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CONTRACT NO. 950137

RANGER TV SUBSYSTEM FLIGHT EVALUATION REPORT FOR FLIGHT MODEL III-3 (RA-8)

Prepared for

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by the National Aeronautics and Space Administration under Contract NAS7-100.

By the

ASTRO-ELECTRONICS DIVISION
DEFENSE ELECTRONIC PRODUCTS
RADIO CORPORATION OF AMERICA
PRINCETON, NEW JERSEY

AED R-2677

Issued: May 14, 1965

1 of 199

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Preface

This report presents an evaluation of the performance of Flight Model III-3 of the Ranger TV Subsystem during the testing preceeding the launch of Ranger VIII and during the Ranger VIII mission. This Flight Model was developed as a part of the Ranger Block III Project by the Astro-Electronics Division of RCA for the Jet Propulsion Laboratory under Contract No. 950137.

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Section I
Introduction

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Section I
Introduction

The Ranger VIII Spacecraft was launched from Cape Kennedy, Florida, at 17:05:01 GMT on February 17, 1965. At 09:34:30 GMT on February 20, 1965, video data of the lunar surface were transmitted to Earth. The picture-taking operation continued uninterrupted for 23 minutes and 10 seconds until the Ranger VIII Spacecraft (RA-8) impacted on the Moon at 09:57:37 GMT. A total of 7140 pictures of the lunar surface was obtained by the full-scan and partial-scan cameras of the Flight Model III-3 TV Subsystem. The pictures covered an area extending from Mare Nubium, across the lunar highlands, to Mare Tranquilitatis. The final high-resolution pictures were taken in Mare Tranquilitatis.

This report continues the documentation of the history of Flight Model III-3 TV Subsystem, which began with the "Test Report for Modified Flight Model III-3 Ranger Subsystem," issued on February 2, 1965. The period of coverage provided in this report begins with the shipment of the TV Subsystem to JPL and continues through the flight of Ranger VIII. Performance of the TV Subsystem during the RA-8 mission is presented, together with a performance evaluation of the individual equipments that comprised Flight Model III-3. Preflight tests of Flight Model III-3 at JPL and at the Eastern Test Range (ETR) are described in Appendices A and B, respectively.

Several modifications were incorporated into Flight Model III-3, which distinguish the RA-8 TV Subsystem from the RA-7 TV Subsystem. These modifications are described in Section II of this report. Section III describes the Ranger VIII mission and the real-time data obtained and evaluated during the mission. In Section IV, an evaluation of the individual groups of equipment that comprised the RA-8 TV Subsystem is presented. These equipments are evaluated in relation to information obtained during the mission. Section V presents the conclusions derived from the evaluation of the data obtained and summarizes the RCA recommendations for future Ranger missions.

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Section II

TV Subsystem Design

A. Introduction

B. RA-8 TV Subsystem Modifications

C. RA-8 Flight Assemblies

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Section II

TV Subsystem Design

A. Introduction

The TV Subsystem of the Ranger VIII Spacecraft basically consisted of six vidicon cameras (2 full-scan, 4 partial-scan); the electronic equipment to control these cameras; the communications chains to transmit the acquired video information back to Earth; telemetry components to monitor the operation of the functional components; a completely independent power source (batteries) for the entire TV Subsystem; a structure to house and support all electronic gear; and passive thermal-control components.

The electronic equipments that comprise the functional groups of the TV Subsystem were separated into two completely redundant, electrically independent channels of operation, designated the F-Channel and P-Channel. Channel separation was characterized by the basic differences of design between the full-scan cameras and the partial-scan cameras. The two camera types differ in the area of the scanned image, and therefore, in the scanning time and frame rate. Consequently, each channel, in addition to the cameras, consists of video-combiner, sequencer, transmitter, control, and power-distribution circuits, which enable independent or simultaneous operation of the channels.

In addition to channel separation, the components of the TV Subsystem are arranged into major functional groups. These groups are:

- Camera Group;
- Telecommunications Group;
- Controls Group;
- Power Group; and
- Thermal Design and Structure Group.

A description of each of the functional groups was presented in Section II of the "Ranger TV Subsystem Flight Evaluation Report for Flight Model III-2 (RA-7)", issued October 30, 1964.

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B. RA-8 TV Subsystem Modifications

Several modifications were incorporated into the Flight Model III-3 Subsystem which distinguish the RA-8 TV Subsystem from the RA-7 TV Subsystem. These modifications were product-improvement, equipment-refinement, or mission-requirement type changes. The changes were based on results of the RA-7 flight, and further design studies, or are directly related to the particular constraints of the RA-8 mission.

1. Camera Group

The modifications to the Camera Group of Flight Model III-3 TV Subsystem are:

- An improved technique for focusing the TV cameras equipped with narrow-angle (76 mm) lenses (P1, P2, and F_b Cameras) was introduced for the first time on RA-8. This revised method of focusing provides for optimum optical focus of the cameras in a true space environment by compensating, during the alignment operation, for the displacement of the plane of best focus that occurs between air and vacuum conditions as a result of the pressure dependence of the index of refraction of air. In practice, a 0.0025-inch shim was used to increase the spacing between the lens and the vidicon faceplate, and the camera was subsequently optically focused in air for a maximum electrical response signal. When the shim was removed, the camera was in proper focus for operation in the space environment of an actual mission.

  The shift in optical focus due to the difference in index of refraction between air and vacuum was computed for the TV cameras with wide-angle (25 mm) lenses (P3, P4, and F_a). The change in focus was not considered sufficient to warrant application of the revised focusing technique to these cameras;

- The gain of the F_b, P1, and P2 Cameras was increased to change the peak-scene-luminance level of these cameras from 2700 foot-lamberts to a nominal 1500 foot-lamberts. This change was implemented on the basis of an increased ability to define the anticipated levels of lunar luminance as a result of the actual camera performance during the RA-7 mission;

- The P1 and P4 Cameras were equipped with new type vidicon tubes having a higher-density mesh structure. The new mesh structure has 1500 wires per inch rather than the 750 lines per inch of the previous-type vidicons. The effect of the increased mesh density is to raise the frequency of the mesh scan noise above the system video passband; and

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- A new type of shutter-shock isolator was fabrocated in the form of a castellated pad from polyurethane Solithane 113 (Thiokol formulation 5), and Solithane material instead of Sty-cast was employed to soft mount the nuvistor in the preamplifier. These changes, along with the pre-selection of nuvistors for minimum microphonic sensitivity, were incorporated to suppress the effects of camera microphonics.

2. *Telecommunications Group*

The modifications to the Telecommunications Group were:

- Modification of the F- and P-Channel Transmitters and Transmitter Power Supplies to incorporate the Resdel (triode) configuration Intermediate Power Amplifiers (IPA) to provide improved temperature/frequency stability for the Transmitter chain;

- Replacement of varactor diodes in the X4 multiplier circuits of the F- and P-Channel Transmitters. The new diodes, which have a bonded-type construction, are more reliable than the pressure-contact-type units previously employed;

- Installation of a new-type "O" ring in the Dummy Load Assembly. The new "O" ring results in a leak rate that is only 20 percent of the value previously encountered.

- Relocation of the Telemetry Processor Assembly to accommodate the IPA modifications; and

- Addition of telemetry points to monitor the cathode currents of the Intermediate Power Amplifiers in the F- and P-Channel Transmitters.

3. *Current Sensing Group*

The circuitry of the Current Sensing Unit on Flight Model III-3 was modified to provide greater resolution of cruise-mode currents while maintaining full-power current indications within the normal telemetry range.

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4. Harness Assembly

The modifications to the Harness Assembly of Flight Model III-3 were:

- A new design harness was constructed, which eliminated unnecessary splices and rerouted cables;
- New High-Rel Cannon connectors were incorporated in the new harness design;
- Special molds were fabricated for forming potting material on right-angle connectors;
- Stainless-steel, screw-lock assemblies were used with the connectors;
- Novathene wire replaced the Rayolin "N" wire used in the harness of the Ranger-VII TV Subsystem; and
- Redundant battery power plugs were provided.

5. Mechanical Group

Battery support bars fabricated from stainless steel replaced the aluminum support bars employed on Ranger VII. The use of stainless steel provides increased strength to the support bars.

6. Thermal Group

The solar absorptivity of the thermal-control paints on the fins was reduced by increasing the percentage of white PV-100 paint in the paint mixture. This reduction in absorption was to compensate for the effects of the increased solar constant during the season of the year in which the RA-8 launch was anticipated.

C. RA-8 Flight Assemblies

A listing of the assemblies that comprised the TV Subsystem of the Ranger VIII Spacecraft is presented in Table 2-1. This table lists the reference designation, serial number, and prelaunch operating time of each assembly.

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TABLE 2-1

ASSEMBLIES ON FLIGHT MODEL III-3 TV SUBSYSTEM DURING RA-8 MISSION

Assembly	Reference Designation	Serial No.	Prelaunch Operating Time (Hours)
P1 Camera	A1A1	042	125.96
Lens		FF1900	
Vidicon		J03308	
Shutter		3026-R1	40 hr. 34.8 min.
P2 Camera	A1A2	022	96.86
Lens		1886	
Vidicon		817	
Shutter		3020-R2	16 hr. 31.2 min.
P3 Camera	A1A3	040	83.61
Lens		857	
Vidicon		927	
Shutter		3031-R2	18 hr. 50.5 min.
P4 Camera	A1A4	048	166.46
Lens		828	
Vidicon		3310	
Shutter		3072	33 hr. 36.7 min.
F_a Camera	A1A5	038	81.36
Lens		805	
Vidicon		635	
Shutter		019-R1	42 hr. 29.4 min.
F_b Camera	A1A6	047	86.36
Lens		1891	
Vidicon		824	
Shutter		034	21.hr. 41.8 min.
P1 Camera Electronics	A2	042	125.96
P2 Camera Electronics	A3	022	96.86
P3 Camera Electronics	A4	037	83.61
P4 Camera Electronics	A5	048	166.46
F_a Camera Electronics	A6	032	81.36
F_b Camera Electronics	A7	047	86.36
Video Combiner	A8	008	223.46

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TABLE 2-1

ASSEMBLIES ON FLIGHT MODEL III-3 TV SUBSYSTEM DURING RA-8 MISSION (Continued)

Assembly	Reference Designation	Serial No.	Prelaunch Operating Time (Hours)
Sequencer	A9	0003	232.86
F Battery	A10	102	5.4 ampere-hours
P Battery	A11	104	6.8 ampere-hours
F-Channel HCVR	A12	013	257.76
F-Channel Transmitter	A14	205	72.5
F-Transmitter Power Amplifier	A15	020	72.9
F-Transmitter Power Supply	A16	013	76.5
Low-Current Voltage Regulator	A17	011	250.46
P-Channel Transmitter	A19	206	85.0
P-Transmitter Power Amplifier	A20	302	77.1
P-Transmitter Power Supply	A21	015	62.9
Four-Port Hybrid	A24	006	258.36
Dummy Load Assembly	A25	301	258.36
Telemetry Assembly	A26	006 (1)	Cruise: 130.6 Terminal: 72.02
Temperature Sensor	A27	008	247.26
Sequencer Power Supply	A28	0006	259.86
F-Channel Telemetry Processor	A29	301	261.96
P-Channel Telemetry Processor	A30	302	271.96
Distribution Control Unit	A34	004	246.76
Electronic Clock	A35	003	284.76
P-Channel HCVR	A37	008	253.7
15-Kc Filter Box	A38	009	260.76
Command Control Unit	A39	006	356.36
Current Sensing Unit	A40	004	311.76
Current Transformer Unit	A41	001	311.76

(1) 15-point commutator was changed at ETR prior to launch.

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TABLE 2-1
ASSEMBLIES ON FLIGHT MODEL III-3 TV SUBSYSTEM DURING RA-8 MISSION (Continued)

Assembly	Reference Designation	Serial No.	Prelaunch Operating Time (Hours)
Current Transformer Unit	A42	002	311.76
Clock Plug		002	64.25
F-Battery Jumper Plug	30P13	001	Installed 2/12/65
P-Battery Jumper Plug	30P14	001	Installed 2/12/65
Harness Assembly	30W1	001	
Harness Assembly	30W2	003	
Harness Assembly	30W3	002	
Harness Assembly	30W4	002	
Harness Assembly	30W5	003	
Harness Assembly	30W6	002	
Harness Assembly	30W7	003	
Harness Assembly	30W8	002	
Harness Assembly	30W9	002	
Harness Assembly	30W10	003	
Harness Assembly	30W11	002	
Harness Assembly	30W12	001	
Cable Assembly	30W14	001	
Cable Assembly	30W15	001	
Harness Assembly	30W25	001	
Harness Assembly, RF	30W26	012	
Harness Assembly, RF	30W27	012	
Harness Assembly, RF	30W28	013	
Harness Assembly, RF	30W29	007	
Harness Assembly	30W30	001	
Harness Assembly	30W31	001	
Cable Assembly, RF	30W32	001	
Cable Assembly, RF	30W33	001	

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TABLE 2-1
ASSEMBLIES ON FLIGHT MODEL III-3 TV SUBSYSTEM DURING RA-8 MISSION (Continued)

Assembly	Reference Designation	Serial No.	Prelaunch Operating Time (Hours)
Harness Assembly	30W39	002	
Harness Assembly	30W36	001	
Cable Harness	30W24	002	

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Section III

Ranger-VIII Mission and Real-Time Data

A. Spacecraft Data Analysis Team

B. Ground Support Equipment (GSE)

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Section III

Ranger-VIII Mission and Real-Time Data

A. Spacecraft Data Analysis Team

1. General

The function of the TV Subsystem group within the Spacecraft Data Analysis Team (SDAT) was to establish the preflight procedures and guidelines for control of the RA-8 TV Subsystem both for standard and nonstandard modes of operation during the RA-8 mission, and to analyze the TV Subsystem telemetry data being transmitted by the Spacecraft in order to establish the best possible flight plan for the TV Subsystem.

The deep-space tracking network, with stations at Woomera, Australia; Johannesburg, Republic of South Africa; and Goldstone, California, received the transmitted telemetry signals from the Spacecraft and relayed the data, in real time, to the Space Flight Operations Facility (SFOF) at the Jet Propulsion Laboratory in Pasadena, California. The TV Subsystem SDAT analyzed this data, determined the status of the TV Subsystem, and established the flight procedure for the remainder of the mission. It was the responsibility of the TV Subsystem SDAT to inform the Spacecraft SDAT and Flight Operations Director (FOD) of any changes to the flight plan required to obtain optimum TV Subsystem performance. The SDAT also assisted in the prelaunch test evaluation as telemetry data was transmitted, in real time, from the Eastern Test Range (ETR). Thus, from launch minus approximately 3 hours until impact, the TV Subsystem SDAT continuously monitored and analyzed the data from the TV Subsystem. Based on this data, the TV Subsystem SDAT continuously updated the TV Subsystem flight procedure to ensure that the RA-8 mission requirement would be fulfilled; that is, high-resolution television pictures of the lunar surface would be obtained.

A portion of the Spacecraft status board at SDAT is presented in Figure 3-1.

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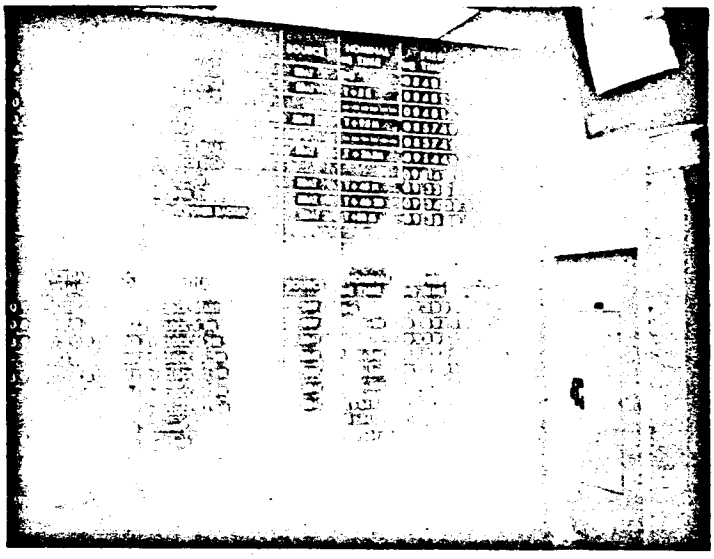

Figure 3-1. RA-8 Spacecraft status board at SDAT

2. Ranger-VIII Mission Profile

a. Prelaunch

Three hours before launch (Day 48 - 14:00:00 GMT), the TV Subsystem was turned on in the reduced-power mode for a final check. Telemetry and video indications were normal at this time. The countdown continued, and at launch minus 15 minutes, cruise-mode (15-point) telemetry was initiated and received from the Spacecraft. Again the telemetry data, evaluated by both the ETR launch team and SDAT, indicated that all assemblies of the TV Subsystem were functioning normally in accordance with the predicted curves and plots of the SDAT TV Book.

b. Launch

The Ranger-VIII Spacecraft was successfully launched from the Eastern Test Range at 17:05:01 GMT on February 17, 1965 (Day 48). The launch was accomplished

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by an Atlas-Agena launch vehicle. A complete RA-8 mission events list is presented in Table 3-1. At launch, the umbilical cable was disconnected from the launch vehicle, removing the full-power inhibit circuit which had limited the r-f power output from the TV Subsystem to a reduced level of approximately 125 milliwatts. TV Subsystem telemetry data were received by SDAT from the ETR during the first seven minutes of launch. These data confirmed that all TV Subsystem parameters were normal during the entire launch phase.

The tracking station at Johannesburg, South Africa (DSIF 51), acquired two-way lock of the Spacecraft approximately 28 minutes after launch (Day 48 - 17:33:20 GMT) and commenced to relay telemetry data to SDAT with message No. 1 taken at 17:43:00 GMT.

TABLE 3-1
RA-8 MISSION EVENTS LIST

Mission Event	Event Time (GMT)		Nominal Mission Time
	Predicted	Actual	
DAY 48			
1. Prelaunch Test	—	13:59:59	T-116'
2. Cruise-Mode Telemetry On	—	16:40:00	T-15'
3. Spacecraft on Internal Power	—	17:00:00	T-5'
4. CC&S Uninhibit	17:03:00	17:03:01	T-2'
5. CC&S Clear	17:04:01	17:04:01	T-1'
6. Launch (L)	17:05:01	17:05:01	T = L
7. Spacecraft/Agena Separation (S)	17:30:00	17:30:14	L + 23' (=S)
8. Transmitter Power Up	17:28:01	—	—
9. TV Clock Start	17:30:00	17:30:14	S + 0
10. DSIF-51 View Period Start	—	17:34:00*	—
11. DSIF-41 View Period Start	—	17:52:00*	—
12. Solar Panels Extend Command	18:05:01	18:05:01	L + 60'
13. Solar Panels Extended	18:06:01	18:05:40	—
14. Sun Acquisition Command	18:08:01	18:08:01	L + 63'
15. Sun Acquisition Complete	—	18:14:20	—
16. Earth Acquisition Command	20:36:01	20:36:01	L + 211'
17. Earth Acquisition Complete	—	20:40:10	—
18. DSIF-41 View Period End	—	23:15:00*	—

TABLE 3-1
RA-8 MISSION EVENTS LIST (Continued)

Mission Event	Event Time (GMT)		Nominal Mission Time
	Predicted	Actual	
DAY 49			
19. TV Clock 8-hour Pulse	01:30:14	01:30:12	S + 8 hours
20. DSIF-12 View Period Start	—	06:08:00*	—
21. DSIF-51 View Period End	—	08:40:00*	—
22. TV Clock 16-Hour Pulse	09:30:12	09:30:36	S + 16 hours
23. Midcourse Maneuver Start (M)	—	10:00:39	M + 0
24. Roll Correction Start	10:00:44	10:00:45	—
25. Roll Correction End	10:01:37	10:01:38	—
26. Pitch Correction Start	10:10. 09	—	—
27. Pitch Correction End	10:21:30	—	—
28. Midcourse Motor Ignition	10:27:09	10:27:09	M + 26.5'
29. Midcourse Motor Turn-off	10:28:08	10:28:11	—
30. Sun Reacquisition Command	10:30:39	10:30:40	M + 30'
31. Sun Reacquisition Complete	—	10:40:12	—
32. Earth Reacquisition Command	10:58:39	10:58:40	M + 58'
33. Earth Reacquisition Complete	—	11:00:42	—
34. DSIF-41 View Period Start	—	12:00:00*	—
35. DSIF-12 View Period End	—	16:01:00*	—
36. TV Clock 24-Hour Pulse	17:31:00	17:30:48	S + 24 hour
37. SDIF-51 View Period Start	—	20:00:00*	—
DAY 50			
38. DSIF-41 View Period End	—	00:36:00*	—
39. TV Clock 32-Hour Pulse	01:31:00	01:30:52	S + 32 hours
40. DSIF-12 View Period Start	—	06:11:00*	—
41. DSIF-51 View Period End	—	07:30:00*	—
42. DSIF-41 View Period Start	—	12:00:00*	—
43. DSIF-12 View Period End	—	16:37:00*	—
44. TV Clock 48-Hour Pulse	17:31:00	17:31:08	S + 48 hours
45. DSIF-51 View Period Start	—	20:00:00*	—
DAY 51			
46. DSIF-41 View Period End	—	00:47:00*	—
47. DSIF-12 View Period Start	—	06:10:00	—
48. DSIF-51 View Period End	—	08:00:00*	—
49. Terminal Maneuver Start (T)	08:48:10	08:48:10	T + 0
50. Pitch Correction No. 1 Start	08:48:15	08:48:16	—

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TABLE 3-1
RA-8 MISSION EVENTS LIST (Continued)

Mission Event	Event Time (GMT)		Nominal Mission Time
	Predicted	Actual	
DAY 51 (Cont'd)			
51. Pitch Correction No. 1 Complete	08:48:16	—	—
52. Yaw Correction Start	08:57:40	08:57:40	T + 9.5'
53. Yaw Correction Complete	08:57:41	—	—
54. Pitch Correction No. 2 Start	09:14:40	09:14:40	T + 26.5'
55. Pitch Correction No. 2 Complete	09:14:41	—	—
56. TV Clock 64-Hour Pulse	09:31:24	09:31:29	S + 64 hours
57. CC&S TV Turn On (Warmup)	09:33:10	09:33:09	T + 45'
58. TV Full-Power On	09:34:30	09:34:28	T + 46' 20"
59. TV Full-Power Backup	09:38:10	—	T + 50'
60. TV Clock Warmup	09:46:29	—	I - 11'
61. TV Clock Full Power	09:47:49	—	—
62. Impact	—	09:57:38.1	I

* Approximate time

The Woomera, Australia, Tracking Station (DSIF 41) first viewed the Spacecraft at 17:54:00 GMT, with message No. 1 to SDAT reporting all TV Subsystem parameters normal. Temperature sensors on the camera lens housing and the top hat indicated initial temperature increases which leveled off at less than 90° F and then began to decrease toward the predicted cruise-mode values.

c. Cruise Mode

Agena booster separation (S) occurred at L + 25 minutes and initiated the 64-1/4 count of the TV Subsystem Clock. Overseas Tracking Station DSIF 51 at Johannesburg, South Africa, verified that the Clock was operating, by means of a cruise-mode telemetry indication received at 17:43:00 GMT. Agena booster separation also provided a backup for the removal of the full-power inhibit circuit, and started a mechanical timer which provided backup functions for the Spacecraft. At separation plus 30 minutes (S + 30), a contact closure of the wafer-type timer switch provided initial arming of the silicon controlled rectifier (SCR) gates in the High-Current Voltage Regulators (HCVR) of the TV Subsystem. At separation plus 35 minutes, the Spacecraft solar panels were deployed. This activiated a microswitch which provided a backup function for the enabling of the SCR gates. At L + 69

minutes, Spacecraft acquisition of the Sun was accomplished, and 3 hours and 35 minutes later, the Earth acquisition occurred. Thus, the Spacecraft was oriented in its normal cruise-mode position, with the Z-axis pointing toward the Sun and high-gain antenna pointing toward the Earth. The 15-point telemetry continued to indicate normal TV Subsystem performance with temperatures slowly stabilizing toward nominal cruise-mode values. The 8- and 16-hour Clock telemetry steps occurred on time within the Clock tolerance. A midcourse maneuver was initiated at approximately L + 17 hours during a Goldstone Tracking Station (DSIF-12) contact which began with two-way r-f lock at 05:57:00 GMT on Day 49. Data from Goldstone indicated perturbations of the top-hat and lower-shroud temperatures as a result of the midcourse maneuver. The temperature of the top hat (data point No. 7 of the 15-point telemetry) increased to a peak of 110°F at 10:37:00 GMT; dropped to 79°F at 10:47:00 GMT; and then slowly increased to a stabilizing temperature of 84°F. The lower-shroud temperature (data point No. 8 of the 15-point telemetry) increased to a peak of 100°F at 10:37:00 GMT and then dropped rapidly to 80°F. When the midcourse maneuver was completed, the Spacecraft was re-oriented in its normal cruise-mode position, and within 16 hours, all temperatures of the TV Subsystem had returned to their pre-midcourse values.

The 24- and 32-hour Clock telemetry steps indicated that the Clock was operating slow by approximately one second per hour, but well within specification. At the time of the 32-hour telemetry step, the Clock also provided an output signal which removed the Clock-output inhibit function and the RTC-5 Clock turn-off inhibit. * Thirty hours after launch, the temperatures of the TV Subsystem had stabilized at the following values:

- F_a Camera Lens Housing — 65°F
- P-Channel Battery — 80°F
- Top Hat (shroud) — 84°F
- Lower Shroud — 80°F
- F_b Camera Electronics — 71°F

The 48-hour Clock telemetry step further confirmed a slow Clock operation of one second per hour. At this time, analysis of the battery capacities and temperatures indicated that the F- and P-Channels could operate in the full-power mode for 45 and 41 minutes, respectively, with the constraint being temperature.

* The display of analog telemetry data from DSIF-41 on the SDAT strip-chart recorder revealed about twelve noise spikes in the cruise-mode telemetry. Checks with the tracking station revealed that the orgin of the noise was the communication link between SDAT and the DSIF-41 tracking station.

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d. Terminal Mode

An RTC-8 command was transmitted to the Spacecraft which inhibited the terminal maneuver. An RTC-6 command was transmitted at 08:47:30 GMT of Day 51 to initiate the CC&S terminal sequence, which would result in turn-on of both television channels by CC&S command. Because of the sequence of events, the TV Clock would be used only as a back-up command for F-Channel turn-on at Impact minus 11 minutes, if required. The 64-hour TV Clock step occurred about two minutes before the CC&S warmup command. TV Subsystem was placed in warmup mode by the CC&S TV-2 command at 09:33:09 GMT. The F- and P-Channels of the TV Subsystem were commanded into full-power operation by the outputs of the 80-second timers in the Camera Sequencer Assembly. The full-power back-up command (TV-3), initiated by the CC&S five minutes after the TV-2 command, was not required. Video data were received at the Goldstone Station at 09:34:28 GMT. The Television Subsystem operated normally until impact, with video pictures of the lunar surface transmitted on both F- and P-Channels for 23 minutes and 10 seconds.

3. RA-8 TV Subsystem Telemetry

a. General

The TV Subsystem telemetry provided diagnostic information on the important Subsystem parameters so that any necessary, real-time adjustments could be made to correct or improve Subsystem performance, and in the event of a failure, an analysis could be made of the telemetry data to isolate the cause. A PAM/FM/FM* telemetry system was employed to monitor 104 parameters of the TV Subsystem. Telemetry data were transmitted by the TV Subsystem's two high-power Transmitters on a 225-kc subcarrier, and by the Spacecraft's low-power Transmitter on an IRIG** Channel-8, 3-kc subcarrier. Channel 8 was the prime data link. During cruise mode, a 15-point commutator sampled eleven Subsystem parameters and four telemetry references in the TV Subsystem. Figure 3-2 shows sample 15-point telemetry frames and defines the parameter monitored by each data point, When either F- or P-Channel of the TV Subsystem is turned on into the warmup mode, the 15-point cruise-mode telemetry data are switched off Channel 8 and the diagnostic telemetry data sampled by a 90-point commutator are transmitted over Channel 8. The format for the 90-point commutator is similar to the 15-point commutator shown in Figure 3-2, with more and different parameters being sampled. The TV Subsystem parameters sampled by the

* PAM/FM/FM - pulse amplitude modulated/frequency modulated/frequency modulated.
** IRIG - Intra Range Instrumentation Group.

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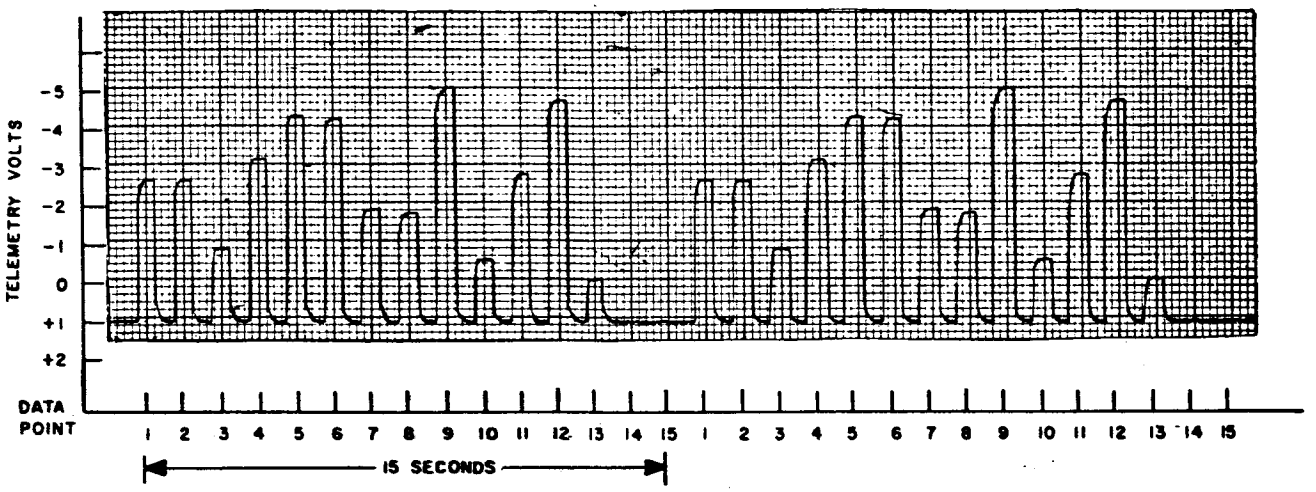

DATA POINT NO. AND PARAMETER MONITORED		TELEMETRY VOLTS (-)	ENGINEERING UNITS
1.	F_a CAMERA LENS HOUSING TEMPERATURE	2.55	66°F
2.	LCVR OUTPUT VOLTAGE	2.55	27.4 VOLTS
3.	P-BATTERY CURRENT	0.8	0.165 ma
4.	P-BATTERY INTERNAL TEMPERATURE	3.15	81°F
5.	F-BATTERY TERMINAL VOLTAGE	4.25	34.8 VOLTS
6	P-BATTERY TERMINAL VOLTAGE	4.2	36.4 VOLTS
7.	TOP HAT TEMPERATURE (-y SIDE)	1.8	84°F
8.	LOWER SHROUD TEMPERATURE (-y SIDE)	1.7	78°F
9	CLOCK TIME STEPS	5.0	48 TO 64 HR. CLOCK PERIOD
10.	F-BATTERY CURRENT	0.5	0.038 ma
11.	F_b CAMERA ELECTRONICS TEMPERATURE	2.7	71°F
12.	FULL SCALE REFERENCE	4.7	—
13.	ZERO REFERENCE	0	—
14.	FRAME REFERENCE	+1.1	—
15.	FRAME REFERENCE	+1.1	—

Figure 3-2. Sample frames of cruise-mode telemetry data from 15-point commutator (Echo Site recording)

90-point commutator are listed in Table 3-2. As a backup function, the 90-point commutator also modulates a 225-kc voltage controlled oscillator (VCO) whose output is transmitted over the P-Channel high-power Transmitter. Likewise, the telemetry data from the 15-point commutator are switched to and transmitted over the F-Channel high-power Transmitter.

b. Space Flight Operations Facility

In the Data Analysis area of the Space Flight Operations Facility (SFOF), several devices were employed for monitoring TV Subsystem telemetry data. The 3-kc analog telemetry signal was recieved during Spacecraft contacts by the Goldstone and Woomera tracking stations, and was sent directly to the SFOF for display on a Sanborn strip-chart recorder. The telemetry signal was also fed into the Central Computing Complex (CCC) which sampled each data point and printed out the actual telemetry voltage for that data point. The CCC has four modes of operation: three in cruise mode and one in terminal mode. The CCC printer output for Mode 1 is in raw data units; for Mode 2 is in telemetry units; and for Mode 3 is in engineering units. The CCC Mode 4 provides a printer output of 13 selected data points of the 90-point terminal telemetry in telemetry units. The CCC was limited to single-mode operation in real time. The telemetry data were also displayed on strip-chart recorders at all tracking stations. The telemetry was read off the strip charts at 30-minute intervals and the values sent to the SDAT through the administrative teletype network. During Spacecraft passes over the Johannesburg station, administrative teletype messages were the only source of data available, since the analog telemetry signal was not available to the SFOF from this station.

The telemetry points of the TV Subsystem were calibrated prior to flight in accordance with the procedures of RCA Specification RTSP-1100A, Appendix N. Several of the telemetry points in the camera equipment monitor two parameters, and are not easily calibrated when the cameras are integrated in the TV Subsystem. Therefore, calibration of the camera telemetry is performed during camera bench testing, and the accuracy of the telemetry points is verified during system tests prior to the mission.

The calibration data for telemetry points were then fed into a computer. The computer provided a printout of conversion tables which transformed all telemetry voltages into the represented engineering units. The tables were used for conversion of the telemetry data during the flight; any data exceeding the predetermined limits would be labeled with an "A" following the printout to alert SDAT. Also, at various times during cruise mode, depending on when computer time was available, a tape recording of the received cruise-mode telemetry data was fed into the computer which was programmed to plot the data as a function of time and also to print out a complete listing of the data in engineering units as a function of time.

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TABLE 3-2
TV SUBSYSTEM PARAMETERS MONITORED DURING TERMINAL MODE BY 90-POINT TELEMETRY COMMUTATOR

Data Point No.	Parameter Monitored
1	P1 Camera Vertical Sweep
2	P1 Camera Horizontal Sweep
3	P1 Camera G1 and Focus Current
4	P1 Camera +1000 V and 300 V
5	P1 Camera Shutter and Lamp Drive
6	P1 Camera Vidicon Filament
7	Zero Reference
8 thru 14	Same as 1 thru 7 except for P2 Camera
15 thru 21	Same as 1 thru 7 except for P3 Camera
22 thru 28	Same as 1 thru 7 except for P4 Camera
29 thru 34	Same as 1 thru 6 except for F_a Camera
35	Full-Scale Reference
36 thru 42	Same as 1 thru 7 except for F_b Camera
43	F_b Camera Electronics Temperature (Sensor No. 2)
44	F Battery Case Temperature (Sensor No. 4)
45	P Battery Case Temperature (Sensor No. 5)
46	P Unregulated Bus
47	P Regulated Bus (-27.5 V)
48	F Unregulated Bus
49	F Regulated Bus (-27.5V)
50	Lower Shroud Temperature (+Y) (Sensor No. 12)
51	Bottom Deck Temperature (-X, -Y Quadrant) (Sensor No. 13)
52	Second Deck Temperature (-Y) (Sensor No. 14)
53	Second Deck Temperature (+Y) (Sensor No. 15)
54	LCVR Input Voltage
55	F-Channel Full-Power Command

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TABLE 3-2
TV SUBSYSTEM PARAMETERS MONITORED DURING TERMINAL MODE BY 90-POINT TELEMETRY COMMUTATOR (Continued)

Data Point No.	Parameter Monitored
56	P Battery Current
57	F Battery Current
58	F Battery Terminal Voltage
59	P Battery Terminal Voltage
60	P-Channel Full-Power Command
61	F Sequencer "T" Flip-Flop (No. 2)
62	Zero Reference
63	F Sequencer Oscillator (18 Kc)
64	P Sequencer Voltage (+12V)
65	P Sequencer Voltage (-12V)
66	P Sequencer Oscillator (18 Kc)
67	F Sequencer Voltage (+12V)
68	F Sequencer Voltage (-12V)
69	F Sequencer "T" Flip-Flop (No. 1)
70	P Sequencer "R" Flip-Flop (No. 1)
71	P Sequencer "R" Flip-Flop (No. 2)
72	P Video Combiner Output
73	F Transmitter IPA Cathode Current
74	F Video Combiner Output
75	P Transmitter PA Heat Sink (Sensor No. 6)
76	F Battery Internal Temperature (Sensor No. 8)
77	F Transmitter PA (+1000 V)
78	F Transmitter IPA (-500 V)
79	F Transmitter PA Cathode Current
80	F Transmitter PA Heat Sink (Sensor No. 7)

TABLE 3-2
TV SUBSYSTEM PARAMETERS MONITORED DURING TERMINAL MODE BY 90-POINT TELEMETRY COMMUTATOR (Continued)

Data Point No.	Parameter Monitored
81	P Transmitter IPA Cathode Current
82	P Transmitter PA (+1000 V)
83	P Transmitter IPA (-500 V)
84	P Transmitter PA Cathode Current
85	F_a Camera Lens Housing Temperature (Sensor No. 1)
86	Camera Bracket Temperature (Sensor No. 3)
87	Full Scale Reference
88	Zero Reference
89	Frame Reference
90	Frame Reference

Just before TV Subsystem turn-on in warmup mode, the computer was programmed (switch to Mode 4) for the reception 90-point diagnostic telemetry data. The data outputs available to the TV Subsystem SDAT during terminal mode were:

- Strip-chart recording of the analog telemetry signal in real time;
- Real-time computer printouts of 13 selected telemetry points;
- Matrix printouts of all 90-point telemetry data about 1-1/2 to 2 minutes behind real time; and
- Telephone and administrative teletype messages of selected telemetry points are read out on the strip-chart recorders from the Goldstone Tracking Station.

After impact, complete computer tabulations and plots of the 90-point telemetry data were available.

4. SDAT Data Accuracy (Computer Output)

In order to establish the accuracy of the data from the various tracking stations, data point No. 9 of the 15-point telemetry (the Clock pulse) was selected as a reference and

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its incremental change was noted. The telemetry from all tracking stations varied no more than 0.1 telemetry volt from the nominal value.

Telemetry data from the Woomera, Goldstone, and Johannesburg tracking stations were plotted as minimum and maximum values sampled every hour during Spacecraft view periods. Cruise-mode telemetry data from all tracking stations were further analyzed and compared. The telemetry points analyzed were data points No. 9 (Clock pulse), No. 2 (LCVR output), and No. 8 (lower-shroud temperature) of the 15-point telemetry. Computer-processed CCC data from analog information supplied by Woomera and Goldstone tracking stations exhibited a spread of less than 0.2 telemetry volt; data forwarded from the Johannesburg tracking station was comparable in accuracy.

5. Transition From Cruise-Mode to Terminal-Mode Telemetry

When warmup mode of the TV-Subsystem was initiated, 90-point diagnostic telemetry data were transmitted over Channel 8. Since the terminal-mode (90-point) telemetry includes data on the same telemetry points sampled by the cruise-mode (15-point) telemetry, a basis of reference was provided for ensuring the accuracy of the telemetry readouts. A strip-chart recording of analog telemetry data transmitted over F-Channel and Channel 8 and recorded at the Goldstone tracking station on Day 51 at 09:47:40 (approximately 10 minutes before impact) was examined for incremental changes in telemetry voltages. The results of this comparison are presented in Table 3-3.

TABLE 3-3

COMPARISON OF 15-POINT AND 90-POINT TELEMETRY READOUTS DURING TERMINAL MODE

Parameter Monitored	Telemetry Readout (Telemetry Volts)	
	15-Point (F-Channel)	90-Point (Channel 8)
F_a Camera Lens Housing Temp.	2.7	2.7
P-Battery Current	4.55	4.6
F-Battery Terminal Voltage	3.4	3.4
P-Battery Terminal Voltage	3.4	3.4
F-Battery Current	4.2	4.2
F_b Camera Electronics Temp.	2.9	2.9

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6. *Telemetry Evaluation of TV Subsystem Performance*

The cruise-mode telemetry was employed to monitor TV Subsystem temperatures and power-supply operation. The actual temperatures of the TV Subsystem assemblies during cruise and terminal modes were almost exactly as predicted in preflight calculations. The cruise-mode temperatures are plotted in Figures 3-3 through 3-7. Terminal-mode temperatures are plotted in Figures 3-8 through 3-19.

The TV Subsystem power supply consisted of a Battery and a High-Current Voltage Regulator (HCVR) for each of the F- and P-Channels, and a Low-Current Voltage Regulator (LCVR) on the P-Channel only. The power-supply units functioned nominally throughout the mission. An evaluation of the power-supply units, based on analysis of the telemetry obtained, is presented in Paragraph F of Section IV.

At the start of F-Channel warmup, 90-point diagnostic telemetry data were transmitted over Channel 8. The signal profile from telemetry data point Nos. 55 and 60 (full-power commands) indicated that both channels went into warmup mode for 80 seconds and were then turned-on into full-power operation by the Control Programmer and Camera Sequencer. The Transmitter telemetry data indicated normal supply voltages and operating temperatures for both channels. The Power-Amplifier cathode-current profiles for the Transmitters were almost identical to prelaunch full-power tests, thus confirming a high-power output for both channels. All telemetry indications for the TV Camera equipment were normal.

The telemetry data for the F-Channel Video Combiner output, shown in Figure 3-20, indicated that the video output was greater than expected. This telemetry point (data point No. 74 of the 90-point telemetry) measures the amplitude of the composite video signal at the Video-Combiner output; the video signal for each camera has a range of 1.5 telemetry volts from sync tip to peak white. This data point is used only to indicate that a video signal is being applied to the modulator circuit of the Transmitter. Its use as a light meter is quite limited, because it monitors two cameras that have a four-to-one difference in dynamic range and the data sample was not synchronized with the camera readouts. The telemetry data for the output of the P-Channel Video Combiner (data point No. 72 of the 90-point telemetry) are presented in Figure 3-21.

The performance of the TV Subsystem telemetry was nominal throughout the mission. The 90-point commutator had stopped on data point No. 70 at the end of the prelaunch test and started on the same point at the initiation of full power. It can be assumed that there was no movement of the commutator during cruise mode. Thus, on the basis of the analysis of the telemetry data, it may be concluded that the TV Subsystem performed a nominal mission.

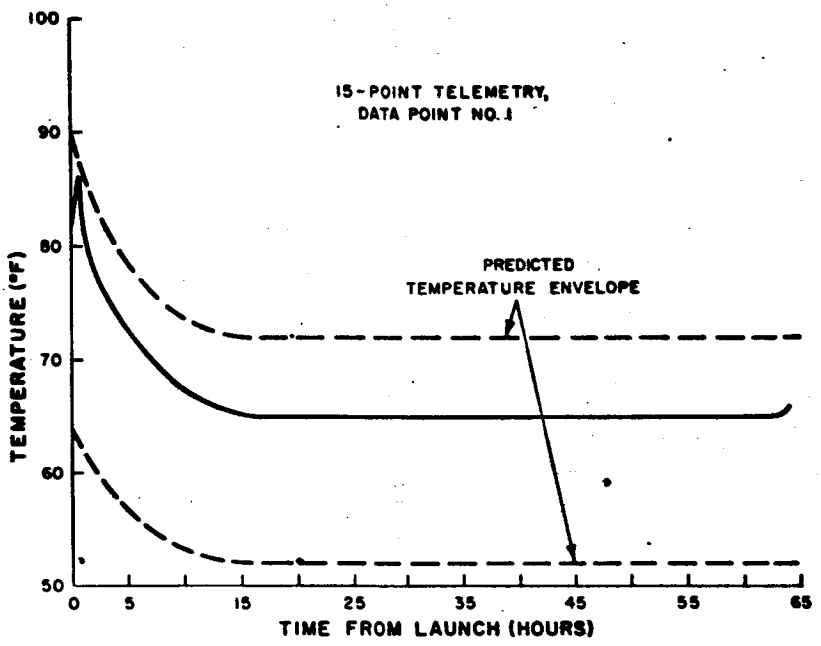

Figure 3-3. Actual F_a Camera Lens Housing temperature during cruise mode

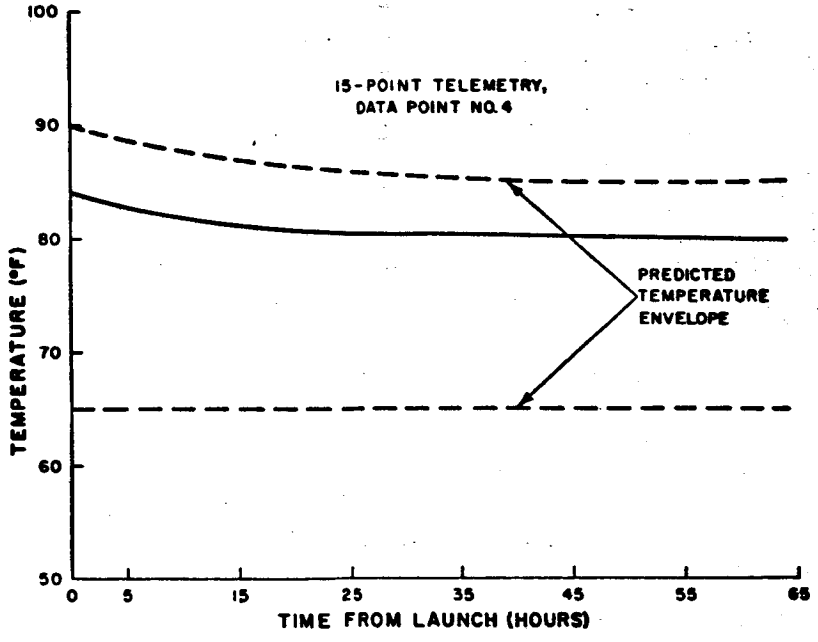

Figure 3-4. Actual P-Battery internal temperature during cruise mode

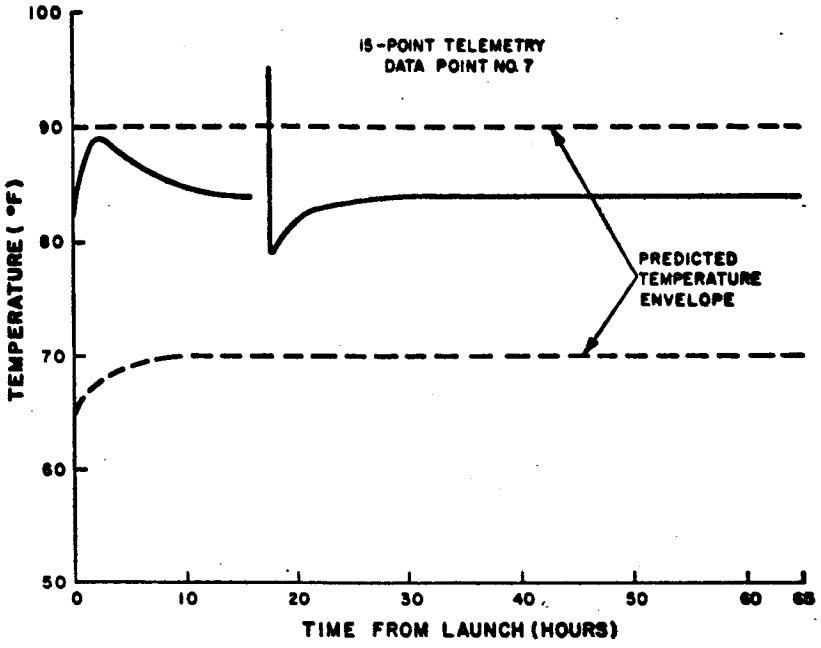

Figure 3-5. Actual Top Hat temperature during cruise mode

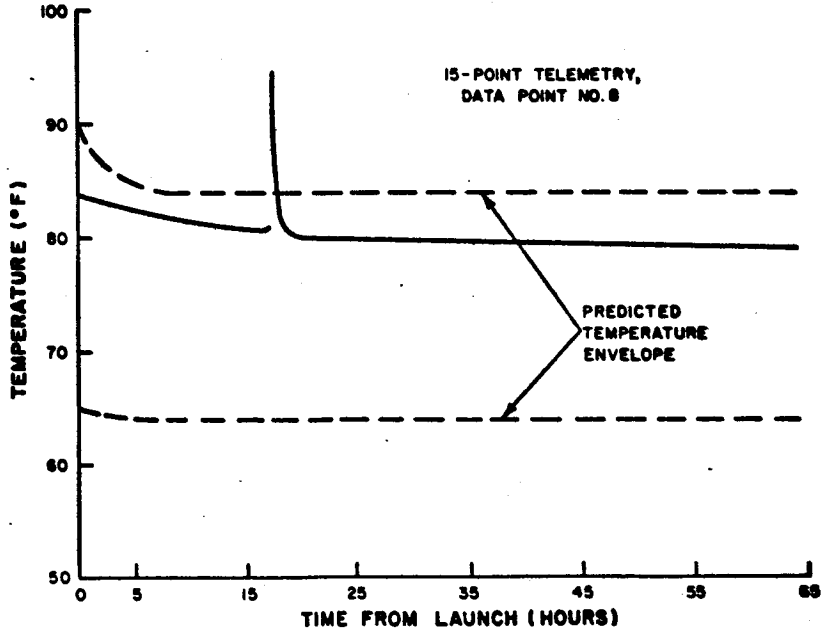

Figure 3-6. Actual Lower Shroud temperature during cruise mode

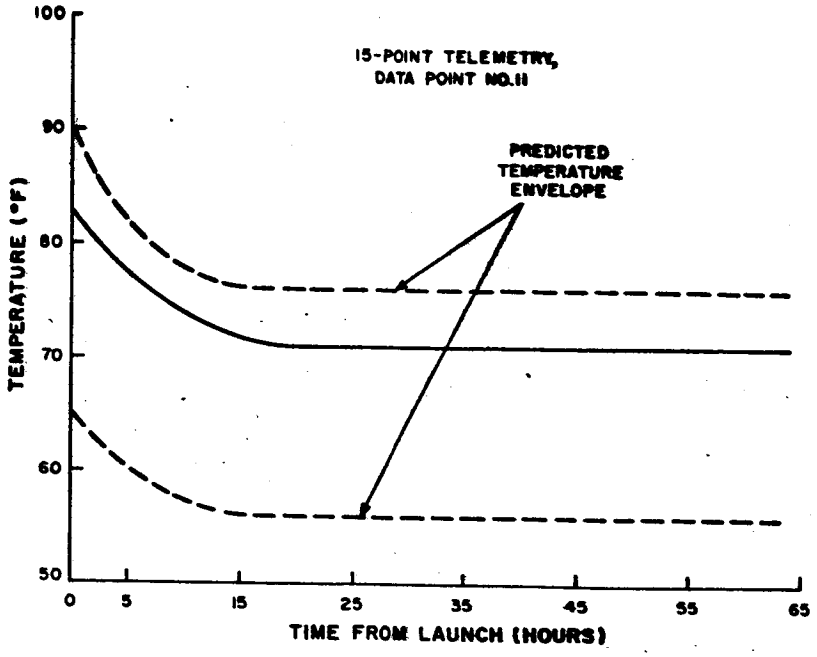

Figure 3-7. Actual F_b-Camera Electronics temperature during cruise mode

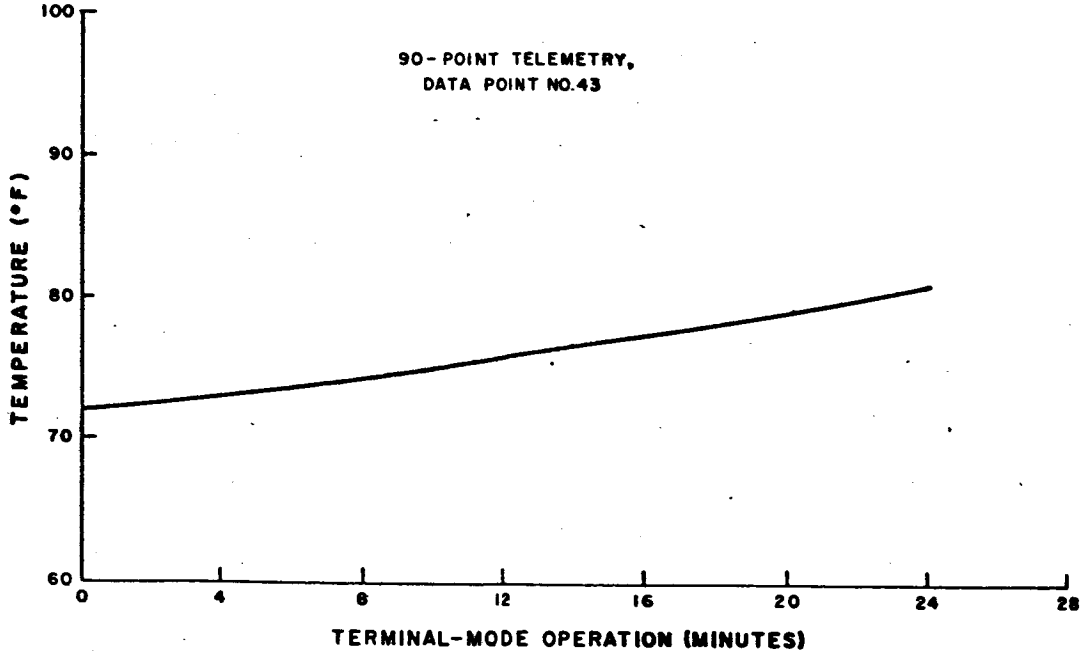

Figure 3-8. Actual F_b-Camera Electronics temperature during terminal mode

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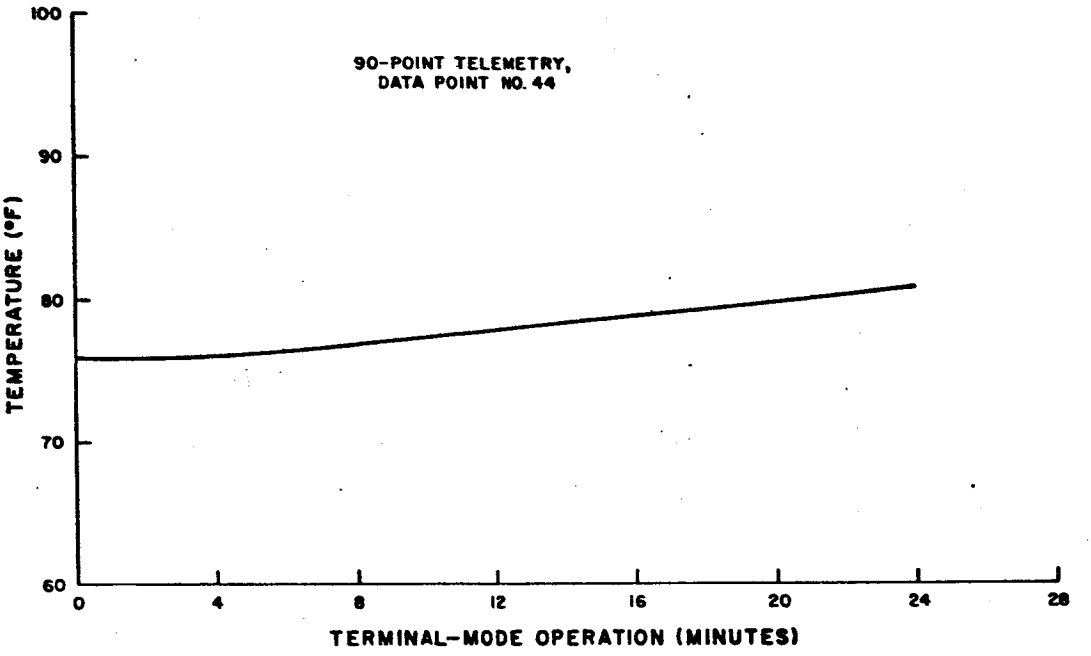

Figure 3-9. Actual F-Battery Case temperature during terminal mode

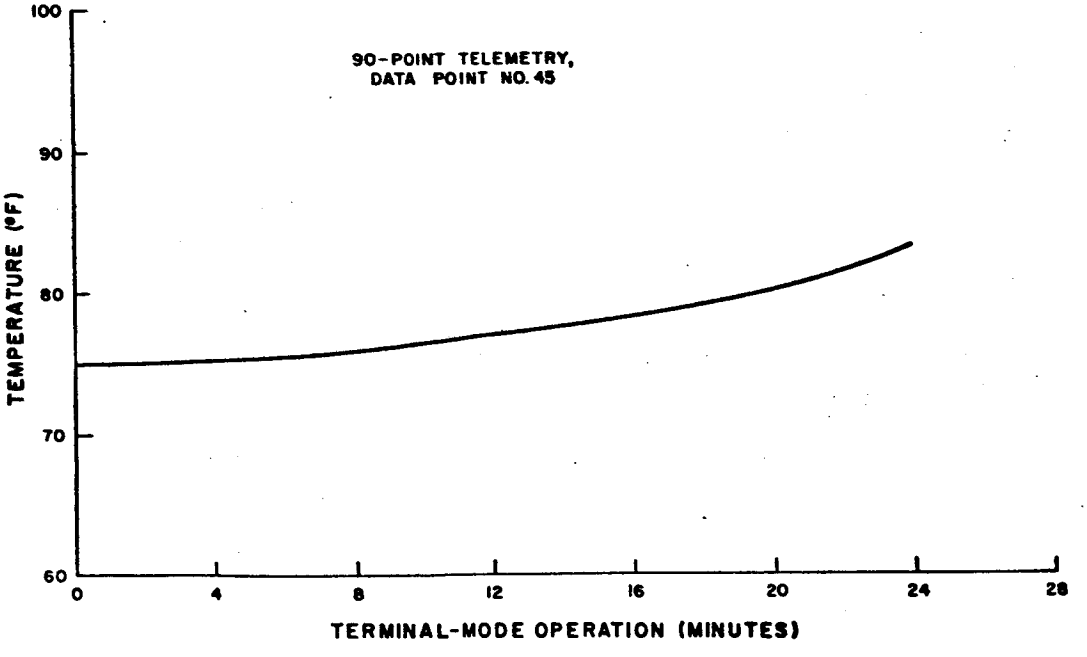

Figure 3-10. Actual P-Battery Case temperature during terminal mode

4

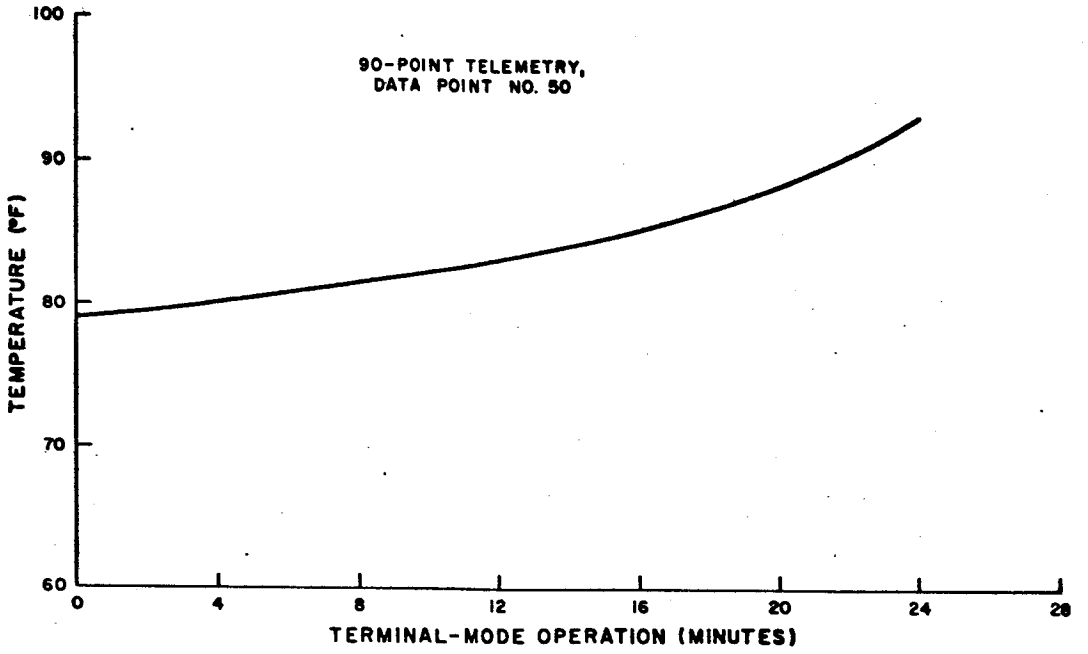

Figure 3-11. Actual Lower Shroud (+y side) temperature during terminal mode

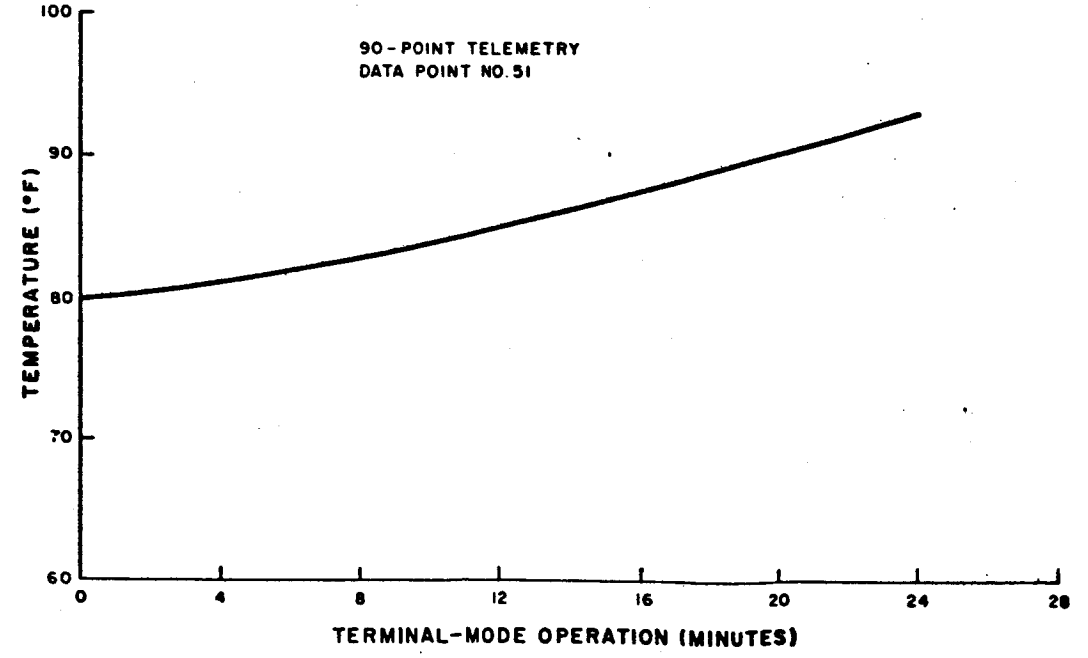

Figure 3-12. Actual Bottom Deck temperature during terminal mode

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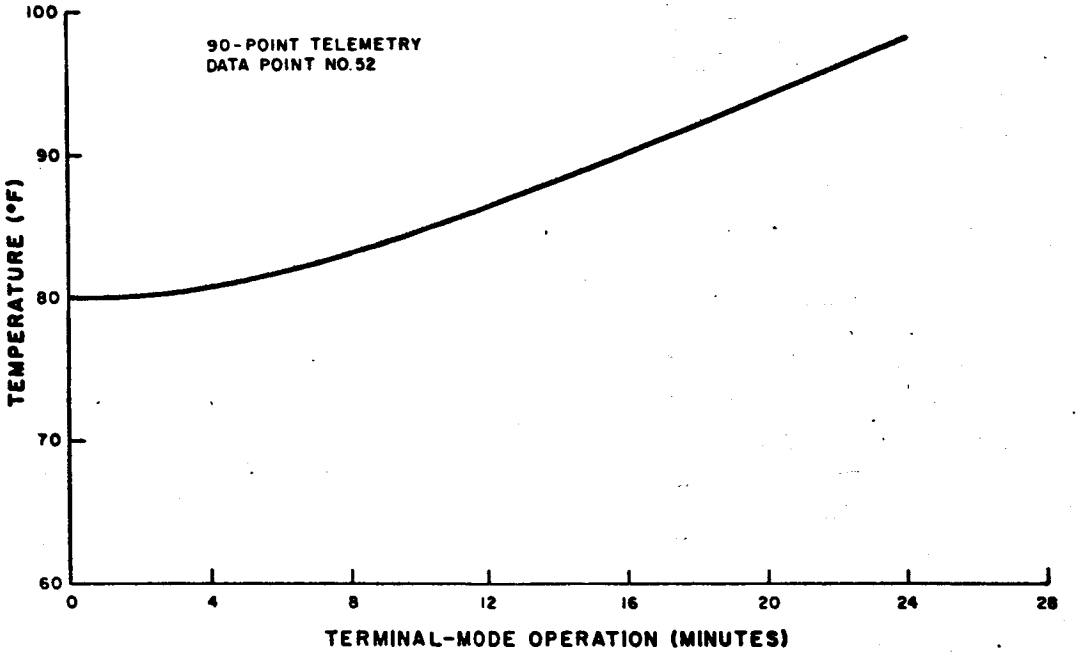

Figure 3-13. Actual Second Deck (–y side) temperature during terminal mode

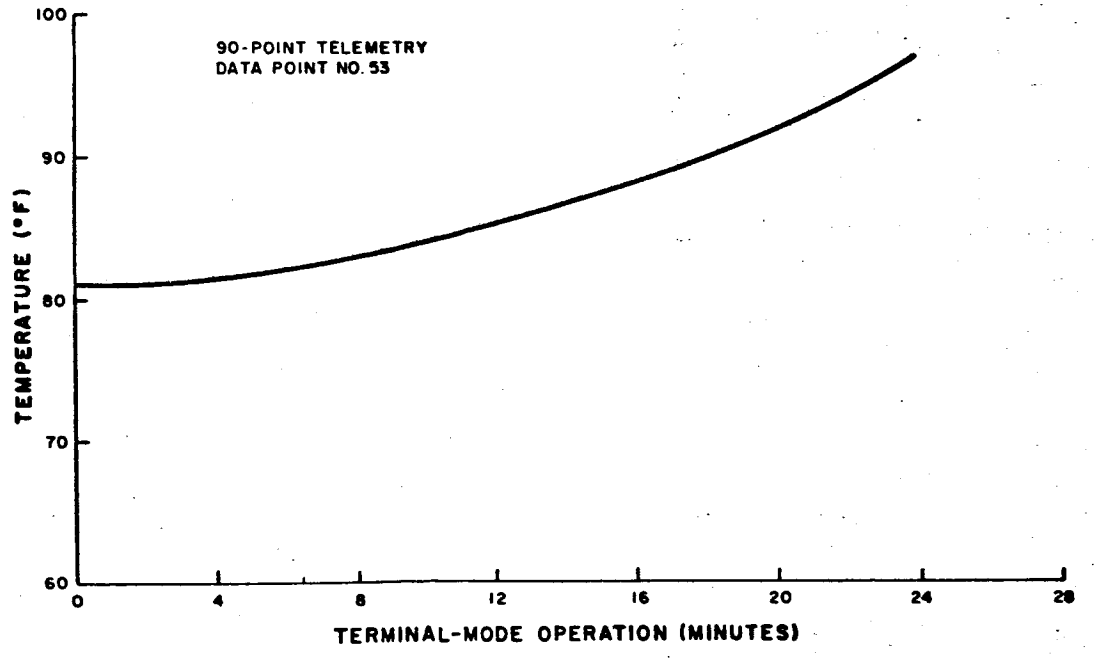

Figure 3-14. Actual Second Deck (+y side) temperature during terminal mode

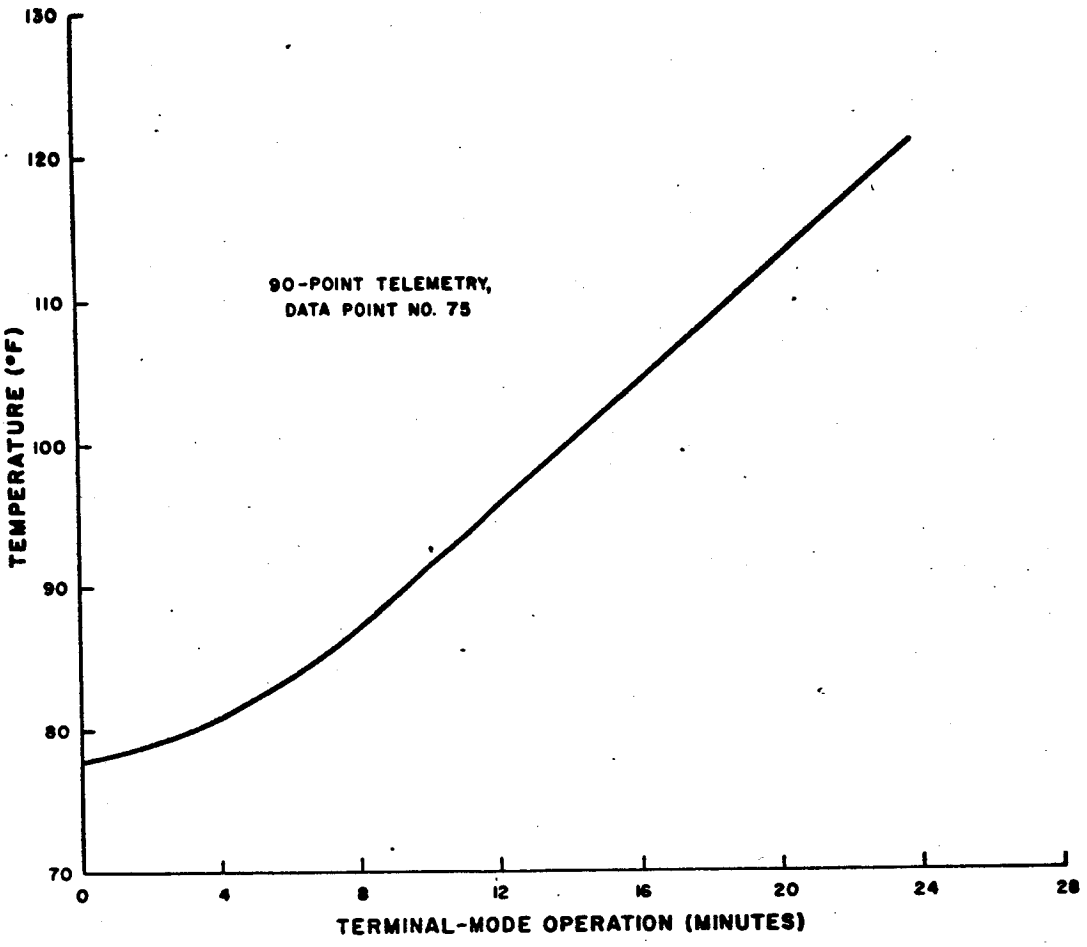

Figure 3-15. Actual P-Channel Transmitter heat-sink temperature during terminal mode

