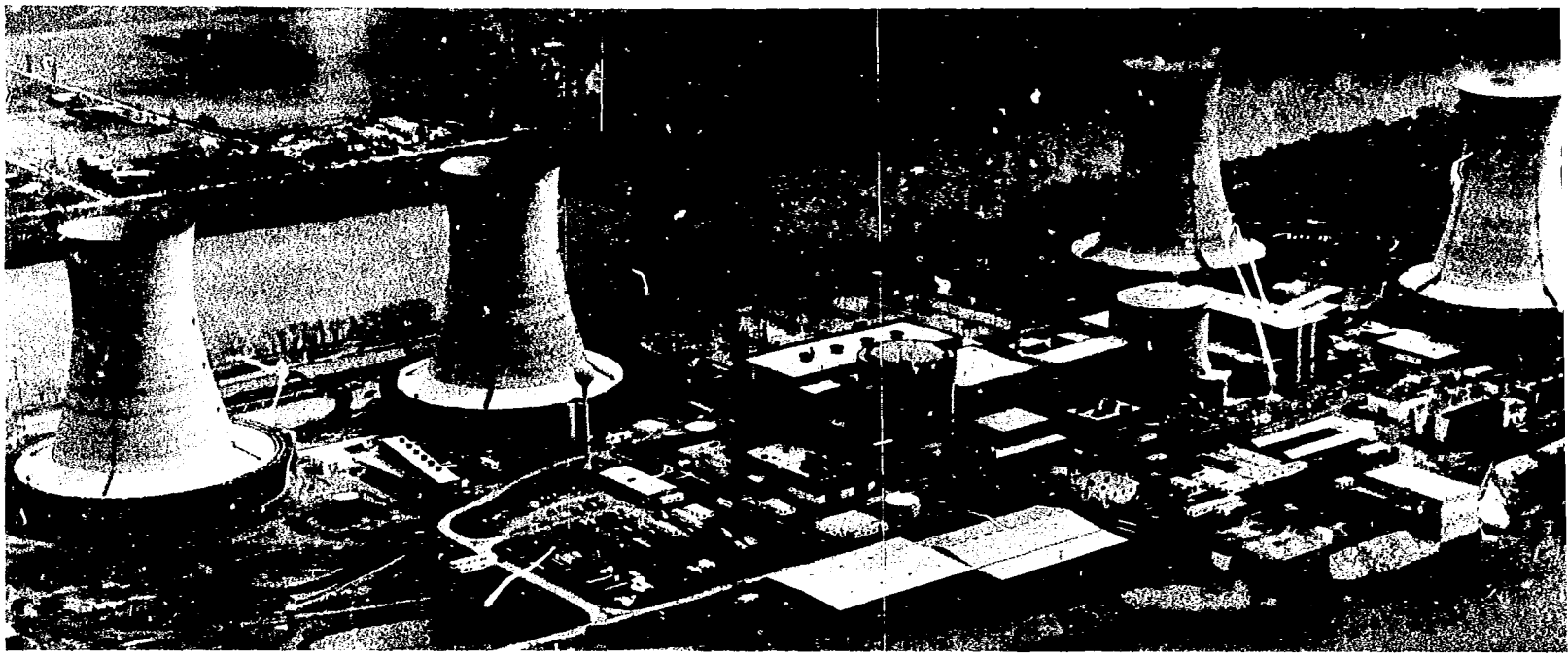

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FIELD MEASUREMENTS AND INTERPRETATION OF TMI-2 INSTRUMENTATION: HP-R-211

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U.S. Department of Energy
Three Mile Island Operations Office
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

During and following the TMI-2 accident, a number of instruments failed or were suspected of providing erroneous readings. Because of this problem, industry concerns were focused upon the behavior of instrumentation under adverse conditions. To better understand failure mechanisms, the Technical Integration Office (TIO) contracted Technology for Energy Corporation (TEC) to perform field measurements on a set of selected instruments to determine current in-situ operating characteristics. For some instruments, these measurements were to be performed prior to removal (and replacement with new instruments) in order to have a cross reference with post removal observations.

This report provides the information gathered by TEC on the area radiation monitor HP-R-211. This detector was located at 305 feet elevation, just inside the entry hatch (ante-room) used during initial entries into containment. This instrument consisted of a Victoreen Model 857-2 detector assembly connected to a Victoreen Model 856-2 panel alarm and approximately 520 feet of interconnecting cable. This instrument was believed to have failed due to low radiation level indications and due to a lack of response to the manually activated checksource in the detector. As a result of this failure, the detector was a candidate for early replacement to provide long-term radiation monitoring capability inside containment at the entry hatch.

2. INSTRUMENT LOCATION, CABLING, AND TERMINATIONS

A review of appropriate drawings from Victoreen and Burns & Roe (itemized in the Appendix in the measurement procedure, page A-5) resulted in the composite electrical diagram shown in Figure 2-1. From this information, Table 2-1 gives a list of the appropriate termination points for performing measurements in the Control Room in Cabinet 12. Also noted in Figure 2-1 are the cable lengths pulled during instrument installation (before final trimming) between each termination and/or junction point.

The detector assembly is a Victoreen Model 857-2 which is shown in Figure 2-2 along with required interfacing connections to the readout module. Figure 2-3 shows the functional layout of the detector and associated readout module. This assembly is a "medium range" device with a range of 0.1 to 10^4 mR/hr. An electrical diagram of the detector circuit is shown in Figure 2-4. As shown in Figure 2-1, the circuit is somewhat complicated by the presence of a remote alarm/meter which is used as a local indication of the radiation levels inside the entry hatch.

Since measurements were being made in the control room, there was no way to remove the effect of the remote meter (attached to the signal line) from the observed instrument response. However, since the remote meter was located outside containment, it did not experience severe operating environments and thus was not considered to present any measurement problems. Similarly, the Model 856-2 Readout Module, located in the control room, was not specifically considered to be a source of instrumentation problems except in its function of supplying power to the detector assembly.

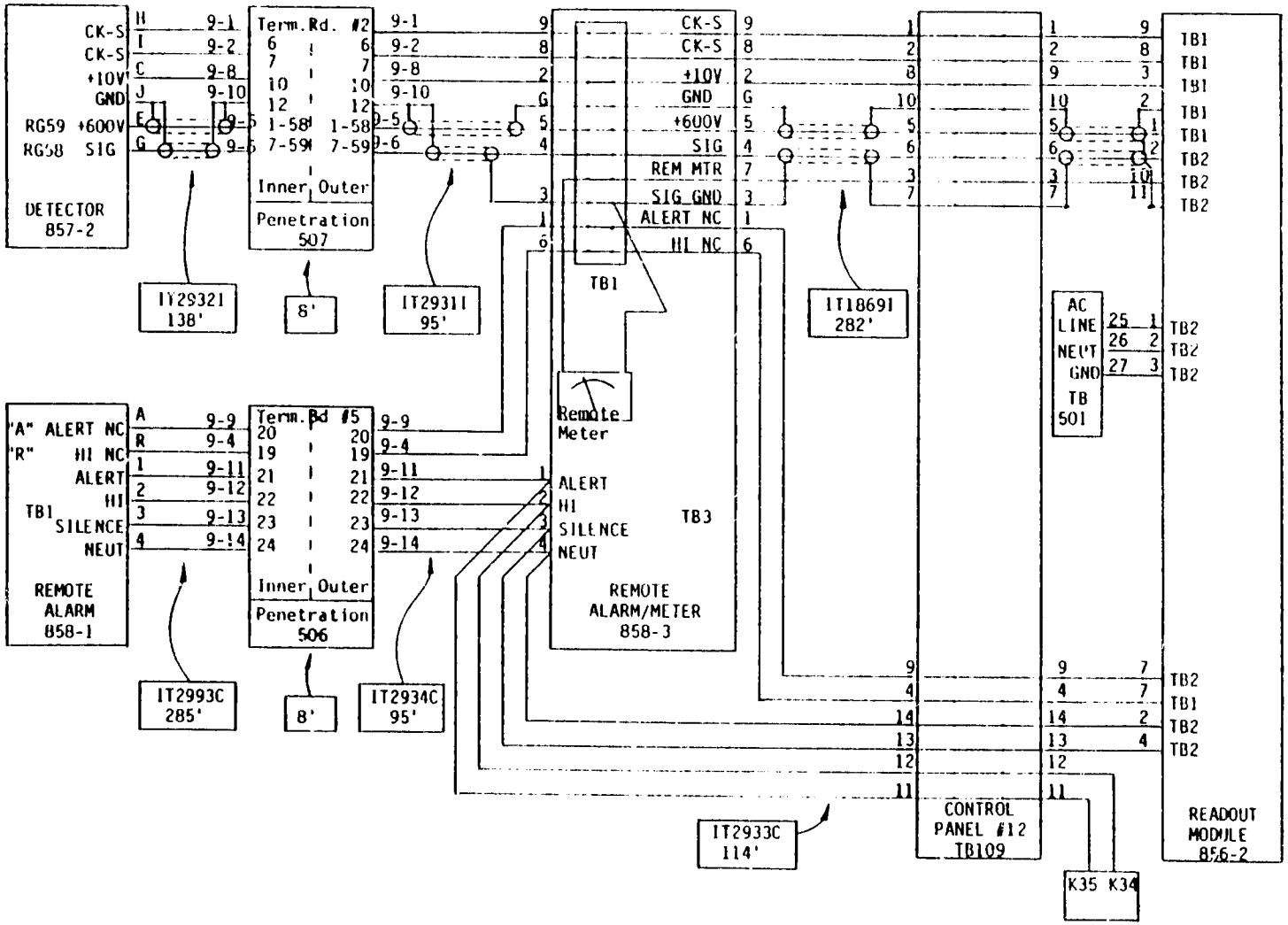


Figure 2-1. HP-R-211 Composite Electrical Diagram.

Table 2-1

TERMINATION POINTS FOR HP-R-211 MEASUREMENTS

Signal	Cabinet 12 Identification*
+10V Power Supply	TB109-8
+600V High Voltage	TB109-5
Signal Out	TB109-6
Ground	TB109-10
CS**	TB109-1
CS**	TB109-2

*From cable IT2931I

**CS = Checksource coil positive and return contacts (exact identification not necessary).

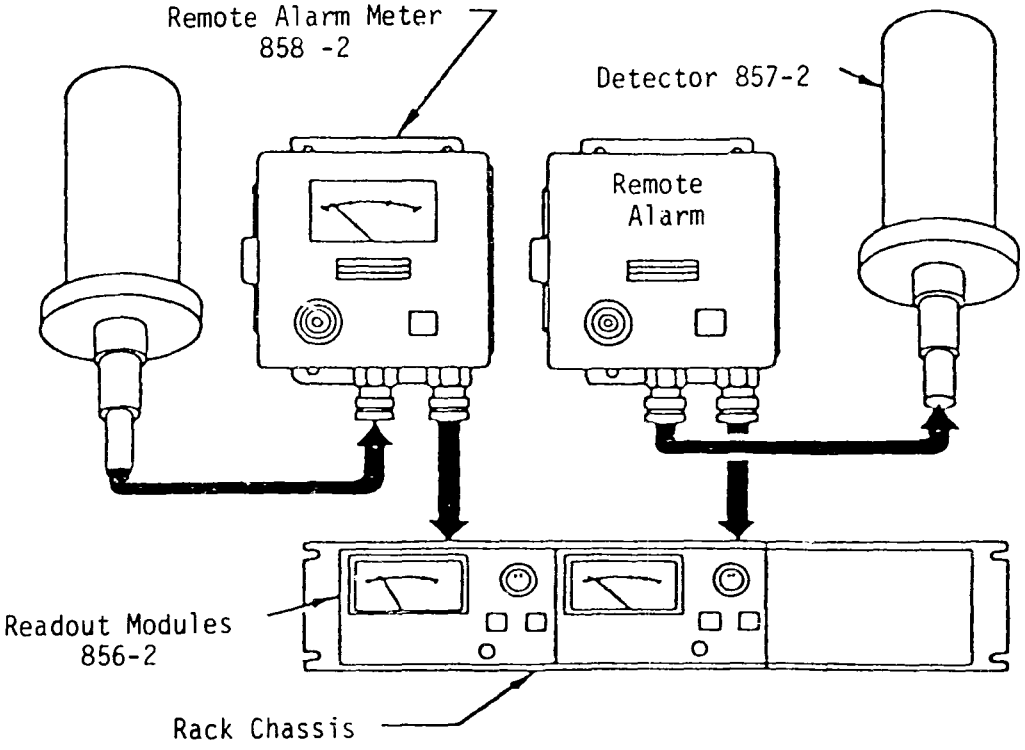


Figure 2-2. Sketch of Instrumentation for HP-R-211.

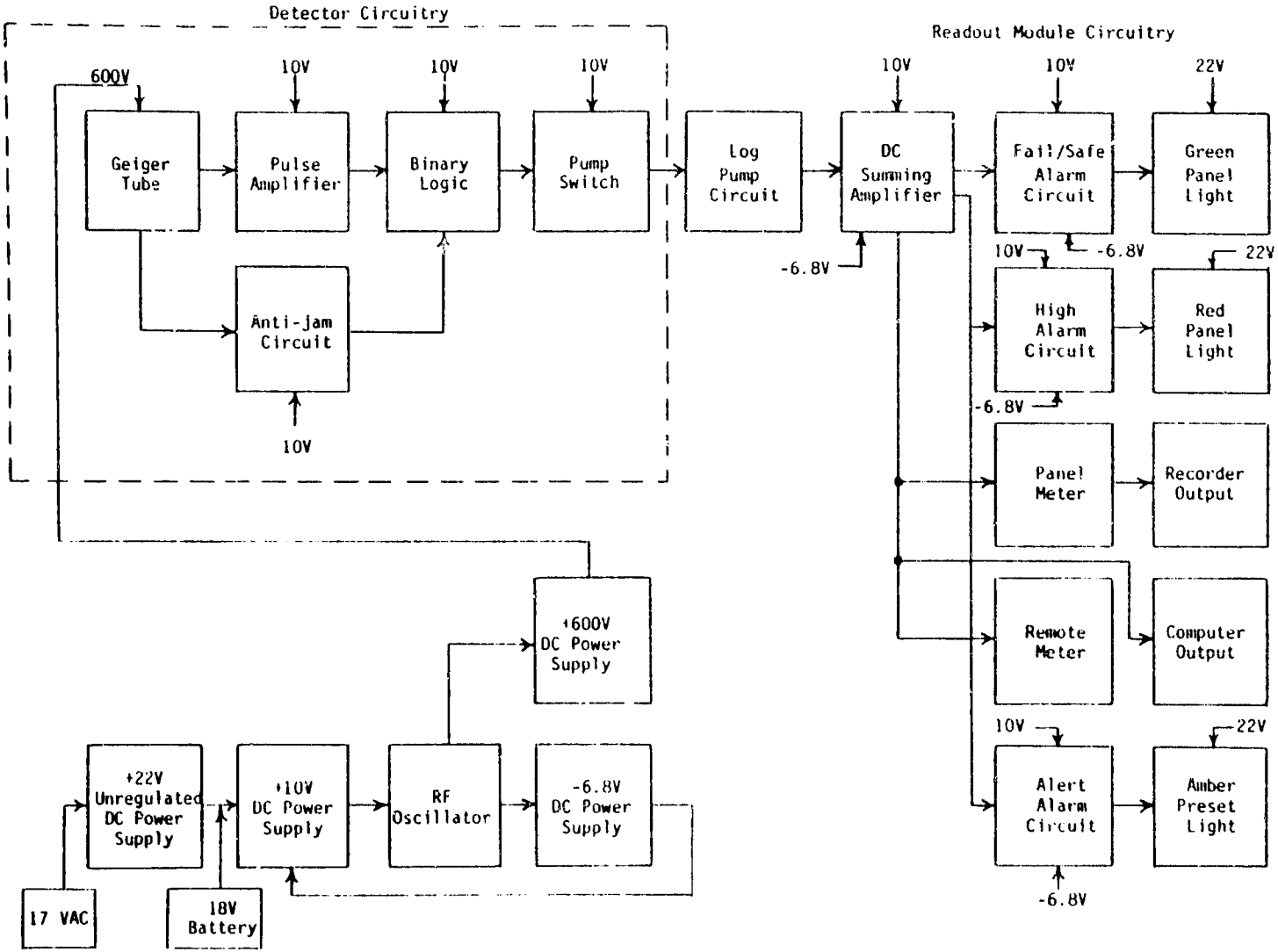


Figure 2-3 Functional Layout of Detector and Readout Module.

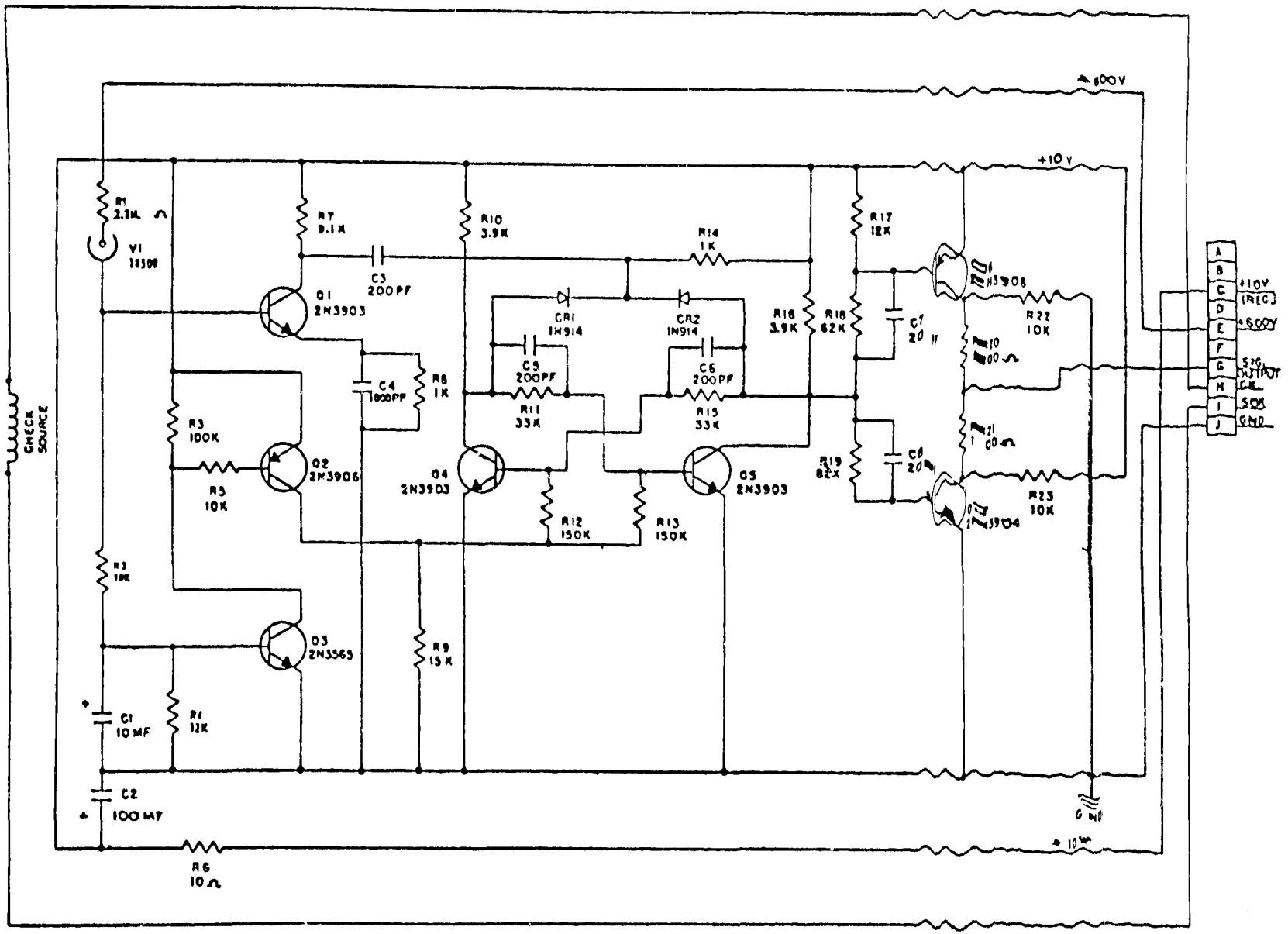


Figure 2.4 Electrical Circuit of Detector Card

3. PREPARATION OF MEASUREMENT PROCEDURES

As a result of generating the composite electrical diagram and from a review of the Victoreen Area Monitor Operation Manual, the major types of measurements to be performed were identified as

1. Determine as-found condition of Readout Module and Remote Meter and record signal output
2. Perform passive measurements (i.e., passively monitor signals) on each electrical connection consisting of time domain waveforms, very-high frequency spectrum analysis (i.e., MHz region), and frequency spectra below 100 kHz
3. Perform resistance, capacitance, impedance, and Time Domain Reflectometry (TDR) active measurements (i.e., actively introducing a test signal).

These measurements were designed to verify the operation of the Readout Module (especially the power supplies) and the Remote Meter/Alarm. The focus of the measurement was on the detector assembly, cabling, and terminations/connections to the assembly. The Appendix contains the detailed procedure which was followed during the measurement program, and a summary of measurements is presented in the next section.

4. MEASUREMENTS

Since HP-R-211 was a candidate for removal and possible replacement, measurements were attempted at five different conditions:

1. Laboratory measurements on a spare detector and readout module assembly
2. Pre-insertion detector pin measurements on two spares
3. Measurements on the installed detector-readout assembly
4. Measurements with a replacement detector installed at the remote meter location
5. Attempted measurements on the newly installed detector (only TDR cable measurements were possible).

Each set of measurements is described in the following sections.

4.1 LABORATORY MEASUREMENTS (MOCK-UP)

Prior to performing the measurements on the installed instrumentation, a preliminary set of measurements were taken on a spare detector and readout module assembly. Pages A-3 to A-16 in the Appendix are the actual field data sheets for the measurements. A summary of the important data is presented in Table 4-1. Of equal importance to the measurements on the detector were the calibration data obtained on the equipment to be used for the field tests. Pages A-17 to A-22 show the results of these measurements with the resulting equipment calibration (i.e., conversion values) data.

Table 4-1

SUMMARY OF MOCK-UP MEASUREMENTS
(DETECTOR RESISTANCES)

Measurement Points	Polarity +	Polarity -
Checksource (+) Checksource (-)	30.4 ohms	30.4 ohms
Signal in Shield	8.85	7.23
Signal in +10V	---	---
Shield +10V	7.47	11.90

Notes: (a) All values in ohms x 10^3 unless otherwise indicated

(b) First signal to positive terminal and second to negative is considered Polarity +

(c) All measurements made with a Keithley 177 DVM on 20×10^3 ohm scale.

4.2 PRE-INSERTION DETECTOR PIN MEASUREMENTS

Prior to possible insertion into containment for replacement of HP-R-211, measurements were made on two detector connector pins to determine a typical range of normal values for resistances. These measurements were carried out on two different Model 857-2 detectors, serial numbers 111 and 1405. Table 4-2 shows the data obtained from these pin measurements which was used for later comparison to the data obtained from the HP-R-211 assembly. Note that there is only a small variation in measured values between the detectors and that the change in resistances with polarity is the result of active components (i.e., transistors) in the detector circuitry.

4.3 INSTALLED DETECTOR-READOUT MEASUREMENTS

Measurements were also performed on the HP-R-211 assembly in its as-found condition. The field data sheets for these measurements are shown in the Appendix on pages A-23 to A-41. When measurements began, the local and remote meters were indicating 1.5 and 3.5 mR/hr, respectively. Prior to performing further measurements, a recording of the Signal Out line was made on an FM tape recorder using AC coupling to remove an offset of approximately 7V in the signal. Following this recording, passive measurements were made on certain signals with the following results:

(a) 10V Power Supply @ 9.4V

(b) Signal DC Voltage @ 7.5V with no checksource

@ 7.5V with checksource

Table 4-2

SUMMARY OF DETECTOR PIN RESISTANCE MEASUREMENTS

Measurement Points	Detector #111		Detector #1405	
	Polarity +	Polarity -	Polarity +	Polarity -
Checksource (+) Checksource (-)	---	---	30 ohms	30 ohms
Signal In Shield	8.77	7.34	8.79	7.16
Signal In +10V	8.27	6.56	8.38	6.84
Shield +10V	7.44	11.77	7.37	11.84

Notes: (a) All values are in ohms x 10^3 unless otherwise indicated

(b) First signal to positive terminal; second to negative is considered Polarity +

(c) All measurements made with a Keithley 177 DVM or $20x10^3$ ohm scale.

(c) 600V Power Supply @ 605V

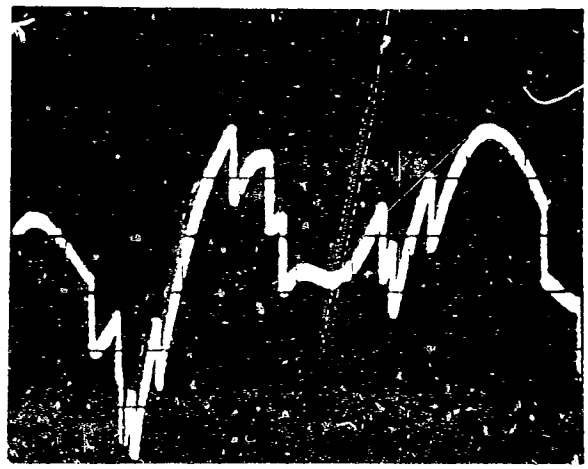
(d) Checksource Current @ 13 ma.

These measurements indicated that the 10V power supply was somewhat low, that the signal did not significantly change when the checksource was applied, that there was an offset in the signal line (detected during earlier recording), and that the 600V supply and checksource coil were operating correctly.

A series of time plots of all instrument line responses were obtained by photographing the trace from a storage oscilloscope. Figures 4-1 to 4-3 show typical results of these measurements for the 600V supply, signal, and 10V supply, respectively. The complete set of photographs is shown in the Appendix on pages A-79 to A-86. Frequency domain spectrum plots were also obtained for each signal over both a 0-5 MHz band and a 0-100 kHz band and the complete set of data can be found on pages A-87 to A-92. Figures 4-4 to 4-6 show the 0-100 kHz plots of the signal spectra, but not the high-frequency band, since little information is present at those frequencies. From these measurements of the waveforms, the following summary is obtained:

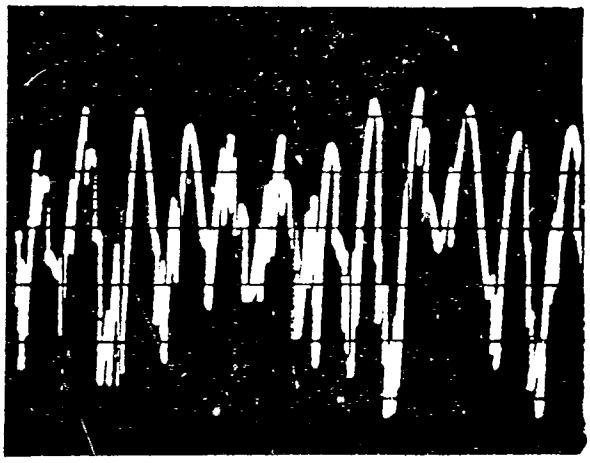
(1) 600V supply: 1V P-P @ 120 Hz present
small 20 kHz and harmonics
small 95 kHz present
random pulses present (see 1/f spectrum)
at lower frequencies

(2) Signal : 3.4V P-P random pulses present
small 32 kHz and harmonics present



a) Vertical Scale
0.2V/Div

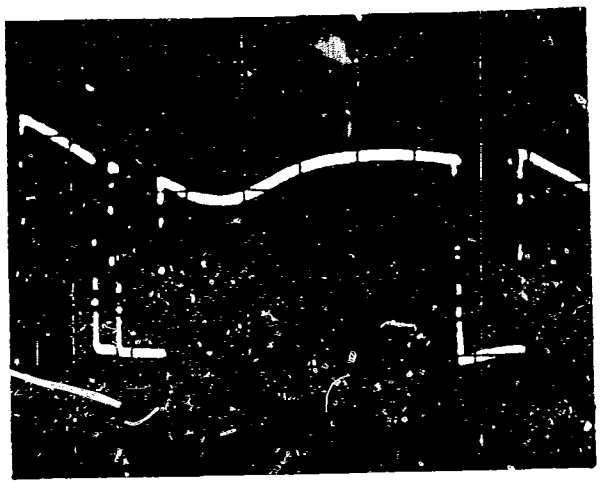
Horizontal Scale
2 ms/Div



b) Vertical Scale
0.2V/Div

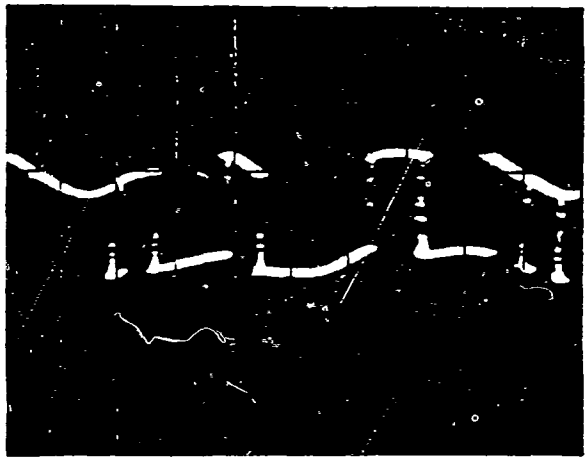
Horizontal Scale
10 ms/Div

Figure 4-1. Typical AC Fluctuations Present on 600 V Supply.



a) Vertical Scale
1V/Div

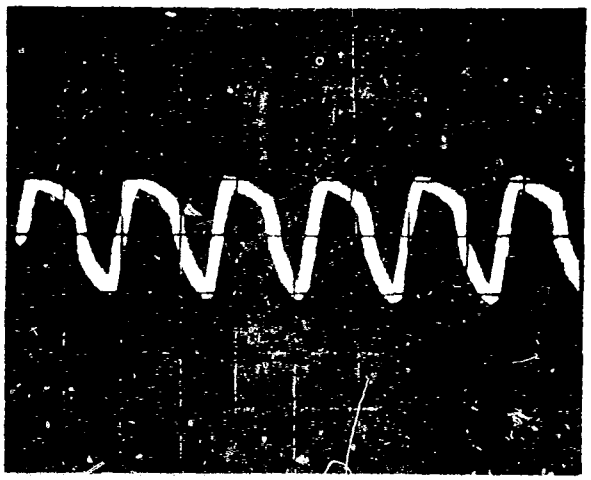
Horizontal Scale
1 ms/Div



b) Vertical Scale
1V/Div

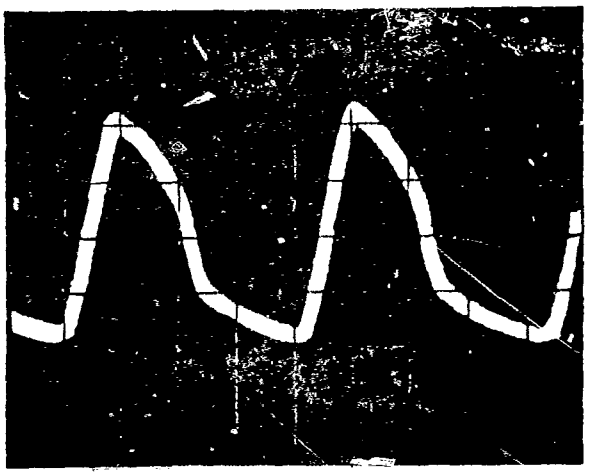
Horizontal Scale
2 ms/Div

Figure 4-2. Typical Output Signal.



a) Vertical Scale
1V/Div

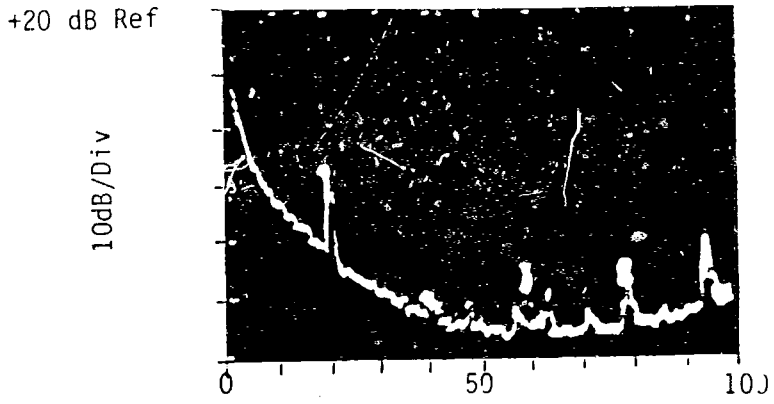
Horizontal Scale
5 ms/Div



b) Vertical Scale
0.5V/Div

Horizontal Scale
2 ms/Div

Figure 4-3. Typical Fluctuations on the 10 Volt Power Supply.

