Silva
071875

SUMMARY OF TESTS, RESULTS AND CONCLUSIONS FOR THE ERL DATA COMPARISON STUDY AT WILLISTON, N. D.

JULY 16, 17, and 18, 1975

Purpose: To determine the comparability of data gathered by the Model 20C and 20D spectroradiometers.

Personnel: Morgan McIntosh, LEC
Jim Jones, LEC
Jim Shaffer, LEC
B.F. Robinson, Purdue/LARS
L.L. Biehl, Purdue/LARS
L.F. Silva, Purdue/LARS

Silva

I. Introduction

Preliminary investigation of reflectance spectra computed from data gathered by the Model 20C and 20D indicated the following:

> The computed reflectance values based on data from the ERL 20D were significantly greater than the computer reflectance values based on data from the LARS 20C for identical targets.
>
> Reflectance spectra of the Model 20D exhibited considerable offset between the reflectance values of the silicon detector and the lead sulfide detector.

As a result of these differences, it was felt that some form data comparison study was necessary. It was decided that the ERL instruments, vehicles and crew, having completed data taking activities at Garden City, Kansas, would join the LARS instruments, vehicles and crew which were operating at Williston, N.D. The requirement of LARS test facilities, suitable buildings, and typical field conditions obviated the choice of Williston, N.D. as a site for the comparisons. The opportunity for side-by-side measurements of the NASA canvas reflectance panels and recency of the data taking activities indicated that July, 1975 would be the optimum time for the comparisons.

II. General Procedures

In order to isolate possible causes for the differences in the data, work proceeded according to the following plan:

A. Comparison of Procedures

It was affirmed that both ERL and Purdue used the painted barium sulfate surfaces to calibrate their instruments from a distance of 8 feet. This verified previous observations of the operations of both instruments which indicated that the reflectance standards were viewed and positioned properly.

Procedures for pointing the instruments were examined and it was found that they could be geometrically pointed at targets and standards with sufficient accuracy. However, an operator trained in interpreting the level indicator located in the ERL instrument van was required. This was felt not to be a serious difficulty as all operators are aware of the procedures and a TV camera (which went out of service during the ferry) is normally used to view the target area.

It was also reviewed that repeatable procedures involving the use of plumb bobs were used to ascertain the altitudes of the instruments.

To ensure the correct machine processing of the ERL data, four data runs were recorded to measure the reflectance of sunlit grass. The second incident observation was accomplished with half of the solar port covered. This should produce a reflectance spectra having roughly twice the reflectance of the spectra obtained using the full solar port. Purdue had previously run similar tests on their system.

B. Evaluation of Instrument Performance

Since the Model 20C had the most recent routine instrument performance tests, it was decided to run the same tests on the Model 20D. These tests consisted of examination of the electronic signals and optical behavior of the instrument.

It was found that the chopping frequency was satisfactory and that the noise level on the system signals was acceptable.

A shift in signal "zero level" was experienced when the tape recorder was turned on. After verifying and investigating this, all measurements of the system's static behavior were made with the tape recorder "on". It was determined that the tape recorder status did affect the data. See Table I.

The only instrument signals which indicated faulty electronic processing were the synchronously demodulated signals for the lead sulfide and silicon detectors (before filtering). This originated with assymetric reference signals due to the phasing network. Tests of the gain coefficients for the electronic processing proved them to be accurate to within the uncertainty of the measurement procedure. It is certain that the gain coefficients do not cause any appreciable error. See Table I and II.

Tests performed using a high intensity source of radiation indicated that the output voltage versus irradiance for the silicon channel was linear; however, the lead sulfide channel was not linear for intensities near to typical solar conditions. (See Figure 1 and Table III). Spectral scans were recorded for several relative intensities. The source of the non-linearity was not determined.

Tests performed on the incident optics indicated that the Incident/Target mirror was not perfectly adjusted to reflect the full solar port radiation into the detectors. Since the stray radiation under severe circumstances was very low and the mirror position was judged to be highly repeatable, it is probable that the incident radiant power was measured with satisfactory consistency.