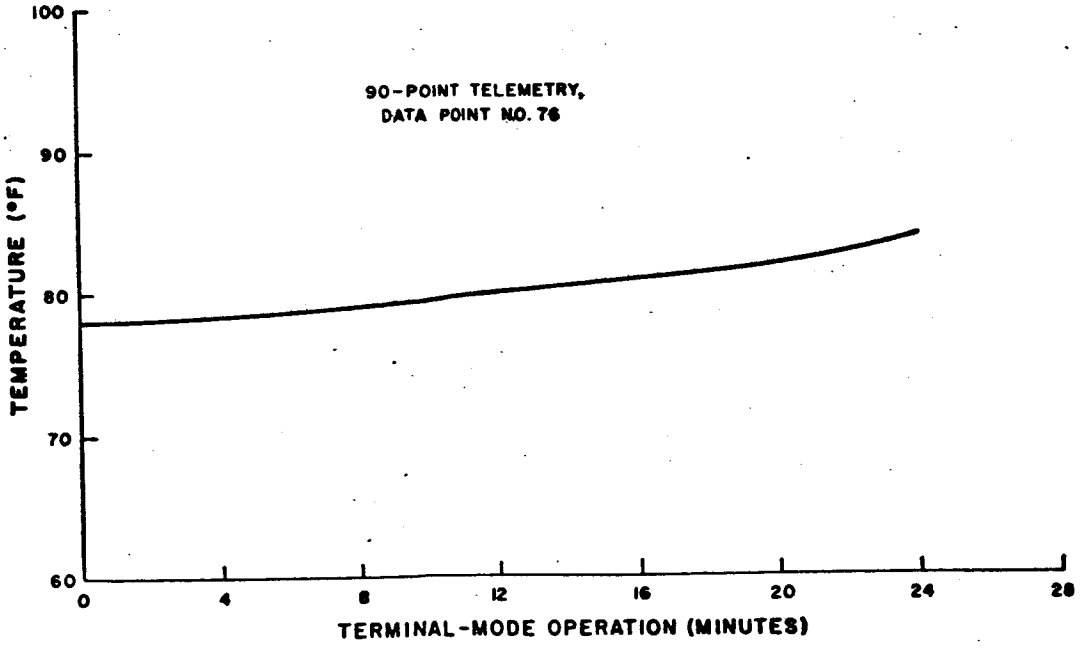

Figure 3-16. Actual F-Channel Battery Internal temperature during terminal mode

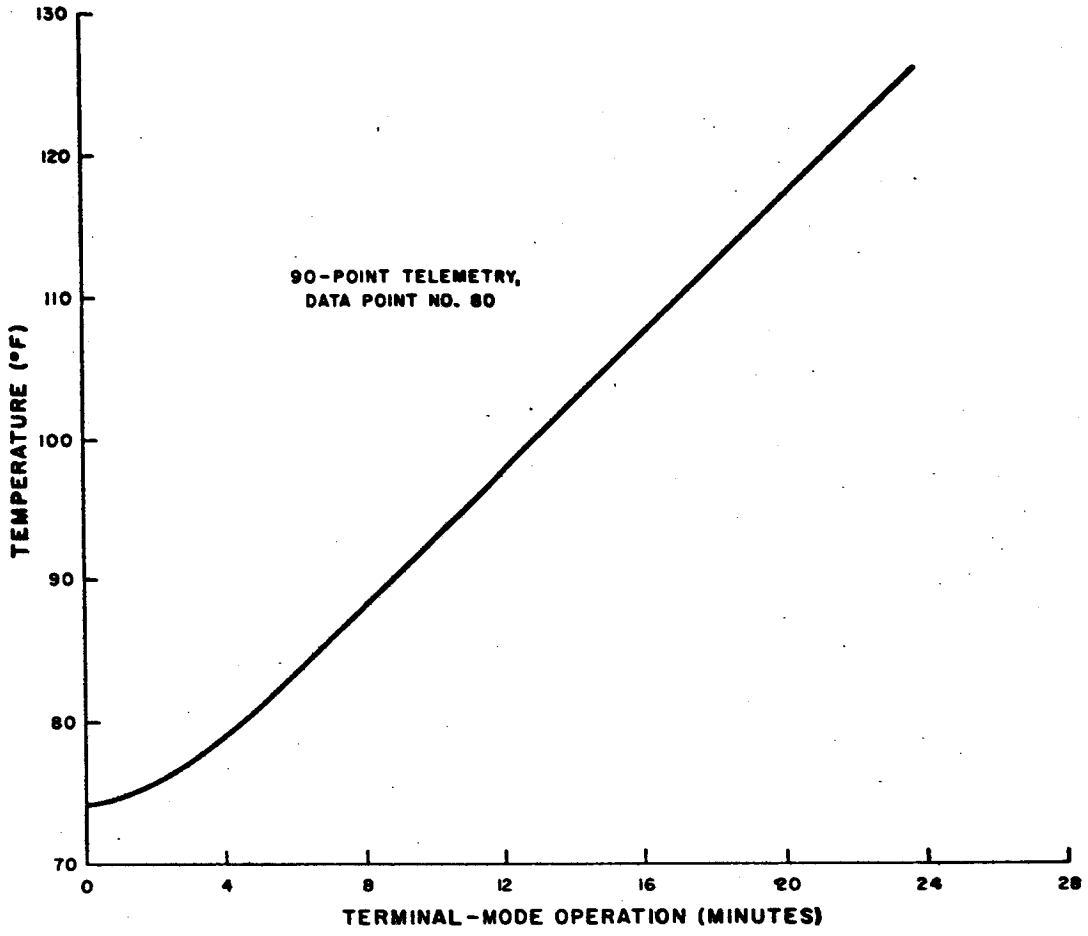

Figure 3-17. Actual F-Channel Transmitter heat-sink temperature during terminal mode

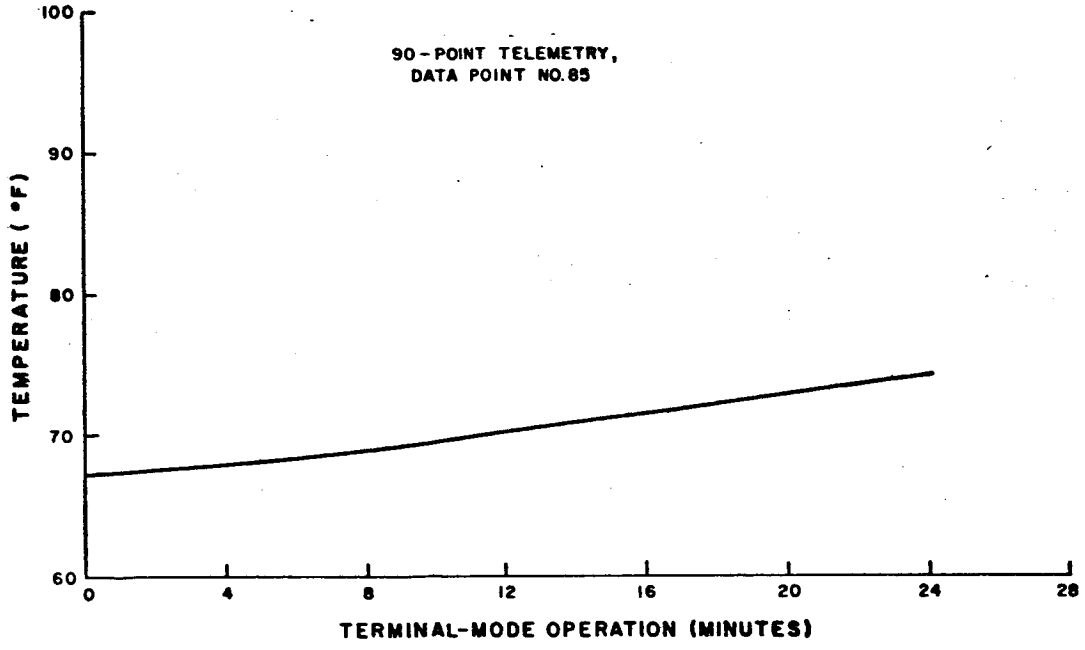

Figure 3-18. Actual F_a Camera Lens housing temperature during terminal mode

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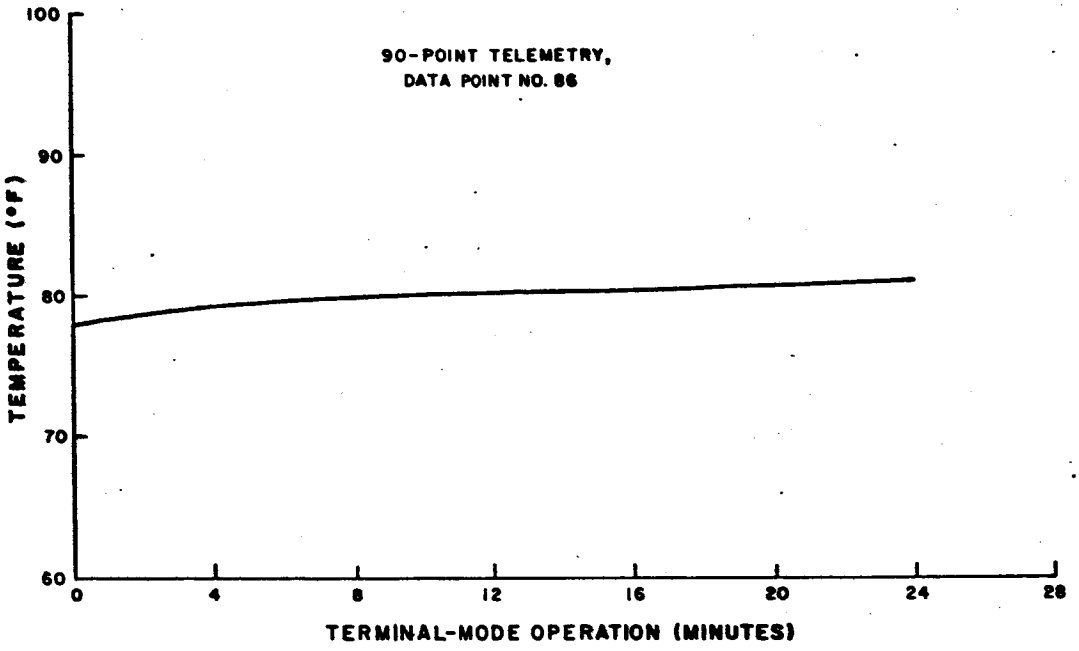

Figure 3-19. Actual Camera mounting bracket temperature during terminal mode

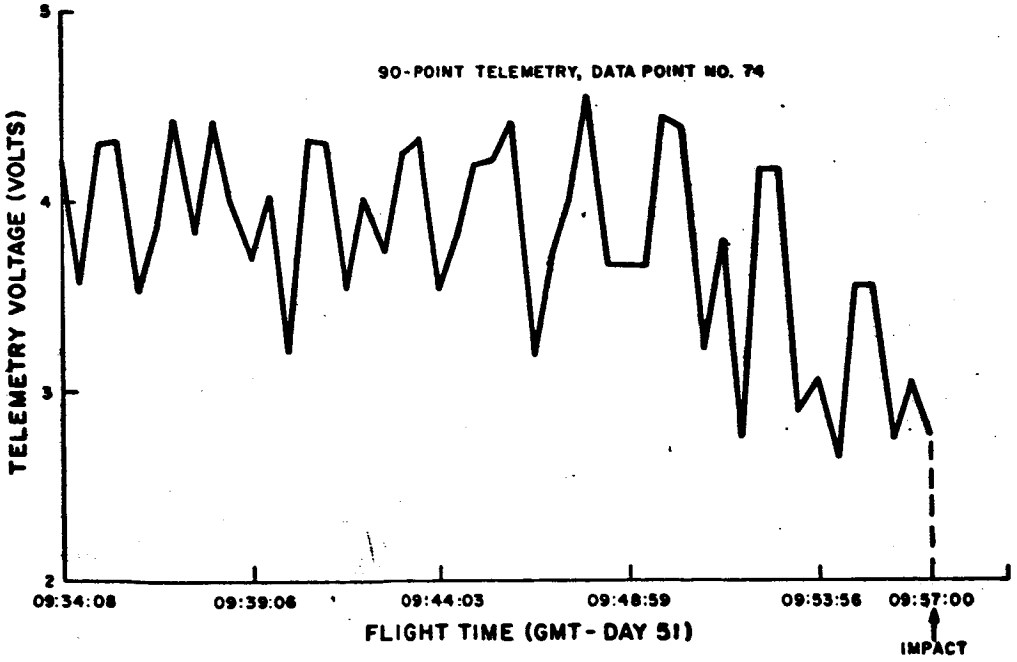

Figure 3-20. F-Channel Video Combiner output during terminal mode

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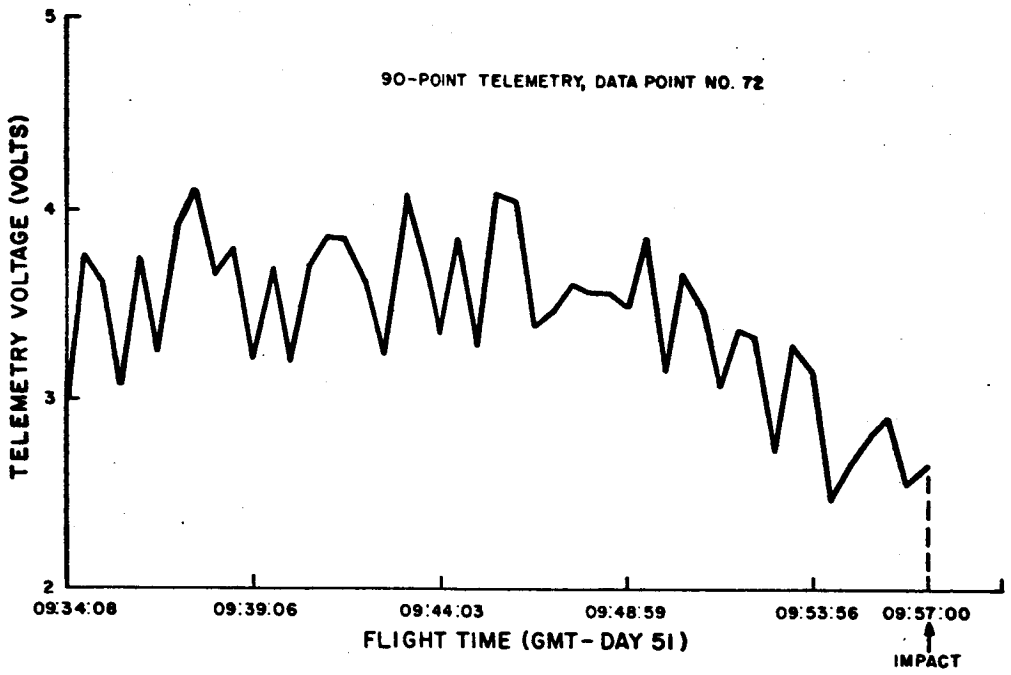

Figure 3-21. P-Channel Video Combiner output during terminal mode

B. Ground Support Equipment (GSE)

1. Prelaunch and Pretrack Preparation

Approximately 72 hours before launch of the RA-8 Spacecraft, a complete alignment of the Ranger Ground Support Equipment (GSE) at the Echo site (DS1F-12) and Pioneer site (DS1F-11) of the Goldstone Tracking Station was initiated. This alignment was performed in accordance with the procedures of Ranger specification Nos. RTSP-1200A, RTSP-1220A, Appendix B, and RTSP-1240C, as specified in Ranger Operational Procedure No. ROP-1. The data from the alignment procedures were submitted to JPL more than 24 hours before launch. No discrepancies were noted in any of the test data obtained.

After launch, an abbreviated check of overall GSE operation was performed before each pass of the RA-8 Spacecraft over the Goldstone Tracking Station. The pretrack checkouts were performed in accordance with Ranger Operational Procedure ROP-2. No discrepancies were noted in the test data obtained.

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2. Film-Recorder Calibration

a. Cathode Ray Tube (CRT) Evaluation

The evaluation of cathode ray tubes (CRT) to select the most suitable units for use in the GSE film recorders during the RA-8 mission followed the same general procedures employed during previous Ranger missions. Curves for 35-mm film density as a function of CRT grid-drive voltage were obtained for eight selected cathode ray tubes, and a record of CRT performance was obtained with different lens f-stops on the 35-mm film cameras. All 35-mm film for the evaluation was developed to a gamma of 1.40, as determined from previous Ranger missions.

Analysis of the obtained test data, with respect to repeatability and optimization of CRT operating conditions, resulted in the classification of four CRT's as mission units, and four CRT's as backup units. Table 3-4 lists the CRT's with respect to classification and assignment.

TABLE 3-4
CATHODE RAY TUBE ASSIGNMENT AND CLASSIFICATION FOR RA-8 MISSION

Film Recorder Number	Mission CRT		Backup CRT	
	Serial No.	Camera Lens f-Stop No.	Serial No.	Camera Lens f-Stop No.
1	2804	5.6	1294	4.0
2	4211	3.5	3012	3.5
3	2866	5.6	027	5.6
4	4207	3.5	028	3.5

As part of the overall mission procedure specified in Ranger Operational Procedure ROP-4, a final curve for 35-mm film density as a function of CRT grid-drive voltage was obtained for each mission CRT immediately before the the third Spacecraft view periods by DSIF-11 and DSIF-12. These data, which are used for final evaluation and adjustment of the CRT's, are presented in Figures 3-22 through 3-25.

b. Flight-Model Film Calibration

After the initial curves for film density as a function of grid-drive were obtained and the mission CRT's were designated, the G2 grid-drive conditions were

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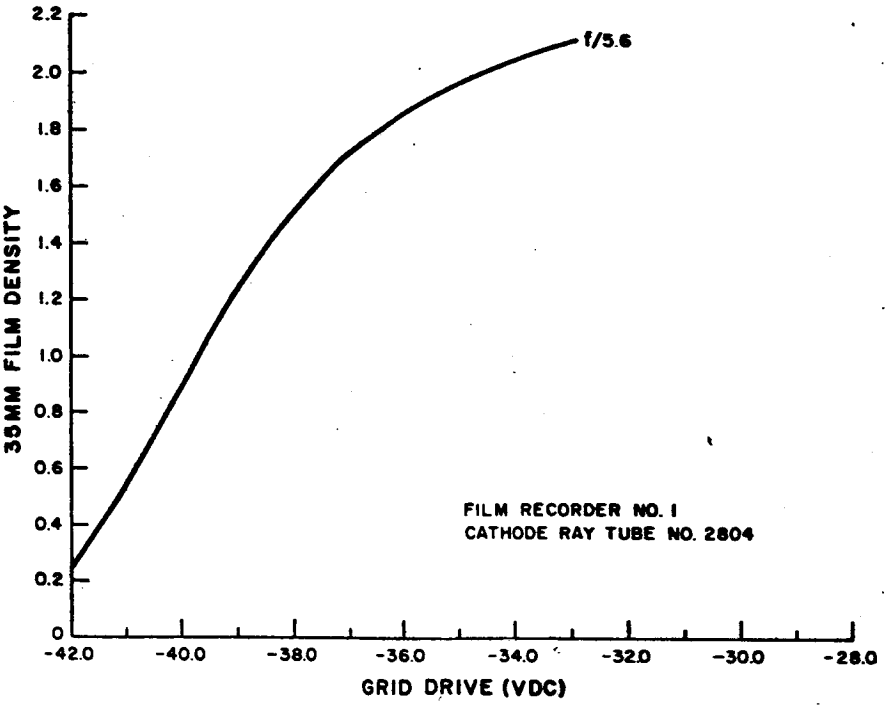

Figure 3-22. 35-mm film density as a function of CRT grid drive for Film Recorder No. 1

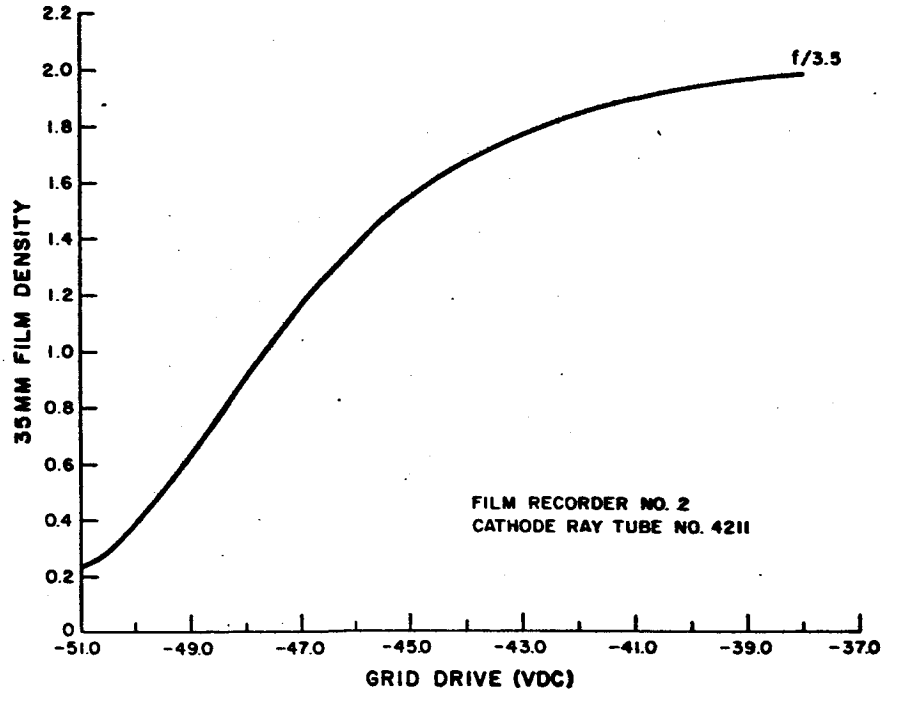

Figure 3-23. 35-mm film density as a function of CRT grid drive for Film Recorder No. 2

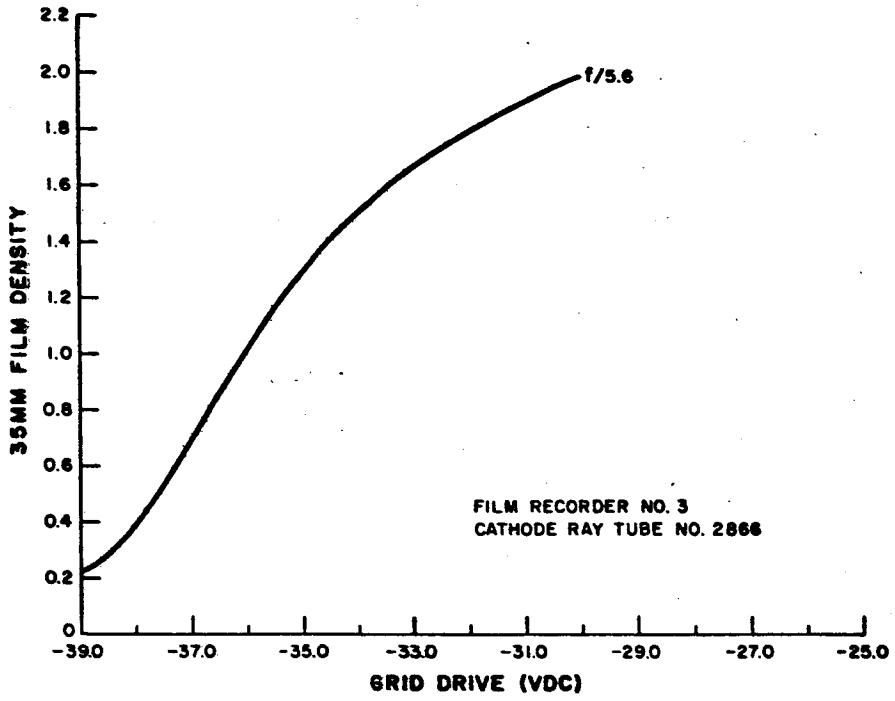

Figure 3-24. 35-mm film density as a function of CRT grid drive for Film Recorder No. 3

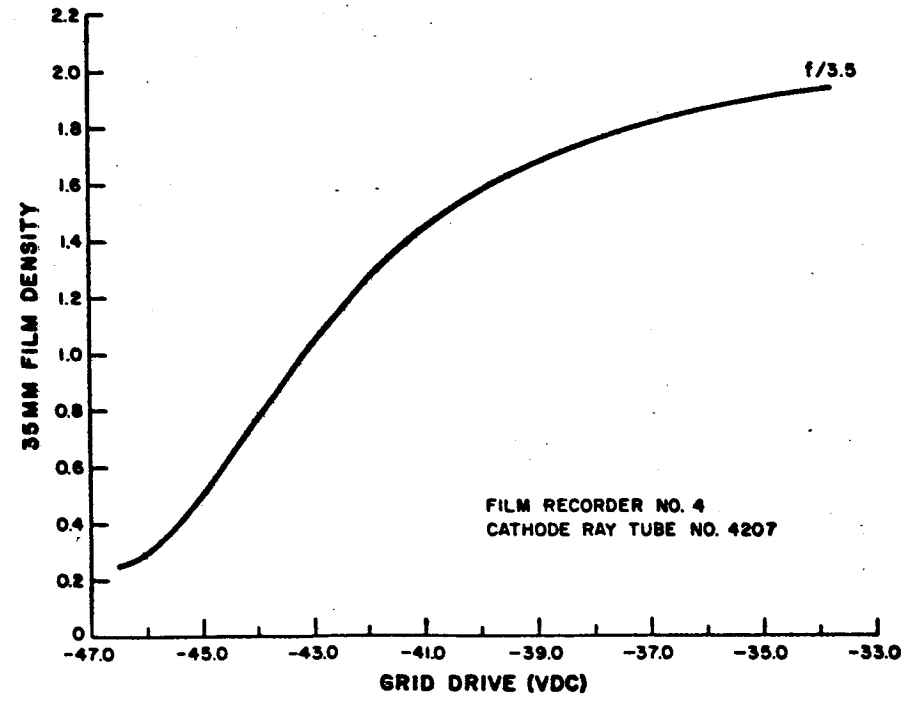

Figure 3-25. 35-mm film density as a function of CRT grid drive for Film Recorder No. 4

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determined for each mission CRT. A magnetic tape recording of the RA-8 camera-calibration data obtained at the Eastern Test Range (ETR) was utilized for this operation. The film-development gamma and CRT operating parameters (other than the G2 grid) were held constant, and the G2 bias and gain were adjusted to obtain the proper film densities for black and peak-white video levels. The criteria utilized during the film-density calibration were:

- Black was defined as the lowest video signal (peak-to-peak voltage from sync tip) obtained with the TV camera lens capped. The G1 bias of the CRT was then adjusted to obtain a 35-mm film density of 0.4 ±0.05 for that video signal; and

- Peak white was defined as the highest peak-white signal (peak-to-peak voltage from sync tip) given on the TV camera-calibration data sheets. The G1 gain of the CRT was then adjusted to obtain a 35-mm film density of 1.9 ±0.1 for that video signal.

Film Recorders No. 1 and 3 were adjusted for the F_a and F_b Cameras, and Film Recorders No. 2 and 4 were adjusted for the P1, P2, P3, and P4 Cameras. Film Recorders No. 1 and 2 were located at the Echo site (DSIF-12), and Film Recorders No. 3 and 4 at the Pioneer site (DSIF-11).

For the RA-8 mission, peak white was designated to be the video signal that was obtained for collimator brightnesses of 650 foot-lamberts as an input for the F_a, P3, and P4 Cameras, and 1500 foot-lamberts as an input for the F_b, P1, and P2 Cameras.

Figures 3-26 through 3-29 are the calibration curves for the four flight film recorders and express the 35-mm film density as a function of the illumination on the vidicons of the RA-8 cameras. As a final mission calibration of the film recorders, the RA-8 camera calibration data from the magnetic tapes were played through the film recorders and recorded on 35-mm prime data film.

3. *Post Impact Data Handling*

a. General

The procedure for post-impact handling and reproduction of Ranger VIII data at the Goldstone Tracking Station was specified in the following documents:

- Ranger Operational Procedure No. ROP-4, Rev. C, dated February 12, 1965, entitled "Data Handling Procedure for Ranger VIII Mission"; and

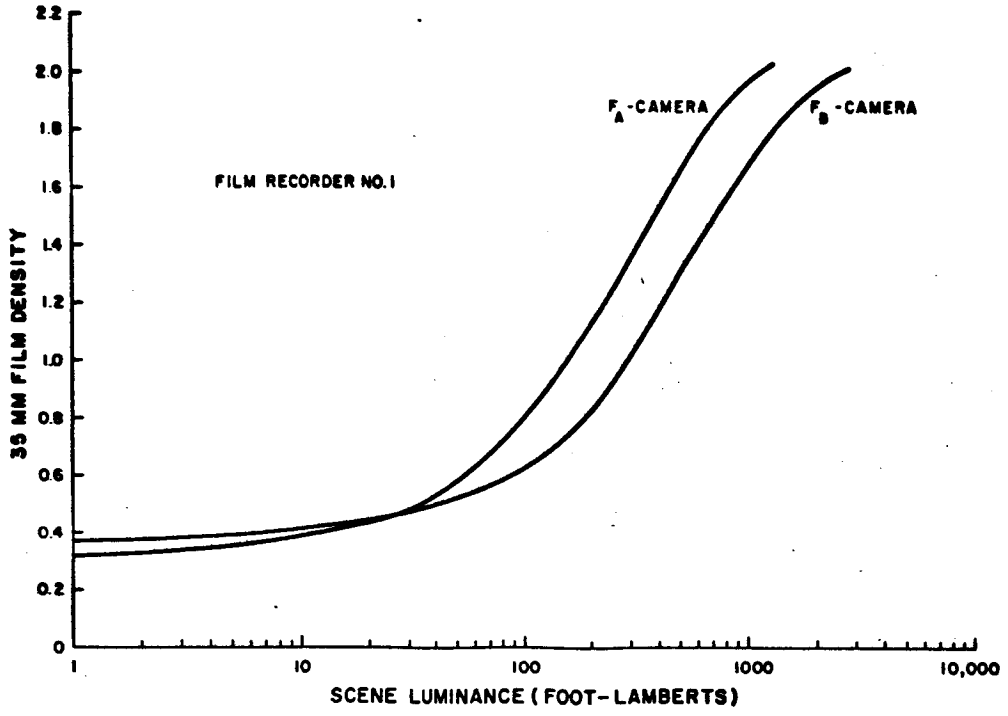


Figure 3-26. 35-mm film density as a function of scene luminance for RA-8 full-scan cameras for Film Recorder No. 1

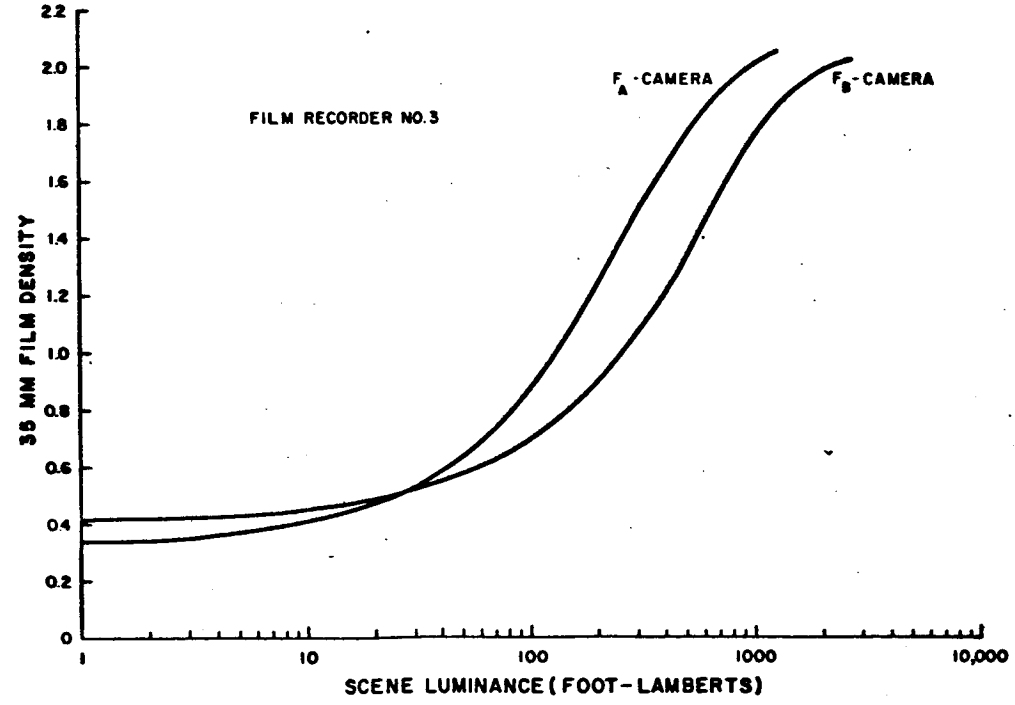
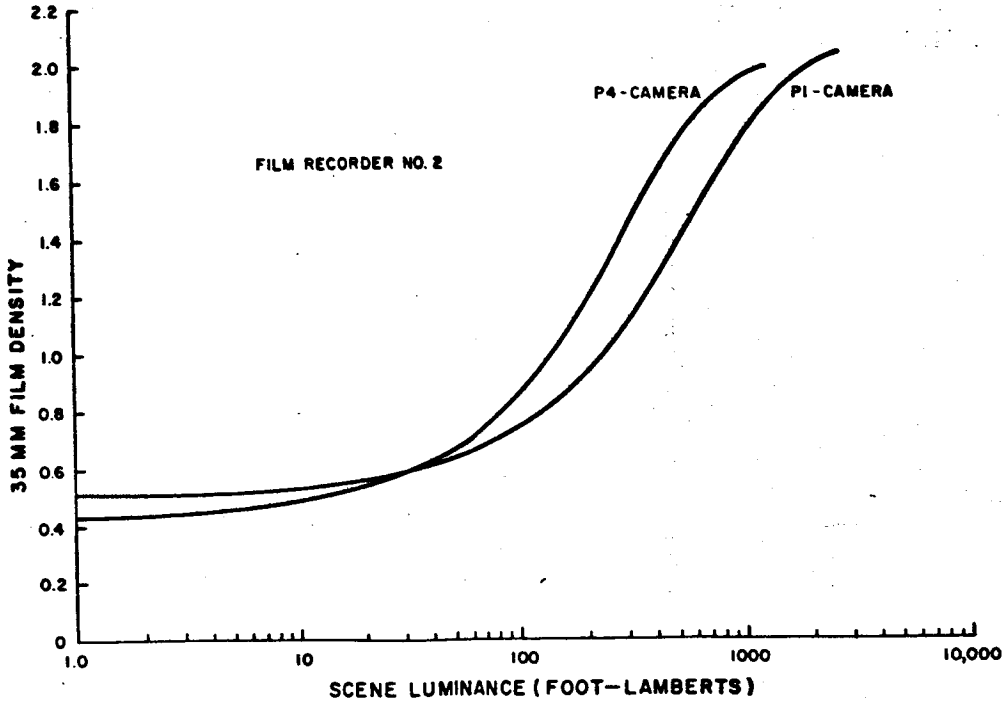
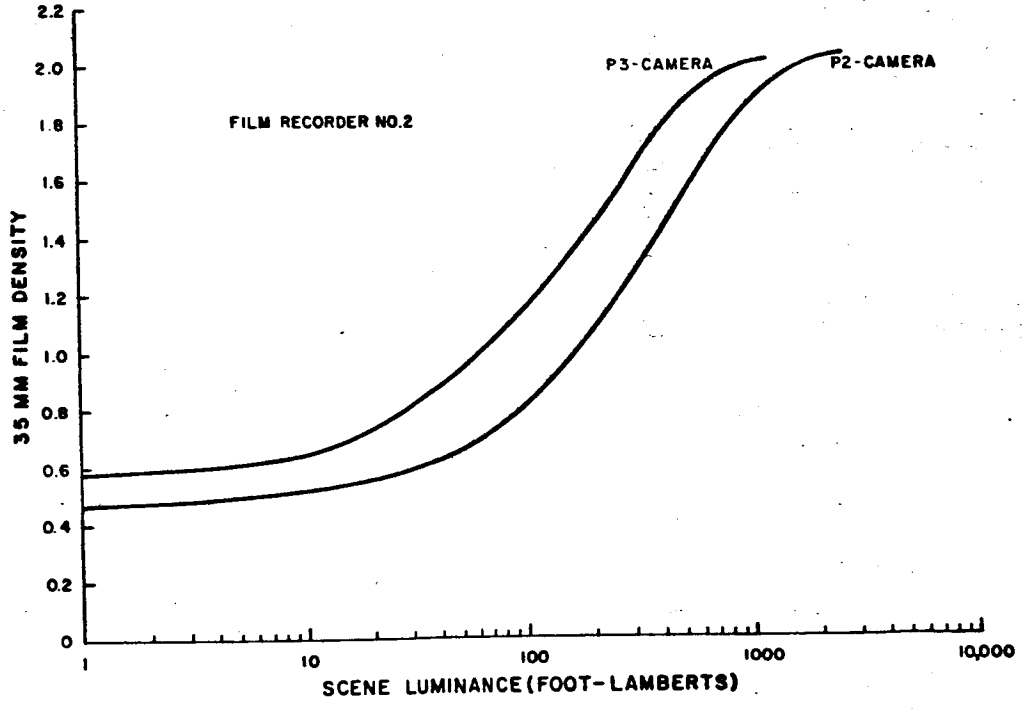


Figure 3-27. 35-mm Film density as a function of scene luminance for RA-8 full-scan cameras for Film Recorder No. 3



a. P1 and P4 Cameras



b. P2 and P3 Cameras

Figure 3-28. 35-mm film density as a function of scene luminance for RA-8 partial-scan cameras for Film Recorder No. 2

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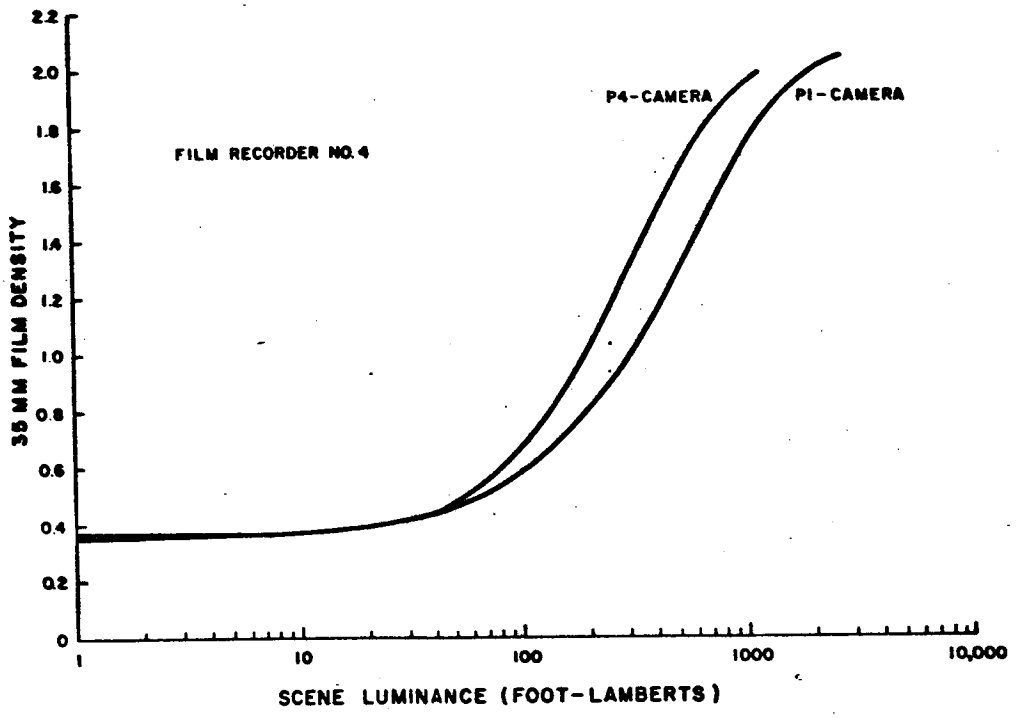
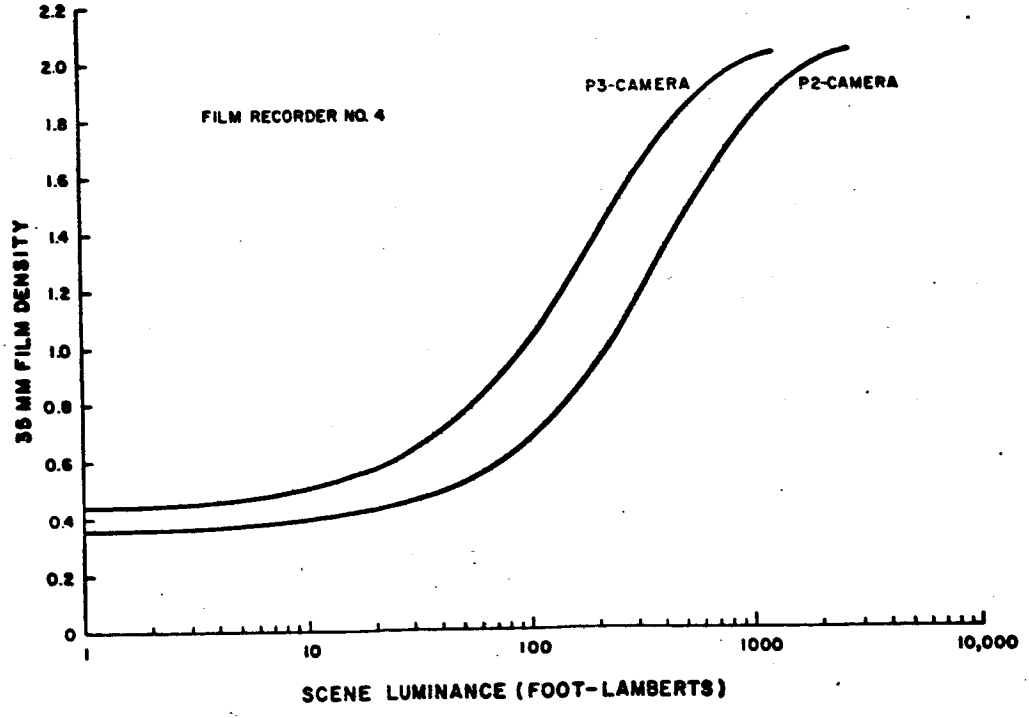


a. P1 and P4 Cameras



b. P2 and P3 Cameras

Figure 3-29. 35-mm Film density as a function of scene luminance for RA-8 partial-scan for Film Recorder No. 4

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- JPL Procedure No. EPD 265, dated February 1, 1965, entitled "Ranger Block III Video Ground Data Handling Procedures".

These procedures were followed with two exceptions:

- Recording of the tape playback of the RA-8 camera calibration data (from ETR) onto the Prime Original Data (POD) 35-mm film was delayed so that the Pioneer-site SODUB* and all Polaroid pictures from the RA-8 mission could be delivered to the Ranger project scientists within the time limit of impact plus 3 hours; and

- In order to minimize the time required for recording the RA-8 camera calibration data on the POD film, two tape recorders (one at the Echo site, and one at the Pioneer site) were used for playback of the seven RA-8 camera calibration tapes, and the remaining two recorders were used to rewind the tapes.

The added requirement to record the complete RA-8 camera-calibration data on the Prime Original Data (POD) films dalayed distribution of the Secondary Original Data (SOD) films by almost two hours.

b. RA-8 Data Reproduction

Reproduction of the RA-8 data on February 20, 1965, progressed without incident at the Echo and Pioneer sites. However, when the duplicate film copies were developed at Consolidated Film Industries, at Los Angeles, California, several problems developed.

(1) Reproduction of RA-8 Data at Echo-Site. The SOD film copies of the full-scan video data from Film Recorder No. 1 (Echo Site) revealed overlapping of frames and torn sprocket holes. Small pieces of 35-mm film were found in the 35-mm camera, Serial No. 810, that was mounted on Film Recorder No. 1. Investigation revealed that the shock-absorber spring in the camera had broken at the mounting screw on the shock absorber, as shown in Figure 3-30.

The function of the shock absorber is to reduce the forces exerted on the film during acceleration of the large-diameter, film-feed reel. If the spring breaks, the film perforations will be torn and incorrect spacing of the frames with some overlap will result. This is more likely to occur at the start of a full film magazine. Tests with lightly loaded film magazines at Goldstone and JPL, without a shock-absorber

*SODUB is a tape duplicate of a secondary original data (SOD) tape.

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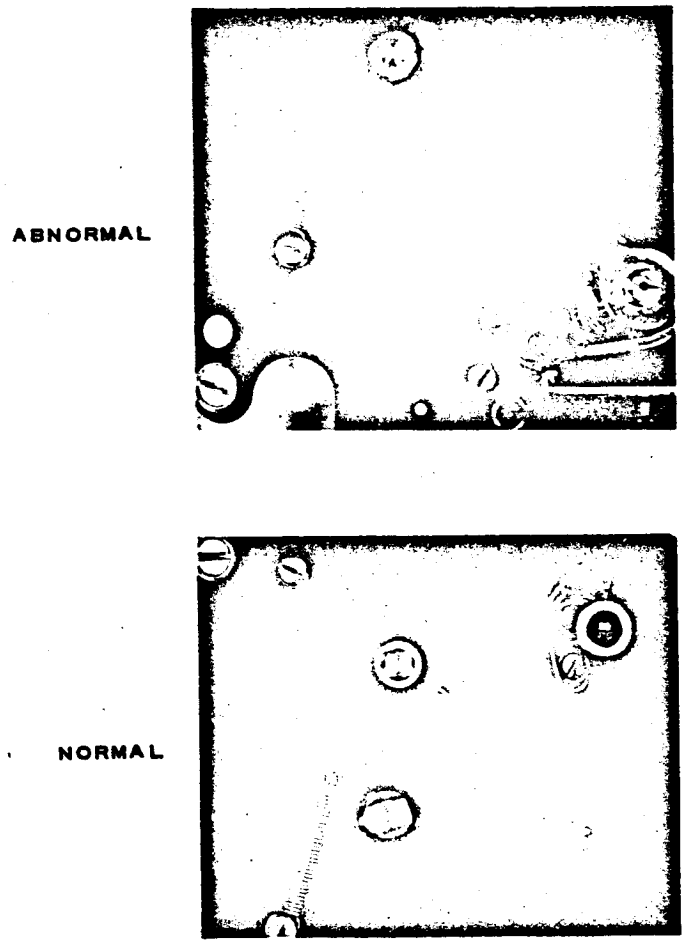

Figure 3-30. Broken shock-absorber spring on 35-mm Film Camera

spring, indicated normal operation. A later test with a full magazine also did not malfunction. The failure of the shock-absorber spring was considered to be a random occurrence.

To prevent a recurrence of this malfunction, the shock-absorber springs of each 35-mm camera at the Goldstone Tracking Station were inspected and replaced with springs that were x-rayed for flaws. Also, as a precautionary measure, the quantity of film in the magazines was reduced from 250 to 230 feet. The torn sprocket holes caused a delay in development of the film because of a possible jamming of the film-processing equipment. Review of the Echo-site Prime Original Data film revealed no problem, thus indicating that the spring probably failed after impact.

The film copies of tapes 1A and 2A at the Echo site indicated temporary loss of horizontal lock during the initial portion of the tape playback. The first few frames of

both tapes were normal, followed by loss of horizontal lock on two frames of tape 1A and nine frames of tape 2A. Subsequent tests at Goldstone indicated that the tape recorders at the Echo site were not at full operating speed prior to the start of video recording. The tape recorders at the Pioneer site were operated in such a manner that the transport "OFF" time was minimized and thus capstan speed was maintained at the start of the record of video data. There was no loss of tape-recorded data since the operation of the tape recorders provided overlapping at each tape change. This loss of data on the 35-mm film is considered normal for rapid tape changes, and this explanation is included to cover the particular 35-mm frames which exhibited the horizontal sync problem. Special tests were performed at the Echo site to determine the tape-recorder speed at the start of the recording of video information after a tape change. The test is described in Paragraph c.

(2) RA-8 Data Reproduction at Pioneer Site. After a review of the 35-mm film copies from Echo site, it was decided that additional 35-mm film sets of the RA-8 video data should be made at the Pioneer Station. Prior to film reproduction, the gains of the cathode ray tubes (CRT) in Film Recorders No. 3 and 4 were adjusted to compensate for RA-8 mission light levels greater than peak white. The CRT gain of Film Recorder No. 3 was reduced by 0.8 volt, and the CRT gain of Film Recorder No. 4 was reduced by 1.5 volts.

The film was developed at a gamma of 1.4. Review of the Pioneer-site film copies revealed two-problem areas.

- The full-scan video data from Film Recorder No. 3 at Pioneer site exhibited some 60-cycle noise throughout most of the frames. An example of this interference is shown in Figure 3-31. The problem was originally observed during the pretrack testing, and a check of the equipment revealed a 50-millivolt shift at approximately a 30-cycle rate in the base line of the CRT grid voltage. The problem was localized to the horizontal-yoke driver, tube V2 of the camera-control and yoke-driver chassis. This tube, type 7027A, was replaced and the problem was corrected.

- In addition, the first 200 frames of partial-scan video data from Film Recorder No. 4 exhibited banding, or groups of black and white lines. This abnormality is shown in Figure 3-32. Since the problem was observed in playback mode and disappeared after two hundred frames, a possible saturation of the tape demodulator was suspected. The linearity of the Pioneer partial-scan tape demodulator was checked and found to be normal, as shown in Figure 3-33.

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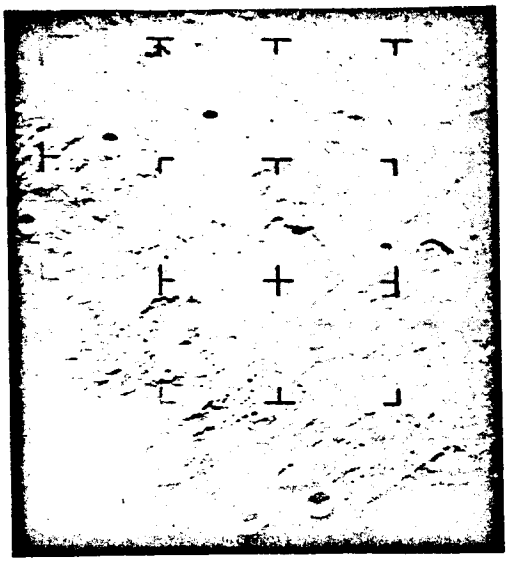

Figure 3-31. Example of 60-kc noise exhibited on full-scan video data from Film Recorder No. 3

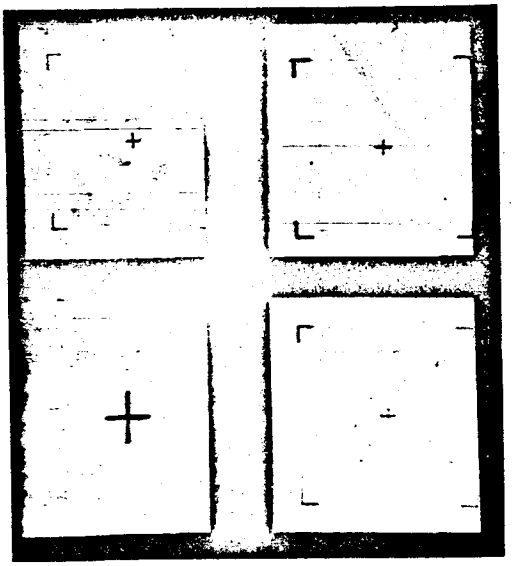

Figure 3-32. Example of line banding exhibited on partial-scan video output from Film Recorder No. 4

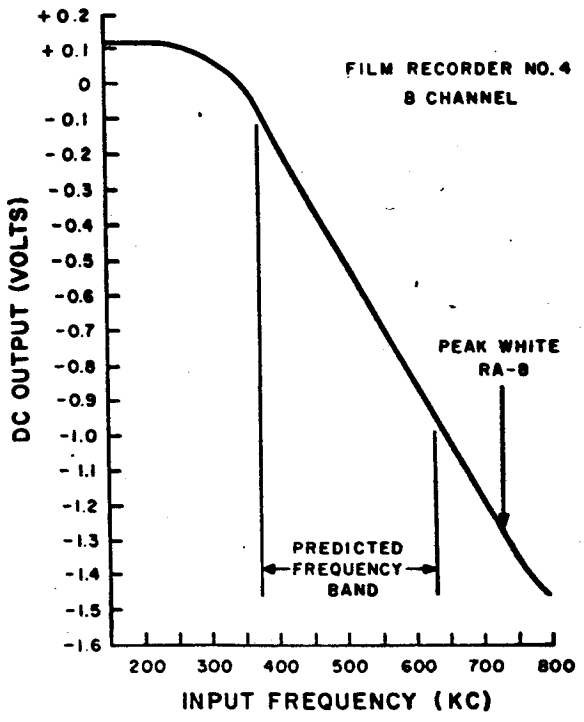

Figure 3-33. Linearity of Pioneer Site Tape Demodulator (Film Recorder No. 4)

Further investigation diagnosed the banding problem as interference in the vertical-deflection circuitry of the Film Recorder No. 4. The banding was manifested in the video as a discontinuity in horizontal lines at the beginning of a frame, and as a random vertical displacement of scan lines throughout the frame. The problem of line discontinuities was observed randomly during playback of the video tape, but was more prevalent during the earlier portion of the operation. The condition was reproduced during test and was related to the long-duration horizontal sync pulses that resulted in reticle bending in the P3 video of the Echo-site data. The long-duration horizontal sync pulses, coupled with the length of the vertical sync pulse, produced a notch in the vertical-drive signal to the film-recorder deflection circuitry. This situation was a function of the time constant of the vertical-integrator circuit. When the interference occurred, definite modulation products, due to white video-to-sync pulse excursions at the end of horizontal line time, were observed along with the resultant long-duration horizontal sync pulses.

Efforts to reproduce the banding problem during post-flight tests were unsuccessful; however, similar interference problems were encountered during subsequent operation of Film Recorder No. 4. The vertical banding problem was found to be unique to the deflection chassis in Film Recorder No. 4 at Pioneer site, and was isolated to grounding problems in the chassis. When this situation was corrected, normal operation was restored.

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c. Special Test of Tape-Recorder Speed

(1) Summary. Using the Echo-site procedure for tape changes, Tape Recorders No. 1 and 2 were checked for constant tape speed at the start of recording after a hurried tape change. Tape Recorder No. 1 operated satisfactorily, requiring no longer than one second from start to stabilize capstan speed. Tape Recorder No. 2 exhibited varying performance, taking as long as 8 seconds to reach normal operating speed.

Using the tape-change procedure employed at the Pioneer site under similar circumstances, both tape recorders operated satisfactorily, with initial tape-recording speed in error for less than one second.

(2) Test Procedure. The operating procedure employed at the Echo site during mission-directed tape changes is as follows:

- Stop tape recorder;
- Turn off tape transport power;
- Change tapes;
- Turn on tape-transport power within 30 seconds after power turn off;
- Allow 10 seconds for capstan speed to reach normal;
- Depress RECORD buttons;
- Recording begins within 4 to 6 seconds (function of machine alignment).

Tests were performed by simulating a tape change but not actually changing tapes. After tape-recorder warmup, a precision 1-Mc signal was recorded for approximately 1 minute. The tape recorder was then stopped and tape-transport power turned off for 30 seconds. Ten seconds after return of transport power, the RECORD buttons were depressed, resulting in the start of video recording within 5 seconds thereafter. Recording was continued for approximately one minute. The playback of the recorded 1-Mc signal from the time of simulated tape change was compared with the source signal. In particular, the reappearance of the signal following simulated tape change was observed and compared with the precision 1-Mc signal source, which was displayed on an oscilloscope. The time required for the playback signal to coincide with the reference signal is equivalent to the time required for the tape recorder to attain normal operating speed after turn-on following the tape change.

The test was repeated several times on Tape Recorders No. 1 and 2. Results indicated that Tape Recorder No. 1 attained normal recording speed in one second or less after the start of video recording for each test run.

The tests on Tape Recorder No. 2 gave varying results, requiring from one to 8 seconds after the start of video recording to reach proper recording speed. Analysis of the test results indicated that the frequency of the reproduced signal was initially higher than the 1-Mc reference and remained relatively constant for 4 to 6 seconds. The frequency then shifted rapidly towards the 1-Mc level, with some overshoot noted during this transition period; the signal then indicated normal tape speed.

Because of the variation in test results on Tape Recorder No. 2, the test was repeated, with the tape-transport power-off time reduced from 30 seconds to 25 seconds to simulate a faster tape change. This test was followed by another test run in which the transport power-off time was increased to 35 seconds to simulate a slower tape change.

The results of the test with the 25-second power-off time indicated normal operation, with a tape speed error of one second or less. The test with an increased power-off interval also indicated more consistent results, with 6 to 8 seconds of initial speed error. The basic test was modified to simulate the tape-change procedure employed at the Pioneer site. In this procedure, capstan speed is maintained as follows: Recording is the same as in the Echo-site procedure, but the transport power is turned off for 8 seconds simulating the time for removal and attachment of the take-up reel. Then, transport power is turned on for 17 seconds and off for a 5-second interval to simulate final threading of tape to the supply reel. Upon return of tape-transport power, the 30-second interval of the basic test is attained and the remainder of the test is the same as the Echo-site procedure.

Results of tests on Tape Recorders No. 1 and 2, using the modified test procedure to simulate a mission-directed tape change, indicated satisfactory operation, with initial tape-speed errors of less than one second for both tape recorders.

(3) Conclusions. Tape Recorder No. 2 at Echo site does not attain proper operating speed as quickly as Tape Recorder No. 1, under the test conditions employed. It should be noted that the 30-second power-off interval of the transport was determined empirically, and was used to simulate the time required to effect a tape removal and replacement under mission conditions. Furthermore, the 30-second interval was thought to be of sufficiently short duration that the capstan speed would not be reduced enough to require more than 10 or 15 seconds to attain normal speed.

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d. Development and Review of Prime Original Data (POD)

The Prime Original Data 35-mm film was developed at a gamma of 1.3 several days after impact. The development gamma was reduced from the normal 1.4 to compensate for the high light levels during the initial portion of terminal mode. Review of the 35-mm film revealed several problems that had not occurred during prelaunch or pretrack testing.

(1) Horizontal Line Displacement. The first and most serious problem was the horizontal displacement of several lines of video coincident with the presence of black-to-white, end-of-scan line transitions. The problem was observed in the POD and SOD data from the Echo site, and in the SOD data from the Pioneer site, and was manifested as bending of the reticles in the P3 Camera video and as line displacement in the video from the other P Cameras. An example of the condition is shown in Figure 3-34.

The horizontal sync circuits of the GSE Data Display Equipment are adjusted to minimize line jitter and frame pull-in problems. Switching logic is provided to prevent missing or out-of-time sync pulses from producing severe line pull-in of the video. Proper operation of the GSE horizontal sync circuitry required that the horizontal sync pulses of the received partial-scan video data not exceed the nominal width of 111 microseconds. However, during the RA-8 mission, partial-scan horizontal sync pulses exceeding the 111-microsecond duration were observed, with some pulses approaching 120 microseconds, depending on the detector balance setting of the GSE bandpass sync separator and the video level of specific scan lines. When the duration of the horizontal sync pulses exceeded the preset protection time (112 to 113 microseconds), the horizontal sync timing was derived from the sync-pulse leading edge rather than the normal trailing-edge sync pulse. The resultant time instability of the sync-pulse leading edge produced the observed horizontal video offset. The P3 Camera video, with reticle marks ending horizontal lines, is a worst-case condition; the leading-edge timing was shifted by as much as 5 microseconds in this case.

In order to prevent a recurrence of this problem during the RA-9 mission, the protection switching circuitry of the GSE horizontal sync circuits have been readjusted to accommodate video sync-pulse durations of up to 120 microseconds; this precludes the possibility of leading-edge syncing should sync pulses of excessive lengths be received; however, the protective feature of automatically switching to leading-edge sync in the event of erratic generation of sync pulses in the TV Subsystem will be retained.

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d. Development and Review of Prime Original Data (POD)

The Prime Original Data 35-mm film was developed at a gamma of 1.3 several days after impact. The development gamma was reduced from the normal 1.4 to compensate for the high light levels during the initial portion of terminal mode. Review of the 35-mm film revealed several problems that had not occurred during prelaunch or pretrack testing.

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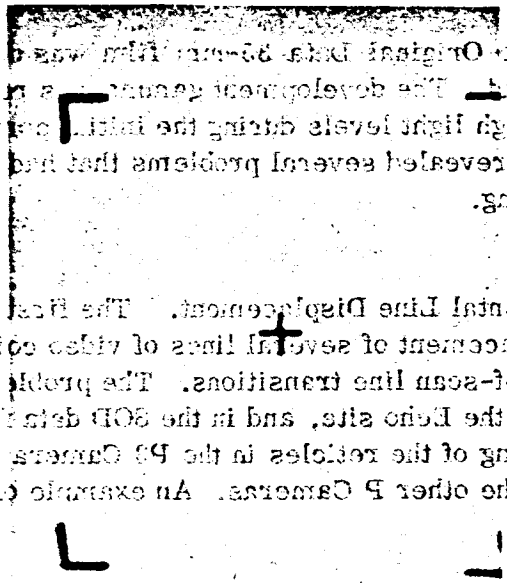

Figure 3-34. Horizontal line displacement observed on P3 Camera video from Film Recorder No. 2.

(2) Double Frame Advance. A second problem observed was in the operation of the 35-mm Film Camera, Serial No. 931, mounted on Film Recorder No. 2 at Echo site. Intermittent double frame advance of the film occurred and resulted in a single unexposed frame between two exposed frames of data. A total of sixteen double frame advances were observed on the POD No. 2 film. Figure 3-35 is an example of a double frame advance. The camera was examined and tested at the Goldstone Tracking Station; however, the cause of the problem could not be isolated. The manufacturer checked and operated the camera for about 12 hours without observing a single instance of double frame advance. A filter capacitor was installed in the pulse-shape circuit of the camera to provide greater noise immunity. In addition, the circuitry associated with the camera at the ground station was tested with a spare camera. No problem was encountered. It should be noted that a minimum of data was affected by this problem with approximately ten to twelve horizontal lines displaced in 16 frames of P1 Camera video data.

(3) Superimposed Flat Field. The final problem noted occurred on the POD No. 4 film at Pioneer site. Multiple exposures of a flat field were superimposed on the last partial-scan frame (at impact) on Film Recorder No. 4. This problem was due to operator failure to advance the film momentarily after impact.

RE-ORDER No. 65-350

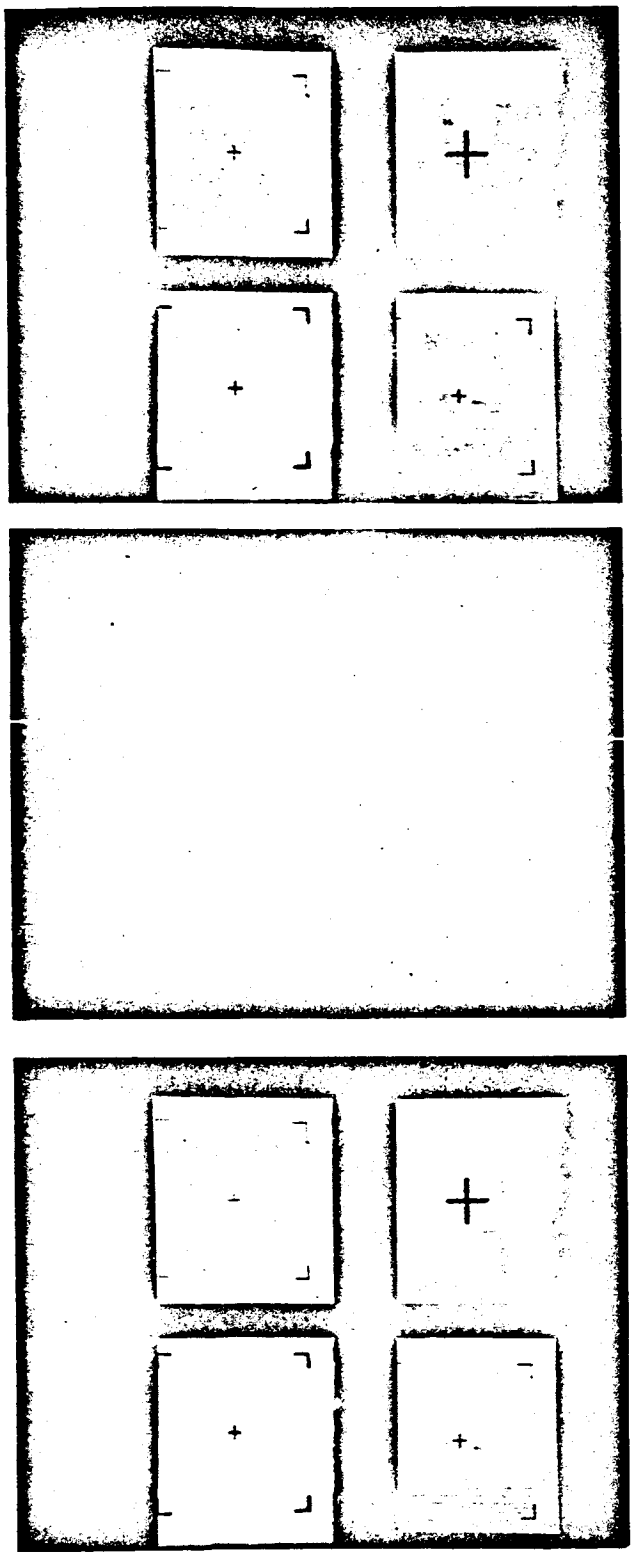

Figure 3-35. Example of double frame advance in 35-mm film camera, Serial No. 931

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Section IV

Flight Model iii-3 (RA-8) Equipment Performance

A. General
B. Camera Group
C. Thermal Control Group
D. Telecommunications Group
E. Controls Group
F. Power Group

RE-ORDER No. 65-350

Section IV

Flight Model III-3 (RA-8) Equipment Performance

A. General

The receipt of 7,140 high-quality television pictures of the lunar surface attests to the overall performance of the Flight Model III-3 TV Subsystem during the Ranger VIII mission, and in particular to the performance of the TV Camera Assemblies. The telemetry data received throughout the RA-8 mission indicated that the thermal-control, power, and telecommunications equipment functioned as predicted from the results of prelaunch system tests. Proper operation of the control circuitry is evidenced by the fact that all commands were processed and executed on time and in good order.

The level of performance of the TV cameras and associated video processing equipment can be evaluated by a review of the 35-mm film and magnetic-tape recording of the video information obtained. The large bandwidth in the r-f channel permits an accurate determination of all important parameters for the Camera Group. The quality of the pictures, the video signal levels, and signal strength measured during the mission are used to evaluate the performance of the Communications Group. The Thermal-Control and Power Groups are best evaluated from the telemetry received. Proper functioning of all equipment was necessary to achieve the quality and quantity of the pictures obtained.

This section discusses the performance of the Camera Group in detail. An evaluation of the thermal-control equipment and a correlation of the predicted mission temperatures with those actually experienced are also presented. The performance of the Telecommunications Group is evaluated, with a review of the power level, frequency stability, and deviation of the transmitters, and the accuracy of the telemetry-processing equipment. The Controls Group, and the Batteries and associated voltage regulators are also evaluated.

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B. Camera Group

1. Picture Analysis

a. General

The four partial-scan and two full-scan TV cameras aboard the RA-8 Spacecraft obtained 7140 pictures during the 23-minute 10-second full-power mode of the mission. All pictures were of good quality with the exception of the pictures obtained by the P2 Camera during the final 5 minutes of terminal-mode operation. The mesh of the vidicon in the P2 Camera became microphonic during this period, and although the microphonic signal was objectionable, there was very little loss of information. The microphonic signal produced a number of horizontal bars across the picture. The amplitude of these bars is less than 20 percent of the dynamic range, so that lunar-surface details are still visible in all frames.

The exposure settings of the cameras with 3-inch focal-length, f/2 lenses (F_b, P1, P2) provided balanced pictures during the entire mission, while the exposure settings of the cameras with 1-inch focal-length, f/0.95 lenses (F_a, P3, P4) provided optimum pictures only during the last 10 minutes of the mission. There was considerable compression of video in the "on-line" kinescope display of the F_a, P3, and P4 pictures during the first thirteen minutes of operation. There is, however, very little saturation in the video signals from the TV Cameras. This problem can be corrected by adjusting the drive signal to the GSE kinescope and recording video on 35-mm film from the playback of the magnetic tape.

The Camera Assemblies performed satisfactorily throughout the mission and would have met mission requirements for ground resolution if a terminal maneuver had been performed to align the common optical axis of the six cameras with the Spacecraft velocity vector. Examination of film reproduced from magnetic tape playback revealed that impact occurred after 13 percent of a P4-Camera picture had been read out. The preceding picture from the P2 Camera represented an area of approximately 23 by 29 meters. Craters as small as 0.3 meter in diameter would have been visible; however, the lack of a terminal maneuver caused approximately 1.3 meters of smear in each of the partial-scan pictures. The last picture from the P1 Camera represented an area of approximately 56 by 70 meters, and would have shown craters as small as 0.75 meter in diameter. Table 4-1 lists the resolution, area coverage, and translational smear in each of the final 24 partial-scan pictures and the final four full-scan pictures. The geometry of the Spacecraft approaching impact is presented in Figure 4-1.

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TABLE 4-1
CHARACTERISTICS OF FINAL PARTIAL-SCAN AND FULL-SCAN PICTURES

Camera	Time from Impact (msec)	Range (kilometers)	Emission Angle (degrees)	Resolution (m/olp)*	Approximate Coverage (meters x meters)	Translational smear (meters)
P4	86.8	0.19	38.0	0.21	21 x 27	6.2
P2	286.8	0.627	37.0	0.233	23 x 29	5.6
P3	486.8	1.080	37.8	1.21	121 x 154	1.07
P1	686.8	1.5061	36.8	0.56	56 x 71	2.33
P4	926.8	2.07	38.0	2.31	231 x 294	0.56
P2	1126.8	2.48	37.8	0.93	93 x 118	1.40
P3	1326.8	2.95	37.8	3.30	330 x 420	0.39
P1	1526.8	3.355	36.8	1.25	121 x 159	1.04
P4	1766.8	3.95	38.0	4.42	442 x 560	0.30
P2	1966.8	4.33	37.0	1.61	161 x 205	0.81
P3	2166.8	4.83	37.8	5.40	540 x 686	0.24
P1	2366.8	5.203	36.8	1.94	195 x 248	0.67
P4	2606.8	5.83	38.0	6.53	653 x 830	0.20
P2	2806.8	6.18	37.0	2.31	231 x 293	0.56
P3	3006.8	6.70	37.8	7.50	750 x 950	0.17
P1	3206.8	7.05	36.77	2.63	263 x 333	0.50
P4	3446.8	7.70	38.0	8.63	863 x 1100	0.15
P2	3646.8	8.04	37.0	3.00	300 x 381	0.43
P3	3846.8	8.57	37.77	9.60	960 x 1220	0.14
P1	4046.8	8.895	36.75	3.32	332 x 422	0.39
P4	4286.8	9.58	38.0	10.70	1070 x 1360	0.12
P2	4486.8	9.89	36.94	3.69	369 x 470	0.35
P3	4686.8	10.44	37.75	11.7	1170 x 1500	0.11
P1	4886.8	10.74	36.74	4.00	400 x 510	0.32
F_a	2070.0	4.21	29.0	4.70	1880 x 2150	0.86
F_b	4650.0	10.99	41.9	4.10	1640 x 2200	0.43
F_a	7210.0	14.51	28.8	16.2	6500 x 7400	0.25
F_b	9770.0	23.06	41.8	8.6	3440 x 4600	0.21

*m/OLP - Resolution is given in meters per optical line pair

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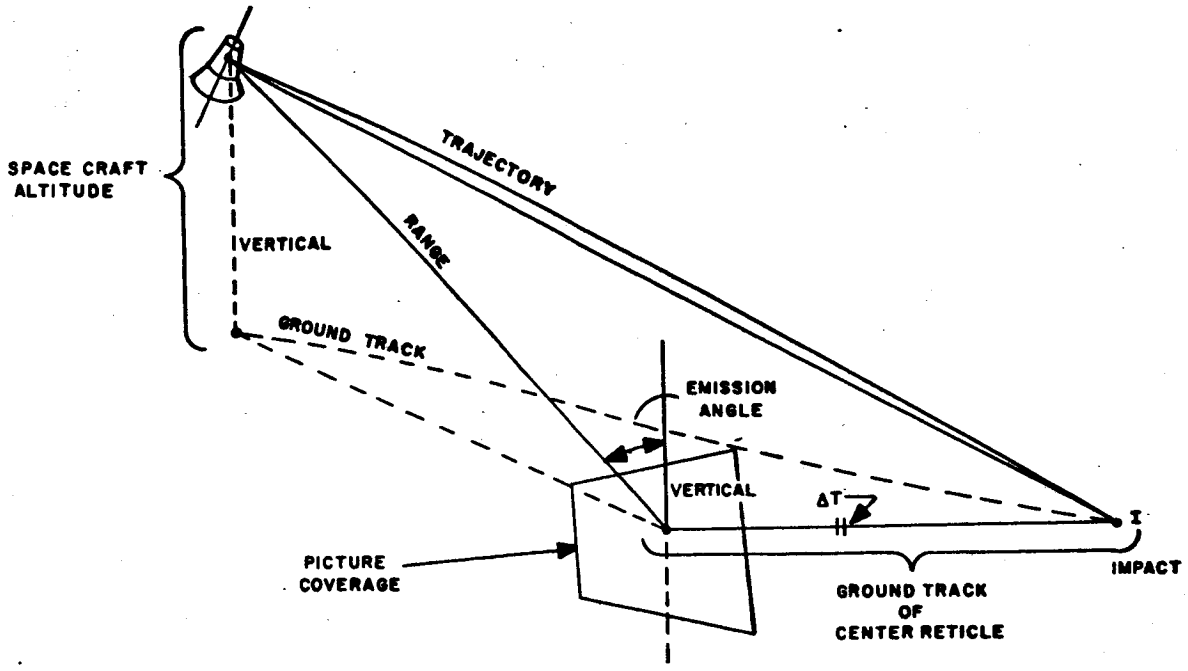

ΔT = SMEAR DURING EXPOSURE

Figure 4-1. Spacecraft geometry prior to impact

b. Final Partial-Scan Picture

The final partial-scan picture was a fragment from the P4 Camera and is shown in Figure 4-2. By use of a line selector, it was determined that impact occurred approximately 340 microseconds after the start of scan line 036. By measuring the projected image, it was determined that 13 percent of the P4 picture had been readout at impact, or that approximately 25.1 milliseconds of the total 193-millisecond readout time of the P4 camera had been completed. Knowing the vertical-blanking time (6.6 milliseconds) and the time from the end of P4 shutter travel to the beginning of P4 Camera readout (55 milliseconds) that occurs during P2 Camera readout, the approximate time of P4 Camera exposure before impact can be determined:

25.1 milliseconds of P4 Camera video readout

6.6 milliseconds of vertical blanking

55.0 milliseconds during P2 Camera video readout

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87 milliseconds; APPROXIMATE TIME OF P4 CAMERA EXPOSURE BEFORE IMPACT.