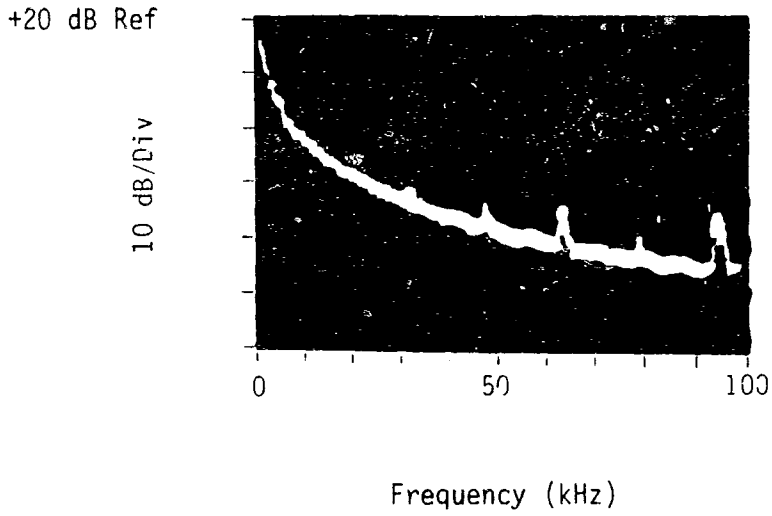


Note:

20 kHz Harmonics Intensified

AC RMS = 0.109 Volts

Figure 4-4. Frequency Spectra for 600 Volt Power Supply.

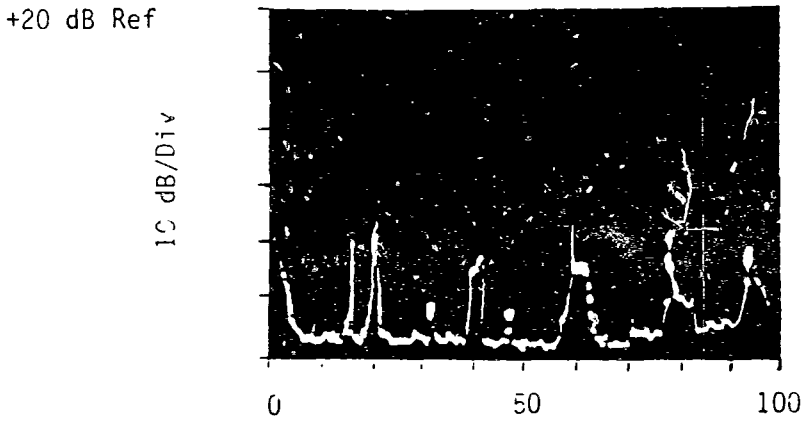


Note:

32 kHz Harmonics intensified

AC RMS = 1.35 Volts

Figure 4-5. Frequency Spectra for Output Signal.



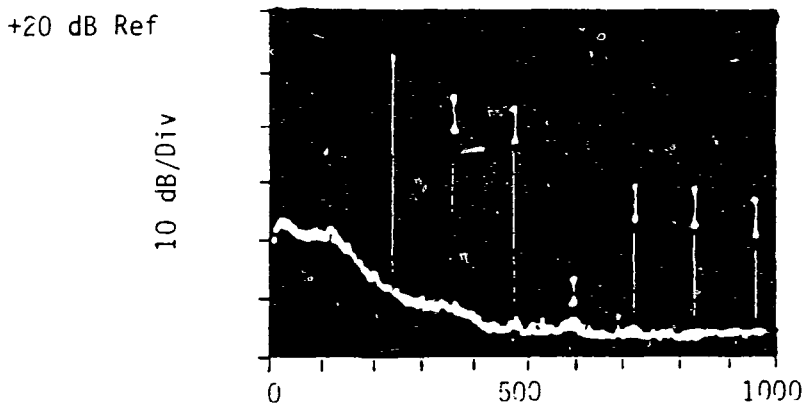
a) 0-100 kHz Range

Note:

16 kHz Harmonics Intensified

20 kHz Harmonics Present

AC RMS = 0.301 Volts



b) 0-1 Hz Range

Note:

120 Hz Harmonics Intensified

AC RMS = 0.712 Volts

Figure 4-6. Frequency Spectra for 10 Volt Power Supply.

(3) 10V supply : 2V P-P @ 120 Hz present
small 16 kHz and harmonics present
small 20 kHz and harmonics present.

This data again indicates a problem in the 10V supply due to the excessive 120 Hz AC present. Another problem is obvious in the small amplitude of the Signal pulses since they should span approximately 10V.

After completion of these measurements, the normal instrument calibration procedure was performed on the readout module electronics. The raw data sheets from the calibration are given on pages A-62 and A-63.

Application of the calibration procedures resulted in replacement of a capacitor in the +22V supply in the readout module, which directly feeds the 10V supply. This capacitor was the cause of the low supply voltage and probably caused the excessive 120 Hz fluctuations by allowing the rectified AC line signal to pass through. After the calibration, all voltages were restored to normal values.

After calibration of the readout module, power was removed from the instrument and the field cable links were opened between the detector and the readout module. A series of capacitance and impedance measurements were made at the field side (directly to detector) of the terminal blocks. The data obtained from this test is erratic due to the presence of long cables and active components in the detector, but may be found on page A-39 of the Appendix.

The integrity of the cable between the control room cabinet and the detector was then tested by performing TDR measurements. Figure 4-7 shows a typical TDR result for the Signal Out line with inflection points identified, and Table 4-3 lists the inflection points for all lines measured. Notice that there is some scatter in the predicted location of electrical interfaces, but this is not unexpected when using TDR measurements. A complete set of TDR traces for all cables can be found in the Appendix on pages A-94 to A-107.

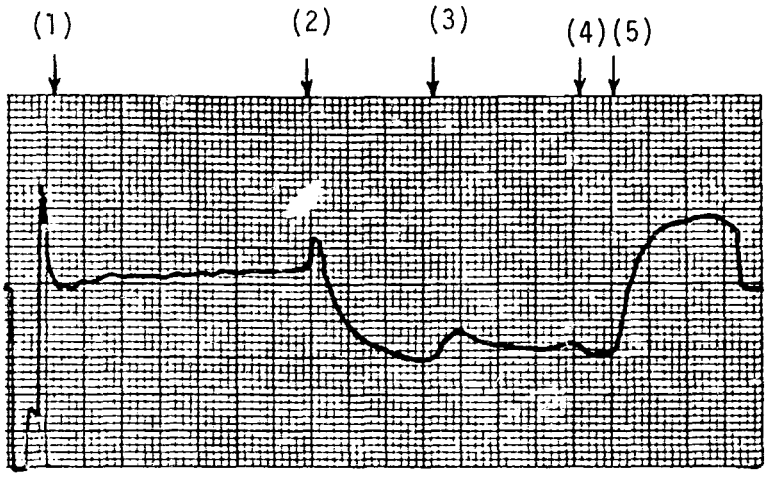
Upon completion of the TDR measurements, resistance measurements were performed on all combinations of signal lines at the terminal block. Note that this measurement is different from the detector pin measurements due to the length of cabling between the detector and the terminal block. However, this effect should be small (as confirmed by TDR data) and results should be comparable to the data taken previously. Table 4-4 lists the important measurements and a complete list can be found on page A-41.

4.4 MEASUREMENTS FOLLOWING REMOTE INSTALLATION OF NEW DETECTOR

Following the completion of measurements on the installed HP-R-211 system, a replacement model 887-2 detector (serial # 111) was installed by removing connections to the containment detector at the ante-room (remote) junctions. Before proceeding with measurements, the normal field calibration was performed on the detector-readout system using a calibration source. An adjustment to change the meter readouts upward by approximately a factor of two was needed, which is not unusual for expected variations with a new detector. The TMI calibration data sheets are given in the Appendix on pages A-64 to A-67.

Legend

(1) End of connecting cable & terminal
(2) Terminal block R increase
(3) Terminal block R increase
(4) Start of reduced R cable
(5) End of cable



Horizontal Scale:
26.3 ft/Div

Vertical Scale:
0.1 V/Div
(500 mρ/Div)

Figure 4.7 TDR Results of Signal Out Cable.

Table 4-3

SUMMARY OF TDR INFLECTION POINTS

Signal	Distance (ft)*	Description**	Probable Cause
Checksource	163	Increased R point	terminal block
	253	Increased R point	terminal block
	342	Slight continuous R decrease	?
	379	Large R increase	checksource coil
+600V (RG59)	174	Increased R point	terminal block
	174+	Continuous R decrease	?
	268	Increased R point	terminal block
	368	Slight continuous R decrease	?
	405	Large R increase	detector circuitry
Signal (RG58)	174	Increased R point	terminal block
	174+	Continuous R decrease	?
	263	Increased R point	terminal block
	368	Slight continuous R decrease	?
	395	Large R increase	detector circuitry

Table 4-3 (Continued)

Signal	Distance (ft)*	Description**	Probable Cause
+10V	163	Increased R point	terminal block
	242	Increased R point	terminal block
	342-358	Slight R decrease	?
	379	Large R increase	detector circuitry
Signal (RG58) with terminal block added	174	Increased R point	terminal block
	174+	Continuous R decrease	?
	363	Increased R point	terminal block
	384	Slight continuous R decrease	?
	405	Large R increase	detector circuitry

*TDR to terminal block test cable (10 ft) not included in distance.

**R is the abbreviation for resistance.

Table 4-4

RESISTANCE DATA FROM HP-R-211

Measurement Points	Polarity +	Polarity -
Checksource (+) Checksource (-)	40.2 ohms	40.2 ohms
Signal in Shield	8.62	6.53
Signal in +10V	305 ohms	305 ohms
Shield +10V	6.47	8.59

Notes: (a) All values in ohms x 10^3 unless otherwise indicated.

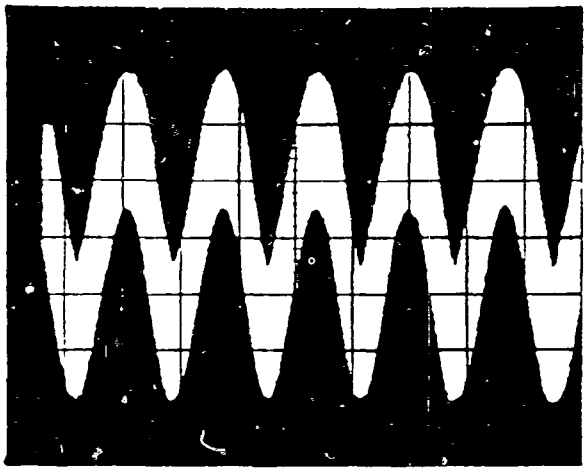
(b) First signal to positive terminal and second to negative is considered Polarity +.

(c) All measurements made with a Keithley 177 DVM on $20x10^3$ ohm scale.

After calibration, both the remote and local meters indicated a dose rate of 0.5 mR/hr at the ante-room location of the replacement detector and the signal from the detector was recorded (see page A-43). The 10V supply measured 9.99V, the 600V supply measured 605V, and the checksource coil measured 14 ma current, when tested. The signal output was ranging from 0 to 9.9V when measured with a DVM with background dose rate conditions and similarly varied when the checksource was activated, but at a much faster rate which appeared as approximately an averaged 5V level.

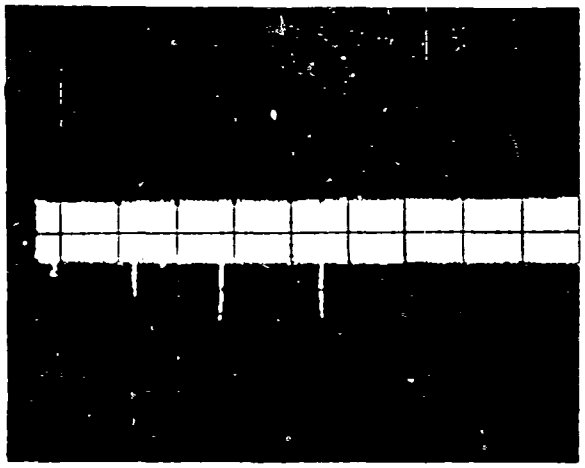
Time traces were taken of the output waveforms by photographing a storage oscilloscope trace. Figures 4-8 and 4-9 illustrate waveforms which exhibited the main differences between the original waveforms and the new ones (a complete set of plots are given on pages A-109 to A-115). Figure 4-8 shows the absence of the 120 Hz contamination on the 600V supply (which was also true for the checksource lines and the 10V supply). This improvement was probably the result of repairing the power supply capacitor in the readout module and is not indicative of the effect of replacing the detector. Figure 4-9 shows the pulsed voltage on the signal line, which has a significantly greater amplitude: 3.5V range previously and 9.9V with the new detector.

Both the high frequency and low frequency spectra taken on the signals show a continued low level contamination at both 16 and 20 kHz and harmonics; however, the magnitude is much lower than previously shown. The complete set of spectra are given in the Appendix on pages A-116 to A-121.



a) Vertical Scale
20 mV/Div

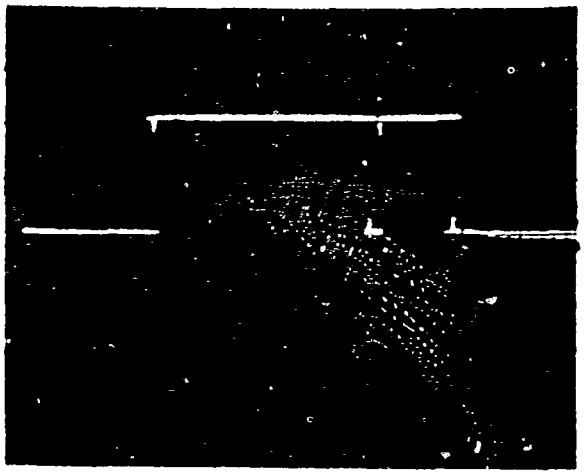
Horizontal Scale
10 mS/Div



b) Vertical Scale
100 mV/Div

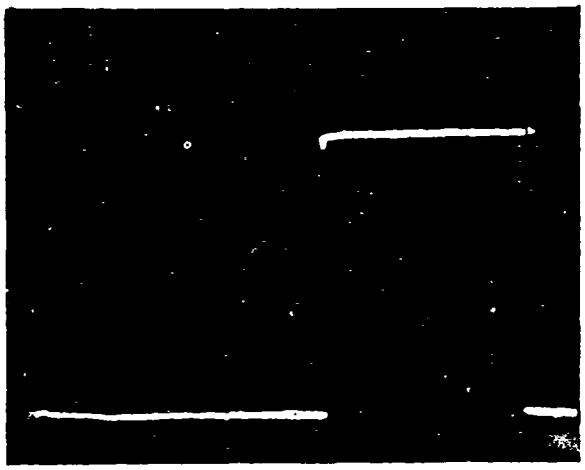
Horizontal Scale
0.2 Sec/Div

Figure 4.8 AC Fluctuations on 600V Supply After Replacement of Detector.



a) Vertical Scale
0.5 V/Div

Horizontal Scale
1 Sec/Div



b) Vertical Scale
0.2 V/Div

Horizontal Scale
0.5 Sec/Div

Figure 4.9 Fluctuation of SIGNAL OUT After Replacement of Detector.

4.5 MEASUREMENTS FOLLOWING ATTEMPTED DETECTOR REPLACEMENT IN CONTAINMENT

Following the testing of the detector installed in the ante-room, the containment monitor was to be replaced with the detector (serial # 111) which was just tested and calibrated. However, during the removal of the old detector, the connector to the detector was broken and insertion of the new detector was not possible. Dispute this problem, the old detector was removed for testing by Sandia Laboratory. Since there was no detector installed in the HP-R-211 circuit, the only measurements that would possibly provide any useful data were the TDR measurements on the cable. The results of these measurements are summarized in Table 4-5 and the strip chart traces are shown on pages A-123 to A-132.

Table 4-5

SUMMARY OF TDR INFLECTION POINTS FOR DAMAGED CABLE

Signal	Distance (ft)*	Description**	Probable Cause
Checksource	168	Increased R point	terminal block
	247	Increased R point	terminal block
	342	Slight continuous R decrease	?
	379	Large R increase	open circuit
+600V (RG59)	179	Increased R point	terminal block
	179+	Continuous R decrease	?
	274	Increased R point	terminal block
	374	Slight continuous R decrease	?
	405	Large R increase	open circuit
Signal (RG58)	174	Increased R point	terminal block
	174+	Continuous R decrease	?
	268	Increased R point	terminal block
	368	Slight continuous R decrease	?
	395	Large R increase	open circuit

Table 4-5 (Continued)

Signal	Distance (ft)*	Description**	Probable Cause
+10V	163	Increased R point	terminal block
	245	Increased R point	terminal block
	342	Slight continuous R decrease	?
	384	Large R increase	open circuit

*TDR to terminal block test cable(s) (15 ft) not included in distance.

**R is the abbreviation for resistance.

5. DATA ANALYSIS

Following the actual field data gathering and on-site preliminary interpretations (given in Section 4), detailed analysis of the data was performed off-site. This data analysis consisted both of reducing the recorded data and interpretation of measurements to infer physical characteristics of the instrumentation.

5.1 REDUCTION OF RECORDED DATA

As described in the previous section, a recording was made of the detector output signals for three conditions:

1. Original HP-R-211 response
2. HP-R-211 response after electronic calibration
3. Replacement detector following complete calibration.

Examination of the waveforms from the original detector showed that there was a +6V offset on the signal with pulses rising to 9.5V and falling back to 6V also present. The operations manual for the detector indicates that the proper range of signals is approximately 0-10V (with a 0.8V possible variation due to electronics). This correct span of operation observed on the output of the replacement detector indicated that some problem existed in the detector or in the containment penetration (cable passing into containment). However, it is extremely unlikely that a cable problem would produce a signal with an offset and pulses correspondingly clipped at the offset value. Hence, the detector was selected as the most likely candidate for having failed (i.e., not producing its normal output response).

A more quantitative analysis of the detector recordings was also attempted because, as noted during field measurements, the pulse rate (but not the pulse height) from the original detector appeared to be consistent with believed containment radiation levels. A summary of the count rate for the three measurements is given in Table 5-1. Note that the operation of the device requires that two ionizing events occur to produce the "up" and "down" transition of the output. This is due to the "flip-flop" logic in the detector circuitry. Because the output wave forms were observed to be of improper range for the original detector, a pulse shaping circuit was applied to the reproduced signal to generate a proper indication of the detector response. The diagram for this circuit is shown in Figure 5-1.

The first amplifier stage was applied to remove any signal offset (AC coupled) and to convert the detector output into overloaded pulse events (saturation of maximum amplifier output at approximately 11V). This produces a well-defined range of the signal between -11V and +11V for processing by the threshold detector. Any delay introduced by the amplifier is not important since ionization events in the detector would be random, and hence not effected by such delays. Following the amplifier, a threshold detector circuit was inserted and adjusted to trigger at approximately +5V with a hysteresis of 5V. This produced an output of +9.2V when the detector signal exceeded 5V and maintained this output until the signal dropped below 0V, which triggered an 0V output. The range of 0 to 9.2V was chosen because this was the minimum range normally resultant from the detector circuit. (However, a test to determine the effect of this range was also performed later.)

Table 5-1

COUNT RATES MEASURED FROM SIGNAL RECORDINGS

Description of Data	Average* Count Rate (CPS)	Average** Reading in mR/hr	Ratio of CPS/(mR/hr)
Original Detector as found)	301(3)†	200(3)	1.51
Original Detector (after electrical calibration	293(4)	103(5)	1.52
Replacement Detector (background)	0.23(.08)	0.29(.09)	0.79
Replacement Detector (checksource)	7.2(0.5)	5.2(0.1)	1.38

*Actual detector ionization event rate is twice the listed value.

**From a readout module connected to a pulse shaping circuit applied to the reproduced signal with a 9.2V range.

†Numbers in parentheses are the associated standard deviations.

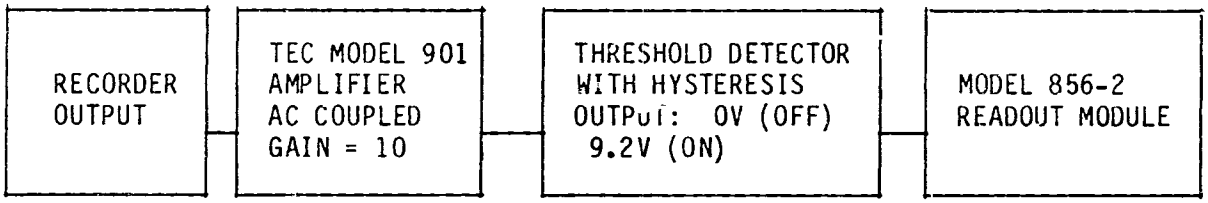


Figure 5-1. Diagram of Pulse Shaping Circuitry.

Referring to Table 5-1, the original detector count rates with the assumed pulse shaping are indicative of dose rates of approximately 200 mR/hr inside containment instead of 1.5 mR/hr as indicated on the control room readout. A review of the readout meter theory of operation shows why this extreme variation in indication occurs. The readout meter converts the detector signal transitions to logarithmic levels using a "log-pump" circuit. This circuit essentially consists of a series of capacitors (one for each decade range) which are charged by the maximum signal level and are then discharged through a resistor when the minimum signal level occurs. The resultant voltage output from the series of R-C circuits is summed to produce the readout value, with adjustments for "zero" and "span". Each R-C circuit (stage) is staggered by approximately a factor of ten in time response so that the more rapidly the input signal changes, the more stages reach near constant outputs and hence indicate higher radiation levels.

This entire circuit is dependent on the span of the input signal to generate the discharge levels from the capacitors through the resistors and is not sensitive to offset values due to the capacitive coupling. Since the range of the pulses was only 3.5 volts on the original detector, the readout module was not capable of interpreting the correct radiation levels. To understand the effect of various pulse ranges, a simple experiment was performed using a function generator, at various frequencies and output levels, acting as a "detector" input into a model 856-2 readout module. Figure 5-2 shows the results of this test. As expected from the log-pump circuit operating principles, at low signal ranges there is very little dependence of the meter on the input frequency (i.e., simulated

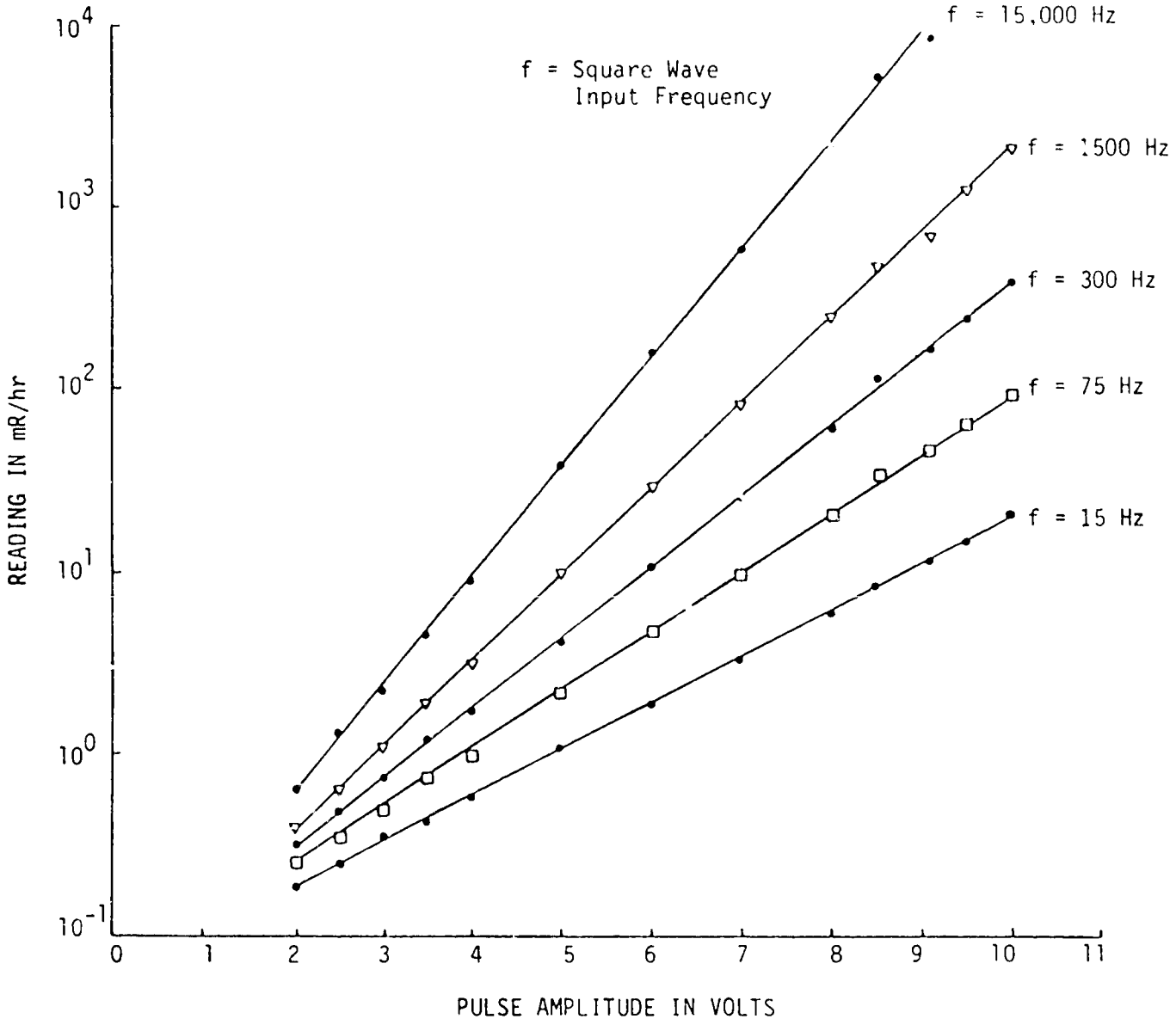


Figure 5-2 Victoreen Alarm/Rate Meter Response to Test Signals.

ionization events) due to the low charge/discharge levels in the circuit. This data sugggests that for the original detector with a 3.5V range, the response of the readout meter would not exceed 5 mR/hr event at full-scale radiation levels.

From Table 5-1 and Figure 5-2, there appears to be a near-constant conversion between pulse rate and readout indication at a fixed pulse voltage span with variations occurring at low radiation levels. This behavior is expected since the design of the system uses only the frequency of ionization events to generate an output (at a fixed pulse range). From the data gathered, this constant appears to be approximately 1.5 CPS/(mR/hr) which was also observed during mock-up testing (see page A-20). The variations in Table 5-1 for the replacement detector data are probably due to improper adjustments to the readout module, non-linearities at low readings, and difficulties in reading the meter at low values (needle variations). Note that the ratios of 1.55 and 1.51 are obtained for the replacement ratios in Table 5-1 if one standard deviation is added to the count rate and one standard deviation is subtracted from the dose rate. Thus the value of 1.5 CPS/(mR/hr) appears to be statistically acceptable as a count rate to dose rate conversion value.

For completeness in interpretation of this value, two other factors must be considered. Referring to Figure 5-2, a factor of 2 increase in response occurs if the output pulses of the detector change from 9.2V to 10V. Thus, if the meter were calibrated to expect pulses spanning 10 volts, the conversion value of 0.75 CPS/(mR/hr), or 1.33 (mR/hr)/CPS, is predicted.

The observations of a reading of 0.5 mR/hr background and of 9.9V pulse transitions during the measurements on the replacement detector suggest that this value is more nearly correct. With this conversion factor considered, the inferred dose rate indicated by HP-R-211 was 400 mR/hr inside containment. The second factor that needs to be emphasized is the fact that two ionization events must occur in the GM tube of the detector to achieve a complete pulse output. As mentioned previously, this is due to the "flip-flop" output conditioning of the detector in which each GM tube event triggers a change in state (i.e., ON to OFF or OFF to ON).

5.2 INTERPRETATION OF MEASUREMENTS

After acquiring the data and performing some analysis of the recorded data, HP-R-211 appeared to be non-functional (using the installed instrumentation) due to a reduced amplitude signal produced in the detector output circuitry. By comparing restored signal indications to expected dose rate levels, the remainder of the detector and the entire readout module appears to be operating correctly, at least within normal variations due to lack of recent calibration and some potential changes in the GM tube sensitivity.

As a result of these findings, an attempt to predict the problem in the detector was made based on comparisons of measurements obtained on the new detectors and on the HP-R-211 detector. Figure 2-4 shows the electrical circuit within the detector housing, and Tables 4-2 and 4-4 give the resistance measurements for the reference and original detectors, respectively. Note that the cable resistances are included in data from

the original detector since it was installed inside containment; but any small resistances would not seriously change the results, and TDR measurements indicated no large cable resistances.

The only significant differences observed in the HP-R-211 data compared to the references were an increase in checksource resistance by 10 ohms, a low resistance path of only 305 ohms from signal in to +10V supply, and a small reduction in resistance between shield and +10V supply. The increase in the checksource resistance is within the expected variation in coil resistances and the added cable resistance and is not considered important. The extremely low resistance of 304 ohms between the signal line and the shield (ground) is probably responsible for the small reduction in the shield to +10V resistance, and therefore will not be considered separately unless analysis indicates otherwise.

Referring to the electrical circuit schematic in Figure 2-4, there are numerous paths between the signal line and the 10V supply, but only two main paths exist in the output section transistors Q6, Q7, and associated resistors. (The output section is considered the likely problem area due to indications of all other sections operating.) The first path consists of two fixed resistors R23 (10 k-ohm) and R21 (100 ohm), and the second path consists of Q6 (2N3906) and R20 (100 ohm). For the first path to produce a low resistance with a single failure, R23 would need to have a resistance of 200 ohms since R23 is normally much larger than the 304 ohms measured. However, the mechanism for such a reduction in resistance is not clear and, if R23 were reduced that low, normal operation of Q7 to pull the

signal to ground would connect the +10V to ground through a 200 ohm resistance. If this occurred, the load on the 10V supply would have been 50 ma, which is much greater than the normal load, and would have produced variations in the 10V supply due to this excessive load. No extreme voltage variations were observed (see page A-84), which indicates this path was not responsible for the offset in the output.