Tests performed on the telescope optics indicates that the primary mirror for the $3/4^{o}$ field of view was securely mounted and smoothly adjustable. The size and shape of the $3/4^{o}$ field of view indicate that after other system adjustments the focal distance adjustment may need to be recalibrated. The location of the $3/4^{o}$ and 15^{o} FOV with respect to the geometrical center indicated that the field of view selecting mirror needs to be adjusted. (See Figure 2). In view of the number of times this mirror was flipped and its apparent repeatability, it is probable that this is a stable condition of the mirror.

C. Comparison of Instruments Using Large Diffuse Targets

1. Dynamic Tests

Both systems were taken to the helicopter calibration site where data were taken over the five canvas panels following normal procedures. The ERL Model 20D was carefully positioned to ensure the reflectance standard was filling the 15° field of view. On the next to darkest panel an instrument-to-reflectance-standard distance of six feet was used for one series of observations.

The instruments were placed side-by-side and data were taken over a uniform patch of grass. The instruments were positioned to ensure that they were viewing the same area.

The instruments each took calibration data over their calibration panels and then the panels were switched and treated as targets.

2. Static Tests

Using a helium pluecker tube having a distinct line at 1.014μm, the circular variable filters for the lead sulfide detectors both instruments were stopped at approximately that wavelength. Then, each system, using its own reflectance standard, measured the reflectance of the patch of grass using a digital volt meter. See Table IV. The results indicate that the computed reflectivities agree favorably when identical procedures are followed.

Following the comparison above, the CVF for the silicon detector of the ERL Model 20D was stopped at approximately 1.014μm. Data was taken over the patch of grass. Due to the low signal level available from the silicon detector it was not possible to measure the reflectivity of the grass. However, the calibration panel to solar port ratios were determined to be within 3%.

D. Irradiance and Wavelength Calibration

A helium pluecker tube was used to irradiate the solar port to provide helium lines for the ERL 20D. The spectrum was scanned and the response recorded. The response can be treated as a data run to produce a digital graph of the observation. Then the actual wavelength of the spectral lines can be compared to the wavelength scale. This procedure was followed for the LARS 20C about July 10, 1975.

Irradiance calibration was performed about July 10, 1975 at Williston, ND for the 20C. However, it was decided that ERL would perform the irradiance calibration in its laboratory.

III. Conclusions

Based on the results given above, the following conclusions may be drawn:

Optical mis-alignment probably caused the Model 20D to miss some portion of the calibration panel during operations at Garden City. This would cause a sizeable increase in the apparent reflectance of the target.

The assymetry in the synchronous demodulation process of the lead sulfide detector signal would cause a slight decrease in the apparent reflectance of the target and tend to make the infrared reflectance appear to be a few percent less than the visible and near infrared reflectance. The effect appears as a small "offset" in the spectrum.

The nonlinear responsivity function for the lead sulfide channel would cause an increase in the apparent reflectance of the target and, as well, an offset in the spectrum.

The distribution of sensitivity over the fields of view for the two detectors is different (this is normal). However, when some parts of the field of view miss the barium sulfate standard, an "offset" in spectrum may be produced.

IV. Recommendations

Samples of the data gathered over the summer at Garden City, Kansas should be examined for the following items:

(i) solar port response minus cover-on response corrected for sun angle (ie: ÷ cos θ)

(ii) 15^{o} FOV response to canvas panels minus cover-on response. Corrected for sun angle.

The purpose of (i) is to track the responsivity of the solar port over the period of the summer. The purpose of (ii) is similar for the 15^{o} FOV. The canvas panels are suggested because they provide a stable reflectance large enough to fill the FOV of the instrument.