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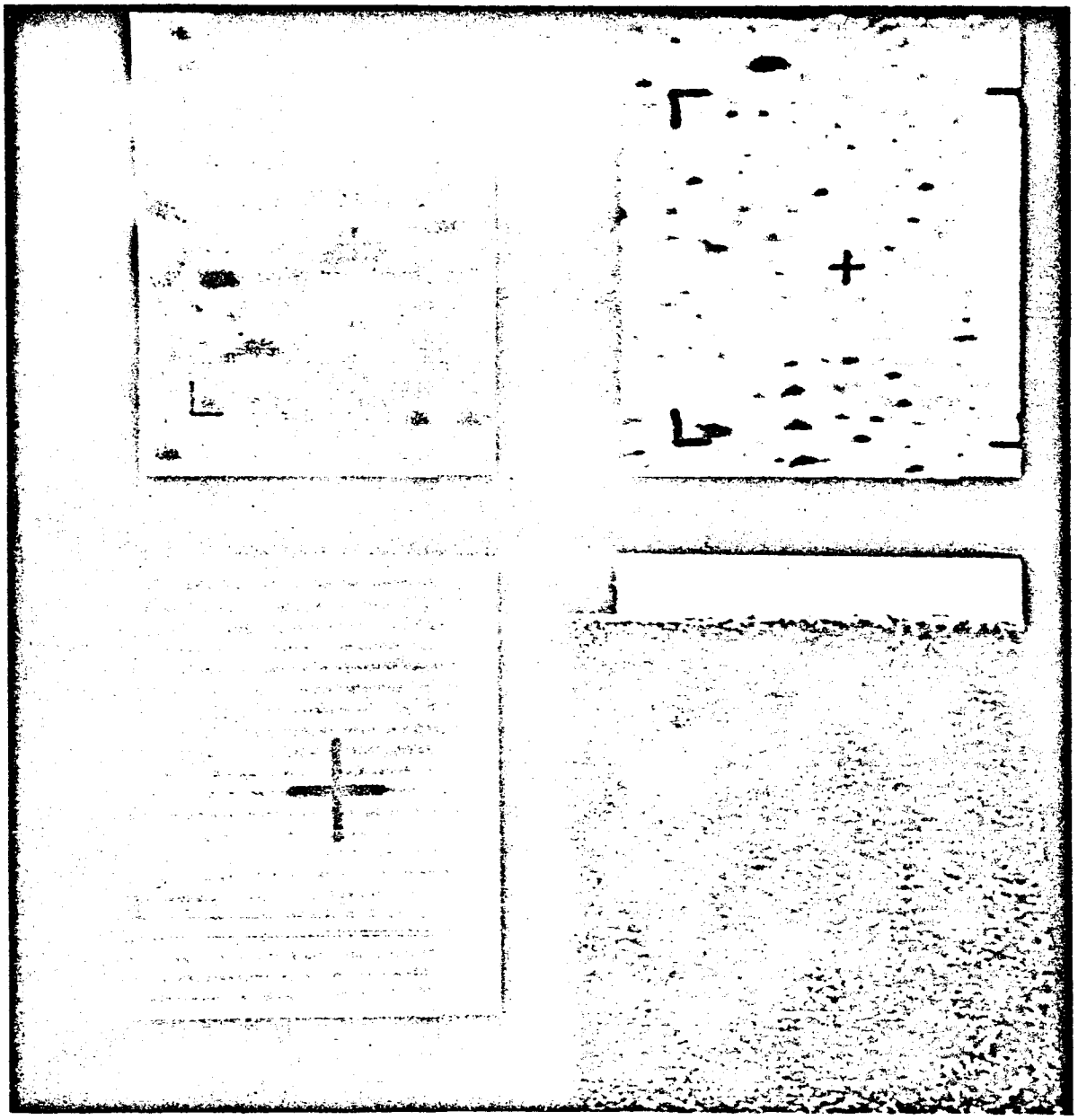

Figure 4-2. Final partial-scan pictures obtained by Ranger VIII

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The 55-millisecond period during P2 Camera readout is an optimistic figure. The average time of this interval was measured as 60 to 65 milliseconds in tests performed at RCA, so that exposure may have taken place as much as 97 milliseconds before impact.

Computation of the distance from the camera to the lunar surface during shutter operation requires knowledge of the time of exposure before impact, the velocity vector of the Spacecraft, and the orientation of the Spacecraft with respect to the velocity vector. Spacecraft velocity is determined by tracking of radio signals from the Spacecraft. Spacecraft orientation is determined from attitude data transmitted from the Spacecraft, which is processed by a computer in the ground station to determine the lunar-surface features that will be photographed. Some inaccuracies exist in the computer printouts because of measurement precision and errors in the attitude-control system of the Spacecraft.

Based on the information available, it was determined that the final picture from the P4 Camera was taken at a distance of 160 meters from the lunar surface.

c. Final Full-Scan Picture

The final full-scan picture, shown in Figure 4-3, was taken by the F_a Camera. The line selector indicated that impact occurred on scan line 889, after 1.97 seconds of video had been read out. Knowing the vertical blanking time (46 milliseconds) and the time from the end of F_a shutter travel to the start of F_a Camera readout (65 milliseconds), the approximate time of exposure of the final F_a Camera picture can be determined:

1.97 seconds of F_a Camera video readout

0.046 seconds of vertical blanking

0.065 seconds during F_b Camera video readout

2.08 seconds; APPROXIMATE TIME OF F_a CAMERA EXPOSURE BEFORE IMPACT.

The F_a Camera was approximately 3.7 kilometers from the moon at the time of the last exposure. The coverage provided by the last F_a-Camera picture was approximately 1.8 by 2.1 kilometers, and craters down to 6 meters in diameter could be seen. The translational smear in the final F_a picture was about 4 meters.

The final F_b picture, shown in Figure 4-4, was taken 2.56 seconds earlier, or 4.65 seconds before impact. This picture represents lunar-surface coverage of approximately

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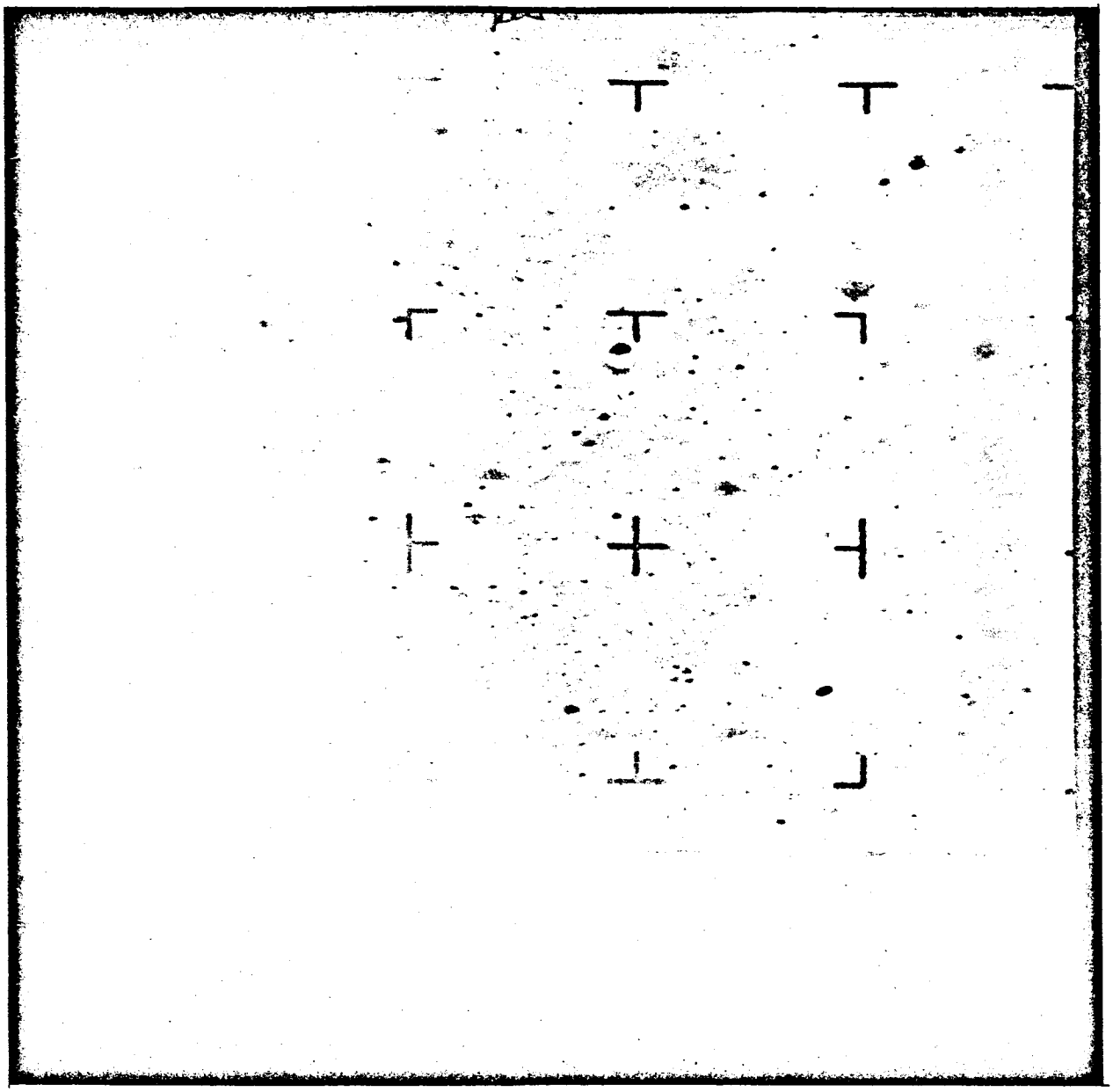

Figure 4-3. Final F_a Camera picture obtained by Ranger VIII

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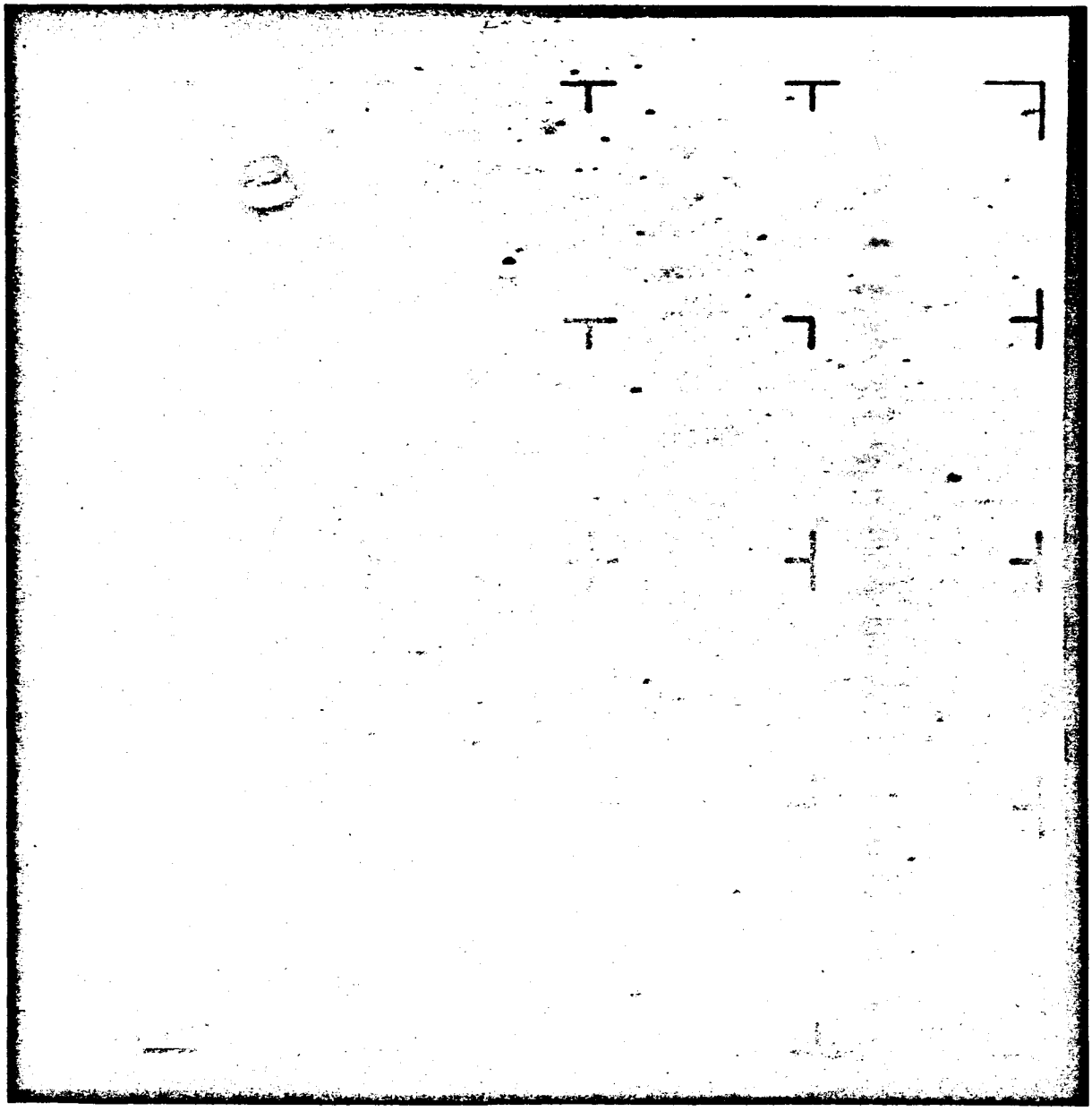

Figure 4-4. Final F_b Camera picture obtained by Ranger VIII

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1.6 by 2.7 kilometers. The final F_b picture had only 1.7 meters of translational smear, so that much more detail can be discerned than in the final F_a picture.

d. Picture Nesting

Because a terminal maneuver of the RA-8 Spacecraft was not performed, the mission requirement of picture nesting was not accomplished. The fulfillment of picture nesting was based on the prerequisite that the common optical axis of the television cameras is aligned along the Spacecraft velocity vector. Although there was no nesting in the pictures, considerable coverage overlap existed in all but the final few pictures from the partial-scan cameras.

The pictures provided continuous coverage of the lunar surface over a distance of more then 750 miles, as shown in Figure 4-5, and more than 50 percent overlap existed in all pictures but those taken during the final 30 seconds. As the Spacecraft approached the lunar surface, the degree of overlap in successive F_b pictures and successive F_a pictures was reduced. Figure 4-6 indicates the area coverage of the last three F_a pictures taken during the final 12 seconds before impact. The amount of overlap in the successive pictures decreases until the final picture is approximately tangent to the previous F_a picture. There is less reduction in picture overlap in the final F_b pictures, as indicated by Figure 4-7. The field of view of the F_b Camera, however, does overlap the field of view of the F_a Camera, and the combined coverage of the F_a and F_b pictures provides more than 50 percent overlap on all pictures transmitted by the full-scan cameras. The amount of overlap is high even in the last F_a and F_b pictures as shown by Figure 4-8.

2. Evaluation of Camera Performance

An evaluation of camera performance during the RA-8 mission was made by reviewing 35-mm film copies of the Prime Original Data (POD) and Secondary Original Data (SOD). These data were analyzed to determine whether the camera performance during the mission deviated from the performance observed in prelaunch tests at RCA, JPL, and ETR. In particular, the performance of the cameras during System Test No. 7, performed at ETR on February 5, 1965, was used as the basis of comparison.

a. Image Degradation

(1) Shutter-Induced Noise. Review of the partial-scan data revealed the presence of some shutter-blade discharge noise. The noise was equally distributed

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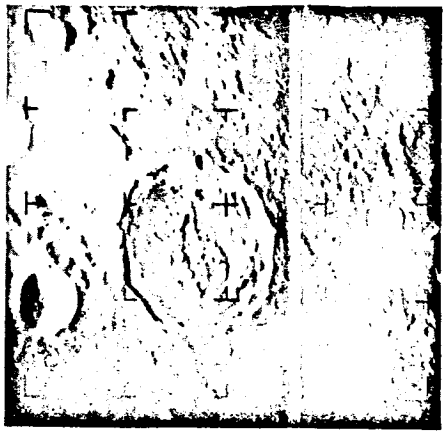
between the video outputs of the P2 and P3 Cameras, and was limited to only a few of the 1600 frames of video data received. These fast noise pulses had been observed in test to be predominantly in time coherence with the end-of-shutter stroke. They are induced into the video output by an electrostatic discharge from the shutter blade to the detent spring, as described in Ranger Block III 21st Bimonthly Progress Report. When the shutter blade travels along the nyloc blade guide in the shutter assembly, it acquires an electrostatic charge. The blade then discharges when gravity causes it to contact the grounded detent spring.

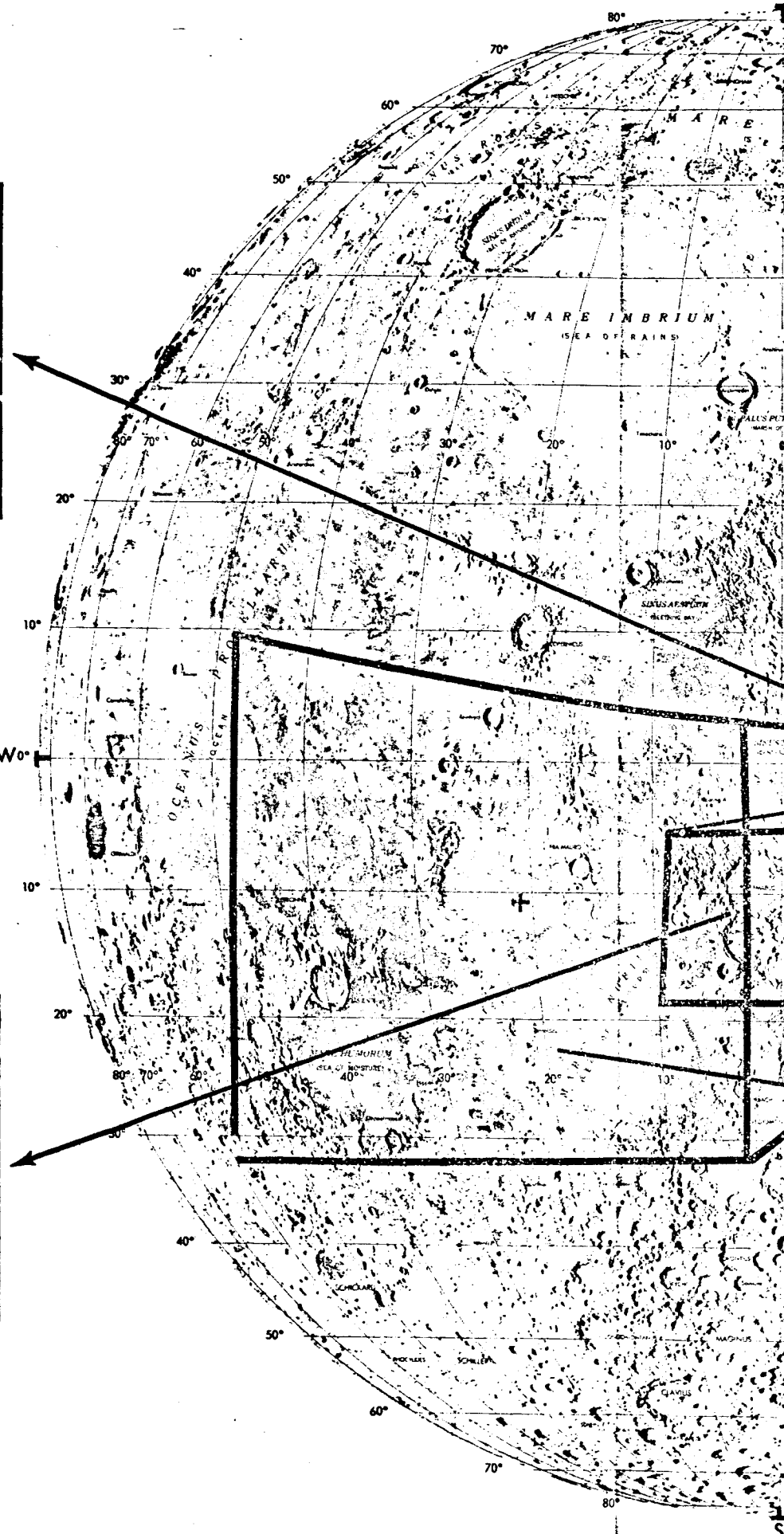
The amount of shutter blade discharge noise observed in the P2 Camera video output was considerably less during the mission than in system testing. Less than 1 percent of the P2 pictures contained shutter-blade discharge noise pulses compared with 40 percent during System Test No. 7. This reduction in noise was anticipated, based on the results of the RA-7 mission compared with test results. The reduction is attributed to the fact that during a mission, the shutter is operating in a zero gravity field so that no force existed to cause blade contact with the detent spring.

As stated, the noise pulses observed during the mission were equally distributed between the P2 and P3 Camera. This was expected since the noise on the P2 Camera video output was experienced while the camera was tested in the vertical position, and the P3 Camera exhibited the same type noise while the Spacecraft was tested in the horizontal position. Since the P3 shutter is mounted on the camera with the drive coil down, this behavior is normal.

(2) Vidicon and Nuvistor Microphonics. The vidicon mocrophonic level of the P2 Camera was higher during the final 5 minutes of the RA-8 mission than the level observed during prelaunch system testing. The vidicon mesh of the P2 Camera became microphonic after 18 minutes of full-power operation. This problem was not experienced during the major portion of prelaunch testing since most simulated missions and tests entailed less than 15 minutes of camera operating time. During the tests at RCA, however, a 30-minute operational test of the P-Channel was performed. During this test, the P2 Camera exhibited a similar microphonic signal near the end of the test run. This camera also revealed some microphonic characteristics during thermal-vacuum testing at 95°F, which were similar to the performance experienced after 18 minutes of full-power operation during the RA-8 mission.

The 35-mm films of the P2 Camera video output were studied to determine the effect of the mesh microphonics on picture quality. The magnitude of the microphonics was judged subjectively by assigning a 0-to-10 rating to each video frame. The microphonic rating scale is defined in Table 4-2. With this technique of rating the severity of observed microphonics, a video frame assigned a rating of 10 exhibits severe microphonics; a level of 5 indicates moderate microphonics; and a level of 1 indicates that the microphonics are scarcely discernible.

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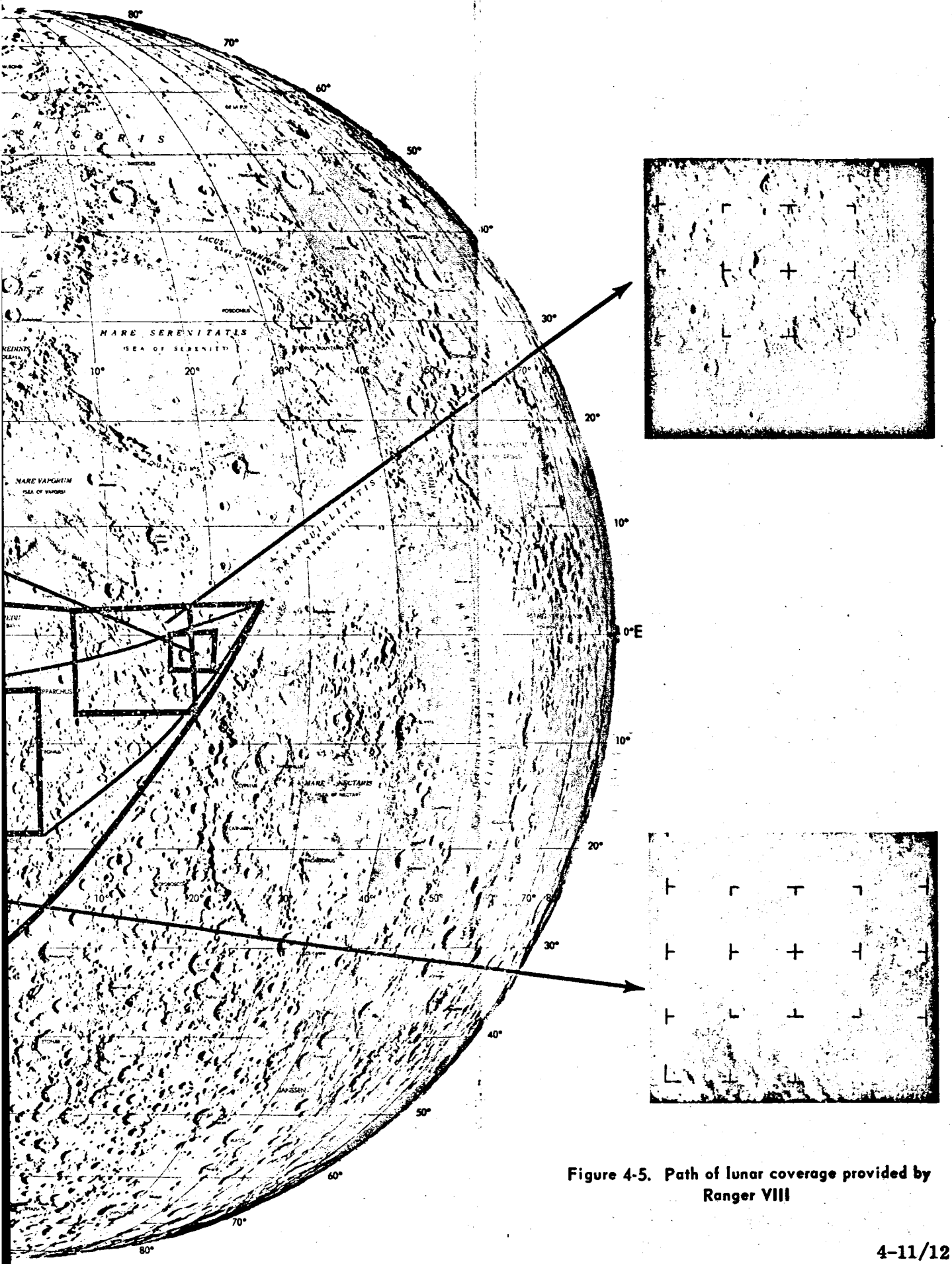

Figure 4-5. Path of lunar coverage provided by Ranger VIII

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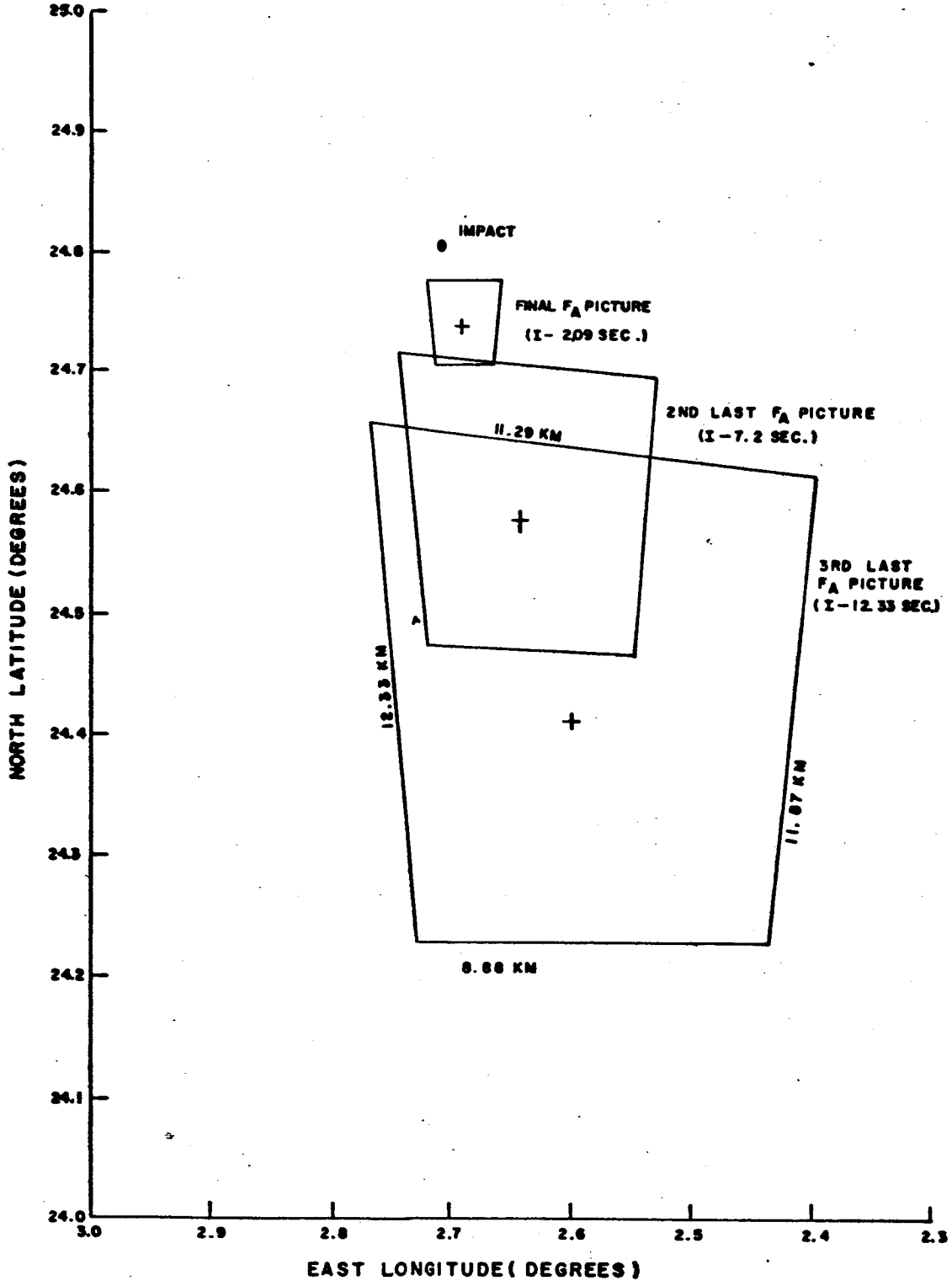

Figure 4-6. Degree of overlap provided by final three pictures from the F_a Camera

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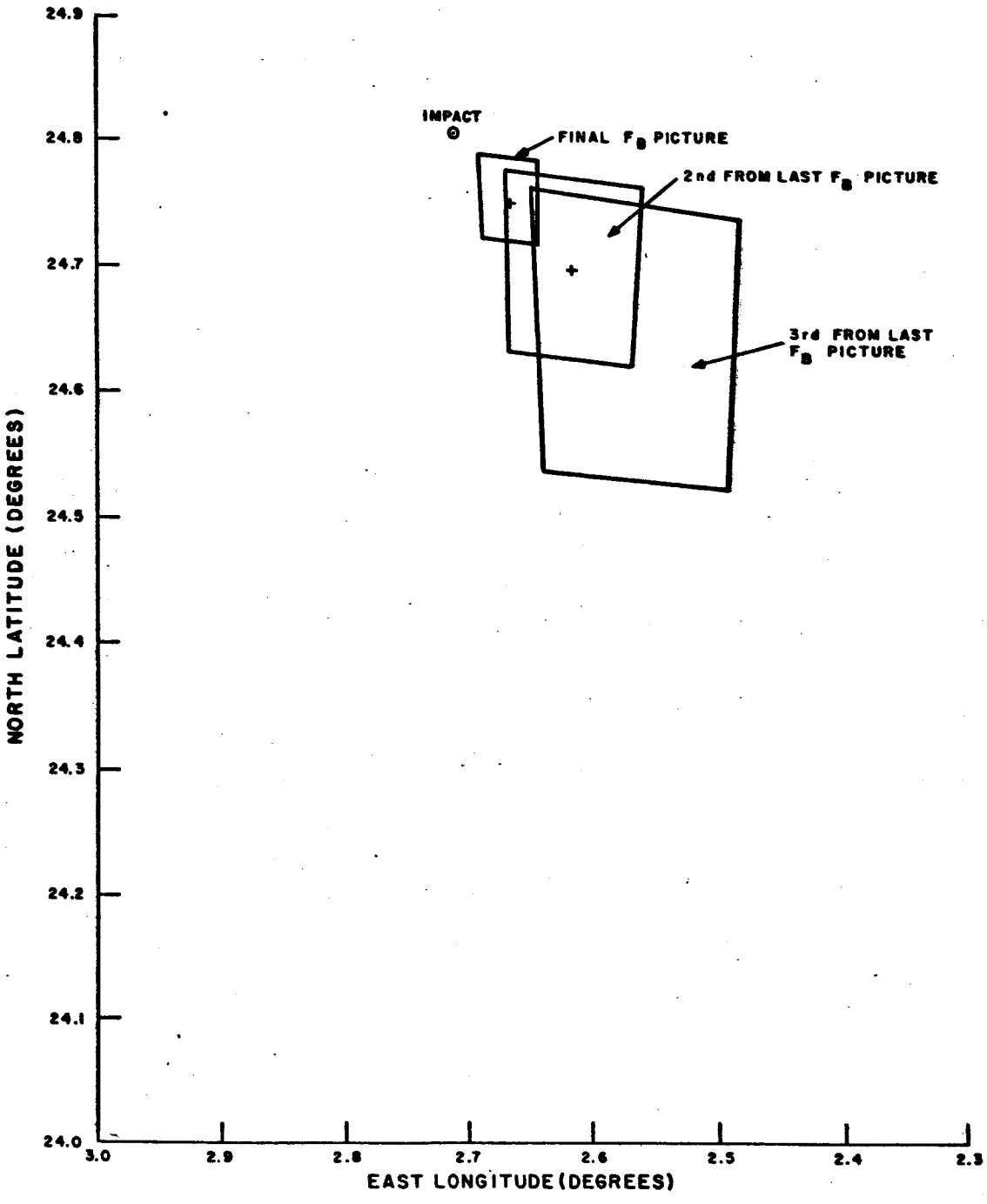

Figure 4-7. Degree of overlap provided by final three pictures from the F_b Camera

RE-ORDER No 65-350

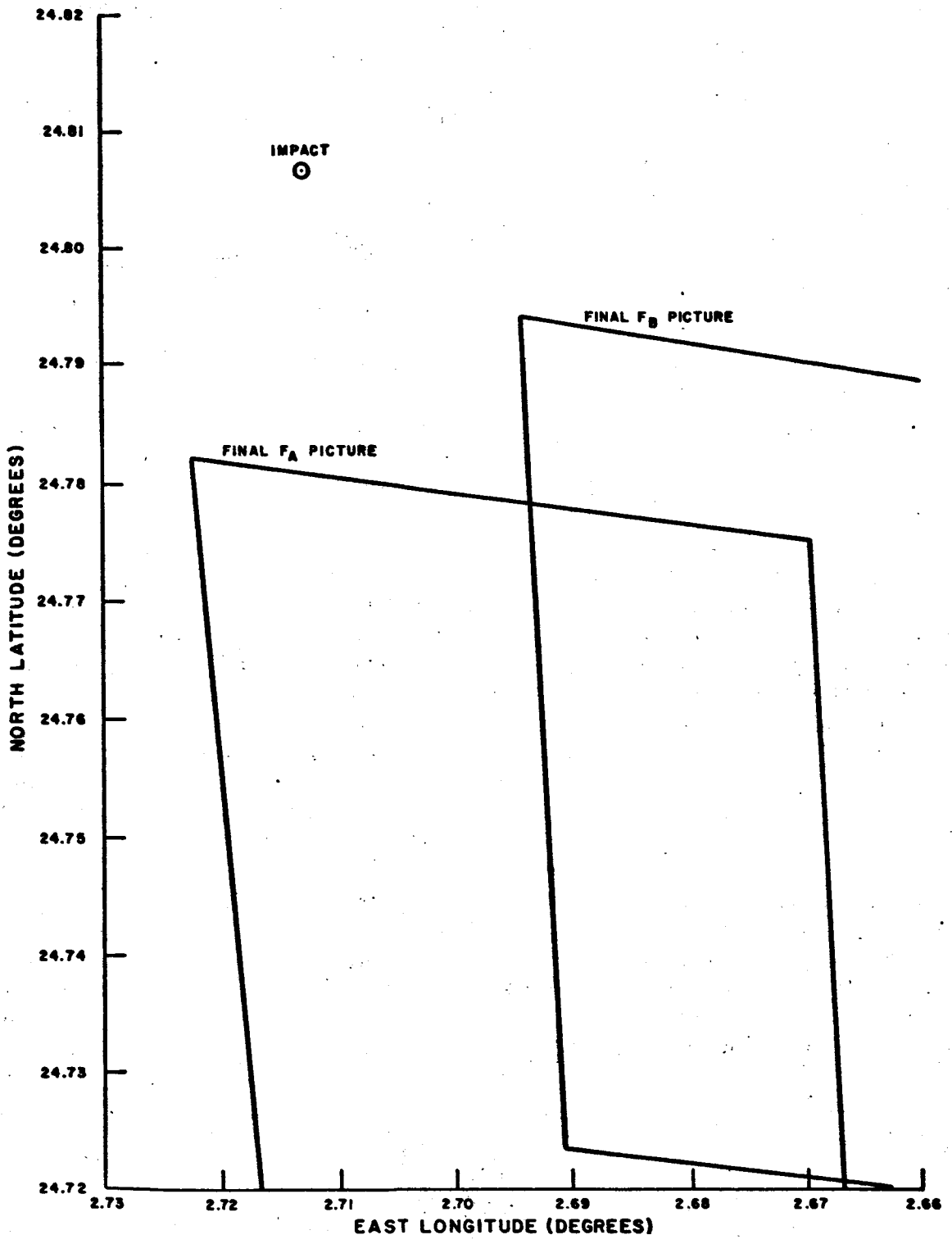

Figure 4-8. Degree of overlap provided by final pictures from the F_a and F_b Cameras

RE-ORDER No. 65-350

TABLE 4-2
MICROPHONIC RATING SCALE OF P2 CAMERA PICTURES

Rating	Severity of Microphonics
0	Not visible
1	Scarcely discernible
2 to 3	Visible, but no loss of picture detail
4 to 5	Moderate
6 to 8	Objectionable. Finer picture detail difficult to distinguish
9 to 10	Severe. Video data lost due to high-amplitude signal

A picture assigned a rating of 10 would have horizontal bars going from black to white. From the 1600 frames of P2 Camera video reviewed, 120 frames were assigned a microphonic level of 4 or 5, and 40 frames were rated at a level of 6, 7, or 8. Therefore, 160 video frames were found to have a moderate or objectionable level of mesh microphonics. Even with this number of microphonic frames, there was very little loss of video information, because the lunar scene changed very little in adjacent pictures. The microphonic level was not constant in a series of exposures, so there are non-microphonic pictures in each series of exposures of a given point on the lunar surface. Examples of P2 Camera video exhibiting moderate and severe levels of microphonics are presented in Figure 4-9.

Shutter-induced microphonics (noise appearing in the video output of a camera whose vidicon mesh is sensitive to the shock produced by shutter operation of another camera) appeared in the video outputs of three partial-scan cameras. The vidicon mesh of the P2 Camera was the most sensitive. The performance of this camera during the final 5 minutes before impact has already been discussed. Earlier in the full-power mode of the RA-8 mission, the P2 Camera exhibited the effects of sensitivity to the operation of the P4 Camera shutter. The microphonics observed appeared as amplitude displacement of a few scan lines near the bottom of the scanned raster. This noise, however, was quickly damped out. The P1 Camera also displayed the effects of sensitivity to the P3 shutter, but at a very low level. The video output of the P3 Camera displayed occasional and very low-amplitude microphonics, excited by operation of the P2 Camera shutter. The overall performance of the cameras, in relation to shutter-induced microphonics, was greatly improved by the modifications to the shutter isolators.

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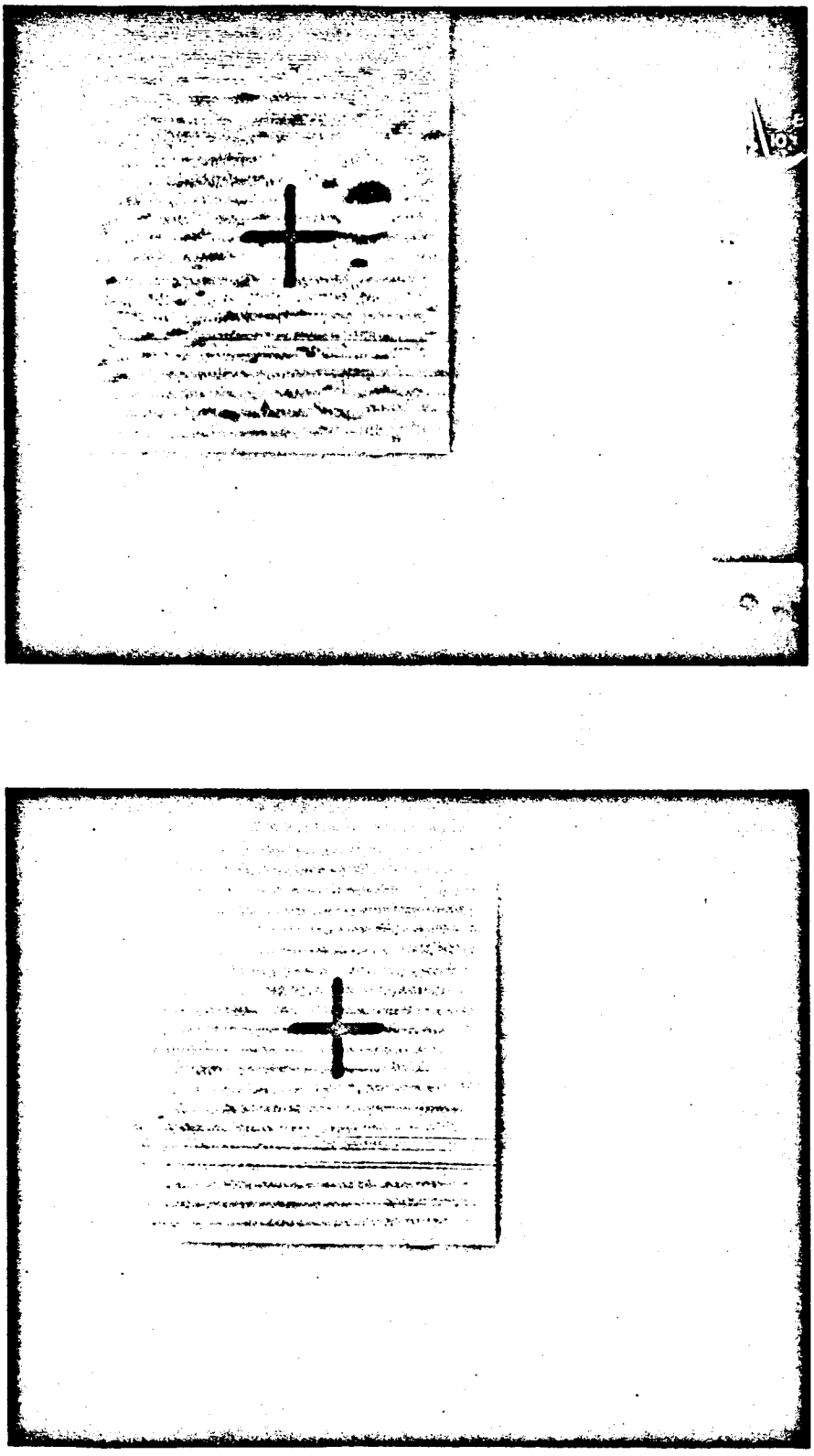

b. Severe mesh microphonics

Figure 4-9. Examples of P2 Camera video data exhibiting moderate and severe vidicon microphonics

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The video outputs of the F_a and F_b Cameras were free of vidicon and Nuvistor microphonics. Craters as small as 1/300th of the picture height are recognizable, while craters 1/200th of picture height exhibit good contrast. Shading in the full-scan pictures appears to be the same as observed during prelaunch tests.

The only partial-scan camera exhibiting nuvistor microphonics was the P3 Camera. The nuvistor of this camera was sensitive to the shutter operation of the full-scan cameras. The nuvistor microphonic signal appears as a band of disturbances of 20 milliseconds duration and having a frequency of 5-1/2 cycles per scan line, and occurs every third frame in a series of 15 consecutive frames. During this time, the position of the disturbance starts at the top and moves down the scanned raster. This microphonic noise is repeated for 15 frames in every 63 frames observed.

(3) 15-Kilocycle Crosstalk. Some 15-kc crosstalk noise was observed in the video output from the F_b Camera. This noise originates in the erase deflection circuitry of the F_a Camera. The F_b Camera is being read out while the F_a Camera is being erased and prepared for exposure. Part of the prepare cycle of the full-scan cameras involves increasing the vertical sweep read rate from 0.39 cps to 15 kc so that the scan-erase image is beyond the bandwidth of the scanning aperture and video amplifier. The sweep voltages must also be increased to ensure that a sufficient area of the photoconductor will be scanned at the 15-kc rate. The 15-kc signal present in the vertical deflection coil of the F_a Camera appears in the F_b Camera video output as a low-amplitude sine wave of 30 cycles on each horizontal scan line. The phase between the 15-kc signal and the horizontal sweep signal is nearly constant so the effect is the 30 vertical bands appearing on the picture. The amplitude of the crosstalk signal is generally less than 50 microvolts, peak-to-peak. The output of the F_a Camera was not affected by 15-kc crosstalk during the RA-8 mission.

b. Shutter-Exposure Variations

The variations in exposure between the "in" and "out" strokes of the shutters were relatively minor during the RA-8 mission. The speed of the shutter blade is approximately the same for all cameras. The RA-8 shutters were selected to give uniform exposure, and much smaller variations were noted as compared to the Ranger VII mission.

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c. Residual Image

Very little or no evidence of any residual signal from previous exposures existed in the RA-8 video data. The partial-scan cameras displayed less than one percent of residual image. The pictures from the full-scan cameras also had very little residual image, and no residual information could be observed in the final full-scan pictures.

d. Light Transfer Characteristics

Prior to launch, the light transfer characteristics of each RA-8 camera were determined. This was accomplished by measuring the response of the camera to a narrow white bar of known luminance. The response was measured at the center of the scanned format. The gains of the F_b, P1, and P2 Cameras were adjusted for a peak scene luminance of 1500 foot-lamberts, and the gains of the F_a, P3, and P4 Cameras were adjusted for a peak scene luminance of 650 foot-lamberts. The luminance of the calibration source was varied and the video excursions at the output of the distribution amplifier were recorded. The data recorded were plotted for each camera and resulted in the light transfer curves presented in Figures 4-10 and 4-11. A tape playback of the video recorded during these tests was recorded on the 35-mm film copy of the video received during the mission. By using a densitometer, the luminance of points on the lunar surface can then be determined.

3. *Analysis of RA-8 Camera Modifications*

The several modifications incorporated into the cameras of the RA-8 TV Subsystem provided improved performance over the RA-7 mission. Most of the modifications to the cameras were intended to reduce the level of microphonics experienced with particular cameras.

Some of the nuvistors used in the preamplifier circuit of the Ranger VIII cameras were preselected for minimum microphonic susceptibility. During the RA-8 mission, only the video output of the P3 Camera, for which the nuvistor was not specially selected, revealed any indications of nuvistor microphonics. In addition, the revised method of mounting the nuvistor in the camera head contributed to the reduction of microphonics. The use of polyurethane for encapsulating the nuvistor greatly reduced the sensitivity of the nuvistor to microphonics. In future cameras, the suspension of nuvistors in polyurethane material, coupled with pre-selection of the nuvistors, should eliminate the nuvistor microphonic problem.

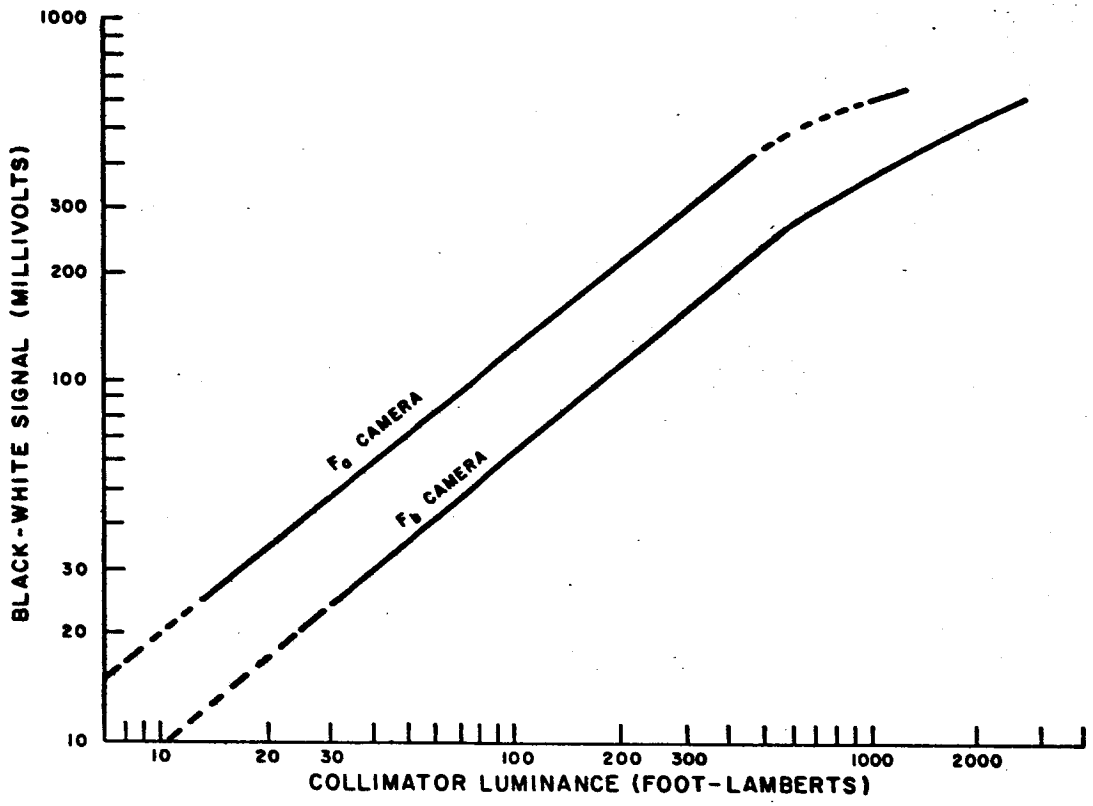

Figure 4-10. Light transfer characteristic curves for the RA-8 full-scan cameras

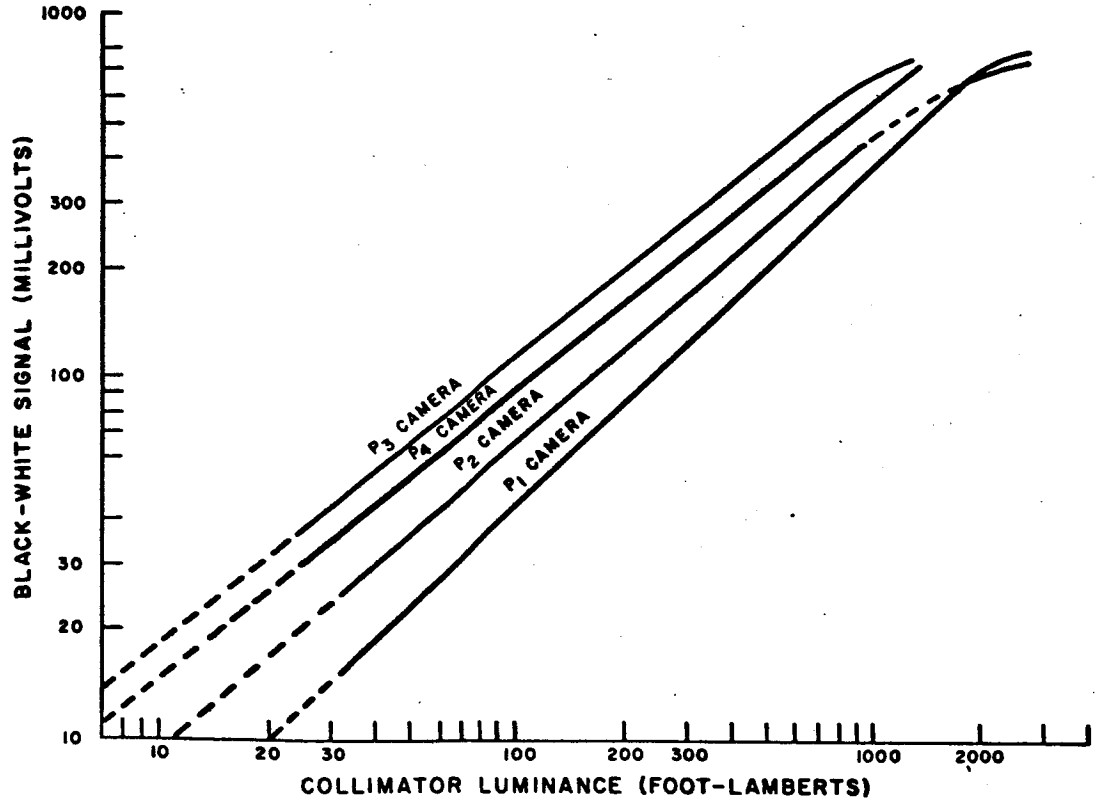

Figure 4-11. Light transfer characteristic curves for the RA-8 partial-scan cameras

Another camera modification credited with suppressing the level of microphonics was the new-design shutter isolator installed on the RA-8 cameras. The modification involved a change of the shutter shock isolators from individual grommet configurations to a complete castellated-gasket configuration designed to provide an interference fit in the camera head. The new isolator was fabricated from blue polyurethane (Thiokol formulation 5).

The new technique for aligning the vidicon and focussing the cameras resulted in higher-resolution video data during the mission. The new technique, described in Section II, was developed after a shift of the best focal plane of the cameras, between ambient and vacuum conditions, was discovered during RA-8 prelaunch tests. An additional change in the location of the focal plane resulted from the thermal expansion and contraction of camera components. The new focussing technique minimized this problem by compensating for the anticipated change in focal length in vacuum. The cameras were focussed at ambient condition with a 0.0025-inch shim installed between the lens and vidicon faceplate. When the shim was removed, the camera was properly focussed for operation in a vacuum environment.

C. Thermal Control Group

The thermal configuration of the RA-8 TV Subsystem is shown in Figure 4-12. Primary temperature-control surfaces are:

- Thermal shroud (polished aluminum vehicle skin);
- Thermal fins; and
- Thermal shields (insulators).

The construction of the shroud and fin assembly is such that solar energy striking the Spacecraft parallel to its axis illuminates only the top surfaces of the fins, i.e., no direct sunlight is incident upon the thermal shroud. The flow of thermal energy with this condition is as follows:

- Sunlight strikes the fin surface at a normal angle of incidence and a portion is absorbed. The remainder is reflected to space and other parts of the Spacecraft.
- Part of the energy absorbed by the fin is radiated from the front and rear surfaces of the fin; the remainder flows into the thermal shroud.

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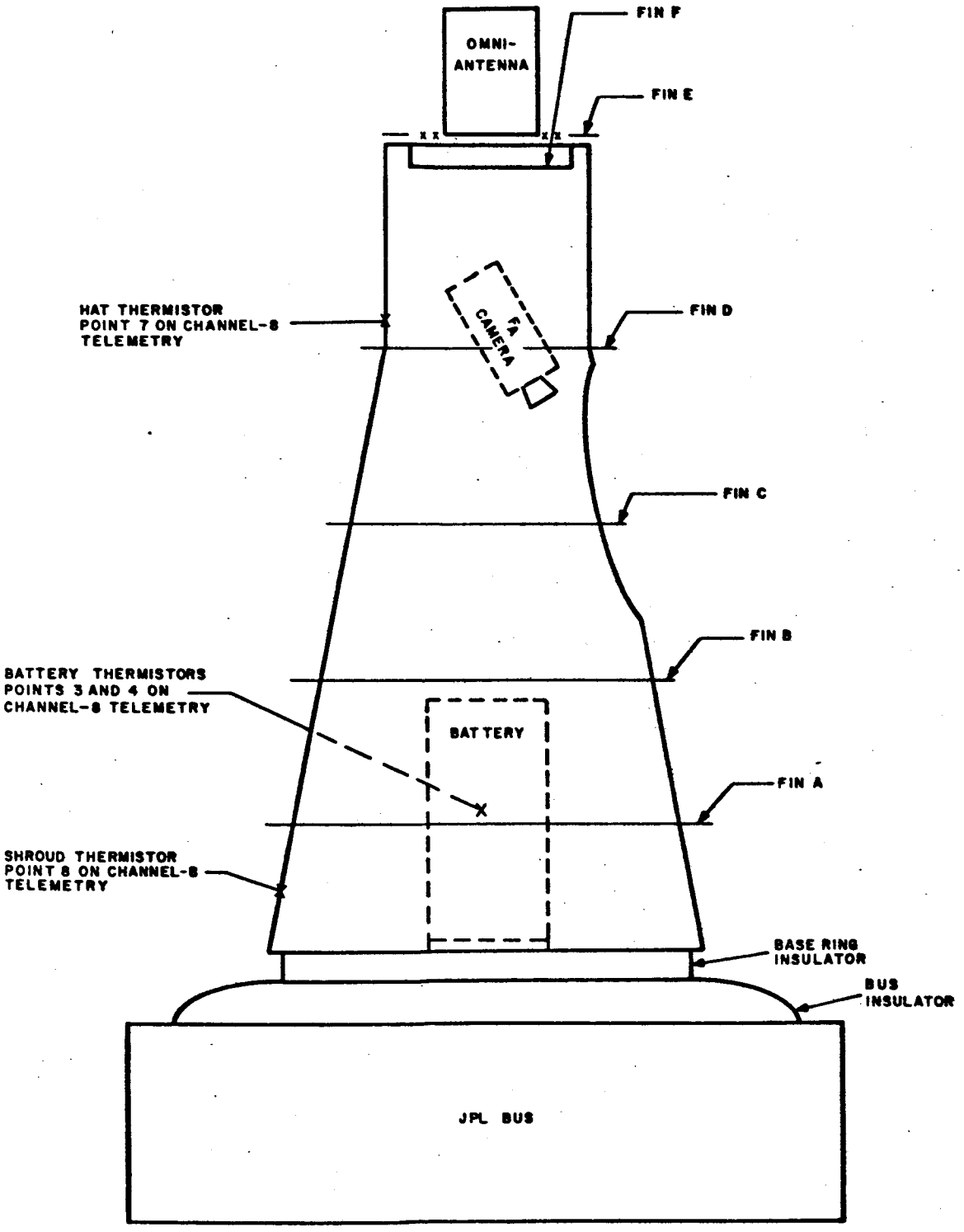

Figure 4-12. Thermal configuration of the TV Subsystem

- The energy flowing into the thermal shrouds from the fins is radiated from the shroud surface (polished aluminum), establishing a temperature field on the shroud surface.

- The temperature field established on the shroud is essentially isothermal; since the shroud envelopes all electronic equipment, the equipment will come to this same temperature at steady-state conditions. During full-power operation of the equipment, the temperatures of individual components are maintained below maximum temperature limits due to the "heat-sinking" properties of the Spacecraft.

1. Flight Temperature Predictions

To predict the flight temperatures for RA-8, the ratio factors determined from the analysis of the RA-6 flight data were used. The determination of these factors is covered in Appendix E of the "Flight Evaluation Report for Flight Model III-2," issued October 30, 1964. The equations used in the temperature calculations were derived from the "least squares fit of Spacecraft temperatures" described in Appendix D of the same report.

The energy input to the TV Subsystem was calculated by applying the ratio factors to the results of the calculations for the direct solar energy input, which was incident upon the top surfaces of the temperature-control fins. The ratio factors empirically account for reflections and deviations from predicted inputs as experienced in the RA-6 flight.

The ratio factor ψ is applicable to the inputs of fins A, B, C, and D; the ratio factor ϕ is applicable to the inputs of fins E and F. The direct solar input to fin A is given by:

$$Q_A' = S\, A_A \alpha_A$$

where

Q_A' = direct solar input to fin A

S = solar constant

A_A = area of fin A

α_A = absorptivity of fin A.

With the ratio factor applied, the input to the fins is given by:

$$\text{Fin A} = Q_A = Q_A' \psi$$

Fin B = $Q_B = Q_B' \psi$

Fin C = $Q_C = Q_C' \psi$

Fin D = $Q_D = Q_D' \psi$

Fin E = $Q_E = Q_E' \phi$

Fin F = $Q_F = Q_F' \phi$.

From previous determinations, it was found that $\psi = 1.37$ and $\phi = 0.85$. Therefore, using the RCA absorptivity (α) measurements, the input to fin A is given by:

$$Q_A = SA_A \alpha_A \psi = (0.925)\ (58.5)\ (0.48)\ (1.37) = 35.6 \text{ watts}$$

The inputs to the other fins are:

$Q_B = 48.3$ watts

$Q_C = 58.0$ watts

$Q_D = 63.4$ watts

$Q_E = 7.1$ watts

$Q_F = 29.5$ watts.

The cruise-mode telemetry equilibrium temperatures are given by the following equations:

$$\sigma T^4_{HAT} = (1.0934)X + (0.7130)Y + (0.0590)Z \times 10^{-3} \text{ watts/in}^2$$

$$\sigma T^4_{VID} = (0.9065)X + (0.6608)Y + (0.1941)Z \times 10^{-3} \text{ watts/in}^2$$

$$\sigma T^4_{SHR} = (1.1656)X - (0.2603)Y - (0.0921)Z \times 10^{-3} \text{ watts/in}^2$$

$$\sigma T^4_{BAT} = (1.0892)X - (0.0762)Y + (0.0559)Z \times 10^{-3} \text{ watts/in}^2$$

$$\sigma T^4_{CAM} = (1.0837)X - (0.1281)Y + (0.1457)Z \times 10^{-3} \text{ watts/in}^2$$

where

HAT = Thermal shroud hat, -Y side

VID = F_a Camera lens housing

SHR = Thermal shroud, -Y side, below fin A

BAT = Battery, internal, P-Channel

CAM = Camera Electronics, -Y side

σ = Stefan-Boltzmann radiation constant

T = Temperature, °K

$X = Q_A + Q_B + Q_C + Q_D + Q_E + Q_F = 241.9$ watts

$Y = -2Q_A - Q_B + Q_D + 2Q_E + 2Q_F = 17.1$ watts

$Z = -2Q_A + Q_B + 2Q_C + Q_D - 2Q_E - 2Q_F = 83.3$ watts.

Substituting these X, Y, and Z values in the equilibrium temperature equations, the results are:

σT^4_{HAT}	= 0.280	T = 23°C = 73°F
σT^4_{VID}	= 0.244	T = 13°C = 55°F
σT^4_{SHR}	= 0.274	T = 21°C = 70°F
σT^4_{BAT}	= 0.270	T = 20°C = 68°F
σT^4_{CAM}	= 0.274	T = 21°C = 70°F

Using the JPL/STL measured absorptivities (α) in the same equations, the results are:

σT^4_{HAT}	= 0.291	T = 26°C = 79°F
σT^4_{VID}	= 0.254	T = 16°C = 61°F
σT^4_{SHR}	= 0.285	T = 24°C = 75°F
σT^4_{BAT}	= 0.280	T = 23°C = 73°F
σT^4_{CAM}	= 0.286	T = 24°C = 75°F

Based on the results of the RA-7 flight data, the flight temperatures, except for the camera electronics, followed the values that were obtained by using the JPL measurements. The RA-7 flight results show that the camera electronics temperature was just below the value calculated using the RCA absorptivity measurements. The

cruise-mode temperatures predicted for the RA-7 flight are listed in Table 4-3. The equations used in calculating the remaining predicted temperatures are:

$$(\sigma T^4)_{PAF} = (1.0709)X - (0.0177)Y + (0.1532)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{PAP} = (1.0926)X - (0.0429)Y + (0.0888)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{CBR} = (1.010)X + (0.7780)Y + (0.2004)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{VREG} = (1.013)X + (0.0862)Y + (0.1228)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{TPS} = (1.0778)X - (0.0127)Y + (0.004)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{CON} = (1.1388)X + (1.6419)Y + (0.1642)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{SHRD} = (1.1013)X - (0.1818)Y + (0.0471)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{SHRBC} = (1.1174)X - (0.0427)Y + (0.2437)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{DK3} = (1.1583)X - (0.2385)Y + (0.0967)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{DK4} = (1.153)X - (0.1721)Y - (0.0808)Z \times 10^{-3} \text{ watts/in}^2$$

$$(\sigma T^4)_{DK5} = (1.0865)X - (0.0157)Y - (0.0663)Z \times 10^{-3} \text{ watts/in}^2$$

where

PAF = Power Amplifier, -X side, cavity end, F-Channel

PAP = Power Amplifier, +X side, cavity end, P-Channel

CBR = Camera Mounting Bracket

VREG = High-Current Voltage Regulator, +Y side, P-Channel

TPS = Transmitter Power Supply, +X side, P-Channel

CON = Temperature Control Plate, center (fin F)

SHRD = Thermal Shroud, +Y side, below fin A

SHRBC = Thermal Shroud, -Y side, between fins B and C

DK 3 = Deck No. 3, -Y side

DK 4 = Deck No. 4, -Y side

DK 5 = Deck No. 5, -Y side.

TABLE 4-3
CRUISE-MODE EQUILIBRIUM TEMPERATURE PREDICTIONS FOR FLIGHT MODEL III-2

Location on TV Subsystem	Calculated by RCA Absorptivity Temperature		Calculated by JPL/STL Absorptivity Temperature		Actual Flight Telemetry, RA-8 Temperature	
	°C	°F	°C	°F	°C	°F
Thermal Shroud, Hat, (-Y side)	23	73	26	79	29	84
Camera Lens Housing	13	55	16	61	18	65
Thermal Shroud, (-Y side, below fin A)	21	70	24	75	26	79
P-Battery, Internal	20	68	23	73	27	80
Camera Electronics, (-Y side)	21	70	24	75	22	71
F-Channel Power Amplifier, (-X side, cavity end)	21	70	24	75	-	-
P-Channel Power Amplifier, (+X side, cavity end)	21	70	24	75	-	-
Camera Mounting Bracket	21	70	23	73	-	-
P-Channel HCVR, (+Y side)	17	63	20	68	-	-
P-Transmitter Power Supply, (+X side)	18	64	21	70	-	-
Temperature Control Plate (fin F)	30	86	33	91	-	-
Thermal Shroud, (+Y side, below fin A)	20	68	23	73	-	-
Thermal Shroud, (-Y side, between fins B & C)	26	79	29	84	-	-
Deck No. 3, (-Y side)	25	77	28	82	-	-
Deck No. 4, (-Y side)	21	70	24	75	-	-
Deck No. 5, (-Y side)	17	63	20	68	-	-

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2. *Thermal-Control Paints Applied to RA-8*

The paints used on the fins of the RA-8 TV Subsystem were a mixture of PV-100 white paint and MIL-E-5557 type III black paint and are identified as light gray (RCA Drawing 1758619-29) and dark gray (RCA Drawing 1758619-30), respectively. Mixtures of the gray paints were prepared in November 1964 for use on the RA-8 TV Subsystem. In an effort to obtain the same flight temperatures on RA-8 as occurred on RA-7, the solar absorptivities of the paints were decreased. This decrease allowed for the increased solar constant at the time of the anticipated February launch. The desired values of solar absorptivity for the RA-8 paints were 0.48 and 0.67 as compared with 0.51 and 0.71 for RA-7. Samples of the paint were sent to JPL for measurement at STL. The spectral-measurement history of these paints, which were used in the final finishing of the thermal shroud, is given in Table 4-4.

TABLE 4-4
SPECTRAL-MEASUREMENT HISTORY

Paint Description	Absorptivity Measured By:	Design Absorptivity Values Desired	Samples Painted at RCA (Nov. 1964)	Samples Painted During Painting of RA-8 Fins at JPL (Dec. 1964)	RA-8 Fins Measured with Portable Reflectometer at ETR (Feb. 1965)
Light Gray RCA 1758619-29	RCA	0.48	0.49	0.49	0.49
	JPL/STL	0.51	--	0.52	--
Dark Gray RCA 1758619-30	RCA	0.67	0.65	0.65	0.65
	JPL/STL	0.71	--	0.69	--

Measurements of absorptivity at ETR on the RA-8 thermal shroud fins were obtained using the Lion Model 25A portable reflectometer and the RCA prepared calibration standards. The accuracy of this reflectometer is estimated to be ±5 percent.

The paint used on the omni-antenna was white PV-100.

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3. RA-8 Cruise-Mode Temperatures vs. Flight Predictions

a. Thermal Shroud Hat

The temperature of the hat was monitored during cruise mode by Channel 8 (15-point) telemetry, data point No. 7. From time of launch until Sun and Earth acquisition, the temperature of the hat, which is a sheet-metal structure with a low-heat capacity, increased to 88°F. The temperature then decreased and within 16 hours reached stability at 84°F. During midcourse maneuver, the temperature of the hat varied from 100°F to 78°F. When Sun and Earth acquisition was again accomplished, the temperature of the thermal shroud hat restabilized at 84°F until impact.

The predicted temperature range during stabilized cruise mode was from 70°F to 90°F. The hat reacts significantly to small changes in energy input because it is large in area and low in thermal mass. It is for this reason that the temperature fluctuations occur when the axis of the Subsystem is not normal to the Sun, as is the case early in flight and during the midcourse maneuver.

b. Camera Lens Housing

The temperature of the F_a-Camera lens-housing was monitored during cruise mode by data point No. 1 of the 15-point telemetry. The camera lens-housing temperature increased from 83°F at launch to 86°F before Sun and Earth were initially acquired. The temperature steadily decreased and within 16 hours after launch reached stability at 65°F. Midcourse maneuver did not appear to affect the lens-housing temperature. During the last 2 hours before impact, including terminal operation, the F_a Camera lens-housing increased 9°F. This rise in temperature was attributed to the energy reflected from the Moon.

The predicted temperature range of the camera lens housing during stabilized cruise mode was from 52°F to 72°F. The temperature increase due to the light reflected from the Moon to the camera lens area was predicted, based upon the flight of RA-7, to be between 7.5 and 8.5°F, dependent upon impact site.

c. Thermal Shroud (-Y Side, Below Fin A)

The temperature of the thermal shroud in the area below fin A on the -Y side was monitored by data point No. 8 of the 15-point telemetry. During the period between launch and initiation of midcourse maneuver, the temperature of this point

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decreased steadily from a launch temperature of 85°F to 81°F. Upon initiation of the midcourse maneuver, this area was exposed to an increased solar input and rose sharply to 95°F, cooling rapidly to 80°F after the Sun and Earth were reacquired. Temperature stability was obtained at 79°F after 45 hours of flight. During terminal operation, the temperature increased 14°F.