The second path would require Q6 to have a 200 ohm short from emitter to collector (in the unpowered state) to produce the low resistance measurement. Since this path normally enables the HI output state (+10V) through a 100 ohm resistor, the loading on the signal line due to the readout module must be very low, and no variation on the 10V supply would be expected. Also, mechanisms for such a transistor failure are much more likely than for the resistor, R23, to have a reduction in resistance. This would also explain the reduction in the shield to 10V supply lines due to the formation of a 10.2 k-ohm path through resistor R22 if Q6 failed. As a result of this type of reasoning, along with analyses to determine alternate causes of the offset observed, it is felt that the cause of the offset present in the signal line is due to a low resistance path through Q6.

6. CONCLUSIONS

Based on the measurements, data reduction, and circuit analysis of HP-R-211, the likely cause of the apparent failure of the monitor was a failure of transistor Q6 (see Figure 2.4). This resulted in a low resistance path between the 10V power supply and the signal, which held the Signal Out level within 3.5 volts of the power supply level, even when Q7 attempted to pull the level to ground.

Further analysis indicated that if the detector output signals were conditioned to their proper levels using external circuitry, a dose rate of approximately 400 mR/hr was indicated. Current results indicate that this circuitry would have been capable of restoring the proper signal if the Q6 failure progressed to fully open or shorted.

Other measurements indicated that with the exception of the failure of Q6 inside the detector housing, the HP-R-211 monitoring system was functioning properly.

APPENDIX

FIELD DATA SHEETS AND FIGURES

Included in this Appendix are the original field data sheets from the measurements which were left as originally filled out without corrections or alterations, except for some added comments. Also included is a complete set of photographs and strip chart results from the measurement program. Due to the separate measurements taken, this Appendix is divided into the following sections with starting page numbers given.

SECTION A.1

MOCK-UP MEASUREMENTS PRIOR TO FIELD TESTS

(with Figures)

REVIEW & PRE TEST COPY

Technology for Energy Corporation	TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0
PROCEDURE	APPROVED M.V. Mathis, Director, Tech. Serv. Div.	DATE 8-11-80

PURPOSE: The purpose of these measurements is to gather baseline data and information in preparation for removal and replacement of Area Radiation Monitor HP-RT-0211 from the reactor building TMI Unit 2. The tests specified in this procedure are designed to assess the condition of the in-containment instrument module (gamma detector), associated cabling, and readout devices. This assessment will require the use of Time Domain Reflectometry (TDR), Impedance (Z), Spectral Analysis (frequency domain), special calibration measurements, and general oscilloscope observations (with recording) of waveforms from/to the unit under test (UUT).

PROCEDURE (ADMINISTRATIVE:

A. Limitations and Precautions

1. Nuclear Safety. Area radiation monitor HP-RT-0211 is part of a redundant ARM system at elevation 305'. The unit is not considered part of the engineered reactor safeguards system thus has no nuclear safety relevance.

2. Environmental Safety. Area radiation monitor HP-RT-0211 can be taken out-of and restored to service without producing a hazard to the environment.

3. Personnel Safety. The test described herein produces no additional personnel safety hazards other than normally associated with performing instrument calibrations and tests. Since the UUT is to be replaced by a calibrated spare, personnel safety should be enhanced by the ability to more ~~reliability~~ reliably monitor the radiation levels at El-305'.

4. Equipment Protection. In the performance of each test described herein, care will be taken to insure adequate equipment protection as follows:

   a. In all cases actual test hookups to the Unit-2 instrumentation shall be made and verified by Instrumentation Personnel.

   b. All passive measurements (Spectral Analysis and Oscilloscope observations) of waveforms and signals from powered instruments shall be pervormed using high input impedance probes or inputs ($Z = \geq 1$ Meg ohm) to prevent loading of signals.

   c. In all Time Domain Reflectometry and Impedance measurements, power will be removed from the unit under test and low level test signals prescribed in Table 4-1 shall be utilized to perform cable

integretary measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT1869I (terminations shall be removed and replaced on TB109 of Cabinet 12). Should these tests reveal cable integretary problems further verification measurements will be made at TB1 of the appropriate Remote Alarm/Meter (Victoreen Model 858-3) located in the anteroom.

Table 4-1 Active Measurements

Active Signal Parameter	Time Domain Reflectometry	Impedance
Voltage	225 mV nominal (into 50 ohm base)	$\leq$ 5V rms
Frequency	---	100Hz, 1kHz, 10kHz, 100kHz
Current	$\leq$ 10mA	$\leq$ 100mA
Other	225mV, 110 picosecond pulses	---

d. In the calibration verification measurements section, baseline data on the as-found condition will be recorded prior to the performance of any adjustments or electronic calibrations. Furthermore, the replacement detector will be connected to TB-109 (Cabinet 12) through an interface cable and calibrated by Instrumentation personnel using applicable procedures for Calibration of the Victoreen Area Radiation Monitor (field calibration source corrected for half-life decay). Baseline passive measurements will be repeated on the replacement unit.

B. Prerequisites

1. The Shift Supervisor/Shift Foreman shall be notified for concurrance prior to the performance of those measurements.

2. Instrumentation personnel shall be assigned to assist in the performance of these measurements.

3. All measurements and test instrumentation shall be in current calibration (traceable to NBS).

4. The Shift Supervisor/Shift Foreman shall be notified prior to starting and upon completion of the measurements.

C. Procedure for Performing Measurements

References:

1. Victoreen Dwg. No. 904550, Wiring Diagram Area Monitors Channels HP-R-211 & HP-R-212 (Sheet 5 of 11).
2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.
3. Burns & Roe Dwg. 3024, Sh. 30A.
4. Burns & Roe Dwg. 3043, Sh. 16D.
5. Burns & Roe Dwg. 3045, Sh. 34.
6. Burns & Roe Dwg. 3045, Sh. 34B.
7. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.
8. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.
9. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 8553B, 8552B Modules).
10. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.
11. Instruction Manual, Tektronix Model 335 Oscilloscope.
12. Instruction Manual, Lockheed Store-4 Recorder.
13. Instruction Manual, Tektronix SC502 Oscilloscope.
14. Composite Electrical Connection Diagram, HP-R-211 (Sketch dtd 8/8/80).

Victoreen Instrument Company Dwg. 904550 (Ref. 1) and B&R Drawings 3024 (Ref. 3) show the appropriate termination points for passive measurements of signals from HP-RT-0211 as follows:

TEC	TITLE	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
			REV. 0

Signal	~~Penetration~~ CABLE IT2931I	Cabinet 12
+10V		TB109-8
600V		TB109-5
SIG		TB109-6
GND		TB109-10
CS		TB109-1
CS		TB109-2

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

1. PRE-REMOVAL, POST-REMOVAL: Notify Shift Supervisor/Shift Forman of start of test on HP-RT-0211.

2. PRE-REMOVAL, POST-REMOVAL: Verify power is applied to HP-RT-0211.

Signature/Date

3. PRE-REMOVAL, POST-REMOVAL: record present signals and readings and indications on 856-2 Readout Module (Local & Remote). Record Signal-in at TB109-6 ("T"), and record output from TB1 of 856-2 Readout A9 for a unit for one hour on FM Tape Recorder. Remove recorder when finished.

7½ IPS DIRECT CHAN 1 DC COUPLED USING 4658 AMP
GAIN = 50mV

TEC	TITLE	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-C211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
			REV. 0

Meter/Indicator/Switch	Local	Rmte
MR/hr Meter Reading	_____	_____
Off-Operate-Alarm Function Switch	_____	N/A
Fail Safe Indicator	On___Off___	N/A
High Alarm-Reset Indicator	On___Off___	N/A

_____
Signature/Date

4. PRE-REMOVAL, POST-REMOVAL: Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = $\pm$ 1%) measure the DC voltage or current at the following test points.

NOTE: For signal d. it will be necessary to depress Fall-Safe Check Source push button during the measurement.

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

SIGNAL	CABINET 12	TEST LEAD	READING
a.	TB109-8 TB109-10	(+) (-)	(10V) 10.084 50mV p-p 60/25K 20mV p-p 60
b.	TB109-6 TB109-10	(+) (-)	(SIG IN) _____ CS OUT CS IN
*c.	TB109-5 TB109-10 M	(+) (-)	(600V) _____
**d.	TB109-1 (open field side) TB109-1 (cabinet side)	(+) (-)	(≤500 mA est.) _____

*Use electrostatic voltmeter
**Link closed after measurement

10 MIN

_____
Signature/Date

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

5. PRE-REMOVAL, POST-REMOVAL: Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

SIGNAL	CABINET 12	PARAMETER	PHOTO ____	PHOTO ____	PHOTO ____
a.	TB109-1 TB109-10	CS	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
b.	TB109-2 TS109-10	CS	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
* c.	TB109-5 TB109-10	+600V	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
d.	TB109-6 TB19-10	SIG	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
e.	TB109-8 TB109-10	+10V	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
f.	TB109-10 TB501-27	GND ACGND	Time Base ____ Vert Gain ____	_____ _____	_____ _____

*Use X10 probe

Sync the oscilloscope and photograph the waveform using three time base and vertical gain settings. Mark the back of the photographs with the instrument tag number and parameter measured.

Signature/Date

TEC	TITLE	NO.
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	TP-101
		REV. 0

6. PRE-REMOVAL, POST-REMOVAL: Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

SIGNAL	CABINET 12	PARAMETER	PHOTO #
a.	TB109-8 TB109-10	+10V GND	1
b.	TB109-6 TB109-10	SIG IN GND	
*c.	TB109-5 TB109-10	+600V GND	

50MHz
TEKTRONIX 465B
0-5 50MV

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope presentation adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., space, RF bandwidth, ~~video~~ bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

RF

SPECTRUM IDENT	FREQUENCY	AMPLITUDE	REMARKS
~~PHOTO #1~~			
PHOTO #1	25kHz & Harmonics		

Signature/Date

TEC	TITLE	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
			REV. 0

7. PRE-REMOVAL, POST-REMOVAL: Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

SIGNAL	CABINET 12	PARAMETER	PHOTO #
*a.	TB109-5 TB109-10	+600V GND	
b.	TB109-6 TB109-10	SIG IN GND	
c.	TB109-8 TB109-10	+10V GND	2

30 MIN

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max)

If PSD plots from any one of the three signals show high and unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

Signature/Date

8. PRE-REMOVAL ONLY: Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

TEC	TITLE	NO. TP-101
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	REV. 0

Procedure Step	Before	After	Remarks
See attached instrument shop procedure data sheet.			

Instrument Shop Procedure No. _____

_____
Signature/Date

9. PRE-REMOVAL, POST-REMOVAL: Remove all power from HP-RT-0211 (Tag Open TB501 links 25, 26, and 27 per procedure AP 1002).

_____
Signature/Date

10. PRE-REMOVAL, POST-REMOVAL: Open links for all field wires from Cable IT1869I at TB109 (Cabinet 12).

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

TERMINAL	SIGNAL IDENT.
TB109-1 (Blue)	C.S.
TB109-2 (Orange)	C.S.
TB109-3 (White)	Rem. Meter
TB109-4 (Yellow) IT2933C	HI N.C.
TB109-5 (RG 59/U, 72 OHM)	60DV
TB109-6 (RG 58/U, 50 OHM)	SIG IN
TB109-7 (RG 58/U, 50 OHM)	Shield
TB109-8 (Red)	+10V
TB109-9 (Green) IT2933C	Alert N.C.
TB109-10 (Blk) (RG 59/U, 72 OHM)	GND Shield

Signature/Date

11. PRE-REMOVAL, POST-REMOVAL: Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

TEST POINT	FROM		TO	
	CABLE	WIRE COLOR/TYPE	CABLE	WIRE COLOR/TYPE
a.	IT1869I	Blue	IT1869I	Orange
b.	IT1869I	RG 59/U Center	IT1869I	RG 59/U Shield
c.	IT1869I	RG 58/U Center	IT1869I	RG 58/U Shield
d.	IT1869I	Red	IT1869I	Black
e.	IT1869I	Black	IT1869I	TB109-10

Record the data required below:

Test Point	Capacitance			Impedance		
Frequency →	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz
a. COIL!	(INDUCTOR 4.51 mH)	(INDUCTOR 4.45 mH)	(INDUCTOR 2.86 mH)	30.2 Ω	41.4 Ω	4.25 kΩ
b. 60 Hz	262 pF	271 pF	263 pF	5.94 MΩ	588 kΩ	6.05 kΩ
c. 30 MIN	4.2 nF	.62 nF	361 pF	2.86 kΩ	2.86 kΩ	2.35 kΩ
d.	108 μF	103 μF	INDUCTOR	18.7 Ω	11.1 Ω	11.1 Ω
e.	INDUCTOR	INDUCTOR	INDUCTOR	97.6 mΩ	99.1 mΩ	1.31 Ω

Signature/Date

TEC	TITLE	NO.
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	TP-101
		REV. 0

12. PRE-REMOVAL, POST-REMOVAL: Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

Test Point	High R @ N ft.	Low R @ N ft.	Instrument Settings Ampl Range Mu[illegible]	Photo No. *
a.				
b.				
c.				
d.				
e.				

45 MIN

*Utilize strip chart where available.

Signature/Date

13. PRE-REMOVAL, POST-REMOVAL: Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

NOTE: Open links for IT2933C from TB109 terminals 11, 12, 13, and 14. The appropriate wires should be marked accordingly.

TEC

TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

Polarity From = + To = − Polarity From = − To = +

TEST POINT	FROM LINK	TO LINK	RESISTANCE	R
CS a.	TB109-1	TB109-2	30.4 Ω	30.4 Ω
b.		TB109-5		
c.		TB109-6		
d.		TB109-7		
e.		TB109-8		
f.		TB109-10		
g.	TB109-2	TB109-5		
h.		TB109-6		
i.		TB109-7		
j.		TB109-8		
k.		TB109-10		
l.	TB109-5	TB109-6	> 20 MΩ	> 20 MΩ
m.		TB109-7		
n.		TB109-8		
600V o.		TB109-10	> 20 MΩ	> 20 MΩ
5V p.	TB109-6	TB109-7	8.85 kΩ	7.23 kΩ
q.		TB109-8		
r.		TB109-10		
s.	TB109-7	TB109-8		
t.		TB109-10	.68 Ω	.56 Ω
10V u.	TB109-8	TB109-10	11.9 kΩ	7.47 kΩ

453 MΩ

Close all links on TB109 (opened in Step 10) when finished with this step.

Signature/Date

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote ~~Meter/Alarm Unit~~ (Ante-room). Record S/N of Detector used

S/N

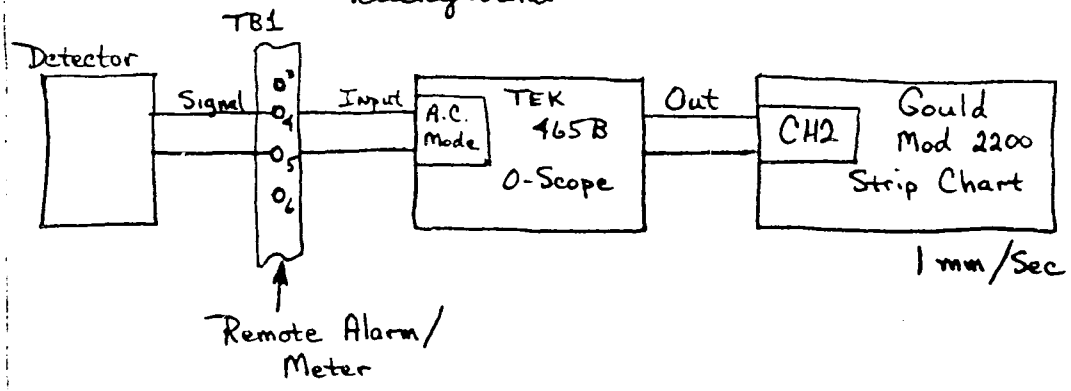
Signature/Date

TMI Tests @ EG&G Trailer

8/12/80

MV Mathis
JT Smith
JE Jones

① 17:04 Recording Pulses from Detector (10 Minute Span) Background

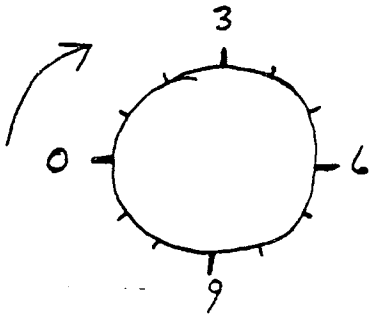


② 17:14 Recording Pulses with Check Source
Speed: 10 mm/Sec [See Figure Above]

– Performed ~~a~~ TDR measurements of 10' test cable mock-up (see analysis sheet). Using Gould 2200 strip chart recorder at 5 mm/sec speed, a length calibration factor was obtained. This ~~fact~~ measurement yielded 19 full divisions on the strip chart corresponding to 10 divisions on the TDR display. Thus ft/division will be divided by 1.9 when recorded on strip charts.

JE Jones

Cable Dielectric Settings



10' Calibration Values (Open)

Cable Pair	"Other" Setting	
Red - Black (#22)	4.25	> 4.50 Value Selected !
Blue - Orange	4.75	

Measurements (10' Length Cable) [10' Test Cable & Clips Used]

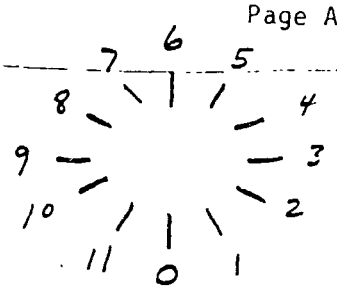
Cable Pair	Length (Open)	Length (Closed)	Dielectric
Red - Black (#22)	10.25'	10.1'	OTHER
RG58	10'	10.1'	SOLID POLY
RG59	9.9'	9.9'	SOLID POLY
Blue - Orange	9.9'	10.0	OTHER
Black - RG59 Shield	9.85'	10.05	OTHER
Blue - Violet	9.9'	10.0'	OTHER

Due to above measurements, the "Solid Poly" setting will be adequate for the RG58 & RG59 cables and the "Other" setting selected [at 4.5 relative value on potentiometer] for other cables.

8/12/80

J E Jones

VAR POT



MOCK-UP DETECTOR CABLE
P calibrated for 10'

Cable open	SET UP		
Blue to org	OTHER	VAR	6.25
RG59	OTHER	VAR	5.50
RG58	OTHER	VAR	5.50
Red to B/K	OTHER	VAR	6.00
B/K to RG59 shield	OTHER	VAR	5.00

CABLE TERMINATED INTO DETECTOR

	Off of Scale	From STEP CHG.
Blue to Org.	10.3'	10.6'
RG 59	10.2'	10.4'
RG 58	10.2'	10.4'
Red to B/K	11.0'	11.2'
B/K to RG59 Shield	10.85'	10.8'

G.M. Mueller results
8/11/80

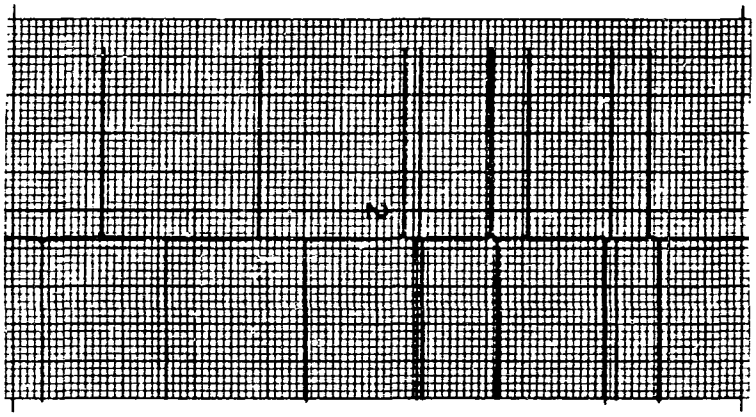
MOCK-UP TEST

Test in Trailer

(1) Background of Detector

Background Reading ∿ 0.2 mR/hr

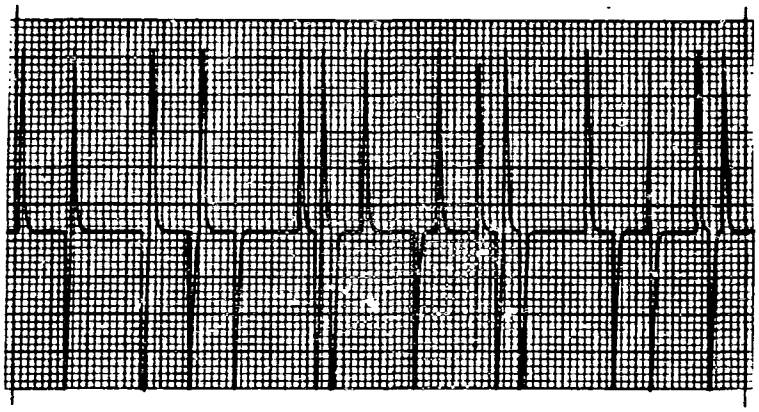
102 Counts/10 min.
Chart Speed: 1 mm/s



(Typical)

(2) Check Source in Detector

Check Source Reading ∿ 2 mR/hr
184 Counts/1 min.
Chart Speed 10mm/s



(Typical)

Mock-up Test (Trailer)

Low Frequency Spectrum

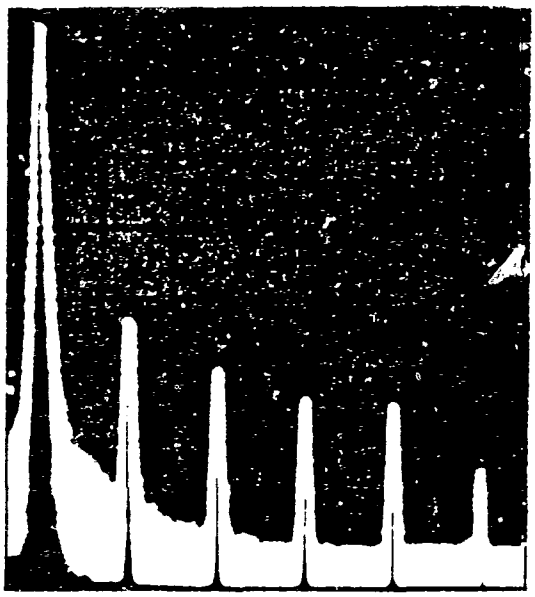


PHOTO #1

BW = 1KHz

Horiz. Scale: 20 KHz/Div
(0.1 s/Div Scan)

Vert. Scale: 10 dB/Div

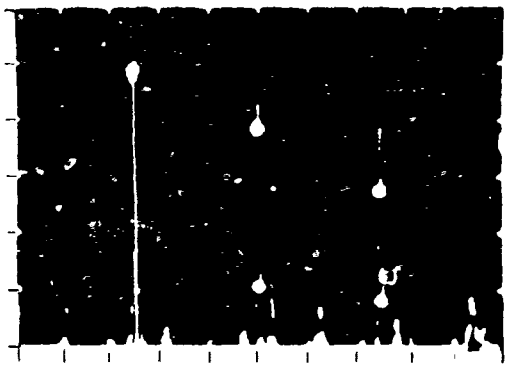
+10V Signal (AC Coupled)

Mock-up Test (Trailer)

Low Frequency Spectrum

0.0116 RMS

PHOTO #2



+10V Signal (AC Coupled)

Range: 0 - 100 KHz

20 KHz Harmonics Intensified

Vert. Scale: +10 dB Ref;
10 dB/Div

SECTION A.2

PRE-INSERTION DETECTOR PIN MEASUREMENTS

(Procedure pages used to record data)

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

SERIAL #1405

PRE-INSERTION PIN MEASUREMENTS

TEST POINT	FROM		TO	
	CABLE	WIRE COLOR/TYPE	CABLE	WIRE COLOR/TYPE
a.	IT1869I	Blue	IT1869I	Orange
b.	IT1869I	RG 59/U Center	IT1869I	RG 59/U Shield
c.	IT1869I	RG 58/U Center	IT1869I	RG 58/U Shield
d.	IT1869I	Red	IT1869I	Black
e.	IT1869I	Black	IT1869I	TB109-10

Record the data required below:

Test Point	Capacitance			Impedance		
Frequency →	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz
a.						
b.	-16 → +60pF	24pF	18.6pF	O.F.	6.6MΩ	720 kΩ
c.	3.9nF	0.30nF	47pF	2.93 kΩ	2.93 kΩ	2.85 kΩ
d.	108 μF	103 μF	O.F.	18.5Ω	10.9Ω	10.7Ω
e.						

J E Jones 8/14/80
Signature/Date

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

SERIAL #1405

(TEC#8032) Kiethly 177 DMM : 200 kΩ Scale

PRE-INSERTION PIN MEASUREMENTS

TEST POINT	+ FROM LINK	− TO LINK	RESISTANCE Polarity +	RESISTANCE Polarity −
a.	TB109-1	TB109-2	30Ω	30Ω
b.		TB109-5	~	~
c.		TB109-6	~	~
d.		TB109-7	~	~
e.		TB109-8	~	~
f.		TB109-10	~	~
g.	TB109-2	TB109-5	~	~
h.		TB109-6	~	~
i.		TB109-7	~	~
j.		TB109-8	~	~
k.		TB109-10	~	~
l.	TB109-5 (E)	TB109-6	~	~
m.		TB109-7	~	~
n.		TB109-8	~	~
o.		TB109-10	~	~
p.	TB109-6 (G)	TB109-7	9.7kΩ	9.7kΩ
q.		TB109-8	9.7kΩ	9.63kΩ
r.		TB109-10	9.7kΩ	9.7kΩ
s.	TB109-7	TB109-8	17.7kΩ	17.2kΩ
t.		TB109-10	0	0
u.	TB109-8	TB109-10	17.7kΩ	17.7kΩ

Note: {TB109-7, TB109-10} are identical at detector

20K scale MBM 8-14-80

~ = OPEN

Close all links on TB109 (opened in Step 10) when finished with this step.

Case : Shorted To Ground

J E Jones 8/14/80
Signature/Date

14 PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm Unit (Ante-room).

Signature/Date

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

SERIAL #111

(TEC #8032) Kiethly 177 DMM : 20 kΩ Scale

PRE-INSERTION PIN MEASUREMENTS

TEST POINT	FROM LINK	TO LINK	RESISTANCE Polarity +	RESISTANCE Polarity −
a.	TB109-1	TB109-2		
b.		TB109-5		
c.		TB109-6		
d.		TB109-7		
e.		TB109-8		
f.		TB109-10		
g.	TB109-2	TB109-5		
h.		TB109-6		
i.		TB109-7		
j.		TB109-8		
k.		TB109-10		
l.	TB109-5	TB109-6		
m.		TB109-7		
n.		TB109-8		
o.		TB109-10		
p.	TB109-6	TB109-7	8.77 kΩ	7.34 kΩ
q.		TB109-8	8.27 kΩ	6.56 kΩ
r.		TB109-10	8.77 kΩ	7.34 kΩ
s.	TB109-7	TB109-8	7.44 kΩ	11.77 kΩ
t.		TB109-10	0	0
u.	TB109-8	TB109-10	11.77 kΩ	7.44 kΩ

Note: {TB109-7 / TB109-10 are identical at detector

Close all links on TB109 (opened in Step 10) when finished with this step.

Jeff Mueller 8/15/80
Signature/Date

JEJ

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm Unit (Ante-room).

Signature/Date

SECTION A.3

PROCEDURES FOR PRE-REMOVAL AND POST-REMOVAL MEASUREMENTS

Technology for Energy Corporation	TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0
PROCEDURE	APPROVED M.V. Mathis, Director, Tech. Serv. Div.	DATE 8-11-80

PURPOSE: The purpose of these measurements is to gather baseline data and information in preparation for removal and replacement of Area Radiation Monitor HP-RT-0211 from the reactor building TMI Unit 2. The tests specified in this procedure are designed to assess the condition of the in-containment instrument module (gamma detector), associated cabling, and readout devices. This assessment will require the use of Time Domain Reflectometry (TDR), Impedance (Z), Spectral Analysis (frequency domain), special calibration measurements, and general oscilloscope observations (with recording) of waveforms from/to the unit under test (UUT).

PROCEDURE (ADMINISTRATIVE:

A. Limitations and Precautions

1. Nuclear Safety. Area radiation monitor HP-RT-0211 is part of a redundant ARM system at elevation 305'. The unit is not considered part of the engineered reactor safeguards system thus has no nuclear safety relevance.

2. Environmental Safety. Area radiation monitor HP-RT-0211 can be taken out-of and restored to service without producing a hazard to the environment.

3. Personnel Safety. The test described herein produces no additional personnel safety hazards other than normally associated with performing instrument calibrations and tests. Since the UUT is to be replaced by a calibrated spare, personnel safety should be enhanced by the ability to more ~~reliability~~ reliably monitor the radiation levels at El. 305'.

4. Equipment Protection. In the performance of each test described herein, care will be taken to insure adequate equipment protection as follows:

   a. In all cases actual test hookups to the Unit-2 instrumentation shall be made and verified by Instrumentation Personnel.

   b. All passive measurements (Spectral Analysis and Oscilloscope observations) of waveforms and signals from powered instruments shall be pervormed using high input impedance probes or inputs ($Z = \geq 1$ Meg ohm) to prevent loading of signals.

   c. In all Time Domain Reflectometry and Impedance measurements, power will be removed from the unit under test and low level test signals prescribed in Table 4-1 shall be utilized to perform cable

integretary measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT1869I (terminations shall be removed and replaced on TB109 of Cabinet 12). Should these tests reveal cable integretary problems further verification measurements will be made at TB1 of the appropriate Remote Alarm/Meter (Victoreen Model 858-3) located in the anteroom.

Table 4-1 Active Measurements

Active Signal Parameter	Time Domain Reflectometry	Impedance
Voltage	225 mV nominal (into 50 ohm base)	$\leq$ 5V rms
Frequency	---	100Hz, 1kHz, 10kHz, 100kHz
Current	$\leq$ 10mA	$\leq$ 100mA
Other	225mV, 110 picosecond pulses	---

d. In the calibration verification measurements section, baseline data on the as-found condition will be recorded prior to the performance of any adjustments or electronic calibrations. Furthermore, the replacement detector will be connected to TB-109 (Cabinet 12) through an interface cable and calibrated by Instrumentation personnel using applicable procedures for Calibration of the Victoreen Area Radiation Monitor (field calibration source corrected for half-life decay). Baseline passive measurements will be repeated on the replacement unit.