If the responsivity of the solar port and the responsivity of the 15^{o} FOV are determined to be constant, then the barium sulfate versus solar port calibrations performed on July 18 may be used for the summer's data for sun angles above 40^{o} with an estimated uncertainty of 11% to 16% of reflectance value for a lambertian target.

$$\rho = \pi \frac{L}{E} = \left(\frac{R_{TGT}}{R_{SP}}\right) \times \left(\frac{R_{SP}}{R_{BaSo4}}\right) \times \left(\rho_{BaSo4}\right)$$

$$\frac{\Delta\rho}{\rho} = 3\% + 10\% + 3\%$$

3%: Based on Repeatability of $\frac{R_{TGT}}{R_{SP}}$ from past years

10%: Estimate of maximum effect of non-lambertion behaviour for solar port for $\theta_E > 40^{o}$

3%: Based on last measurements of Barium Sulfate Paint at LARS using Model 20C. (Probably a low estimate of actual uncertainty because of the field condition of 4' x 4' reflectance standards)

For sun angles less than 40^{o} the uncertainty will be greater. Subsequent tests can be made by comparing reflectance values (ERL corrected values) measured for the canvas panels by both instruments. These tests can indicate the measured difference between the reflectances measured by both systems and provide a measure of the uncertainty.

It is possible that the canvas panels can be used to improve the comparibility of the data in case either the solar port or the 15^{o} FOV should prove to be unstable over the summer. This would require further study of the data.

One problem which must be yet considered is the possibility that the field of view of the Model 20D was not always filled with the desired target. The line-up procedures used by ERL will enable an evaluation at each plot. Since three spectra were taken at each plot it is probable that two spectra will be satisfactory and certain that at least one will be on target.