The predicted temperature range for stabilized cruise mode was from 64°F to 84°F.

d. P-Channel Battery

The temperature of the P-Channel Battery was monitored during cruise mode by an internally located thermistor (data point No. 4 of the 15-point telemetry). The Batteries, which are high in thermal mass, were not affected by transient changes in solar input as occurs during midcourse and terminal maneuvers. The Battery temperature steadily decreased from a launch temperature of 84°F to a stabilized cruise temperature of 80°F after 45 hours of flight. During terminal operation, the Battery temperature increased by 4°F.

The predicted temperature range during stabilized cruise mode was from 65°F to 85°F.

e. Camera Electronics

The Camera Electronics temperature was monitored during cruise mode by data point No. 11 of the 15-point telemetry. Reaction of this equipment to brief changes in solar input, as occurs during the midcourse and terminal maneuvers, is limited by the thermal mass and location within the TV Subsystem. Temperature of this component decreased from 83°F at launch to a stable temperature of 71°F within 20 hours of flight. Terminal operation caused a 10°F increase in the temperature of these units.

The predicted temperature range during stabilized cruise mode was from 56°F to 76°F.

f. Summary

Temperatures of the five points monitored during cruise mode were all within 5°F of the midpoint of the predicted range of stabilized cruise-mode temperatures. Thus, the temperatures of the spacecraft were within the range of desirable operation for the initiation of terminal operation as verified during a number of tests at this same level. A comparison of test temperatures and flight temperatures for the same period of operation are listed in Table 4-5.

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TABLE 4-5
RA-8 TEMPERATURES VS. FLIGHT TEMPERATURES

Telemetry Point Location	III-3 Test Cruise Mode		III-3 Test 23 Min Full Power		III-3 Test 30 Min Full Power		RA-8 Flight Stabilized Cruise Mode Prediction		RA-8 Actual Flight Stabilized Cruise		RA-8 Impact 23 Min Full Power	
	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
P-Channel Battery, Internal	24	75	27	80	30	86	24 ±5	75 ±10	26	79	29	84
F-Channel Battery, Internal	23	73	27	80	29	84	--	--	--	--	29	84
P-Channel Battery, External	23	73	26	79	29	84	--	--	--	--	29	84
F-Channel Battery, External	23	73	27	80	29	84	--	--	--	--	29	84
F_a Camera Lens Housing	28	82	28	82	28	82	16 ±5	61 ±10	18	64	24	75
Camera Mounting Bracket	27	80	27	80	27	80	--	--	--	--	28	82
Camera Electronics	29	84	37	98	39	102	19 ±5	66 ±10	21	70	27	80
Thermal Shroud Hat (-Y)	21	70	24	75	24	75	27 ±5	80 ±10	29	84	29	84
Thermal Shroud Lower (-Y)	25	77	32	89	35	95	24 ±5	75 ±10	26	79	33	91
Thermal Shroud Lower (+Y)	25	77	30	86	33	91	--	--	--	--	34	93
Bulkhead Near P-Channel P.A.	26	79	48	118	54	129	--	--	--	--	50	122
Bulkhead Near F-Channel P.A.	27	80	52	125	56	133	--	--	--	--	52	125
Deck 5 (-X, -Y)	21	70	27	80	30	86	--	--	--	--	34	93
Deck 4 (+Y)	25	77	32	89	35	95	--	--	--	--	36	97
Deck 4 (-Y)	26	79	35	95	33	102	--	--	--	--	38	100

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D. Telecommunications Group

Evaluation of telecommunications performance during the RA-8 mission is based on the r-f power transmitted by the F- and P-Channel Transmitters. The data obtained during the RA-8 mission supports the contention that the communications performance compared closely with the results of prelaunch final system tests, which were nominal.

This section describes the various techniques that were employed to measure the r-f power transmitted for each channel from the TV Subsystem Four-Port Hybrid. The results of the different power-measuring techniques vary by ±1 db; however, this is of no consequence, since the received r-f signal level was 10 db above receiver threshold. At such a strong signal level, the peak-to-peak signal-to-rms noise ratio was approximately 40 db, and no degradation of picture quality would have occurred as the result of a 1-db decrease in the received signal level.

1. *RF Power Output During Terminal Mode*

Several techniques were employed to measure the r-f power output of the F- and P-Channel Transmitters during terminal mode of the RA-8 mission. RCA used two techniques: one employing a spectrum analyzer, and the other employing a diode detector. JPL measured the r-f output power by means of a third technique, which employed a filter system.

a. Spectrum Analyzer Technique

A spectrum analyzer was connected to the output of one of the 30-Mc isolation amplifiers as shown in Figure 4-13. The JPL Beacon and RCA Transmitter signal levels were approximately 2 db higher than anticipated; however, the difference between the two levels was approximately 19 db, which indicates that the power output from the Four-Port Hybrid Assembly on the Spacecraft was approximately 30 watts per channel.

b. Diode-Detector Power Monitor Technique

At the Pioneer site of the Goldstone Tracking Station, a special technique was employed to measure and record the r-f signal levels from the F- and P-Channel Transmitters as referred to the r-f signal input at the maser amplifier on the JPL ground antenna. The configuration used to effect the measurements is shown in Figure 4-13. A diode-detector circuit was incorporated into the dual-channel limiter amplifier. This circuit, shown in Figure 4-14, detects the i-f signal in the dual-channel limiter

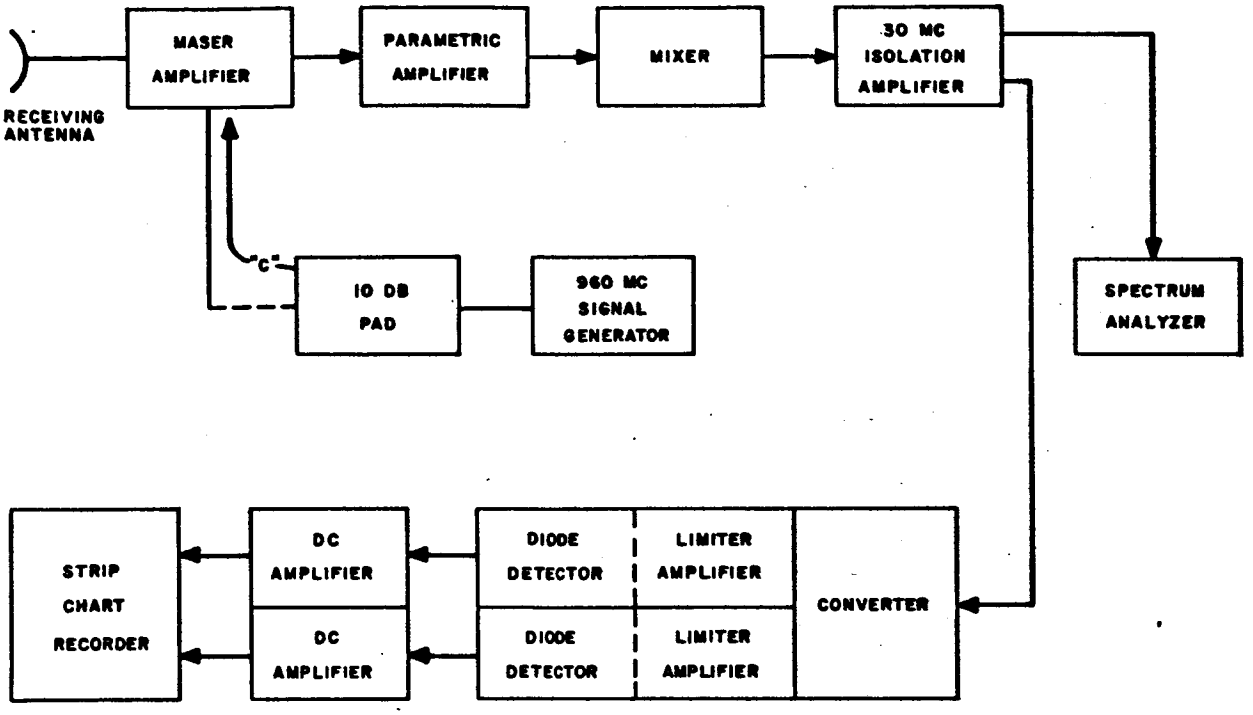


Figure 4-13. Diode-detector technique of terminal-mode power measurement

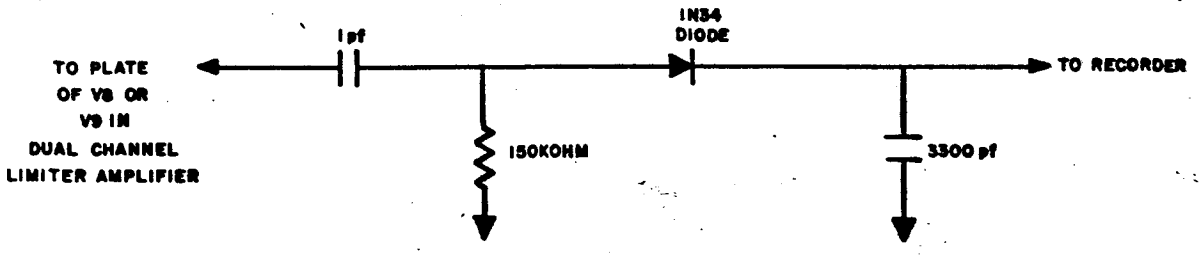


Figure 4-14. Diode-detector circuit.

amplifier before the signal is limited, and provides a d-c output, which varies as a function of r-f signal strength.

The d-c signal is then amplified in a Sanborn Model 150-1000-A amplifier, and used to drive the pen of a Sanborn Model 154-100B strip-chart recorder. A separate readout is obtained for each channel.

The power-monitor configuration was designed to provide an accurate means of calibration. The calibration was accomplished by feeding a signal from a Hewlett-Packard Model 612A signal generator, set to the frequency of the appropriate channel Transmitter, through the path indicated by "C" in Figure 4-13. The power-loss figure through this path, from the RCA room to the maser amplifier, was provided by JPL.

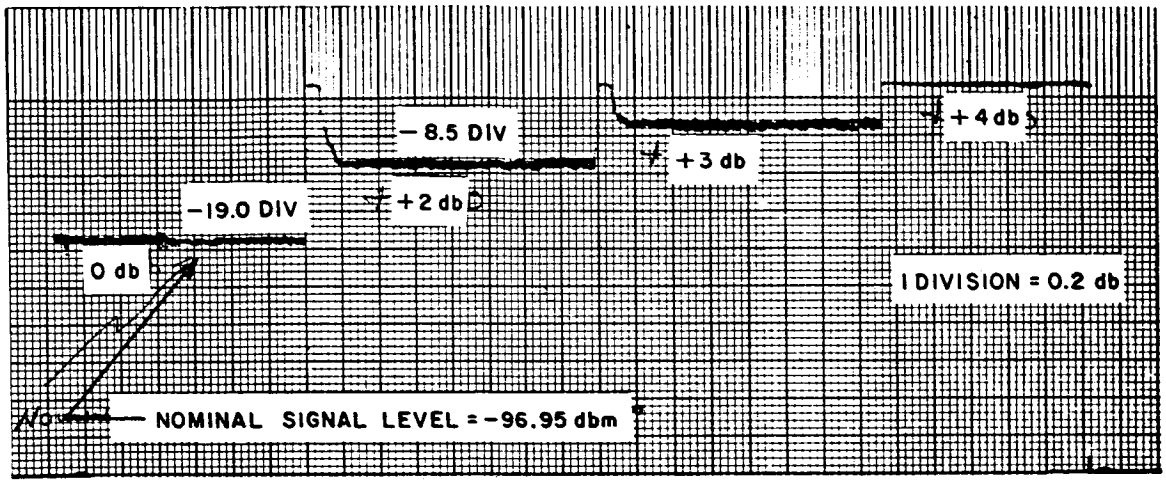
Based on a nominal-mission signal level of -96.95 dbm at the maser amplifier, the required output level setting of the signal generator was calculated as follows:

Loss, RCA room to maser amplifier	44.85 db
Loss, 10-db pad and signal generator cable	11.10 db
Total losses	55.95 db
Nominal mission signal level at maser amplifier	-96.95 dbm
Signal generator setting required for nominal signal	-41.00 dbm

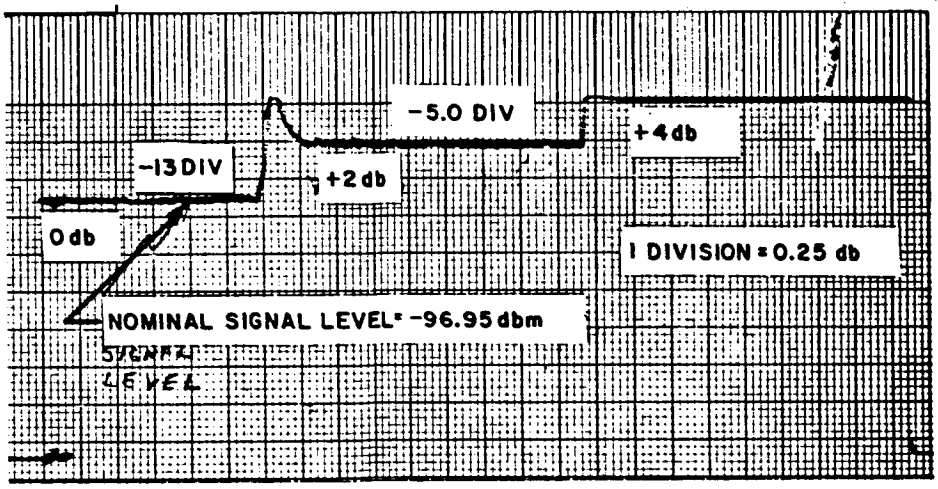
The gains of the d-c amplifiers were then adjusted to provide readouts at about 3/4 full scale on the strip-chart recorder for a nominal -96.95 dbm input to the maser amplifier. The strip-chart recorder was also calibrated at a +2 db interval, and in 3 db intervals down to -21 db.

Calibrations were performed just before ground-station acquisition of the Spacecraft (approximately 4.5 hours before TV Subsystem warmup) and within 5 minutes after impact. The same calibration signal was also used to calibrate the vertical scale of the spectrum analyzer. Coincident with these calibrations, the front end bandwidth and maser-amplifier gain were checked by JPL. The bandpass curve for the 30-Mc amplifiers remained essentially unchanged from pre-acquisition of the Spacecraft to post-impact. The gain of the maser amplifier decreased from 10 db to 9.15 db during this same period.

Using the post-impact calibration results obtained 5 minutes after impact, the data recorded by the diode-detector, power-monitor technique indicated power outputs from the F- and P-Channel Transmitters that were 1 db above the anticipated levels. The post-impact power calibration recordings for F- and P-Channel are presented in Figure 4-15.



a. F-Channel power - calibration signal



b. P-Channel power - calibration signal

Figure 4-15. Post-impact calibration signals for F- and P-Channel power-output calculations

Figure 4-16 shows the power profiles recorded during the first 2 minutes of full-power operation. The calculations of the power output for each channel during these first 2 minutes are also given. Figure 4-17 is a plot of the power profiles for the F- and P-Channels that result from the diode-detector power-monitor technique, using values of power losses provided by JPL. The power output for each minute of full-power operation is presented in Table 4-6. The power profile was excellent, as anticipated.

The strip-chart recordings obtained during the mission were in error as to the absolute magnitude of the received signal level. The recordings did, however, indicate a smooth amplitude as a function time over the 23-minute full-power operation, and would have recorded the time and relative amplitude of any momentary reduction of Transmitter power output, if such a malfunction had occurred.

c. JPL Power-Measuring Technique

In the r-f power measuring technique used by JPL at the Echo site, the output signal from the 30-Mc isolation amplifiers was heterodyned to a 2-Mc signal and applied to three separate filters, which were centered at an equivalent of 959.52 Mc (center frequency of F-Channel), 960.05 Mc (center of frequency of JPL Beacon), and 960.58 Mc (center frequency of P-Channel). The F-Channel filter had a 3-db bandwidth of 900 kc. The output of each filter was connected to a high-frequency, true-rms voltmeter, type 3400a, which had a 3-db bandwidth from 10 cps to 8 Mc.

The JPL configuration is shown in Figure 4-18. Calculation of the F-Channel output power using the JPL power-monitor technique is as follows:

(1) The output of the F-Channel filter at full power plus 20 minutes was -16.00 dbv;

(2) The output of the F-Channel filter after impact (antenna still pointing at moon) was -36.50 dbv;

(3) $C/N = {}^{C+N}/_{N} = 20.5$ db

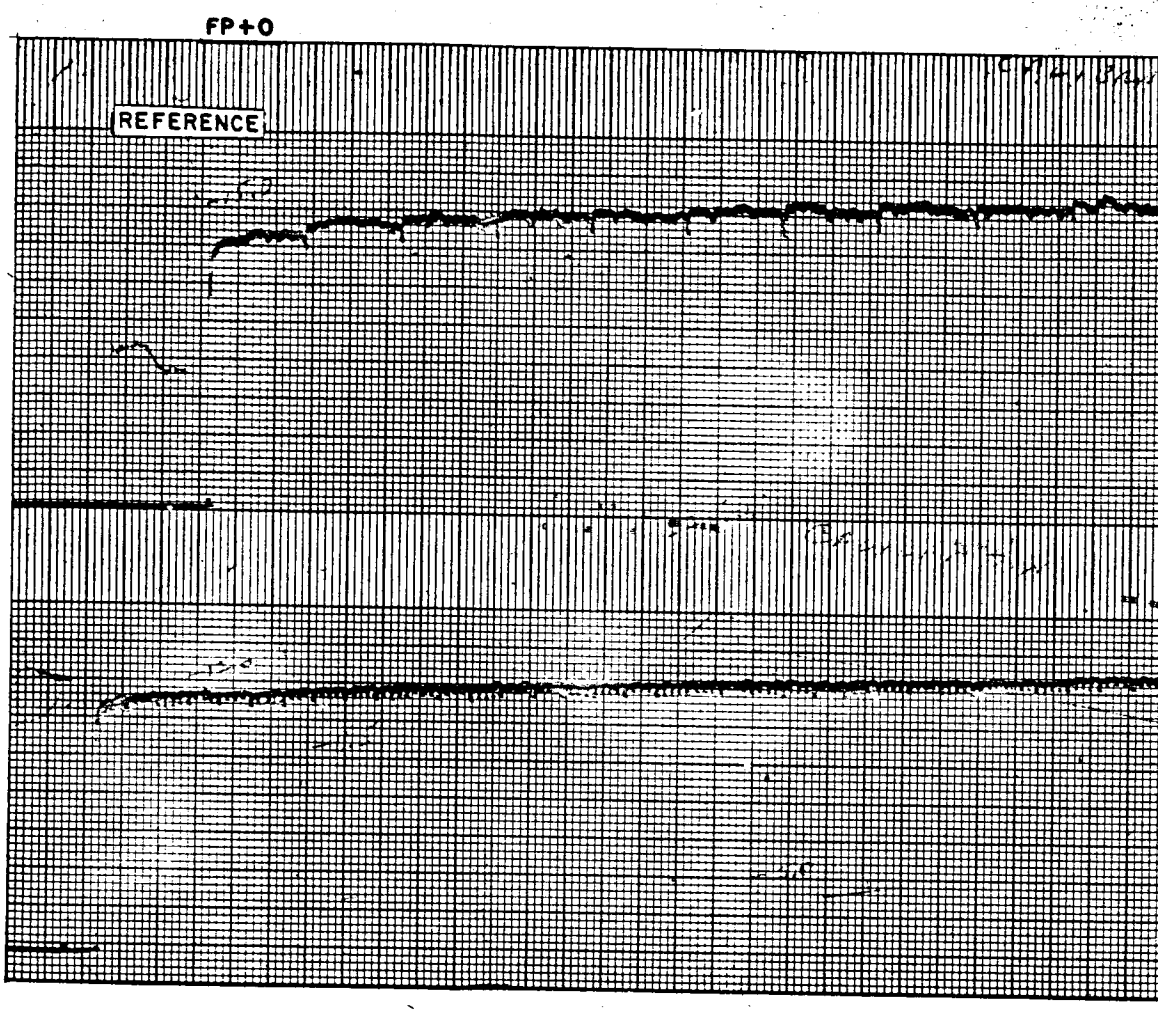
(4) System noise level (N) at the input to the maser amplifier is kTB,

where

k is Boltzman's constant;

T is receiver temperature, and

B is the bandwidth of the F-Channel filter;



LOSSES FROM FOUR PORT HYBRID OUTPUT TO MASER AMPLIFIER INPUT

1. TOTAL LOSSES

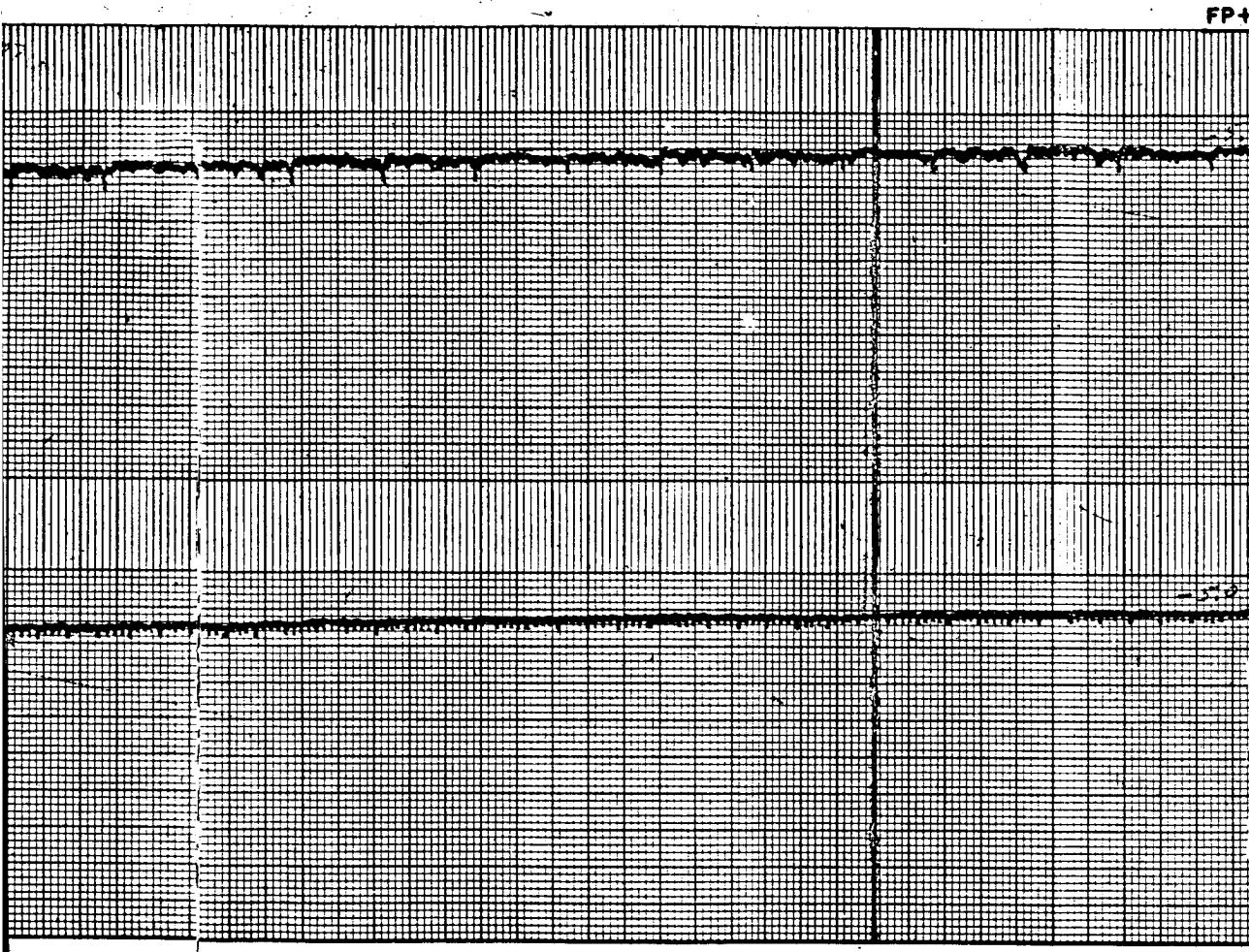
J.P.L. SPACECRAFT	1.37 db
ANTENNA POINTING	0.30
POLARIZATION	0.14
SPACE PATH LOSS	203.50
RECEIVER CIRCUIT	0.53
TOTAL LOSSES	205.82 db

2. ANTENNA GAINS

TRANSMITTING ANTENNA	20.28 db
RECEIVING ANTENNA	45.70
TOTAL GAIN	65.98 db

3. NET LOSS (4-PORT HYBRID OUTPUT TO MASER AMPLIFIER INPUT)

	205.82 db
	65.98
	139.84 db



POWER OUTPUT AT FULL-POWER PLUS 10 SECONDS

1. F-CHANNEL POWER OUTPUT

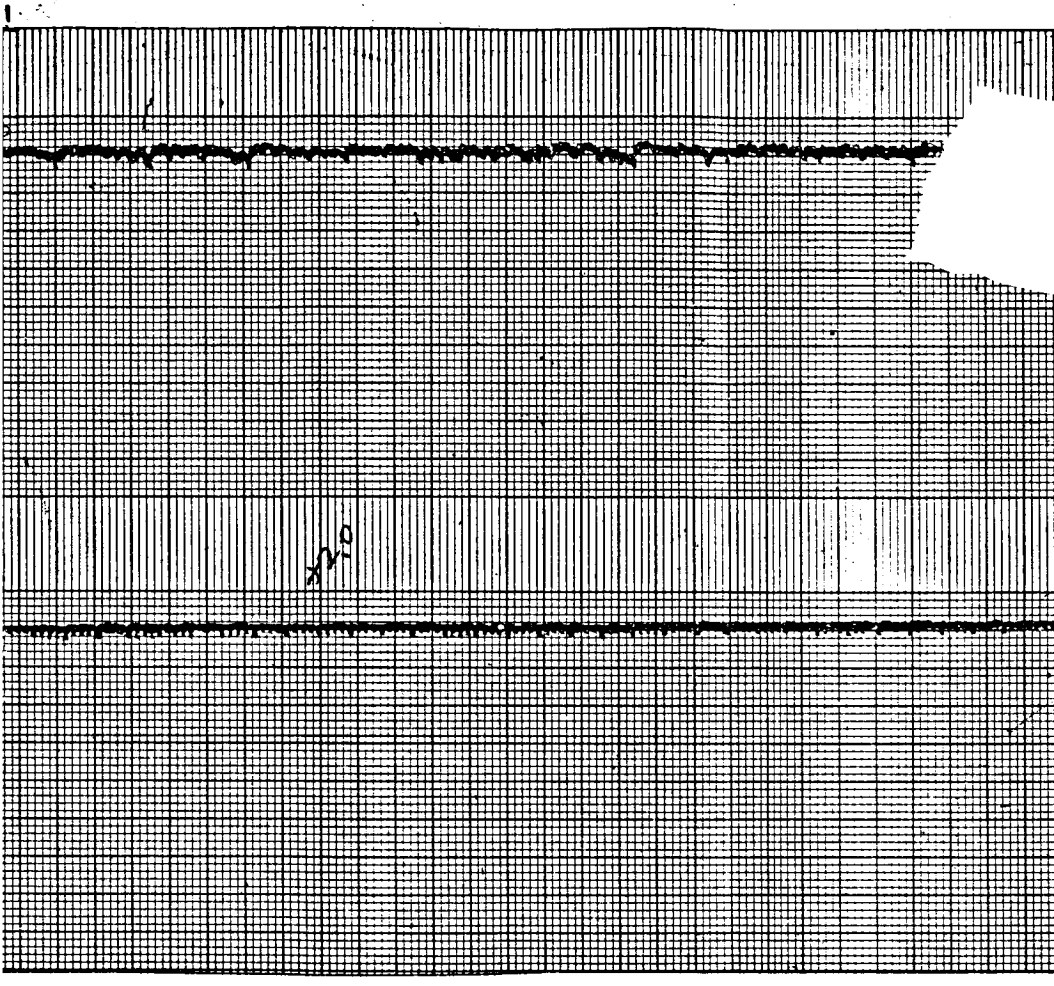
a. F-CHANNEL POWER AT INPUT TO MASER AMPLIFIER = NOMINA
PLUS DIFFERENCE BETWEEN NOMINAL AND RECEIVED SIGNA
F-POWER = −96.95 dbm + (19 − 14 DIVISIONS)(0.2 db/DIV)
= −95.95 dbm

b. F-TRANSMITTER POWER OUTPUT AT 4-PORT HYBRID = INPU
MASER AMPLIFIER PLUS NET LOSSES TO SPACECRAFT
F-POWER = −95.95 dbm + 139.84 dbm = + 43.89 dbm
= 24.4 WATTS

2. P-CHANNEL POWER OUTPUT

a. P-CHANNEL POWER AT INPUT TO MASER AMPLIFIER
P-POWER = −96.95 dbm + (13 − 11 DIVISIONS)(0.25 db/DIV)
= −96.45 dbm

b. P-TRANSMITTER OUTPUT AT 4-PORT HYBRID
P-POWER = −96.45 + 139.84 = + 43.39 dbm
= 21.8 WATTS



L SIGNAL
L LEVELS

T AT

POWER OUTPUT AT FULL-POWER PLUS I MINUTE

1. F-CHANNEL POWER OUTPUT

a. F-CHANNEL POWER AT INPUT TO MASER AMPLI

F-POWER = 96.95 dbm + 2db + (8.5 - 5 DIVISIONS)(C

= 94.25 dbm

b. F-TRANSMITTER POWER OUTPUT AT 4-PORT

F-POWER = 94.25 dbm + 139.84 dbm = + 45.59

= 36.1 WATTS

2. P-CHANNEL POWER OUTPUT

a. P-CHANNEL POWER AT INPUT TO MASER AMPL

P-POWER = - 96.95 dbm + 2 dbm

= - 94.95 dbm

b. P-CHANNEL TRANSMITTER OUTPUT TO 4-POR

P-POWER = 94.95 dbm + 139.84 dbm = + 44.89 d

= 30.9 WATTS

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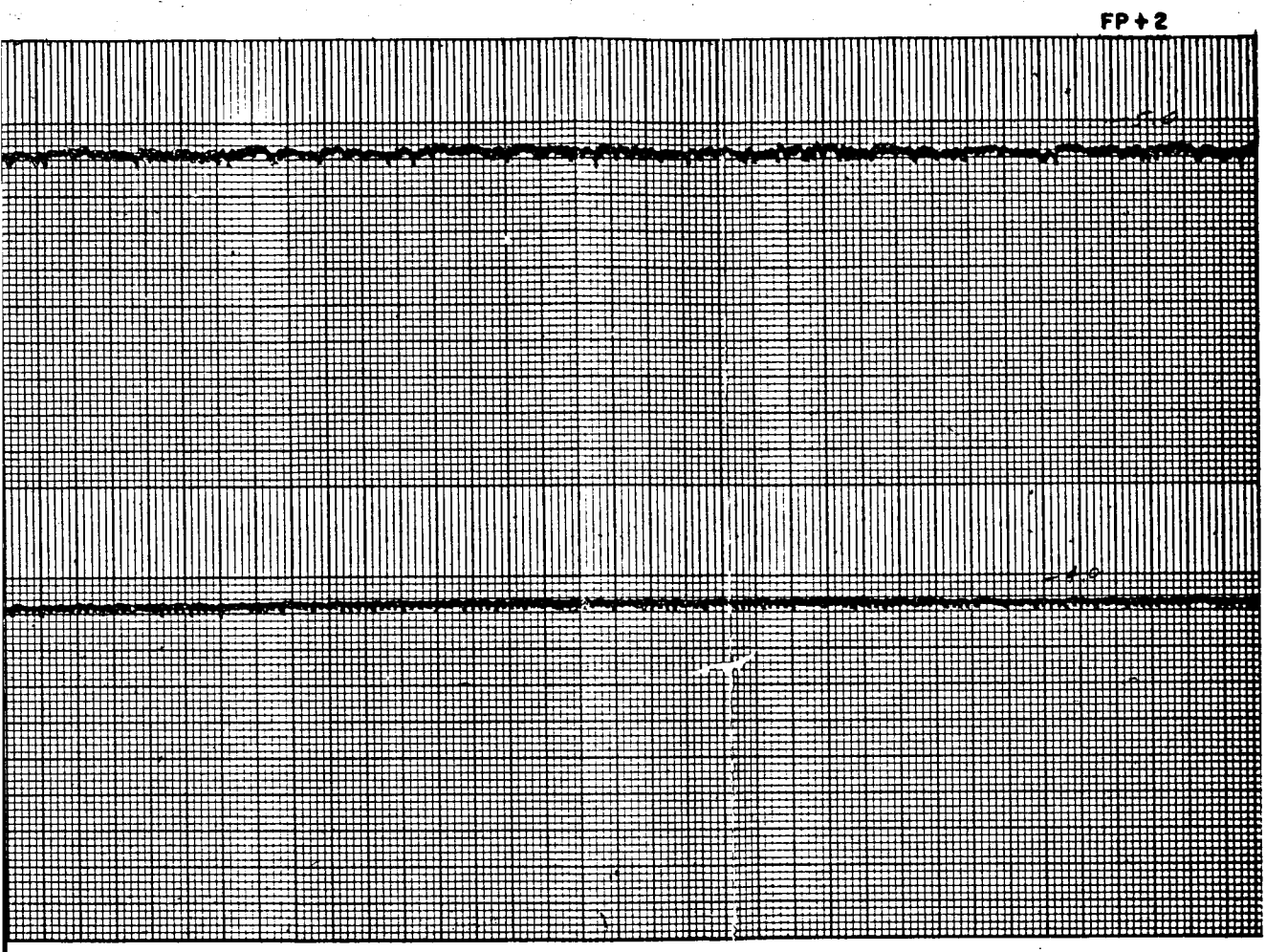

POWER OUTPUT AT FULL-POWER PLUS 2 MINUTES
1. F-TRANSMITTER OUTPUT = 36.1 WATTS
2. P-TRANSMITTER OUTPUT = 32.6 WATTS

IER
2 db/DIV)

YBRID
bm

FIER

HYBRID
m

Figure 4-16. F- and P-Channel power profile; turn-on to full power plus two minutes

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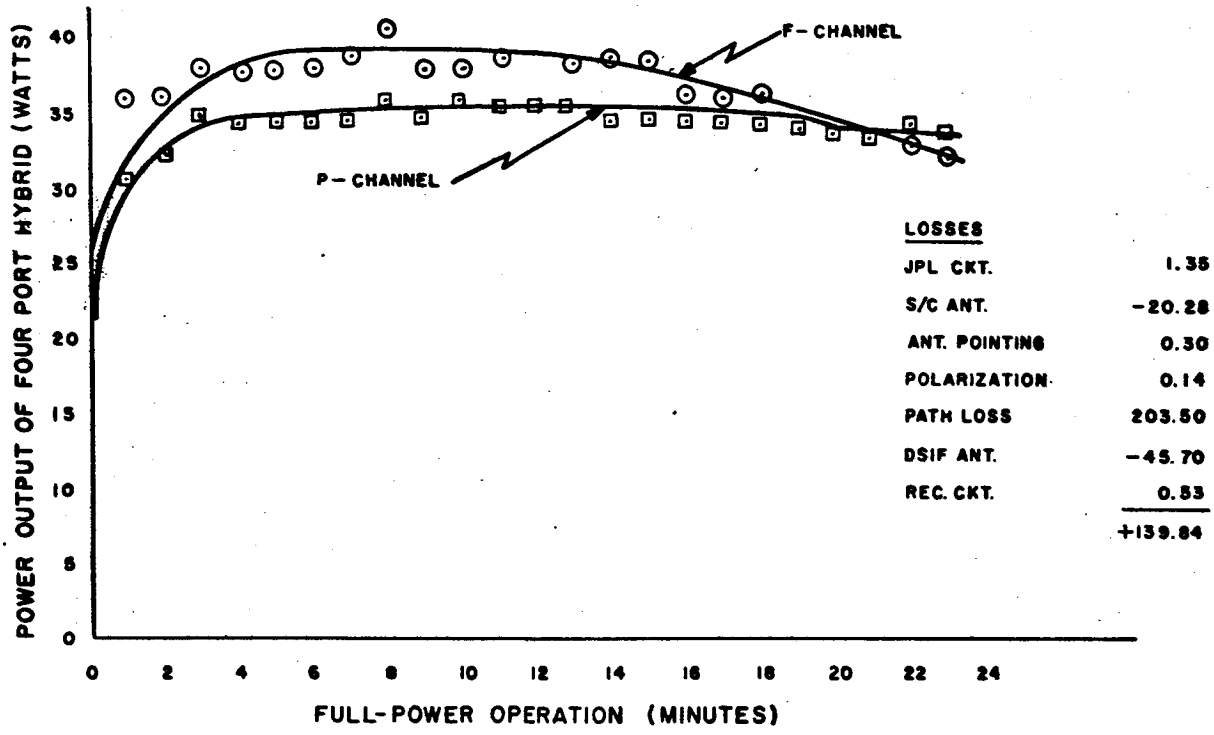

Figure 4-17. F- and P-Channel power profile throughout terminal mode

Therefore,

$$N = -198.6 \text{ dbm} + 10 \log 154\ k + 10 \log (900 \times 10^3)$$

$$N = -198.6 + 21.75 + 59.52$$

$$N = -117.30 \text{ dbm}$$

(5) Therefore, the signal level at the input to the maser amplifier for F-Channel is C = -96.83 dbm.

(6) The F-Channel output of the four-port hybrid is then

$$P = -96.83 + 139.84^*$$

$$P = +43.01 \text{ dbm}$$

$$P = 20.0 \text{ watts}$$

*Path loss to Spacecraft - provided by JPL.

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TABLE 4-6
F- AND P-CHANNEL POWER OUTPUT DURING TERMINAL MODE

Minutes of Full-Power Operation	F-Channel Power Output		P-Channel Power Output	
	DBM (Positive)	Watts	DBM (Positive)	Watts
0	43.89	24.4	43.39	21.8
1	45.59	36.1	44.89	30.9
2	45.59	36.1	45.14	32.6
3	45.79	38.0	45.39	34.6
4	45.79	38.0	45.39	34.6
5	45.79	38.0	45.39	34.6
6	45.79	38.0	45.39	34.6
7	45.89	39.0	45.39	34.6
8	46.09	40.6	45.51	35.6
9	45.79	38.0	45.39	34.6
10	45.79	38.0	45.51	35.6
11	45.89	39.0	45.51	35.6
12	45.89	39.0	45.51	35.6
13	45.79	38.0	45.51	35.6
14	45.79	38.0	45.39	34.6
15	45.79	38.0	45.39	34.6
16	45.59	36.2	45.39	34.6
17	45.59	36.2	45.39	34.6
18	45.59	36.2	45.39	34.6
19	45.39	34.5	45.39	34.6
20	45.29	33.8	45.27	33.6
21	45.29	33.8	45.27	33.6
22	45.19	33.0	45.27	33.6
23	45.09	32.3	45.27	33.6

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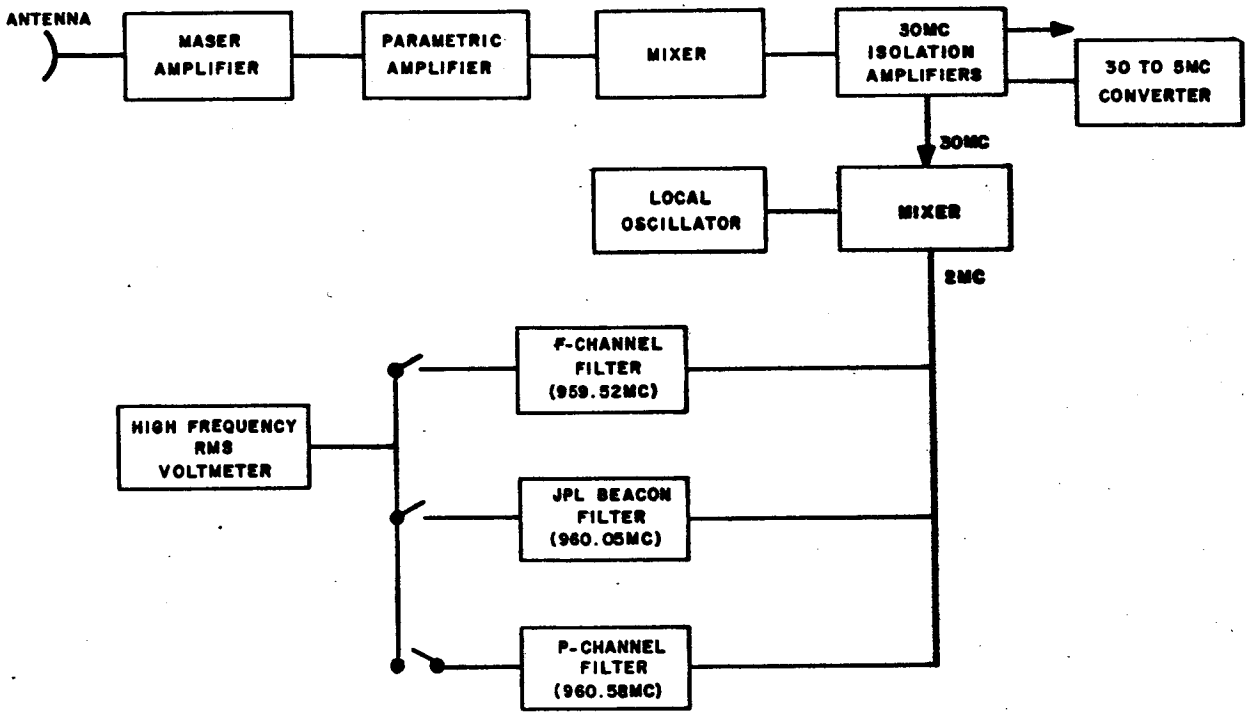

Figure 4-18. JPL Power-monitor Configuration

d. Telemetry

The 90-point telemetry obtained during terminal mode indicated that the power output of F-Channel was slightly higher than the value obtained during the final prelaunch system test. The power output of P-Channel was slightly lower. The IPA cathode current for F-Channel was slightly higher than nominal, while the P-Channel IPA cathode current was normal.

2. Transmitter

Performance of the F- and P-Channel Transmitters can be evaluated by a review of operational characteristics during the mission.

a. Center Frequency

The center frequency of the F-Channel carrier signal was 7 kc below nominal, as expected. The center frequency of the P-Channel carrier signal was 20 kc above nominal, as expected.

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b. Frequency Stability

The frequency of the F-Channel carrier drifted 7 kc during the 23 minutes of full power operation. This was expected. The frequency of the P-Channel carrier drifted 8 kc during the first 2 minutes of full-power operation, and then only 3-kc for the remainder of the mission, as expected.

c. Deviation

Deviation of the F- and P-Channel carriers was normal.

d. Transient Response

The rise time of the F-Channel signal was normal. The rise time of the P-Channel signal was slow during the first half of terminal mode, but improved during the later half of the mission. This variation of rise time was not a serious problem, since trailing-edge sync timing is employed. The slow rise time of the P-Channel signal was the result of a negative rate response at higher frequencies, which goes positive after the modulator warms up.

3. Telemetry Components

Performance of the telemetry components of the Communications Group can be evaluated by a review of the operating characteristics during the mission.

a. Cruise Mode

All telemetry components operated satisfactorily during cruise mode. The center frequency of the Channel-8 3-kc voltage controlled oscillator (VCO) was 3000 ± 1 cps, and had a deviation of approximately 95 cps. All 15-point telemetry data were normal and free of noise.

b. Terminal Mode

The center frequencies of the F- and P-Channel 225-kc VCO's were 0.5 to 1.0 kc higher than nominal. However, the frequencies were within the linear range

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of the 225-kc discriminators in the ground station. The 15- and 90-point telemetry data received from the F- and P-Channel Transmitters were accurate and free of noise.

E. Controls Group

1. *Satisfaction of Mission Requirements*

Operation of Controls Group during the RA-8 mission was normal. TV Subsystem turn-on was accomplished by a CC&S warmup command (TV-2) from the Spacecraft Bus as part of the terminal-maneuver sequence. Full-power operation of the TV Subsystem was initiated by outputs from the F- and P-Channel 80-second timers in the Sequencer Assembly. No irregular or anomalous operation of the Controls Group was observed throughout the mission.

Some functions of the Controls Group, such as F- and P-Channel turn-off by RTC-5 command, and initiation of Subsystem warmup mode by Clock output or by RTC-7 command, were not exercised. Thus, no statement concerning the performance of these functions can be made.

2. *Evaluation of Performance*

a. Electronic Clock

The performance of the Electronic Clock during the RA-8 mission was satisfactory. The 64-1/4 hour count by the Clock was initiated by the closure of a microswitch in the Spacecraft Bus at Agena-booster separation (S + 0).

All telemetry pulses from the Clock, up to and including the 64-hour pulse, occurred well within the specified time limits. Since TV Subsystem turn-on was not accomplished by the Clock output pulse, no positive indication of Clock turn-on was available.

Table 4-7 lists the predicted and actual elapsed time to each Clock telemetry pulse, beginning with Clock start at Agena booster separation. The time for the Clock output pulse, determined by extrapolation, was assumed to have occurred after an elapsed time of 64 hours 16 minutes 15 seconds, or 75 seconds later than nominal, but well within the 5-minute tolerance.

A comparison of flight versus test performance of the Clock is presented in Table 4-8.

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TABLE 4-7

PREDICTED AND ACTUAL ELAPSED TIMES[1] OF CLOCK TELEMETRY PULSES

Clock Telemetry Pulse	Time (GMT)	Elapsed Time from Clock Start(s)	
		Actual	Predicted
Start[2]	Day 48 - 17:30:14	S + 0	S + 0
1	Day 49 - 01:30:2	S + 7 h 59 m 58 s	S + 8 hrs.
2	Day 49 - 09:30:36	S + 16 h 0 m 24 s	S + 16 hrs.
3	Day 49 - 17:30:48	S + 24 h 0 m 34 s	S + 24 hrs.
4	Day 50 - 1:30:38	S + 32 h 0 m 38 s	S + 32 hrs.
5	Day 50 - 17:31:08	S + 48 h 0 m 54 s	S + 48 hrs.
6	Day 51 - 09:31:29	S + 64 h 1 m 15 s	S + 64 hrs.

[1] Measurement accuracy is +0, -15 seconds.

[2] Time of Agena-booster separation. No telemetry is available for this event due to lack of ground-station visibility.

TABLE 4-8

COMPARISON OF FLIGHT AND TEST PERFORMANCES OF ELECTRONIC CLOCK

Test	Operating Temperature (°F)	Performance*
Unit Flight Acceptance Test	32	64-1/4 hours - 33 sec
	131	64-1/4 hours + 86 sec
Clock Time Test on TV Subsystem	72	64-1/4 hours + 62 sec
Mission	71	64-1/4 hours + 75 sec

*Measurement accuracy is + 0, -15 seconds.

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b. 80-Second Timer Circuits

The F- and P-Channel 80-second timers in the Sequencer Assembly performed satisfactorily during the mission to initiate full-power transmission.

The count of the 80-second timers was initiated by the CC&S warmup command from the Spacecraft Bus as part of the terminal-maneuver sequence. Timer periods observed during the mission are given in Table 4-9. The accuracy of the individual observations is within ± 0.100 seconds, resulting in a maximum error of 0.200 for the nominal timer period. Comparison of flight and test performances for the 80-second timers is presented in Table 4-10.

TABLE 4-9
80-SECOND TIMER PERIODS DURING RA-8 MISSION

	Start Warmup (GMT)	Start Full Power (GMT)	Timer Period (Seconds)
P-Channel Timer	09:33:09	09:34:28	79.0
F-Channel Timer	09:33:09	09:34:31	82.0

TABLE 4-10
COMPARISON OF FLIGHT AND TEST PERFORMANCES OF F- AND P-CHANNEL 80-SECOND TIMERS

Test	Temperature (°F)	Timer Period (Seconds)	
		P-Channel	F-Channel
Unit Flight Acceptance Test	32	78.83	81.86
	131	80.15	81.77
RA-8 Mission Test*	95	79.0	82.0
RA-8 Actual Mission*		79.0	82.0

*Measurement accuracy is ± 1.0 second.

c. Command Control Unit (CCU)

Operation of the Command Control Unit was normal during the RA-8 mission. Cruise-mode turn-on was accomplished 15 minutes prior to launch through the "Cruise On Test" umbilical line to the Command Control Unit.

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Clock turn-on was also performed through the CCU by means of a microswitch closure on the Clock-start input line at Agena-booster separation.

d. Distribution Control Unit (DCU)

All command and control functions of the Distribution Control Unit, which were exercised, were performed satisfactorily during the mission.

e. HCVR Control Module

All portions of the HCVR control module, which were exercised, performed satisfactorily. The turn-on fail-safe features incorporated in this module functioned in a proper manner.

F. Power Group

The Power Group of the RA-8 TV Subsystem consisted of the F- and P-Channel Batteries, the F- and P-Channel High-Current Voltage Regulators (HCVR), and the Low-Current Voltage Regulator (LCVR). The performance of all assemblies of the Power Group was normal during the RA-8 mission.

1. Batteries

The F- and P-Channel Batteries performed nominally throughout the mission. Figure 4-19 shows the budgeted and expended power capacities of the F- and P-Channel Batteries for each phase of the RA-8 mission. A capacity of 29.1 ampere-hours was budgeted for the F-Channel Battery. Of that amount, a total of 13.3 ampere-hours was expended during the mission. The cruise-mode output voltages of the F- and P-Channel Batteries are shown in Figure 4-20. Under the no-load conditions at launch, the F-Channel Battery voltage was 35.5 volts. From Clock start (L + 23 minutes) until F-Channel turn-on, the F-Battery supplied 40 milliamperes of current to operate the TV Subsystem Clock. There was not a sharp drop in the F-Battery voltage at Clock start, but the voltage did decrease gradually throughout cruise mode. The Battery reached a plateau voltage of 34.9 volts at launch plus 11 hours and remained at that level until warmup mode. At initiation of F-Channel warmup, the F-Battery output dropped to 33.3 volts at a current drain of 8.0 amperes; and during

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full-power operation, the output dropped to 32.5 volts at a current drain of 13 amperes. The output-voltage profiles for the F- and P-Channel Batteries are shown in Figures 4-20 and 4-21 for cruise and terminal mode, respectively.

For P-Channel, the budgeted Battery capacity was 34.5 ampere-hours, while 24.0 ampere-hours of that amount was actually expended during the mission. The prelaunch voltage of the P-Channel Battery was 37.9 volts. During cruise mode, the P-Channel Battery provided the power to operate the cruise-mode telemetry circuitry, which provided a current drain of 165 milliamperes. At launch plus 16 hours, the P-Channel Battery had reached a plateau of 34.6 volts and remained at this level until P-Channel warmup. At initiation of warmup mode, the P-Battery output voltage dropped to 32.8 volts at a current drain of 10 amperes. At full-power operation of P-Channel, the P-Battery voltage decreased to an output of 32.3 volts at a current drain of 15 amperes.

Both the F- and P-Battery output voltages increased slightly (approximately 0.1 volt) during the full-power mode due to increasing battery temperatures. The operating temperatures of the F- and P-Batteries ranged from 75 to 85°F during cruise and terminal mode. This was an ideal operating range for the Batteries and well within the predicted temperature envelope of 65 to 90°F. The temperature profile for the P-Channel Battery during cruise mode is presented in Figure 3-4. The temperature profile for the F-Channel Battery during terminal mode is presented in Figure 3-16.

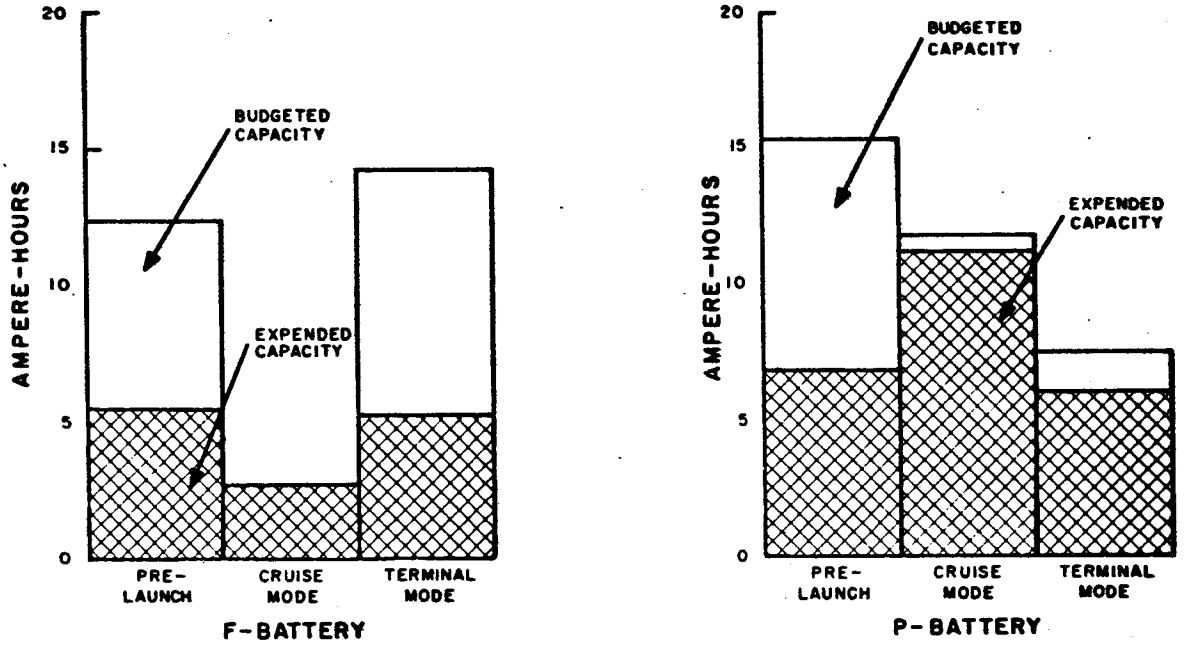

Figure 4-19. F- and P-channel budgeted and actual Battery capacities

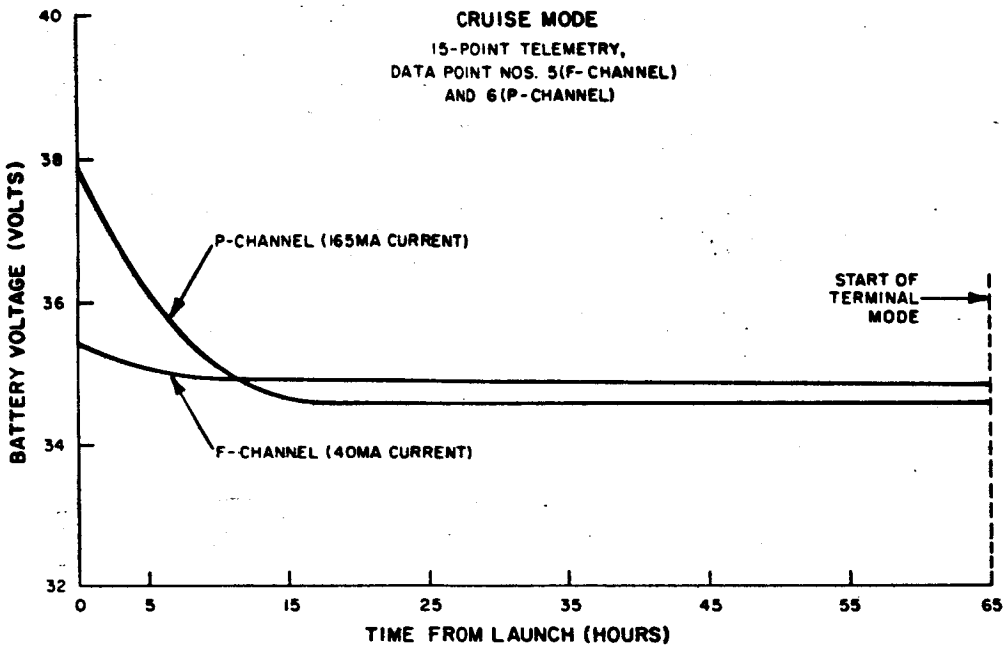

Figure 4-20. F- and P-Channel Battery output voltages during cruise mode

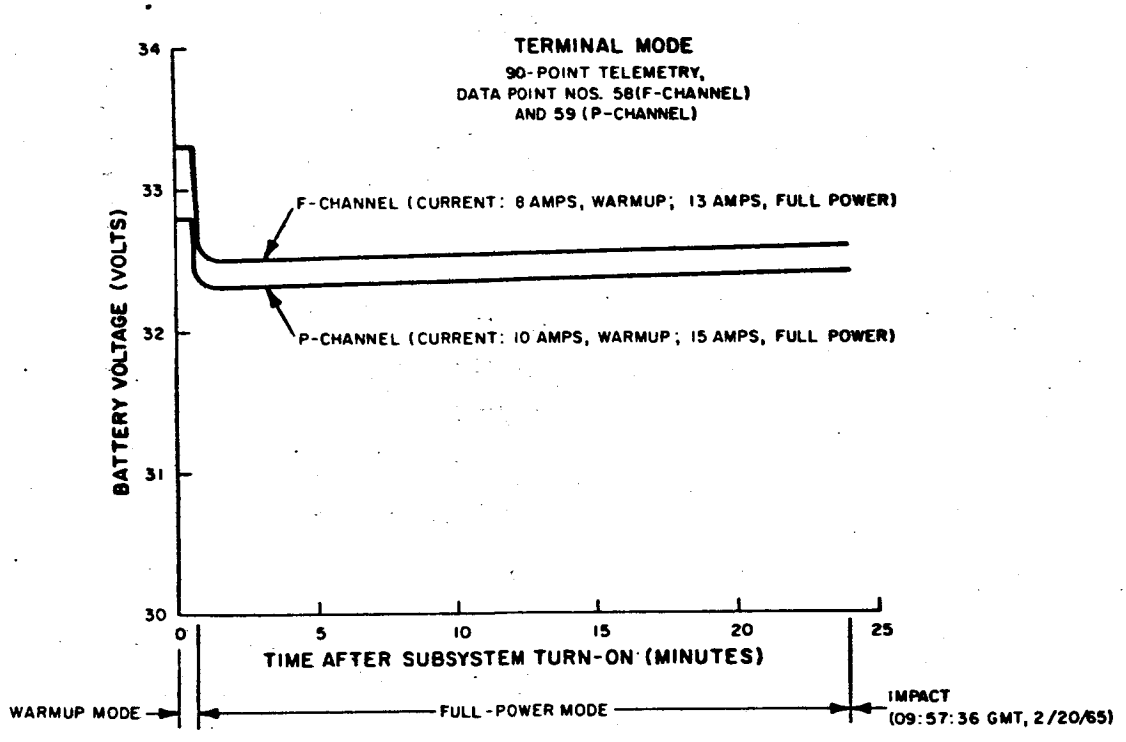

Figure 4-21. F- and P-Channel battery output voltages during full-power operation

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2. *Voltage Regulators*

The outputs of the Low-Current Voltage Regulator (LCVR) and the F- and P-Channel High-Current Voltage Regulators (HCVR) were constant during their respective periods of operation. The output of the Low-Current Voltage Regulator was -27.4 volts throughout the mission. The F- and P-Channel High-Current Voltage Regulators each provided an output of -27.65 volts during full-power operation. These outputs were well within the specified output of -27.5 ± 0.5 volts.

The performance of the High-Current Voltage Regulators during the RA-8 mission was consistent with the performance observed during prelaunch testing. Table 4-11 presents a comparison of the mission and prelaunch test performances. The differences observed in the outputs of the regulated voltages are probably due to reading accuracy.

TABLE 4-11
COMPARISON OF PERFORMANCE OF HIGH-CURRENT VOLTAGE REGULATORS DURING PRELAUNCH TESTING AND RA-8 MISSION

	Environment		Voltage	
	Pressure (mm Hg)	Temperature (°F)	Unregulated Input (Volts)	Regulated Output (Volts)
F-Channel High-Current Voltage Regulator				
Unit Test	10^{-5}	32	-33.0 -30.5	-27.69 -27.20
	10^{-5}	131	-33.0 -30.5	-27.61 -27.09
Mission Verification Test Number 3 (No wires test)	10^{-5}	75	-32.08	-27.5
Mission	Space		-32.5	-27.65
P-Channel High-Current Voltage Regulator				
Unit Test	10^{-5}	32	-33.0 -30.5	-27.6 -27.6
	10^{-5}	131	-33.0 -30.5	-27.79 -27.77
Mission Verification Test Number 3 (No wires test)	10^{-5}	75	-31.85	-27.45
Mission	Space		-32.4	-27.45

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Section V

Conclusions and Recommendations

A. Fulfillment of Mission and Design Objectives
B. Performance of Subsystem Equipment Groups
C. Ground Support Equipment Performance

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Section V

Conclusions and Recommendations

A. Fulfillment of Mission and Design Objectives

The performance of Flight Model III-3 TV Subsystem during the Ranger VIII mission fulfilled the equipment design objectives in all respects. Analysis of the 7140 pictures, transmitter power profile, and telemetry data obtained during the flight indicated that the performance of all assemblies of the TV Subsystem satisfied the specification requirements and that the performance was completely consistent with previous test experience.

Based on the requirement for limiting performance as stated in EPD-156, Revision 1, " .....the over-all spacecraft system shall be capable of producing high quality television photography showing best resolutions in the range of one-half to five meters per optical line pair," the TV Subsystem of the RA-8 Spacecraft satisfied the fundamental system design requirement for high-resolution pictures of the lunar surface.

Although the specific mission objective of providing lunar-surface pictures at a resolution of 0.2 to 0.5 meter, per optical line pair was not attained, the successful operation of the partial-scan cameras and transmitter chain to the instant of impact indicated that this objective could have been met by performing a Spacecraft terminal maneuver to align the common optical axis of the six-camera array with the Spacecraft velocity vector at impact. Review of the camera performance and Spacecraft-trajectory data indicated that the translational image smear in the last two pictures from the partial-scan (P2 and P4) cameras, exceeded the inherent camera resolution by a factor of approximately 25:1, and as a result, these pictures were not usable. If a Spacecraft terminal maneuver had been performed, the inherent resolution of the last complete frame from the P2 Camera, which was taken from a range of about 627 meters, would have been 0.23 meter per optical line pair, thus completely satisfying the mission objectives. The final P3 picture was taken from a range of 1.08 kilometers and had an inherent resolution of 1.21 meters per optical line pair. Translational image smear in the final P3 picture was about 1.07 meters. Although the effects of image motion during the exposure of the camera are apparent, it is considered that this final P3 frame represents the best usable high-resolution video data obtained during the Ranger VIII mission.

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B. Performance of Subsystem Equipment Groups

1. Camera Group

Following the RA-7 mission, several design improvements were incorporated into the TV cameras of Flight Model III-3 TV Subsystem, and new calibration techniques were evolved. These modifications are described in Section II of this report. In all instances, the modifications contributed significantly toward improved camera performance. Thus, it may be concluded that the equipments of the Camera Group, in its modified configuration, performed in a satisfactory manner and fulfilled all mission and design requirements. However, certain problems and equipment limitations were apparent throughout the testing and flight of the cameras of the Flight Model III-3 TV Subsystem. Because of the historical nature of these problems, the RA-8 schedule constraints, and the fact that these problems do not seriously limit equipment performance, it is recommended that solutions to these problems be sought for post Ranger lunar missions.

a. Shading

The problem of shading has been experienced with all Ranger cameras. Recent tests at RCA have indicated that shading results from errors of the manner in which the electron scanning beam strikes the photoconductor surface of the vidicon tube (abnormal velocity components present). Considerable reduction of these errors can be achieved with the following modifications. The deflection coils of the camera must be moved with respect to the focus coil in the vidicon yoke, so that the magnetic components are in a more desirable portion of the electron beam path. The mesh of the vidicon must be separated from the G3 (wall) electrode and operated at a higher potential. Finally, the vidicon must be carefully aligned within the yoke cavity so that the electron gun of the vidicon is positioned in the center of the applied fields.

b. Video Detail

Detail in the video output can be enhanced by the incorporation of electronic circuitry to compensate for apertures caused by the lens and electron-beam size. This technique will cause some reduction in the signal-to-noise ratio; however, the resultant signal-to-noise ratio will still be of sufficient magnitude to produce high-quality pictures. During tests at RCA, pictures have been produced with significant resolution at more than 1000 TV lines. These pictures were, of course, obtained with a video bandwidth greater than 200 kc.

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c. Nonlinear Video Amplifier

The incorporation of a nonlinear video amplifier is recommended so that the gamma value of the camera light-transfer characteristic can be adjusted to a predetermined value. The TV cameras presently include electronic circuitry to prevent signals from a high-luminance scene from causing interference in the adjacent communications channel.

Cameras with high values of gamma (0 to > 0.9) have limited dynamic range. This limitation is particularly evident at low-luminance values. The vidicon has adequate response at high- and low-light levels, but clipping of the signal occurs in the video processing. The range of luminance levels that can be accommodated is, therefore, dependent on the gamma value of the camera. The incorporation of gamma-correction circuitry would enable all cameras to have wider dynamic range and uniform gamma.

2. Thermal Control

Although the temperatures of the RA-8 TV Subsystem were well within the anticipated thermal limits, some improvement could be realized on Flight Model III-4 (RA-9), schedule time permitting.

The thermal data obtained during the RA-8 mission indicated that the temperatures of the TV Subsystem were higher than nominal by 4 to 5 degrees F. Temperatures of the RA-9 TV Subsystem could be maintained closer to nominal by use of a thermal-paint mixture with a slightly lower ratio of absorptivity (α) to emissivity (ϵ).

3. Telecommunications Group

Performance of the Telecommunications Group during the RA-8 mission was satisfactory, and no changes are recommended to the equipment.

The techniques employed during the RA-8 mission for measuring the received r-f power were adequate to verify performance of the Spacecraft communications equipment. To improve the accuracy of the r-f power measurements, it is recommended that the present techniques be supplemented by the addition of a relative measurement of r-f power for each channel with respect to the JPL beacon.

4. Controls Group

In view of the normal operation of the Controls Group during the RA-8 mission, no changes are recommended.

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5. Power Group

Based on the satisfactory operation of the RA-8 Power Group, no practical recommendations can be made to improve performance.

C. Ground Support Equipment Performance

1. Post-Impact Data Performance

As a result of the discrepancies noted in the tape-playback data following the RA-8 mission, some modifications should be considered for the RA-9 mission.

a. Camera Calibration Tapes

The portions of the prelaunch calibration tapes required to be recorded on the Primary Original Data (POD) film should be determined from JPL. If only the camera transfer data is required, an abbreviated tape could be prepared prior to the mission. If all the calibration data is necessary, it is recommended that the calibration tapes be played back in entirety previous to the terminal mode. A registration of black and peak white levels would be included on the POD film for reference.

b. Data Duplication

After post-impact calibration data has been recorded, data duplication should include film records from the tapes at both the Pioneer and Echo sites. Assuming a mission similar to the RA-8 flight, data from Echo site would be the playback of tapes 1 and 2A, and tapes 2 and 1A; at Pioneer site, playback of tapes 3 and 4A, and tapes 4 and 3A. This combination would cover all configurations of recorded data.

c. Checkout

As a result of the recommendation specified in (a), more time would be afforded to equipment and set-up checkouts prior to the duplication of data. Polaroid checks together with rapid developed samples would provide greater confidence in data, and, if scheduled, would not seriously delay the reproduction of the video data.

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2. GSE Logic Circuitry

Modifications will be made to the switching logic at the Echo and Pioneer sites to preclude a recurrence of the "picture bending" that resulted from the receipt of sync pulses of long duration. The timing of the switching protection circuits will be increased from 111 microseconds to 120 microseconds.

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Appendix A
Testing of Flight Model III-3 TV Subsystem at JPL

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Appendix A
Testing of Flight Model III-3 TV Subsystem at JPL

A. General

This appendix is a continuance of the test history of Flight Model III-3 TV Subsystem. The test program was initiated with Subsystem testing at RCA. The results of that test phase were reported in "Test Report for Flight Model III-3 Ranger TV Subsystem," issued February 2, 1965. The second phase of the test program - System Tests at JPL - is described herein.

The purpose of the tests performed at JPL was to verify the performance of the electronic equipment in the TV Subsystem and the electrical integrity of the TV Subsystem integrated with the Spacecraft Bus. These tests were designed to verify the satisfactory operation of the TV Subsystem in ambient, simulated-launch, and simulated-flight (space) environments. The test program also served to verify the procedures and operational readiness of the Ground Support Equipment used to check out the integrated Spacecraft prior to launch.

This appendix provides a brief description of each test performed on Flight Model III-3, together with an evaluation of the test data obtained. Analysis of each malfunction report (MR) referenced in the appendix is presented in Tables C-1 or C-2 of Appendix C. Flight Model III-3 TV arrived at JPL on October 18, 1964, and the test phase commenced on October 19, 1964. The test program of Flight Model III-3 at JPL is summarized in Table A-1.

B. Initial Test Phase

1. Post-Shipment Electrical Test (RTSP-1100A, Appendix R)

A post-shipment electrical test of the Flight Model III-3 TV Subsystem was performed on October 19, 1964. This test was performed in accordance with the procedures of RCA Specification RTSP-1100A, Appendix R, "Abbreviated Subsystem Test."

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TABLE A-1
TV SUBSYSTEM TESTS AT JPL

Title of Test	Date	Test Procedure
Post-Shipment Electrical Test	10/19/64	RTSP 1100A, Appendix R
TV Subsystem Checkout	10/20/64	JPL Procedure 3R212.05
System Test No. 2	10/21/64	JPL Procedure 3R300.15
Backup Functions System Test	10/23/64	JPL Procedure 3R305.07
System and EMI Test No. 3	10/26/64	JPL Procedure 3R300.15
ESF Television Full-Power RF Test	10/28/64	JPL Procedure 3R235.02
TV Subsystem and Shroud-Lights Compatibility, and RF Losses Test	10/31/64	JPL Procedure 3R405.03
ESF Operational Checkout	11/2/64	JPL Procedure 3R317.03
Pre-Countdown Dummy Run	11/2/64	JPL Procedure 3R303.06
Countdown Dummy Run	11/3/64	JPL Procedure 3R308.06
Pyrotechnic-Extension System Test	11/4/64	JPL Procedure 3R313.06
Communications Verification Test	11/6/64	Special Test
Camera Calibration	11/7/64	Special Test
Abbreviated Subsystem Test	11/13/64	RTSP 1100A, Appendix R
Pre-Vibration Verification Test	11/13/64	Special Test
X-Axis Vibration Test	11/16/64	JPL Procedure 3R311.04
Y-Axis Vibration Test	11/17/64	JPL Procedure 3R311.04
Z-Axis Vibration Test		
• Thrust	11/18/64	JPL Procedure 3R311.04
• Torsional	11/20/64	JPL Procedure 3R311.04
Post-Vibration System and EMI Test No. 4	11/23/64	JPL Procedure 3R300.16
Abbreviated TV Subsystem Test	11/24/64	RTSP 1100A, Appendix R

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TABLE A-1
TV-SUBSYSTEM TESTS AT JPL (Continued)

Title of Test	Date	Test Procedure
Pre-Mission Verification Test	11/24/64	JPL Procedure 3R302.05
Mission Test No. 1	12/1/64	JPL Procedure 3R302.08
Mission Test No. 2	12/4/64	JPL Procedure 3R302.08
Special P2- and P4-Camera Thermal Vacuum Test	12/5/64	Special Test
Special RFI Test	12/7/64	Special Test
F-Channel Transmitter Power Supply Rework Test	12/9/64	Special Test
P-Channel HCVR Rework Test	12/10/64	Special Test
Pre-RF Link Verification Test	12/10/64	JPL Procedure 3R320.02
RF Link Verification Test	12/12/64	JPL Procedure 3R320.02
Directional Antenna Deployment Test	12/14/64	JPL Procedure 3R243.00
Spacecraft - SFOF Compatibility Test	12/28/64	JPL Procedure 3R318.03
Pre-Shipment System Test	12/29/64	JPL Procedure 3R300.18

a. Purpose of Test

The post-shipment electrical test was performed to verify that no damage was incurred by the TV Subsystem during shipment from RCA to JPL.

b. Description of Test

The TV Subsystem was not mated to the Spacecraft Bus for this test. The thermal shrouds were removed from the Subsystem, and collimators were attached to the cameras. The Subsystem was powered from external (OSE) power during this test.