B. Prerequisites

1. The Shift Supervisor/Shift Foreman shall be notified for concurrance prior to the performance of those measurements.

2. Instrumentation personnel shall be assigned to assist in the performance of these measurements.

3. All measurements and test instrumentation shall be in current calibration (traceable to NBS).

4. The Shift Supervisor/Shift Foreman shall be notified prior to starting and upon completion of the measurements.

C. Procedure for Performing Measurements

References:

1. Victoreen Dwg. No. 904550, Wiring Diagram Area Monitors Channels HP-R-211 & HP-R-212 (Sheet 5 of 11).
2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.
3. Burns & Roe Dwg. 3024, Sh. 30A.
4. Burns & Roe Dwg. 3043, Sh. 16D.
5. Burns & Roe Dwg. 3045, Sh. 34.
6. Burns & Roe Dwg. 3045, Sh. 34B.
7. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.
8. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.
9. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 8553B, 8552B Modules).
10. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.
11. Instruction Manual, Tektronix Model 335 Oscilloscope.
12. Instruction Manual, Lockheed Store-4 Recorder.
13. Instruction Manual, Tektronix SC502 Oscilloscope.
14. Composite Electrical Connection Diagram, HP-R-211 (Sketch dtd 8/8/80).

Victoreen Instrument Company Dwg. 904550 (Ref. 1) and B&R Drawings 3024 (Ref. 3) show the appropriate termination points for passive measurements of signals from HP-RT-0211 as follows:

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

Signal	Cable ~~Penetration~~ IT2931I	Cabinet 12
+10V		TB109-8
600V		TB109-5
SIG		TB109-6
GND		TB109-10
CS		TB109-1
CS		TB109-2

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

1. PRE-REMOVAL, POST-REMOVAL: Notify Shift Supervisor/Shift Forman of start of test on HP-RT-0211.

2. PRE-REMOVAL, POST-REMOVAL: Verify power is applied to HP-RT-0211.

✓ TMI Tech. 8/13/80 JED
Signature/Date

3. PRE-REMOVAL, POST-REMOVAL: record present signals and readings and indications on 856-2 Readout Module (Local & Remote). Record Signal-in at TB109-6 ("T"), and record output from TB1 of 856-2 Readout A9 for a unit for one hour on FM Tape Recorder. Remove recorder when finished.

7½ IPS DIRECT (CHAN 1)
DC COUPLED THRU 465B AMPLIFIER — No! +8V offset required AC coupling.
G=50 mV & CALIBRATED

TEC	TITLE	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
			REV. 0

Meter/Indicator/Switch	Local	Rmte
~~mR/hr~~ mR/hr Meter Reading	1.5 mR	3.5 mR
Off-Operate-Alarm Function Switch	OPERATE	N/A
Fail Safe Indicator	On ✓ Off ___	N/A
High Alarm-Reset Indicator	On ___ Off ✓	N/A

TMI Tech. 8/13/80
Signature/Date

4. PRE-REMOVAL, POST-REMOVAL: Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = ± 1%) measure the DC voltage or current at the following test points.

   NOTE: For signal d. it will be necessary to depress Fall-Safe Check Source push button during the measurement.

TEC

TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

SIGNAL	CABINET 12	TEST LEAD	READING
a.	TB109-8 TB109-10	(+) (-)	(10V) 9.9V
b.	TB109-6 TB109-~~10~~ 7	(+) (-)	(SIG IN) 7.5V CS OUT 7.5V CS IN
*c.	TB109-5 TB109-~~10~~ 10	(+) (-)	(600V) 605 V
**d.	TB109-1 (open field side) TB109-1 (cabinet side)	(+) (-)	(≤500 mA est.) -13 mA

NOTE: LAST CALIBRATION 2/78.

*Use electrostatic voltmeter
**Link closed after measurement

J E Jones 8/13/80
Signature/Date

TEC | TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 | REV. 0

5. PRE-REMOVAL, POST-REMOVAL: Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

SIGNAL	CABINET 12	PARAMETER	PHOTO 3	PHOTO 4	PHOTO 5
✓a.	TB109-1 TB109-10	CS	Time Base 5mSec Vert Gain 2V	2 mSec 1V	1 mSec 1V
			PHOTO 6	PHOTO 7	PHOTO 8
✓b.	TB109-2 TB109-10	CS	Time Base 5mSec Vert Gain 2V	2 mSec 1V	1 mSec 1V
			PHOTO 9	PHOTO 10	PHOTO 11
✓*c.	TB109-5 TB109-10	+600V	Time Base 5mSec Vert Gain .2V	2mSec .2V	10 mSec .2V
			PHOTO 12	PHOTO 13	PHOTO 14
✓d.	TB109-6 TB19-~~10~~ 7	SIG	Time Base 1mSec Vert Gain 1V	2 mSec 1V	2mSec 2V
			PHOTO 15	PHOTO 16	PHOTO 17
✓e.	TB109-8 TB109-10	+10V	Time Base 2mSec Vert Gain 2V	5mSec 1V	2mSec .5V
			PHOTO 18	PHOTO 19	PHOTO 20
*f.	TB109-10 TB501-27	GND ACGND	Time Base 10mSec Vert Gain 2mV	20 mSec 1 mV	.2 mSec 1mV
			Time: 10 μSec (21) Gain: 10 mV	Time: 50 μSec (22) Gain: 10mV	Time: 2mSec (23) Gain: 5mV

Note: Fuse on 110 V blown... Repeat Tests

*Use X10 probe

Sync the oscilloscope and photograph the waveform using three time base and vertical gain settings. Mark the back of the photographs with the instrument tag number and parameter measured.

Signature/Date 8/13/80

TEC	TITLE	NO.
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	TP-101
		REV. 0

6. PRE-REMOVAL, POST-REMOVAL: Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

SIGNAL	CABINET 12	PARAMETER	PHOTO #
a.	TB109-8 TB109-10	+10V GND	24, 25
b.	TB109-6 TB109-7	SIG IN GND	26
c.	TB109-5 TB109-10	+600V GND	27

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope presentation adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., RF bandwidth, RF bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

SPECTRUM IDENT	FREQUENCY	AMPLITUDE	REMARKS
#24	0 - 1.4 MHz	~	Low Range Noise
#25	0 - 3.5 MHz	~	Low Range Noise
#26	0 - 3.5 MHz	~	Low Range Noise
#27	0 - 3.5 MHz	~	Very Low Noise

J E Jones 8/13/80
Signature/Date

TEC	TITLE	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
			REV. 0

7. PRE-REMOVAL, POST-REMOVAL: Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

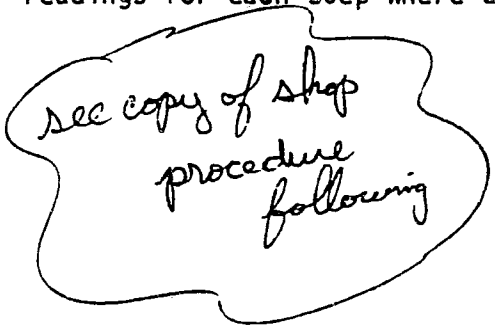
SIGNAL	CABINET 12	PARAMETER	PHOTO #	REMARKS
*a.	TB109-5 TB109-10	+600V GND	28	← 20 kHz & Harmonics Peaks
b.	TB109-6 TB109-~~10~~7	SIG IN GND	29	← Dominantly 1/f Noise ~32kHz Harmonics
c.	TB109-8 TB109-10	+10V GND	30,31	← Peaks at 16kHz & 20 kHz Harmonic @20 Hz Harmonics

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max)

If PSD plots from any one of the three signals show high and unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

J E Jones 8/13/80
Signature/Date

8. PRE-REMOVAL ONLY: Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:



TEC	TITLE	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
			REV. 0

Procedure Step	Before	After	Remarks
———	———	———	LAST CALIBRATION 2/78 ←
See Attachment Pages 1A & 1B			
Major Change: +22V unregulated P.S. was @ +13.7V. Capacitor replaced ⇒ 20.2V & +10V adjusted downward since it comes from +22V line.			
See attached instrument shop procedure data sheet.			

Instrument Shop Procedure No. _____

8/13/80
TMI Tech 8/14/80
Signature/Date

9. PRE-REMOVAL, POST-REMOVAL: Remove all power from HP-RT-0211 (Tag Open TB501 links 25, 26, and 27 per procedure AP 1002).

TMI Tech 8/14/80
Signature/Date

10. PRE-REMOVAL, POST-REMOVAL: Open links for all field wires from Cable IT1869I at TB109 (Cabinet 12).

TEC	TITLE	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
			REV. 0

TERMINAL	SIGNAL IDENT.
TB109-1 (Blue)	C.S.
TB109-2 (Orange)	C.S.
TB109-3 (White)	Rem. Meter
TB109-4 (Yellow) IT2933C	HI N.C.
TB109-5 (RG 59/U, 72 OHM)	600V
TB109-6 (RG 58/U, 50 OHM)	SIG IN
TB109-7 (RG 58/U, 50 OHM)	Shield (Signal)
TB109-8 (Red)	+10V
TB109-9 (Green) IT2933C	Alert N.C.
TB109-10 (Blk) (RG 59/U, 72 OHM)	GND Shield

TMI Tech 8/19/80
Signature/Date

11. PRE-REMOVAL, POST-REMOVAL: Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

TEC

TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

TEST POINT	FROM * (Red Lead)		TO * (Black Lead)	
	CABLE	WIRE COLOR/TYPE	CABLE	WIRE COLOR/TYPE
a.	IT1869I	Blue (TB109-1)	IT1869I	Orange (TB109-2)
b.	IT1869I	RG 59/U Center(-5)	IT1869I	RG 59/U Shield (-6)
c.	IT1869I	RG 58/U Center(-6)	IT1869I	RG 58/U Shield(-7)
d.	IT1869I	Red (-8)	IT1869I	Black (-10)
e.	IT1869I	Black (-10)	IT1869I	TB109-10
f.	IT1869I	RG 58/U Shield	IT1869I	RG 58/U Center

* Values in parenthesis refer to normal TB connection position.

Record the data required below:

Test Point	Capacitance			Impedance		
Frequency →	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz
(Coil) a.	O.F.	-5.77 µF	-3.36 nF	40.4Ω	49.1Ω	436Ω
b.	-50nF	5nF	10nF	O.F.*	O.F.*	54Ω
c.	O.F.	90nF	12nF	U.F.	570Ω	116Ω
d.	O.F.	20µF	-40nF	U.F.	25Ω	48.7Ω
e. (reverse polarity)	-6 → 9 mF	-382µF	-56nF	400-1400 mΩ	924 mΩ	28.6Ω
f.	ERR4	ERR4	12nF	ERR4	ERR4	116Ω

O.F. = overflow ; U.F. = underflow

* intermittant kΩ reading?

ERR4 = open or shorted; or DC bias won't work

J E Jones 8/14/80
Signature/Date

TEC	TITLE	NO. TP-101
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	REV. 0

12. PRE-REMOVAL, POST-REMOVAL: Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

Test Point	High R @ N ft.	Low R @ N ft.	Instrument Settings Ampl	Range	Mult	Strip Chart ~~Photo~~ No. *
a.			500	100'/Div	1	[redacted] 12a-1, -2
b.						[redacted] 12b-1, -2
c.						[redacted] 12c-1, -2
d.						[redacted] 12d-1, -2
e.						[redacted] 12e-1, -2

*Utilize strip chart where available.

Repeat c. With Terminal Blocked 10' COAX → f. 12f-1, -2

E Jones 8/14/80
Signature/Date

13. PRE-REMOVAL, POST-REMOVAL: Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

~~NOTE:~~ Open links for IT2933C from TB109 terminals 11, 12, 13, and 14. The appropriate wires should be marked accordingly.

No

TEC

TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

TEST POINT	FROM LINK	TO LINK	RESISTANCE (POLARITY From = +, To = −)	RESISTANCE (POLARITY From = −, To = +)
a.	TB109-1	TB109-2	40.2 Ω	40.2 Ω
b.		TB109-5	>20 mega Ω	>20 mega Ω
c.		TB109-6	>20 mega Ω	>20 mega Ω
d.		TB109-7	>20 mega Ω	>20 mega Ω
e.		TB109-8	>20 mega Ω	>20 mega Ω
f.		TB109-10	>20 mega Ω	>20 mega Ω
g.	TB109-2	TB109-5	>20 mega Ω	>20 mega Ω
h.		TB109-6	>20 mega Ω	>20 mega Ω
i.		TB109-7	>20 mega Ω	>20 mega Ω
j.		TB109-8	>20 mega Ω	>20 mega Ω
k.		TB109-10	>20 mega Ω	>20 mega Ω
l.	TB109-5	TB109-6	>20 mega Ω	>20 mega Ω
m.		TB109-7	>20 mega Ω	>20 mega Ω
n.		TB109-8	>20 mega Ω	>20 mega Ω
o.		TB109-10	>20 MΩ	>20 mega Ω
p.	TB109-6	TB109-7	8.62 kΩ	6.53 kΩ
q.		TB109-8	305 Ω	305 Ω
r.		TB109-10	10.0 kΩ	10.0 kΩ
s.	TB109-7	TB109-8	6.97 kΩ	8.59 kΩ
t.		TB109-10	1.96 Ω	1.96 Ω
u.	TB109-8	TB109-10	8 kΩ	6.47 Ω

Scale = 20K
2K
20K
20K
2A 10Ω 200Ω
20K

Close all links on TB109 (opened in Step 10) when finished with this step.

[signature] 8/19/80
Signature/Date

* links closed on TB109 ← 1 through 9

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote (Meter)/(Alarm) (Ante-room). RECORD S/N OF DETECTOR USED.

[illegible] 111
S/N

★ replaced detector

[signature] 8/19/80
Signature/Date

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

15. PRE-REMOVAL ONLY: Apply power to HP-RT-0211. After a minimum of 30 minutes warm up time perform ~~electronic~~ calibrations in accordance with applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

PROCEDURE STEP	BEFORE	AFTER	REMARKS
ELECTRONIC CALIBRATION NOT NEEDED -- PERFORMED IN STEP 8 & NO CHANGES HAVE OCCURRED.			

G E Jones

Signature/Date

16. PRE-REMOVAL ONLY: Utilizing the Victoreen field calibration source perform calibration with source decay corrections in accordance with applicable Instrument Shop Procedures.

See copy of Shop procedure following.

Instrument Shop Procedure No.

TMI Tech 8/14/80
Signature/Date

G E J

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

17. Repeat Step 3. PRE-REMOVAL ONLY

	LOCAL	RMTE
~~MR~~ mR/Hr Meter Reading	.5 mR/hr	.5 mR/hr
Off-Operate-Alarm Function Switch	OP	N/A
Fail Safe Indicator	On ✓ Off ___	N/A
High Alarm-Reset Indicator	On ___ Off ✓	N/A

~~Record~~ (See Step 3, p.4) 15 Minutes Background, Then Refer To Logbook

J E Jones 8/14/80
Signature/Date

18. Repeat Step 4. PRE-REMOVAL ONLY

SIGNAL	CABINET 12	TEST LEAD	READING
a.	TB109-8 TB109-10	(+) (-)	(10V) 9.99V
b.	TB109-6 TB109-~~10~~7	(+) (-)	(SIG IN) 0-9.88V (CS OUT) 5.0V (CS IN)
*c.	TB109-5 TB109-~~10~~70	(+) (-)	(600V) 605
**d.	TB109-1 (Open-Field Side) TB109-1 (Cabinet Side)	(+) (-)	(<500 ~~MA~~ mA est.) -14.1

*Use electrostatic voltmeter
**Link closed after measurement

J E Jones 8/14/80
Signature/Date

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

19. Repeat Step 5. PRE-REMOVAL ONLY

SIGNAL	CABINET 12	PARAMETER	PHOTO ~~32~~ 35	PHOTO 36	PHOTO 37
✓ a.	TB109-1 TB109-10	CS	Time Base ~~5 mSec~~ 5 mSec Vert Gain ~~.2V~~ .2V	2 mSec 50 mV	50 µSec 50 mV
			PHOTO 38	PHOTO 39	PHOTO 40
✓ b.	TB109-2 TB109-10	CS	Time Base 10 mSec Vert Gain 50 mV	2 mSec 50 mV	50 µSec 20 mV
			PHOTO 41	PHOTO 42	PHOTO 43
✓ *c.	TB109-5 TB109-10	+600V	Time Base 10 mSec Vert Gain 20 mV	.2 Sec 100 mV	20 mSec 100 mV
			PHOTO 32	PHOTO 33	PHOTO 34
✓ d.	TB109-6 TB19-~~10~~7	SIG	Time Base 1 Sec Vert Gain .5V	.2 Sec .5 V	.5 Sec .2 V
			PHOTO 44	PHOTO 45	PHOTO 46
✓ e.	TB109-8 TB109-10	+10V	Time Base .1 mSec Vert Gain 20 mV	5 mSec 50 mV	.2 mSec 20 mV
			PHOTO 47	PHOTO 48	PHOTO 49
✓ f.	TB109-10 TB501-27	GND ACGND	Time Base .2 mSec Vert Gain 5 mV	.2 mSec 2 mV	50 µSec 2 mV

* Use x10 Probe

E Jones 8/14/80
Signature/Date

20. Repeat Step 6. PRE-REMOVAL ONLY

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

SIGNAL	CABINET 12	PARAMETER	PHOTO #
a.	TB109-8 TB109-10	+10V GND	50
b.	TB109-6 TB109-~~10~~ 7	SIG IN GND	51
*c.	TB109-5 TB109-10	+600V GND	52

* CAUTION: DECOUPLE.

SPECTRUM IDENT	FREQUENCY	AMPLITUDE	REMARKS

J E Jones 8/14/80
Signature/Date

TEC	TITLE	NO.
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	TP-101
		REV. 0

21. Repeat Step 7. PRE-REMOVAL ONLY

SIGNAL	CABINET 12	PARAMETER	PHOTO #
✓* a.	TB109-5 TB109-10	+600V GND	53
✓ b.	TB109-6 TB109-~~10~~ 7	SIG IN GND	54
c.	TB109-8 TB109-10	+10V GND	55

*DECOUPLE

J. E. Jones
Signature/Date

22. Repeat Step 9. PRE-REMOVAL ONLY

TMI Tech 8/19/80
Signature/Date
JEJ

23. PRE-REMOVAL ONLY: Remove interface cable connected in Step 14 and re-connect apprpriate field terminals to TB1 of the Remote Meter/Alarm Unit (Ante-room).

TMI Tech 8/19/80
Signature/Date
JEJ

24. PRE-REMOVAL ONLY: Reapply power by closing links opened in Step 22. Verify unit is operating as before by comparing meter readings with those taken in Step ~~8~~ 8.

TEC	TITLE	NO. TP-101
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	REV. 0

25. Repeat Step 3 at least 1 hour prior to entry for removal of HP-RT-0211. RECORDER MUST BE STARTED NO EARLIER THAN 1 HOUR BEFORE ENTRY...POWER LINKS SHOULD BE OPENED FOR REPLACEMENT OF DETECTOR THEN CLOSED.

    ALL SUBSEQUENT STEPS ARE FOR POST REMOVAL MEASUREMENTS.

26. POST-REMOVAL ONLY. Repeat Step 3: (p 23)

    Signature/Date

27. POST-REMOVAL ONLY. Repeat Step 4: (p 24)

    Signature/Date

28. POST-REMOVAL ONLY. Repeat Step 5: (p 26)

    Signature/Date

29. POST-REMOVAL ONLY. Repeat Step 6: (p 27)

    Signature/Date

30. POST-REMOVAL ONLY. Repeat Step 7: (p 28)

    Signature/Date

TEC	TITLE	NO.
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	TP-101
		REV. 0

(p 29)

31. POST-REMOVAL ONLY. Repeat Step 9. (Do Not Do Step 8).

Signature/Date

32. POST-REMOVAL ONLY. Repeat Step 10. (p 29)

Signature/Date

33. POST-REMOVAL ONLY. Repeat Step 11. (p. 30)

Signature/Date

34. POST-REMOVAL ONLY. Repeat Step 12. (p. 32)

Signature/Date

35. POST-REMOVAL ONLY. Repeat Step 13. (p. 32)

Signature/Date

36. POST-REMOVAL ONLY. Apply power to HP-RT-0211 and verify proper operation utilizing applicable instrument shop procedures.

Signature/Date

TEC	TITLE	NO. TP-101
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	REV. 0

I hereby certify that this Test Procedure has been completed as written and that all data has been correctly entered and filed as requested.

TEC Representative _____
Signature/Date

Instrumentation _____
Signature/Date

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

Signal	Penetration IT2931I	Cabinet 12
+10V		TB109-8
600V		TB109-5
SIG		TB109-6
GND		TB109-10
CS		TB109-1
CS		TB109-2

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

X. PRE-REMOVAL, POST-REMOVAL: Notify Shift Supervisor/Shift Forman of start of test on HP-RT-0211.

X. PRE-REMOVAL, POST-REMOVAL: Verify power is applied to HP-RT-0211.

Signature/Date

(26) 3. ~~PRE-REMOVAL~~, POST-REMOVAL: record present signals and readings and indications on 856-2 Readout Module (Local & Remote). Record Signal-in at TB109-6 ("T"), and record output from TB1 of 856-2 Readout A9 for a unit for one hour on FM Tape Recorder. Remove recorder when finished.

7½ IPS Direct (Chan 1)
DC Coupled Thru 465B Amplifier
G = 50mV Calibrated

TEC	TITLE	NO. TP-101
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	REV. 0

Meter/Indicator/Switch	Local	Rmte
~~Mr~~ mR/hr Meter Reading	_____	_____
Off-Operate-Alarm Function Switch	_____	N/A
Fail Safe Indicator	On___Off___	N/A
High Alarm-Reset Indicator	On___Off___	N/A

_____
Signature/Date

(27) 4. ~~PRE-REMOVAL~~ POST-REMOVAL: Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = $\pm$ 1%) measure the DC voltage or current at the following test points.

NOTE: ~~4~~ For signal d. it will be necessary to depress Fall-Safe Check Source push button during the measurement.

TEC

TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

SIGNAL	CABINET 12	TEST LEAD	READING
a.	TB109-8 TB109-10	(+) (-)	(10V) _____
b.	TB109-6 TB109-~~10~~7	(+) (-)	(SIG IN) _____ _____ CS OUT CS IN
*c.	TB109-5 TB109-~~10~~10	(+) (-)	(600V) _____
**d.	TB109-1 (open field side) TB109-1 (cabinet side)	(+) (-)	(<500 mA est.) _____

*Use electrostatic voltmeter
**Link closed after measurement

_____
Signature/Date

TEC | TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 | REV. 0

(28) 5. ~~PRE-REMOVAL;~~ POST-REMOVAL: Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

SIGNAL	CABINET 12	PARAMETER	PHOTO ____	PHOTO ____	PHOTO ____
a.	TB109-1 TB109-10	CS	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
b.	TB109-2 TB109-10	CS	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
*c.	TB109-5 TB109-10	+600V	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
d.	TB109-6 TB19-~~107~~	SIG	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
e.	TB109-8 TB109-10	+10V	Time Base ____ Vert Gain ____	_____ _____	_____ _____
			PHOTO ____	PHOTO ____	PHOTO ____
f.	TB109-10 TB501-27	GND ACGND	Time Base ____ Vert Gain ____	_____ _____	_____ _____

*Use X10 probe

Sync the oscilloscope and photograph the waveform using three time base and vertical gain settings. Mark the back of the photographs with the instrument tag number and parameter measured.

_____
Signature/Date

TEC	TITLE	NO. TP-101
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	REV. 0

(29) 6. ~~PRE-REMOVAL~~, POST-REMOVAL: Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

SIGNAL	CABINET 12	PARAMETER	PHOTO #
a.	TB109-8 TB109-10	+10V GND	_____
b.	TB109-6 TB109-~~10~~7	SIG IN GND	_____
*c.	TB109-5 TB109-10	+600V GND	_____

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope presentation adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., ~~Video~~, RF bandwidth, RF ~~video~~ bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

SPECTRUM IDENT	FREQUENCY	AMPLITUDE	REMARKS

_____
Signature/Date

TEC	TITLE	NO.
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	TP-101
		REV. 0

(30) 7. ~~PRE-REMOVAL~~, POST-REMOVAL: Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

SIGNAL	CABINET 12	PARAMETER	PHOTO #
*a.	TB109-5 TB109-10	+600V GND	
b.	TB109-6 TB109-~~107~~	SIG IN GND	
c.	TB109-8 TB109-10	+10V GND	

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max)

If PSD plots from any one of the three signals show high and unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

_____
Signature/Date

8. PRE-REMOVAL ONLY: Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

TEC	TITLE	NO.
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	TP-101
		REV. 0

Procedure Step	Before	After	Remarks

See attached instrument shop procedure data sheet.

Instrument Shop Procedure No. _____

_____
Signature/Date

(31) 9. ~~PRE-REMOVAL~~, POST-REMOVAL: Remove all power from HP-RT-0211 (Tag Open TB501 links 25, 26, and 27 per procedure AP 1002).

_____
Signature/Date

(32) 10. ~~PRE-REMOVAL~~, POST-REMOVAL: Open links for all field wires from Cable IT1869I at TB109 (Cabinet 12).

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

TERMINAL	SIGNAL IDENT.
TB109-1 (Blue)	C.S.
TB109-2 (Orange)	C.S.
TB109-3 (White)	Rem. Meter
TB109-4 (Yellow) IT2933C	HI N.C.
TB109-5 (RG 59/U, 72 OHM)	600V
TB109-6 (RG 58/U, 50 OHM)	SIG IN
TB109-7 (RG 58/U, 50 OHM)	Shield (Signal)
TB109-8 (Red)	+10V
TB109-9 (Green) IT2933C	Alert N.C.
TB109-10 (Blk) (RG 59/U; 72 OHM)	GND Shield

Signature/Date

(33) 11. ~~PRE-REMOVAL~~, POST-REMOVAL: Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

TEST POINT	FROM		TO	
	CABLE	WIRE COLOR/TYPE	CABLE	WIRE COLOR/TYPE
a.	IT1869I	Blue	IT1869I	Orange
b.	IT1869I	RG 59/U Center	IT1869I	RG 59/U Shield
c.	IT1869I	RG 58/U Center	IT1869I	RG 58/U Shield
d.	IT1869I	Red	IT1869I	Black
e.	IT1869I	Black	IT1869I	TB109-10

Record the data required below:

Test Point	Capacitance			Impedance		
Frequency →	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz
(Coil) a.						
b.						
c.						
d.						
e.						

Signature/Date

TEC	TITLE	NO. TP-101
	IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	REV. 0

(34) 12. ~~PRE-REMOVAL~~, POST-REMOVAL: Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

Test Point	High R @ N ft.	Low R @ N ft.	Instrument Settings Ampl	Range	~~Mult~~	Photo No. *
✓a.						
✓b.						
✓c.						
✓d.						
✓e.						

*Utilize strip chart where available.

J. E. Jones 8/15/80
Signature/Date

(35) 13. ~~PRE-REMOVAL~~, POST-REMOVAL: Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

NOTE: Open links for IT2933C from TB109 terminals 11, 12, 13, and 14. The appropriate wires should be marked accordingly.

TEC	TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)	NO. TP-101
		REV. 0

TEST POINT	FROM LINK	TO LINK	RESISTANCE POLARITY From = + To = −	RESISTANCE POLARITY From = − To = +
a.	TB109-1	TB109-2		
b.		TB109-5		
c.		TB109-6		
d.		TB109-7		
e.		TB109-8		
f.		TB109-10		
g.	TB109-2	TB109-5		
h.		TB109-6		
i.		TB109-7		
j.		TB109-8		
k.		TB109-10		
l.	TB109-5	TB109-6		
m.		TB109-7		
n.		TB109-8		
o.		TB109-10		
p.	TB109-6	TB109-7		
q.		TB109-8		
r.		TB109-10		
s.	TB109-7	TB109-8		
t.		TB109-10		
u.	TB109-8	TB109-10		

Close all links on TB109 (opened in Step 10) when finished with this step.

Signature/Date

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm Unit (Ante-room).

Signature/Date

SECTION A.4

DATA SHEETS FROM TMI TECHNICIAN CALIBRATIONS

DETECTER

Model _____
Serial _____

RATEMETER

Model 856-2
Serial 359

FCK Posit.	Desired Mr./Hr.	As Found	As Left	Toler.
Closed				
Iter.				
Open				

Check Source Rdg. _____ Mr/Hr

Fail Safe _____ Volts

Ratemeter

Mr/Hr	Desired Mv. Out	As Found	As Left	Toler.
10^4	1.00V	1.005	1.000	±.03 v
10^3	.800V	.811	.806	±.03 v
10^2	.600V	.612	.607	±.03 v
10	.400V	.415	.411	±.03 v
1	.200V	.217	.215	±.03 v
.1	.000	.024	.024	±.03 v

Pwr. Supply	As Found	As Left	Toler.
-6.8V	-6.85 -6.800	-6.84	±.5V
10.0V	10.44 9.31	10.00	±.1V
22.0V	20.20 1366	20.20	±3.0V

Alarm Set. Pt.	As Found	As Left	Toler.
			±1 Minor Division

EQUIP. DIGITEC SER.NO. 61260552 LAST CAL. 3-20-80 DUE 9-20-80

EQUIP. FLUKE DVM SER.NO. 530314 LAST CAL. 7-25-80 DUE 1-25-81

EQUIP. _____ SER.NO. _____ LAST CAL. _____ DUE _____

PERFORMED BY Ed. Heffner DATE 9-13-80 APPROVED BY _____ DATE 8/14/80

Section _____

DETECTER

Model _____
Serial _____

RATEMETER

Model 856-2
Serial 359

FCK Posit.	Desired Mr./Hr.	As Found	As Left	Toler.
Closed				
Iter.				
Open				

Check Source Rdg. _____ Mr/Hr

Fail Safe _____ Volts

Ratemeter

(AFTER CHANGING C-1 in Ratemeter)

DIGITEC INPUT VOLTS DC	Mr/Hr	Desired Mv. Out	As Found	As Left	Toler.
16.39	10^4	1.00V	.999	.999	±.03 v
21	10^3	.800V	.807	.807	±.03 v
16.18	10^2	.600V	.611	.611	±.03 v
11.20	10	.400V	.415	.415	±.03 v
6.13	1	.200V	.218	.218	±.03 v
.95	.1	.000V	.024	.024	±.03 v

Pwr. Supply	As Found	As Left	Toler.
-6.8V	-6.85	-6.85	±.5V
10.0V	+10.99 ~~+10.92~~	+10.00	±.1V
22.0V	20.20	20.20	±3.0V

Alarm Set. Pt.	As Found	As Left	Toler.
			±1 Minor Division

EQUIP. DIGITEC SER.NO. 61260552 LAST CAL. 3-20-80 DUE 9-20-80

EQUIP. FLUKE DUM SER.NO 530314 LAST CAL. 7-25-80 DUE 1-25-81

EQUIP. _____ SER.NO. _____ LAST CAL. _____ DUE _____

PERFORMED BY Ed. Heffner DATE 8-14-80 APPROVED BY _____ DATE 8-14-80

DATA S. _T 1
RADIATION MONITORING SYSTEM

Procedure Step												
6.1.1.2	MONITOR	HP-R- 211	LOCAL METER (AS FOUND)		AS LEFT		RECORDER TRACE MARKED YES/NO		INT			
			FCK SOURCE KNOB POSITION									
			CLOSED		INTERMEDIATE				OPEN			
	DESCRIPTION		RATEMETER	INT RECORDER INT	RATEMETER	INT RECORDER INT	RATEMETER	INT RECORDER INT	RATEMETER	INT RECORDER INT	RATEMETER	INT RECORDER INT
6.1.2.3												
6.1.2.4												
6.1.2.5	Source		30 MR/hr	MR/hr	250 MR/hr	MR/hr			1300 MR/hr	MR/hr		
6.1.1.3	Background		- 1 MR/hr	- MR/hr	- MR/hr	- MR/hr			- MR/hr	- MR/hr		
6.1.3.1	Actual Source Readings		29 MR/hr	MR/hr	249 MR/hr	MR/hr			1299 MR/hr	MR/hr		
6.1.4.1	Original Reading		54	MR/hr	400	MR/hr			2000	MR/hr		
6.1.4.2	Original Reading Date		1975									
6.1.4.3	Expected Reading		48	MR/hr	352	MR/hr			1762	MR/hr		
6.1.4.4	+15% of Expected Reading		55	MR/hr	409	MR/hr			2026	MR/hr		
6.1.4.5	-15% of Expected Reading		41	MR/hr	299	MR/hr			1498	MR/hr		
6.1.5.1	Actual Source Reading within 15% of Expected? Yes/No		* NO	*	* NO	*			* NO	*		
	Setpoint Data											
			ALERT		INT		HIGH				INT	
6.1.6.1	Required Setpoint											
AL 6.1.6.3	Indicated "As Found"											
Hi 6.1.6.4	Setpoint				MR/hr					MR/hr		
AL 6.1.6.7	"Tripped" Observed											
Hi 6.1.6.8	Setpoint				MR/hr					MR/hr		
6.1.6.9	Observed Setpoint within One Minor Division of Required Yes/No		*		*							
	Check Source, Recorder, Acceptance Criteria, Sign-Off											
6.1.7	Observed Increase in Reading Due to Check Source				0 MR/hr					INT		
6.1.7.2	Recorder Trace Marked Yes/No				*					INIT.		