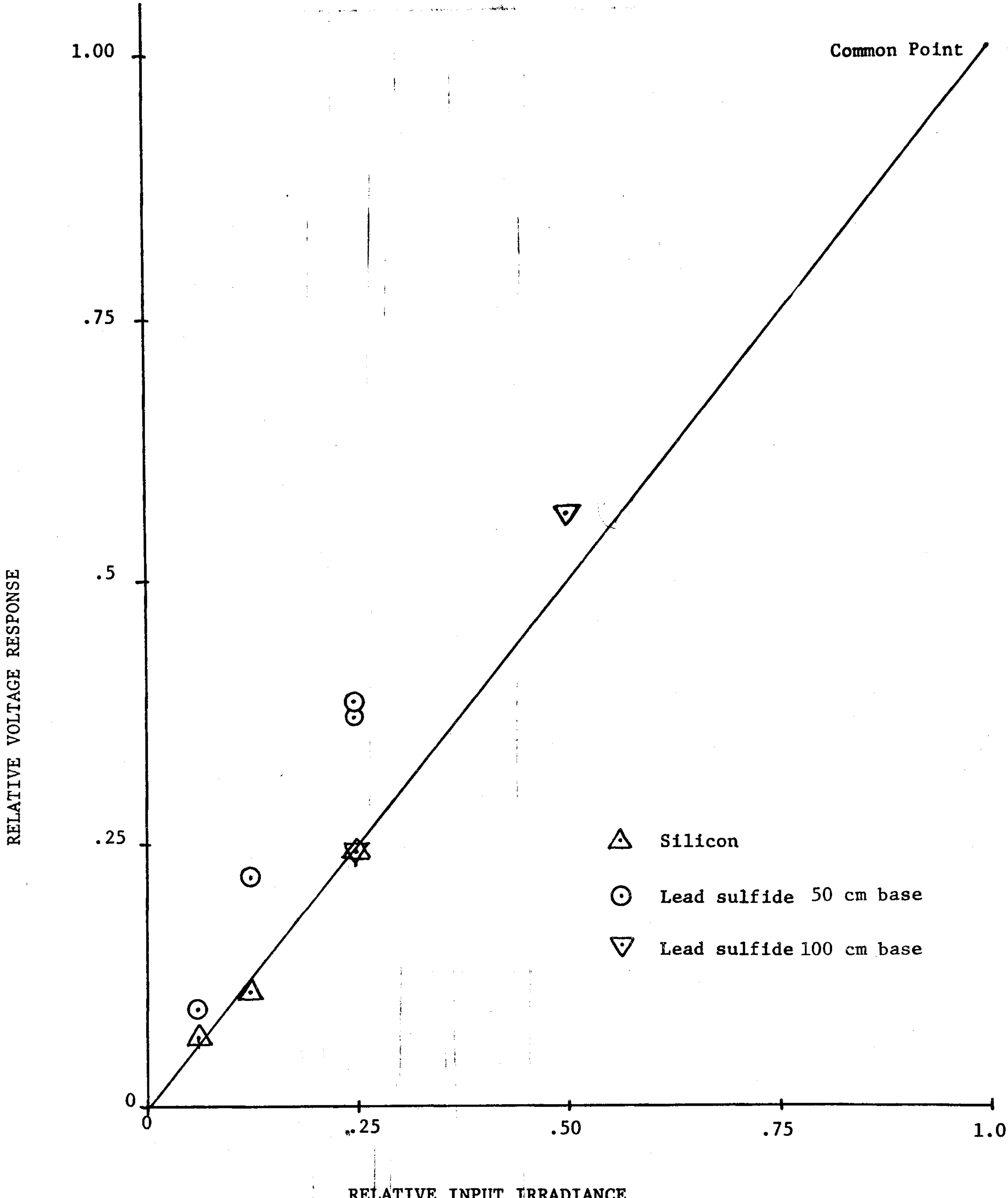

Figure 1. Responsivity Functions

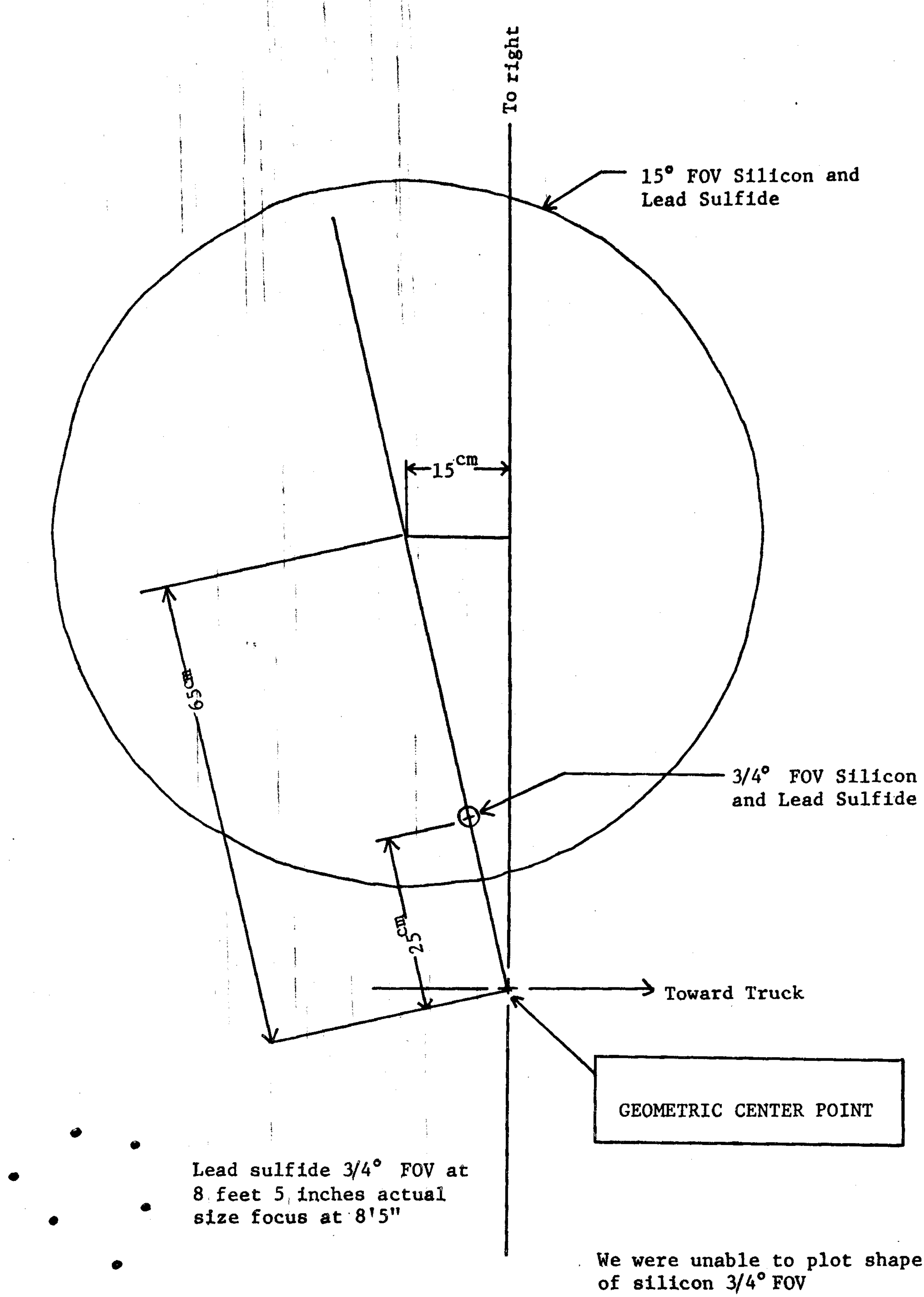

Figure 2. Field of View Maps (½ Power Points).

Table I EFFECT OF TURNING MAGNETIC TAPE RECORDER "ON"

					FLOATING DUN				
					TAPE INPUT		PANL OUT		
STATUS	FOV	GAIN	SCAN RATE	TAPE DECK	RDG	VAR	RDG	VAR	SITUATION
INC	15	0.3 x 2	0.033	OFF	*2.465	±.005	-.005	±.005	Both Covers on
INC	15	0.3 x 2	0.033	ON	*2.440	±.006	-.005	±.005	Both Covers on
TGT	15	0.3 x 2	0	OFF	2.462	±.006	-.005	±.003	Both Covers on
TGT	15	0.3 x 2	0	ON	2.435	±.006	-.005	±.005	Both Covers on
INC	15	0.3 x 2	0	OFF	.647	±.006	-3.113	±.004	INC open (sunlit)
INC	15	0.3 x 2	0	ON	.675	±.005	-3.123	±.006	INC open (sunlit)

*Average value for several revolutions

Table 1A Signal Difference Measured at tape deck

TAPE DECK OFF	TAPE DECK ON
Reading - Zero Ref = Response .47-2.462 = -1.815 ± .007	Reading - Zero Ref = Response .675 - 2.435 = -1.760 ±.008
Average Difference = 3%	

Table 1B Signal Difference Measured at Front Panel

TAPE DECK OFF	TAPE DECK ON
Reading - Zero Ref = Response -3.113 -(-0.005) = -3.108 ±.007	Reading - Zero Ref = Response -3.123 -(-0.005) = -3.118 ±.007
Average Difference = 0.3%	

Table II GAIN CALIBRATION

PbS	HIGH INTENSITY IRRADIATION				LOW INTENSITY IRRADIATION			
GAIN	RAW RESP	OCCULT	*DIFF	RATIO	RAW RESP	OCCULT	*DIFF	RATIO
1.0	+1.694±.002	+2.431	-0.737	.1664				
1.0 x 2	+.951±.002	+2.431	-1.480	.3341				
0.3	+.213±.003	+2.423	-2.21	.4989	+1.703	+2.429±.001	-.726	.1506
0.3 x 2	-2.004±.006	+2.425	-4.429	1	+.970±.003	+2.419±.001	-1.449	.3007
0.1					-0.000±.001	+2.412±.001	-2.412	.5005
0.1 x 2					-2.435±.005	+2.384±.001	-4.819	1
Closed	+2.436							

* The lead sulfide signal is synchronously demodulated for an output having negative polarity.