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c. Test Evaluation

The initial run of the post-shipment electrical test was terminated when a current overload in the Ground Support Equipment (GSE) caused a circuit breaker to trip at the power distribution center (MR 1579). The problem was corrected and a second test run commenced.

During the second test run, the collimator attached to the F_a Camera was observed to be out of focus (MR 1580). Following completion of the test, a third test run was performed to verify proper operation of the F_a Camera. The PTM F_a collimator was installed on the F_a Camera for this test run, in which only the F-Channel was operated (first 8 minutes of the test procedure in RTSP-1100A, Appendix R).

Review of the video outputs obtained during the second test run indicated that all cameras performed satisfactorily, with the exception of the F_a Camera which appeared to be defocussed. Investigation revealed that the F_a collimator was focussed at 12 feet rather than at infinity. The performance of the F_a Camera was rechecked using the PTM F_a collimator, and the video data obtained in this third test run indicated normal camera operation.

The video outputs of P2 and P3 Cameras exhibited slight microphonics. Shutter-induced noise was observed in approximately 10 percent of the frames of the P2-Camera video output. A shift in video was noted at approximately one-third the distance from the top of each P4-Camera frame. This was attributed to an accidental reversal of ground leads on the P2 and P4 Cameras, and was corrected. The output of the F_b Camera revealed evidence of approximately 30 mv of 15-kc noise. The appearance of these anomalies were not significant enough to be detrimental to acceptable picture quality, and the camera operation was therefore considered satisfactory.

The test data recorded for the communications and power components were normal, indicating proper operation. The data were normal both for the F- and P-Channel test run and for the special F-Channel test run to recheck the performance of the F_a Camera.

All telemetry data were normal, with the exception of the outputs of data points No. 81 and 84 of the 90-point telemetry, which were out of specification. These points represent the P-Channel IPA cathode current and Power Amplifier cathode voltage, respectively. The telemetry specification limits for these parameters were subsequently revised to reflect more accurately the TV communications performance.

The GSE performance was normal, except that some tearing in video was observed during tape playback (MR 1581).

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2. TV Subsystem Checkout (JPL Procedure No. 3R212.05)

A TV Subsystem checkout test was performed on October 20, 1964, in accordance with JPL Procedure No. 3R212.05.

a. Purpose of Test

The purpose of this test was to verify electrical compatibility of the TV Subsystem with the Spacecraft Bus; to establish the operational readiness of the TV Subsystem by performing a functional checkout; and to verify radio-frequency (r-f) compatibility between the r-f components of the TV Subsystem and Spacecraft Bus, with the TV Subsystem operating in the full-power mode when the high-gain antenna is radiating.

b. Description of Test

Mating of the TV Subsystem to the Spacecraft Bus was performed during the test. The thermal shroud was removed, and collimators were attached to the cameras. Voltage and resistance checks were performed on the TV Subsystem before mating with the Spacecraft Bus. The resistance check was performed with Subsystem power off. The Subsystem was powered using external (OSE) power for the voltage measurements.

A functional checkout of the TV Subsystem was performed before electrically mating to the Spacecraft Bus. Simulated CC&S warmup, CC&S full-power and RTC-7 full power commands were used to effect this checkout. External power was employed to operate the TV Subsystem during this test.

Following electrical integration of the TV Subsystem with the Spacecraft Bus, a second functional checkout of the TV Subsystem was performed. Subsystem turn-on in the warmup mode was accomplished by RTC-7 TV command from the TV Operational Support Equipment (OSE). This test also verified that no radio-fequency interference (rfi) existed between the TV Subsystem and the 890-Mc Transponder/Receiver on the Spacecraft Bus, while the TV Subsystem was operating in the full-power mode with r-f power radiating from the high-gain antenna. The output level of the Channel-8 Voltage Controlled Oscillator (VCO) was also adjusted during this test, and the loss of the TV-sequence sync pulses was simulated to check the free-running capability of the P1 Camera. Internal battery operating power was employed for this test.

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Another functional checkout of the TV Subsystem was performed, in which the Subsystem was operated in the full-power mode by Spacecraft real-time commands (RTC-7). This test also ensured that there was no r-f interference to the 960.05-Mc Transmitter on the JPL Bus from the TV Subsystem with the high-gain antenna radiating. The TV Subsystem was powered by batteries during this test.

c. Test Evaluation

Operation of the F_a and F_b Cameras was normal during the tests. There appeared to be a reduction in the presence of 15-kc background noise observed previously on the output of the F_b Camera. The P1- and P3-Camera outputs were normal, while P2-Camera output exhibited some shutter-induced noise in approximately 25 percent of the recorded 35-mm frames. Overall picture quality was acceptable during these tests.

The power profile during the TV Subsystem checkout test was normal. The r-f power output recorded during the full-power modes of operation was slightly higher than observed in tests at RCA. This was attributed to the r-f output being radiated from the high-gain antenna during this test. The telemetry was normal. Two OSE malfunctions occurred during the test: a faulty video gate (MR2145) and a faulty telemetry recorder (MR2141). Neither malfunction affected TV Subsystem operation.

C. System Test Phase

1. System Test No. 2 (JPL Procedure 3R300.15)

The initial system test involving TV Subsystem operation was performed on October 21, 1964, in accordance with JPL Procedure 3R300.15.

a. Purpose of Test

The purpose of this test was to verify proper TV Subsystem operation when the total Spacecraft system is subjected to an accelerated mission simulation at ambient conditions.

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b. Description of Test

The Spacecraft was mounted on the System Test Stand and the TV Subsystem was powered by batteries. Direct-access cables were connected between the TV Subsystem and OSE to provide the required test stimuli and to enable the monitoring of Subsystem circuit and functional operation. The TV Subsystem was commanded through a terminal-mode operation by means of RTC-7F and RTC-7P full-power commands. To enable evaluation of the cameras, collimators were attached, and the video outputs of the cameras were recorded on 35-mm film. R-f output was obtained through hardline connections between the omni antenna and OSE.

c. Test Evaluation

During this test, all cameras operated normally. Communications performance and power profile were normal. The Channel-8, 90-point telemetry data was observed to be noisy; however, the redundant 90-point telemetry data received on the output of the P-Channel Transmitter were normal. The noise in the Channel-8 telemetry was attributed to a malfunction in the GSE (MR 2146). Two further GSE malfunctions occurred during the test; the kinescope was out of focus (MR 2147), and GSE Unit 10, Detector/Amplifier exhibited a d-c level shift (MR 2144). The overall performance of the TV Subsystem was considered good.

2. Backup Functions System Test (JPL Procedure 3R305.07)

The backup functions system test was performed on October 23, 1964, in accordance with JPL Procedure 3R305. 07.

a. Purpose of Test

The purpose of this test was to verify that the backup functions of the Spacecraft would provide the required command redundancy. This test checked only those command functions that were not exercised during system test No. 2.

b. Description of Test

The Spacecraft was operated in the same manner as for system test No. 2, except that failure modes of primary functions were simulated. The TV

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Subsystem was monitored for proper operation when activated by means of backup function commands. The commands that were tested are: Agena Separate Microswitch, Hydraulic Timer Command, Solar Panel TV Arming Microswitch, CC&S Warmup Command, and Cruise on Test Command.

c. Test Evaluation

The performance of TV Subsystem during the backup functions test was good. The resolution of each camera was evaluated and the results were as follows: for the F_a Camera, 750 TV lines; F_b Camera, 600 TV lines; P1 Camera, 175 TV lines; P2 Camera, 160 TV lines; P3 Camera, 160 TV lines; and P4 Camera, 165 TV lines. All cameras operated normally and exhibited good focus. However, examination of the 35-mm film of the video outputs showed that some frames of P2-Camera video output contained shutter-induced noise, and that P3-Camera output contained 15-kc noise of very small amplitude, (i. e. , approximately 15 mv). The performance of communications and GSE was found to be good, and power profile was normal.

3. System and EMI Test No. 3 (JPL Procedure 3R300.15)

The system and electro-magnetic interference (emi) test No. 3 was performed on October 26, 1964, in accordance with JPL Procedure 3R300.15.

a. Purpose of Test

The purpose of this test was to ensure that the r-f levels encountered during launch-pad operations do not interfere with Spacecraft functions.

b. Description of Test

The Spacecraft was in flight configuration for this test , and was operated in the same manner as in system test No. 2. During the test, the Spacecraft was radiated from sources which simulated all launch booster vehicle and ETR r-f equipment in the vicinity of the launch pad. The TV Subsystem was monitored during the test, and if any interference was detected, the source was to be located by successively turning off the r-f sources.

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c. Test Evaluation

No r-f interference was observed during this test. All cameras operated normally and exhibited good focus. The resolution of each camera was evaluated and the results were as follows: for the F_a Camera, 750 TV lines; F_b Camera, 525 TV lines; P1 Camera, 190 TV lines; P2 Camera, 200 TV lines; P3 Camera, 200 TV lines; and P4 Camera, 195 TV lines. Slight microphonics were observed in the video outputs of P1 and P2 Cameras, and some shutter-induced noise was evident in the video output of the P2 Camera. Performance of communications and telemetry equipments was good, and power profile was normal.

Examples of the video outputs of the full-scan and partial scan cameras are presented in Figures A-1 and A-2.

D. ESF Simulation Test Phase

1. ESF Television Full Power RF Test (JPL Procedure 3R235.02)

The Explosive Safe Facility (ESF) full-power r-f test was performed on October 28, 1964, in accordance with JPL Procedure 3R235. 02.

a. Purpose of Test

The purpose of this test was to check the r-f connection between the TV Subsystem and Communications Case II of the Spacecraft Bus, and to verify that the r-f path between the TV Subsystem and the directional antenna operates properly during full-power operation.

b. Description of Test

The Spacecraft was mounted on the system test stand and the directional antenna was installed in its nested position. Microwave absorbent material was placed beneath the directional antenna and a calibrated r-f probe was installed to monitor the r-f power output. A new set of batteries was installed in the TV Subsystem. The TV Subsystem was operated in the full-power mode, and the r-f power at the output of the directional antenna was measured for the duration of the 5-minute full-power operation.

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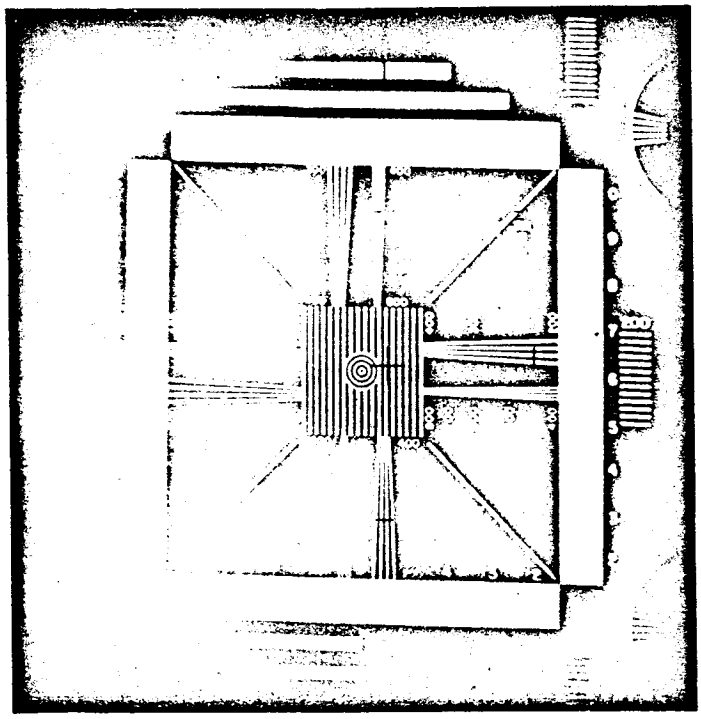
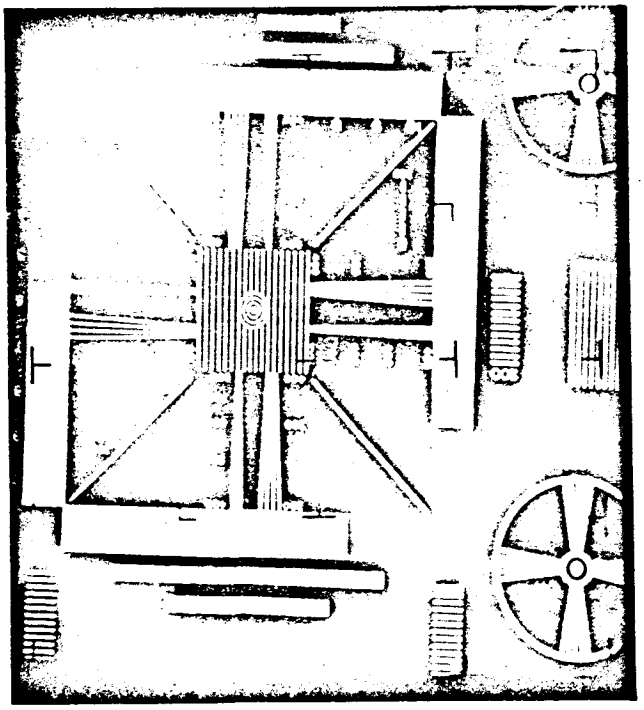


a. Video output of F_a Camera



b. Video output of F_b Camera

Figure A-1. Video outputs of full-scan cameras during System Test No. 3

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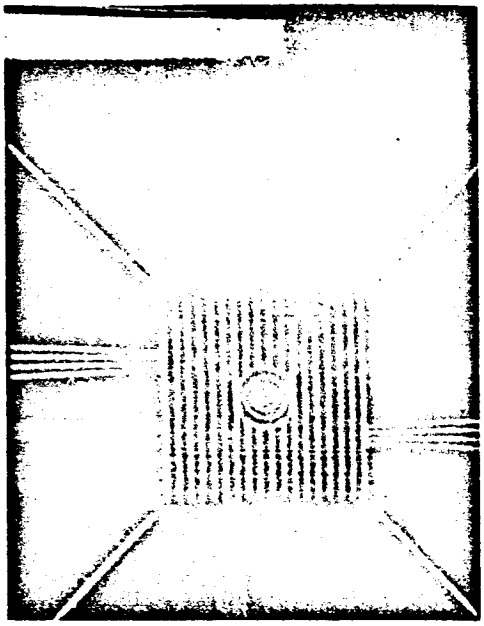
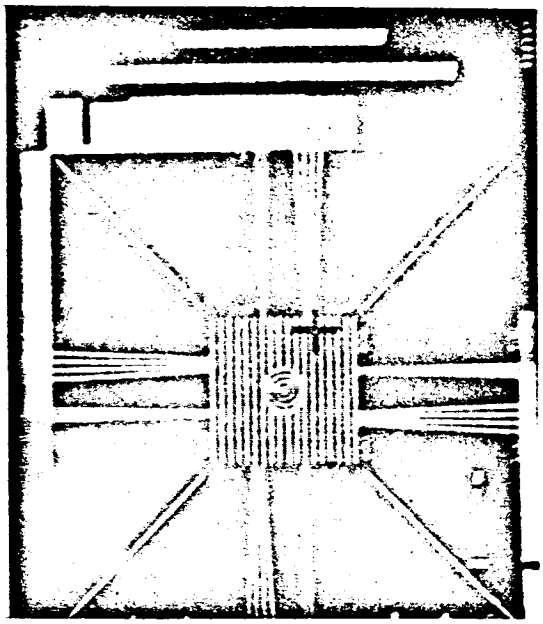
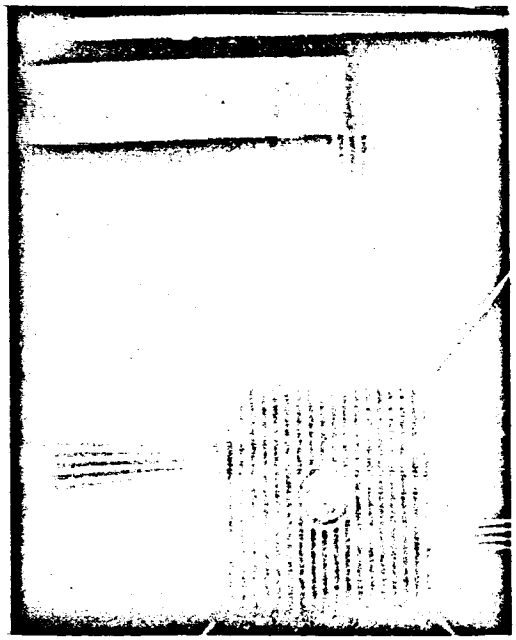


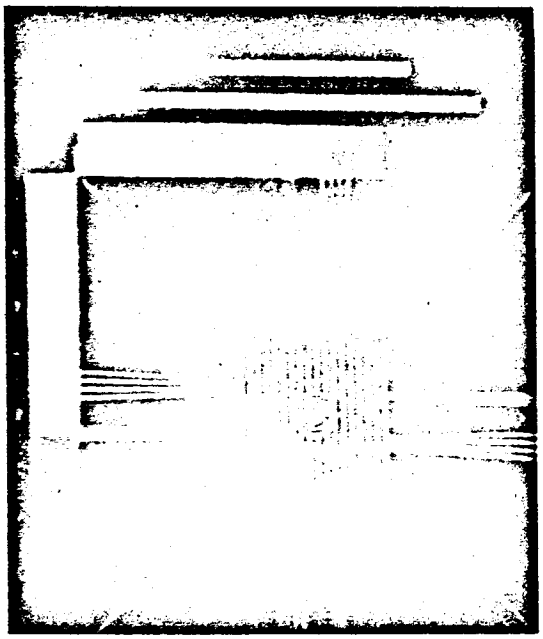
a. P1 Camera



b. P3 Camera



c. P2 Camera



d. P4 Camera

Figure A-2. Video outputs of partial-scan cameras during System Test No. 3

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c. Test Evaluation

The telemetered r-f power profile and Communications Group voltages indicated normal TV Subsystem operation, and proper power output which ranged from 53.0 to 59.5 watts. All cameras operated normally during this test. Examination of the 35-mm film revealed some shutter-induced noise in the video output of the P2 Camera; slight mesh microphonics in the output of the P4 Camera; and a slight, shutter-induced, microphonic condition in the output of the F_b Camera. Except for F-Channel 15-point data which was unintelligible, the recorded telemetry data were normal. The degradation of F-Channel telemetry data was attributed to a faulty 225-kc VCO in the Telemetry Assembly (MR 2148). The power profile was normal.

2. *TV Subsystem and Shroud Lights Compatibility, and RF Losses Test (JPL Procedure 3R405.03)*

The TV Subsystem and shroud lights compatibility, and r-f losses test was performed on October 31, 1964, in accordance with JPL Procedure 3R405.03.

a. Purpose of Test

The purpose of this test was to verify the proper operation and alignment of the Agena shroud lights with the six TV camera array, and to determine the r-f transmission losses of the omnidirectional and directional antennas when the Agena shroud is in place.

b. Description of Test

With the Agena shroud installed, the TV Subsystem was operated at reduced power by initiating the RTC-7 command. The compatibility and alignment of the TV Subsystem cameras with the locations of the Agena shroud lights were checked by viewing the lights on the TV monitors. Furthermore, the r-f transmission losses of the omnidirectional antenna were measured at the shroud r-f coupler, and the directional antenna losses were measured with a probe located in the LMSC* mock-up forward equipment rack.

*Lockheed Missiles and Space Company

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c. Test Evaluation

During this test, the appropriate shroud lights were found to be within the field of view of each camera. Viewing of the lights on the monitors served as a check that TV Subsystem was functioning, and no further means of evaluating camera performance were employed. Communications performance and power profile were normal. Also, the telemetry was normal, except for the degradation of F-Channel 15-point telemetry data, which was observed during the previous test.

3. ESF Operational Checkout (JPL Procedure 3R317.03)

The ESF Operational Checkout was performed on November 2, 1964, in accordance with JPL Procedure 3R317. 03.

a. Purpose of Test

The purpose of this test was to provide a cross-check of TV Subsystem performance and to verify that RTC-7 commands will not turn on the TV Subsystem while the "ground bus enable function" is reset. In addition, this test served as a check of the susceptibility of the Subsystem to electro-magnetic (EMI) and radio-frequency interference (RFI).

b. Description of Test

The Spacecraft was in flight configuration, with the Agena shroud installed. It was mounted on the transporter, and powered by batteries. To enable an evaluation of the cameras, the shroud lights were checked and installed. The TV Subsystem was commanded through the terminal mode by means of RTC-7 reduced power command.

c. Test Evaluation

During this test, all cameras operated normally. As long as the JPL beacon signal was radiating through the directional antenna, no radio-frequency interference was observed on the video output. This was attributed to the higher power output and faster warmup of the Resdel-configuration (triode) IPA as compared to the tetrode IPA used on Flight Model III-2 TV Subsystem. After the JPL beacon signal

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was switched from the directional to the omnidirectional antenna, some radio-frequency interference was observed on the video outputs of the P4 and F_a Cameras. This, however, was not considered to be a flight problem. The telemetry was normal, except for the 225-kv VCO malfunction which was described in the preceeding test. Power profile and communication performance were normal. The power outputs of the two communications channels were observed on a spectrum analyzer, but no recordings were made. The relative amplitudes of the signals that were noted indicated no abnormalities during this test.

E. Launch Pad Simulation Tests

1. *Pre-Countdown Dummy Run (JPL Procedure 3R303.06)*

The pre-countdown dummy run was performed on November 2, 1964, in accordance with JPL Procedure 3R303. 06.

a. Purpose of Test

The purpose of this test was to familiarize the test personnel with the pre-launch checkout procedures used at the Eastern Test Range (ETR), and to verify the compatibility of Blockhouse Launch Complex Equipment with the Spacecraft.

b. Description of Test

The Spacecraft was mounted on the Agena adapter and the Agena shroud was installed. During the cruise-mode operation, the TV Subsystem was tested to verify that RTC-7 commands would not turn on the TV Subsystem while the "ground bus enable function" is reset. The Subsystem was then operated in a reduced-power mode, and the Agena shroud lights were observed on a monitor to ensure that the TV Subsystem was functioning properly.

c. Test Evaluation

The test results were similar to those obtained for the preceding test. The operation of the TV Subsystem was considered acceptable.

2. Countdown Dummy Run (JPL Procedure 3R308.06)

The Countdown Dummy Run was performed on November 3, 1964, in accordance with JPL Procedure 3R308. 06.

a. Purpose of Test

The purpose of this test was to simulate the launch countdown and to verify that all Spacecraft systems are operating properly.

b. Description of Test

The configuration for this test was the same as for pre-countdown dummy run, except that simulated ETR and launch-vehicle electro-magnetic interference sources were used to simulate the launch environment. The test procedure that was followed in checking the TV Subsystem was the same as that used for the preceding test.

c. Test Evaluation

The test results were similar to those obtained for the ESF operational checkout. The operation of the TV Subsystem was normal.

F. Pyrotechnics Extension System Test

1. Pyrotechnic Extension System Test (RF Link With EMI) (JPL Procedure 3R313.06)

The Pyrotechnic Extension System test (r-f link with emi) was performed on November 4, 1964, in accordance with JPL Procedure 3R313. 06.

a. Purpose of Test

The purpose of the test was to verify proper operation of the Pyrotechnic Extension System with live squibs installed and with the Spacecraft radiated with electro-magnetic interference (emi) simulating ETR launch environment.

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b. Description of Test

The Spacecraft was mated to the LMSC flight adapter in the test pit area of Building 179. The Agena shroud was removed and the external control cables were disconnected. The Spacecraft was operated in a modified flight sequence with simulated emi conditions. The r-f power density at the squib location was checked during the emi portion of the test. The data was monitored by means of an r-f link. The TV Subsystem was tested in warmup and full-power modes of operation.

c. Test Data Evaluation

During this test, camera evaluation could not be performed because of insufficient light in the pit. The examination of the 35-mm film showed camera operation to be normal. Since no "Echo-Sorb" material was used, the communications power profile was not calibrated. Also, reflections inside the pit obviated any accurate calibration of the pick-up losses. Except for the malfunction of the F-Channel 225-kc VCO, the operation of telemetry was normal; the power profile was also normal. The overall performance of the TV Subsystem was deemed normal.

G. Special Tests (Field Operations Rework)

Following the Pyrotechnic Extension System Test, the TV Subsystem was demated from the Spacecraft Bus for field-operations rework. The original rework schedule called for the following to be accomplished:

- Replacement of the F-Channel 225-kc VCO in the Telemetry Assembly;
- Replacement of shutter shock isolators on all cameras;
- Replacement of shutters on F_a, P3 and P4-Cameras; and
- Refocusing of F_b, P1, and P2 Cameras for mission environment.

However, during the rework, P4 Camera, Serial No. 45/45, exhibited objectionable microphonics and a noisy raster, and it was replaced with Camera, Serial No. 48/48 (MR 2150). Similarly, P2 Camera exhibited noise spikes in the raster (MR 2251), and plugs A2P2 and A3P5 were accidentally reversed (MR 2252). However, since P2

Camera was operating within acceptable limits, it was not replaced. The field operations rework was performed from November 6, 1964, through November 13, 1964, and the following special tests are those which yielded significant data during this period.

1. Communications Verification Test

The Communications Verification Test was performed on November 6, 1964, in accordance with the procedure described in Table A-2.

a. Purpose of Test

The purpose of this test was to verify operation of the Communications Group following replacement of the F-Channel 225-Kc VCO in the Telemetry Assembly.

b. Description of Test

The procedure used in this test is detailed in Table A-2.

c. Test Evaluation

The results of the Communications Verification Test were satisfactory. The power output as measured at the Four-Port Hybrid ranged between 58 and 62 watts, while the telemetered data from Communications equipment were normal.

2. Camera Calibration

The camera calibration was performed on November 7 and 8, 1964, in accordance with a modified version of RTSP1100A, Appendix C.

a. Purpose of Test

The purpose of this test was to determine the performance of the cameras after shutters and shutter shock isolators were replaced, and after F_b, P1 and P2 Cameras were refocused.

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TABLE A-2
COMMUNICATIONS VERIFICATION TEST PROCEDURE

Time	Mode of Operation
T-2	Cruise on
T+0	Both Channels in Warmup Mode
T+1' 20"	Both Channels in Full-Power Mode
T+11'	29.5 Volts on F-Channel
T+13'	32.0 Volts on F-Channel
T+13' 15"	Reset P-Channel
T+14'	Set P-Channel
T+15'	31.0 Volts on F-Channel
T+17'	29.5 Volts on P-Channel
T+19'	32.0 Volts on P-Channel
T+19' 15"	Reset F-Channel
T+20'	Set F-Channel
T+21'	31.0 Volts on P-Channel
T+30' 30"	Reset P-Channel
T+31'	Set P Reset F-Channel
T+31' 20"	Both Channels OFF
T+32'	Cruise OFF

b. Description of Test

All cameras functioned normally. The resolution of each camera was evaluated using an Itek chart. The results are expressed as percent of signal amplitude obtained when scanning a given line pattern, and were as follows: for F_a Camera, 30.5 and 6.5 percent at 448 and 672 TV lines, respectively; F_b Camera, 20 and 5.3 percent at 448 and 672 TV lines, respectively; P1 Camera, 10.8 percent at 167 TV lines; P2 Camera, 33.3 and 10.4 percent at 112 and 167 TV lines, respectively; and P3 Camera, 29.6 and 12.3 percent at 134 and 167 TV lines respectively. The focus was found to be good; some shutter-induced noise was evident in the video outputs of the P2 and P3

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Cameras; while the video output of the F_a and F_b Cameras were somewhat microphonic. Since the P4 Camera was subsequently replaced (MR 2150), no results regarding its performance are reported herein.

3. *Abbreviated TV Subsystem Test (RTSP 1100A, Appendix R)*

The abbreviated TV Subsystem test was performed on November 13, 1964, in accordance with RTSP 1100A, Appendix R.

a. Purpose of Test

The purpose of this test was to verify proper operation of the TV Subsystem subsequent to field operations rework.

b. Description of Test

This test was performed on the TV Subsystem with the thermal shroud removed and with external power. The test procedure detailed in RTSP 1100A, Appendix R, was modified to allow for the use of collimators on the cameras.

c. Test Evaluation

During this test, the resolution of each camera was evaluated, and the results were as follows: for F_a Cameras, 700 TV lines; F_b Camera, 650 TV lines; P1 Cameras, approximately 200 TV lines; P2 Camera, approximately 200 TV lines; and P3 Camera, approximately 220 TV lines. Except for some 15-kc noise evident in the raster of F_b Camera, and some microphonics at the output of P2 Camera induced by the P4-Camera shutter, the overall video performance was considered exceptionally good. The performance of telemetry, communications and GSE was normal.

H. Vibration Tests

1. Pre-Vibration Verification Test (Special Test)

The pre-vibration verification test was performed on November 13, 1964.

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a. Purpose of Test

The purpose of this test was to verify the performance of the TV Subsystem when it is in flight configuration prior to subjecting the Subsystem to vibration testing.

b. Description of Test

This test was performed in three parts. During the first two test sequences, the TV Subsystem was powered by external power; for the last test sequence, internal battery power was used. First, the TV Subsystem was commanded through a full-power sequence by means of RTC-7 commands. A light gun provided the light source for each camera, and the results were recorded on magnetic tape and Polaroid photographs. Next, a CC&S command was used to initiate the full-power sequence. Finally, the TV Subsystem was run through a warmup sequence using internal power.

c. Test Evaluation

The performance of the TV Subsystem during all sequences of this test was normal.

2. X-Axis Vibration Test (JPL Procedure 3R311.04)

The X-axis vibration test was performed on November 16, 1964, in accordance with JPL Procedure 3R311.04.

a. Purpose of Test

The purpose of the X-axis vibration test was to verify that the TV Subsystem was capable of withstanding X-axis vibrations equivalent to or greater than the vibrations imparted by the Atlas and Agena vehicles during the launch and orbit-injection operations. During the vibration test, the TV Subsystem was operated in the cruise mode. Since the TV Subsystem was to perform its picture-taking function during the terminal phase of the mission, proper operation after the specified levels of vibration was also required as part of this test.

b. Description of Test

Batteries were installed on the TV Subsystem, and it was then mated with the Spacecraft Bus. The entire Spacecraft was mounted on a special test fixture designed to simulate the shear and tension ties normally utilized to mate the Spacecraft to the Agena adapter, (ref: JPL Procedure 3R115).

During the vibration, the output of the Spacecraft was monitored by a two-way r-f link. A Stoddard antenna was positioned adjacent to the Spacecraft omni-antenna and interconnected to a directional antenna located on the roof of the Environmental Test Laboratory (ETL) at JPL for transmission to the System Test Complex located in the Spacecraft Assembly Facility.

Prior to actual vibration of the Spacecraft, a modal survey was performed in accordance with JPL Procedure 3R117, and X-axis equalization and noise burst tests were performed. During the entire test, the TV Subsystem was operated in the cruise mode of operation.

Following the X-axis vibration test, a functional verification test was performed on the TV Subsystem. Prior to the full-power sequence, a white reflective surface was placed within the fields of view of the cameras, and then illuminated. The OSE was connected in hardline mixed-signal configuration for reception of the r-f signals from the TV Subsystem.

c. Test Evaluation

Collimators were not employed in this test, so that a detailed evaluation of the cameras and video output was not possible. Except for some chopper-amplifier-induced raster noise in the output of the P2 Camera, all cameras appeared to function normally. Communications performance was normal. R-f power output peaked at 59 watts after 2.5 minutes of operation. At the end of a 6-minute test, the r-f power output was 56.1 watts. Telemetry operation was normal, as was the power profile for both batteries.

3. Y-Axis Vibration Test (JPL Procedure 3R311.04)

The Y-axis vibration test was performed on November 17, 1964, in accordance with JPL Procedure 3R 311.04.

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a. Purpose of Test

The purpose of this test was the same as that of the X-axis vibration test, except that the vibrations were imparted to the Y-axis of the Spacecraft.

b. Description of Test

The TV Subsystem was mated to the JPL Spacecraft Bus. Power for operation of the TV Subsystem equipment was provided by batteries installed in the TV Subsystem. The test setup and procedure for the Y-axis vibration test was the same as for the X-axis vibration test, except that modal survey was not required as a prerequisite. Following the vibration test, an electrical verification test was performed on the TV Subsystem.

c. Test Evaluation

The cameras of the TV Subsystem performed satisfactorily during the vibration and post-vibration verification tests. During the communications performance sequence of the post-vibration verification test, a directional coupler failed (MR2253). After the directional coupler was replaced, the sequence was repeated and the results obtained were normal. The telemetry data obtained during this test indicated that the performance of the TV Subsystem was normal. Similarly, power profile for both batteries was normal.

4. Z-Axis Vibration Test (JPL Procedure 3R311.04)

The Z-axis vibration test was performed on November 18, 1964, in accordance with JPL Procedure 3R311.04.

a. Purpose of Test

The purpose of the Z-axis test was the same as that for the X-axis, except that the vibrations were imparted to the Z-axis of the Spacecraft.

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b. Description of Test

The TV Subsystem was mated to the JPL Spacecraft Bus. Power for the TV Subsystem equipment was provided by batteries installed in the TV Subsystem. The test setup and procedure for the Z-axis vibration test was the same as for the X-axis vibration test, except that the test was performed in two parts: thrust and torsional, and a modal survey was not required as a prerequisite. Following the vibration test, an electrical verification test of the TV Subsystem was performed.

c. Test Evaluation

The overall performance of the TV Subsystem during this test was similar to that of the two preceding tests and was deemed satisfactory. During the first minute of the post-vibration verification test, there was too much attenuation between JPL receiver and the OSE. Attenuation was decreased by removing an attenuation pad, and the test was completed without any further incident.

I. Post-Vibration Verification Test

1. Post-Vibration System and EMI Test No. 4 (JPL Procedure 3R300.16) R300.16)

The post-vibration and emi test was performed on November 23, 1964, in accordance with JPL Procedure 3R300.16.

a. Purpose of Test

The purpose of this test was to verify that TV Subsystem operation had not been degraded as a result of the vibration tests.

b. Description of Test

During this test, the Spacecraft configuration was not altered from the setup used for the vibration test sequences, except that collimators were installed on the cameras. The procedure that was followed during this test was essentially the

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same as that for system and emi test No. 3, except that an RTC-5 command was employed for TV Subsystem turn-off. In addition, the TV Subsystem was placed in warmup mode by means of a CC&S TV 3 command, thereby verifying both TV Subsystem turn-on command functions.

c. Test Evaluation

During this test, the resolution of each camera was evaluated and the results were as follows: For the F_a Camera, 700 TV lines; F_b Camera, 625 TV lines; P1 Camera, 200 TV lines; P2 Camera, 200 TV lines; P3 Camera, 200 TV lines; and P4 Camera, 200 TV lines. Although the P2 Camera exhibited both chopper-induced raster noise and shutter-induced noise, all cameras performed normally. Operation of communications and telemetry was good, while the battery power profile was normal. The overall performance of the TV Subsystem was deemed satisfactory.

J. Vacuum-Thermal Tests

1. Abbreviated TV Subsystem Test (RTSP 1100A, Appendix B)

The abbreviated TV Subsystem test was performed on November 24, 1964, in accordance with RTSP 1100A, Appendix R.

a. Purpose of Test

The purpose of this test was to verify the proper operation of the TV Subsystem, after the installation of the thermal harness, as a preparatory measure before thermal-vacuum testing.

b. Description of Test

Prior to this test, the thermal harness, thermal shroud, and collimators were installed on the TV Subsystem. During the test, the equipments of the TV Subsystem were operated by external power. The test procedure detailed in RTSP 1100A, Appendix R, was modified to allow for the use of collimators on the cameras. After the completion of the test, the TV Subsystem was switched over to battery power, and was operated in the full-power mode for approximately 30 seconds. This test was performed in an ambient environment.

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c. Test Evaluation

During this test, the performance of all cameras was similar to that in the preceding test, except that the output of the P2 Camera was free of the chopper-induced raster noise. Communications performed normally but playback of the F-Channel 15-point telemetry data was noisy. This malfunction was later isolated to F-Channel discriminator in the GSE (MR2254).

2. Pre-Mission Verification Test (JPL Procedure 3R302.05)

The pre-mission verification test was performed on November 24, 1964, in accordance with JPL Procedure 3R302.05.

a. Purpose of Test

The purpose of this test was to verify the integrity of all cable interconnections between the RA-8 Spacecraft and the System Test Complex which controls the Spacecraft. To ensure proper operation of TV Subsystem before subjecting it to the mission tests, an abbreviated electrical test was performed.

b. Description of Test

The Spacecraft Bus and TV Subsystem were mated and then installed in the JPL space simulator. The cables were connected in accordance with JPL Procedure 3R116, and collimators were refocused for use in vacuum and installed on the cameras. Before the test proper was started, a Vacuum Fail Control, which turns off all high voltage supplies to the Spacecraft in the event of a loss of vacuum in the chamber, was checked for proper operation. In the event that the pressure in the chamber is 10^{-4} mm Hg or more, this control resets CC&S commands A-1 and A-4, and interrupts the battery line to the TV Subsystem. This test was performed on external power.

c. Test Evaluation

The overall performance of TV Subsystem during the pre-mission verification test was good. Resolution of each camera was evaluated and the results were as follows: For F_a Camera, 700 TV lines; F_b Camera, 580 TV lines; P1 Camera,

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180 TV lines; P2 Camera, 200 TV lines; P3 Camera, 210 TV lines; and P4 Camera, 216 TV lines. However, there were two malfunctions in the OSE Equipment. Because of a mis-wired circuit, the GSE Vacuum Fail Control Circuit failed to operate (MR2256); also, because "Cruise Test" switch induced a transient, the "No Sync" indicator on Rack 4 of the Blockhouse Control Panel Checkout Unit illuminated when the "Cruise Test On" switch was reset (MR2255).

3. *Mission Test No. 1 (JPL Procedure 3R302.08)*

The mission test No. 1 was performed during the period from December 1 through December 4, 1964, in accordance with JPL Procedure 3R302.08.

a. Purpose of Test

The purpose of this test was to verify proper operation of the TV Subsystem in a near-space vacuum and high-temperature (35°C) environment. Furthermore, its purpose was to detect any interactions that may result from operation in a normal flight sequence when the Spacecraft is exposed to a space environment, and to demonstrate its capability to operate for an extended period of time under these conditions, as is required during the mission.

b. Description of Test

The TV Subsystem configuration was the same as in the previous test, and its operation was monitored and controlled by the System Test Complex. The TV Subsystem was powered by batteries. A power control relay was connected between the batteries and the High-Current Voltage Regulators to enable the use of batteries or external power. A real-time (66 hr) mission was run at pressures of 10^{-5} mm Hg or less, and at a temperature of approximately 35°C. The chamber-wall temperature was reduced to approximately -180°C, and the test temperature was obtained by means of strip heaters installed on the solar-illuminated surfaces of the TV Subsystem. The test was started on December 1, 1964, at 1700 hrs., and the sequence of TV Subsystem operation is given in Table A-3.

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TABLE A-3
MISSION TEST NO. 1, TV-SUBSYSTEM TEST SEQUENCE

Date	Time	Mode of Operation	Remarks
12/1/64	17:00:00	TV-Subsystem set to "Cruise On."	Start of the test; Simulated launch
12/1/64	18:58:40	6 4-1/4 hour count of TV Subsystem Clock started by simulated operation of Agena separation switch.	Simulated Agena separation
12/4/64	11:19:30	F-Channel warmup initiated by onboard Clock command.	F-Channel was set to full power automatically by the 80-second timer
12/4/64	11:29:52	The F- and P-Channel 80-second timers were reset manually, and then TV-3 was reset by CC&S command, thereby placing F- and P-Channels in warmup condition.	
12/4/64	11:31:17	F- and P-Channels turned off by RTC-5 command.	
12/4/64	11:31:59	TV Subsystem turned off manually.	End of Test

c. Test Evaluation

During this test, the resolution of each camera was evaluated and the results were as follows: For the F_a Camera, 710 TV lines; F_b Camera, 600 TV lines; P1 Camera, 200 TV lines; P2 Camera, 200 TV lines; P3 Camera, 180 TV lines; and P4 Camera, 140 TV lines. Except for P4 Camera, where defocusing resulted in a resolution of 140 TV lines (MR2259), the focus of all cameras was good. The P2-Camera video output exhibited some shutter induced noise, nuvistor microphonics due to P4-Camera Shutter operation, and microphonics due to vidicon mesh vibration.

Communications were normal, and both 15-point and 90-point telemetry data were satisfactory. Telemetry data were obtained over Channel-8, P-Channel and F-Channel. The turn-on of F-Channel, however, was found to be late by 5 minutes and 50 seconds; the malfunction was traced to the on-board Clock (MR2258). Furthermore, the GSE clock timer, located on Unit 18 of the OSE, was malfunctioning (MR2257). The power profile was normal.

The performance of TV Subsystem was conditionally acceptable. The complete acceptance of the TV Subsystem was contingent on P2 and P4 Cameras and the spare on-board Clock becoming acceptable. The P2-Camera performance would be deemed acceptable if the microphonics were reduced to satisfactory levels when the camera is operated at nominal temperature of 20°C. The P4-Camera would be deemed acceptable provided that the defocusing proved to be a consequence of the high-temperature (35°) environment, and not a consequence of vacuum. It was determined that the malfunctioning Clock would be replaced by a spare Clock after the spare had passed a special test consisting of two real-time missions in vacuum at 20°C and 35°C ambient at the assembly level. Furthermore, once installed in the TV Subsystem, the spare on-board Clock was required to pass the Clock verification test.

4. Mission Test No. 2 (JPL Procedure 3R302.08)

The mission test No. 2 was performed during the period from December 4 through December 7, 1964, in accordance with JPL Procedure 3R302.08.

a. Purpose of Test

The purpose of this test was to verify proper operation of the TV Subsystem in a near-vacuum and low-temperature (11°C) environment. Furthermore, its purpose was to detect any interactions that may result from operation in a normal flight sequence when the Spacecraft is exposed to a space environment, and to demonstrate its capability to operate for an extended period of time under these conditions, as is required during a mission. In addition, during this test, the Mission Test No. 1 requirements were fulfilled by performing the special P2- and P4-Cameras thermal-vacuum test. The details of the special test are presented separately, after discussion of mission test No. 2.

b. Description of Test

Since this test was performed immediately after mission test No. 1, the vacuum in the space simulator was preserved, and consequently, the Spacecraft

configuration remained the same as for the previous test. The test was started with the TV Subsystem at 35°C, and its temperature was allowed to decrease to 19.5°C; the temperature of the Subsystem was then stabilized, and the above-mentioned special test was performed. Subsequently, the TV Subsystem temperature was allowed to decrease further; at 11°C, the temperature was again stabilized, and the remainder of the test was performed. The sequence of the test is detailed in Table A-4.

c. Test Evaluation

During this test, the resolution of each camera was evaluated and the results were as follows: For F_a Camera, 800 TV lines; F_b Camera, 600 TV lines; P1 Camera, 200 TV lines; P2 Camera, 200 TV lines; P3 Camera, 210 TV lines; and P4 Camera, 210 TV lines. The focus of all cameras was good, and only the output of the P2 Camera exhibited some microphonics. The performance of Communications was good, and the power profile was normal.

Early in the test, the telemetry data indicated the P-Channel bus voltage to be low; this was attributed to a malfunction of the High-Current Voltage Regulator (HCVR). Since this condition did not degrade the P-Channel output, the HCVR was replaced after the completion of the test (MR2262). Also, while monitoring the OSE recorder for the 16-hour Clock pulse, it was noted that the F-Battery monitor point, transmitted over Channel-8 15-point telemetry, indicated 2.5 volts. This reading corresponds to a current drain of 2.5 amperes. Since the only unit drawing current from F-Battery at that time was the Clock, the latter was turned off, (see Table A-4). Subsequently, it was determined that at the time when this particular F-Battery readout was obtained, Channel-8 telemetry was being switched from Mode 1 to Mode 3. The resultant recorder indication thus corresponded to Mode 2 telemetry during which no 15-point data are transmitted and during which OSE recorder reads midscale, i.e., 2.5 volts. Thereafter, the Clock was turned on, and was operated for 32 hours. Prior to the 32-hour Clock pulse, several RTC-5 commands were sent; these commands did not turn off the Clock, thereby indicating that the Clock "turn-off inhibit" circuits were functioning properly. After the 32-hour Clock pulse was received, another RTC-5 command was sent to turn off the Clock.

Furthermore, radio-frequency interference (rfi) was noted on the output of the JPL 890-Mc Transponder/Receiver and on Channel-8 90-point telemetry whenever the TV Subsystem was operated in the full-power mode. To investigate this interference, it was decided to perform a special rfi test after the completion of the mission test No. 2. Since 90-point telemetry data were transmitted simultaneously over the P-Channel 225-kc VCO, there was no loss of data; telemetry performance was considered good.

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TABLE A-4
MISSION TEST NO. 2, TV-SUBSYSTEM TEST SEQUENCE

Date	Time	Mode of Operation	Remarks
12/4/64	15:33:39	TV Subsystem set to "Cruise On."	Start of the Test
12/4/64	15:39:00		Simulated launch
12/4/64	16:12:40	6 4-1/4 hour count of TV Subsystem Clock started by the simulated operation of the Agena separation switch.	Simulated Spacecraft separation
12/5/64	08:46:00	F- and P-Channel warmup initiated by RTC-7 command.	This sequence constituted the Special P2 and P4 Camera Test. Prior to this sequence the TV Subsystem was stabilized at 19.5°C
12/5/64	08:50:02	F- and P-Channels turned off by RTC-5 command.	
12/5/64	10:30:00	TV Subsystem Clock turned off manually.	Suspected malfunction of the Clock
12/5/64	14:18:00	TV Subsystem Clock turned on manually.	A 32-hour checkout of the Clock started
12/7/64	08:15:00	TV Subsystem Clock turned off by RTC-5 command.	The 32-hour Clock pulse was received; end of Clock checkout.
12/7/64	09:15:00	F- and P-Channel warmup initiated by CC&S TV2 command.	Started terminal mode sequence
12/7/64	09:26:00	F- and P-Channels turned off by RTC-5 command.	End of Test

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5. Special P2- and P4-Camera Thermal-Vacuum Test

The special P2- and P4-Camera thermal-vacuum test was performed on December 5, 1964. This special test was performed concurrently with and as an additional sequence of mission test No. 2.

a. Purpose of Test

The purpose of this test was to evaluate the operation of P2 and P4 Cameras in a vacuum and at a nominal temperature (19.5°C).

b. Description of Test

After the temperature of the TV Subsystem was reduced and stabilized at 19.5°C, the warmup mode of the TV Subsystem was initiated by RTC-7 command. Eighty seconds later, the TV Subsystem was set automatically to the full-power mode; after operating for 2 minutes and 42 seconds on full power, the TV Subsystem was turned off by RTC-5 command.

c. Test Data Evaluation

During this test, the resolution of each camera was evaluated and the results were as follows: For the F_a Camera, 750 TV lines; F_b Camera, 600 TV lines; P1 Camera, 200 TV lines; P2 Camera, 200 TV lines; P3 Camera, 200 TV lines; and P4 Camera, 180 lines. The focus of all cameras was good, and it was surmised that the defocusing of P4 Camera during the mission test No. 1 was due to high temperature, and not to the vacuum environment. The video output of the P4 Camera, which was defocused at 35°C and is now in focus at 19.5°C, is shown in Figure A-3.

Similarly, the P2 Camera did not exhibit excessive microphonics. The performance of telemetry and communications was satisfactory, and the power profile was normal. Since the operation of P2 and P4 Cameras was normal, the TV Subsystem was acceptable for the next test.

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K. Special Tests

1. Special RFI Test

The special radio-frequency interference (rfi) test was performed on December 7 and 8, 1964.

a. Purpose of Test

The purpose of this test was to determine the cause of the rfi noted on the output of the 890-Mc Transponder/Receiver and on the Channel-8 90-point telemetry during the mission test No. 2.

b. Description of Test

The special rfi test consisted of five sequences; each of which was run under slightly different conditions of environment or power input. Pertinent details for each sequence are given in Table A-5.

TABLE A-5
TEST CONDITIONS FOR SPECIAL RFI TEST

Sequence	Date	Temperature	Pressure	Power	Duration of Test
1	12/7/64	11°C	Vacuum	External	20 min 49 sec
2	12/7/64	11°C	Vacuum	Internal	14 min 36 sec
3	12/8/64	Ambient	Vacuum	External	28 min 39 sec
4	12/8/64	Ambient	Vacuum	External	12 min 33 sec
5	12/8/64	Ambient	Ambient	External	13 min 27 sec

Since test sequences 1 through 4 were performed after mission test No. 2, the vacuum in the space simulator was preserved, and the TV Subsystem configuration remained

the same as for the previous tests. Also, the configuration was not changed for sequence 5, even though it was performed outside the space simulator. The operation of TV Subsystem during each sequence was similar; first, the TV Subsystem was set in the cruise mode of operation, and then the warmup of the F- and P-Channels was initiated. The two channels were switched to full-power operation automatically by the outputs of the 80-second timers. Next, one of the channels was reset manually to warmup, left in this condition for a minute or two, and then returned to full power operation. The other channel was similarly cycled, and the procedure was repeated several times for each channel. Finally, the two channels were turned off, and cruise mode of operation was terminated, thereby ending the sequence. During this test, special effort was made to note any occurrence of rfi and to determine its cause. In addition, TV Subsystem operation was monitored in the usual manner.

c. Test Evaluation

The test results indicate that the rfi originated from P-Channel; whenever P-Channel was set to full power, rfi was observed on the output of the 890-Mc Transponder/Receiver. When P-Channel was switched to warmup mode, the interference level was considerably reduced. While the source of rfi was located during this test, the reason for rfi being coupled to the output of the 890-Mc Transponder/Receiver could not be determined.

The resolution of each camera was evaluated during each sequence, and it was found to be the same throughout the test; the resolution was evaluated as follows: For the F_a Camera, 750 TV lines; F_b Camera, 600 TV lines; P1 Camera, 200 TV lines; P2 Camera, 200 TV lines; P3 Camera, 200 TV lines; P4 Camera, 200 TV lines. The focus of all cameras was good; however, the output of the P1, P2 and P3 Cameras exhibited some shutter-induced noise during the first two test sequences.

The performance of telemetry was normal. Starting with sequence 2, the 90-point telemetry data indicated a malfunction of the +1000-volt supply in the P-Channel Transmitter Power Supply. The malfunction was due to intermittent operation of a relay in the power supply (MR2260), and resulted in +1000 volts being applied to the P-Channel Transmitter Power Amplifier during warmup and reduced-power modes of operation. The malfunction was reflected in the power profiles obtained for sequences 3, 4, and 5. The performance of communications, however, was not affected and appeared to be normal throughout the test.

2. P-Channel Transmitter Power Supply Rework Test

The P-Channel Transmitter Power Supply rework test was performed on December 9, 1964.

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a. Purpose of Test

The purpose of this test was to correct the malfunction described in the preceding test. Transmitter Power Supply, Serial No. 017, was replaced (MR2260). This test was performed to verify the proper operation of P-Channel communications equipment after Transmitter Power Supply, Serial No. 015, was installed in the TV Subsystem.

b. Description of Test

TV Subsystem was demated from the JPL Bus and the new power supply was installed. Clock, Serial No. 008, was also removed at this time (See MR2258), and testing continued without an on-board Clock until Clock, Serial No. 003, was installed on December 18, 1964. Subsequently, the rework test was performed on the TV Subsystem in accordance with the sequence presented in Table A-6.

TABLE A-6
P-CHANNEL TRANSMITTER POWER SUPPLY REWORK TEST

Time	Mode of Operation
T-6'00"	TV Subsystem set to "Cruise On"
T+0'00"	P-Channel warmup initiated
T+1'20"	P-Channel set to full power by output from the 80-second timer
T+17'55"	F-Channel warmup initiated
T+19'55"	F-Channel set to full power by output from the 80-second timer
T+22'30"	P-Channel reset to warmup manually
T+23'00"	Both channels turned off
T+30'40"	TV Subsystem turned off

To verify proper operation of the cameras, a light gun was used as a source of illumination, and Polaroid photographs were taken of the monitor display. The test was performed on external power.

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c. Test Evaluation

The TV Subsystem performance was normal. The replacement of P-Channel Transmitter Power Supply cleared the +1000 volt supply malfunction encountered during the rfi test.

3. *P-Channel High-Current Voltage Regulator Rework Test*

The P-Channel High-Current Voltage Regulator (HCVR) rework test was performed on December 10, 1964.

a. Purpose of Test

When the data obtained during mission test No. 2 were analyzed, it became apparent that P-Channel HCVR, Serial No. 012, had malfunctioned. This unit was replaced by HCVR, Serial No. 008. The purpose of P-Channel HCVR rework test was to verify proper operation of the TV Subsystem after the new HCVR was installed.

b. Description of Test

The TV Subsystem, less the Clock, was mated to the JPL Spacecraft Bus, and the test was performed on external power, in accordance with the sequence presented in Table A-7.

To determine the minimum r-f level at which the r-f link verification test (which was to follow this test) could be run, the r-f level was intentionally set low. The operation of the cameras was checked by placing a light box within the field of view of all the cameras, and then viewing the outputs from the cameras on the monitor display.

c. Test Evaluation

During this test, the performance of all the cameras was normal. The video output contained some r-f noise which was attributed to the very low r-f levels used during this test. The performance of communications was satisfactory, and telemetry data were normal. Although the telemetry points for HCVR, Serial No. 008, were not calibrated at this time, the telemetered data was comparable to that obtained by direct measurement with a digital voltmeter.

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TABLE A-7
P-CHANNEL HCVR REWORK TEST

Time	Mode of Operation
09:51:15	TV Subsystem set to "Cruise On"
09:51:30	F- and P-Channel warmup initiated by RTC-7 command
09:52:50	F- and P-Channel set to full-power by outputs from the 80-second timers
10:01:50	F- and P-Channels turned off by RTC-5 command
10:01:55	TV Subsystem turned off

L. RF Link Tests

1. Pre-RF Link Verification Test (JPL Procedure 3R320.02)

The pre-RF link verification test comprised the terminal-mode sequence specified in JPL Procedure 3R320.02, and was performed on December 10, 1964.

a. Purpose of Test

The purpose of this test was to verify proper electrical performance of the TV Subsystem before proceeding with r-f link verification test.

b. Description of Test

During this test, the Spacecraft configuration was the same as during the mission tests except for the following changes. The Spacecraft, less a Subsystem Clock, was mounted directly to the space simulator floor, and a copper screen was placed around it. Except for the control cable to the power relay between the Batteries and High-Current Voltage Regulators, all hardware connections were removed. The strip heaters and camera collimators were also removed. The communication with the Spacecraft was accomplished by means of r-f links utilizing probe antennas.

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TV Subsystem was turned on into warmup mode by CC&S TV-2 command. After 80 seconds, the F- and P-Channels were automatically set to the full-power mode of operation. Ten minutes later, the TV Subsystem was turned off by an RTC-5 command. The operation of the cameras was checked by placing a light box within their field of view and viewing it on the monitor display. The test was performed on internal power at ambient temperature and pressure.

c. Test Evaluation

During this test, the operation of all cameras was satisfactory; telemetry data and power profile were normal. No rfi was observed, but this was attributed to a newly installed directional coupler which provided an additional 19.43 db isolation between P-Channel output and the rfi checkout equipment. The performance of communications was deemed satisfactory.

2. RF Link Verification Test (JPL Procedure 3R320.02)

The r-f link verification test was performed from December 10 through December 12, 1964, in accordance with JPL Procedure 3R320.02.

a. Purpose of Test

The purpose of this test was to verify the proper operation of the TV Subsystem in a simulated space environment with a minimum of support equipment connected to the Spacecraft.

b. Description of Test

During this test, the Spacecraft configuration was the same as for the previous test, that is, operated by battery power, and a light box was used to illuminate the cameras. The test was performed in the space simulator at pressures of 10^{-4} mm Hg, or less. The chamber wall temperature was reduced to approximately 180°C, and the test temperature of approximately 22.5°C was obtained by means of solar simulation. The test was started on December 10, 1964, at 1700 hours, and was aborted two hours later because the solar-simulator temperature caused unexpected stresses on the Spacecraft due to the mounting method employed for the test. The test was started for the second time on December 11, 1964, at 09:49 hours using a correct mounting

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method. Approximately twenty hours later, the terminal-mode sequence was performed in accordance with JPL Procedure 3R320.02.

c. Test Evaluation

The operation of all cameras was similar to that observed during the previous test, and it was deemed satisfactory. Communications performance and power profile were normal. The i-f amplifier in GSE F-Channel tape recorder was intermittent, and towards the end of the test, oxide buildup on the recording head caused P-Channel and Channel-8 signals to fade. A comparison of 15-point telemetry temperature data with that received at the JPL Telemetry Processing Station indicated an agreement to within 3°F. The 90-point telemetry data were normal, and all telemetry data was deemed good.

3. Directional Antenna Deployment Test (JPL Procedure 3R243.00)

The directional antenna deployment test was performed on December 14, 1964, in accordance with JPL Procedure 3R243.00.

a. Purpose of Test

The purpose of this test was to verify the performance of the TV Subsystem during deployment of the directional antenna through its range of flight angles. Specifically, the purpose of the test was to monitor the outputs of the TV Subsystem for any occurrence of rfi due to the articulation of the antenna.

b. Description of Test

During this test, the Spacecraft configuration was the same as for the previous tests, except that the solar panels were installed and extended. The directional antenna drive was powered from an external 400-cycle source, and the antenna was articulated in a continuous motion from 0 to 155 degrees and then back to 0 degrees.

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c. Test Evaluation

During this test, the performance of all cameras was normal, except for some intermittent loss of F- and P-Channel video synchronization. This loss of synchronization was expected, and was caused by the motion of the antenna. Similarly, F- and P-Channel telemetry was normal, except for a short period during antenna retraction, when P-Channel synchronization was lost. As there was no loss of telemetry transmitted over the omniantenna, the 90-point telemetry data were recovered from the tape. The power profile was normal, while the communications profile appeared to vary slightly. The latter was attributed to re-radiation changes caused by the deployment of the antenna. No rfi was noted during this test.

On December 15, 1964, subsequent to directional antenna deployment test, the mechanical inspection (JPL Procedure 3R127) was performed and no degradation of TV Subsystem was reported. On December 16, 1964, the cause of rfi generated by the P-Channel communications equipment was investigated. The results showed that P-Channel equipment was operating normally, and P-Channel output was within the specified limits. Finally, HCVR, Serial No. 008, which was previously installed in the P-Channel, was calibrated.

M. SFOF Test

1. Spacecraft—Space Flight Operations Facility (SFOF) Compatibility Test (JPL Procedure 3R318.03)

The Spacecraft-SFOF compatibility test was performed on December 28, 1964, in accordance with JPL Procedure 3R318.03.

a. Purpose of Test

The purpose of this test was to ensure the compatibility between Spacecraft and SFOF equipment, and to test both in normal pre-flight and flight operations.

b. Description of Test

The Spacecraft, complete with the TV Subsystem Clock, was mounted on the system test stand and held parallel to the floor. The collimators were installed on

the cameras, and r-f output was fed through hardline connections to the OSE. The test, which comprised an accelerated mission simulation at ambient conditions, was conducted on external (OSE) power.

c. Test Evaluation

During this test, the resolution of P-Cameras was evaluated, and the results were as follows: For the P1 Camera, 175 lines; P2 Camera, 175 lines; P3 Camera, 210 lines; and P4 Camera, 200 lines. The focus of P1 and P2 Cameras was found to be soft; this was attributed to the collimators which were not refocused for ambient conditions after the thermal-vacuum tests. Furthermore, severe noise bursts were evident on the 35-mm film record of P2-Camera video output. This problem was present only when the TV Subsystem was mounted in the horizontal position (MR2268). The performance of F_a Camera was normal; the RETMA chart on F_b collimator was not centered, so that the performance of the F_b Camera could not be evaluated.

Both 15-point and 90-point telemetry was normal, except for the loss of 15-point telemetry at C + 30 minutes due to the shut-down of P-Channel external power supply (MR2267). The switch controlling P-Channel power supply was accidentally turned off; after 1 minute and 43 seconds, the switch was turned to on, and 15-point telemetry reappeared. Communications performance was normal, and no rfi was observed on the output of the JPL 890 Mc Transponder/Receiver.

N. Pre-Shipment Test

1. Pre-Shipment System Test (JPL Procedure 3R300.18)

The pre-shipment system test was performed on December 29, 1964, in accordance with JPL Procedure 3R300.18.

a. Purpose of Test

The purpose of this test was to verify proper Spacecraft operation after the reassembly and to ensure that the Spacecraft was ready for shipment to ETR.

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b. Description of Test

The Spacecraft was mounted vertically on the system test stand and was connected to external power supplies. Direct access between the Spacecraft and OSE was provided by cables, which carried stimuli and allowed monitoring of Spacecraft circuits and functions. To enable evaluation of the cameras, collimators were attached. Prior to the test, the alignment of all the collimators was verified, and the P1, P2 and F_b collimators were refocused and realigned. The Spacecraft was then subjected to an accelerated mission simulation at ambient conditions.

c. Test Evaluation

During this test, the resolution of each camera was evaluated and the results were as follows: For the F_a Camera, 700 TV lines; F_b Camera, 625 TV lines; P1 Camera, 200 TV lines; P2 Camera, 200 TV lines; P3 Camera, 210 TV lines; and P4 Camera, 210 TV lines. The focus of all cameras was good, and only slight microphonics were observed. The performance of communications was good, while telemetry and power profile were normal. The Spacecraft was considered ready for shipment to the Eastern Test Range.

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Appendix B

Prelaunch Testing of Flight Model III-3 TV Subsystem at the Eastern Test Range (ETR)

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Appendix B
Prelaunch Testing of Flight Model III-3 TV Subsystem at the Eastern Test Range (ETR)

A. General

Following the pre-shipment electrical test on December 29, 1964, the Flight Model III-3 TV Subsystem was shipped from JPL on January 6, 1965, and arrived at the Eastern Test Range (ETR) on January 10, 1965. The test program at ETR commenced on January 12, 1965, with the post-shipment electrical test, and terminated with the launch on February 17, 1965. A summary of the tests performed on Flight Model III-3 at ETR is presented in Table B-1.

The ETR test program consisted of checkout and test of the TV Subsystem integrated with the Spacecraft Bus in the Spacecraft Checkout Facility (SCF) Hanger AO, operations in the Explosive Safe Facility (ESF), and operations on the launch pad in conjunction with the Atlas and Agena launch vehicles. The purpose of the prelaunch testing at ETR was to re-affirm the operational readiness of the TV Subsystem integrated with the Spacecraft Bus; to ensure that all systems of the RA-8 Spacecraft were compatible with the launch vehicle; and to ensure that all systems of the RA-8 Spacecraft were in a "go" condition at the time of launch. These tests also provided the opportunity to verify launch procedures and increase the proficiency of operating personnel to ensure smooth a launch operation.

This appendix presents a brief description of each test performed on the TV Subsystem together with an evaluation of the test data obtained. An analysis of each malfunction report (MR) referenced in the appendix is presented in Tables C-1 or C-2 of Appendix C.

B. Post-Shipment Electrical Test

1. *Abbreviated Subsystem Test*

A post-shipment electrical test was performed on January 12, 1965. This test was performed in accordance with the procedures of RCA Specification RTSP-1100A, Appendix R, "Abbreviated Subsystem Test."

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TABLE B-1
TV SUBSYSTEM TESTS AT ETR

Title of Test	Date	Test Procedure
Post-Shipment Electrical Test	1/12/64	RTSP-1100A
Clock Verification and TV Subsystem Tilt Test	1/15/64	Special Test
Backup Functions Test	1/15/64	JPL Procedure 3R305.09
System Test No. 6	1/18/65	JPL Procedure 3R300.19
Operational Checkout-RF Link	1/20/65	JPL Procedure 3R315.04
ESF Television Full-Power Test	1/26/65	JPL Procedure 3R235.04
ESF Operational Checkout	1/28/65	JPL Procedure 3R317.04
Pre-Countdown Dummy Run	1/29/65	JPL Procedure 3R304.06
Countdown Dummy Run	1/29/65	JPL Procedure 3R309.07
Joint Flight Acceptance Composite Test	2/1/65	JPL Procedures 3R309.05 and 3R307.02
Camera Calibration	2/4/65	JPL Procedure 3R220.03
Special RFI Test	2/4/65	Special Test
Final System Test No. 7	2/5/65	JPL Procedures 3R300.20 and ETR 3R300.06
ESF Television Full-Power Test	2/9/65	JPL Procedure 3R235.05
ESF Operational Checkout	2/12/65	JPL Procedure 3R317.05
Pre-Countdown Test	2/13/65	JPL Procedure 3R304.07
Simulated Countdown Test	2/15/65	JPL Procedure 3R309.08
Launch Countdown Test	2/17/65	JPL Procedure 3R309.08

a. Purpose of Test

This test was performed to verify that no damage was incurred by the TV Subsystem during shipment from JPL to the ETR.

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b. Description of Test

The TV Subsystem was not mated to the Spacecraft Bus for this test. In addition, the thermal shrouds were removed from the Subsystem; collimators were attached to the cameras; and the TV Subsystem was operated by external (OSE) power.

c. Test Data Evaluation

Review of the video performance indicated that all cameras operated normally; however, there were some problems in the video performance attributable to the GSE. These problems consisted of (1) video tearing at the start of each P-Camera picture, (2) fast noise spikes in the on-line video, and (3) no recording of the full-scan video. The video tearing, which was caused by a sync problem in the GSE, and the fast noise spikes in the on-line video were corrected following the test. Recording of the full-scan video was also restored after the test when a defect in the record oscillator was corrected.

The telemetry, power, and communication performance were all normal. It was concluded that the TV Subsystem showed no deliterious effects from its shipment.

C. Special Tests

1. Clock Verification and TV Subsystem Tilt Test

Two special tests, the Clock verification test and the TV Subsystem tilt test, were conducted on January 15, 1965. Because the tests were performed as a single test, they are discussed simultaneously.

a. Purpose of Test

The Clock verification test was performed at the ETR because this was the first opportunity to verify the operation of this Clock, Serial No. 003, after its installation in the TV Subsystem. This clock had previously undergone environmental testing at RCA which included a 64-1/4 hour check at 0°C and another 64-1/4 hour check at 55°C. Both checks were performed in a vacuum environment; the Clock performed normally.

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The TV Subsystem tilt test was performed to verify that the camera shutters would operate normally when the Subsystem was tilted. The TV Subsystem was tilted first in a -Y direction until the Subsystem Z-axis was parallel to the floor, and then in a +Y direction.

b. Description of Test

For this test, the TV Subsystem was mounted on the Subsystem test stand, and powered by batteries. The test sequence is given in Table B-2. For this test, F-Channel turn on was effected by Clock command.

TABLE B-2
CLOCK VERIFICATION AND TV SUBSYSTEM TILT TEST SEQUENCE

Date	Time	Operation Function
1/12/65	13:45:00	Clock turn on.
1/13/65		RTC-5 command sent just before the 32-hour Clock pulse. Clock did not turn off.
1/15/65	06:01:02(T+0)	F-Channel warmup effected by Clock command.
	T+1' 20"	F-Channel in full power.
	T+2' 00"	P-Channel in warmup.
	T+3' 20"	P-Channel in full power. TV Subsystem in vertical position.
		Subsystem tilted in the -Y direction until the Z axis parallel to floor.
		Subsystem returned to vertical and tilted in the in the +Y direction until the Z axis parallel to floor.
	T+6' 30"	RTC -5 command sent. Both channels and Clock off.
	T+6' 40"	Cruise off.

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c. Test Evaluation

Proper operation of the Clock was verified. Failure of the Clock to turn off on 1/13/65, after receipt of the RTC-5 command, indicated the Clock turn-off inhibit circuit was functioning properly. The actual Clock pulse times and the amplitudes of the Clock telemetry pulses are listed in Table B-3. The Clock lost only 62 seconds during the 64-1/4-hour test in comparison to the specification of ±5 minutes on the long count.

TABLE B-3
CLOCK PERFORMANCE

Scheduled Pulse Time (hours)	Variation (seconds, -15, +0)	Telemetry Pulse Amplitude (volts)
0	-	0.8
8	+16	1.6
16	+16	2.5
24	+27	3.1
32	+35	4.1
48	+50	5.0
64	+71	0.8
64-1/4	+62	-

Telemetry performance was normal; both 15- and 90-point telemetry data were good. The communications and power performance was also normal.

All camera shutters operated properly. The position of the TV Subsystem did not affect shutter operation; however, its position did affect the shutter-induced noise in the video output of certain cameras. With the Subsystem in the vertical position, a significant amount of shutter-induced noise appeared in the video output of the P2-Camera; however, when the Subsystem was tilted in the -Y direction, the noise was greatly reduced, but still noticeable.

With the Subsystem between the vertical position and the full 45-degree tilt in the +Y direction, there was no shutter-induced noise in the video output of any camera. With the Subsystem fully tilted in the +Y direction, a significant amount of shutter-induced noise appeared in the video output of the P3-Camera.

The kinescope in the GSE was out of focus during this test. This malfunction was caused by incorrectly adjusted kinescope focus voltage which was corrected after the test was completed (MR 2303). The results of this test were satisfactory.

D. Initial System Tests

1. Back-Up Functions Test (JPL Procedure 3R305.09)

The back-up functions test was performed on January 15, 1965, in accordance with JPL Procedure 3R305.09.

a. Purpose of Test

The purpose of this test was to verify proper operation of the back-up command functions which cannot be conveniently checked during regular systems tests.

b. Description of Test

The TV Subsystem was mated with the Spacecraft Bus for this test, and the Subsystem was powered by an external power source. Collimators were mounted on the cameras, and all camera outputs were recorded on 35-mm film. R-f output was through hardline connections between the omni-directional antenna and the OSE. The back-up commands tested are listed in Table B-4.

c. Test Evaluation

All back-up commands functioned normally during the test. Both the 15- and 90-point telemetry data were normal. All cameras performed normally; however, some noise was observed in the outputs of the F_b and P2 Cameras. In the video output of the F_b Camera, some 15-kc noise was evident. The P2-Camera video output revealed some (1) shutter-induced noise in alternate frames, (2) microphonics induced by the shutter of the P4-Camera, and (3) microphonics caused by vibration of the vidicon mesh (approximate amplitude of 50 mv). In general, the focus of all cameras was good, and the general appearance of the video ranged from normal (for the P2-Camera), to

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TABLE B-4
COMMANDS TESTED DURING BACK-UP FUNCTIONS TEST

Command	Function
Agena Separate Microswitch	Starts the 64-1/4 hour count of the Clock.
Hydraulic Timer Command	Provides a ground enable for the SCR gate current-limiting resistors. Activates Cruise Mode.
Solar Panel TV Arming Microswitch	Switch activation provides a ground enable for the SCR gate current-limiting resistors. Activates Cruise Mode. (This command is in parallel with the Hydraulic Timer Command)
CC&S TV2 Command	Places F- and P-Channels into warmup.
Cruise On Test Command	Removes power from the Clock. (This command is from the GSE.)

good, to excellent (for the P4 Camera). The resolution of the cameras was as follows: for the F_a Camera, 725 TV lines; F_b Camera, 640 TV lines; P1 Camera, 200 TV lines; P2 Camera, 200 TV lines; P3 Camera, 210 TV lines; and P4 Camera, 210 TV lines. Communications and GSE performance was good and the power profile was normal. The overall performance of the TV Subsystem during this test was good.

2. *System Test No. 6 (JPL Procedure 3R300.19)*

System test No. 6 was performed on January 18, 1965, in accordance with JPL Procedure 3R300.19.

a. Purpose of Test

The purpose of this test was to verify the electrical performance of the TV Subsystem, integrated with the Spacecraft Bus, during an accelerated simulated mission in an Earth environment.

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b. Description of Test

This test was performed in a manner similar to the back-up functions test, except that no failure modes were simulated. All phases of TV Subsystem operation were verified, from pre-launch to impact.

c. Test Data Evaluation

Camera performance during this test was normal; similar to the performance obtained during the back-up functions test, except that the microphonics in the video of the P2-Camera appeared to be of smaller amplitude. There was a light leak in the 35-mm recorder camera of the GSE; however, the leak was minor and did not significantly affect the video. The leak was corrected after the test. The 15- and 90-point telemetry data were normal, but the computer data were erratic. The Channel-8 telemetry was normal and readable but appeared to be noisy. This was due to the r-f signal being at the threshold level (-130 dbm). With a higher signal level (-125 dbm), the Channel-8 telemetry was noise free. The communications and power profiles were normal. Overall, the performance of the TV Subsystem was normal.