* Acceptance Criteria: All Yes/No Blanks Indicate "Yes".
** Record "Pegged" if Meter Pegs High Due to Background.

New Calibration Sticker Attached Yes/No

PERFORMED BY:
AND DATE: _____

APPROVED BY:
AND DATE _____

Place Old Cal.
Sticker Here

DATA SHEET 1
RADIATION MONITORING SYSTEM

2612-R5
Revision 0
07/19/78

Procedure Step 6.1.1.2 MONITOR HP-R- 211 LOCAL METER AS FOUND (AS LEFT) RECORDER TRACE MARKED YES/NO INT

Procedure Step	DESCRIPTION	FCK SOURCE KNOB POSITION CLOSED RATEMETER	INT	RECORDER	INT	INTERMEDIATE RATEMETER	INT	RECORDER	INT	OPEN RATEMETER	INT	RECORDER	INT
6.1.2.3													
6.1.2.4													
6.1.2.5	Source	48 MR/hr		MR/hr		350 MR/hr		MR/hr		1800 MR/hr		MR/hr	
6.1.1.3	Background	/- MR/hr	-	MR/hr		/- MR/hr	-	MR/hr		/- MR/hr	-	MR/hr	
6.1.3.1	Actual Source Readings	47 MR/hr		MR/hr		349 MR/hr		MR/hr		1799 MR/hr		MR/hr	
6.1.4.1	Original Reading	54		MR/hr		400		MR/hr		2000		MR/hr	
6.1.4.2	Original Reading Date	1975											
6.1.4.3	Expected Reading	48		MR/hr		352		MR/hr		1762		MR/hr	
6.1.4.4	+15% of Expected Reading	55		MR/hr		409		MR/hr		2026		MR/hr	
6.1.4.5	-15% of Expected Reading	41		MR/hr		299		MR/hr		1498		MR/hr	
6.1.5.1	Actual Source Reading within 15% of Expected? Yes/No	* YES	*			* YES	*			* YES	*		

Setpoint Data

		ALERT	INT	HIGH	INT
6.1.6.1	Required Setpoint				
AL 6.1.6.3 / Hi 6.1.6.4	Indicated "As Found" Setpoint		MR/hr		MR/hr
AL 6.1.6.7 / Hi 6.1.6.8	"Tripped" Observed Setpoint		MR/hr		MR/hr
6.1.6.9	Observed Setpoint within One Minor Division of Required Yes/No		*		*

Check Source, Recorder, Acceptance Criteria, Sign-Off

6.1.7	Observed Increase in Reading Due to Check Source	7 MR/hr	INT	
6.1.7.2	Recorder Trace Marked Yes/No	*	INIT.	

* Acceptance Criteria: All Yes/No Blanks Indicate "Yes".
** Record "Pegged" if Meter Pegs High Due to Background.

New Calibration Sticker Attached Yes/No

PERFORMED BY:
AND DATE: _____

APPROVED BY:
AND DATE _____

Place Old Cal. Sticker Here

DATA SHEET 1
RADIATION MONITORING SYSTEM

2612-R5
Revision 0
07/19/78

Procedure Step												
6.1.1.2	MONITOR	HP-R-211 remote meter	(AS FOUND)		AS LEFT		RECORDER TRACE MARKED YES/NO		INT			
			FCK SOURCE KNOB POSITION									
			CLOSED			INTERMEDIATE				OPEN		
	DESCRIPTION		RATEMETER	INT	RECORDER	INT	RATEMETER	INT	RECORDER	INT	RATEMETER	INT	RECORDER	INT
6.1.2.3												
6.1.2.4												
6.1.2.5	~~Source~~ Reading	.25	MR/hr		MR/hr	200	MR/hr		MR/hr	780	MR/hr		MR/hr	
6.1.1.3	Background	1	- MR/hr		- MR/hr	-1	MR/hr		- MR/hr	-1	MR/hr		- MR/hr	
6.1.3.1	Actual Source Readings	24	MR/hr		MR/hr	199	MR/hr		MR/hr	779	MR/hr		MR/hr	
6.1.4.1	Original Reading (1975)		54		MR/hr		400		MR/hr		2000		MR/hr	
6.1.4.2	Original Reading Date	1975												
6.1.4.3	Expected Reading		48		MR/hr		352		MR/hr		1762		MR/hr	
6.1.4.4	+15% of Expected Reading		55		MR/hr		405		MR/hr		2026		MR/hr	
6.1.4.5	-15% of Expected Reading		41		MR/hr		299		MR/hr		1498		MR/hr	
6.1.5.1	Actual Source Reading within 15% of Expected? Yes/No		* NO		*		* NO		*		* NO		*	
	Setpoint Data													
			ALERT			INT	HIGH					INT		
6.1.6.1	Required Setpoint													
AL 6.1.6.3	Indicated "As Found"													
Hi 6.1.6.4	Setpoint				MR/hr						MR/hr			
AL 6.1.6.7	"Tripped" Observed													
Hi 6.1.6.8	Setpoint				MR/hr						MR/hr			
6.1.6.9	Observed Setpoint within One Minor Division of Required Yes/No		*				*							
	Check Source, Recorder, Acceptance Criteria, Sign-Off													
6.1.7	Observed Increase in Reading Due to Check Source		4		MR/hr						INT			
6.1.7.2	Recorder Trace Marked Yes/No		*								INIT.			

* Acceptance Criteria: All Yes/No Blanks Indicate "Yes".
** Record "Pegged" if Meter Pegs High Due to Background.
New Calibration Sticker Attached Yes/No

PERFORMED BY:
AND DATE: E. Heffner 8-15-80

APPROVED BY:
AND DATE

Place Old Cal.
Sticker Here

DATA SHEE
RADIATION MONITO..NG SYSTEM

2612-R5
Revision 0
07/19/78

Procedure Step 6.1.1.2 MONITOR HP-R-211 remote meter AS FOUND (AS LEFT) RECORDER TRACE MARKED YES/NO INT

		FCK SOURCE KNOB POSITION									
		CLOSED				INTERMEDIATE				OPEN	
	DESCRIPTION	RATEMETER	INT	RECORDER	INT	RATEMETER	INT	RECORDER	INT	RATEMETER	INT	RECORDER	INT
6.1.2.3											
6.1.2.4											
6.1.2.5	~~Source~~ READING	45 MR/hr		MR/hr		350 MR/hr		MR/hr		1750 MR/hr		MR/hr	
6.1.1.3	Background	1 - MR/hr	-	MR/hr	-	1 - MR/hr	-	MR/hr	-	1 - MR/hr	-	MR/hr	-
6.1.3.1	Actual Source Readings	44 MR/hr		MR/hr		349 MR/hr		MR/hr		1749 MR/hr		MR/hr	
6.1.4.1	Original Reading (1975)	54		MR/hr		400		MR/hr		2000		MR/hr	
6.1.4.2	Original Reading Date	1975											
6.1.4.3	Expected Reading	48		MR/hr		352		MR/hr		1762		MR/hr	
6.1.4.4	+15% of Expected Reading	55		MR/hr		405		MR/hr		2026		MR/hr	
6.1.4.5	-15% of Expected Reading	41		MR/hr		299		MR/hr		1498		MR/hr	
6.1.5.1	Actual Source Reading within 15% of Expected? Yes/No	* YES		*		* YES		*		* YES		*	

Setpoint Data

		ALERT	INT	HIGH	INT
6.1.6.1	Required Setpoint				
AL 6.1.6.3	Indicated "As Found"				
Hi 6.1.6.4	Setpoint	MR/hr		MR/hr	
AL 6.1.6.7	"Tripped" Observed				
Hi 6.1.6.8	Setpoint	MR/hr		MR/hr	
6.1.6.9	Observed Setpoint within One Minor Division of Required Yes/No	*		*	

Check Source, Recorder, Acceptance Criteria, Sign-Off

6.1.7 Observed Increase in Reading Due to Check Source 7 MR/hr INT

6.1.7.2 Recorder Trace Marked Yes/No * INIT.

* Acceptance Criteria: All Yes/No Blanks Indicate "Yes".

** Record "Pegged" if Meter Pegs High Due to Background.

New Calibration Sticker Attached Yes/No

PERFORMED BY AND DATE: E. Heffner 8-15-80

APPROVED BY: AND DATE

Place Old Cal. Sticker Here

8.0

SECTION A.5

PHOTOGRAPHS, STRIP CHARTS, AND RECORDER LOG PAGES FROM PRE-REMOVAL AND POST-REMOVAL MEASUREMENTS

SECTION A.5.1

RECORDER LOG PAGES

FIELD SERVICE DATA SHEET

PL Name T. Smith

Page No. 1

DATA SHEET - PLANT: TMI

UNIT 2 RUN TP101 DATE 8-13-80

TIME	TAPE ft	PWR	TAPE Tec-1138
START 10:20 A.m.	100 ft		SPEED 7½ ips
STOP 11:35	end of tape		BAND

ROD POSITION: GROUP ___, ___; GROUP ___, ___; GROUP ___, ___.

BORON (ppm) ___ EFPD ___ CYCLE ___

RECORDER CHANNEL	SIGNAL	AMP	BW	GAIN	VDC
1	Hp-PT-0211			1	
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

COMMENTS: AT Footage of 220 ATTENUATION of ~~22~~ 2 WAS USED

TEC Form No.

8-13-80

MEASUREMENTS AT TMI Control Room

EG+G Idaho Support

TAPE Recording Log Sheet

- Channel 1 of STORE FOUR RECORDER ; SET on DIRECT RECORD
- TAPE # 1138
- TAPE SPEED 7½ IPS
- The Following TEST FOOTAGE WAS Recorded

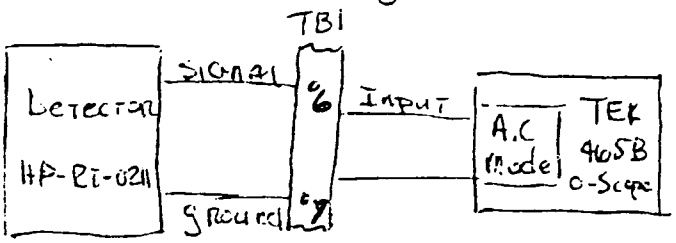
  0-25 ft → 1 VOLT PEAK TO PEAK AT 10 hz

  25-50 ft → 1 VOLT " AT 100 hz

  50-75 ft → 1 VOLT " " AT 1k hz

- 100 ft THE START of the ACTUAL TEST

The following DIAGRAM is the Recorded SETUP



(old) S/N ____

Tek Scope WAS CALIBRATED with the Following INSTRUMENT

Tec# 7801 ; FUNCTION GENERATOR

Tec# 8030 ; Freq. COUNTER

Tec# 8032 ; DMM

Check Source Switch ACTIVATED AT TAPE footage of 876

Check Source deACTIVATED AT 900 ft.

PL Name T Smith Page No. 2

DATA SHEET - PLANT: TMI

UNIT 2 RUN TP102 DATE 8-19-80

TIME	TAPE ft	PWR	TAPE TE-1139
START	100		SPEED 7½ ips
STOP	End of Tape		BAND

ROD POSITION: GROUP ___, ___; GROUP ___, ___; GROUP ___, ___.

BORON (ppm) ___ EFPD ___ CYCLE ___

RECORDER CHANNEL	SIGNAL	AMP	BW	GAIN	VDC
1	Hi-PT-0211			1	
2	S/N 111				
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

COMMENTS:

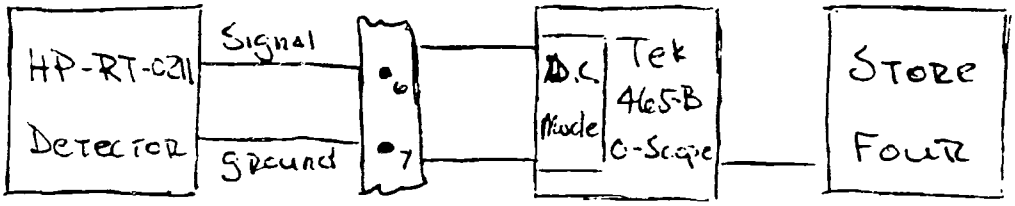
EC Form No.

8-14-80

MEASUREMENTS AT TMI Control Room
EG&G Idaho Support

TAPE Recording Log Sheet
TAPE # 1139
TAPE Speed 7½ ips
ATTENUATION 1
Channel 1 Signal from HP-RT-0211

TEST SET up



New S/N 111

Tek Scope was calibrated 8-14-80 with the following instruments at 10:1 attenuation

Tec # 7801 - Function Generator
Tec # 8030 - Frequency Counter
Tec # 8032 - DMM

Calibration Footage

25-75 ft. → 2.8 V peak to peak @ 500 hz.

Tape # 1139 con't.

Starting footage; 125 → Starting Time 2:90.
15 minutes into Recording At 725 ft.

Alternate measurements were started

1) Check Source Switch Activated At Tape footage of 876
2) Check Source Switch deactivated At Tape footage of 960
3) Check Source Switch Activated At Tape footage 1111
4) Check Source Switch deactivated At Tape footage 1165

These steps were in the process of doing steps 18 while step 17 was in progress

Recorder disconnected At 1818 ft, reconnected At 1830 ft

Tape Stopped At 2312 ft.

FIELD SERVICE DATA SHEET

PL Name T. Smith Page No. 3

DATA SHEET - PLANT: 8-15-80

UNIT 2 RUN TP103 DATE 8-15-80

TIME	TAPE ft	PWR	TAPE Tec - 1417
START	100		SPEED 7½ ips
STOP	end of Tape		BAND

ROD POSITION: GROUP ___, ___; GROUP ___, ___; GROUP ___, ___.

BORON (ppm) ___ EFPD ___ CYCLE ___

RECORDER CHANNEL	SIGNAL	AMP	BW	GAIN	VDC
1				1	
2	Hp-PT-0211				
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

COMMENTS:

8-15-80

MEASUREMENT AT TMI CONTROL ROOM

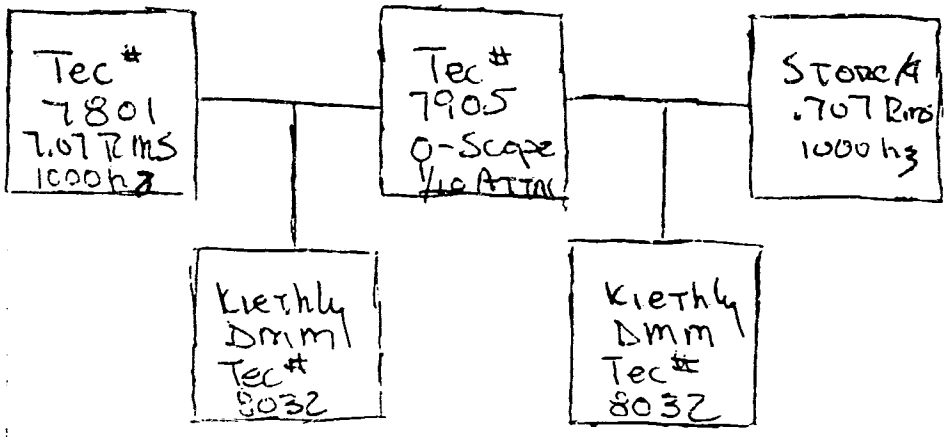
EG+G IDAHO SUPPORT

TAPE RECORDING LOG SHEET

TAPE # 1197

TAPE SPEED 7½ I.P.S.

CALIBRATION SETUP



CALIBRATION FOOTAGE

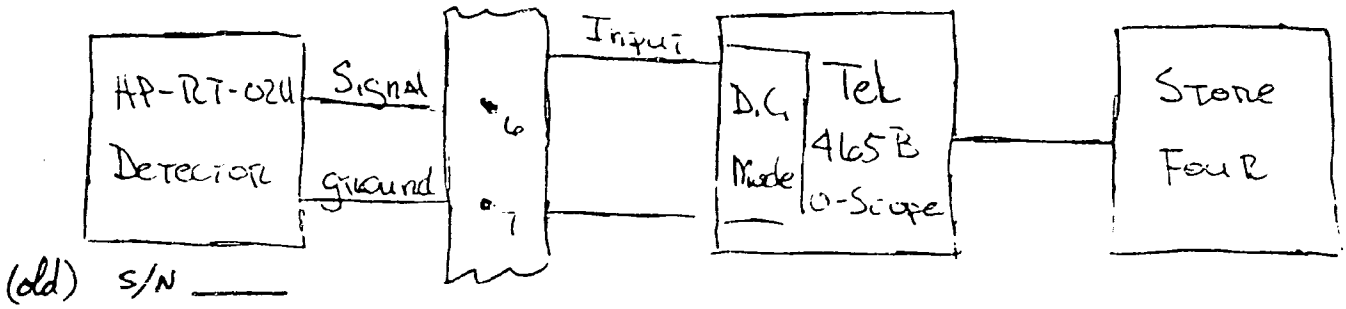
0-95 FT. - .707 RMS 1000hz, 7½ I.P.S. THIS IS GARBAGE AS SIGNAL WAS SWITCHED FROM CHANNEL #1 TO CHANNEL #2 1/10 ATTENUATION

60-83 FT - .707 Rms 1khz on CHANNEL #2 7½ I.P.S. 1/10 ATTENUATION

100 FT to end of tape; CHANNEL #2 RECORDING of HP-RT-0211 output, 7½ IPS 1/1 ATT.

* 2230 FT. POWER TO THE DECTECTOR WAS DISCONNECTED

Recording Set-up



(old) S/N ____

SECTION A.5.2

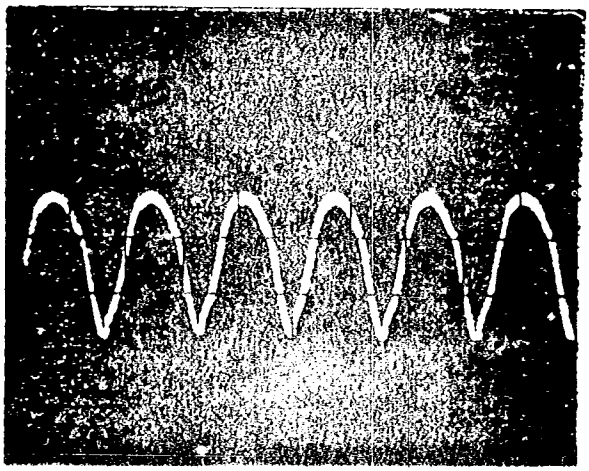
PRE-REMOVAL PHOTOGRAPHS OF TIME AND FREQUENCY DOMAIN MEASUREMENTS OF WAVEFORMS

PRE-REMOVAL

Time Domain

#5.a	Check Source to GND Photo #3, 4, 5	
#5.b	Check Source to GND Photo #6, 7, 8	
#5.c	+6.00 VDC to GND Photo #9, 10, 11	
#5.d	Detector Signal to GND Photo #12, 13, 14	
#5.e	+10 VDC to GND Photo #15, 16, 17	
#5.f	GND to AC GND Photo #18, 19, 20	110 VAC fuse blown
#5.g	GND to AC GND Photo #21, 22, 23	Replaced blown fuse