SILICON	LOW INTENSITY IRRADIATION				HIGH INTENSITY IRRADIATION			
GAIN	RAW RESP	OCCULT	DIFF	RATIO	RAW RESPONSE	OCCULT	DIFF	RATIO
1.0					-2.314±.001	-2.478±.001	.164	.0502
1.0 x 2					-2.153±.001	-2.480	.327	.1001
.3					-1.989±.002	-2.475	.486	.1488
.3 x 2					-1.500±.002	-2.474±.001	.974	.2981
.1	-1.957±.002	-2.474	.499	.1634	-0.832±.002	-2.466±.001	1.634	.5002
.1mx 2	-1.438±.002	-2.472±.002	1.034	.3387	+0.810±.005	-2.457±.001	3.267	1
.03	-0.930±.002	-2463±.002	1.533	.5021				
.03 x 2	+0.600±.003	-2.453±.003	3.053	1				
Closed	-2.481±.003							

Table III $1/R^2$ CALIBRATION

III A LEAD SULFIDE - CVF STOPPED (DVM at INPUT TO AMPEX)						
SOLAR PORT STATUS	TRIAL #1				TRIAL #2	
	LAMP TO PORT DISTANCE (CM)				LAMP TO PORT DISTANCE (CM)	
	50	100	150	200	50	100
CLOSED		2.436				
OPEN	-.545±.006	+1.285±.001	+1.778±.002	+2.162±.001	-.438±.004	+1.349±.002
OCCULT	+2.426±.001	+2.429±.001	+2.431±.001	+2.425±.001	+2.425±.001	+2.430±.001
Δ	-2.971±.006	-1.144±.002	-0.65±.002	-0.273±.002	-2.886±.004	-1.081±.00
RATIO #1	*1.0	.385	.219	.092	1.0	.375
RATIO #2		*1.0	.569	.240		

* Ratio 1 is based on 50 cm responses; Ratio 2, 100 cm.

IIIBB SILICON CVF STOPPED (DVM at INPUT to AMPEX)				
SOLAR PORT STATUS	LAMP TO PORT DISTANCE (CM)			
	50	100	150	200
CLOSED		2.481	±.003	
OPEN	+.198±.004	-1.826±.003	-2.184±.003	-2.304±.002
OCCULT	-2.420±.003	-2.460±.003	-2.471±.003	-2.471±.003
Δ	+2.618±.005	+.634±.004	.287±.004	.167±.004
RATIO	1.0	.242	.110	.064

TABLE IV. COMPARATIVE STUDY OF REFLECTIVITIES MEASURED AT 1.014μm BY THE SPECTRORADIOMETER SYSTEMS

Model 20C PbS (Using LARS Reflectance Panel)

SUBJECT	INCIDENT	TARGET	GAIN
Covers on	0.006 ± .006	0.006 ± .006	0.3
Covers on	0.008 ± .002	0.006 ± .002	1.0
Cal. Panel	0.840 ± .002	2.935 ± .005	1.0
Grass	2.670 ± .005	4.500 ± .006	0.3
COMPUTED REFLECTIVITY = .476			

Model 20D PbS (Using ERL Reflectance Panel)

SUBJECT	INCIDENT	TARGET	GAIN
Covers on	2.470	2.460	.01
Cal. Panel	1.030	-.835	.01
Grass	+.915	+.725	.01
COMPUTED REFLECTIVITY = .488			
Cal. Panel to Solar Port Response = 2.288			

Model 20D Si (Using ERL Reflectance Panel)

SUBJECT	INCIDENT	TARGET	GAIN
Covers on	-2.460	-2.460	.003
Cal. Panel	.480	1.920	.003
Cal. Panel to Solar Port Response = 2.212			