3. Operational Checkout by RF Link

Testing of the r-f link was performed on January 20, 1965, in accordance with JPL Procedure 3R315.04.

a. Purpose of Test

The purpose of this test was to verify that the TV Subsystem will operate properly when commands to the Spacecraft and data from the Spacecraft are transmitted and received by means of the r-f link (no wires).

b. Description of Test

The Spacecraft was in flight configuration for this test (all GSE and ground cables disconnected). Instead of collimators, a white material illuminated by flood lamps provided the target for exposure of the cameras. Two terminal modes of operation were performed during this test. TV Subsystem turn-on for the first terminal

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mode was accomplished by CC&S command, and turn-on for the second terminal mode was by the RTC-7 command. An RTC-5 command was used to terminate each of the two sequences.

c. Test Data Evaluation

Since comparable performance was observed throughout this test, the evaluation given herein refers to both terminal-mode sequences. The performance of all cameras was satisfactory. However, there was some evidence of noise which was as follows: chopper-induced raster noise was observed in the video outputs of the P1, P2, and P3 Cameras; shutter-induced noise was observed on the outputs of F_b and P2 Cameras; 15-kc raster noise was observed on the output of the F_b Camera; and noise induced by vidicon mesh vibration was noted on P2-Camera video output. The operation of communications was normal, and no radio-frequency interference (rfi) was evident during the entire test. Power at the output of F- and P-Channels was observed on a spectrum analyzer. The output of each channel was 23.3 watts during the first sequence; while during the second sequence, the power was 21.8 and 23.8 watts for F- and P-Channels, respectively. Both 90-point and 15-point telemetry data were good, and battery power profile was normal. A review of the 35-mm film revealed a displacement of the horizontal scan lines, which was attributed to a shorted diode in GSE Display Equipment (MR2304).

E. Initial Explosive-Safe Facility (ESF) Tests

1. ESF Television Full-Power RF Tests (JPL Procedure 3R235.04)

The ESF television full-power r-f test was performed on January 26, 1965, in accordance with JPL Procedure 3R235.04.

a. Purpose of Test

The purpose of this test was to check the r-f connection between the TV Subsystem and the Communications Case II in the Spacecraft Bus, and to verify that the r-f path from TV Subsystem to the directional antenna operates properly when TV full-power is applied. In addition, the purpose of the test was to check the explosive-safe-facility operation and procedure prior to the final ESF full-power test, which is performed just before the launch.

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b. Description of Test

The Spacecraft was mounted on the Agena Adapter and the directional antenna was installed in its nested position. Microwave-absorbent material was placed beneath the directional antenna and a calibrated probe, with which the r-f output was monitored, was installed. A copper screen was placed around the Spacecraft, and batteries were installed in the TV Subsystem. After the Spacecraft was turned on, the TV Subsystem was set to full-power mode of operation. The r-f power output was measured, and the operation of the cameras was checked by viewing a white target surface which was illuminated by flood lamps. The test was performed on battery power.

c. Test Evaluation

The performance of the cameras was similar to that observed during the previous test, except that some rfi and ignition noise was exhibited in the outputs of the F-Cameras. The rfi was attributed to radar transmissions in the vicinity of the test facility, and it disappeared as soon as the F-Channel output attained peak power. Similarly, after the first minute of full-power operation, the ignition noise, which was attributed to automotive operation in the area, decreased considerably. The operation of communications was satisfactory, and both 15-point and 90-point telemetry data were normal. The power profile of the batteries was normal.

2. *ESF Operational Checkout (JPL Procedure 3R317.04)*

The ESF operational checkout was performed on January 28, 1965, in accordance with JPL Procedure 3R317.04.

a. Purpose of Test

The purpose of this test was to verify that the Spacecraft was ready for launch pad operation. The test provided a crosscheck of TV Subsystem performance and allowed monitoring the Subsystem susceptibility to electro-magnetic interference (emi) and rfi.

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b. Description of Test

The Spacecraft was in flight configuration, and the Agena shroud was installed. The Spacecraft was mounted on the transporter and powered by batteries. To permit the evaluation of cameras, the Agena shroud lights were checked and installed. The TV Subsystem was commanded through a terminal-mode operation by means of an RTC-7 reduced-power command. The test was performed twice; excessive rfi during the first test run dictated that the test be terminated before switchover of the JPL beacon signal from the directional antenna to the omni-antenna was effected. After the Stoddart antenna was repositioned so that the r-f input to the OSE increased, the complete test was repeated.

c. Test Evaluation

During the second test run, which is evaluated herein, the effects of two types of rfi were evident at the video output. When the JPL beacon and the TV communications signals were being transmitted over the directional antenna, the relatively strong beacon signal caused interference in the TV signal. This type of interference was exhibited on the monitor display as impulse spots. During switchover of the beacon signal to the omnidirectional antenna, no rfi was evident. After switchover, stray r-f signals under the Agena shroud from the omnidirectional antenna were detected by the cameras, and appeared as "herringbone" and "checkerboard" types of interference on the monitor display. Examples of the herringbone and impulse rfi are shown in Figure B-1. This type of interference was anticipated and is not considered a flight problem. The performance of the TV Subsystem was considered satisfactory, and 90-point and 15-point telemetry data were normal.

F. Initial Launch Pad Tests

1. Pre-Countdown Dummy Run (JPL Procedure 3R304.06)

The pre-countdown dummy run was performed on January 29, 1965, in accordance with JPL Procedure 3R304.06.

a. Purpose of Test

The purpose of this test was to verify the compatibility of Blockhouse Launch Complex equipment with the GSE and the Spacecraft. Its secondary purpose was to familiarize the test personnel with prelaunch checkout procedures.

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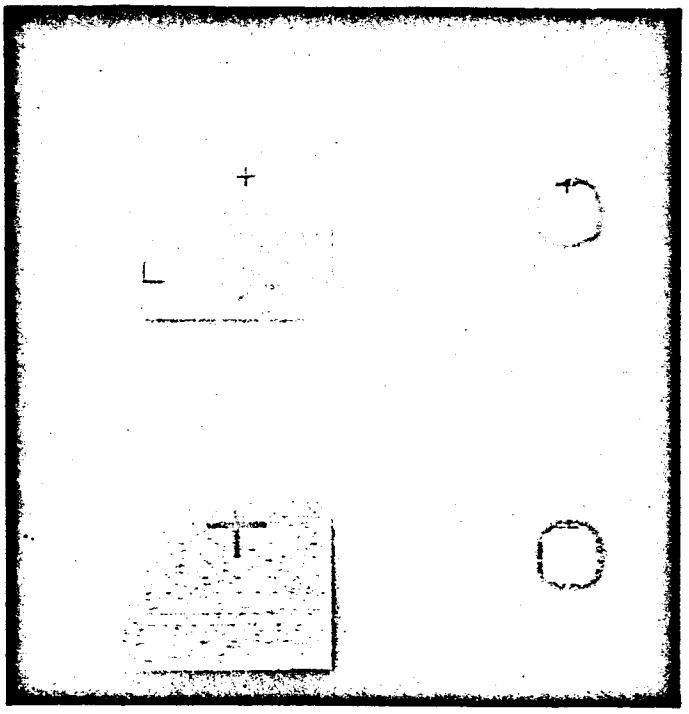

Figure B-1. Examples of impulse and herringbone r-f interference during ESF operational test

b. Description of Test

The Spacecraft was mated to the Atlas-Agena launch vehicle which was in place on the launch pad at ETR Complex 12. During the cruise mode of operation, the TV Subsystem was tested to verify that an RTC-7 command would not effect the turn-on of the TV Subsystem while the "ground bus enable function" is reset. The Subsystem was then operated in the reduced-power mode, and monitoring of the Agena shroud lights served as a check that the TV Subsystem was functioning. The test was performed using battery power.

c. Test Evaluation

The performance of all cameras was satisfactory, except that the effects of rfi similar to those reported for the previous test, were observed on the video outputs of the cameras. Communications, 15-point and 90-point telemetered data, and the power profile of the batteries were normal. The overall performance of TV Subsystem was deemed good.

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2. Countdown Dummy Run (JPL Procedure 3R309.07)

The countdown dummy run was performed on January 29, 1965, in accordance with JPL Procedure 3R309.07.

a. Purpose of Test

The purpose of this test was to simulate the launch countdown and to verify that all Spacecraft Subsystems are operating properly. Its secondary purpose was to familiarize test personnel with countdown procedures.

b. Description of Test

The configuration of the Spacecraft during this test was the same as for the pre-countdown dummy run, and the test procedure that was followed in checking out the TV Subsystem was the same as that used for the preceeding test.

c. Test Evaluation

The performance of the TV Subsystem was identical to that reported for the previous test.

3. Joint Flight Acceptance Composite Test (J-Fact) (JPL Procedures 3R309.05 and 3R307.02)

The joint flight acceptance composite (J-fact) test was performed on February 1, 1965, in accordance with JPL Procedures 3R309.05 and 3R307.02.

a. Purpose of Test

The objectives of the J-fact test were to demonstrate that no incompatibilities existed between the Spacecraft and the Atlas/Agena launch vehicle; to verify that the procedures that were to be used during the launch operations are compatible;

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and to verify proper TV Subsystem operation while the Spacecraft was assembled to the Atlas/Agena vehicle with the umbilical plug removed and in plus time (after simulated launch).

b. Description of Test

This test is similar to the countdown dummy run. However, all launch facilities were employed according to a Master J-Fact Countdown, and the TV Subsystem was operated. The configuration of the Spacecraft for the J-fact test was unchanged from previous launch pad tests.

c. Test Evaluation

The performance of the TV Subsystem was identical to that reported for the pre-countdown dummy run.

G. Special Tests

1. Camera Calibration (JPL Procedure 3R220.03)

The Camera Calibration was performed during the period from February 2 through February 4, 1965, in accordance with JPL Procedure 3R220.03.

a. Purpose of Test

The purpose of this test was to measure the camera parameters which would allow the interpretation of photometric data from the pictures received during the mission. The information obtained during this test was intended for use in compensating the characteristics of each camera. The camera parameters measured during this test were linearity, noise, light-transfer characteristics, erase, and shading.

b. Description of Test

The TV Subsystem was operated with the thermal shrouds removed, and a fan was used to prevent the communications and camera equipment from overheating.

The TV Subsystem was powered by external power. The light-transfer characteristics of each camera were determined by measuring the response of the camera to a narrow white bar of known luminance. The response was measured at the center of the scanned format. The gains of the F_b, P1, and P2 Cameras were adjusted for a peak scene luminance of 650 foot-lamberts, while the F_a, P3, and P4 Cameras were adjusted for a peak scene luminance of 1500 foot-lamberts. The luminance of the calibration source was varied, and the video excursions at the output of the distribution amplifier were recorded.

The test was performed with collimators installed and the calibration of the collimators was verified before and after the test. At the end of the test, during the collimator allignment, the full-scale reference (data point No. 12) of the 15-point telemetry data was found to be erratic. The malfunction was traced to the 15-point Commutator which was subsequently replaced (MR2307).

c. Test Evaluation

The data obtained during this test were plotted, and the resultant light transfer curves for each camera are presented in Figures B-2 and B-3. The residual image of the F_a and F_b Cameras was found to be 6.5 percent and 2.5 percent, respectively. The residual image of the P-Cameras was negligible. The 15-kc noise in the outputs of the F-Cameras, when viewing a black surface, was approximately 20 millivolts; noise levels of 45 millivolts and 70 millivolts were measured in the outputs of F_a and F_b Cameras, respectively, when the F_a Camera was illuminated with 650 foot-lamberts and the F_b Camera was illuminated with 1500 foot-lamberts. Furthermore, the noise level in the outputs of the P1 and P4 Cameras was approximately 8 millivolts, while the noise in the outputs of the P2 and P3 Cameras varied between 13 and 15 millivolts.

2. *Special RFI Test*

A special rfi test test was performed during the period from February 2 through February 4, 1965. This test and the camera calibration described in the preceeding paragraph were run concurrently.

a. Purpose of Test

The purpose of this test was to investigate the r-f cable 30W33, which is located in P-Channel, as a possible source of rfi that was previously observed on the output of the 890 Mc Transponder/Receiver.

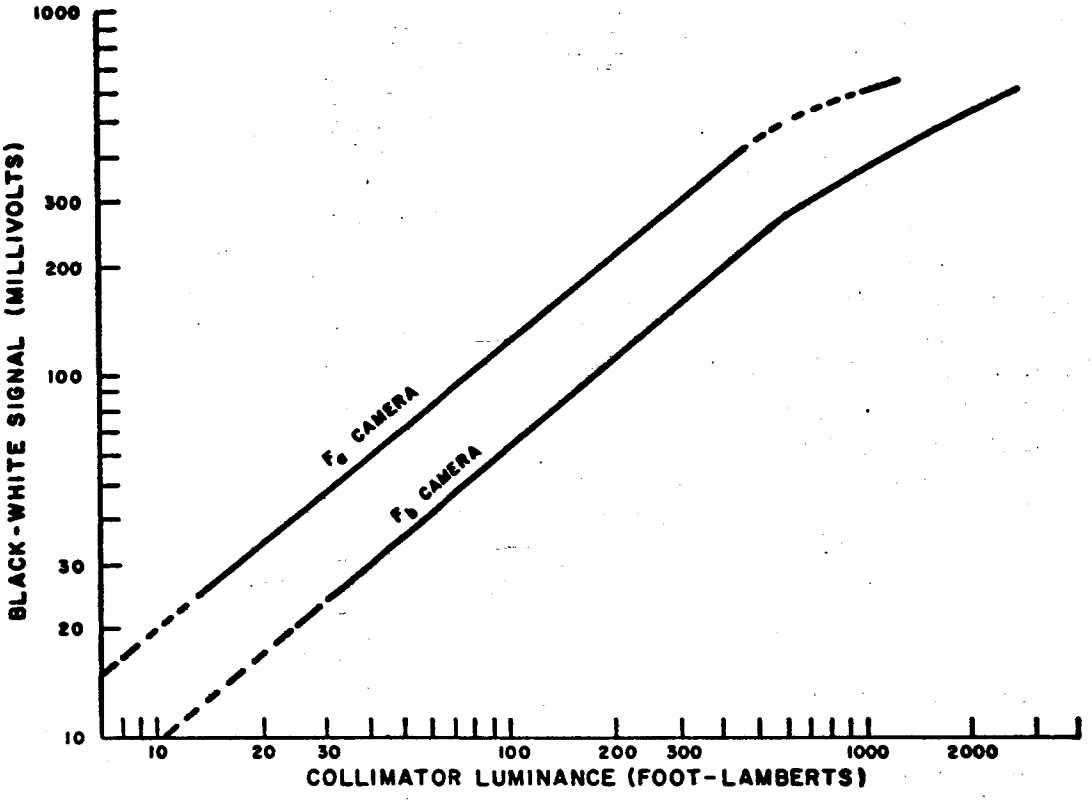

Figure B-2. Light transfer characteristic curves for the RA-8 full-scan cameras

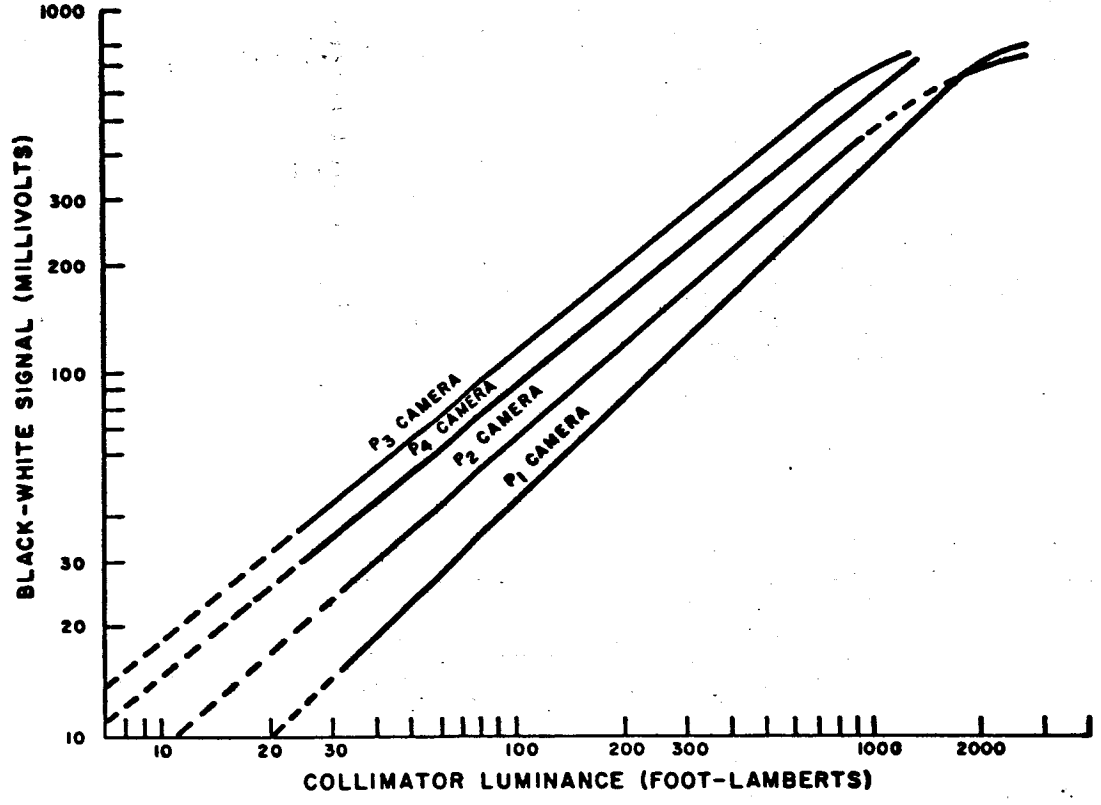

Figure B-3. Light transfer characteristic curves for the RA-8 partial-scan cameras

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b. Description of Test

The r-f cable 30W33 applies the output of the Intermediate Power Amplifier (IPA) to the Power Amplifier (PA). Initially, the r-f cable 30W33 was disconnected from P-Channel PA and connected directly to the GSE. The TV-Subsystem was then operated in the reduced-power mode, and the 890 Mc Transponder/Receiver output was monitored for the presence of rfi. The cable was then removed from the Subsystem, and X-ray photographs of the cable were taken. Next, the cable was installed as described above, and the reduced-power sequence was repeated. Finally, r-f cable 30W33 was connected to the P-Channel Power Amplifier, and the Subsystem was operated in the full power mode. Again, the 890-Mc Transponder Receiver was monitored for rfi. TV Subsystem was powered by an external source during all sequences of this test.

c. Test Evaluation

No rfi was observed during any of the sequences of this test. Similarly, the X-ray photographs provided no evidence of fabrication abnormalities which would indicate that the r-f cable 30W33 was the cause of the previously observed rfi. During this test, the performance of TV Subsystem was normal.

H. Final System Test

1. System Test No. 7 (JPL Procedure 3R300.20 and ETR 3R300.06)

The final system test was performed on February 5, 1965, in accordance with JPL Procedure 3R300.20 and ETR Procedure 3R300.06.

a. Purpose of Test

The purpose of this test was to verify TV Subsystem operation when the Spacecraft is subjected to an accelerated mission simulation in ambient environment.

b. Description of Test

The Spacecraft was mounted on the Agena Adapter and direct-access cables were connected between the Spacecraft and OSE to provide test simuli and to

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enable the monitoring of Spacecraft circuits and functions. The TV Subsystem was commanded through a terminal-mode operation by means of RTC-7F and RTC-7P full-power commands. To enable evaluation of the cameras, collimators were attached, and the video outputs of the cameras were recorded on 35-mm film. R-f output was obtained through hardline connections between the omni-antenna and OSE. The test sequence, as specified in JPL Procedure 3R300.20, was performed using external power. Procedure ETR 3R300.06 requirements were fulfilled by operating the TV Subsystem in full-power mode for two minutes, deriving operating power from the on-board batteries. The flight batteries, Serial Nos. 102 and 104, were installed for this test and were used to power the TV Subsystem in all subsequent tests.

c. Test Evaluation

All cameras operated normally and exhibited good focus. The resolution of each camera was evaluated and the results were as follows: for the F_a Camera, 775 TV lines; F_b Camera, 675 TV lines; P1 Camera, 200 TV lines; P2 Camera, 200 TV lines; P3 Camera, 210 TV lines; and P4 Camera, 210 TV lines. Slight microphonics were observed on the video outputs of the P2 and P3 Cameras, some shutter-induced noise was present on the output of P2 Camera, and 15-kc noise was evident in the raster of F_b Camera. The operation of communications was satisfactory; the r-f outputs of the F- and P-Channels, as observed on a spectrum analyzer, and the telemetered data indicated normal performance of communications. Similarly, operation of both 15-point and 90-point telemetry was satisfactory. The performance of GSE and the power profiles obtained during both sequences were normal. Examples of the full-scan and partial-scan video outputs recorded during this final system test are presented in Figures B-4 and B-5.

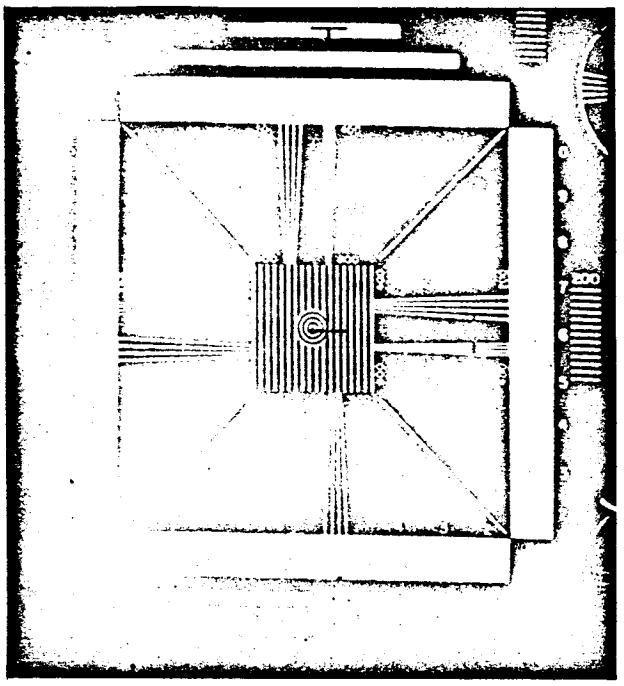
I. Final Explosive-Safe Facility (ESF) Tests

1. *ESF Television Full-Power RF Test (JPL Procedure 3R235.05)*

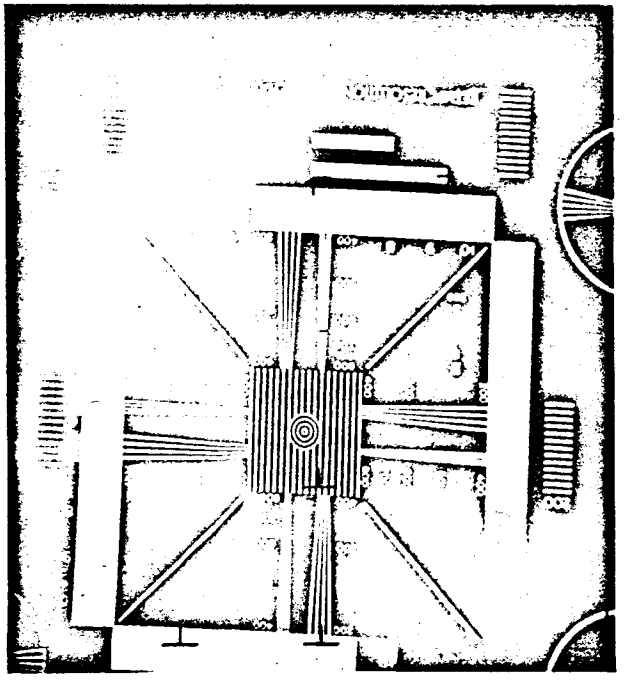
The ESF television full-power r-f test was performed on February 9, 1965, in accordance with JPL Procedure 3R235.05.

a. Purpose of Test

The purpose of this test was to check the r-f connection between the TV Subsystem and the Communications Case II in the Spacecraft Bus, and to verify that



a. F_a-Camera video output



b. F_b Camera video output

Figure B-4. Full-scan video output during System Test No. 7

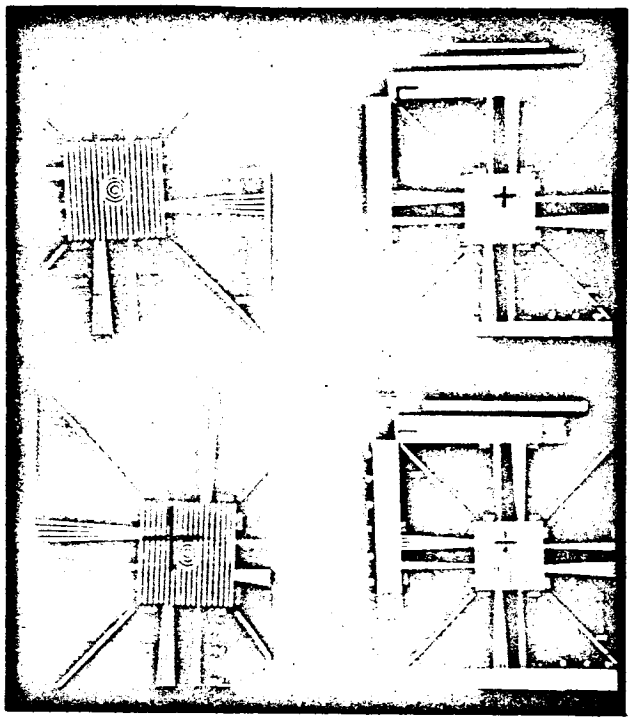


Figure B-5. Partial-scan video output during System Test No. 7

the r-f path from TV Subsystem to the directional antenna operates properly when full power is applied.

b. Description of Test

The Spacecraft was mounted on the Agena Adapter and the directional antenna was set in its nested position. Microwave-absorbent material was placed beneath the directional antenna and a calibrated probe, with which the r-f power output was monitored, was installed. A copper screen was placed around the Spacecraft. After the Spacecraft was turned on, the TV Subsystem was set to full-power mode of operation. The r-f power output was measured and the operation of the cameras was checked by viewing a white target surface which was illuminated by flood lamps. Flight batteries provided power during the test.

c. Test Evaluation

The r-f connection between the TV Subsystem and Communications Case II of the Spacecraft Bus functioned properly. The operation of TV Subsystem was normal.

However, two malfunctions were noted in GSE. During the test, the 960-Mc r-f preamplifier was not functioning properly, and it was replaced (MR2309). During the review of the 35-mm film obtained during the test, several frames of video were found to be broken. The malfunction was isolated to the a-c contacts of the Motor On switch in the Film Recorder No. 1 (MR2310). The switch was replaced and the recorder tested prior to the next test.

2. *ESF Reduced-Power Operational Checkout (JPL Procedure 3R317.05)*

The ESF reduced power operational checkout was performed on February 12, 1965, in accordance with JPL Procedure 3R317.05.

a. Purpose of Test

The purpose of this test was to verify that the Spacecraft was ready for launch-pad operation. The test provided a crosscheck of TV Subsystem performance and allowed monitoring the susceptibility of the TV Subsystem to emi and rfi.

b. Description of Test

The Spacecraft was in flight configuration, and the Agena shroud was installed. The Spacecraft was mounted on the transporter and powered by the flight batteries. The Agena shroud lamps were used to check camera operation. The TV Subsystem was commanded through a terminal-mode operation by means of RTC-7 reduced power command.

c. Test Evaluation

The operation of TV Subsystem throughout this test was normal. When both the video and beacon signals were transmitted over the directional antenna, noise spikes were evident on the outputs of all cameras. This noise was attributed to automotive ignition interference and was expected. After the beacon signal was switched to the omnidirectional antenna, "checkerboard" and "herringbone" types of interference were observed at the outputs of the P2 and P4 Cameras. This rfi was due to the stray signals under the Agena shroud, from the omnidirectional antenna, that are detected by the cameras. This interference is not a flight problem. At the end of this test, the TV Subsystem was considered ready for operational checkout on the launch pad.

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J. Final Launch Pad Tests

1. *Pre-Countdown Test (JPL Procedure 3R304.07)*

The pre-countdown test was performed on February 13, 1965, in accordance with JPL Procedure 3R304.07.

a. Purpose of Test

The purpose of this test was to verify the compatibility of Blockhouse Launch Complex Equipment with the OSE and the Spacecraft. The test also served to verify all Spacecraft electrical interfaces and to ensure that all subsystems were in the ready condition.

b. Description of Test

The Spacecraft was mated to the Atlas Agena launch vehicle which was in place on the launch pad at ETR Complex 12. During the cruise mode of operation, the TV Subsystem was tested to verify that an RTC-7 command would not effect turn-on of the TV Subsystem while the "ground bus enable function" was reset. The Subsystem was then operated in reduced-power mode, and monitoring of the shroud lights served as a check that the TV Subsystem was functioning. The Subsystem was powered by the flight batteries.

c. Test Evaluation

The performance of the TV Subsystem was the same as during the previous test except that no ignition interference was observed. The TV Subsystem was deemed ready for launch.

2. *Simulated Countdown (JPL Procedure 3R309.08)*

The simulated countdown was performed on February 15, 1965, in accordance with JPL Procedure 3R309.08.

a. Purpose of Test

The purpose of this test was to simulate the launch countdown and to verify that all Spacecraft Subsystems were operating properly. Its secondary purpose was to familiarize test personnel with countdown procedures. This test was performed instead of the Simulated System Launch Test which could not be performed because of a conflict in the ETR schedule.

b. Description of Test

The configuration of the Spacecraft during this test was the same as for the pre-countdown test, and the procedure that was followed in checking out the TV Subsystem was the same as that used for the proceeding test.

c. Test Evaluation

The performance of the TV Subsystem was similar to that observed during the previous test, and the Subsystem was deemed ready for launch.

3. Launch Countdown (JPL Procedure 3R309.08)

The launch countdown was performed on February 17, 1965, in accordance with JPL Procedure 3R309.08.

a. Purpose of Test

The purpose of this test was to confirm that all the Spacecraft Subsystems were operative. Following this test the actual launch occurs.

b. Description of Test

The configuration of the Spacecraft during this test was the same as for the simulated countdown, and the procedure that was followed in checking out the TV Subsystem was the same as that used in the preceeding test.

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c. Test Evaluation

The performance of the TV Subsystem was normal and the RA-8 Spacecraft was cleared for launch. Launch occured at 1205:00 on February 17, 1965.

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Appendix C

Summary of Malfunction Reports for Flight Model III-3 TV Subsystem

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TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-8 TV SUBSYSTEMS

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
1580 10/19/64	F_a-Camera Assembly Serial No. 038, Flight Model III-3	N/A	Video Out of Focus	Ambient (JPL)	Accident	During the post-shipment operational checkout of Flight Model III-3 at JPL, the F_a-Camera video was out of focus. Since the reticles exhibited sharp focus, the collimator was suspected. This was verified by substituting the PTM collimator. Optical testing reaffirmed defocussing of the F_a Collimator. The defocussing was attributed to the filter being screwed on to its mechanical limits, which also engaged and turned the front element of the collimator, resulting in the defocus. The collimator was re-aligned optically. To prevent a recurrence of the problem, a mechanical stop was provided on the camera adapter so that the stop engaged the end of the collimator barrel before the adapter makes contact with the focus ring.
MR2148 10/28/64	F-Channel 225 kc VCO, Serial No. 148 Flight Model III-3		Center Frequency Out of Specification	Explosive Safe (JPL)	Workmanship	During an Explosive Safe Area TV full-power test, the F-Channel 15-point telemetry was erratic. The frequency of the F-Channel, 225 kc Voltage Controlled Oscillator was measured as a function of input bias, using telemetry calibration chassis A-100. The frequency deviation was normal, approximately 10 kc; however, the center frequency was approximately 8 kc high, which made the recovery of telemetry impossible. This VCO, manufactured by Vector, was removed and replaced with an equivalent unit manufactured by Datatronics. A linearity plot of the VCO was performed and no adjustments were required. Operation of the TV Subsystem was normal. The failed unit was scrapped. Only Datatronics 225 kc VCO's will be used on Flight Units.
QC2150 11/10/64	P4Camera and Camera Electronics Assembly, Serial No. 045/045, Flight Model III-3.	N/A	Noisy Raster	Ambient (JPL)	Nonassignable	During system testing of RA-8 at JPL, the raster of P4 Camera, Serial No. 045/045, was noisy. The appearance of the noise was unique and could not be ascribed to any previously experienced failure mode. The unit was returned to RCA, where, after a review of the 35-mm film obtained during previous systems tests at JPL, the clamped-video test point of the Camera Electronics was monitored and exhibited high-amplitude, random noise. Further review of the 35-mm films as a function of the record time showed that this noise occurrence was completely random and apparently not attributable to a timing sequence from another camera. The system ground lines were checked and it was found that the preamplifier shield ground of the P4 Camera was connected to the P2-Camera head ground lead. This situation was corrected and a systems test rerun. The 35-mm film of the P4 Camera video output revealed some noise on two out of approximately 200 frames. This noise, however, was more in the nature of a random spike rather than the high-amplitude, random type previously experienced. Further investigation revealed that a screw was missing from the 1000-volt mesh filter ground. This situation would make the camera very susceptible to noise pickup. After replacement of this screw, the output video signal observed on a scope revealed random noise spikes at very infrequent intervals. When monitored over a 5-hour period, it was found that the same type of noise spikes could be induced by the turn-on and turn-off of test equipment in the area. The camera output was then played through the GSE, and 750 frames of video were recorded with no observation of noise. P4 Camera, Serial No. 045/045, was integrated on Flight Model III-4 (RA-9). A review of the film record of a systems-test run revealed several

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TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-8 TV SUBSYSTEMS (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
QC2150 11/10/64 (Cont'd)						frames that exhibited noise. It was also noted that the video output of F_b Camera, Serial No. 017/017, exhibited the same characteristic noise. This noise was attributed to a digital voltmeter which was grounded to the TV Subsystem structure during the test. Camera, Serial No. 045/045, was again disassembled, and microscopic investigation revealed no evidence of problems. The Nuvistor tube was replaced at this time to take advantage of the blue-solithane technique of mounting. After assembly, the video output signal from the camera was played through the GSE. Review of 500 frames, taken with a F-type camera grounded to the same mounting bracket and operating, revealed occasional noise induced by the F-shutter. Then, 500 frames of 35-mm film were taken with the vidicon of Camera, Serial No. 045/045, inoperative but with an F-Camera operating. This was to isolate the Camera Electronics as the source of the noise. Review showed these films to be free of noise. The original noisy-raster condition was markedly improved on the RA-8 Spacecraft. The 1000-volt mesh-filter return may have been disconnected or making erratic contact with ground when the original, unique noise problem was observed. If a problem does exist with P4 Camera, Serial No. 045/045, it is not exhibited when the camera is operated alone in bench test. The extremely infrequent occurrence of noise in this camera makes further bench testing unprofitable. The shutter has been changed on this camera, and the camera has been assigned as a spare unit. It has been tested in accordance with RTRB No. 127, and the test data submitted to JPL.
MR2251 11/11/64	P2 Camera Assembly Serial No. 022, Flight Model III-3	Shutter Serial No. 3043R-1	Noise Spikes in Raster	Ambient (JPL)	No Failure	A review of the 35-mm film of the video output obtained during a special test at JPL revealed excessive fast noise spikes in the output of the P2 Camera. The noise usually appeared at alternate operations of the P2 Camera shutter and was generally grouped within a few TV lines near the top of the scanned raster. The duration of the noise spikes varied from a few microseconds to 50 microseconds. The level went to saturated white but recovered with little or no ringing. The P2 shutter, Serial No. 3043R-1, was replaced by shutter, Serial No. 3020R-2, as an exploratory measure (not because of a shutter malfunction), but this did not provide any improvement. However, in later tests, the noise spikes were somewhat lessened. No additional action was taken since the noise spikes were actually within acceptable limits and the camera was and still is operating well within requirements. The shutter was changed in hopes of further improving camera performance. This camera will be critically observed during future testing to ensure that the noise spikes do not reach unacceptable limits.
MR2252 11/13/64	P2 Camera Assembly, Serial No. 022 Flight Model III-3		Reversed Plugs	Ambient (JPL)	Accident	During installation of the P2 Camera Assembly for a special test, plugs A2P2 and A3P5 were accidentally reversed. Power had been applied for 2 minutes and 15 seconds before the plug reversal was discovered. The A2P2 connector carries supply voltages to the preamplifier, while the A3P5 connector carries telemetry voltages. The plug reversal terminated

TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-8 TV SUBSYSTEMS (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
MR2252 11/13/64 (Cont'd)						all camera telemetry circuits in the preamplifier and supply voltages were terminated at the 90-point telemetry commutator. It was determined that no overstressing of parts occurred in the Channel 8 or P-Channel voltage controlled oscillators or in the affected telemetry circuits. All jacks and plugs are clearly stencilled, however, extra care should be taken when these particular plugs are mated since they are the same type.
QC2258 12/4/64	Clock Assembly, Serial No. 008, Flight Model III-3	Incremag Capacitor C3	Clock Turn-on Late	Thermal-Vacuum (JPL)	Workmanship	Turn-on of F-Channel by a Clock output occurred 5 minutes 53 seconds late during high-temperature thermal-vacuum testing of Flight Model III-3 at JPL. This was not within the specified limits of ±5 minutes for turn on. The Clock, Serial No. 008, was returned to RCA where a series of tests on the regulated voltages and the 900-second count isolated the problem to the Incremag unit. With regulated input voltages of 31 and 41 volts, the 900-second count was recorded at 948.99 and 939.526 seconds, respectively. The Incremag was returned to the vendor, where capacitor C3, a type PN1100 mylar unit, between the oscillator and pulse-forming network, was found to be bad. The capacitor was damaged during removal so that the failure mechanism could not be firmly established. Measurement of the leakage current indicated that the value was less than 1 microampere which is within specification. It had first been thought that the leakage current had increased. Measurement of dissipation factor and capacitance revealed that these parameters varied as a function of the mechanical pressure applied to the component. Microscopic inspection of the damaged area on the capacitor showed evidence of potting material which appeared to adhere to the metal portion of the component. A gouge was found in the capacitor. The vendor indicated that no special tools are utilized during assembly of the SCR dumping circuit and all assembly is by hand. The gouge had been attributed to improper handling of a soldering iron. The vendor concluded that the capacitor was damaged before or during assembly of the Incremag unit and that subsequent environmental testing had caused the unit to receive varying degrees of mechanical stress, which, in turn, caused the capacitance or dissipation factor to vary. The degree of parameter variation is thought to be directly related to the number of environmental stresses encountered by the unit. The failed capacitor C3 was replaced and the Incremag unit performed normally. Clock, Serial No. 008, has been assigned to the spare category. Clock, Serial No. 007, has been installed on the RA-8 Spacecraft Spare Clocks, Serial Nos. 003 and 006, were subjected to 2 real-time missions in a thermal-vacuum environment and successfully completed the test.
2307 2/4/65	Telemetry Assembly, Serial No. 006, Flight Model III-3	15-Point Telemetry Commutator, Serial No. 5948	Telemetry Out Of Specification	Ambient (ETR)	Nonassignable	A review of telemetry data during RA-8 collimator alignment indicated that the output from data point No. 12 (full-scale reference) of the 15-point telemetry Commutator, Serial No. 5948, was only half its normal width and normal amplitude. On the next telemetry frame, the amplitude was reduced

TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-8 TV SUBSYSTEMS (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
2307 2/4/65 (Cont'd)						to a small spike. All subsequent telemetry frames indicated an output of +0.2 volt for data point 12 which is an indication of open-circuit condition. The unit was replaced by spare Commutator, Serial No. 5949, and normal operation for all data points, including data point No. 12, was restored. All pins of the disconnected cables were given a pin-retention check and were normal.
2307 2/4/65 (Cont'd)						The failed unit was installed on the Spare TV Subsystem and operation of all data points including data point No. 12 was normal. The Commutator was returned to the vendor where a contact-resistance test indicated that all data points were normal (0.2 ohm). The specification value is less than 1 ohm. This test indicated good contact and good connection for all circuits of data point No. 12. The following items were then examined under a microscope with no indications of abnormalities: the pins of the commutator connector, wire side of the connector with the commutator disassembled, the wires, brushes, and commutator segments. The vendor could not conceive of any failure mode, which would affect only one data point, that was not checked in these tests. Two connectors and a cable, the telemetry unit, and the commutator complete the circuit. The reference voltages for the 15- and 90-point Commutators are obtained from the same source. The full-scale reference voltage for the 90-point Commutator was normal during the time that the full-scale reference voltage for the 15-point Commutator indicated the abnormal +0.2 volt. The commutator will undergo further tests at RCA if required to support the RA-9 Subsystem.
MR2259 12/7/64	P4 Camera, and Camera Electronics Assembly, Serial No. 48/48. Flight Model III-3		De-focussing	Thermal-Vacuum (JPL)	Design	During Mission Verification Test No. 1 in a thermal-vacuum environment (at a nominal 98°F), P4 Camera defocussed. Review of the 35-mm film of the P4 Camera video output revealed that optical defocussing occurred, resulting in a limiting resolution of less than 140 TV lines, the lowest frequency on the test chart. The defocussing was characterized by a reversal of signal in the resolution wedges. At 20°C, camera performance exhibited greatly improved focus with a limiting resolution of 180 TV lines. At 12°C, resolution was greater than 200 TV lines. This improved performance at lower temperatures indicates that the camera is focussed at one side of the depth of focus for the lens. There is probably a focus change of 0.0025 inch between the high and low temperature. Since the P4 Camera provides acceptable performance in the temperature range below 25°C, no corrective action is planned. The nominal temperature range for the mission is 14°C to a maximum of 20°C. Focussing the camera to give satisfactory performance at all temperatures would require removal of the camera from the spacecraft.
2260 12/8/64	Transmitter Power Supply, Serial No. 017, Flight Model III-3	Relay K1	Broken Weld	Thermal-Vacuum (JPL)	Workmanship	During thermal-vacuum test No. 3 on Flight Model III-3 at JPL, the 90-point telemetry indicated the +1000-volt supply from the Transmitter Power Supply was applied to the P-Channel power amplifier at warmup mode. The Transmitter Power Supply, Serial No. 017, was returned to RCA for investigation of the failure. A resistance check between

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CONTRACT NO. 950137

RANGER TV SUBSYSTEM FLIGHT EVALUATION REPORT FOR FLIGHT MODEL III-I (RA-6) AND DESIGN REVIEW REPORT

Prepared for

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

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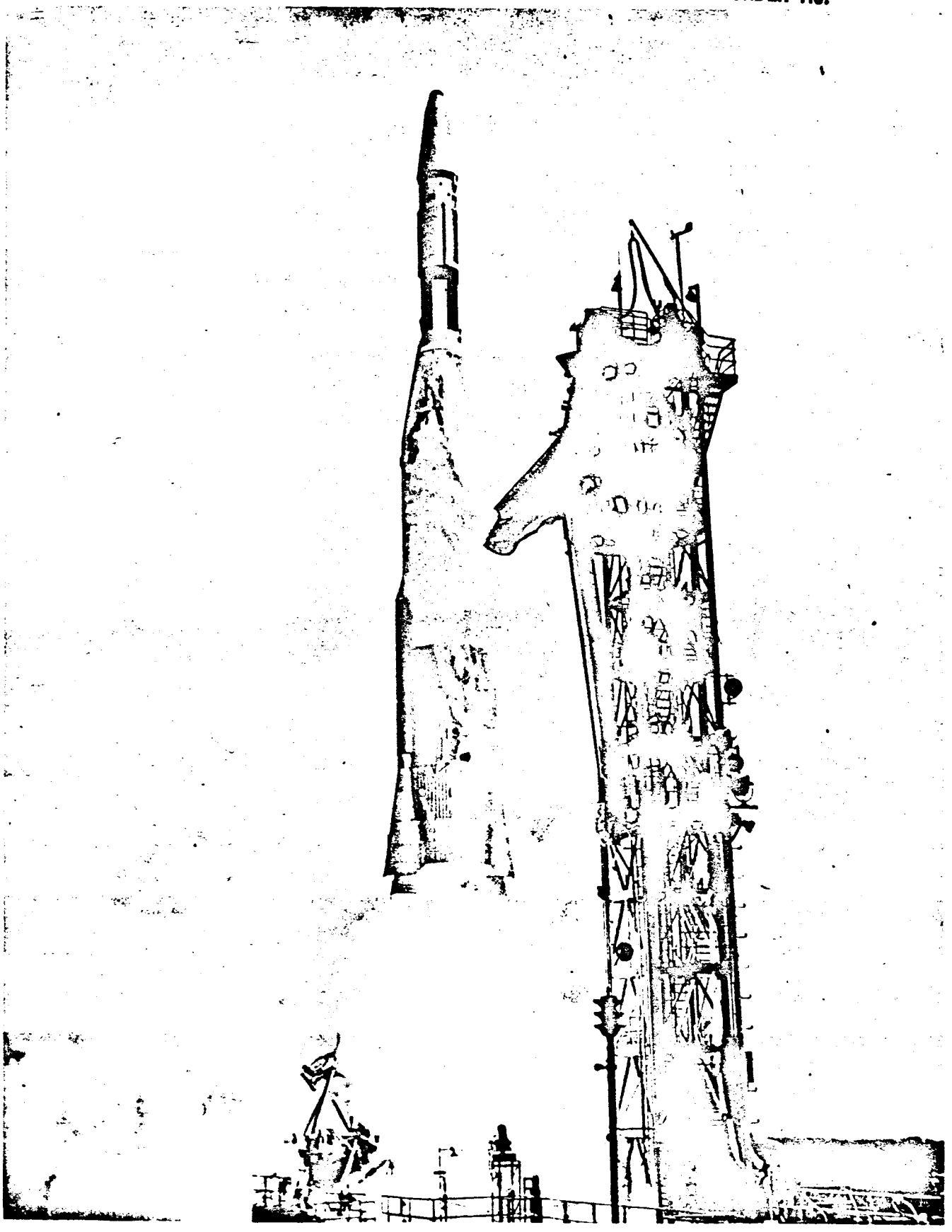
ASTRO-ELECTRONICS DIVISION
DEFENSE ELECTRONIC PRODUCTS
RADIO CORPORATION OF AMERICA
PRINCETON, NEW JERSEY

AED R-2155

Issued: April 6, 1964

RE-ORDER No. 64-139.



Frontispiece: Launch of RA-6

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Preface

This report presents an evaluation of the mission performance of Flight Model III-1 (RA-6) of the Ranger TV Subsystem. An analysis is also presented of the several potential reasons for the RA-6 spacecraft to have failed to obtain high resolution pictures of the moon. The analysis of the design study performed at RCA as a result of the RA-6 mission are described. The recommendation of the design study that are being incorporated into the Block III-PTM, Flight Model III-2 TV Subsystem and the remainder of the Block III Ranger flight equipment are presented. The Ranger TV Subsystem Project is being performed by the Astro-Electronics Division of RCA for the Jet Propulsion Laboratory under Contract No. 950137.

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Section I
Summary

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Section I

Summary

The RA-6 spacecraft was launched from Cape Kennedy, Fla. at 15:49:00 GMT, January 30, 1964. Impact on the moon occurred seventy and three-quarter (70 3/4) hours after launch. The primary objective of the RA-6 mission was not fulfilled since the spacecraft did not return television pictures of the lunar surface.

The testing of the RA-6 TV Subsystem at RCA and the RA-6 Spacecraft at JPL and AMR confirmed the design and the performance of both the TV Subsystem and the Spacecraft. Successful completion of the testing established the confidence required to commit the Spacecraft to flight.

Failure of RA-6 to fulfill the mission objectives led to intensive failure investigation by JPL and RCA. This investigation established the probable cause of failure to be the result of an inadvertent turn-on of the TV Subsystem in a partial-pressure environment during the initial boost phase of flight. The high-voltage elements of the TV Subsystem communications and cameras were probably destroyed by arcing in the partial-pressure environment, and were not able to operate when commanded "on" during the period of lunar encounter. Several mechanisms for the unscheduled turn-on and turn-off of the TV Subsystem during the boost phase were advanced and studied. None of these mechanisms can be conclusively proven in the absence of the failed equipment and definitive flight data. However, testing at RCA has established that the most likely of the mechanisms considered to date is the stepping of the TV Subsystem Command Switch as a result of static-discharge arcing between the Agena umbilical-connector cover and the RTC-7 simulate pin in the umbilical connector. Simulations of this mechanism in testing at RCA has furnished preliminary evidence that arcing in this manner would produce a series of events that fit the accepted failure hypothesis for RA-6.

In this mechanism it is noted that unscheduled telemetry turn-on corresponded approximately to the passage of the Spacecraft into a range of altitudes where the ambient pressure is conducive to arcing and that the unscheduled transmission ceased at approximately the time corresponding to the Spacecraft rising above range of altitudes conducive to arcing. Investigation of potential failure mechanisms that fit the RA-6 mission will continue at RCA in order to minimize the possibility of a recurrence of these types of failures.

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A study of possible design changes in the TV Subsystem and Spacecraft interface were undertaken as a result of the RA-6 flight. This study led to the redesign of the TV Subsystem command and control circuits, telemetry, and the TV Subsystem/Spacecraft interface. The command and control circuits were redesigned to minimize the possibility of an unscheduled turn-on. Redesign of the telemetry circuits was accomplished to provide more meaningful data in the event of an in-flight malfunction. Several other product-improvement type design changes were incorporated in other assemblies of the TV Subsystem. The recommended design changes have been formally reviewed by RCA and coordinated with JPL. These changes have been incorporated in the Block III PTM and flight model assemblies and have been verified by testing of the assembled PTM. A detailed engineering description and analysis of these changes is provided in this report and is submitted for the purpose of formal approval by JPL.

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Section II
Introduction

A. General

B. Summary of Failure Analysis

C. Summary of Design Study

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Section II

Introduction

A. General

On January 30, 1964, at 15:49:00 hours GMT, the Ranger 6 Spacecraft was launched from Cape Kennedy, Florida. Seventy and three-quarter hours later, RA-6 impacted on the moon without accomplishing its primary mission of returning high-resolution television pictures of the lunar surface. This report documents the history of testing of Flight Model III-1, which was the TV Subsystem on Ranger 6, before the RA-6 launch and presents the data collected from Flight Model III-1 during the mission. The purpose of this report is to establish the condition of the TV Subsystem at the time of launch and to present an analysis of the data collected in an effort to ascertain a logical reason for the failure of the RA-6 spacecraft to satisfactorily complete the mission. This report also presents the results of the RCA design study for modification of the TV Subsystem resulting from the RCA investigation of the RA-6 mission.

The Test Report for Flight Model III-1 (AED R-3003, issued November 15, 1963) documents the testing history of this TV Subsystem through the date of its shipment to JPL on August 24, 1963. Sections III and IV of this report present a continuation of the Subsystem testing at JPL and at AMR, up to the time of launch. Section IV also includes a history of the pre-launch checkout of the Ground Station Equipment at the DSIF at Goldstone and the GSE calibration after launch.

The remainder of this report is devoted to the RA-6 mission and the report of the design study. Section V presents a history of the mission itself. Section VI is devoted to a presentation of the 15-point Channel-8 telemetry received from the TV Subsystem during the flight and the methods used to evaluate this data. Section VII presents an analysis of the data collected to determine the failure mode and mechanism as a function of the conditions experienced during the RA-6 flight. Section VIII is a report of the results of a design study performed to determine the design modifications to be made to Flight Model III-2 (RA-7) to improve the probability of a successful mission.

Data collected from the Subsystem testing, the results of tests performed on portions of the Subsystem to substantiate the hypothesized failure modes, and analyses of the failure potential in various portions of the Subsystem are included in the Appendices.

B. Summary of Failure Analysis

On the basis of an analysis of the potential failure modes of the TV Subsystem as restricted by the Channel-8 telemetry that was received during the RA-6 flight, it is concluded by RCA that the most probable cause of failure was an inadvertent turn-on of the TV Subsystem while in a partial-pressure environment. As has been shown in the past, operation under these conditions could cause considerable arcing in both the Camera and Transmitter Chains. This arcing would be the cause of the failure of enough components to have prevented the transmission of any data during the period of lunar encounter.

The reduction of the Channel-8 telemetry indicated that a heavy loading of the TV Subsystem batteries occurred at the time of inadvertent turn-on (15:51:30 to 15:52:37 GMT). The presence of telemetry is concluded to be a manifestation of an inadvertent turn-on of the TV Subsystem either into a warmup of full-power mode. The most probable cause of this turn-on is considered to be a stepping of the Command Switch. Although the mechanism for stepping the Command Switch remains undetermined, testing at RCA has indicated the possibility of a single mechanism that would have caused both the inadvertent turn-on and turn-off of the TV Subsystem by stepping the Command Switch a multiple of four times. This mechanism, which has been simulated in tests at RCA, is arcing from the cover of the Agena umbilical connector to the RTC-7 simulate pin in the Agena umbilical. Arcing is considered to have occurred as a result of static-charge build-up on the Agena skin during the boost phase of flight.

C. Summary of Design Study

Several equipment modifications are being incorporated into the TV Subsystem to minimize the possibility of a repetition of the RA-6 mission. These modifications are based primarily on the most probable failure mode, i.e., anomalous turn-on of the TV Subsystem during the launch phase of the Ranger mission. Other modifications are being made on the basis of less probable failure modes, or as general product-design improvements, but are being incorporated since they could be accomplished concurrently with the primary modifications. These modifications are described in detail in Section VIII of this report and can be summarized as follows:

- Modifications of the command and control circuitry to prevent the possibility of inadvertent turn-on of the TV Subsystem until after spacecraft separation from the Agena.
- Modifications and additions to the telemetry circuits, and modifications to the telemetry design, to improve the readability and usefulness of the telemetry data.

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In addition to the above, a special method of inspection or review of the TV Subsystem assemblies was implemented to determine the effects of life and usage on this equipment. As a part of this program all exposed terminals are being coated and all exposed connectors potted to minimize the possibility of an accidental short.

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Section III

Flight Model III-I Testing at the Jet Propulsion Laboratories (JPL)

A. General

B. Summaries of Operations Performed at JPL

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Section III

Flight Model III-I Testing at the Jet Propulsion Laboratories (JPL)

A. General

The purpose of the testing program at JPL was to verify that the Flight Model III-1 of the Ranger TV Subsystem was in flight-ready condition before shipment of the RA-6 Spacecraft to the Atlantic Missile Range (AMR). This testing program (summarized in Table 3-1) began on August 26, 1963 with a quality-control inspection and a Subsystem test; these were performed to document the condition of the TV Subsystem after delivery to JPL and to establish its operational capabilities before starting System tests.

A total of six System tests, designed to verify the electrical performance of the entire Spacecraft, were performed. Other special electrical tests were conducted separately on the TV Subsystem, either to ensure proper Subsystem operation before a System test or to perform necessary calibration and analysis. In addition, environmental tests and a space-simulated-mission test were performed to demonstrate that the System was capable of operation in space. During the testing at JPL and AED, the P-Channel was operated for a total of 163 hours 50 minutes, and the F-Channel was operated for 152 hours 5 minutes.

Any malfunctions that were encountered during testing were documented and repaired and the test was then repeated to demonstrated that the malfunction was repaired properly. Table 3-2 lists the malfunctions that occurred at JPL and at AMR.

The serial numbers of the assemblies which comprised Flight Model III-1 when shipped to JPL are listed in Table 3-3; also listed are the serial numbers of the assemblies that were shipped to AMR and the assemblies that were used for the actual mission.

The telemetry data recorded during this testing program were used to devise the bar graphs included in Appendix A. These bar graphs show the range of values experienced at certain telemetry points during the modes of operation and conditions listed.

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TABLE 3-1

SUMMARY OF THE FLIGHT MODEL III-1 TESTING PROGRAM AT JPL

Date	Test	Specification
26 August 1963	Quality-Control Inspection	———
26 August	Subsystem Command Checkout	RTSP-1100A, Appendix G
27 August	Subsystem Command Checkout	RTSP-1100A, Appendix G
27 August	System Test No. 1	JPL 3R212.00
28 August	System Test No. 2	JPL 3R300.01
30 August	System Test No. 3	JPL 3R300.01
4 September	Subsystem Command Checkout	RTSP-1100A, Appendix G
6 September	Agena Matchmate Mechanical Test	JPL 3R300.01
6 September	TV-Shroud Light-Compatibility Test	JPL 3R405.00
9 September	Dummy Run Pre-Countdown	JPL R303.04
11 to 13 September	Special Subsystem Communications Test	———
13 September	Subsystem Command Checkout	RTSP-1100A, Appendix G
14 September	System Test No. 4	JPL 3R300.02
16 September	Subsystem Command Checkout	RTSP-1100A, Appendix G
18 September	Subsystem Test	RTSP-1100A, Appendix F
18 September	Subsystem Test	RTSP-1100A, Appendix F
20 September	Vibration Test	JPL 3R311.00
26 September	Subsystem Test	RTSP-1100A, Appendix F
26 September	Pre-Thermal-Vacuum Mission Test	JPL 3R302.01

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TABLE 3-1

SUMMARY OF THE FLIGHT MODEL III-1 TESTING PROGRAM AT JPL (Continued)

Date	Test	Specification
27 to 30 September 1963	Thermal-Vacuum Mission Test (93°F)	JPL 3R302.01
1 to 2 October	Special Thermal-Vacuum Mission Test (93°F)	———
2 October	Pre-Thermal-Vacuum Mission Test	JPL 3R302.01
2 to 8 October	Thermal-Vacuum Mission Test (53°F)	JPL 3R3302.02
10 to 11 October	Determination of TV Subsystem Response Characteristics	JPL 3R220.00
12 October	Temperature Sensor Calibration	———
14 October	Focus and Overlap Check	JPL 3R220.00
16 October	Quality-Control Inspection	JPL Form AA20772
17 October	Final Acceptance Test (System Test No. 5)	JPL 3R300.04
21 to 22 October	Special (Subsystem) Thermal-Vacuum Test	———
6 November	Camera and Vidicon Operating-Point Verification	RCA File No. 92705-20
12 November	Special Communications Check	———
13 November	Special Pre-Thermal-Vacuum Test	JPL
14 November	Special Thermal-Vacuum Test	RTSP-1100A, Appendix D
21 to 22 November	Camera Black-Level Checks	———
26 November	Special Transmitter Tests	———

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TABLE 3-1
SUMMARY OF THE FLIGHT MODEL III-1 TESTING PROGRAM AT JPL (Continued)

Date	Test	Specification
27 November 1963	Subsystem Test	RTSP-1100A, Appendix F
4 December	Subsystem Test	RTSP-1100A, Appendix F
4 December	Modal Shake Test	———
5 December	System Test No. 6	JPL 3R300.07
6 December	Space Flight Operations Center Test	JPL 3R300.05
10 December	Space-Simulator Pre-Mission Verification Test	JPL 3R302.04
10 to 13 December	Space-Simulator Mission Verification	JPL 3R302.04
15 December	Quality-Control Inspection	———

B. Summaries of Operations Performed at JPL

1. *Subsystem Command Checkout (August 26, 1963)*

To ensure that the TV Subsystem was not damaged during shipment, a quality-control inspection and a Subsystem command checkout test were performed. The quality-control inspection revealed no signs of damage due to shipment. However, the Subsystem command checkout test, performed in accordance with Appendix G of RCA Specification RTSP-1100A, was aborted at T + 10 minutes because of the following conditions:

- P-Channel did not reach full-power output when commanded by the Sequencer; full-power output was reached by means of a CC&S command;
- Channel-8 Telemetry did not turn off when RTC-7 command was stepped to zero; and
- Test video was inoperative.

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TABLE 3-2

DETAILED TABULATION OF FAILURES ON THE INTEGRATED FLIGHT MODEL III-1 TV SUBSYSTEM

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
A3431 9/14/63	Battery Model 202 S/N 036 (Block III-1)	Battery	Low battery voltage	Room (JPL)	Nonconfirmed	Batteries were completely discharged. Recharged Batteries.
A3432 9/14/63	Battery S/N 037 Model 202 (Block III-1)	Battery	Low battery	Room (JPL)	Nonconfirmed	Batteries were completely discharged. Recharged Batteries.
A3483 9/16/63	Camera, S/N 025, P-Shutter, S/N 3032. (Block III-1)	Contact Stripe	Broken	Room (JPL) (System test)	Workmanship	A broken contact strip resulted in an open coil in the shutter. Inspection of the strip revealed that it had been soldered to the coil on an angle. Thus the contact strip was subjected to twisting when operated and it snapped. Reliability has issued a memo prohibiting the use of shutter S/N 3032 on flight equipment. It can only be used for preliminary testing of flight equipment.
A3434 9/17/63	Battery S/N 032 Model 202 Block III-1.	Battery	Internal short	Room (JPL)	Secondary	The batteries were overcharged, resulting in overheating. This caused the electrolyte to leak onto the battery-monitor connector.
A3438 9/17/63	Battery S/N 039 Model 202 (Block III-1)	Battery	Internal Short	Room (JPL)	Secondary	The shorting of the pins on the battery monitoring cable caused further shorting of cells in the Battery. The battery sensing switch in the GSE was not operating. Battery voltage was read as 38 volts when it was actually 42.5 volts. No failure report on the GSE switch has been received.
A4265 10/4/63	Type 202 Battery, Serial No. 44, Flight Model III-1	-	Suspected Shorted Cell No. 14	Thermal-Vacuum (Low-Temp.) (JPL)	Wearout	During thermal-vacuum testing at JPL, large quantities of electrolyte leaked from cell No. 14. The voltage of the cell dropped to 0.14V. This battery had received five charge and discharge cycles prior to its wearout. Battery voltages will be closely monitored to detect end-of-tape before it occurs and, thus, prevent damage caused by leakage of electrolyte.
A4266 10/4/63	Type 202 Battery, Serial No. 42, Flight Model III-1	-	-	Thermal-Vacuum (Low-Temp.) (JPL)	Nonconfirmed	During a low-temperature thermal-vacuum test at JPL, a drop in cell voltage was indicated. When the Battery was removed from the chamber, the connector was found to be covered with electrolyte. Later investigation proved that Battery Serial No. 44 had failed and leaked onto the connector. Battery Serial No. 42 was checked out by the vendor and found to be satisfactory.
A3439 10/9/63	Temperature Sensor Assembly Serial No. 004 (Block III-1)	Diode CR1 (types MZ11.2V25 and MZ18V05)	Shorted	Room (JPL)	Accident (Test Error)	The Channel-8 telemetry points Nos. 3 and 4 read zero volts following the application of both GSE and battery power during thermal-vacuum testing. The 2 diodes were found to be shorted when the Temperature Sensor Assembly was inspected. In addition, it was noted that all the inked markings on the terminal boards were blistered and smeared. Further investigation revealed that the wrong lacquer had been applied and the blistering and smearing had occurred during sterilization. Future units will utilize the proper ink and lacquer although these units will not be subjected to sterilization.

TABLE 3-2
DETAILED TABULATION OF FAILURES ON THE INTEGRATED FLIGHT MODEL III-1 TV SUBSYSTEM (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
A4262 11/24/63	Fa Camera, Serial No. 032, Flight Model III-1	Shutter, Serial No. 013	Magnetic Detent Not Holding Shutter	Ambient (JPL)	Design	The Fa Camera was saturating although no light was applied. Although a reading was obtained when the shutter reached the top of its stroke, the magnetic detent was not holding the shutter in the up position. Close inspection revealed the shutter was rebounding off new shock bumpers. An ECN has been issued to shorten the shock bumpers to prevent interference with the shutter.
A4263 11/26/63	Cable 30W31, Serial No. 005, Flight Model III-1		Orientation of Connector and Cable	Ambient (JPL)	Design	Attempts to connect the battery monitor cable, 30W21, Serial No. 005, were unsuccessful because the connector was attached in the reversed direction. An ECN has been written to show the orientation of the connector with respect to the cable.
A4264 11/26/63	Telemetry Assembly, Serial No. 1002, Flight Model III-1	90-Point Commutator	Telemetry Points Erratic	Ambient (JPL)	Nonconfirmed	Following erratic indications from telemetry points Nos. 46, 41, and 66, the commutator was replaced with a spare. The malfunctioning commutator was returned to RCA for tests and was found to be good. It is possible that a connector was responsible for the missing telemetry points.
A4267 1/15/64	Dummy Load, Serial No. 011, Pressure Vessel, Serial No. 003, Flight Model III-1	Valve Core	Leaky	Room (AMR)	Accident	Investigation into the drop in pressure of the pressure vessel for the Dummy Load from 15 to 5 psig revealed that the valve core had been crushed allowing it to leak. The pressure gage and tank filler can be tightened so that the valve core is crushed. Only the individuals who have been properly instructed in the proper use of the filler and pressure gage should make the pressure measurements. Also, all valve cores which have not been changed since December 13, 1963 should be replaced because prior to that date, all pressure checks were made without the realization that the core could be damaged.
A4268 1/16/64	Temperature Sensor Assembly, Serial No. 007, Flight Model III-1	Diodes CR1 and CR2 (Types MZ 11.2V25 and MZ 18V05)	Shorted	Room (AMR)	Awaiting Analysis	Investigation into the inability to obtain battery temperatures revealed that diodes CR1 and CR2 in the Temperature Sensor Assembly were shorted. Both diodes showed evidence of extreme heat, believed caused by an overvoltage. The exact cause of the failure is being investigated.

TABLE 3-3

LOG OF FLIGHT MODEL III-1 ASSEMBLIES

Unit Name	Assembly Designation	Serial Numbers of Assemblies		
		Shipment to JPL	Shipment to AMR	At Time of Launch
P1 Camera Subassembly	A1A1	034	034	034
P2 Camera Subassembly	A1A2	025	025	025
P3 Camera Subassembly	A1A3	019	019	019
P4 Camera Subassembly	A1A4	018	018	018
F_a Camera Subassembly	A1A5	032	032	032
F_b Camera Subassembly	A1A6	020	020	020
Camera P1 Electronics Assembly	A2	036	036	036
Camera P2 Electronics Assembly	A3	025	025	025
Camera P3 Electronics Assembly	A4	019	019	019
Camera P4 Electronics Assembly	A5	021	021	021
Camera F_a Electronics Assembly	A6	029	029	029
Camera F_b Electronics Assembly	A7	041	041	041
Video Combiner Assembly	A8	001	001	001
Control Programmer and Camera Sequencer Assembly	A9	0007	0007	0007
High-Current Voltage Regulator Assembly	A12	5	5	5
Command Switch Assembly	A13	005	005	005
Transmitter Assembly	A14	016	016	016
Power Amplifier Assembly	A15	008	008	008
Transmitter Power	A16	013	014	014
Low-Current Voltage Regulator Assembly	A17	8	8	8
Transmitter Assembly	A19	012	018	012
Power Amplifier Assembly	A20	007	007	007
Transmitter Power Supply Assembly	A21	018	018	018
Four-Port Hybrid Assembly	A24	006	001	001

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TABLE 3-3

LOG OF FLIGHT MODEL III-1 ASSEMBLIES (Continued)

Unit Name	Assembly Designation	Serial Number of Assemblies		
		Shipment to JPL	Shipment to AMR	At Time of Launch
Dummy Load Assembly	A25	011	011	011
Telemetry Assembly	A26	108	108	108
Temperature Sensor Assembly	A27	4	007	007
Sequencer Power Supply Assembly	A28	0008	0008	0008
Telemetry Processor Assembly	A29	008	008	008
Telemetry Processor Assembly	A30	022	022	022
Distribution Control Unit	A34	001	001	001
Electronic Clock Assembly	A35	001	001	001
Power Control Unit	A36	001	001	001
High-Current Voltage Regulator Assembly	A37	9	9	9
Filter Assembly	A38	003	003	003
Harnesses	30W26	001	007	001
	30W27	001	007	001
	30W28	001	007	001
	30W32	001	007	001
	30W33	001	007	001
Batteries	A10	-	-	67
	A11	-	-	68

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The malfunctions listed above were caused by wiring errors in the System Test Console (Unit 18) of the Ground Station Equipment which caused a fuse in the 110-volt input to the Ground Power Supply (Unit 17) to blow, interrupting the +6.3-volt supply to the interface amplifier. These wiring errors also caused a tantalytic capacitor in the Channel-8 turn-off circuit of the GSE to open. The malfunctions were corrected by: (1) wiring Unit 18 properly; (2) replacing the fuse in Unit 17; and (3) replacing the 100-volt, 300-μf tantalytic capacitor in the interface amplifier. At this time, the filter holders were installed on the collimators, and the gain of the interface amplifiers was adjusted to bring the video levels up to acceptable values. Following this corrective action, the test in accordance with Appendix G was again performed, and the Subsystem operated properly.

At the conclusion of the test, the omni-directional antenna, RF cables, and "top hat" were installed on the Subsystem. Subsequently, a brief electrical check was made (without collimators) to ensure that no damage occurred during the foregoing work.

An investigation of amplitude modulation (noise) that was observed on the RF power output during Appendix G testing was started. Measurements were made between the ground point (gold rivet) on each Telemetry Processor Assembly and the Subsystem ground. Polaroid photographs were taken to determine the amount of noise existing at the Assembly ground. The P-Channel appeared to contribute the greatest amount of noise. Application of an external ground reduced the noise considerably; however, the results obtained were not conclusive. The investigation was suspended at this point because of prior testing commitments, but recommendations to improve the Telemetry Processor grounding were made.

2. *Subsystem Command Checkout (August 27, 1963)*

Following mounting of the collimators and installation of the Thermal Shroud, a brief electrical check in accordance with RTSP-1100A, Appendix G, was performed to verify Subsystem operation prior to System test No. 1.

3. *System Test No. 1 (August 27, 1963)*

After mounting the TV Subsystem on the JPL Bus, a System test was performed on Flight Model III-1 in accordance with JPL Procedure 3R212.00. All readings of Steps A1 through A4, A5, and A7 were normal. The only problem encountered was the presence of amplitude modulation on the power-output recording. The source of this trouble was later determined to be the test-complex cabling configuration.

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4. *System Test No. 2 (August 28, 1963)*

This System test was performed in accordance with JPL Procedure 3R300.01. During this test, two problems were encountered:

(1) Several times the F-Channel was improperly placed in the warm-up mode by the Clock, despite RTC-5 inhibit commands; and

(2) Amplitude modulation was present on the power-output recordings.

It was found that the backup-timer microswitch on the JPL bus had remained closed, causing the Clock to restart after receiving an RTC-5 reset command, thereby initiating an improper F-Channel warmup command. A change in operating procedure corrected this condition. The amplitude-modulation problem was solved by changes in cabling at the test complex.

5. *System Test No. 3 (August 30, 1963)*

System test No. 3 was performed in accordance with JPL Procedure 3R300.01. No malfunctions occurred; however, amplitude modulation was still present on the power-output recordings.

6. *Subsystem Command Checkout (September 4, 1963)*

This test was performed in accordance with RCA Specification RTSP-1100A, Appendix G, before the Agena matchmate test. No problems or failures were encountered.

7. *Agena Matchmate Test (September 6, 1963)*

The mechanical segment of the Agena matchmate test was performed without problems. The Subsystem was mounted on the JPL Bus and the entire Spacecraft was mounted on the Agena adapter. The Agena shroud was then lowered over the Spacecraft.

Following the matchmating, a TV-shroud light-compatibility test was performed in accordance with JPL Procedure 3R405.00. Output recordings were made at reduced-power settings. No malfunctions occurred; however, amplitude modulation was still present on the power-output recordings.

8. *Dummy Run Precountdown (September 9, 1963)*

A precountdown dummy run was performed in accordance with JPL Procedure 3R303.04. No problems or malfunctions occurred.

9. *Special Subsystem Communications Test (September 11 to 13, 1963)*

With the TV Subsystem separated from the JPL Bus, six RF power-output checks were made to determine if the P-Channel Transmitter should be retuned and whether a reduction in the input voltage to the F-Channel Power Supply would cause amplitude modulation in the F-Channel output with the P-Channel off. The results of the test indicated that retuning was not necessary. To alleviate the amplitude-modulation problem, the following steps were taken;

- The Telemetry Processors, serial No. 022 and 008, were removed from the structure and a wire was added between the connector ground lug and the gold rivet ground; and
- An area around the processor mounting screws was cleaned to bare metal to improve the electrical contact between the Structure and the cases of the Telemetry Processors. The processors were then re-mounted.