PHOTO #3

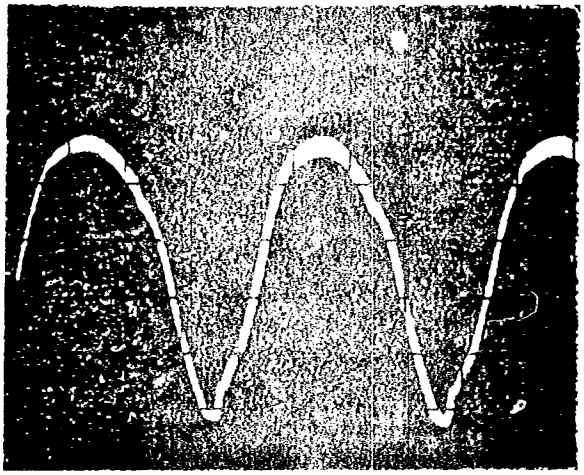


TB 109-1
TB 109-10
Check Source

Vert. Gain: 2V/Div

Horiz. Time Base: 5ms/Div

PHOTO #4

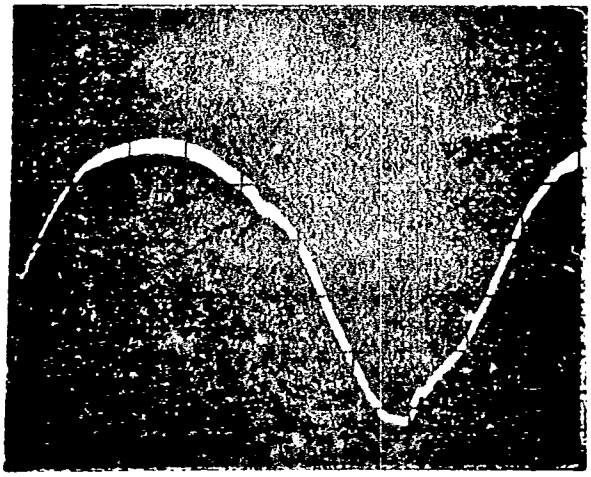


TB 109-1
TB 109-10
Check Source

Vert. Gain: 1V/Div

Horiz. Time Base: 2ms/Div

PHOTO #5

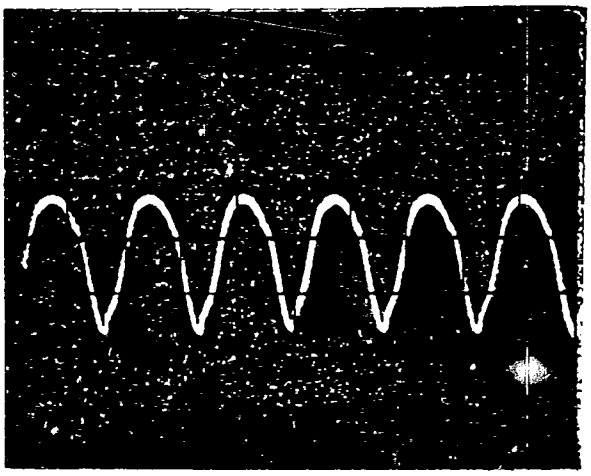


TB 109-1
TB 109-10
Check Source

Vert. Gain: 1V/Div

Horiz. Time Base: 1ms/Div

PHOTO #6

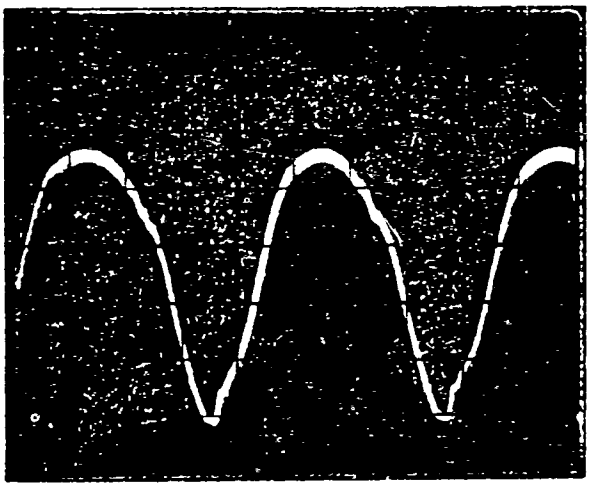


TB 109-2
TB 109-10
Check Source

Vert. Gain: 2V/Div

Horiz. Time Base: 5ms/Div

PHOTO #7

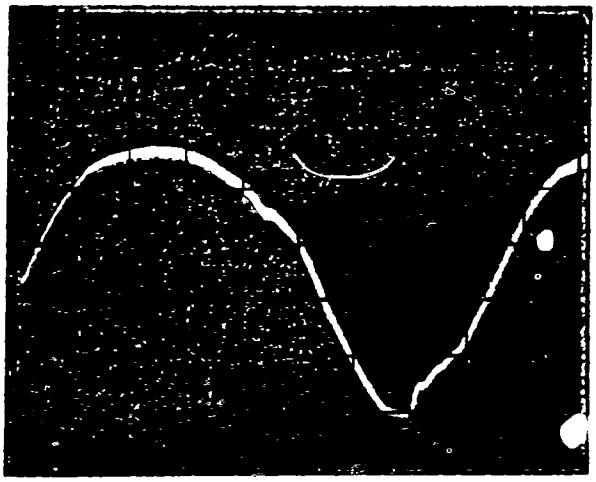


TB 109-2
TB 109-10
Check Source

Vert. Gain: 1V/Div

Horiz. Time Base: 2ms/Div

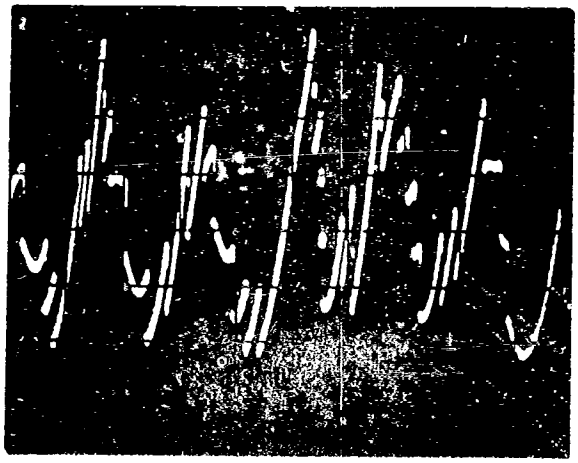
PHOTO #8



TB 109-2
TB 109-10
Check Source

Vert. Gain: 1V/Div
Horiz. Time Base: 1ms/Div

PHOTO #9

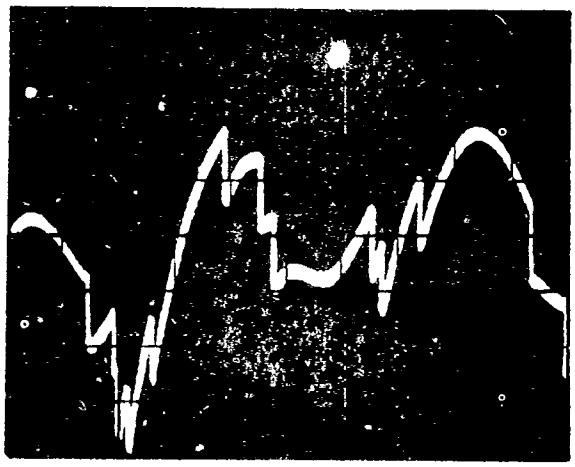


TB 109-5
TB 109-10] +600V

Vert. Gain: 0.2V/Div

Horiz. Time Base: 5ms/Div

PHOTO #10

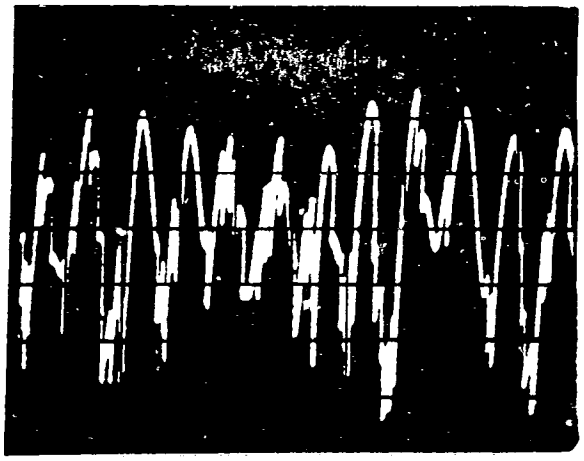


TB 109-5
TB 109-10] +600V

Vert. Gain: 0.2V/Div

Horiz. Time Base: 2ms/Div

PHOTO #11

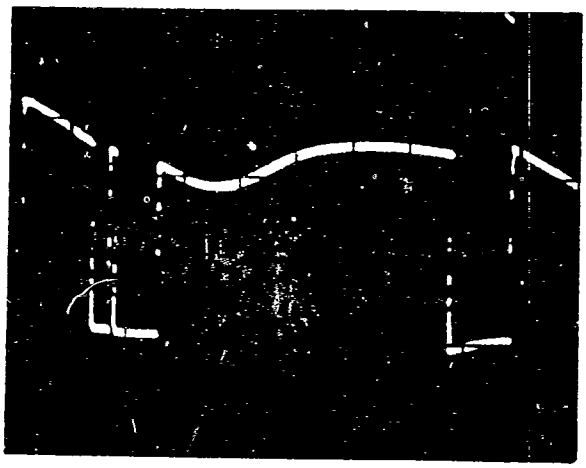


TB 109-5
TB 109-10] +600V

Vert. Gain: 0.2V/Div

Horiz. Time Base: 10ms/Div

PHOTO #12

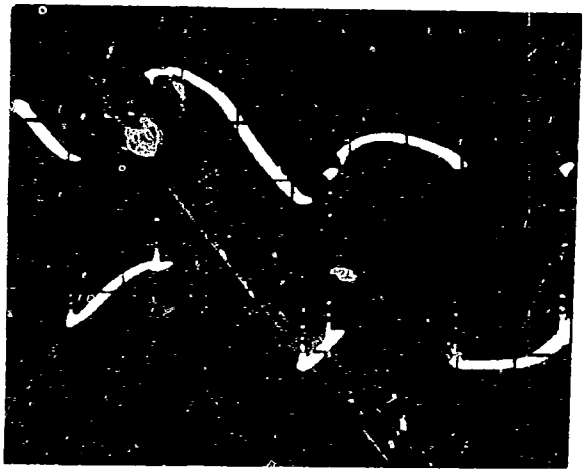


TB 109-6
TB 109-7
Signal

Vert. Gain: 1V/Div

Horiz. Time Base: 1ms/Div

PHOTO #13

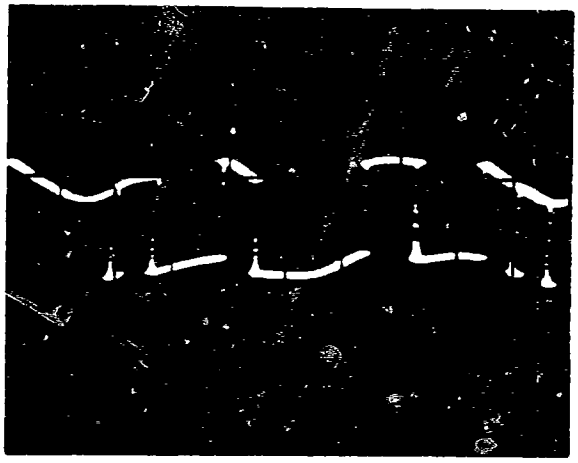


TB 109-6
TB 109-7
Signal

Vert. Gain: 1V/Div

Horiz. Time Base: 2ms/Div

PHOTO #14

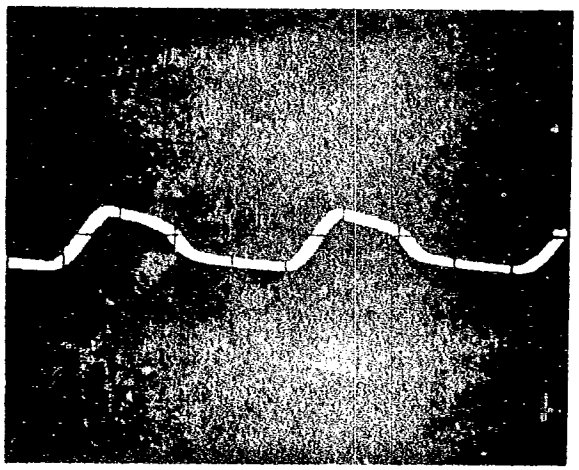


TB 109-6
TB 109-7
Signal

Vert. Gain: 2V/Div

Horiz. Time Base: 2ms/Div

PHOTO #15

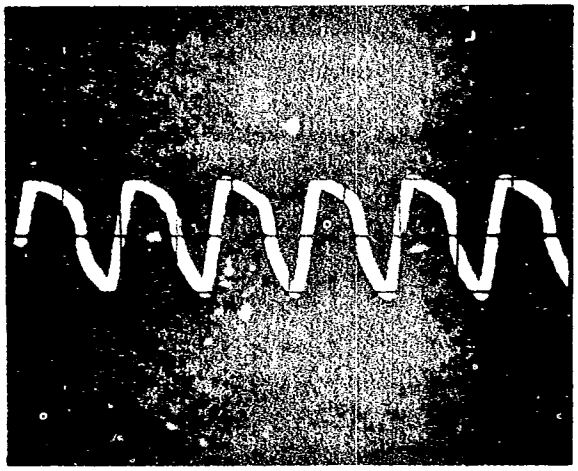


TB 109-8
TB 109-10
+10V

Vert. Gain: 2V/Div

Horiz. Time Base: 2ms/Div

PHOTO #16

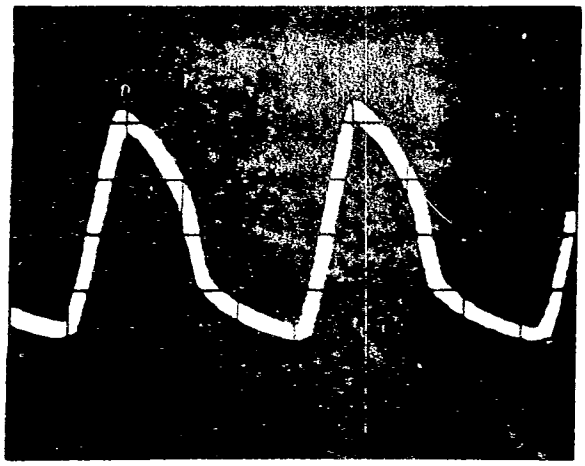


TB 109-8
TB 109-10
+10V

Vert. Gain: 1V/Div

Horiz. Time Base: 5ms/Div

PHOTO #17

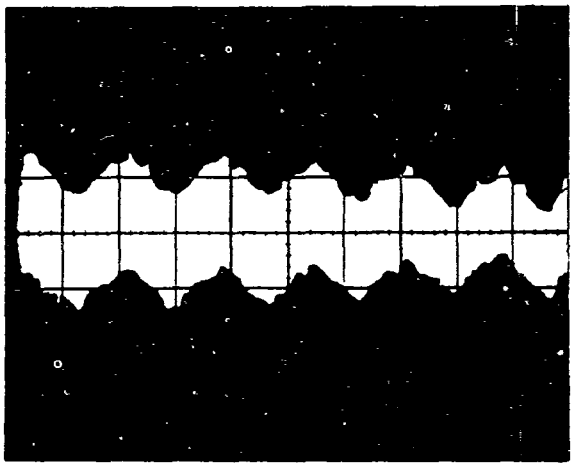


TB 109-8
TB 109-10
+10V

Vert. Gain: 0.5V/Div

Horiz. Time Base: 2ms/Div

PHOTO #18

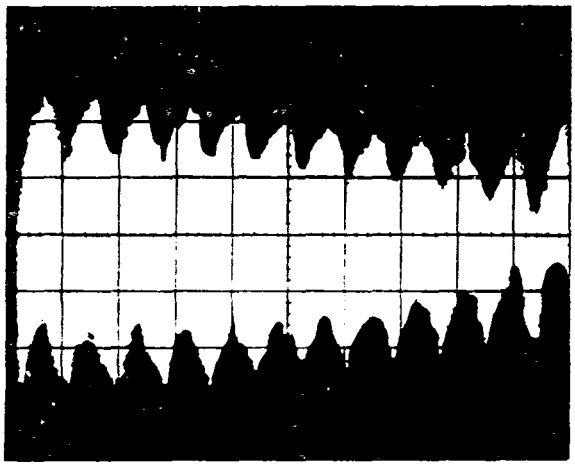


TB 109-10
TB 501-27 GND

Vert. Gain: 2mV/Div

Horiz. Time Base: 10ms/Div

PHOTO #19

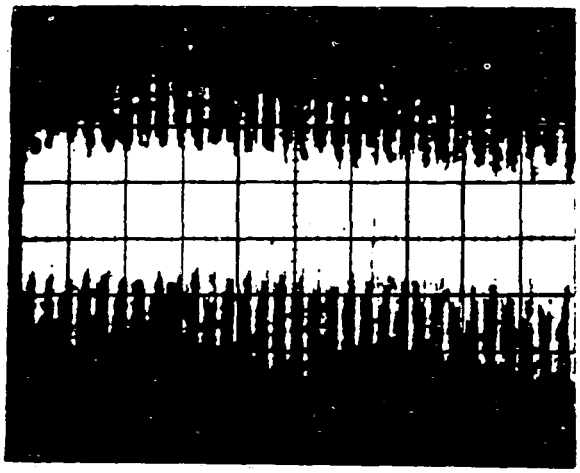


TB 109-10
TB 501-27 GND

Vert. Gain: 1mV/Div

Horiz. Time Base: 20ms/Div

PHOTO #20

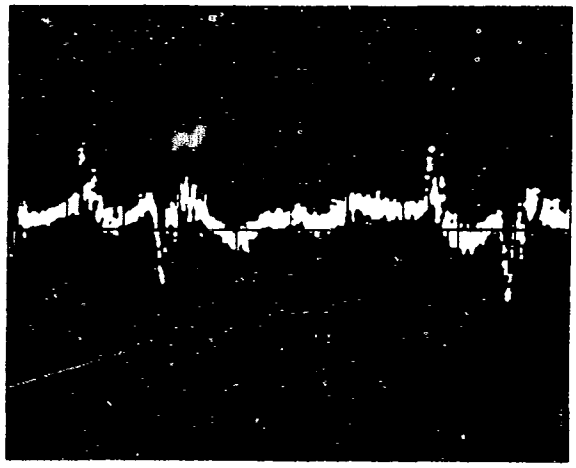


TB 109-10
TB 501-27 GND

Vert. Gain: 1mV/Div

Horiz. Time Base: 0.2ms/Div

PHOTO #21

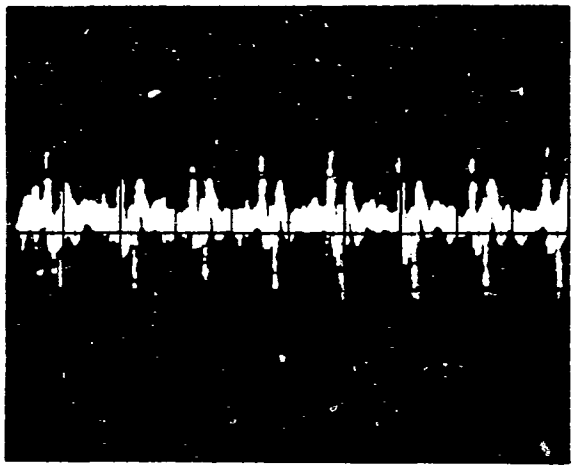


TB 109-10
TB 501-27] GND

Vert. Gain: 10mV/Div

Horiz. Time Base: 10μs/Div

PHOTO #22

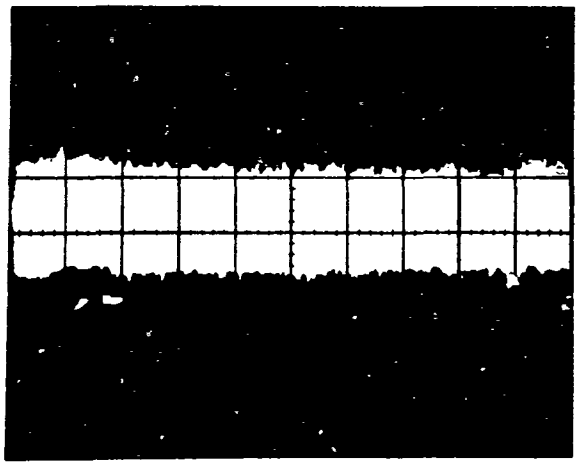


TB 109-10
TB 501-27] GND

Vert. Gain: 10mV/Div

Horiz. Time Base: 50μs/Div

PHOTO #23



TB 109-10
TB 501-27] GND

Vert. Gain: 5mV/Div

Horiz. Time Base: 2ms/Div

PHOTO #24

TB 109-8
TB 109-10
+10V

BW - 3 KHz

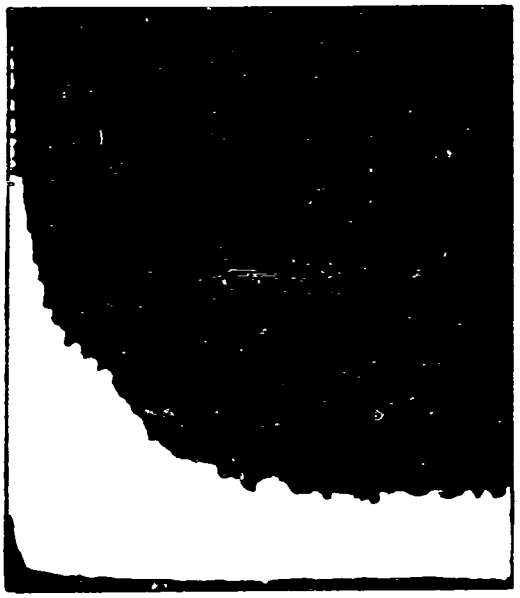
Horiz. Scale: 200 KHz/Div

Scan Time - 100 ms/Div

Vert. Scale: 0dB Ref; 10dB/Div

Input Attenuation: 40 dB

PHOTO #25



TB 109-8
TB 109-10
+10V

BW - 3 KHz

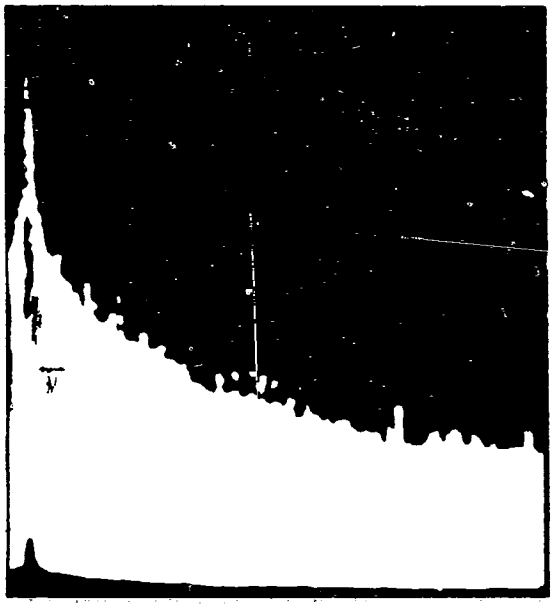
Horiz. Scale: 500 KHz/Div

Scan Time - 0.2 s/Div

Vert. Scale: 0dB Ref; 10dB/Div

Input attenuation: 40 dB

PHOTO #26



TB 109-6
TB 109-7
Signal

BW - 3 KHz

Horiz. Scale: 500 KHz/Div

Scan Time - 0.2 s/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

PHOTO # 27

TB 107-5
TB 107-10
+600V

BW - 3 KHz

Horiz. Scale: 500 KHz/Div

Scan Time: 0.2 s/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

0.109 RMS

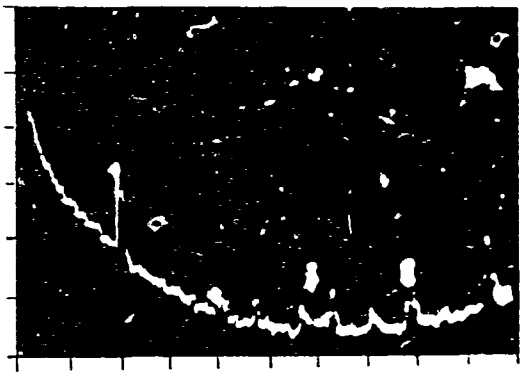


PHOTO #28

TB 109-5
TB 109-10
+600V

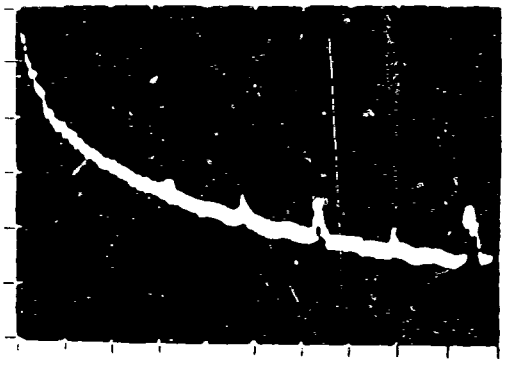
Range: 0 - 100 KHz

20 KHz Harmonics Intensified

Vert. Scale: +20 dB Ref; 10 dB/Div

1.35 RMS

PHOTO # 29



TB 109-6
TB 109-7
Signal

Range: 0 - 100 KHz

32 KHz Harmonics Intensified

Vert. Scale: +20 dB Ref; 10 dB/Div

0.301 RMS

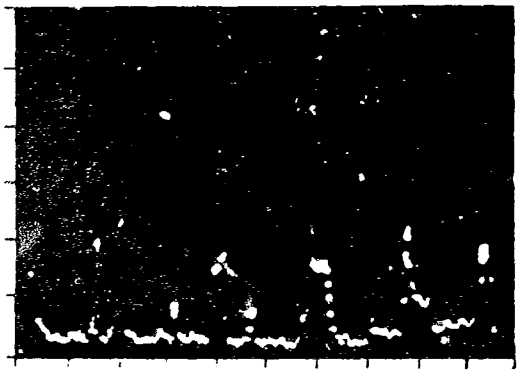


PHOTO #30

TB 109-8
TB 109-10
+10V

Range: 0 - 100 KHz

~16 KHz Harmonics intensified

~20 KHz Harmonics also present

Vert. Scale: +20 dB Ref; 10 dB/Div

0.712 RMS

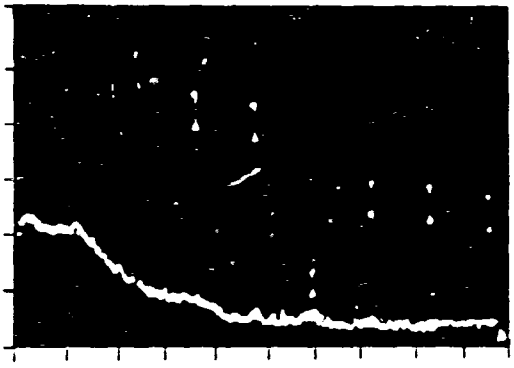


PHOTO #31

TB 109-8
TB 109-10
+10V

Range: 0 - 1 KHz

~120 KHz Harmonics Intensified

Vert. Scale: +20 dB Ref; 10 dB/Div

SECTION A.5.3

PRE-REMOVAL TDR MEASUREMENTS ON CABLE

(Detector Attached)

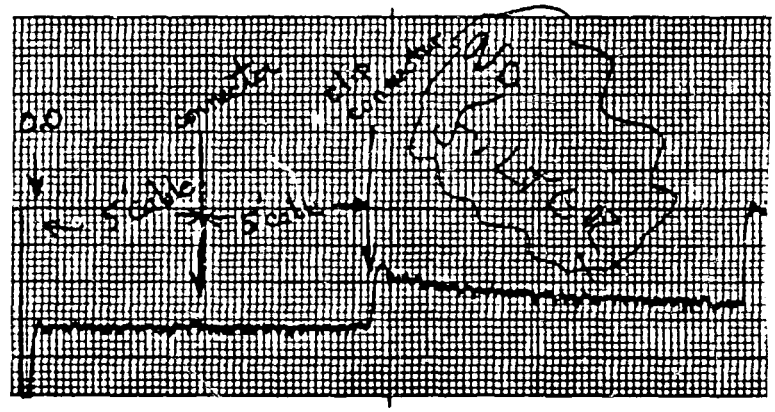
PRE-REMOVAL TDR MEASUREMENTS

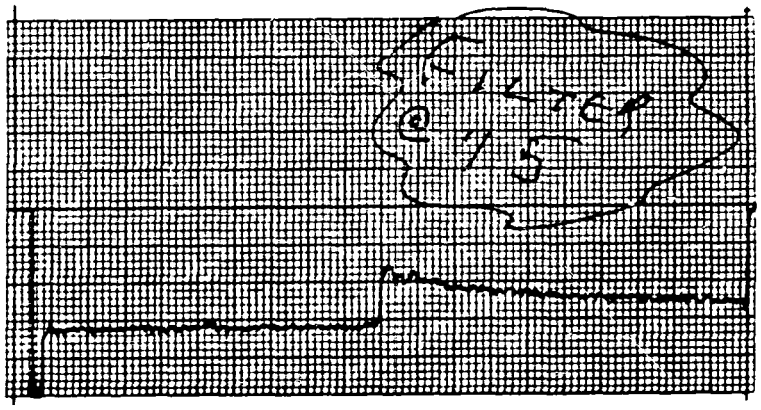
Test	Verify Operability & Necessary LP Filter for Recording	
#12.a	Checksource	Tests 12a-1, 12a-2
#12.b	RG59	Tests 12b-1, 12b-2
#12.c	RG58	Tests 12c-1, 12-c2
#12.d	+10V	Tests 12d-1, 12-d2
#12.e	GND-GND	Tests 12e-1, 12-e2
#12.f	RG58+ 5' cable and terminal block inserted	Tests 12f-1, 12f-2

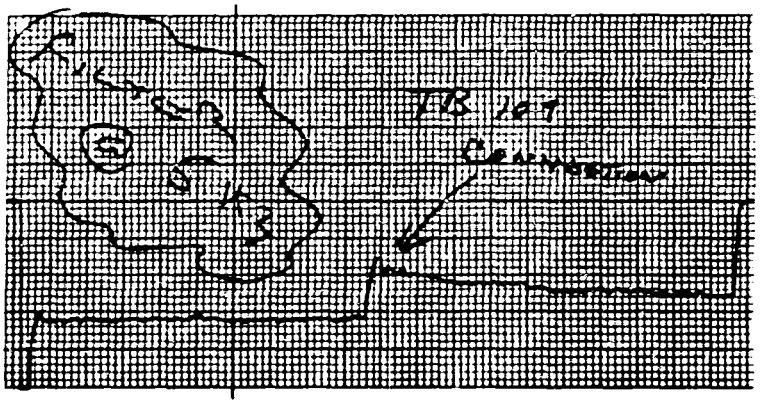
TDR Test Runs

To Determine LP Filters
Setting For Strip Chart Output
Test Run - 10' Coax With Clips

Horiz. Scale: Uncalibrated Chart Speed: 5 mm/s



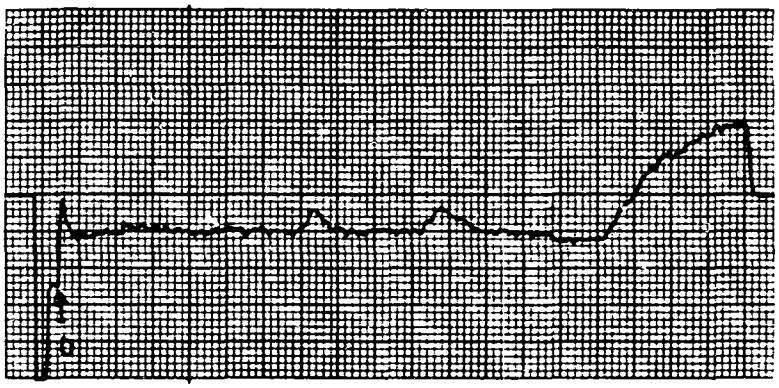




Test 12a - 1

From Blue to Orange

Checksource



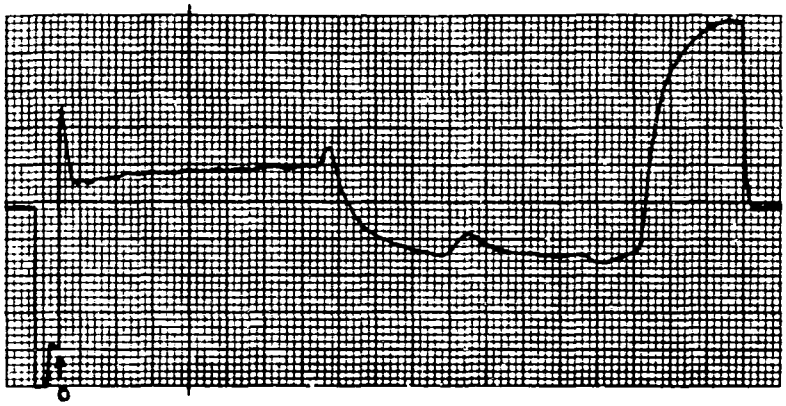
Horizontal Scale: 26.32 ft./Div

Vertical Scale: 0.25 V/Div; 500 m p/Div

Test 12b-1

From RG 59/U Center to RG 59/U Shield

600V to Shield



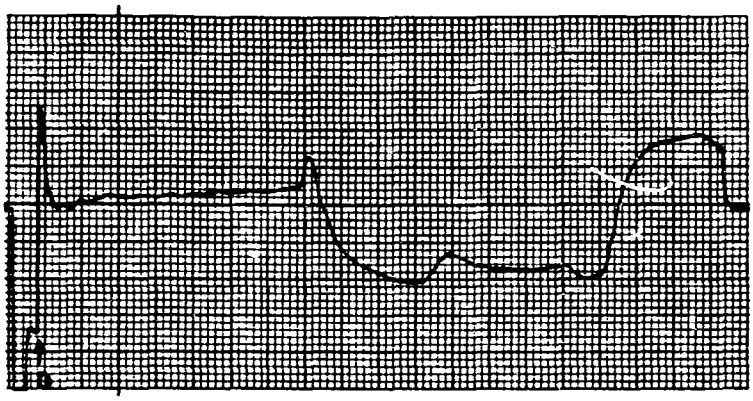
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10V/Div; 500 mV/Div

Test 12c-1

From RG 58/U Center to RG 58/U Shield

Signal to Shield



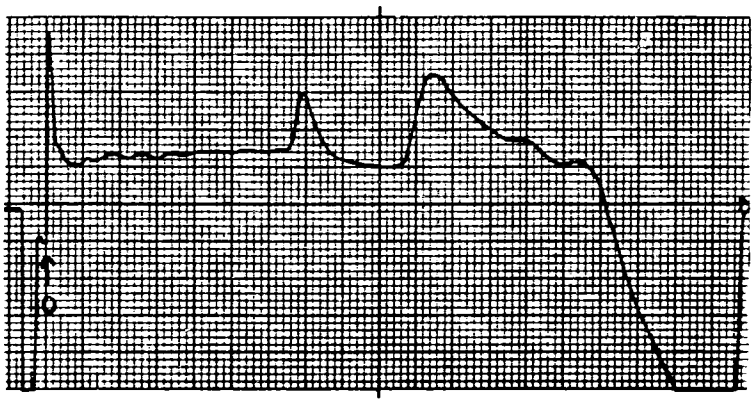
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10V/Div; 500 mρ/Div

Test 12d - 1

From Red to Black

+10V to GND



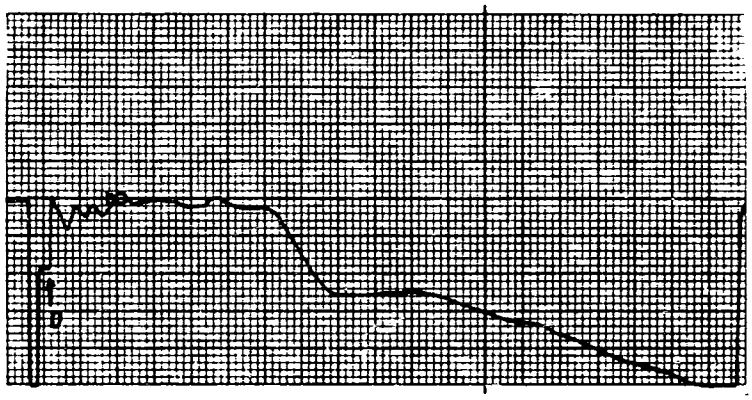
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10V/Div; 500 mρ/Div

Test 12e - 1

From Black to TB109-10

GND to GND



Horizontal Scale: 26.32 ft/Div

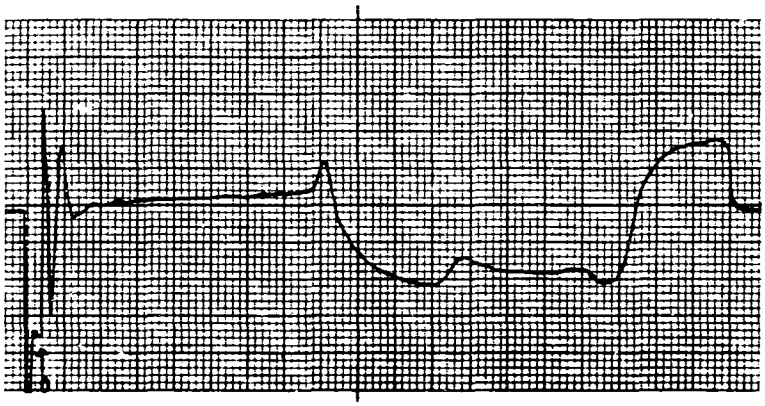
Vertical Scale: 0.25V/Div; 500 mρ/Div

Test 12f - 1

From RU 58/U Shield to RG 58/U Center

Shield to Signal

(12c-1 with new cable and terminal black inserted @ ~ 10')

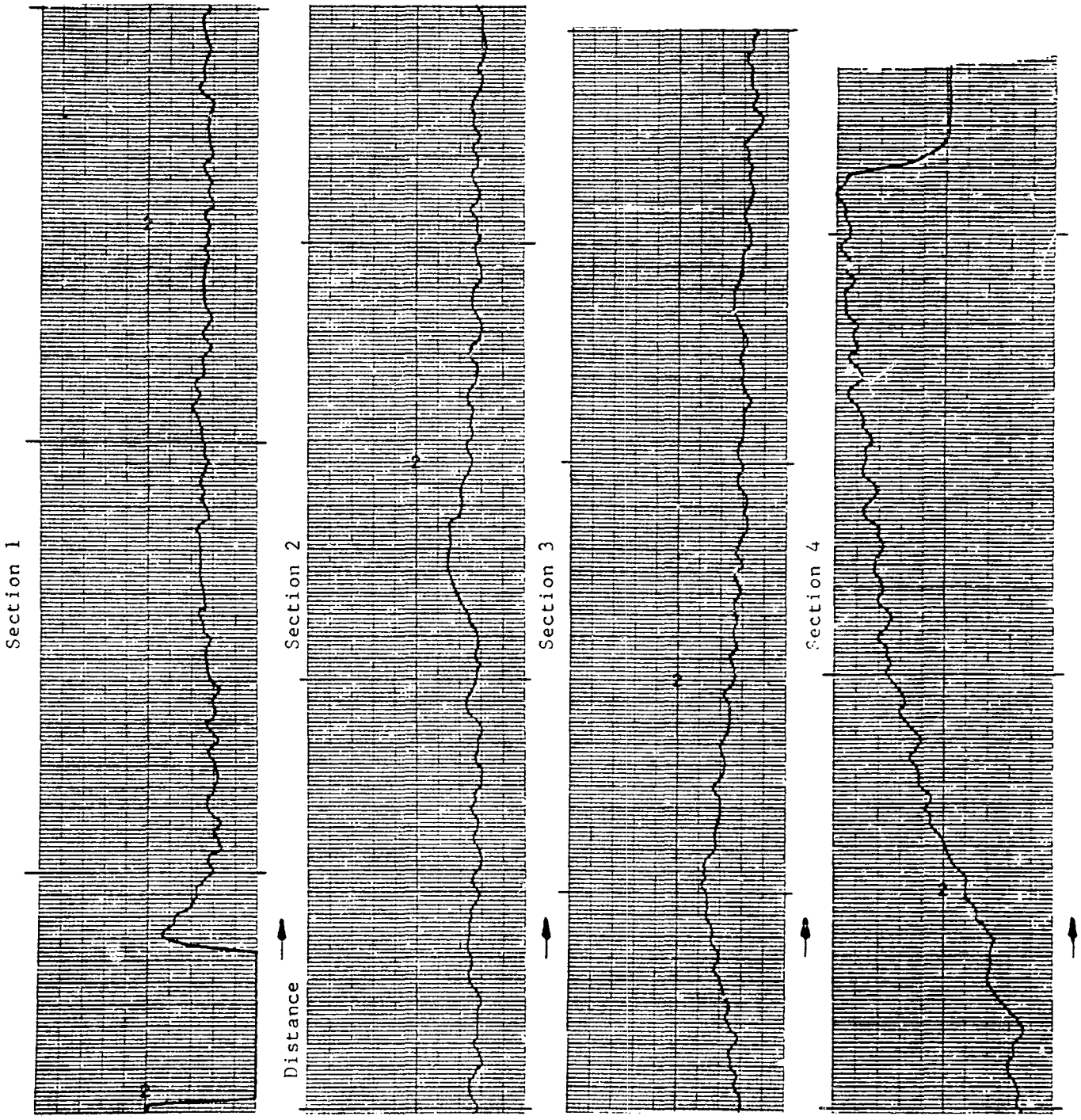


Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10V/Div; 500 mρ/Div

Test 12a-2: From Blue to Orange - Checksource

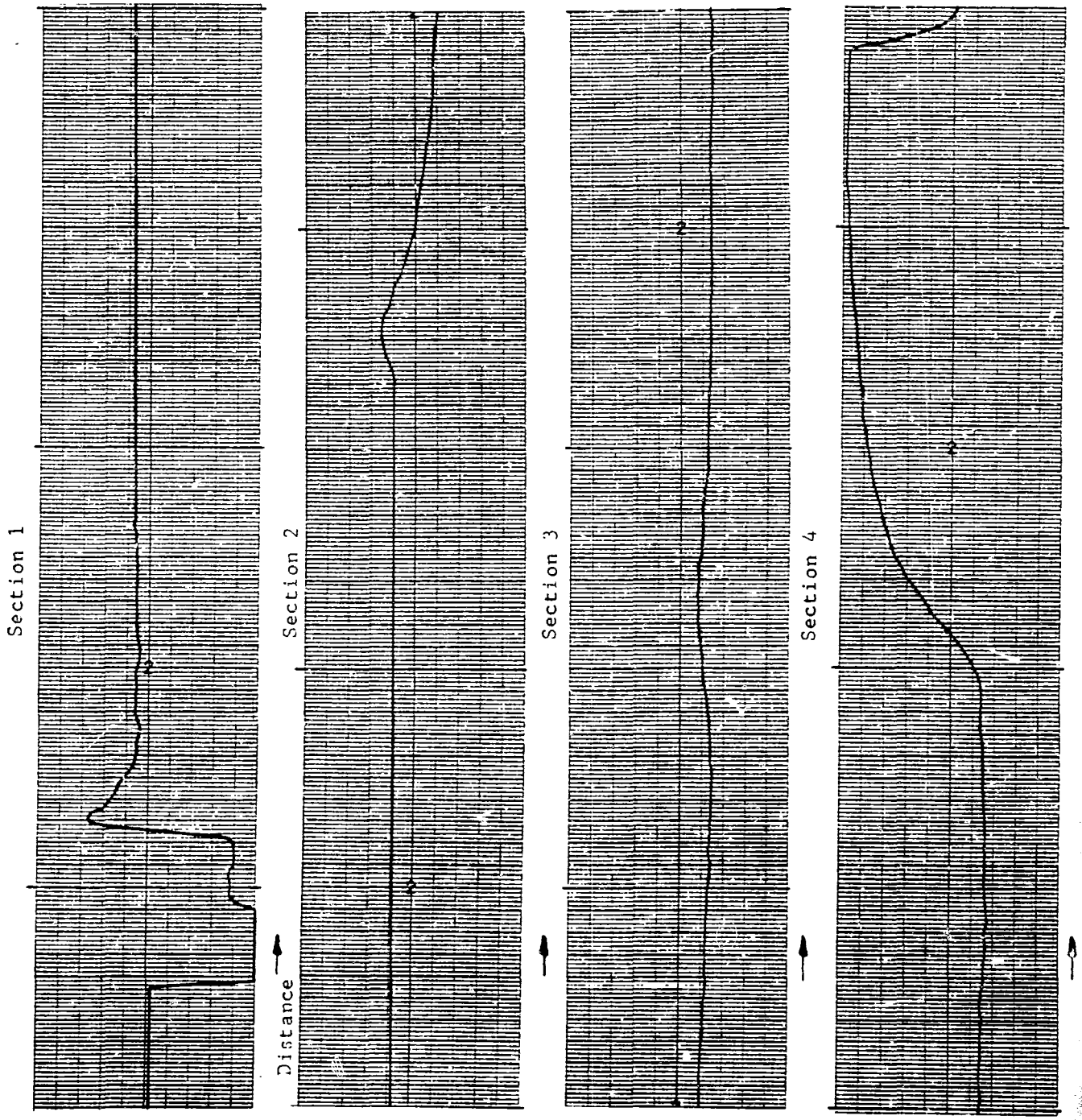
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 mρ/Div



Test 12b-2: From RG 59/U Center to RG 59/U Shield

600 V to Shield

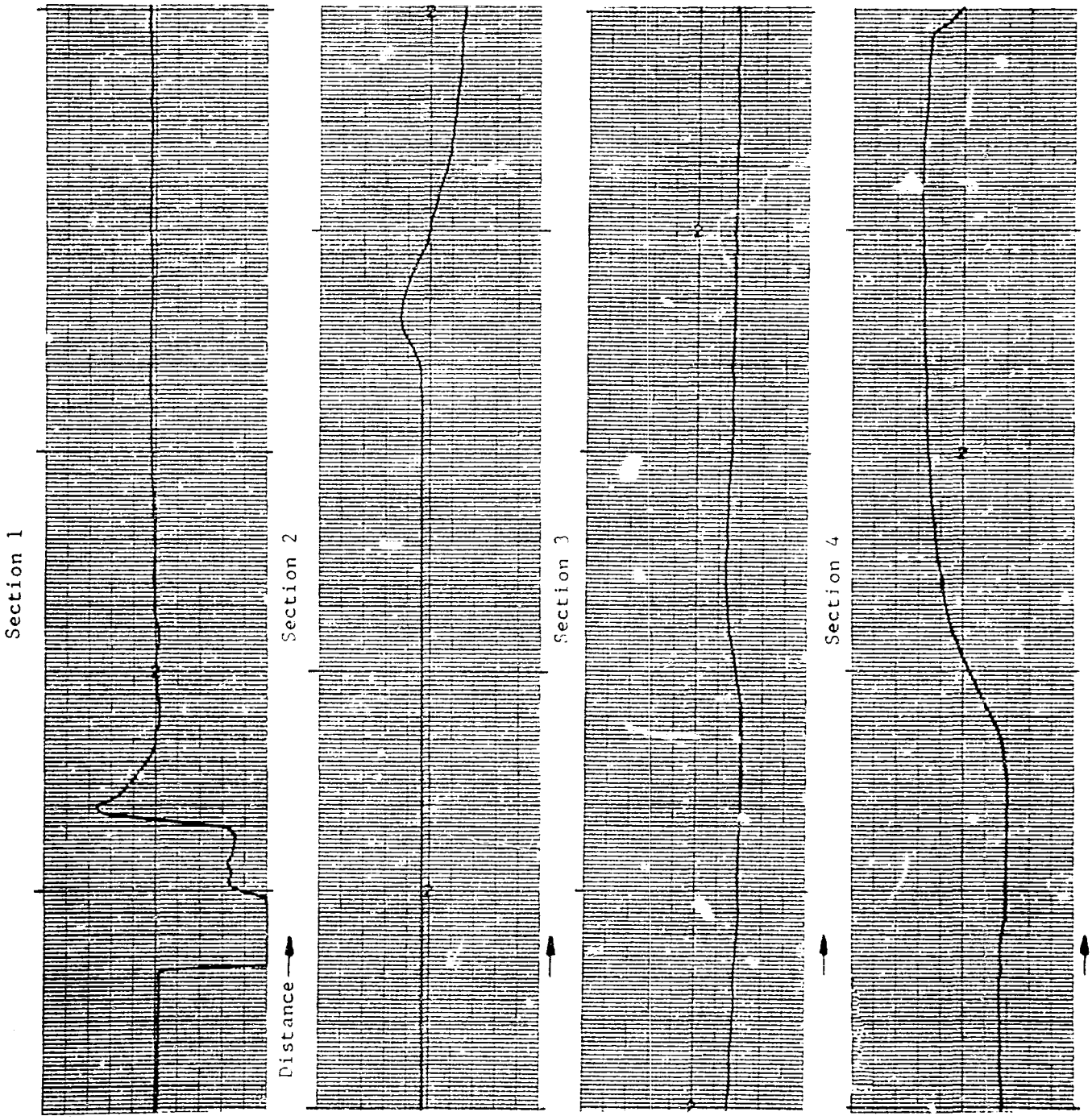
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 mρ/Div



Test 12c-2: From RG 58/U Center to RG 58/U Shield

Signal to Shield

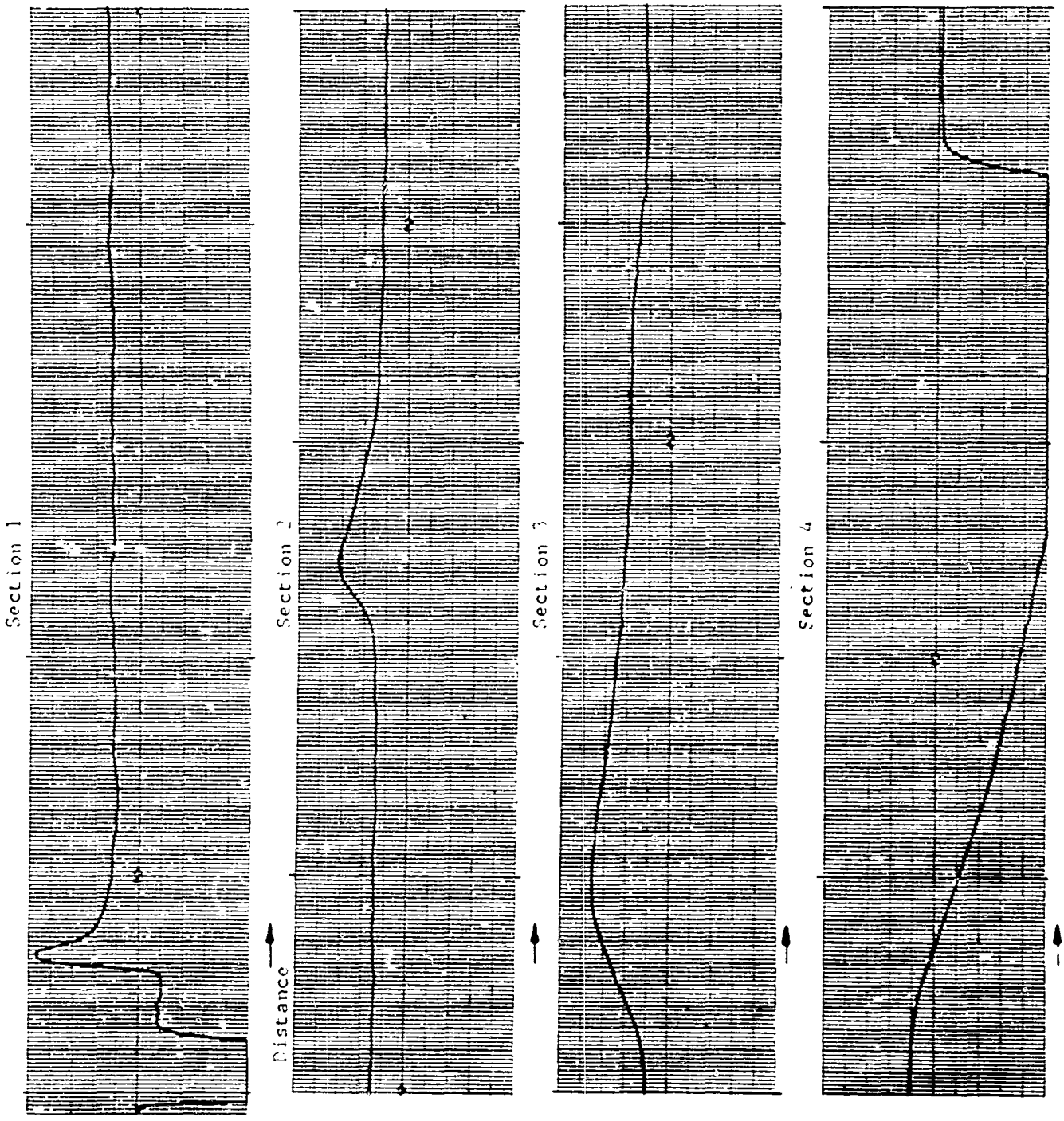
Horizontal Scale: 2.632 ft/Div Vertical Scale: [illegible]V/Div; 500 mp/Div



Test 12c-2: From Red to Black

-10 V to GND

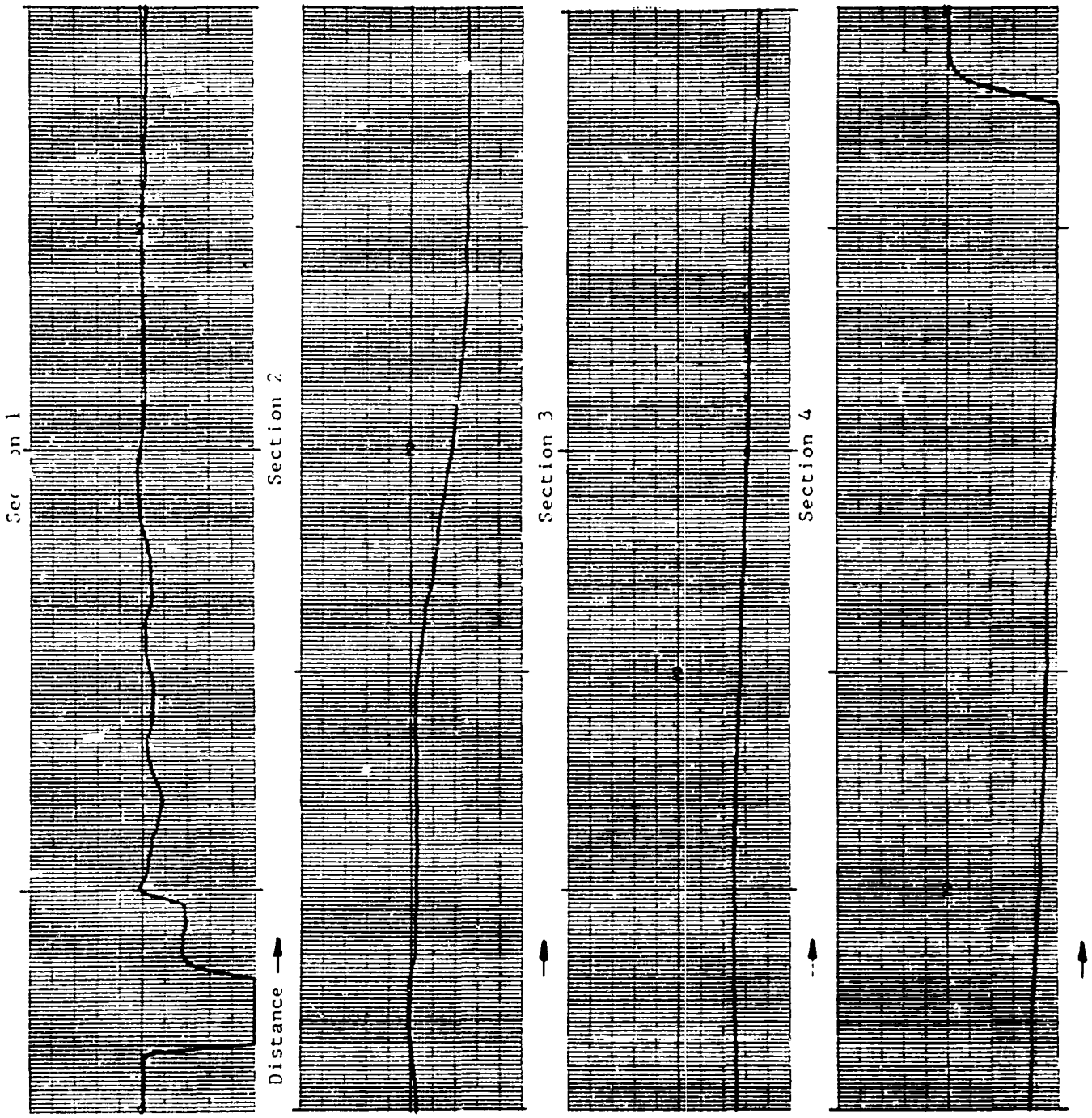
Horizontal Scale: 2.032 ft Div Vertical Scale: 0.10V Div, 500 mv/Div



Test 12e-2: From Black to TB109-10

GND to GND

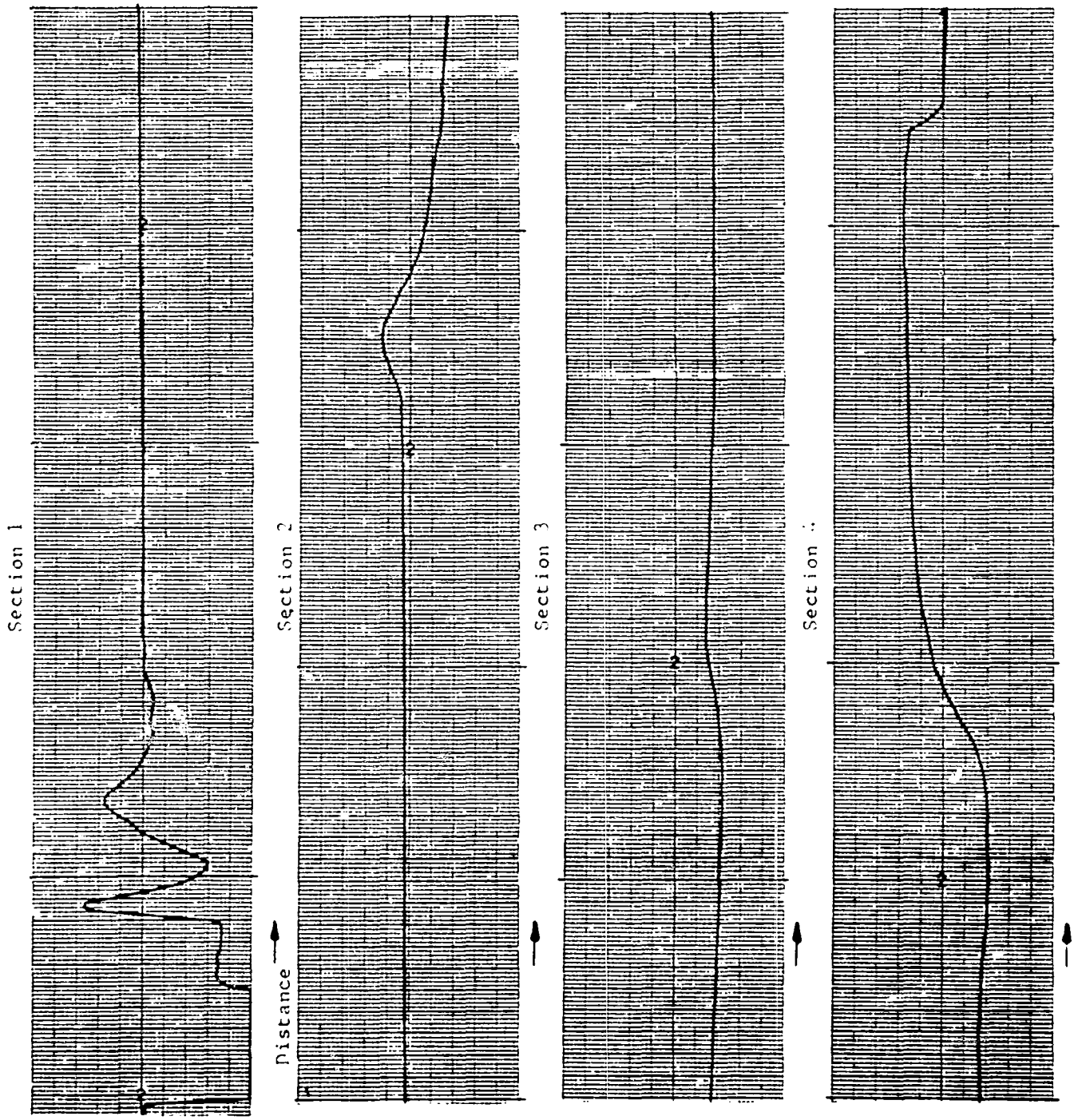
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 mV/Div



Test 12f-2: From RG 58/U Shield to RG 58/U Center

Shield to Signal (Extra test cable and terminal block)

Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 mV/Div



SECTION A.5.4

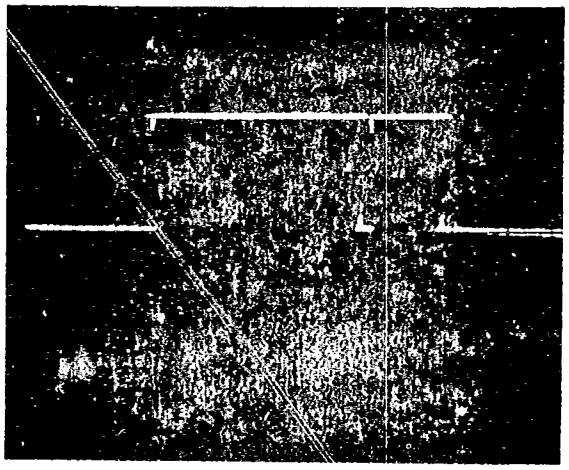
TIME AND FREQUENCY DOMAIN MEASUREMENTS OF WAVEFORMS ON DETECTOR INSTALLED IN THE ANTEROOM

PRE-REMOVAL

Time Domain

#19.a	Check Source to GND Photo #35, 36, 37
#19.b	Check Source to GND Photo #38, 39, 40
#19.c	+600 VDC to GND Photo #41, 42, 43
#19.d	Detector Signal to GND Photo #32, 33, 34
#19.e	+10VDC to GND Photo #44, 45, 46
#19.f	GND to AC GND Photo #47, 48, 49