Before the above modification, 0.1 ohm was measured between the gold rivet and the Structure (using a Simpson ohmmeter, Model 269, set to the R x 1 scale). As a result of the modification, this reading was reduced to zero. Two additional full-power tests were then performed, and the results indicated that the amplitude modulation was considerably reduced but not eliminated.

10. *Subsystem Command Checkout (September 13, 1963)*

This Subsystem test, in accordance with RCA Specification RTSP-1100A, Appendix G, was conducted to ensure proper Subsystem operation before performing System test No. 4. For this test, the Thermal Shields were installed and the collimators were in position.

The power-output recordings indicated that amplitude modulation was still present (possibly caused by the existence of a capacitive effect between portions of the communications equipment and the Thermal Shroud). No other problems were encountered. At this time, sync problems, which existed at the GSE, were eliminated by modifying the circuit that affects the trailing edge of the sync.

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11. System Test No. 4 (September 14, 1963)

This test was performed in accordance with JPL Procedure 3R300.02. The following problems were encountered:

- The P-Channel Battery voltage dropped to 22 volts;
- Power-output recordings showed a steady decline as the voltage dropped off;
- Video went out of sync on the GSE monitor; and
- Telemetry readings became distorted.

To determine what corrective action to undertake, the TV Subsystem was removed from the JPL bus. The Subsystem was then connected in a Subsystem command-checkout configuration in accordance with Appendix G of RCA Specification RTSP-1100A. While in this configuration, operation was not normal. Further checking revealed that an incorrect cabling setup caused the abnormal operation.

Batteries, serial Nos. 036 and 037, were removed from the Subsystem. A check of cell voltages under load indicated that a charge was required.

12. Subsystem Command Checkout (September 16, 1963)

A Subsystem command checkout was performed in accordance with RCA Specification RTSP-1100A, Appendix G, utilizing GSE power to verify Subsystem operation. No malfunctions or problems were encountered.

13. Subsystem Test (September 18, 1963)

A pre-vibration Subsystem test (with the Thermal Shroud removed) was performed in accordance with RCA Specification RTSP-1100A, Appendix F (steps d, e, and f), following the installation of Batteries, serial Nos. 31 and 28. No malfunctions or problems occurred during the test.

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14. *Subsystem Test (September 18, 1963)*

The pre-vibration Subsystem test of paragraph II-B-13 was repeated after the Thermal Shroud was installed and a QC inspection was performed.

During the test, cruise mode could not be turned off by the CC&S SIMULATE CRUISE MODE switch at the System Test Console (Unit 18). The cause for this failure was a bad tantalytic capacitor in Unit 18. Replacement of the capacitor corrected the malfunction.

15. *Vibration Tests (September 20, 1963)*

The vibration tests, simulating anticipated flight vibration conditions, were performed in accordance with JPL Procedure 3R311.00. After each axis of vibration, the following electrical tests were performed:

(1) Sequence 2 before X-axis vibration;

(2) Sequence 8 after X-axis vibration;

(3) Sequence 13 after Y-axis vibration; and

(4) Sequence 19 after Z-axis vibration.

Before the start of actual vibration, a modal survey was performed in accordance with JPL Procedure 3R117 to determine the resonant frequency of the Spacecraft. During this modal survey, a noise was heard in the Spacecraft. In an attempt to determine the source of this noise, the spacecraft was vibrated at the resonant frequency for 30 minutes. During this test, the shutter vibration isolators were damaged.

The following corrective actions were taken;

- Camera shutter isolators were replaced with ones of a new type;
- Noise heard during modal survey was eliminated by replacement of a broken tie-wrap on the RF cable to the omnidirectional antenna; and
- The Subsystem was carefully inspected to determine if any additional damage had been caused by the extended vibration test.

16. *Work Done Before Thermal-Vacuum Testing (September 26, 1963)*

In preparation for thermal-vacuum testing the following work was done:

- The pressures in the Power Amplifiers and the Dummy Load were measured. The pressure in the Dummy Load was 12 psig and it was re-pressurized to 15.5 psig;
- RF output cable 9W147, serial No. 4, was installed in place of 9W147 cable, Serial No. 1;
- The P-Camera shutters listed below were replaced:

Camera S/N	Removed Shutter S/N	New Shutter S/N
018	3046	3031
019	3030	3010
034	3044	3034

- Holes were drilled in the Thermal Shroud to accomodate the thermal harness and the Shroud screws were cleaned;
- The thermal harness and the special instrumentation harness were installed;
- The Thermal Shroud was installed; and
- The TV Subsystem was then subjected to a brief Subsystem test, in accordance with RCA Specification RTSP-1100A, Appendix F (steps d, e, and f), to ensure that no damage resulted from the above work.

17. *Pre-Thermal-Vacuum Test Before 93°F Mission (September 26, 1963)*

With the Subsystem mounted on the JPL Bus, a pre-thermal-vacuum mission verification test was performed in accordance with JPL Procedure 3R202.01. No problems or malfunctions were encountered.

18. *Thermal-Vacuum Mission Verification at 93°F (September 27 through 30, 1963)*

This test was performed in accordance with JPL Procedure 3R202.01. The following problems were encountered:

- A power failure in the test complex reset the clock;
- Camera F_b had no video output except reticles; and
- Power output dropped to approximately zero for an 0.2-second period at C + 55 minutes.

Following a check verifying that the F_b collimator was on during the test run, another mission was run at 93°F. The video from F_b Camera still showed no video except reticles. After the mission, the Camera, collimator, and mirror were inspected; a chemical analysis was made of the residue adhering to their surfaces. This analysis showed that hydrocarbons were being deposited on the mirrors and lenses.

After cleaning the lenses and mirrors, a test at ambient conditions was performed during which the F_b Camera operated in a normal manner. A third run was made at elevated temperatures and ambient pressure. During this run, the F_b Camera lens was capped. No reticles could be seen; therefore, it was determined that the shutter had been operating normally.

To determine the cause of the RF power dropout, the RF cabling was then removed for X-ray inspection. The RF cabling, however, did not cause the dropouts; the dropout was later remedied (see paragraph II-B-33) by replacement of the old configuration coaxial Four-Port Hybrid with a new design Stripline Four-Port Hybrid.

19. *Special Thermal-Vacuum Mission Verification Test (October 1 through 2, 1963)*

This test was run at 93°F for the purpose of checking F_b Camera operation. Satisfactory camera operation was obtained during a 9-minute hardline test. After the chamber was opened, the camera lenses and mirror were inspected and samples were taken of the residue adhering to their surfaces. Chemical analysis of the samples showed varying deposits of hydrocarbons. The difficulty with the F_b Camera video in the Thermal-Vacuum Mission Verification Test (paragraph II-B-18) was attributed to an excessive build-up of hydrocarbons on the mirror, the collimator, and the camera lenses. (The F_b Camera is the only camera which uses a mirror in thermal-vacuum. In addition, the collimator points downward for this test, allowing the residue from the rising gases to be deposited on the lenses.)

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20. *Pre-Thermal-Vacuum Test Before 53°F Mission Verification (October 2, 1963)*

A System electrical check, in accordance with JPL Procedure 3R302.01, was performed to verify proper operation of the TV Subsystem and JPL Bus before the 53°F thermal-vacuum test. No malfunctions or problems were encountered.

21. *Thermal-Vacuum Mission Verification Test at 53°F (October 2 through 8, 1963)*

The thermal-vacuum mission verification test, which was performed in accordance with JPL Procedure 3R302.02, was stopped because voltage at cell No. 14 of the F-Channel Battery dropped to 0.15 volts. The Spacecraft was removed from the chamber and the following conditions were observed:

- White battery electrolyte on the Battery;
- White battery electrolyte on 30W30 and 30W31 cable harnesses;
- Excessive moisture on the collimators; and
- Metal chips in the 9W147 cable.

The drop in battery cell voltage and the electrolyte leakage were caused by deterioration of the batteries themselves. (These batteries had been used beyond their rated life expectancy). The metal chips were probably caused by connector wear.

On instructions from JPL, mock-up batteries were installed and the test was repeated using ground power (October 4 through October 8). At T + 53' 35", a slight decrease in power (approximately 0.2 db) was noted. A check of P-channel telemetry point 84 showed a decrease in the cathode current of the Power Amplifier (possibly the result of a change in reflected power).

22. *Work Done after Thermal-Vacuum Testing (October 10, 1963)*

The TV Subsystem was removed from the JPL Bus and placed on the test stand. The Thermal Shields were removed for repainting. The thermal-vacuum harness was removed except for the transmitter connections which were cut to prevent having to remove the transmitter covers.

As part of the investigation of the RF power dropout (during the 93°F thermal-vacuum test, paragraph II-B-18), the Four-Port Hybrid, serial No. 006, was removed for microscopic inspection. The following conditions were observed:

- Connectors J4 and J2 were badly discolored;
- Connectors J1 and J3 were slightly discolored;
- Rainbow rings were evident on the outer conductors of each of the connectors; and
- The silver plating on connectors J2 and J4 were blistered and flaking.

This Four-Port Hybrid was then replaced with Four-Port Hybrid, serial No. 010; the new Hybrid was installed with a torque of 20 in-lb.

After Quality Control checked to ensure that the Power Amplifiers and Dummy Load contained the proper pressure, the Temperature Sensor Assembly (A27) was removed from the Structure. (It was observed that, during thermal-vacuum, telemetry points 3 and 4 were not operating.) The following conditions were observed:

- Diodes CR1 and CR2 were shorted and
- Discolorations coinciding with the stenciled numbers on the printed circuit board were observed. These discolorations were probably caused by a reaction between the stenciling and the varnish used to coat the stenciling.

Temperature Sensor, serial No. 007, was installed in place of the failed assembly.

23. *Determination of TV Subsystem Response Characteristics*

(October 10 and 11, 1963)

After the TV Subsystem was removed from the JPL Bus, a test, in accordance with JPL Procedure 3R220.00, was performed to determine the response of the TV cameras. No malfunctions or problems occurred.

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24. *Preparation for Final Acceptance Test (October 12 through 17, 1963)*

Following camera calibration, the following program was instituted to ensure flight-ready status of the TV Subsystem before final acceptance testing:

- Battery Monitor harnesses 30W30 and 30W31, serial Nos. 005, were installed;
- The special instrumentation harness was removed. This operation involved removing the Transmitter covers, the Telemetry Processors, and the Filter;
- All RF cables were removed for X-ray inspection;
- The thermal harness and Thermal Shrouds were installed in preparation for Temperature Sensor calibration procedure. This procedure was performed to calibrate the thermistors with Temperature Sensor Assembly, serial No. 007, which was installed after thermal-vacuum testing (paragraph II-B-22);
- The thermal harness and Thermal Shrouds were removed to complete painting of the shrouds;
- The Video Combiner was inspected and reworked;
- On October 14, 1963, a TV Subsystem Focus and Overlap Check was performed in accordance with JPL Procedure 3R220.00; and
- A JPL quality-control inspection was performed on October 16, 1963, and all discrepancies were listed on JPL Electronic Inspection Report Form, No. AA 20772. All discrepancies were corrected and quality-control approval was received.

25. *System Final Acceptance Test (October 17, 1963)*

The System final acceptance test (System test No. 5), in accordance with JPL Procedure 3R300.04, was performed to ensure flight-ready condition of the Spacecraft. No problems or malfunctions were encountered. Amplitude modulation was again present on the power-output recording. This condition was probably due to the cabling at the test complex.

26. *Special Thermal-Vacuum Test (October 21 and 22, 1963)*

This test was performed to determine if cleaning the Four-Port Hybrid would alleviate the power-dropout problem. The Four-Port Hybrid was disassembled, cleaned, reassembled (less six "0" -rings), and installed in the Subsystem. The Subsystem was then placed in the 8-foot vacuum chamber; the chamber pressure was reduced to less than 1×10^{-4} Torr; and a simulated mission, consisting of 5 minutes of warmup followed by 10 minutes of full-power operation, was run. After 2 minutes and 20 seconds of full-power operation, the power output dropped to approximately 15 watts and the mission was aborted.

A discussion with test personnel revealed that the RF cabling in the vacuum chamber contained type-N connectors. Previous Ranger experience had shown that type-N connectors were susceptible to breakdown in a vacuum.

To verify the power dropout, a second mission was run. In this run, the Subsystem was in full power for only 40 seconds before the power dropped to 15 watts. After opening the chamber, a verification test was performed to determine whether the Subsystem had been damaged. No problems or malfunctions were encountered.

During the above tests, no hardline video could be obtained. Investigation of this problem showed that a fuse in the GSE had blown.

After the test, the Four-Port Hybrid was examined for any signs of damage. There were no signs of damage.

27. *Transmitter Power Modification (November 6, 1963)*

To incorporate RDC-27, the Transmitter Power Supplies were removed, and resistors R3 and R4 were changed. This change was required to eliminate transient over-voltage conditions on the IPA tubes at the instant full power is applied (Refer to RCA Special Report on IPA Tube Failures, AED R-2164A, October 24, 1963). In addition to the above change, all bare terminals in the Transmitter Power Supplies were conformal coated in accordance with "TV Subsystem Vacuum Test" (TWX 11-80).

28. *Camera and Vidicon Operating-Point Verification Test (November 6, 1963)*

Camera and vidicon operating-point verification tests were conducted in accordance with procedures set forth in RCA Documents File No. 92705-20. To perform the

measurements called for in the procedures, all vidicon connectors were unplugged and a filament/beam-current monitor was inserted in each vidicon link to provide monitoring at those points. Each P-camera was measured, in turn, and then reconnected in the Subsystem configuration. No problems or malfunctions occurred.

A comparison between data obtained from this test and previous data obtained during camera acceptance testing indicated that no degradation in camera performance had occurred during testing and storage at JPL.

During the two-hour camera operation specified, connectors A26A1P1 and A26A2P2 were unplugged to prevent excessive operation of the telemetry commutators.

29. *Special Communication Check (November 12, 1963)*

A 30-minute power profile was run to verify that transmitter tuning had not changed as a result of: (1) the cleaning and re-installation of the Four-Port Hybrid; (2) the inclusion of RDC-27 (refer to paragraph II-B-27); and (3) the installation of new RF cables in the Subsystem.

During the run, point 51 on the 90-point, 225-kc telemetry read positive. Investigation of the two commutator connectors showed some loose potting material in one of the connectors. After cleaning of the connector, a test of the 90-point telemetry was performed, and the readings on all points were satisfactory.

30. *Operations Before Thermal-Vacuum Testing (November 13, 1963)*

The following operations were performed to prepare the TV Subsystem for thermal-vacuum testing:

- RF cables 30W26, 30W27, 30W28, 30W32 were removed to have the Thermofit markers replaced by glass-tape markers (to be removed before flight);
- The pressures in the Power Amplifiers and the Dummy Load were checked;
- The Thermal Shields, "top hat", and omni-directional antenna were installed;
- A quality-control inspection was performed; all rework was acceptable; and

- A special pre-thermal-vacuum test, in accordance with Appendix G of RTSP-1100A was performed to verify proper operation. No malfunctions or problems were encountered.

31. *Special Thermal-Vacuum Test (November 14, 1963)*

The purpose of this test was to check the installation of the new RF cables in the Subsystem. The run was made in accordance with Appendix D of RTSP-1100A. All outputs monitored were normal and within specification limits.

32. *Camera Black-Level Checks (November 21 and 22, 1963)*

These tests were performed at JPL request to enable determining the correctness of camera gain and black-level settings.

Initial tests were conducted on the P-Cameras following shutter replacement. Measurements were made at the interface between the Video Combiner and the Modulator. Both JPL and RCA collimators were used during the tests. Following the P-Channel Camera check, the F-Channel Cameras were checked in a similar manner.

Adjustments to the gain and black levels were made using JPL collimators in accordance with JPL recommendations.

33. *Transmitter Tests (November 26, 1963)*

Five transmitter tests were run to check the tuning of the F-and P-Channels following installation of a new Stripline Four-Port Hybrid and modification of the Power Amplifier pressure vessels. Tuning was peaked-up during the power runs.

During the tests the F_a Camera shutter did not operate. It was removed and an examination revealed that the new grommet installed under the pre-amplifier head was too long, restricting normal shutter travel. Replacement of the shutter corrected this malfunction.

Telemetry points 46, 51, and 66 intermittently went positive during the power runs. Replacement of commutator, serial No. 1002, with spare commutator, serial No. 1010, in the Telemetry Assembly, serial No. 108, corrected this problem.

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34. *Subsystem Test (November 27, 1963)*

This test, prior to System test No. 6, was performed in accordance with RCA Specification RTSP-1100A, Appendix F (steps d, e, and f). Testing was performed before and after Thermal-Shroud installation. No problems or malfunctions were encountered.

35. *Modal Shake Test (December 4, 1963)*

A modal shake test along the x-x axis at 1.5 g for 1 minute was performed on the Subsystem and JPL Bus at a frequency of 42 cps. No malfunctions or problems were encountered.

36. *Subsystem Test (December 4, 1963)*

This test was performed after a modal-shake verification test to verify normal Subsystem operation. The test was performed in accordance with RCA Specification RTSP-1100A, Appendix F (steps d, e, and f). No problems or malfunctions were encountered.

37. *System Test No. 6 (December 5, 1963)*

This test was performed in accordance with JPL Procedure 3R300.07. The shutter on the F_b Camera did not operate properly while the Spacecraft was in a tilted position. After a check of camera operation in the vertical position, the F_b Camera was removed and the shutter isolators were replaced with shorter ones. Normal operation of the F_b Camera was restored by this change.

38. *Space Flight Operations Center (SFOC) Test (December 6, 1963)*

The SFOC test was performed in accordance with JPL Procedure 3R3000.05. Subsystem operation was normal.

39. *Space-Simulator Pre-Mission-Verification Test (December 10, 1963)*

A space-simulator pre-mission-verification test was performed in accordance with JPL Procedure 3R302.04 before closing the space-simulator door. The only problem encountered during the test was noise on the 225-kc telemetry when the F_b Camera was operating. This problem was attributed to the GSE alignment and the higher light levels transmitted by the collimator for the F_b Camera.

40. *Space-Simulator Mission Verification Test (December 10 through 13, 1963)*

This test was performed in accordance with JPL Procedure 3R302.04. The following problems were encountered:

- The F-Channel gain was set to 1150 mv instead of 900 mv; and
- Battery-external-temperature telemetry point 44 indicated zero.

The incorrect gain setting of F-Channel was found to have resulted from the removal of the Wratten filters from the collimators during testing operations. The cameras, as a consequence, had a 30-percent greater response to the lower-temperature light than did the Prichard meter used for calibration.

The low reading at telemetry point 44 was caused by a defective external thermistor on the Battery. No action was taken to correct this fault because of the age of the battery and the fact that it was not a flight assembly.

41. *Preparation for Shipment to AMR (December 15, 1963)*

After JPL re-checked the attitude-control system in the space simulator (December 13 and 14), the Subsystem was de-mated from the JPL Bus to prepare it for shipment to the Atlantic Missile Range (AMR). After the "top hat", omni-directional antenna, vacuum gages, and thermal harness were removed, an RCA-JPL quality-control inspection was performed. The subsystem was then placed in the shipping container and locked. (Table 2-3 lists the serial numbers of the major components TV Subsystem shipped to AMR.)

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Section IV
Pre-Launch Checkouts

A. General

B. Summaries of TV Subsystem Pre-Launch Testing

C. Summary of Ground Station Equipment Pre-Launch Checkouts

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Section IV

Pre-Launch Checkouts

A. General

Pre-launch checkouts were performed on the TV Subsystem at the Atlantic Missile Range (AMR) and on the Ground Station Equipment (GSE) at the DSIF at Goldstone.

A series of thirteen checkouts were performed on the TV Subsystem beginning on December 28, 1963 and ending on January 30, 1964 (just prior to launch).

A series of two operation-readiness tests and three GSE pre-launch calibrations was performed at the DSIF at Goldstone between January 21 and January 30, 1964. In addition to these checkouts, calibrations of DSIF film recorders No. 1 and 2 were performed beginning on December 26, 1963 and continuing through the second pass of RA-6 over Goldstone.

Plots of the calibration data for each of the film recorders are included in Figures 4-1 through 4-8.

B. Summaries of TV Subsystem Pre-Launch Testing

1. *Subsystem Command Checkout (December 28, 1963)*

A Subsystem command checkout was performed in accordance with RCA Specification RTSP-1100A, Appendix G, to assure that there was no damage to the Subsystem as a result of shipping. The only problem encountered during the checkout was a test-complex grounding problem that produced approximately 200 mv of noise on the video hard-line.

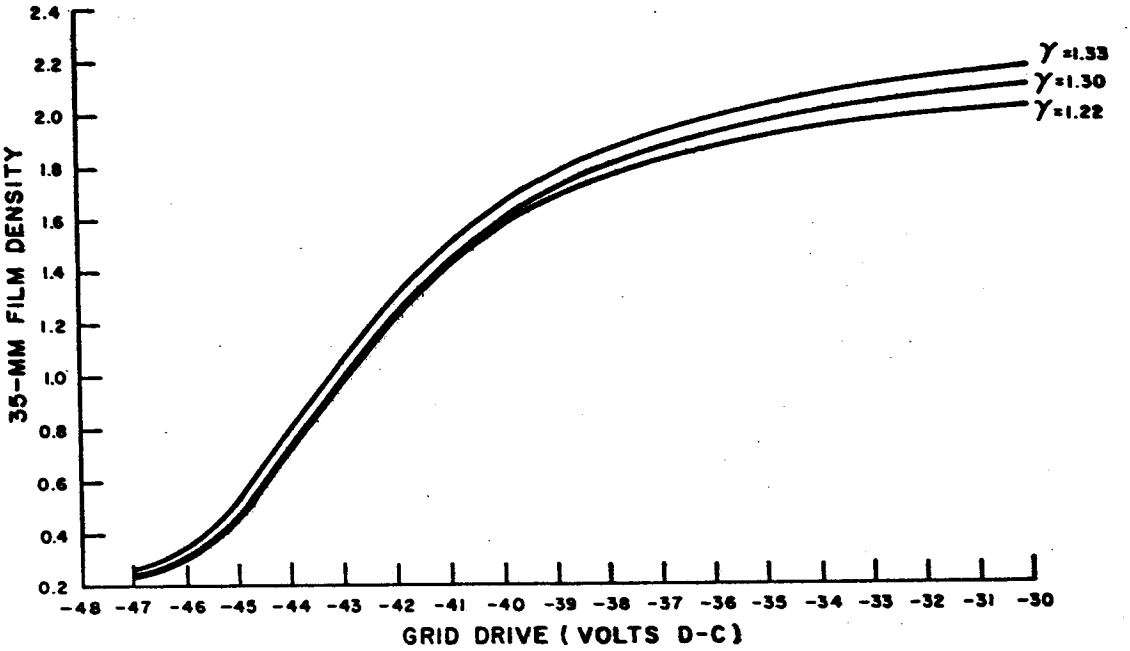

Figure 4-1. Curves of 35-mm film density as a function of initial grid-drive for film recorder No. 2 at f/3.5 during initial calibration of RA-6 mission (CRT No. 1214)

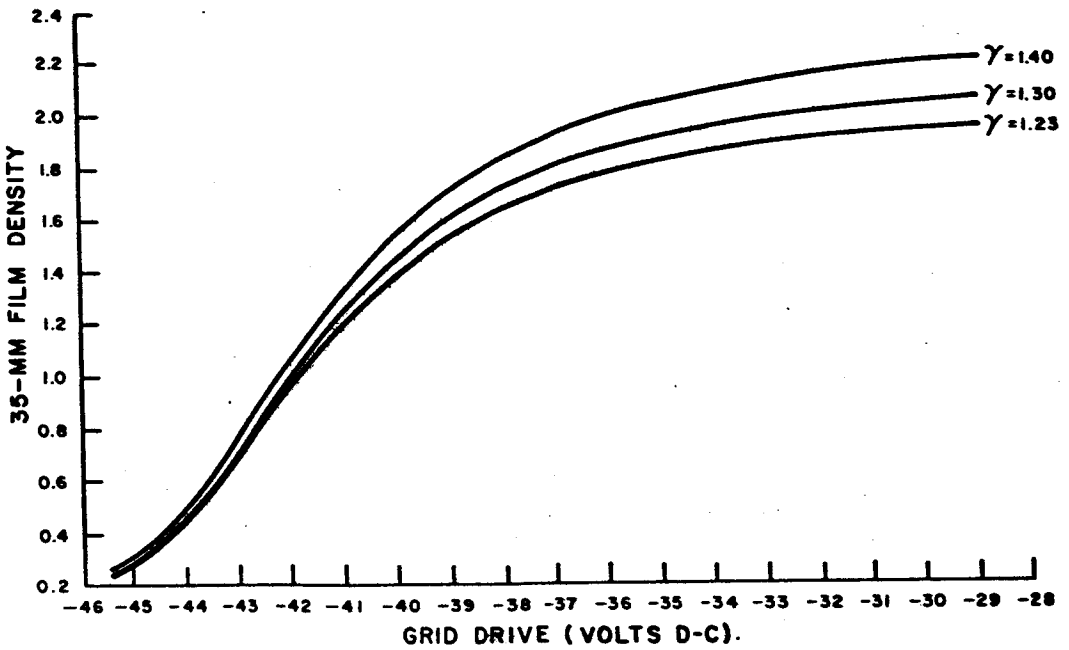

Figure 4-2. Curves of 35-mm film density as a function of initial grid-drive for film recorder No. 2 at f/3.5 during initial calibration of RA-6 back-up (CRT No. 1407)

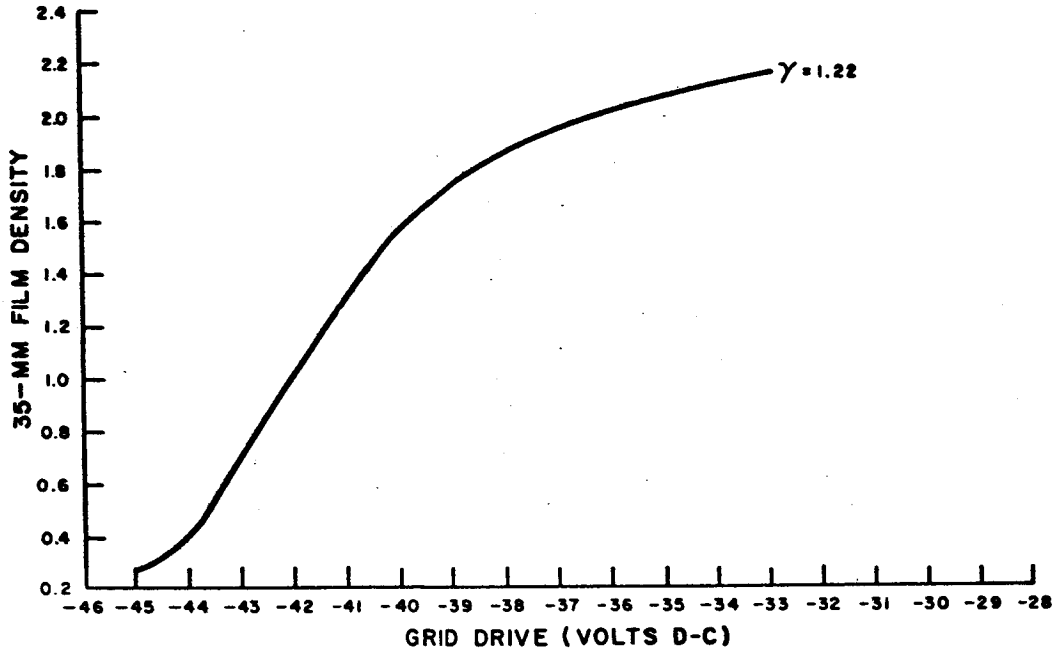

Figure 4-3. Curves of 35-mm film density as a function of initial grid-drive for film recorder No. 1 at f/5.6 during initial calibration of RA-6 mission (CRT No. 032)

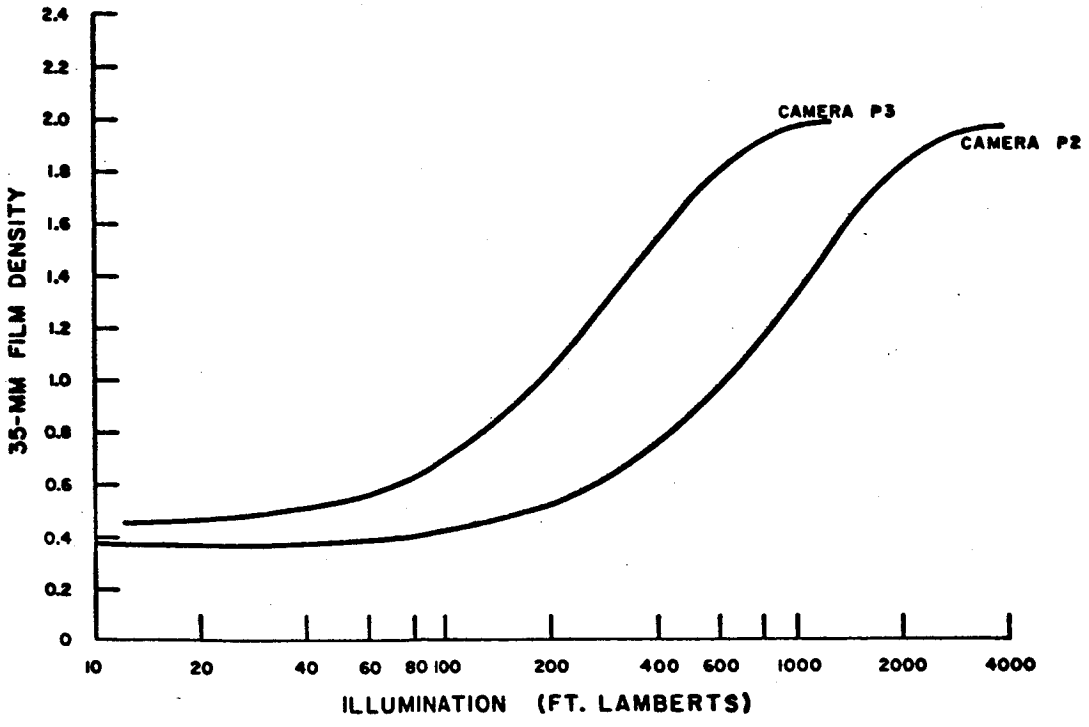

Figure 4-4. Curves of vidicon illumination as a function of 35-mm film density for film recorder No. 2 using calibration tapes from JPL during final calibration of RA-6 mission for cameras P2 and P3 (CRT No. 1214)

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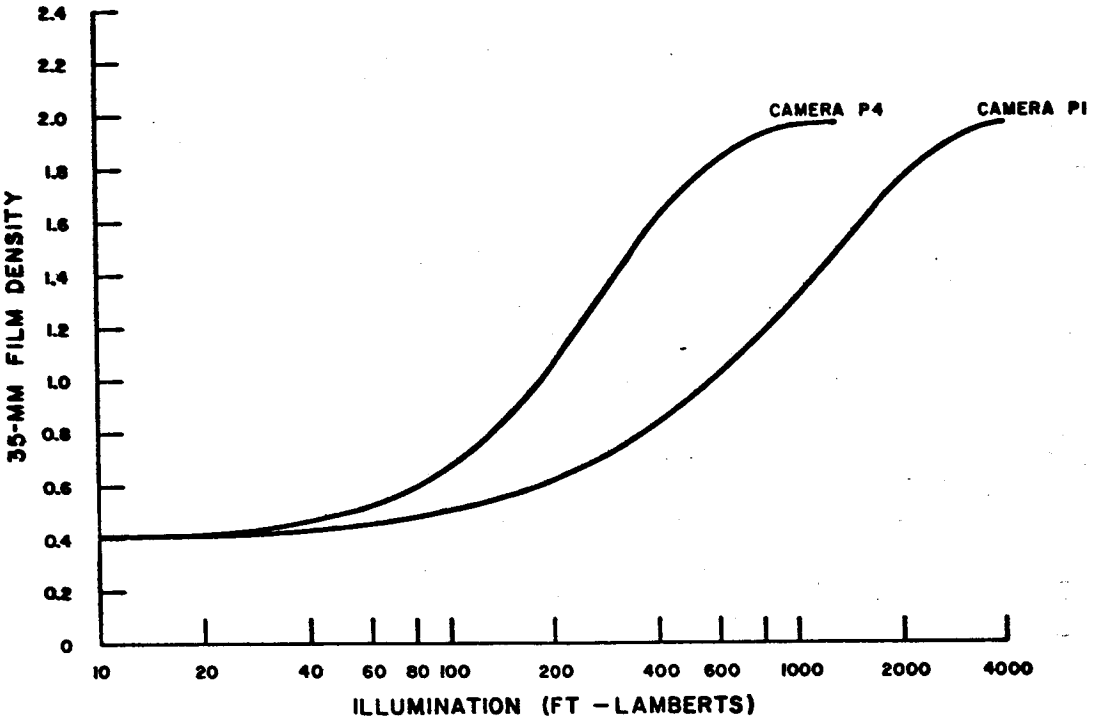

Figure 4-5. Curves of vidicon illumination as a function of 35-mm film density for film recorder No. 2 using calibration tapes from JPL during final calibration of RA-6 mission for cameras P1 and P2 (CRT No. 1214)

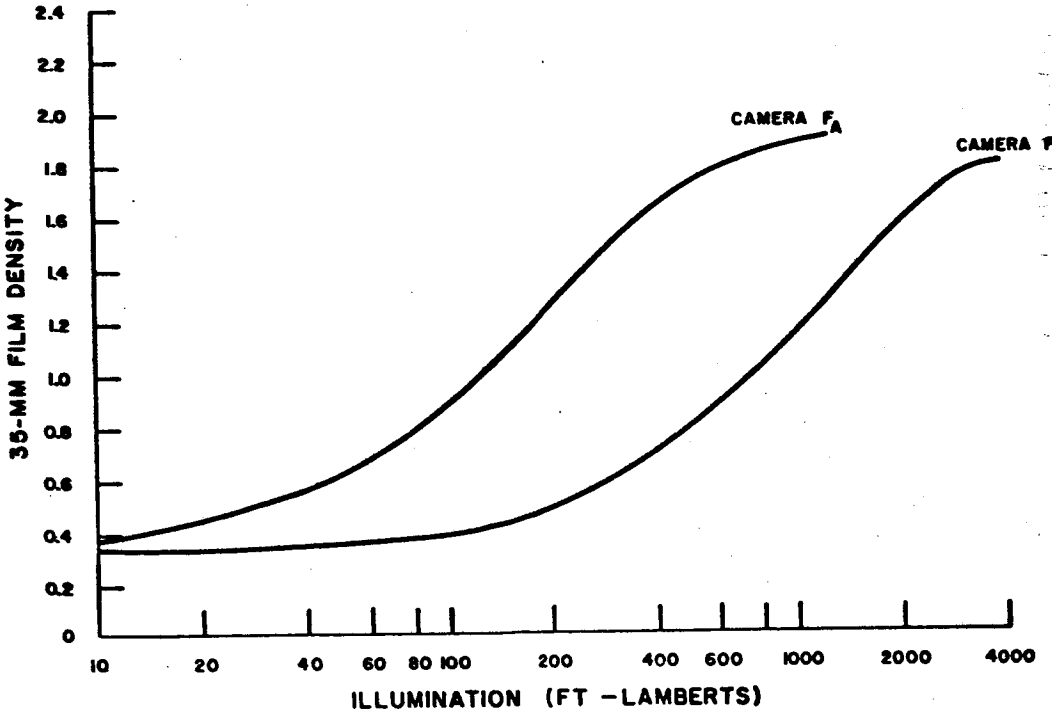

Figure 4-6. Curves of vidicon illumination as a function of 35-mm film density for film recorder No. 1 using calibration tapes from JPL during final calibration of RA-6 mission for cameras F_a and F_b (CRT No. 032)

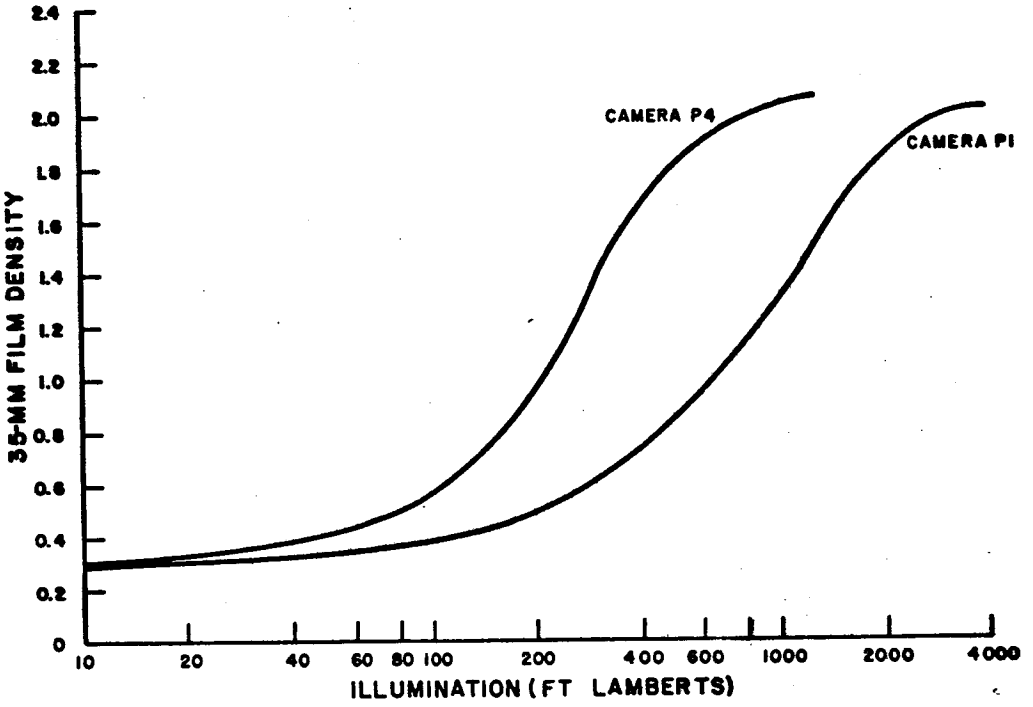

Figure 4-7. Curves of vidicon illumination as a function of 35-mm film density for film recorder No. 2 using calibration tapes from JPL during final calibration of RA-6 back-up, for cameras P2 and P3 (CRT No. 1407)

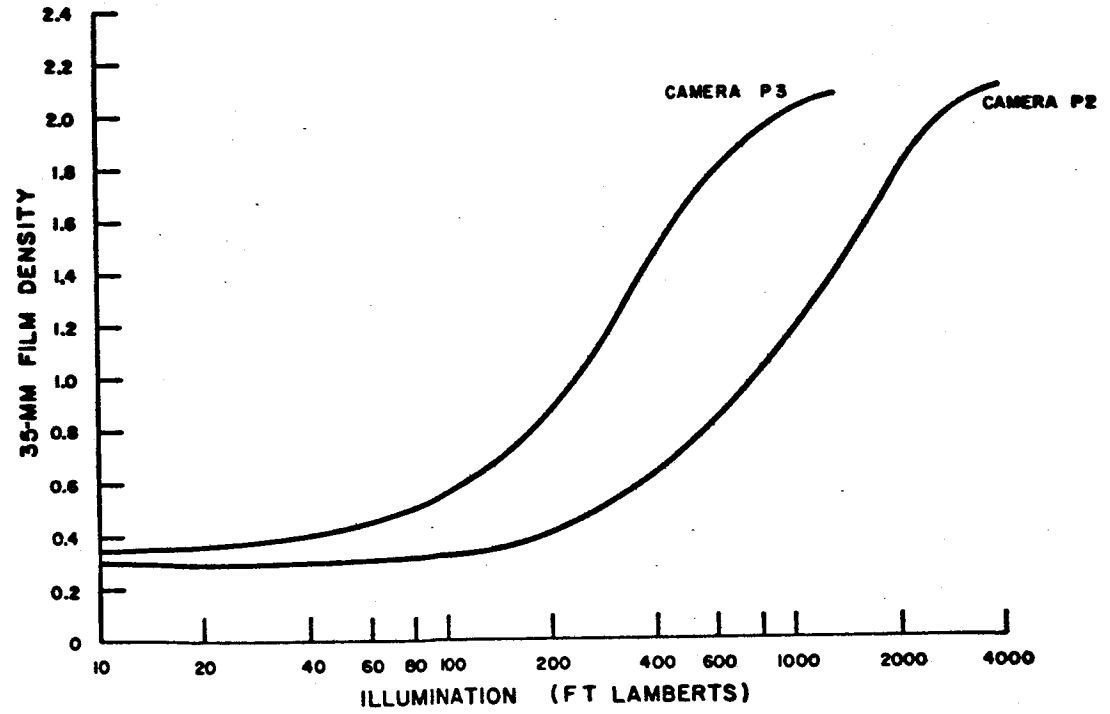

Figure 4-8. Curves of vidicon illumination as a function of 35-mm film density for film recorder No. 2 using calibration tapes from JPL during final calibration of RA-6 back-up, for cameras P1 and P4 (CRT No. 1407)

2. *Transmitter Frequency Check (December 29, 1963)*

The results of this test indicated that the P-channel center frequency was 40 kc high and that the F-channel center frequency was 20 kc high. Both channels were retuned to the proper center frequency.

3. *Subsystem Command Checkout (December 30, 1963)*

A Subsystem command checkout was performed in accordance with RCA Specification RTSP-1100A, Appendix G, to verify the readiness of the Subsystem for the first AMR System test. No malfunctions were encountered during this test. Emergency telemetry was not recorded at this time but was successfully recorded during the battery test.

4. *System Test No. 1 (January 2, 1964)*

System test No. 1 was performed in accordance with JPL Specification 3R 300.07. The following two problems were encountered: (1) approximately 200 mv of noise was present on the hard-line video; and (2) P-channel came on in the full-power mode after approximately 4 minutes of warmup instead of after the normal 5-minute cycle. The remainder of the test proved satisfactory. A short retest was performed with RCA interface cable 30W27 removed; both channels operated satisfactorily during the retest.

5. *ESA Test No. 1 (January 8, 1964)*

ESA test No. 1 was performed in accordance with JPL Specification 3R 304.02. F-channel came on inadvertently in warmup when the battery jumper plug (30J6) was installed improperly. After the plug was removed and reinstalled properly, F-channel did not turn on. However, after fifteen minutes, F-channel came on once more in warmup. The battery jumper plug was once again removed and, after the JPL interface cable was removed from connector 30J1, was reinstalled. Pin T of connector 30J1 was momentarily grounded to reset the Clock relays to the off position. After the JPL interface connector was reinstalled, F-channel did not go into warmup after 15 minutes and the test proceeded with no further problems encountered.

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6. *Launch-Pad Pre-Countdown Dummy Run (January 9, 1964)*

A launch-pad pre-countdown dummy run was performed in accordance with JPL Specification 3R 304.02. No RF was received in the hangar because a gantry cable which connected the service tower dish to the RF probe on the high-gain antenna had broken. After the cable had been repaired, a second pre-countdown dummy run was performed. During the second test, the following two problems were encountered: (1) F-channel could not be locked-in on the video monitor; and (2) P-channel exhibited a very weak and noisy signal. Upon completion of the pre-countdown, a special GSE run was performed in which a signal generator was used to insert the JPL 960-Mc carrier into the receiver at higher levels than those from the RCA 959.58-Mc and 960.58-Mc carriers. Measurements taken indicated that when the JPL 960-Mc signal exceeded the F-channel (959.58 Mc) signal by 7 to 8 db, the F-channel sync was lost. The F-channel was affected to a greater extent than P-channel because the higher-frequency sync pulse causes the F-channel transmitter to deviate toward the JPL carrier frequency, while in P-channel, the higher-frequency sync pulse causes the P-channel transmitter to deviate away from the JPL carrier frequency. Normal video and telemetry were received at the hangar during this special test.

Another pre-countdown dummy run was performed with the JPL Spacecraft power on. The JPL carrier frequency was transmitted from the Spacecraft by the high-gain antenna system to the GSE to establish the repeatability of the previously noted interference. After the interference was established, the JPL carrier frequency was switched to the omni-antenna system, which attenuated the signal by 20 db. No further interference was observed at the hangar.

7. *Agena-Atlas AMR Combined Radiation Test (January 10, 1964)*

An Agena-Atlas AMR combined radiation test was performed in accordance with JPL Specification 3R 310.01 to determine the RF compatibility between the Ranger Spacecraft and the Agena-Atlas when exposed to external AMR RF sources while on the launch pad. As expected, the JPL 960-Mc carrier produced interference when radiated from the high-gain antenna system to the GSE. A 20-db pad was installed in the low-gain-antenna gantry circuit to reduce the relative JPL power as compared to the RCA power. During the period of antenna transfer from the high-gain system to the omni-system, the JPL transmitter died out momentarily permitting proper video reception.

8. Countdown Dummy Run (January 11, 1964)

A countdown dummy run was performed in accordance with JPL Specification 3R 309.02. The TV Subsystem operated for approximately two minutes in the cruise mode during this test. The operation of the Subsystem was satisfactory.

9. J-Fact Test (January 13, 1964)

A J-fact test was performed in accordance with JPL Specifications 3R 309.02 and 3R 307.01. The TV Subsystem operated successfully for one minute in the cruise mode during this test.

10. Agena-Atlas AMR Combined Radiation Test (January 14, 1964)

This test was rerun because of an Agena-destruct fuse failure. The TV Subsystem was operated for approximately two minutes in the reduced-power mode. Operation was normal during this test.

11. Pre-Final System Test Checkout (January 16, 1964)

A pre-final system test checkout was performed in accordance with RCA Specification RTSP-1100A, Appendix G. The only problem encountered was that Channel-8 telemetry points 3 and 4 were zero. Investigation into the problem revealed that diodes CR1 and CR2 in the Temperature Sensor Assembly were shorted. After replacing the Temperature Sensor Assembly, no further problems were encountered.

12. Final System Test at AMR (January 18, 1964)

A final system test performed in accordance with JPL Specifications 3R 300.09 and AMR 3R 300.01. The only problem encountered during the test was an increase in the test complex noise level to approximately 120 mv. However, this did not affect operation of the TV Subsystem.

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13. *Final Assembly and Flight Preparation (January 21 through 25, 1964)*

The final assembly and flight preparation was performed in accordance with JPL Specification 3R 134.03. No problems were encountered during the assembly or the flight preparation.

C. Summary of Ground Station Equipment Pre-Launch Checkouts

A pre-launch checkout was performed on the Ground Station Equipment (GSE) located at the DSIF at Goldstone. The checkout was performed in accordance with the Ranger Operational Procedure for DSIF Operational Support Equipment Pre-Launch System Alignment (ROP-1). Prior to the checkout, two operation-readiness tests were performed to familiarize the equipment operators with the procedures to follow in recording data during the actual mission. These two tests also provided a check of the DSIF network. The pre-launch checkout consists of:

- Video recording and display pre-launch calibration;
- Ground Communications Equipment pre-launch calibration; and
- Ground Support Equipment pre-launch system calibration.

1. *Video Recording and Display Pre-Launch Calibration (January 29, 1964)*

The pre-launch calibration of the video recording and display equipment was performed in accordance with RCA Specification RTSP-1240C. All recorded data were within specified limits, and no malfunctions were encountered during the test.

2. *Ground Communications Equipment Pre-Launch Calibration (January 28 and 29, 1964)*

The pre-launch calibration of the ground communication equipment was performed in accordance with RCA Specification RTSP-1220A, Appendix B. All recorded data were within specified limits, and no malfunctions were encountered during the test.

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3. *Ground Support Equipment Pre-Launch System Calibration (January 29 and 30, 1964)*

The pre-launch system calibration of the ground support equipment was performed in accordance with RCA Specification RTSP-1200A, Appendix A. No malfunctions were encountered during the test.

In addition to these checkouts, a calibration of DSIF film recorders Nos. 1 and 2 was performed beginning December 26, 1963 and continuing through the second pass of RA-6 over Goldstone.

During initial calibration, two CRT's were designated as back-up during the RA-6 mission for each of the film recorders. Each CRT had curves of initial grid-drive versus 35-mm film density plotted, covering a range of film development gammas and, in the case of film recorder No. 1, a variance of f-stops. These results were submitted to JPL. Calculations were made at the DSIF site to establish an f-stop setting and a development gamma offering the best compromise between opacity, linearity, and signal-to-noise ratio. After correlating the results with equipment considerations, an optimum set-up was established. The results of the initial calibration for each CRT are shown in Figures 4-1 through 4-3. Following the initial calibration, periodic verification runs were made using the established conditions.

During final calibration, after completion of the initial calibration and after verification that the results are consistent, calibration tapes from a previous flight model were used to ensure the final calibration of the film recorders. These tapes were secured from JPL and AMR and the final set-up was adjusted to ensure compliance with the following criteria:

- The lowest white (peak-to-peak) voltage for each channel shall be set to a pre-determined upper density limit. All channels, as a result, either equal or exceed this level in density.
- The lowest black voltage for each channel shall be set to a pre-determined lower density limit.
- With the upper and lower density limits established, the calibration tapes shall then be played back and the density readings for the recorded light levels shall be measured. The plotted data represents the curves of vidicon illumination versus 35-mm film density for the individual model.

The curves plotted during the final calibration of the film recorders are shown in Figures 4-4 through 4-8. No curves for the film recorder No. 1 back-up CRT are included because of a failure in the high-voltage power supply of this recorder.

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After completion of this calibration, the Subsystem gray-scale pattern was played through the film recorders and, with all amplifiers fixed, the reference black and white levels were recorded. These settings were used in the video recording and display pre-launch calibration.

One malfunction was encountered in film recorder No. 1 approximately serial No. 1011, was replaced, and within 30 to 45 minutes film recorder No. 1 was returned to operation. Because of the high-voltage power supply failure and because of a previous JPL request to modify the density extremes from 1.9 to 1.6 for peak white voltages and from 0.4 to 0.35 for black voltages, the final calibration curves for the backup CRT for use with film recorder No. 1 were invalid and are not included in this report.

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Section V

Summary of RA-6 Mission

A. Mission Events

B. RA-6 Launch Environment

Section V

Summary of RA-6 Mission

A. Mission Events

Ranger 6, consisting of the JPL Ranger Spacecraft and the Flight Model III-1 of the RCA Ranger TV Subsystem, was launched from Cape Kennedy, AMR, on an Atlas-D/ Agena-B vehicle. Liftoff occurred at 15:49:00 GMT, January 30, 1964. The first non-standard event occurred when the TV Subsystem Channel 8 telemetry inadvertently turned on at 15:51:30.0 GMT and transmitted data until 15:52:36.5 GMT, at which time the transmission ceased. Normal turn-on of the Channel 8 telemetry occurred at a time corresponding to 17 minutes after separation of the Ranger system from the Agena (16:36:34 GMT). Except for a brief period during the midcourse maneuver when the JPL telemetry was switched to Mode II operation, reception of the Channel 8 data continued to be normal until impact.

The first timing pulse from the TV Subsystem clock was received, via the Channel 8 telemetry, on schedule at 16 hours after separation (08:19:50 GMT, January 31, 1964). Subsequent pulses were received as anticipated at separation plus 32 hours, 48 hours, and 64 hours.

Because of the near-perfect trajectory and orientation of the Spacecraft as it approached the moon, it was decided that a "terminal maneuver" would not be employed. Considering the temperatures and voltages of the Subsystem components, as determined by reducing the 15-point telemetry, it was further decided to allow the Subsystem Clock to time out and to initiate warm-up of the F-Channel of the Subsystem at Impact minus 19 minutes. An RTC-7 command would be sent four minutes later to initiate warmup of the P-Channel. Each channel was to be activated into full power when the 5-minute accumulators for each channel completed timing. Because the "terminal maneuver" was not performed, the warmup command and backup full-power command from the JPL CC&S were not used.

The warmup command to the F-Channel of the TV Subsystem was initiated by the TV Subsystem Clock at separation plus 64-3/4 hours (09:05:42 GMT, 2 February 1964).

At this time, a drop in the Channel-8 telemetry point monitoring the F battery indicated that a warmup load had been placed on the F Battery. The first RTC-7 command was initiated at 09:08:00 GMT and verified by the JPL Spacecraft. The state of the P-Channel warmup was confirmed by both a drop in the P-Channel battery voltage and the presence of the 30-second accumulator pulse on the Channel-8 telemetry. No indications of full power were received from either the F- or the P-Channels after five minutes of warmup, and no video was received at the Goldstone DSIF ground station. A second RTC-7 command was initiated at 09:15:29 FMT and verified; however, emergency telemetry was not received. The third RTC-7 command was initiated at 09:19:20 GMT and verified. Impact occurred at 09:24:33 GMT. No video, 225-kc telemetry, or emergency telemetry was received from the TV Subsystem.

Subsequent playback of the magnetic tape records obtained at the Goldstone ground station through narrow-pass filters and processed through a computerized autocorrelation program failed to produce evidence of data transmission from the TV Subsystem.

Table 5-1, below, presents in chronological order essentially all of the discrete events pertaining to the Ranger 6 spacecraft, from the time of power turn-on for the countdown until the spacecraft impacted on the moon. Some of the data contained in the sequence were extracted from spacecraft telemetry recorded by DSIF and AMR tracking stations and reduced at JPL.

TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION

Mission Time	GMT	Subsystem	Event
	Jan 30 (030)		
T-210m	10:22:00	OSE	Turn on S/C external power (transponder, data encoder, CC&S, gyros on)
T-175m	11:00:00	D/E	Mode 2
		RAD	Transfer to high gain antenna
T-160m	11:22:23	D/E	Commutator fast stepping
	11:22:58	D/E	Commutator stopped
T-130m		D/E	Commutator running, Mode 1

TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
T-128m	12:17:01	TV	Ch-8 telemetry on (starts on segment 15)
T-126m	12:19:02	TV	Ch-8 telemetry off (stops between segments 2 and 3)
T-125m		OSE	Transmit two RTC-0's and one RTC-2
	12:23:39	CMD	RTC monitor blip (B-20)
		A/C	Antenna hinge preset to 135 deg
T-113m	12:35:26	CCS	Clear relay check event (B-2-1 blip)
T-100m	12:48:11	OSE	Transmitter off (begin RF frequency checks)
		RAD	S/C receiver out of lock
	12:57:00	OSE	Transmitter on
		RAD	S/C receiver in lock
	13:09:20	PWR	S/C to internal power (battery voltage checks)
	13:15:50	PWR	S/C to external power
T-55m	14:07:05	OSE	Transmitter off (RF frequency checks)
		RAD	S/C receiver out of lock
	14:11:50	OSE	Transmitter on
		RAD	S/C receiver in lock

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TABLE 5-1

DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
T-42m	14:19:40	OSE	Transmitter off
		RAD	S/C receiver out of lock A) 960.028599 Mc D) 960.051951 Mc B) 890.047290 Mc E) -.0078 volts C) 960.051034 Mc F) 76 deg F
	14:19:54	RAD	Transfer from high-gain to omni antenna
	15:15:27	D/E	Rate 4 (H9) sync pulse ends
T-5m	15:43:50	PWR	S/C to internal power
T-2m	15:47:02	CCS	Release inhibit, start launch counter
T-1m	15:48:01.8	CCS	Clear relays event (B-2-1 blip)
T+0	15:49:00(?)	VEH	Ignition (launch plan 30E, azimuth 95 deg)
L+0	15:49:09.092	VEH	Liftoff (umbilical removed)
		PWR	Monitor voltages increase 5% (OSE load removed)
		D/E	Address 66 frequency drops 2.8 cps (OSE load removed)
L+2m		SFA	Squib firing assembly armed by g-switch (no telemetry)

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TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
L+137s	15:51:26.16	VEH	Mark 1
L+140s	15:51:29.10	VEH	Mark 2
	15:51:29.26±.05	(DSIF-71)	Rcvr AGC starts sharp drop, loses lock with S/C carrier.
		(AMR-1/Tel II)	Agena carrier and all subcarriers unchanged.
	15:51:29.7 ± .2	TV	Ch-8 telemetry on; starts between segments 2 and 3; channel noisy
	15:51:30.0	(DSIF-71)	Receiver back in lock (RF returns to previous level)
	15:51:55	D/E	Start of occasional 1-sec frequency shifts (up to 2 cps) on J-deck samples
	15:51:59.0	TV	Ch-8 noise disappears
	15:52:37.5	TV	Ch-8 telemetry off, (stops between segments 9 and 10)
L+288s	15:53:57.27	VEH	Mark 3
L+305s	15:54:13.90	VEH	Mark 4
L+306s	15:54:15.13	VEH	Shroud ejection (Mark 5)
		RAD	Omni-antenna coupler removed, RF drive up 2 db
L+310s	15:54:18.72	VEH	Atlas-Agena separation (Mark 6)
		VEH	Agena 1st ignition (Mark 7) (still over Cape)
		VEH	Agena 1st cutoff (Mark 8) (over Antigua)

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TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-5 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
L+23m	16:12:01.8	CCS	Transmitter power up command (B-2-1) (over Ascension)
		RAD	Plate volts from 150 to 250, omni drive to 35 dbm
		VEH	Agena 2nd ignition (Mark 9) (over YANKEE)
		VEH	Agena 2nd cutoff (injection) (Mark 10) (over YANKEE)
	16:18:33	(DSIF-51)	Transmitter turned on (for possible RTC-7's)
		RAD	S/C receiver in and out of lock for next 26 min
L+30m8s	16:19:17.20	VEH	S/C-Agena electrical disconnect (Mark 11) (over YANKEE) (Remove S/C telemetry from Agena carrier)
L+30m14s	16:19:23.20	VEH	S/C-Agena separation (Mark 12) (over Pretoria YANKEE)
S+0		BYCT	Start BU command timer
		TV	Start BU turn-on timer
		CCS	Relays unclamped
	16:20:32	RAD	S/C receiver in lock with DSIF-51 transmitter (MTS T/M in lock)
		D/E	No more noise on J-deck measurements

TABLE 5-1

DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
	16:30:47	RAD	S/C receiver out of lock (10-sec dropout DSIF-59)
	16:35:44	RAD	S/C receiver locked up with DSIF-51 transmitter (after 70-sec ground receiver dropout)
S+17m	16:36:34	TV	Ch-8 telemetry on, starts between segments 9 and 10
	16:42:13	RAD	S/C receiver out of lock (followed by 16-sec dropout)
	16:44:01	RAD	Locked up 2-way with DSIF-41 transmitter (after 10-sec dropout)
L+60m	16:49:01.8	CCS	Command solar panel extension (B-2-1)
		SFA	Fire solar panel squibs (B-2, B-2-3)
	16:50:06	S/C	Solar panels extended (B-2-4)
L+63m	16:52:01.3	CCS	Command Sun acquisition (Sun sensor error signal starts)
		A/C	DC power on, extend antenna, start Sun acquisition
	16:52:01.8	D/E	B-2-1 blip readout (delay due to synchronization, B-2 pulses with RTC-2 commutator pulses)
	16:53:50	PWR	Switch to solar panel power

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TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
	16:53:30	A/C	Sun acquisition complete (yaw error nulled)
	16:57:13	A/C	Antenna at acquisition angle (135 deg)
L+211m	19:20:02	CCS	Command Earth acquisition
		A/C	E/S power on, start roll search
	19:40:40	A/C	E/S threshold signal
	19:45:00	A/C	Earth acquisition complete
L+270m	20:25:00	DSIF-41	Initiate RTC-0 (command sequence stopped because of marginal ground transmitter power)
	21:08:00	DSIF-51	Initiate RTC-0
	21:10:00	DSIF-51	Initiate RTC-0
	21:12:00	DSIF-51	Initiate RTC-3
	21:12:40	CMD	RTC monitor blip (B-20)
		RAD	Switch S/C transmitter from omni to hi-gain antenna, hi-gain drive at normal 25 dbm
	Jan 31 (031)		
M-70m	07:20:00	DSIF-12	Initiate RTC-0
	07:22:00	DSIF-12	Initiate RTC-0
	07:24:00	DSIF-12	Initiate SC-1 (roll turn: 54 sec, neg)
	07:24:40	CMD	Stored command readout: 25-0450-0 (B-20)

TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
	07:24:44	CCS	Capacitor cycling command (B-2-1)
	07:26:00	DSIF-12	Initiate SC-2 (pitch turn: 328 sec, neg)
	07:26:40	CMD	Stored command readout: 35-0372-0
	07:28:00	DSIF-12	Initiate SC-3 (velocity increment: 135.1 fps)
	07:28:40	CMD	Stored command readout: 03-2610-1
S+16 hr	08:19:50	TV	Backup clock 16-hr pulse
M-10m	08:20:00	DSIF-12	Initiate RTC-3
		CMD	RTC monitor blip (B-20)
	08:20:40	RAD	Switch S/C transmitter from hi-gain to omni antenna; Low-gain drive at normal 35 dbm
	08:30:00	DSIF-12	Initiate RTC-4
M	08:30:39*	CMD	RTC monitor blip (B-20)
		CCS	Start maneuver counter
M+5s	08:30:44*	CCS	Start roll command (B-2-1)
		A/C	E/S power off, start antenna exit, A/P on, start negative roll turn

*These times read from real time SDAT analog record (approximately 1 sec behind DSIF time).

TABLE 5-1

DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
M+59s	08:31:38*	CCS	Stop roll turn command
		A/C	Stop roll turn after 54 sec
	08:32:37*	A/C	Antenna at exit angle
M+9m30s	08:40:08*	CCS	Command start pitch turn
		A/C	Start negative pitch turn
	08:44:00*	PWR	To power sharing mode (panels and battery)
	08:44	(TPS)	Telemetry out of lock (pitch through omni-antenna null)
M+14m58s	08:45:37*	CCS	Command stop pitch turn, Telemetry mode II (B-2-1)
		A/C	Stop pitch turn after 328 sec
		D/E	Telemetry mode II
M+26m30s	08:57:07*	CCS	Command motor ignition (B-2-1), start shutoff computer countdown.
		SFA	Fire motor ignition squibs (B-2-2, B-2-3)
		PROP	Motor ignition
		A/C	Jetvane control, gate accelerometer pulses to CCS
	08:57:20*	D/E	Temperature bridges G and D1, measurements to Ch-2 band edge (power supply shorted out)

*These times read from real time SDAT analog record (approximately 1 sec behind DSIF time).

TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
M+27m37s	08:58:16*	CCS	Command motor cutoff after 1351 accelerometer pulses (B-2-1)
		SFA	Fire motor cutoff squibs (B-2-2, B-2-3)
		PROP	Motor cutoff
M+30m	09:00:38*	CCS	Telemetry mode sun reacquisition, Telemetry mode III
		A/C	A/P off, start Sun reacquisition, start antenna to reacquisition angle
		D/E	Telemetry mode III
	09:01	(TPS)	Telemetry out of lock briefly (turn through null)
	09:01:53*	PWR	Switch to solar panel power
	09:02:49*	A/C	Antenna at reacquisition angle (122 deg)
	09:05	A/C	Sun reacquisition complete
M+58m	09:28:38	CCS	Command Earth reacquisition (B-21)
		A/C	Earth sensor power on, acquisition immediate
	09:44:00*	DSIF-12	Initiate TRC-3
	09:44:39*	RAD	Switch transmitter from omni to hi-gain antenna (B-20) hi-gain drive at normal 25 dbm

*These times read from real time SDAT analog record (approximately 1 sec behind DSIF time).

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TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
	Feb. 1 (032)		
S+32hr	00:20:11	TV	Backup timer 32-hr pulse
S+48hr	16:20:32	TV	Backup timer 48-hr pulse
	23:46	RAD	Ground transmitter transfer DSIF-41 to -51
	Feb. 2 (033)		
	06:00	RAD	2-way with DSIF-12
	08:11:00	DSIF-12	Initiated RTC-0
	08:13:00	DSIF-12	Initiated RTC-9
S+64hr	08:20:41	TV	Backup clock 64-hr pulse
S+64-3/4hr	09:05:42	TV	Backup turn-on clock starts F-Channel 5-min accumulator, battery voltage indicates warmup
	09:08:00	DSIF-12	Initiate RTC-7 (No. 1)
I-15m	09:08:41*	CMD	RTC Monitor blip (B-20)
		TV	Start P-Channel 5-min accumulator
	09:09:20	TV	P-Channel accumulator 30-sec pulse verifies RTC-7 advanced command switch properly
S+64hr50m	09:11	TV	No F-Channel full power video signal
I-10m	09:14	TV	No F- or P-Channel full power video signal

*These times read from real time SDAT analog record (approximately 1 sec behind DSIF time).

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TABLE 5-1
DISCRETE EVENTS PERTAINING TO THE RA-6 MISSION (Continued)

Mission Time	GMT	Subsystem	Event
	09:15:29	DSIF-12	Initiate RTC-7 (No. 2)
	09:16:09*	CMD	RTC monitor blip (B-20)
		TV	No indication of emergency mode
	09:19:21	DSIF-12	Initiate RTC-7 (No. 3)
	09:20:02*	CMD	RTC monitor blip (B-20)
		TV	No indication of full-power video signal
I	09:24:33	S/C	Impact

*These times read from real time SDAT analog record (approximately 1 sec behind DSIF time).

B. RA-6 Launch Environment

Dynamic environmental conditions throughout the boost phase of the RA-6 flight appeared to be below the expected maximums, with the exception of high frequency noise (400 to 1400 cps), as telemetered on Channel 17. These excessive levels appeared only during the transonic phase, T = 15:49:59 GMT (fifty seconds after lift-off), and lasted approximately 5 seconds. The altitude at this time was approximately 17,500 feet, and pressure inside the Agena shroud was approximately 8.5 PSIA. (See Appendix G.)

The maximum level of 0.26 G^2/CPS seen at approximately 850 cps was more than 4 db above the levels applied to the PTM during test (0.1 G^2/CPS). The excessive energy inputs at frequencies ranging from 800 to approximately 1050 cps warrant investigation as possible causes of failures.

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Section VI

Description of the Channel-8 Telemetry Recorded

A. General

B. Methods, Equipment, and Magnetic Tapes Utilized

C. Discussion of Channel-8 Telemetry

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Section VI

Description of the Channel-8 Telemetry Recorded

A. General

The Subsystem operational conditions, as monitored by the Channel-8 telemetry, have been investigated. The purpose of this investigation was to interpret the telemetry recorded during several critical time periods and to establish (as nearly as possible) the values of the sensor data. To accomplish this, the calibration curves as shown in Appendix B were used.

Specifically, the critical time periods which were investigated are as follows (the tables listed include the data reviewed):

• GMT 030:12:17:01	Launch minus 128 minutes (normal pre-launch-pad TV telemetry turn-on). Table 6-1.
• GMT 030:15:51:29	Inadvertent Channel-8 telemetry turn-on. Table 6-2. 67 seconds of data.
• GMT 939:16:36:34	Separation plus 17 minutes. Table 6-3. Normal Channel-8 telemetry turn-on. (Woomera recording)
• GMT 030:16:49:00 to 16:52:00	Separation plus 30 minutes. Table 6-4.
• GMT 033:09:05:42 to 09:24:33	Terminal data. Table 6-5.

The following conclusions were reached:

- There was continuity in the Channel-8 telemetry from the pre-launch readings to the readings at the inadvertent turn-on at launch plus 3 minutes and to the readings at separation plus 17 minutes;

TABLE 6-1

CHANNEL-8 TELEMETRY AT L-128 MINUTES TIME GMT 030-12-17-00 TO 030-12-19-00

Frame No.	Telemetry Point Nos.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	4.25	4.55	2.65	2.65	4.35	4.30	1.35	1.45	0	0	0	4.65	0	1.15	1.15
2	4.25	4.55	2.65	2.65	4.35	4.25	1.35	1.45	0	0	0	4.65	0	1.15	1.15
3	4.25	4.55	2.65	2.65	4.32	4.25	1.35	1.45	0	0	0	4.65	0	1.15	1.15
4	4.25	4.55	2.65	2.65	4.35	4.25	1.40	1.45	0	0	0	4.65	0	1.15	1.15
5	4.25	4.55	2.65	2.65	4.35	4.25	1.35	1.40	0	0	0	4.65	0	1.15	1.15
6	4.22	4.55	2.65	2.65	4.35	4.25	1.35	1.40	0	0	0	4.65	0	1.15	1.15

TABLE 6-2

CHANNEL-8 TELEMETRY DURING TURN-ON AT LAUNCH TIME GMT 030-15-51-29 TO 030-15-52-37

Frame No.	Telemetry Point Nos.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
*1	----	----	2.55	2.50	4.00	3.75	1.00	1.30	0	0	0	4.65	0	1.15	1.15
*2	3.70	4.30	2.23	2.50	3.75	3.60	0.90	1.13	0	0	0	4.65	0	1.15	1.15
3	4.00	4.45	2.53	2.53	4.05	4.05	1.23	1.30	0	0	0	4.65	0	1.15	1.15
4	4.05	4.45	2.53	2.53	4.07	4.05	1.23	1.33	0	--	--	----	--	----	----

*The first two frames were noisy and consequently difficult to interpret.
The readings shown are an average of three separate readings made by the authors.