PHOTO #32

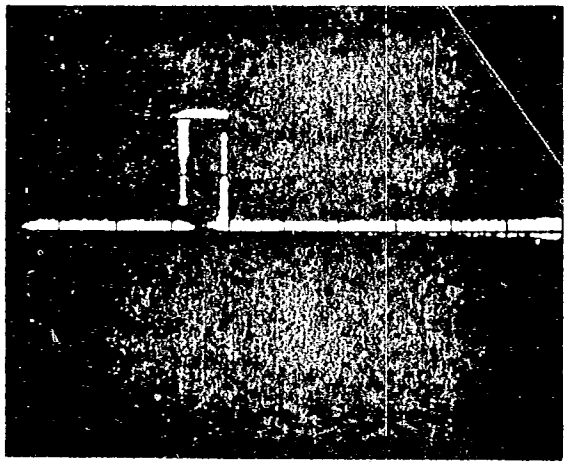


TB 109-6
TB 109-7
Signal

Vert. Gain: 5V/Div

Horiz. Time Base: 1 s/Div

PHOTO #33

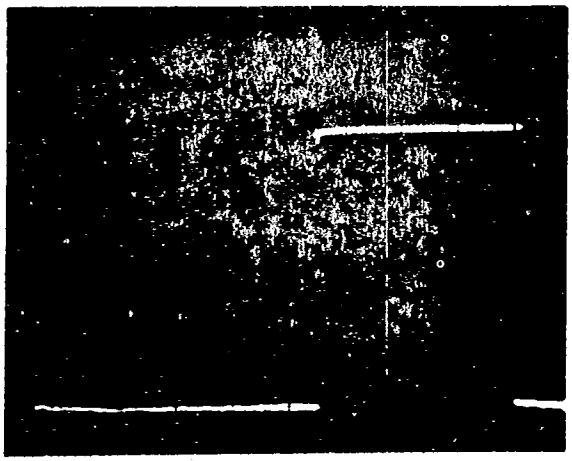


TB 109-6
TB 109-7
Signal

Vert. Gain: 5V/Div

Horiz. Time Base: 0.2s/Div

PHOTO #34

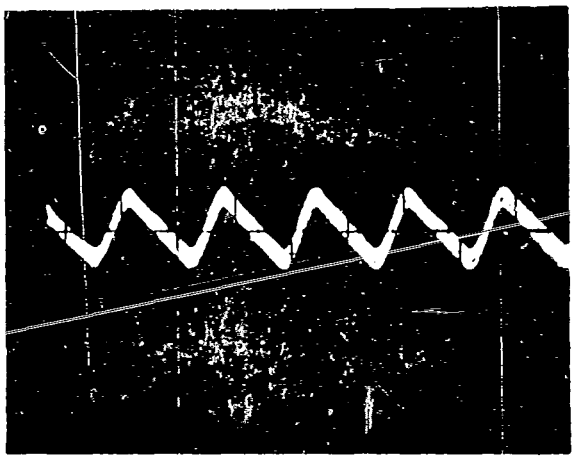


TB 109-6
TB 109-7
Signal

Vert. Gain: 2V/Div

Horiz. Time Base: 0.5s/Div

PHOTO #35

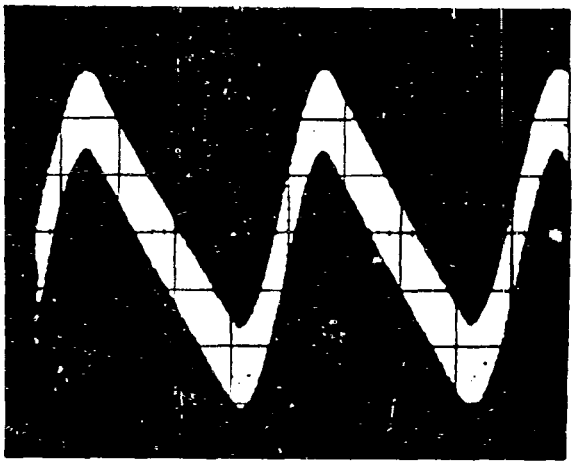


TB 109-1
TB 109-10
Check Source

Vert. Gain: 0.2V/Div

Horiz. Time Base: 5 ms/Div

PHOTO #36

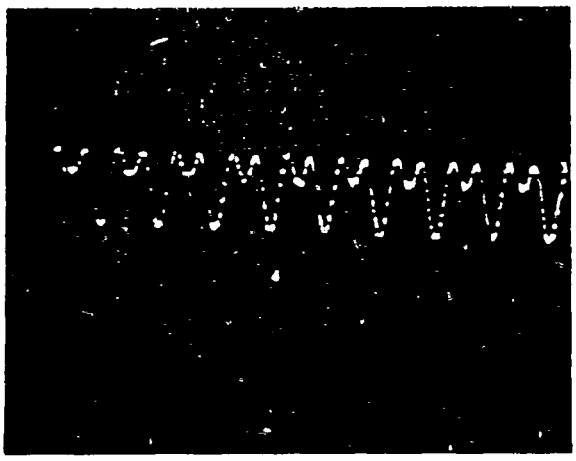


TB 109-1
TB 109-10
Check Source

Vert. Gain: 50mV/Div

Horiz. Time Base: 2 ms/Div

PHOTO #37

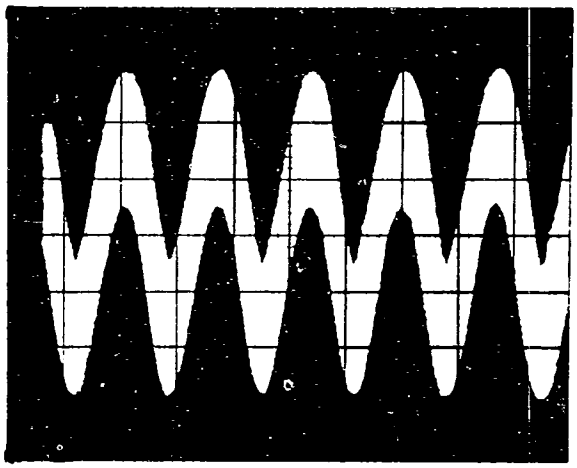


TB 109-1
TB 109-10
Check Source

Vert. Gain: 50mV/Div

Horiz. Time Base: 50 μs/Div

PHOTO #41

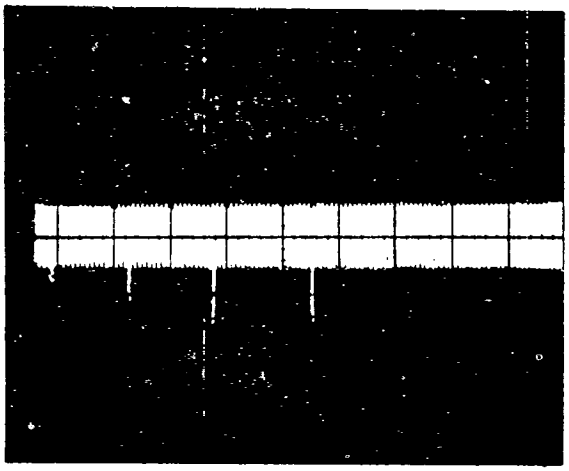


TB 109-5
TB 109-10
+600V

Vert. Gain: 20mV/Div

Horiz. Time Base: 10ms/Div

PHOTO #42

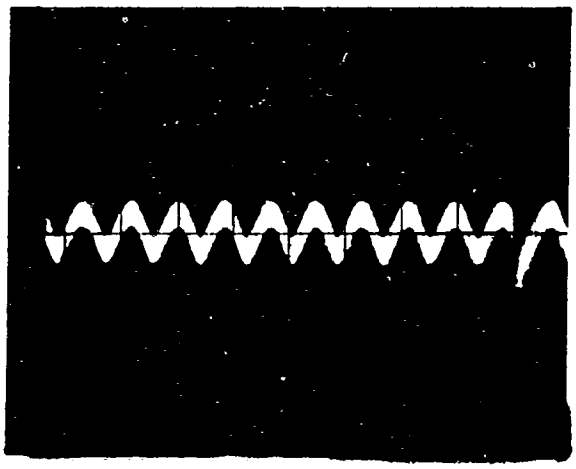


TB 109-5
TB 109-10
+600V

Vert. Gain: 20mV/Div

Horiz. Time Base: 0.2s/Div

PHOTO #43

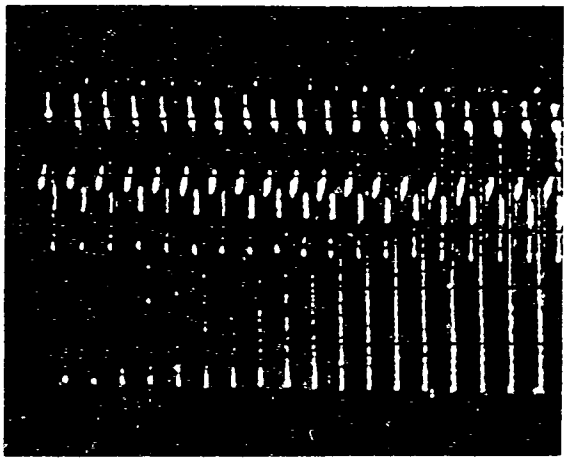


TB 109-5
TB 109-10
+600V

Vert. Gain: 100mV/Div

Horiz. Time Base: 20ms/Div

PHOTO #44

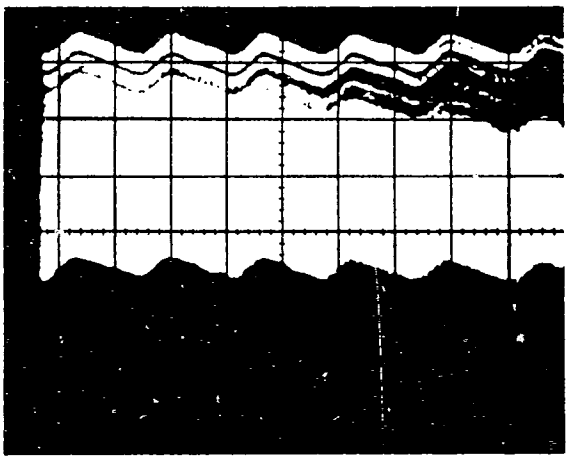


TB 109-8
TB 109-10
+10V

Vert. Gain: 20mV/Div

Horiz. Time Base: 0.1ms/Div

PHOTO #45

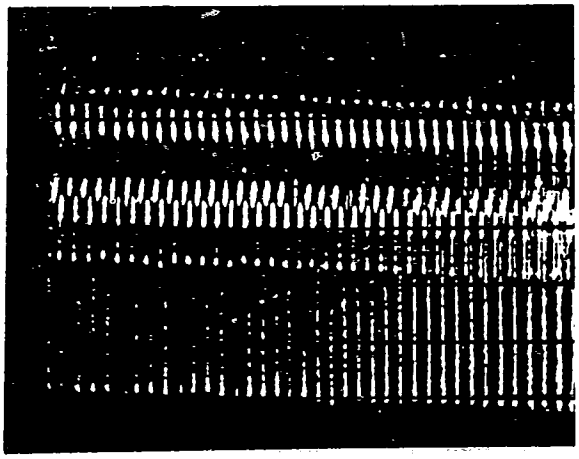


TB 109-8
TB 109-10
+10V

Vert. Gain: 50mV/Div

Horiz. Time Base: 5ms/Div

PHOTO #46

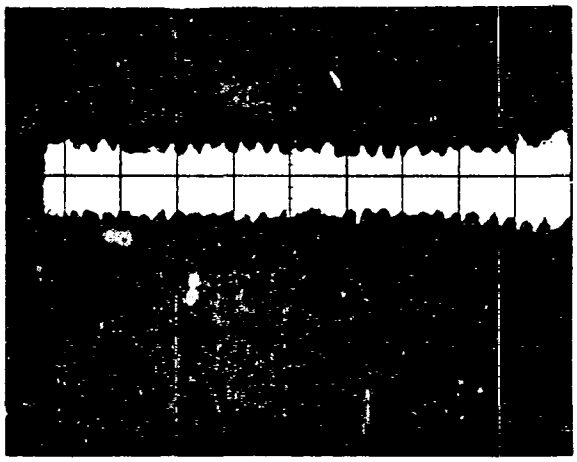


TB 109-8
TB 109-10
+10V

Vert. Gain: 20mV/Div

Horiz. Time Base: 0.2ms/Div

PHOTO #47

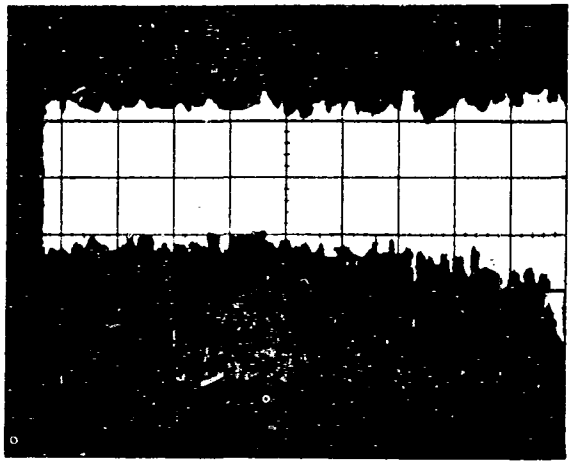


TB 109-10
TB 501-27
GND

Vert. Gain: 5mV/Div

Horiz. Time Base: 0.2ms/Div

PHOTO #48

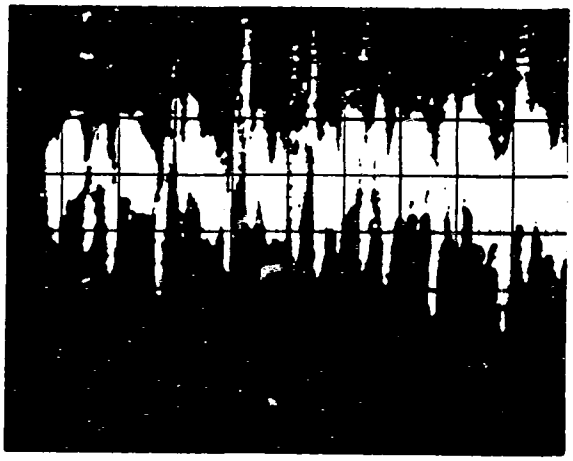


TB 109-10
TB 501-27
GND

Vert. Gain: 2mV/Div

Horiz. Time Base: 0.2ms/Div

PHOTO #49



TB 109-10
TB 501-27
GND

Vert. Gain: 2mV/Div

Horiz. Time Base: 50µs/Div

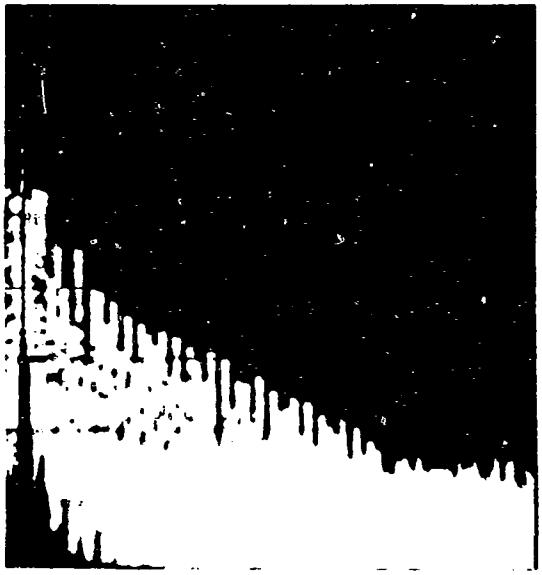


PHOTO #50

TB 109-8
TB 109-10
+10V

BW - 3KHz

Horiz. Scale: 200 KHz/Div

Scan Time: 100 ms/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

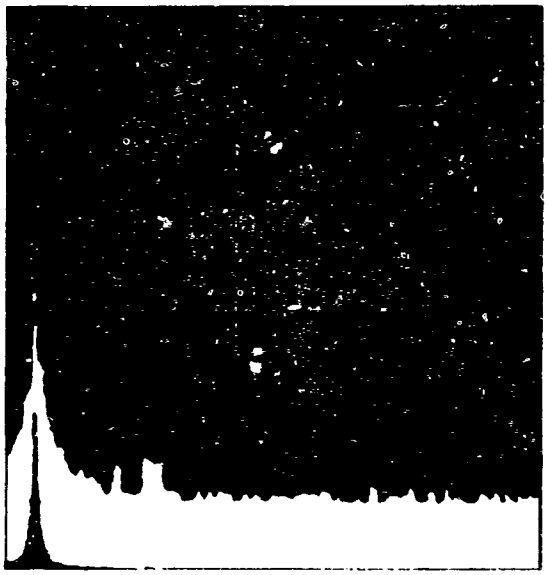


PHOTO #51

TB 109-6
TB 109-7
Signal

BW - 3 KHz

Horiz. Scale: 500 KHz/Div

Scan Time: - 0.2 s/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

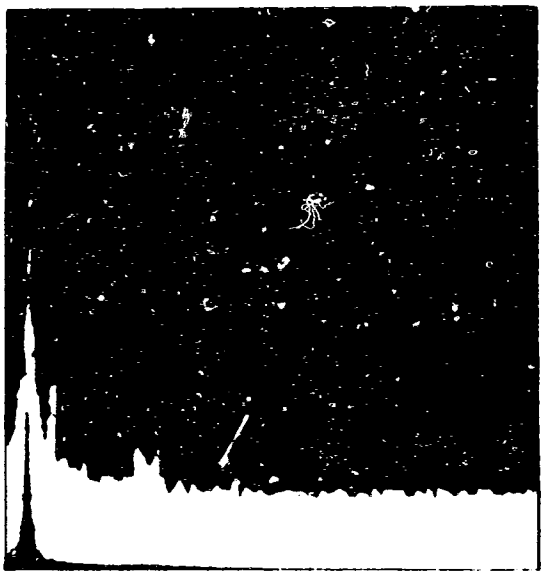


PHOTO #52

TB 109-5
TB 109-10
+600V

BW - 3 KHz

Horiz. Scale: 500 KHz/Div

Scan Time - 0.2 s/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

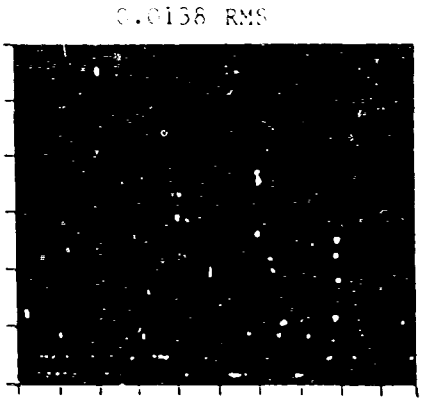


PHOTO #53

TB 109-5
TB 109-10
+600V

Range: 0 - 100 KHz

Vert. Scale: +20 dB Ref; 10 dB/Div

0.00260 RMS

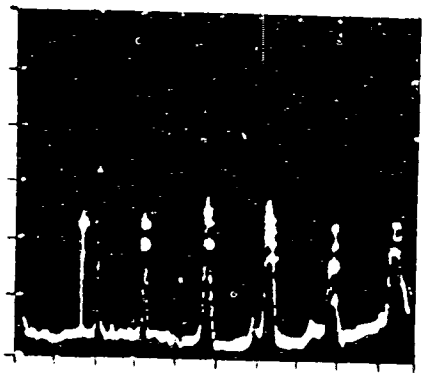


PHOTO #54

TB 109-6
TB 109-7
Signal

Range: 0 - 100 KHz

16 KHz Harmonics Intensified

(20 KHz Harmonics also present)

Vert. Scale: +20 dB Ref; 10 dB/Div

0.0332 RMS

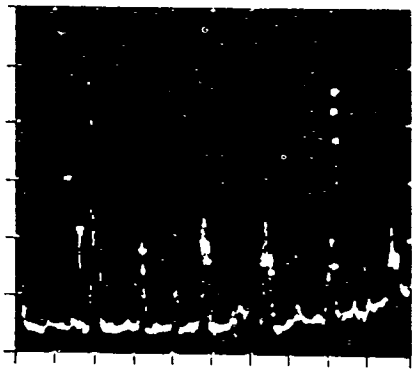


PHOTO #55

TB 109-8
TB 109-10
+10%

Range: 0 - 100 KHz

16 KHz Harmonics Intensified

(20 KHz Harmonics also present)

Vert. Scale: +20 dB Ref; 10 dB/Div

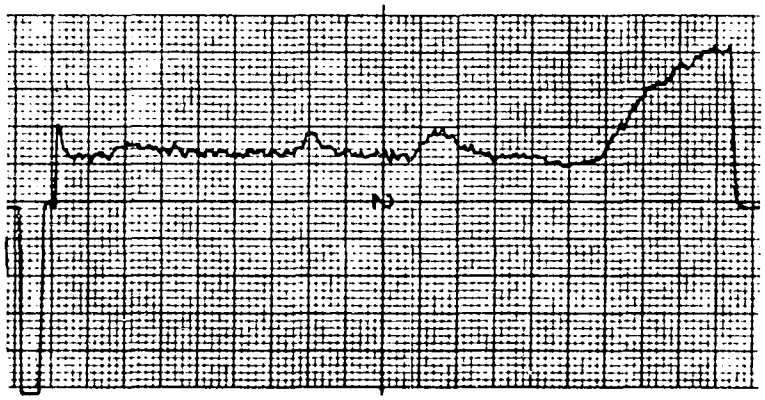
SECTION A.5.5

POST-REMOVAL TDR MEASUREMENTS ON CABLE

Test 34a - 1

From Blue to Orange

Checksource



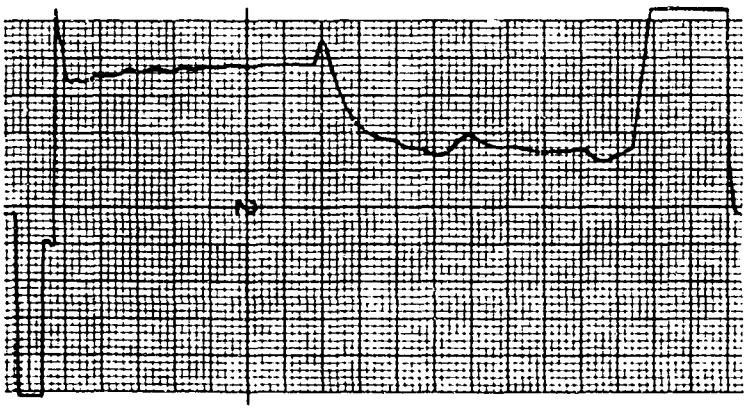
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.25V/Div, 500 mΩ/Div

Test 34b - 1

From RG 59/U Center to RG 59/U Shield

600V to Shield



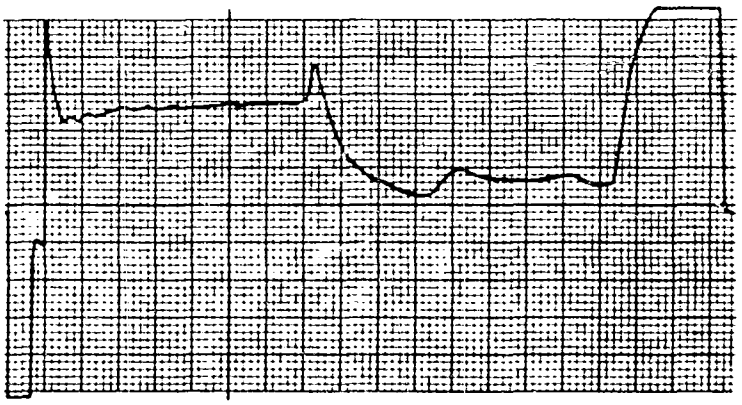
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10 V/Div; 500 mρ/Div

Test 34c - 1

From RG 58/U Center to RG 58/U Shield

Signal to Shield



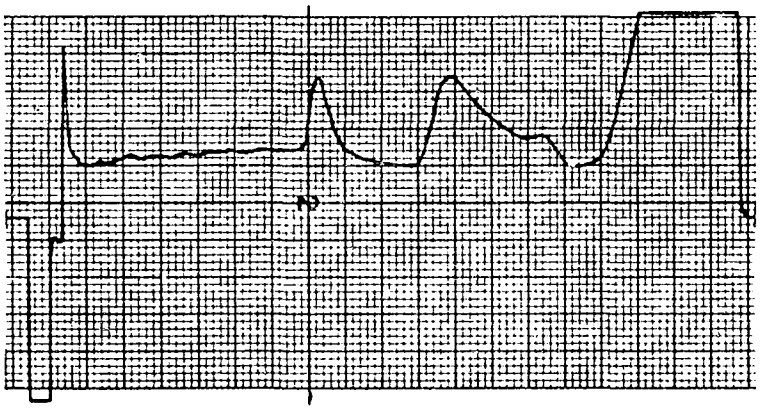
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10 V/Div; 500 mΩ/Div

Test 34d - 1

From Red to Black

+10V to GND



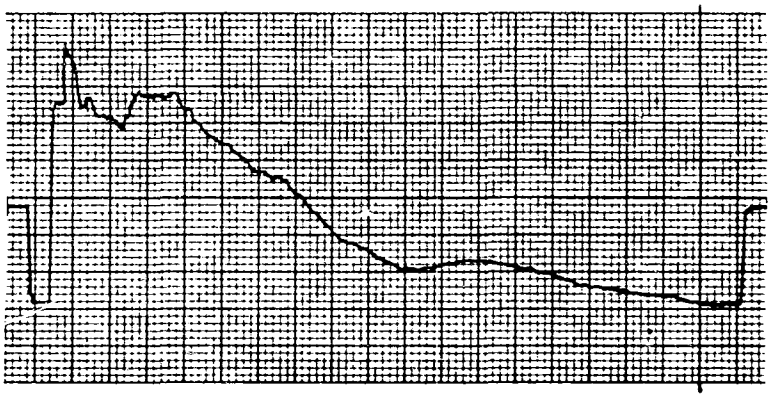
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10 V/Div; 500 mp/Div

Test 34e - 1

From Black to TB109-10

GND to GND

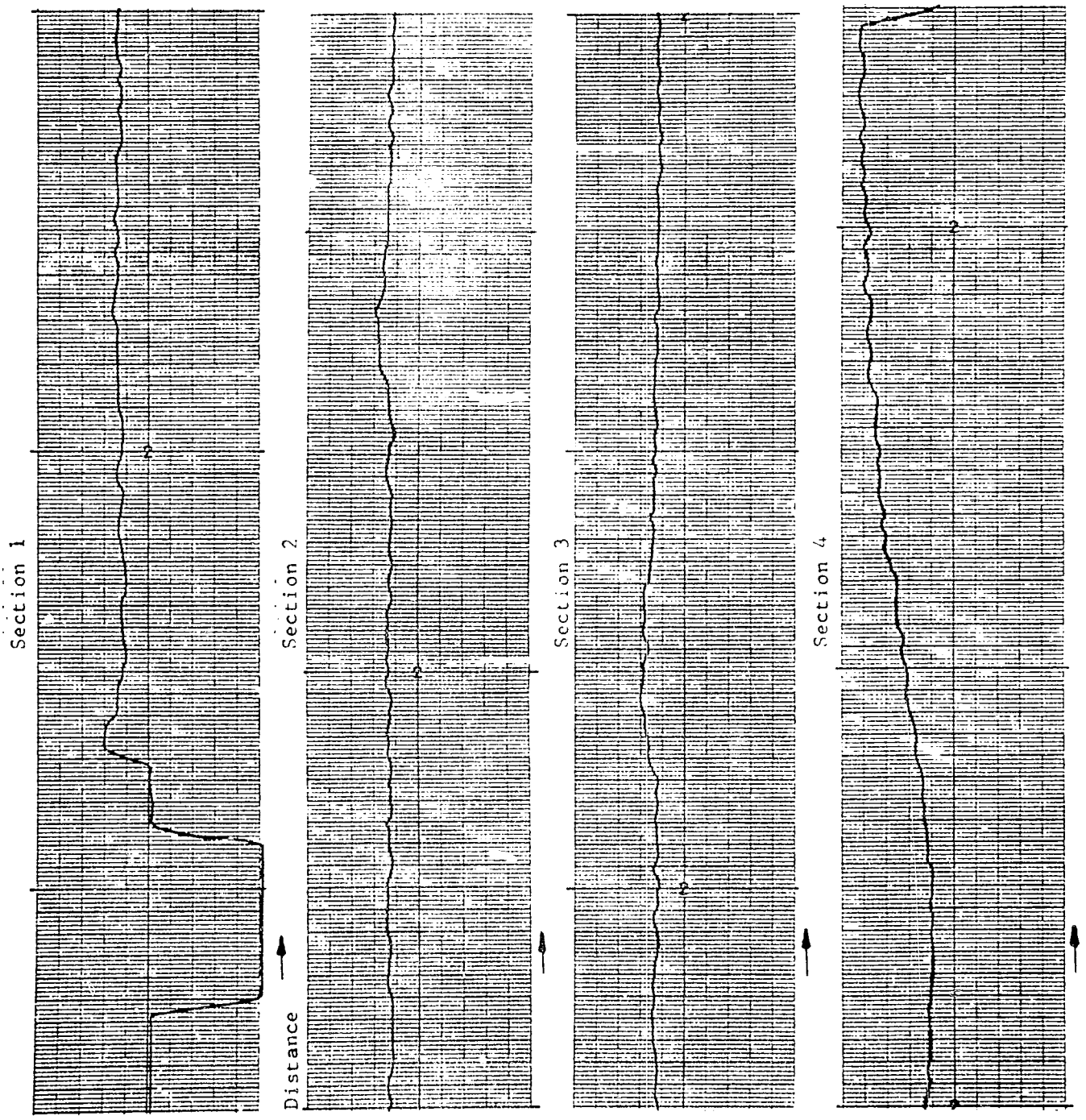


Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.25 V/Div; 500 mp/Div

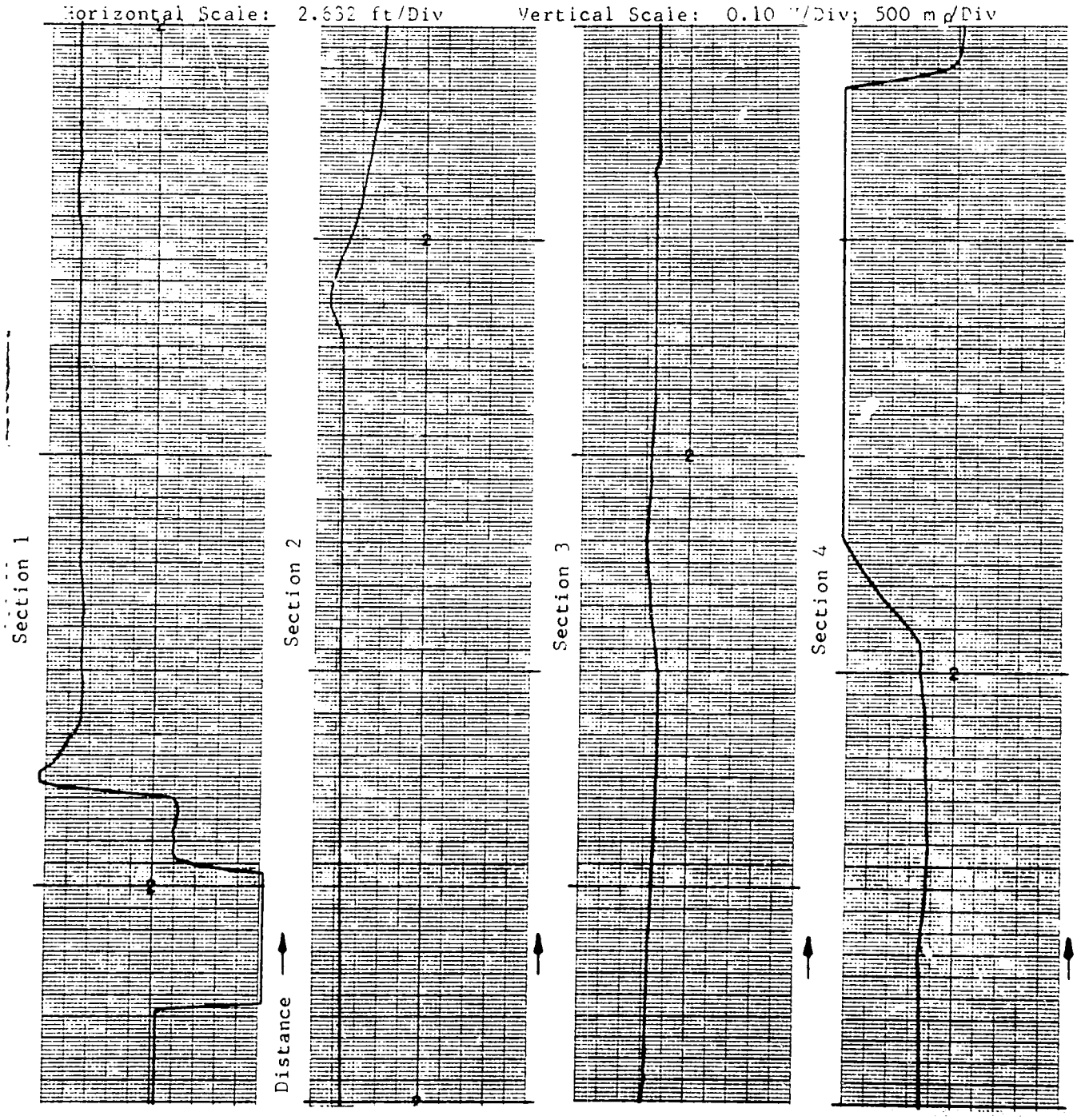
Test 34a - 2: From Blue to Orange - Checksource

Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.25 V/Div; 500 mo/Div



Test 34b - 2: From RG 59/U Center to RG 59/U Shield

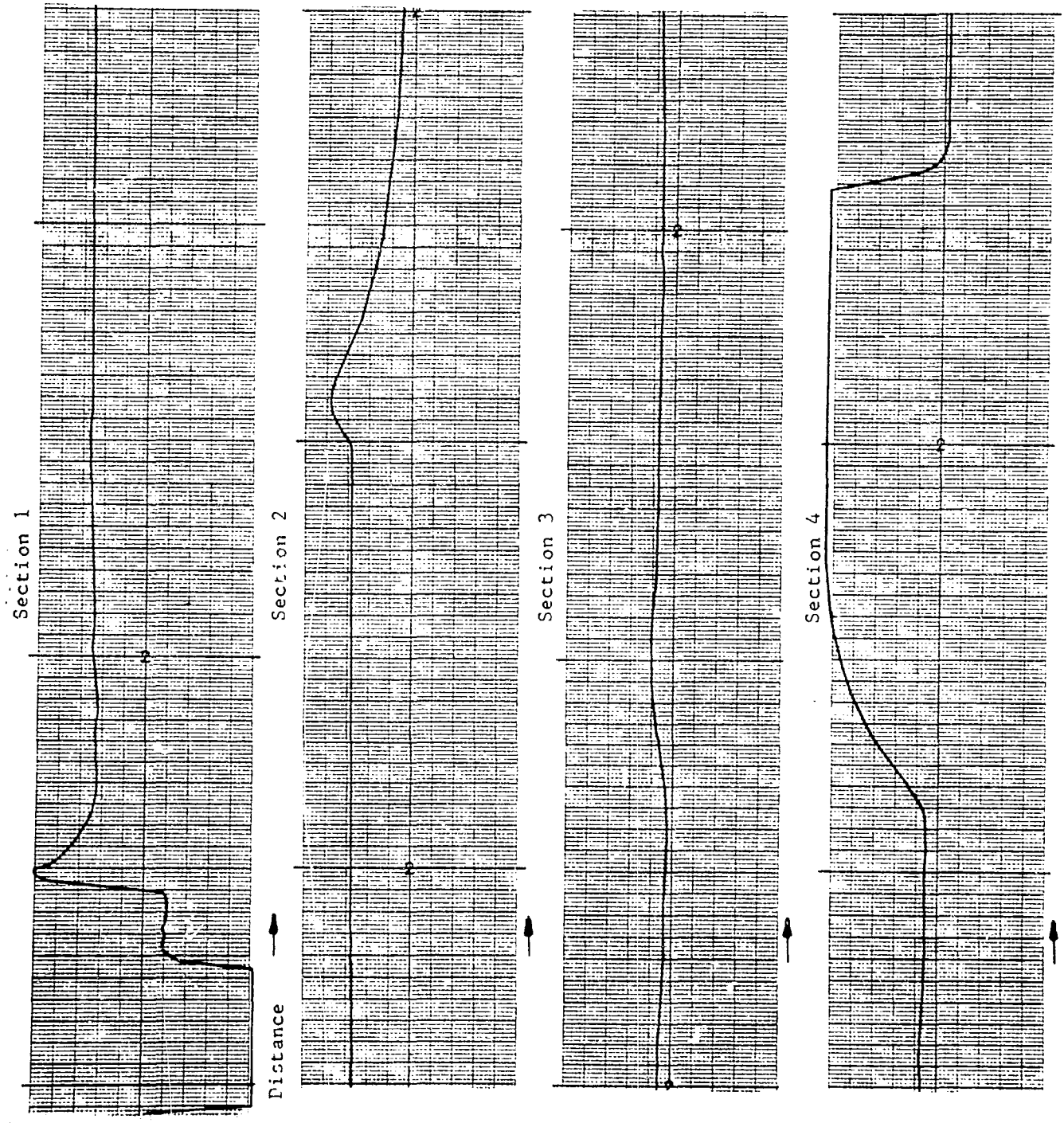
600V to Shield



Test 34c - 2: From RG 58/U Center to RG 58/U Shield

Signal to Shield

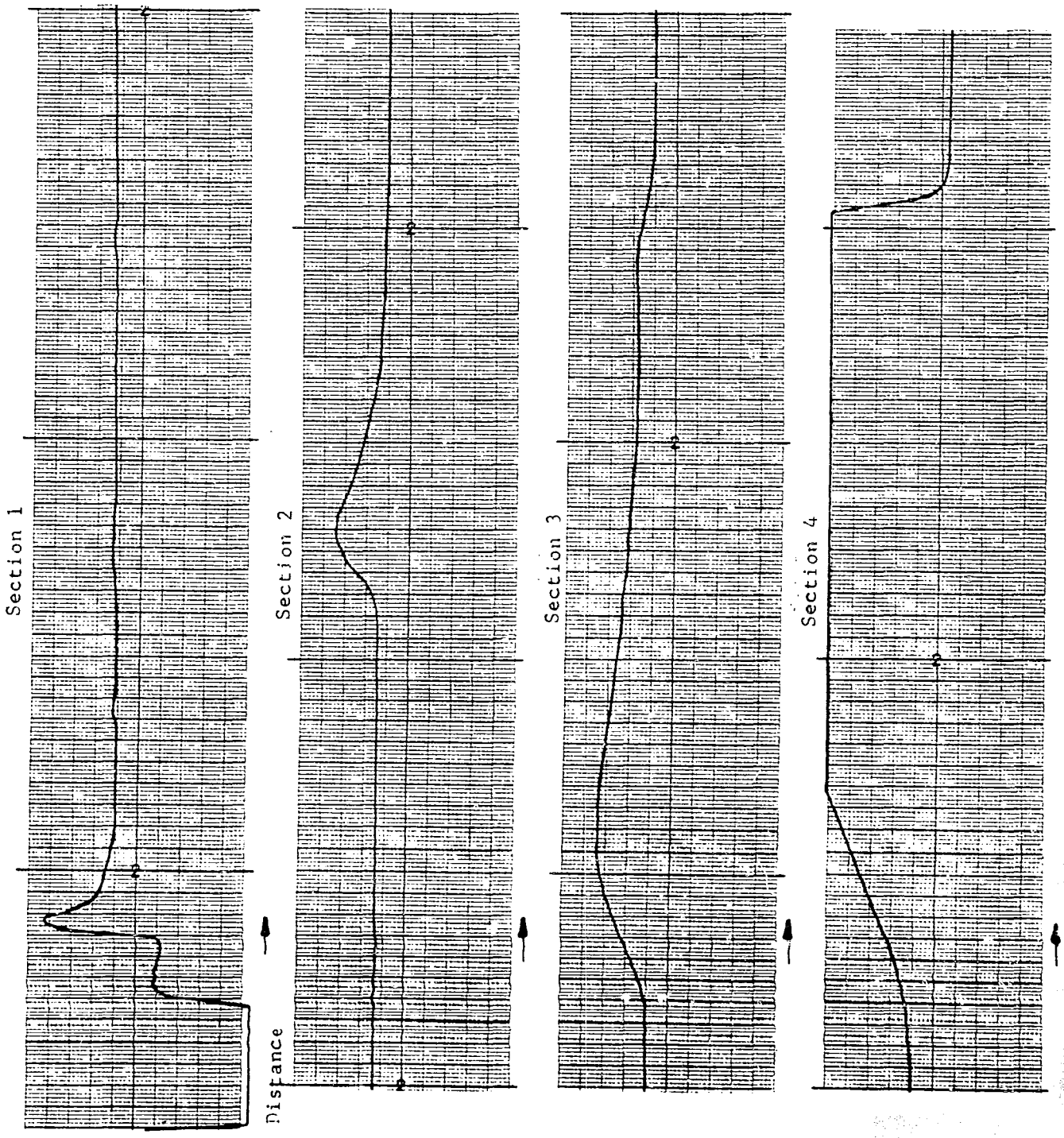
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10 V/Div; 500 mρ/Div



Test 34d - 2: From Red to Black

+10V to GND

Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10 V/Div; 500 mρ/Div



Test 34e - 2: From Black to TBi09-10

GND to GND

Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.25 V/Div; 500 m_ρ/Div