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TABLE 6-3

WOOMERA CHANNEL-8 TELEMETRY DATA TIME 030-16-36-00 TO 030-16-36-40 TURN-ON OF CHANNEL-8 TELEMETRY AT S+17M (TAPE PLAYBACK)

Frame No.	Telemetry Point Nos.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	----	----	----	----	----	----	----	----	-	0	0	4.65	0	1.15	1.15
2	4.25	4.55	2.60	2.60	4.25	4.25	1.60	1.37	0	0	0	4.65	0	1.15	1.15
3	4.25	4.55	2.60	2.60	4.30	4.25	1.65	1.42	0	0	0	4.65	0	1.15	1.15
4	4.25	4.55	2.60	2.60	4.30	4.25	1.65	1.40	0	0	0	4.65	0	1.15	1.15
5	4.22	4.52	2.60	2.60	4.30	4.25	1.65	1.40	0	0	0	4.65	0	1.15	1.15
6	4.20	4.51	2.60	2.60	4.27	4.25	1.62	1.40	0	0	0	4.65	0	1.15	1.15
7	4.22	4.50	2.60	2.60	4.30	4.25	1.62	1.40	0	0	0	4.65	0	1.15	1.15
8	4.25	4.55	2.60	2.60	4.30	4.25	1.65	1.40	0	0	0	4.65	0	1.15	1.15

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TABLE 6-4

WOOMERA CHANNEL-8 TELEMETRY DATA TIME 030-16-49-00 TO 030-16-52-00 (TAPE PLAYBACK)

Frame No.	Telemetry Point Nos.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	4.25	4.53	2.65	2.65	4.30	4.25	1.65	1.35	0	0	0	4.65	0	1.15	1.15
2	4.23	4.50	2.65	2.65	4.30	4.25	1.65	1.35	0	0	0	4.65	0	1.15	1.15
3	4.25	4.55	2.65	2.65	4.33	4.25	1.65	1.35	0	0	0	4.65	0	1.15	1.15
4	4.25	4.55	2.65	2.62	4.30	4.25	1.60	1.35	0	0	0	4.65	0	1.15	1.15
5	4.25	4.55	2.65	2.65	4.32	4.25	1.57	1.33	0	0	0	4.65	0	1.15	1.15
6	4.25	4.55	2.62	2.65	4.30	4.25	1.60	1.35	0	0	0	4.65	0	1.15	1.15
7	4.23	4.55	2.65	2.65	4.30	4.25	1.60	1.30	0	0	0	4.65	0	1.15	1.15
8	4.25	4.55	2.65	2.65	4.32	4.22	1.55	1.30	0	0	0	4.65	0	1.15	1.15
9	4.22	4.55	2.65	2.62	4.30	4.25	1.55	1.33	0	0	0	4.65	0	1.15	1.15

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TABLE 6-5

GOLDSTONE CHANNEL-8 TELEMETRY DATA (IMPACT -22 MINUTES TO IMPACT TAPE PLAYBACK)

GMT	Telemetry Point Nos.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
033-09-02-20	4.22	4.55	3.55	3.55	4.30	4.25	2.20	2.05	4.15	0	0	4.65	0	+1.15	+1.15
09-03-10	4.25	4.55	3.60	3.55	4.30	4.25	2.20	2.05	4.15	0	0	4.65	0	+1.15	+1.15
09-04-00	4.25	4.55	3.55	3.55	4.30	4.25	2.22	2.10	4.15	0	0	4.65	0	+1.15	+1.15
09-05-07	4.25	4.55	3.60	3.60	4.30	4.25	2.25	2.10	4.15	0	0	4.65	0	+1.15	+1.15
09-05-23	4.25	4.55	3.55	3.55	4.17	4.25	2.20	2.10	4.15	0	0	4.65	0	+1.15	+1.15
09-07-05	4.20	4.55	3.60	3.60	4.15	4.20	2.20	2.05	4.15	0	0	4.65	0	+1.15	+1.15
09-07-56	4.20	4.55	3.60	3.60	4.15	4.25	2.20	2.10	4.15	0	0	4.65	0	+1.15	+1.15
09-08-30	4.22	4.55	3.60	3.60	4.15	4.20	2.20	2.10	4.15	0	0	4.65	0	+1.15	+1.15
09-08-49	4.10	4.55	3.60	3.60	4.12	4.10	2.20	2.05	4.15	0	0	4.65	0	+1.15	+1.15
09-09-04	4.12	4.55	3.55	3.60	4.10	4.10	2.20	2.05	4.15	0	4.50	4.65	0	+1.15	+1.15
09-10-11	4.12	4.52	3.60	3.55	4.10	4.10	2.20	2.10	4.15	0	4.50	4.65	0	+1.15	+1.15
09-12-10	4.15	4.55	3.55	3.60	4.12	4.12	2.20	2.05	4.15	0	4.50	4.65	0	+1.15	+1.15
09-13-00	4.12	4.50	3.55	3.60	4.10	4.10	2.20	2.07	4.15	0	4.50	4.65	0	+1.15	+1.15
09-14-09	4.15	4.55	3.60	3.60	4.12	4.12	2.22	2.07	4.15	0	4.50	4.65	0	+1.15	+1.15
09-15-00	4.15	4.55	3.60	3.60	4.10	4.12	2.20	2.10	4.15	0	4.50	4.65	0	+1.15	+1.15
09-16-08	4.15	4.55	3.60	3.60	4.15	4.12	2.02	2.05	4.15	0	4.50	4.65	0	+1.15	+1.15
09-17-00	4.15	4.50	3.60	3.60	4.12	4.15	2.22	2.10	4.17	0	4.50	4.65	0	+1.15	+1.15
09-18-08	4.15	4.55	3.60	3.60	4.12	4.10	2.20	2.10	4.15	0	4.50	4.65	0	+1.15	+1.15
09-20-07	4.15	4.55	3.60	3.60	4.15	4.15	2.22	2.10	4.20	0	4.50	4.65	0	+1.15	+1.15
09-20-23	4.15	4.50	3.60	3.60	4.15	4.15	2.23	2.12	4.20	0	4.50	4.65	0	+1.15	+1.15
09-22-06	4.15	4.55	3.60	3.60	4.15	4.15	2.25	2.15	4.20	0	4.50	4.65	0	+1.15	+1.15
09-22-57	4.15	4.55	3.60	3.60	4.10	4.15	2.20	2.10	4.20	0	4.50	4.65	0	+1.15	+1.15
09-23-46	4.15	4.50	3.60	3.60	4.10	4.10	2.25	2.10	4.15	0	4.50	4.65	0	+1.15	+1.15
09-24-21	4.15	4.50	3.60	3.60	4.13	4.13	2.25	2.15	4.20	0	----	----	--	-----	-----

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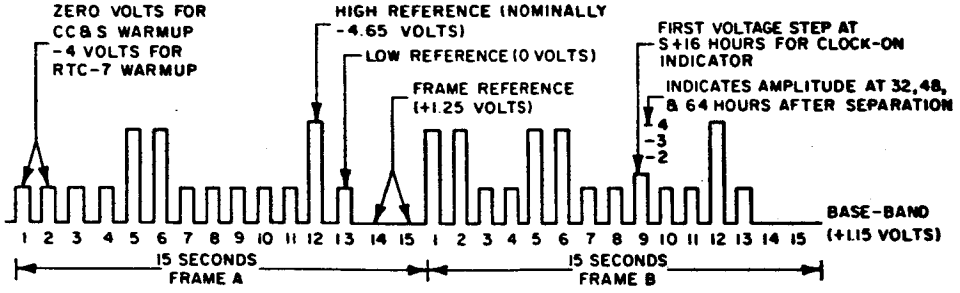
- There was a definite drop in both battery potentials during the inadvertent Channel-8 telemetry turn-on;
- There was a return to almost normal levels of the battery potentials by the time of separation plus 17 minutes; and
- There was another definite drop in both battery potentials during the initial phase of the terminal mode.

The format of the analog record of the Channel-8 telemetry is shown in Figure 6-1. A picture of the telemetry received during the inadvertent turn-on is shown in Figure 6-2. All significant events with regard to the Channel-8 telemetry are listed in Table 6-6.

B. Methods, Equipment, and Magnetic Tapes Utilized

A Gerber variable scale rule was used to read the analog telemetry data. For each frame of data, the scale was set to read 4.65 on point number 12, the reference point of the Channel-8 telemetry. This scaling was checked by reading the amplitude of point number 13, the zero-reference point. This reading should be 1.15. These two values represent the full-scale and pedestal voltages as measured before launch.



DATA POSITION	PARAMETER MONITORED		
1	UNREGULATED D-C, P-CHANNEL	8	SHROUD, Y-AXIS TEMP NO. 11
2	LCVR OUTPUT	9	CLOCK-ON INCREMENTS
3	INTERNAL TEMPERATURE, F-BATTERY	10	NOT USED ON III-1
4	INTERNAL TEMPERATURE, P-BATTERY	11	P 5-MINUTES ACCUMULATOR
5	TERMINAL VOLTAGE, F-BATTERY	12	FULL-SCALE REFERENCE
6	TERMINAL VOLTAGE, P-BATTERY	13	ZERO REFERENCE
7	TOP HAT Y-AXIS TEMP NO. 9	14	FRAME REFERENCE
		15	FRAME REFERENCE

Figure 6-1. Format of analog record of Channel-8 telemetry

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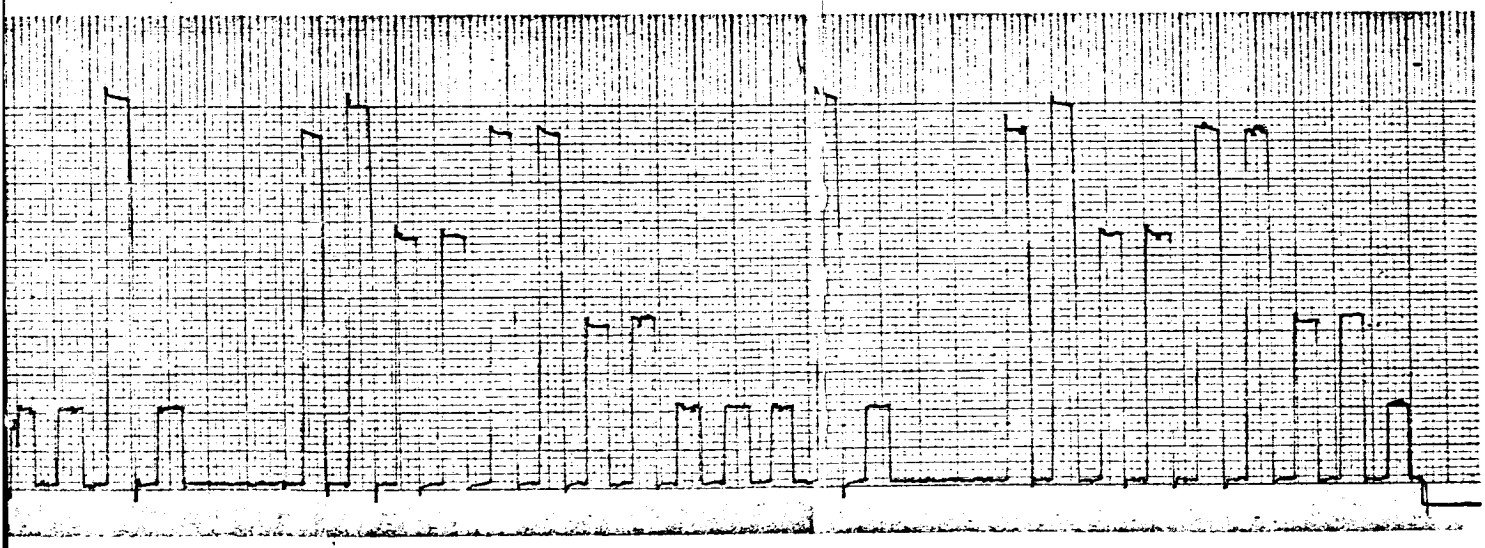

Figure 6-2. Channel-8 telemetry recorded during the inadvertent turn-on at GMT 030:15:51:29

85-2

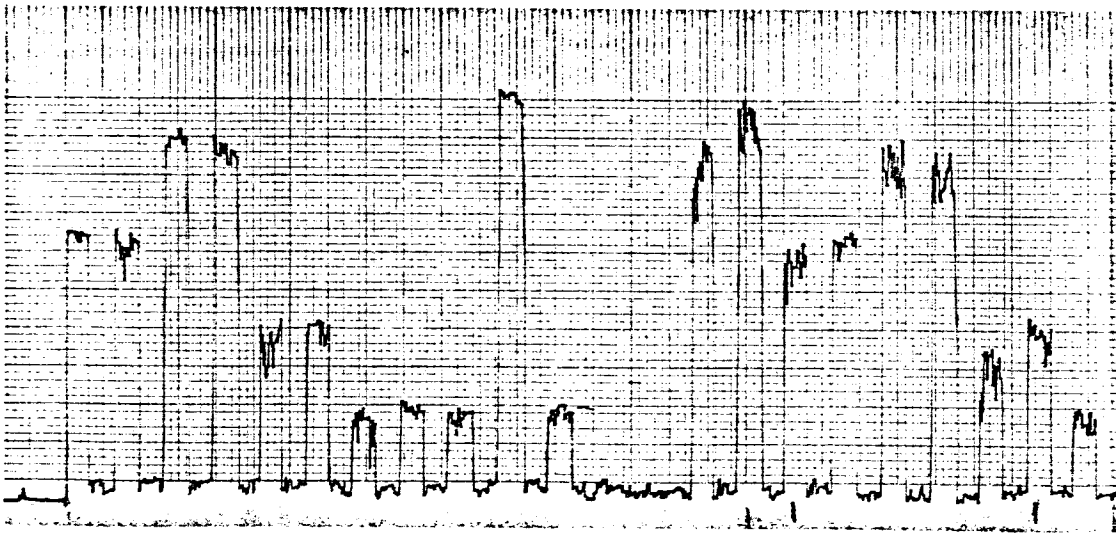

TABLE 6-6
CHANNEL-8 TELEMETRY EVENTS LIST

Time (GMT)	Event
30:12:17:01	Channel-8 T/M ON (Pad Test) Starts on point 15
30:12:19:00	Channel-8 T/M OFF (Pad Test) Stops between points 2 and 3
30:15:51:29	Channel-8 T/M ON (During Launch) Starts on point 3. Telemetry is noisy with the base line shifted down (toward higher frequency)
30:15:51:59	Noise stops on point 10 and base line shifts back to normal
30:15:52:37	Channel-8 T/M OFF Stops between points 9 and 10
30:16:36:34	Channel-8 T/M ON (Separation plus 17 minutes) Starts between points 9 and 10
31:08:19:50	First 1-volt step in clock T/M on Channel-8 point 9
32:00:20:11	Second 1-volt step in clock T/M on Channel-8 point 9
32:16:30:32	Third 1-volt step in Clock T/M on Channel-8 point 9
33:08:20:41	Fourth 1-volt step in Clock T/M on Channel-8 point 9
33:09:05:42	Clock turn-on of F-Channel (point 5 F-battery voltage drops)
33:09:08:00	First RRC-7 sent from DSIF 12
33:09:08:41	B-20 event. RTC T/M monitor indicates that the command was received by the Spacecraft
33:09:08:53	Channel-8 point 6 indicates a drop in the P-Channel battery voltage
33:09:09:16	Channel-8 point 11 indicates the P-Channel sequencer was counting
33:09:10:42	Expected time of F-Channel full power
33:09:13:00	Expected time of P-Channel full power
33:09:15:29	Second RTC-7 sent from DSIF 12
33:09:16:09	B-20 event. RTC T/M monitor indicates that the command was received by the Spacecraft
33:09:19:21	Third RTC-7 sent from DSIF 12
33:09:20:02	B-20 event. RTC T/M monitor indicates that the command was received by the Spacecraft
33:09:20:25	Increase in noise on Channel-8 data points. On the base line and the zero reference points the noise does not increase
33:09:22:07	The noise on the Channel-8 data points returns to its previous level (before 33:09:20:25)
33:09:24:33	IMPACT

Readings were then taken by several persons to ensure agreement and to provide as much accuracy as possible. The Gerber variable scale rule can be read reliably to an accuracy of ±0.5 division. This corresponds to ±50 millivolts on the telemetry readings. Baseline drift and noise were considered in all readings. During the reading of the two noisy frames from the inadvertent turn-on, the base-line drift was considered and the noise averaged.

The telemetry data was obtained by using two methods. The first method involved:

- Taking all records from four magnetic tapes and playing them back on one tape reproducer. The signal was then applied to one set of discriminators and analog recording equipment;
- Taking all data recorded on track No. 5. This was the received signal from the JPL transponder; and
- Not changing the calibrations and adjustments after the initial settings were established. This method resulted in the data that is included in this report.

A second method of extracting the information from the magnetic tapes involved the use of a digital decommutator that compensated for the base-line drift and corrected for calibration shifts. A computer was also used to convert the octal readout of the decommutator to engineering units.

The data reduced by the second method was used to verify the readings made from the analog records. Although the absolute values of the digitized data do not agree precisely with the analog readings, the drops in battery potentials were definitely indicated at the same points.

C. Discussion of Channel-8 Telemetry

The Channel-8 telemetry stopped between points 2 and 3 at the end of the countdown test and started at point 3 during the inadvertent turn-on. The Channel-8 telemetry was received for a period of 67 seconds and stopped between points 9 and 10. At the normal turn-on time (separation plus 17 minutes), the telemetry started between points 9 and 10 and continued until impact. Thus it can be concluded that the Channel-8 telemetry was on only during the time that data was received and recorded.

The battery potentials were closely reviewed. The levels prior to launch were 4.25 (35.2 volts) for the P-battery and 4.35 (36.1 volts) for the F-battery. The potentials dropped to 4.05 (33.6 volts) for both batteries during the inadvertent turn-on. At

separation plus 17 minutes, the reading for the P-Battery had returned to 4.25 (35.2 volts) and the F-Battery to 4.30 (35.7 volts). This voltage drop, 1.6 volts on the P-Battery and 2.5 volts on the F-Battery, is a normal drop for a turn-on of the Subsystem.

The battery potentials were at normal levels from separation plus 17 minutes until the turn-on of F-Channel into the warmup mode by the Clock at GMT 033:09:05:42 when the voltage level of the F-Battery dropped 1.25 volts, a 150 milliunit (Gerber Scale division) drop in telemetry, indicating that a load had been applied to the F-Battery.

The second change in battery potentials occurred at GMT 033:09:08:00 when an RTC-7 command was sent to turn on the P-Channel. At this time, the P-Battery potential dropped 0.8 volt (a 100-milliunit drop in telemetry) indicating that a load had been applied to the P-Battery.

The lowest telemetry readings for both battery potentials occurred between GMT 33:09:08 and 033:09:18, after which both telemetry points indicated that a load had been increase.

The temperatures of the batteries were also closely reviewed. During the inadvertent turn-on, a 2°F rise in temperature was noted from the temperatures before launch. The temperatures of the batteries continued to rise at a rate of 1°F an hour for the first ten hours of the flight. The temperatures remained relatively constant from that point till impact.

A search of the data recorded during the inadvertent turn-on was made to determine if an accumulator pulse had been actuated during that time. No pulse could be found. However, 30 seconds after the first RTC-7 command was received by the Spacecraft, a pulse from the 5-minute accumulator in the P-Channel was received as expected.

The frame times of the Channel-8 telemetry were also measured during this investigation (See Table 6-7 for a listing of the various frame times). There appeared to be little or no change in frame time from the pre-launch test to separation plus 17 minutes. From that time until impact, the frame time decreased slightly.

TABLE 6-7
CHANNEL-8 TELEMETRY FRAME TIME

Pad Test at Launch 30:12:17:00		Inadvertent Turn-on at 30:15:51:30		Turn-on at S+17M 30:16:36:00		Terminal Mode to Impact 33:09:02:00	
Frame No.	Frame Time (seconds)	Frame No.	Frame Time (seconds)	Frame No.	Frame Time (seconds)	Frame No.	Frame Time (seconds)
1	19.7	1	19.6	1	19.1	1	16.6
3	19.5	2	19.6	5	19.4	15	16.9
6	19.4	3	19.5	45	18.6	30	17.0
						60	17.0
						75	17.1

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Section VII

Analysis of the Possible Causes of Failure

A. General

B. Failure-Mode Analysis

C. Analysis of Failure Mechanism

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Section VII

Analysis of the Possible Causes of Failure

A. General

Immediately following the impact of the RA-6 Spacecraft on the moon, a JPL/RCA evaluation team initiated an analysis to determine why the RA-6 system failed to return expected photographic information of the lunar surface. This joint investigation was carried out at JPL through February 14, 1964, following which time, the analysis was continued at AED by the RCA personnel.

The initial investigation at JPL centered on a single failure mode that could have occurred during the terminal phase of the mission and could be correlated with the telemetry information obtained. As part of this investigation, a thorough search of the tapes recorded during the terminal phase of the mission was performed, using the special techniques described in Appendix E of this report. These techniques would have enabled the detection of the presence of any signal emanating from the TV Subsystem Transmitters, including that normally obtained during Subsystem warmup, or even the spike that could be expected during a transmitter-chain failure. Since the tapes were completely devoid of any signal for either channel, it became clearly apparent that the failure occurred prior to the terminal phase of the RA-6 mission.

The Channel-8 telemetry received indicated that the TV Subsystem operated as expected from Agena-separation plus 17 (S+17) minutes until the turn-on of the F-Channel by Clock command. There was no significant drain on either the P- or F-Channel battery; the temperatures of the batteries stabilized after S+10 hours at +20 degrees C above nominal, but well within the design limits of the Subsystem. Any failure occurring during the cruise mode, which could have caused the loss of both transmission channels, would most probably have been detected on the combined RCA/JPL telemetry.

With the limited information available for evaluation, the analysis was concentrated on the period of booster-engine separation, at which time four inadvertent frames of Channel-8 telemetry were received. The analysis first attempted to determine the most probable failure mode that could have occurred during this period, and then sought to isolate the mechanism that could have caused this failure mode.

B. Failure-Mode Analysis

Each group of assemblies within the TV Subsystem was analyzed to determine whether a single failure within that group and isolated within that group could have caused the Subsystem to fail. These analyses are contained in Appendix F. Study of these investigations indicated that the two most probable failure modes had to occur early in the RA-6 mission.

One potential area of failure that was studied was the possibility of a loss of connection between the Four-Port Hybrid Ring on the TV Subsystem and Case 2 on the JPL Bus. This failure would satisfactorily explain the complete loss of RF. However, studies at JPL indicated that a break in the connection would have caused a change in the JPL signal. For such a signal change to occur and not be noticed, would require that it occur very early in the mission. If the connection was made correctly at the Explosive-Safe Area (ESA), the environment required to cause a complete loss of RF would have to be more severe than that apparently encountered during the RA-6 mission. It should also be noted that this failure mode could not, of itself, cause the anomalous turn-on of the Channel-8 telemetry at booster-engine separation, and a second, unrelated failure would have to be advanced to explain this malfunction.

The one failure mode that appears to explain the complete lack of RF during the terminal mode and the anomalous turn-on of Channel-8 telemetry during the launch phase, and is supported by all of the data received, is the inadvertent turn-on of the TV Subsystem during booster-engine separation. If the TV Subsystem went into warmup or full power at this time, the partial-pressure environment inside the Agena-shroud would produce RF arcing. The probability of arcing in this type of environment is discussed in detail in Appendix C of the Block III Ranger TV Subsystem Twelfth Bimonthly Progress Report (AED R-2039, issued on August 1, 1963) and is substantiated by the failure that occurred in June 1962, when the PTM turned on in a partial-pressure environment. The PTM failure was reported in detail in the Monthly Summary of Failures Report No. 4 (AED-1533, issued August 15, 1962) and is indicative of the extent of damage possible under the conditions prevalent at booster-engine separation. The fact that a partial-pressure condition existed at this time can be substantiated by the Lockheed data on the Agena-Shroud pressures, which is included as Appendix G to this report.

It could be inferred, therefore, that if turn-on of the TV Subsystem did occur at booster-engine separation, severe arcing would have resulted, causing the destruction of a sufficient number of critical components to prevent the transmission of any RF signal during the terminal mode. The only datum which mitigates the probability of this failure is the absence of a 30-second pulse on point 11 of the Channel-8 telemetry received for 67 seconds during booster-engine separation. In normal operation on the RA-6 Spacecraft, the P-Channel Camera Sequencer generates a pulse which is displayed on point 11 of the Channel-8 telemetry approximately 30 seconds after the warm-up

command is initiated. The facts indicate that the P-Channel Sequencer was available for producing the 30-second pulse during the anomalous turn-on, since this pulse did appear during the terminal mode, but that it was prevented from doing so by the secondary effects produced (see Appendix F) by the high-voltage arcing in a partial pressure.

By postulating the existence of high-voltage arcing in the Camera Electronics and the Transmitter Power Supplies, an excessive load on the High-Current Voltage Regulator (HCVR) would have occurred which could have reduced its output voltage to less than -20 volts, and probably lower than -5 volts. Input voltages at this level to the 5-minute Accumulator would prevent the Accumulator from starting. If the Accumulator had started counting prior to arcing, a reduction of voltage to less than -5 volts for 10 milliseconds would enable the Accumulator to reset to zero. Since the 30-second pulse had only two opportunities to occur during the 67-second period of telemetry reception, its absence is not too incredulous if high-voltage arcing existed in either the Camera Electronics or the Transmitter Power Supplies. Its failure to appear in the second telemetry frame is understandable, since the heavy battery drain and telemetry noise indicate severe arcing at that time. The failure of the 30-second pulse to appear in the third frame requires only that the Accumulator be reset at least once within 30 seconds prior to the reception of point 11 in the third frame of the Channel-8 telemetry. The reception of Channel-8 telemetry stopped prior to point 11 of the fourth frame.

The drop in output voltage from the HCVR can be substantiated by the presence of high-voltage arcing in the Cameras; the Cameras for each channel are powered by their respective HCVR's through a 3-ampere exothermic fuse. High-voltage arcing in the Cameras causes the HCVR's to limit their current production to 3.6 amperes at zero volt. If this arcing occurs simultaneously in either two F-Channel Cameras or in a minimum of two P-Channel Cameras, the 3.6-ampere current at zero volt from the HCVR would be divided such that only 1.8 amperes will be provided to each of the two Cameras, thus preventing the destruction of the 3-ampere fuse. This current starvation would then cause the Cameras to cease arcing, and the output voltage of the HCVR would rise. When the voltage rises sufficiently high, arcing will resume. This motor-boating effect will continue until the components fail or until the Subsystem is transported beyond the critical-pressure environment. At the same time, a similar effect is produced in the Transmitter Power Supplies on the unregulated lines, which are not current limited. The high-voltage arcing results in a current drain which causes the d-c input to the d-c converter to stop the converter from oscillating. The loss of the a-c component for the high-voltage transformer, as a result of the stoppage of oscillation, causes the arcing to stop. Removal of this shorting effect permits the choppers to resume oscillation, thereby again producing the high-voltage arcing.

The Cameras and Transmitter Power Supplies as a result of high-voltage arcing were certainly noise generators, pulling as much as 60 amperes through the ground planes. These currents could be the source of the noise on both the baseline reference and the sampled data points in the Channel-8 telemetry received. The arcing could be the

source of the base-line drifts which were observed during the initial 31 seconds of the spurious Channel-8 turn-on (See Appendix H). Destruction of components in the Transmitter Power Supplies after the 31 seconds could have been the reason for the abrupt reduction of the noise on the telemetry readout.

C. Analysis of Failure Mechanism

The TV Subsystem was analyzed to determine possible occurrences that could inadvertently energize the Subsystem into the warm-up mode of operation and turn on the Channel-8 telemetry at booster-engine separation. By design, the SCR's in the High-Voltage Current Regulators must be gated-on to supply regulated and unregulated voltages to the Subsystem to put it into the warm-up mode of operation. In the RA-6 Spacecraft, three separate mechanisms were available to provide SCR turn-on. These were:

- Energizing of relay K2 in the DCU;
- Output command from the Electronic Clock; and
- Stepping of the Command Switch to the warmup position.

The energizing of relay K2 in the DCU would cause the SCR's in both the F- and P-Channel HCVR's to fire by tying the SCR's to ground through 220 ohms, thereby putting both channels into the warmup mode of operation. If the Subsystem were to go into the warmup mode because of the closure of the K2 relay in the DCU, then points 1 and 2 would not have been present in the Channel-8 telemetry received. Points 1 and 2 are the input and output of the LCVR and have no connections whatsoever with the K2 relay, so, therefore, are not affected by its closure.

An inadvertent output command from the Electronic Clock would turn on the F-Channel, but not the P-Channel, into the warmup mode by tying the gate of the SCR in the F-Channel HCVR to ground through 220 ohms. The P-Channel chain, therefore, would have been available for normal operation during the terminal mode of operation. Since this was not the case, it can be assumed that the inadvertent turn-on of the TV Subsystem was not caused by an incorrect output command from the Electronic Clock.

There is also a possibility that the SCR gates could have been energized directly by an inadvertent shorting-to-ground of pins 36 and 37 of connector A34J2. Pins 36 and 37 carry the SCR gates for the F-Channel and P-Channel, respectively. The connector itself is used mainly as a ground bus and has large (two different) solder busses joining the ground pins together. Vibration may have caused the solder busses to have come in contact with pins 36 and 37, thereby producing a short-to-ground and a firing of the

SCR's, causing the Subsystem to go into the warm-up mode of operation. Had this possible but improbable situation occurred, points 1 and 2 of the telemetry received during the inadvertent turn-on of Channel-8 would not have been present, since the LCVR would not be activated by this turn-on.

Another possibility for the inadvertent turn-on of the TV Subsystem would be the gating of the SCR's in the High-Current Voltage Regulators by the presence of transients in the cathode or anode circuits. It has been indicated that SCR's will fire when a change in the cathode-anode voltage occurs at a rate of approximately 25 volts per microsecond. In the TV Subsystem, this would require a change in battery voltage from 0 to 35 volts in approximately 1.75 to 2 microseconds. This voltage change across the cathode of the SCR could induce a turn-on mode. To carry this a step further, it has been stated that if the Transmitter Power Supplies were energized in the partial-pressure environment, severe arcing would result. This arcing could induce transients via series inductance on the primary side to back bias the SCR on the anode side and cause the SCR to turn off by reducing current flow to zero; the values for turn-off transient need be only equal to the voltage drop across the SCR. Thus, a transient spike greater than one volt for 20 microseconds could turn off the SCR, and it would remain off if the blocking voltage is applied at a rate of 11 volts per microsecond or less. The inadvertent turn-on possibility assumes that the voltage spike has sufficient power to overcome the load currents. If a transient had caused the turn-on of the Subsystem into the warmup mode, again, points 1 and 2 of the received Channel-8 telemetry would not have been present.

Therefore, the only mechanism which satisfies all of the data received is an inadvertent stepping of the Command Switch. Stepping the Command Switch to the "Warm-Up" position during the critical-pressure environment would cause the SCR's in both HCVR's to fire by grounding their gates through the center tap of the switch, thereby placing both the P- and F-Channels of the Subsystem into the warmup mode. This inadvertent stepping would also initiate operation of the LCVR, thereby providing an indication on points 1 and 2 of the Channel-8 telemetry. Subsequent stepping of the Command Switch through "Emergency-On", "Emergency-Off", and back to the "Zero" position would account for the Subsystem turn-off.

Upon accepting the stepping of the Command Switch as the most probable cause of the inadvertent Subsystem turn-on, the investigation was concentrated on determining what specifically caused the inadvertent actuation of the Command Switch. The sensitivity of the Command-Switch relay driver is a possible cause of the actuation. A high-impedance short, less than 30 kilohms, between the RTC-7 or RTC-7 Simulate input leads and ground would cause the switch to step. An increase in the impedance of the short to 130 kilohms would seat the switch and re-enable the driver circuit. A subsequent reduction in the impedance to the 40-kilohm level would cause the switch to step again. If this situation was repeated four or a multiple of four times, and then the short cleared itself, the Command Switch would have returned to "Zero", and be in position to accept the actual RTC-7 command. Since this command was sent and

received during the terminal phase of the mission and the P-Channel Accumulator pulse was received at the correct time, it must be assumed that the Command Switch was in the zero position and the fault had been cleared when the anomalous Channel-8 telemetry turned-off.

Another possible means of actuating of the Command Switch is the actual receipt of a series of RTC-7 commands from the JPL Bus, due, perhaps, to mechanical chatter or electrical short of the RTC-7 relay. Again, it would require four or a multiple of four actuations of this relay to return the Command Switch to the zero position and turn off the HCVR's and the Channel-8 telemetry.

A short to ground on RTC-7 Simulate anywhere along its route would also step the switch. A short, open, short, situation is again required four times, to step the Command Switch through a complete cycle back to the zero position. RTC-7 Simulate is an extension of the real RTC-7 and goes into the umbilical connector.

One possible means of stepping the Command Switch has been advanced which appears to have a high probability of occurrence; that is an arc from the cover of the umbilical connector to the RTC-7 simulate command line could cause the command switch to step into warm-up. One theory upon which this failure mechanism is based considers the development of an equipotential charge on the entire surface of the launch vehicle and spacecraft. This static charge may be caused by the passage of the engine fuels through the rocket engine feed lines.[1] As long as nothing disturbs this charge, it will continue to increase while the flow of fuel continues.

During the Ranger Mission, however, a change in the configuration of the launch vehicle does take place which could drastically disrupt this equipotential condition. At the time of Booster-Engine separation the booster engine bracket moves into the plume of the sustainer rocket. This plume contains a great number of free electrons and ions and therefore causes the development of a charge on the booster-engine bracket which is very negative in relation to the skin of the missile. By capacitive action this relatively negative charge causes the base of the vehicle to become positive with respect to the equipotential charge that existed on the entire vehicle prior to booster-engine separation. Since the total charge on that portion of the vehicle that remains intact after booster-engine separation would remain constant during this very short period of time, the upper end of the vehicle would become negative with respect to the original equipotential charge. This configuration is shown diagramatically in figure 7-1.

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[1] Frictional Electricity in Missile Systems by P. Molmud of Space Technology Laboratories, Inc., Los Angeles, California

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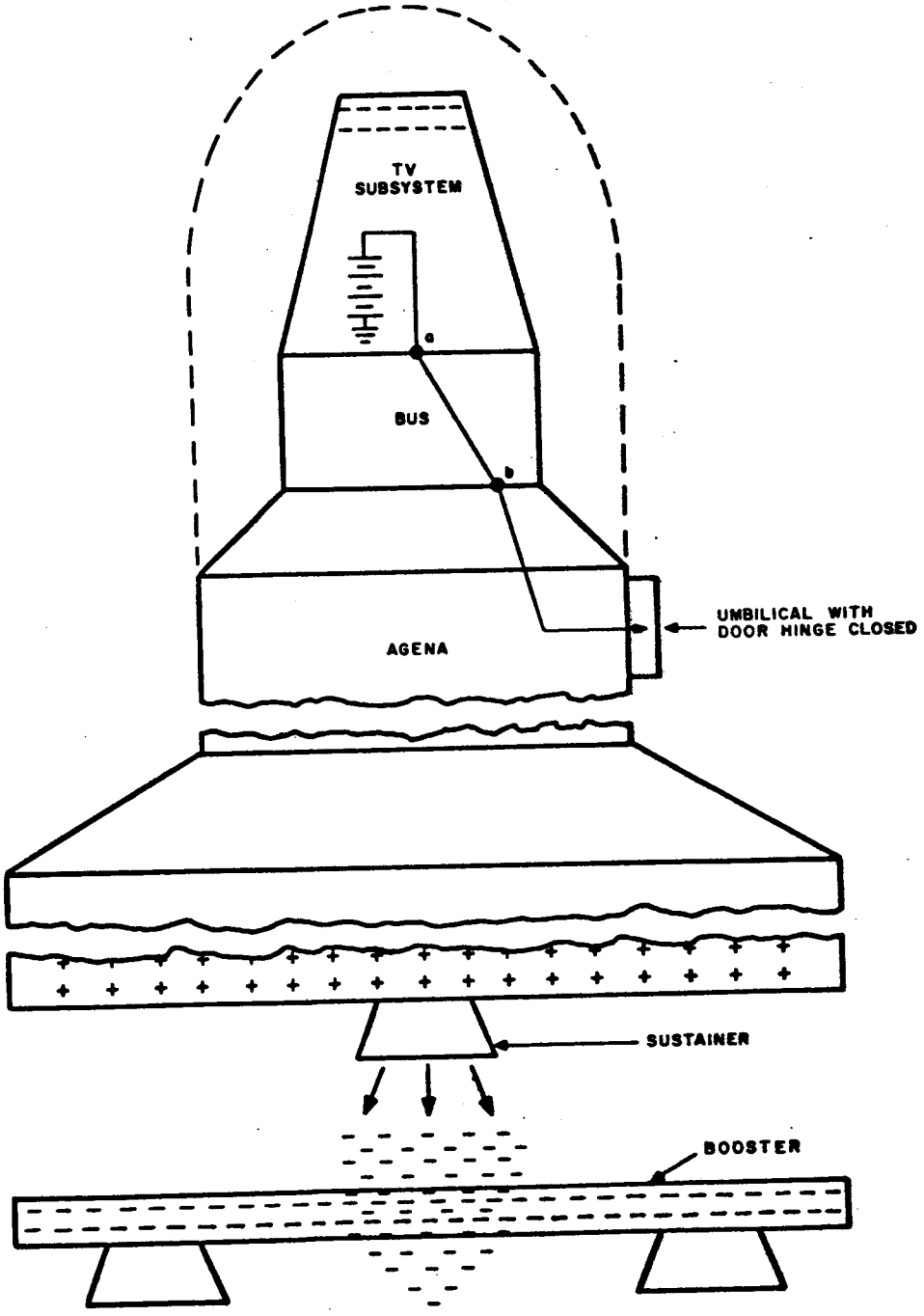

Figure 7-1. Missile configuration at Booster Jettison

The redistribution of charge thus described would cause a considerable change in the effective charge at the umbilical connector on the Agena skin. Since there is no intentional electrical connection between the TV Subsystem ground and the case of the umbilical connector and since the only electrical connection that apparently does exist is through the bolts connecting the TV Subsystem to the Bus, it is possible to hypothesize the existence of a potential difference between the TV Subsystem ground and the case of the umbilical connector. If this potential difference was great enough, and if a partial-pressure condition existed within the umbilical connector, then it would be possible to postulate the existence of an arcing condition inside this connector. If this arcing did take place between pin 4X, which was the RTC-7 simulate line, and the umbilical-connector cover then it is quite possible that a signal would have been sent to the command switch on the TV Subsystem to step into warmup. Figure 7-2 shows the location of pin 4X in the umbilical connector and the relation between this pin and the latch on the umbilical-connector cover. Considering the fact that the RTC-7 simulate pin inside this umbilical disconnect plug is in close proximity to the latching mechanism of the door (approx. 6.3 mm) and the connector is male with rounded pins (See figure 7-2, b & c), it is not unfeasible that arcing would have existed from this latch to the pin if the difference of potential was approximately 300 volts at an altitude of 130,000 ft.[2] (See figure C-3.) From the same reference, if this voltage were present to an altitude of 200,000 ft., it is probable that arcing would have continued throughout this altitude change.

At the time of the anomalous receipt of Channel-8 Telemetry (GMT 030:15:51:29) the vehicle was at an altitude of 172,000 feet and an approximate pressure of 8×10^{-1} mm of Hg. A series of experiments were performed in a vacuum jar with a series of potential differences existent between pin 4X and the cover of the umbilical connector. As shown in Appendix J, which is a description of these tests, arcing took place at a potential of +350 volts applied to the cover plate with the Command Switch at zero volts and a pressure of approximately 1mm of Hg (Equivalent to an altitude of 150,000 ft). The wafer switch stepped into the warmup position. This step was caused by an arc between the umbilical connector cover latch and pin 4X (RTC-7 Simulate). The vacuum jar continued to be evacuated until the pressure level reached approximately 1×10^{-1} mm of Hg (equivalent to an altitude of 250,000 ft). Arcing was seen throughout this pressure change and the wafer switch in the Command Switch stepped through "Emergency-On", "Emergency-Off", and back to "Zero" where it stopped.

The investigation of this potential failure mechanism will continue and further tests will be performed utilizing the umbilical connector and the RA-6 command and control circuitry, but it is felt that the tests already performed prove that such a failure mechanism can be duplicated and therefore is highly possible. Since no other method of actuating the Command Switch has been advanced with as high a probability of occurrence, arcing in the umbilical connector must be considered a prime suspect for the cause of the RA-6 failure.

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[2] High Altitude Flash-over and Corona Problems by: W. T. Starr of General Electric Co., Electrical & Electronic Materials Div., Schenectady, New York

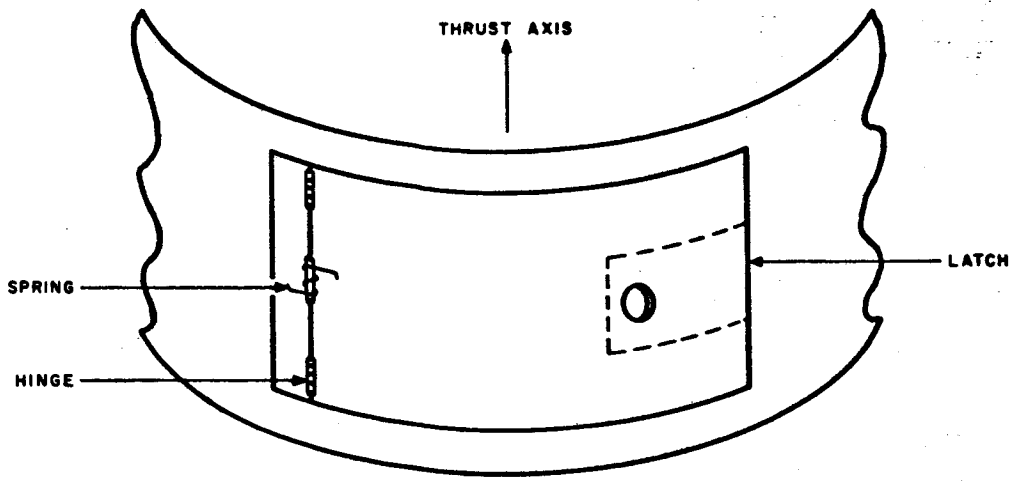

Figure 7-2a. Umbilical plug cover plate on Agena

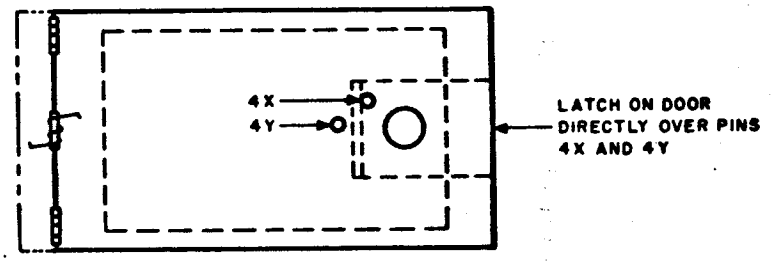

Figure 7-2b. Umbilical plug showing 4x and 4y under the door latch

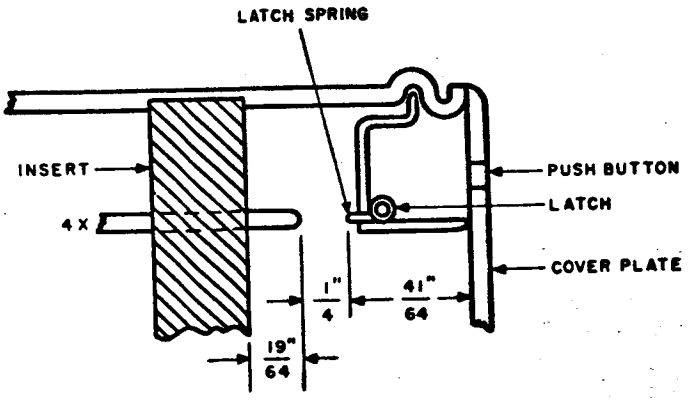

Figure 7-2c. Approximate spacing between RTC-7 simulate pin 4 and latch spring

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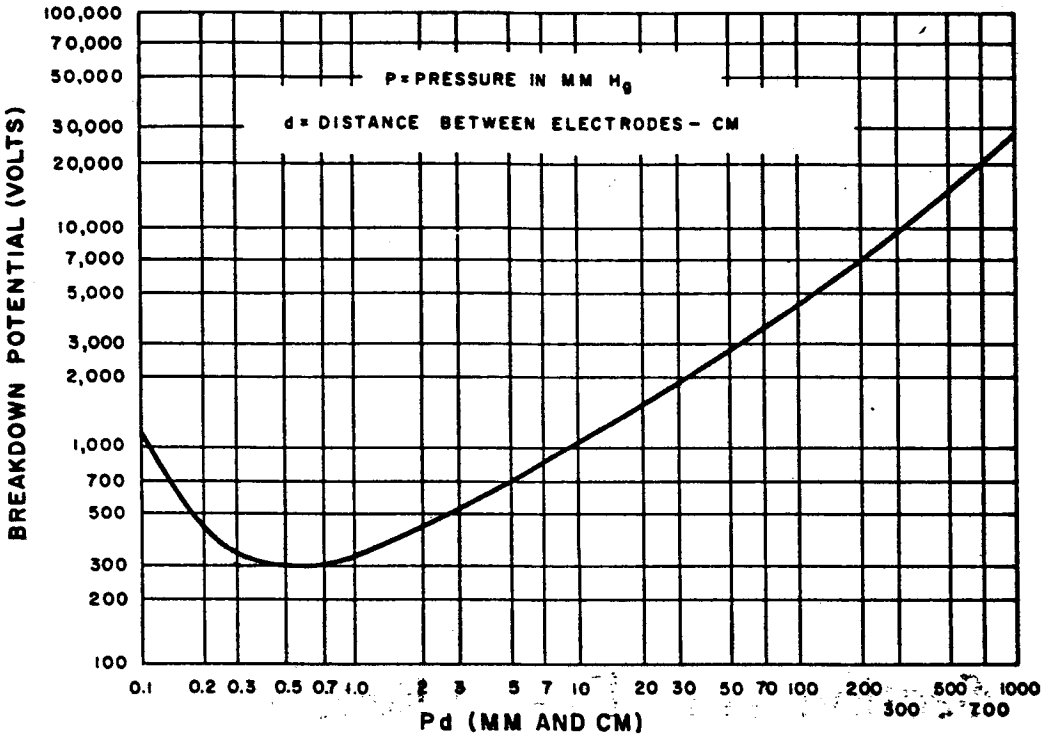

Figure 7-3. Characteristics of breakdown potential

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Section VIII Design Report

A. General

B. Command and Control Circuitry

C. Relay Circuitry Study for Replacing Silicon Control Rectifier

D. Design Modifications to Telemetry Circuitry

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Section VIII
Design Report

A. General

Based on a comprehensive design study, several modifications have been incorporated into the Ranger TV Subsystem to provide a greatly increased probability of success for the RA-7 mission. The design study was initiated immediately following the unsuccessful RA-6 mission and was performed concurrent with and in accordance with the results of the RA-6 failure investigation. The design study was concentrated on major modifications in two areas of the Subsystem, with some additional portions of the Subsystem considered for design refinements.

The areas in which major design modifications occur are the Command and Control circuitry and the 15- and 90-point telemetry. Because the inadvertent stepping of the Command Switch was held to be the most probable cause of turn-on of the RA-6 TV Subsystem into the warmup mode, and because several other portions of the command and control circuitry were seriously questioned by numbers of the JPL/RCA investigation team, it was decided to simplify the entire Command and Control circuitry and provide more reliable methods for turn-on and turn-off of the Subsystem.

Several design modifications were made to the telemetry circuitry to ensure that sufficient monitoring information on the Subsystem is received during the early phases of the RA-7 mission and that the information received provides a better indication of the operation of the Subsystem.

Since many of the Subsystem components were opened for inspection during the failure analysis, a number of minor modifications were made for purposes of design improvement. These modifications will be discussed later in this section of the report.

All of the modifications incorporated into the TV Subsystem for the RA-7 Spacecraft have undergone formal design review by RCA. JPL personnel have participated in these reviews and all design changes have been approved by cognizant JPL personnel.

The TV Subsystem with the new design modifications incorporated is shown in Figure 8-1.

B. Command and Control Circuitry

Since the most probable cause of the inadvertent turn-on of the RA-6 TV Subsystem was a stepping of the Command Switch in the Command and Control circuitry, major design modifications were undertaken to prevent the re-occurrence of this situation on the RA-7 mission. Prior to the initiation of the new design, the RA-6 Command and Control circuit design was examined in the light of the RA-6 failure. After the major disadvantages were determined, a new design was formulated which greatly increased the reliability of the Subsystem.

In general, the new design consisted of a complete simplification of the Command and Control circuitry. This was achieved through the removal of the Command Switch and a more judicious use of commands. A detailed description of the areas in which design modifications were undertaken in the Command and Control circuitry are described in the following paragraphs.

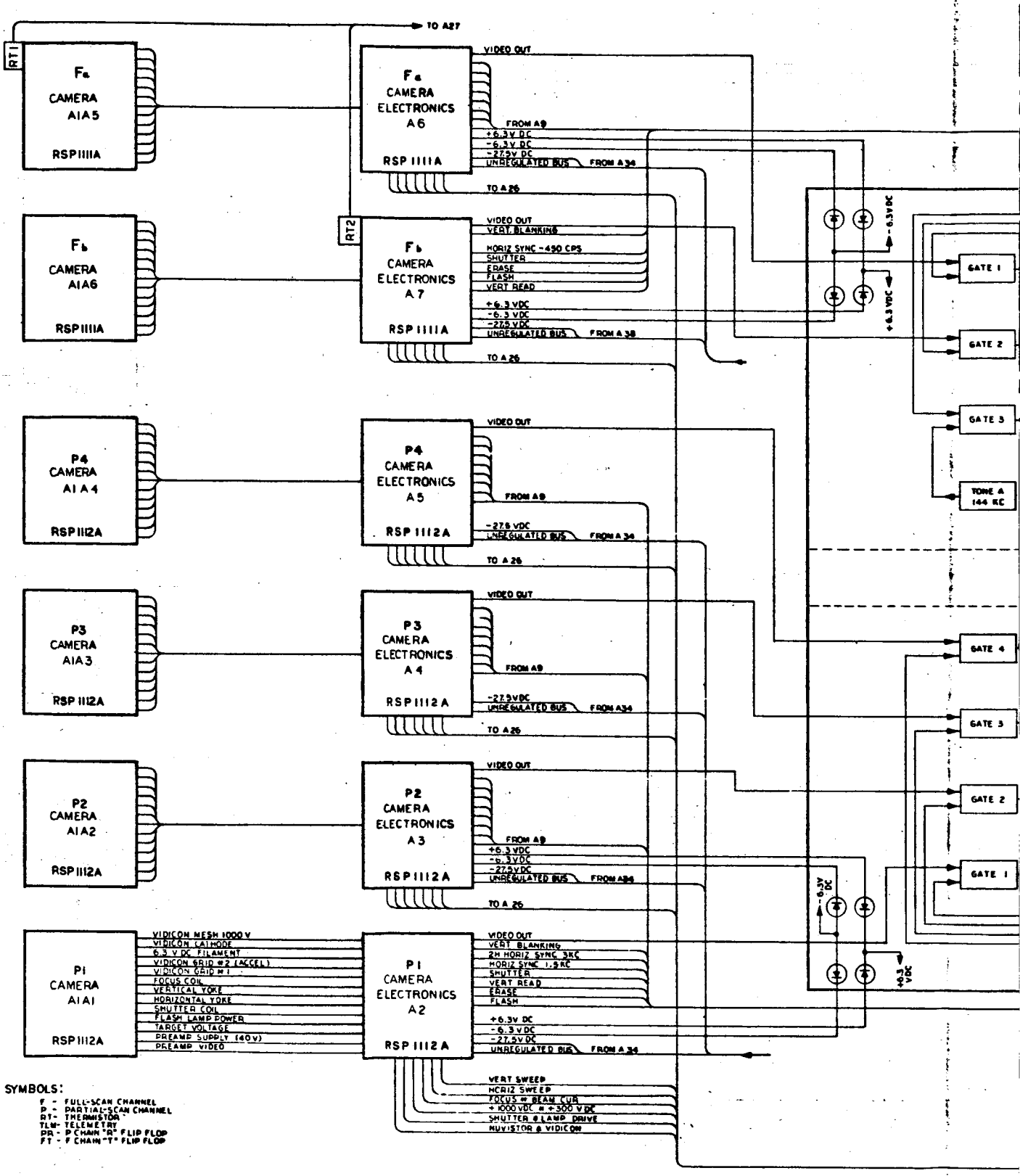
1. *Analysis of the RA-6 Control Design*

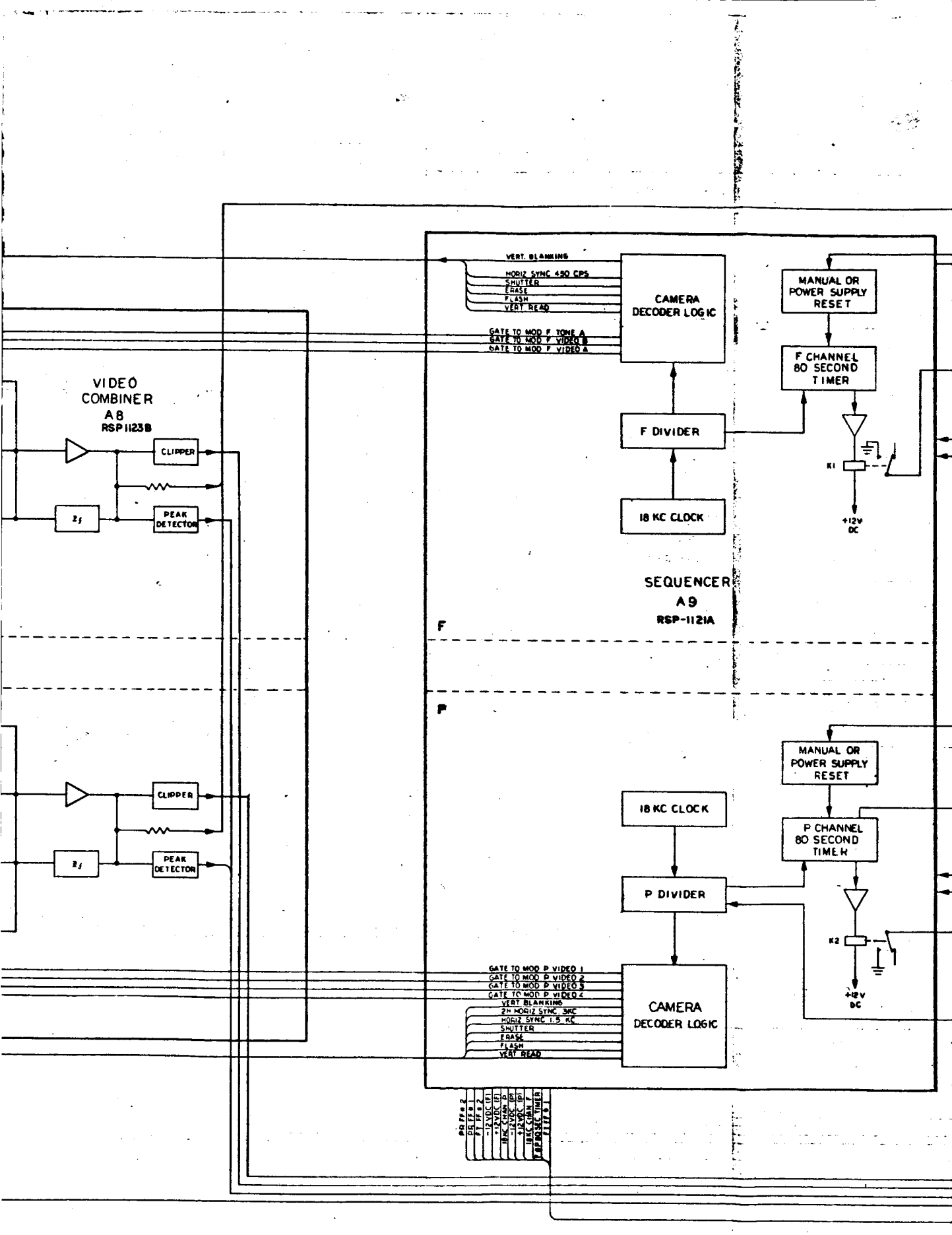
During the failure investigation of the RA-6 mission, an analysis was made of the Command and Control circuitry to determine possible areas where design modifications would increase the probability of success of the RA-7 Spacecraft. A summary of this analysis is given in Table 8-1, and the criteria for modifications as realized in the new design are also presented.

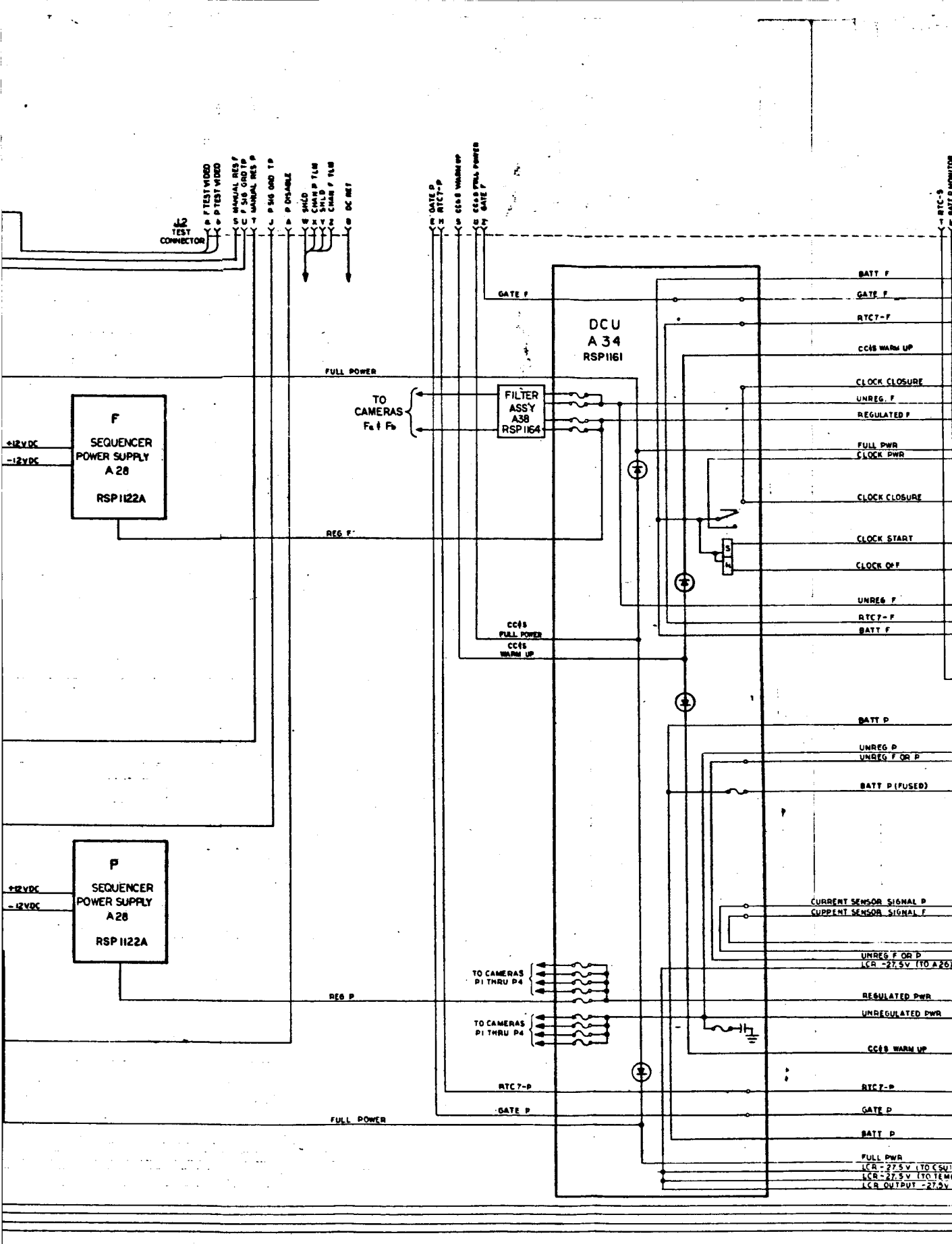
2. *Modifications to the Command and Control Circuitry*

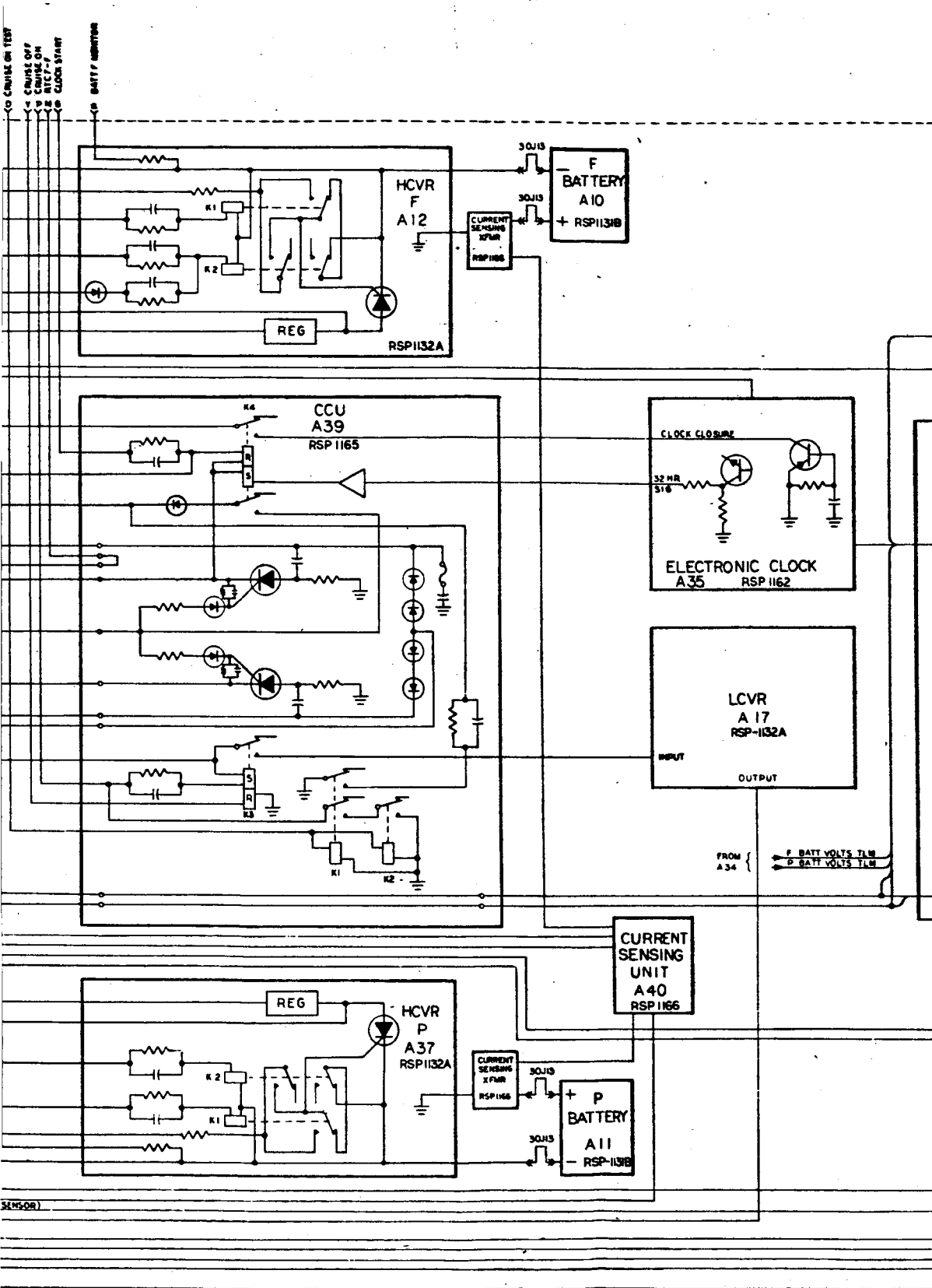
Following the analysis of the potential problem areas in the RA-6 Command and Control circuitry, the command philosophy and logic were revised in such a manner that potential problem areas were at least minimized if not completely eliminated. Circuits were then developed to meet the new philosophical and logical requirements. These circuits were developed with the following objectives in mind.

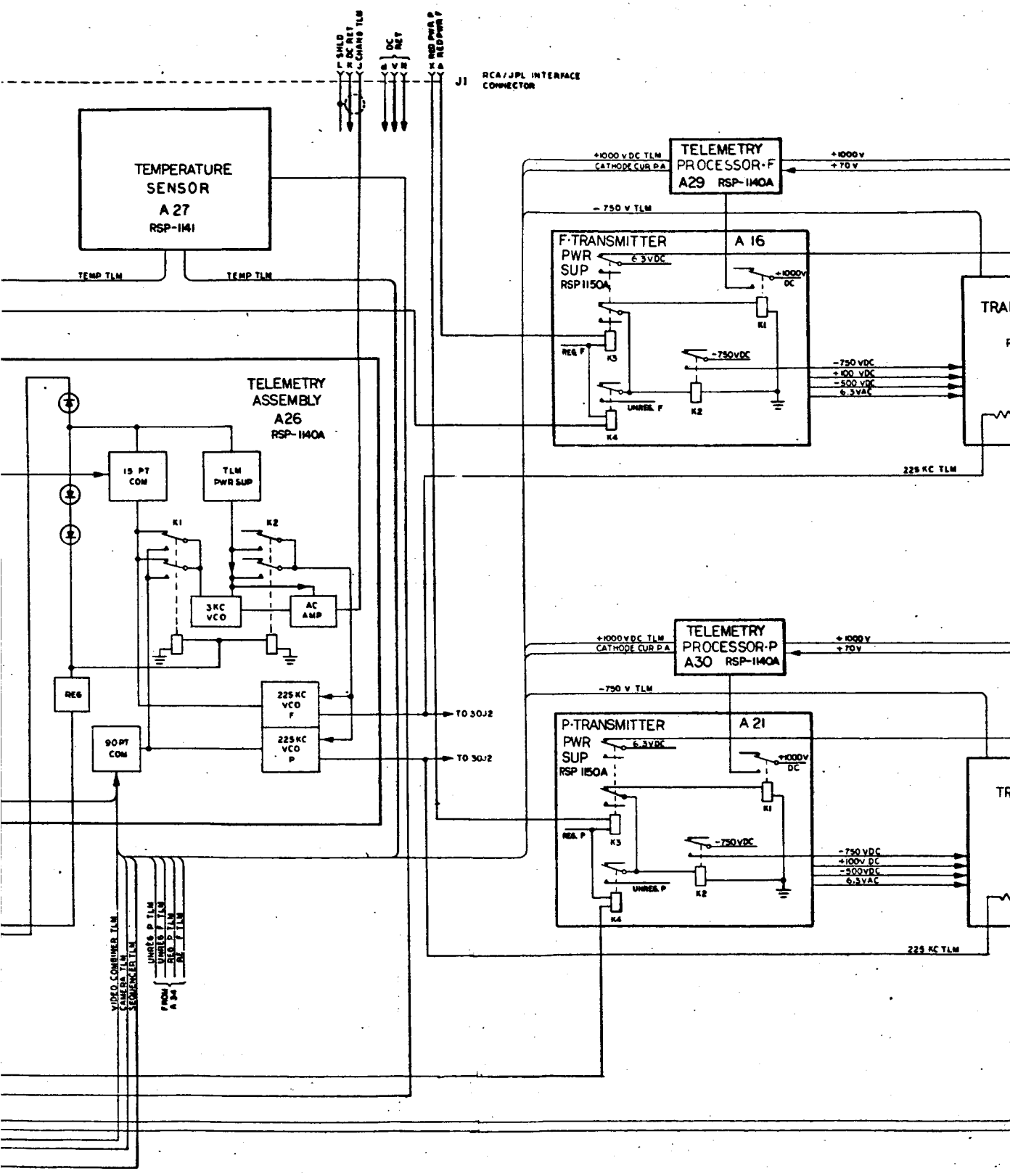
- Prevent premature turn-on of the Subsystem;
- Permit immediate Subsystem turn-off, if it becomes necessary;
- Retain the good features of the former Command and Control circuit; and
- Utilize existing hardware wherever possible.


TO A27
RT1
Fa
CAMERA
A1A5
RSP1111A
Fa
CAMERA
ELECTRONICS
A6
RSP 1111A
VIDEO OUT
FROM A9
+6.3V DC
-6.3V DC
-27.5V DC
UNREGULATED BUS
FROM A34
TO A26
Fb
CAMERA
A1A6
RSP1111A
RT2
Fb
CAMERA
ELECTRONICS
A7
RSP 1111A
VIDEO OUT
VERT BLANKING
HORIZ SYNC -450 CPS
SHUTTER
ERASE
FLASH
VERT READ
+6.3 VDC
-6.3 VDC
-27.5 VDC
UNREGULATED BUS
FROM A38
TO A26
P4
CAMERA
A1A4
RSP1112A
P4
CAMERA
ELECTRONICS
A5
RSP 1112A
VIDEO OUT
FROM A9
-27.5 VDC
UNREGULATED BUS
FROM A34
TO A26
P3
CAMERA
A1A3
RSP 1112A
P3
CAMERA
ELECTRONICS
A4
RSP 1112A
VIDEO OUT
FROM A9
-27.5VDC
UNREGULATED BUS
FROM A34
TO A26
P2
CAMERA
A1A2
RSP1112A
P2
CAMERA
ELECTRONICS
A3
RSP 1112A
VIDEO OUT
FROM A9
+6.3 VDC
-6.3 VDC
-27.5 VDC
UNREGULATED BUS
FROM A34
TO A26
P1
CAMERA
A1A1
RSP1112A
VIDICON MESH 1000 V
VIDICON CATHODE
6.3 V DC FILAMENT
VIDICON GRID #2 (ACCEL)
VIDICON GRID #1
FOCUS COIL
VERTICAL YOKE
HORIZONTAL YOKE
SHUTTER COIL
FLASH LAMP POWER
TARGET VOLTAGE
PREAMP SUPPLY (40V)
PREAMP VIDEO
P1
CAMERA
ELECTRONICS
A2
RSP 1112A
VIDEO OUT
VERT BLANKING
2H HORIZ SYNC 3KC
HORIZ SYNC 1.5KC
SHUTTER
VERT READ
ERASE
FLASH
+6.3V DC
-6.3 VDC
-27.5V DC
UNREGULATED BUS
FROM A34
VERT SWEEP
HORIZ SWEEP
FOCUS & BEAM CUR
+1000 VDC & +300 V DC
SHUTTER & LAMP DRIVE
MUVISTOR & VIDICON
-6.3V DC
+6.3V DC
-6.3V DC
+6.3V DC
GATE 1
GATE 2
GATE 3
TONE A
144 KC
GATE 4
GATE 3
GATE 2
GATE 1
SYMBOLS:
F - FULL-SCAN CHANNEL
P - PARTIAL-SCAN CHANNEL
RT- THERMISTOR
TLM- TELEMETRY
PR - P CHAIN "R" FLIP FLOP
FT - F CHAIN "T" FLIP FLOP


VERT. BLANKING
HORIZ SYNC 450 CPS
SHUTTER
ERASE
FLASH
VERT READ
GATE TO MOD F TONE A
GATE TO MOD F VIDEO B
GATE TO MOD F VIDEO A
CAMERA DECODER LOGIC
MANUAL OR POWER SUPPLY RESET
F CHANNEL 80 SECOND TIMER
F DIVIDER
18 KC CLOCK
K1
+12V DC
VIDEO COMBINER A8 RSP1123B
CLIPPER
PEAK DETECTOR
SEQUENCER A9 RSP-1121A
F
P
MANUAL OR POWER SUPPLY RESET
18 KC CLOCK
P CHANNEL 80 SECOND TIMER
P DIVIDER
K2
+12V DC
GATE TO MOD P VIDEO 1
GATE TO MOD P VIDEO 2
GATE TO MOD P VIDEO 3
GATE TO MOD P VIDEO 4
VERT BLANKING
2H HORIZ SYNC 3KC
HORIZ SYNC 1.5 KC
SHUTTER
ERASE
FLASH
VERT READ
CAMERA DECODER LOGIC


TEST CONNECTOR
F TEST VIDEO
P TEST VIDEO
MANUAL RES F
F SIG GND TP
MANUAL RES P
P SIG GND TP
P DISABLE
SHLD
CHAN P TLM
SHLD
CHAN F TLM
DC REF
GATE P
RTC7-P
CCĆS WARM UP
CCĆS FULL POWER
GATE F
RTC-S
DCU
A 34
RSP1161
GATE F
FULL POWER
TO CAMERAS Fa & Fb
FILTER ASSY A38 RSP1164
F
SEQUENCER POWER SUPPLY A 28
RSP1122A
+12VDC
-12VDC
REG F
P
SEQUENCER POWER SUPPLY A 28
RSP1122A
+12VDC
-12VDC
REG P
FULL POWER
TO CAMERAS P1 THRU P4
TO CAMERAS P1 THRU P4
RTC7-P
GATE P
BATT F
GATE F
RTC7-F
CCĆS WARM UP
CLOCK CLOSURE
UNREG. F
REGULATED F
FULL PWR CLOCK PWR
CLOCK CLOSURE
CLOCK START
CLOCK OFF
UNREG F
RTC7-F
BATT F
CCĆS FULL POWER
CCĆS WARM UP
BATT P
UNREG P
UNREG F OR P
BATT P (FUSED)
CURRENT SENSOR SIGNAL P
CURRENT SENSOR SIGNAL F
UNREG F OR P
LCR -27.5V (TO A26)
REGULATED PWR
UNREGULATED PWR
CCĆS WARM UP
RTC7-P
GATE P
BATT P
FULL PWR
LCR -27.5V (TO CSU)
LCR -27.5V (TO TEM
LCR OUTPUT -27.5V


TO CRUISE ON TEST
CRUISE OFF
CRUISE ON
RTCT-F
CLOCK START
BATT MONITOR
HCVR
F
A12
K1
K2
REG
RSP1132A
CURRENT SENSING XFMR
RSP1166
30J13
F
BATTERY
A10
+ RSP1131B
CCU
A39
RSP1165
K4
K3
CLOCK CLOSURE
32 HR
S16
ELECTRONIC CLOCK
A35 RSP1162
LCVR
A17
RSP-1132A
INPUT
OUTPUT
FROM A34
F BATT VOLTS TLM
P BATT VOLTS TLM
CURRENT SENSING UNIT
A40
RSP1166
HCVR
P
A37
RSP1132A
P
BATTERY
A11
- RSP-1131B
SENSOR)


J1
RCA/JPL INTERFACE CONNECTOR
TEMPERATURE SENSOR A 27 RSP-1141
TEMP TLM
TEMP TLM
TELEMETRY ASSEMBLY A26 RSP-1140A
15 PT COM
TLM PWR SUP
K1
K2
3KC VCO
AC AMP
REG
90 PT COM
225 KC VCO F
225 KC VCO P
TO 30J2
TO 30J2
+1000 V DC TLM
CATHODE CUR P A
TELEMETRY PROCESSOR-F A29 RSP-1140A
+1000 V
+70 V
-750 V TLM
F-TRANSMITTER PWR SUP RSP 1150A
A 16
6.3 VDC
+1000V DC
K1
K3
K2
K4
REG F
UNREG F
-750 VDC
-750 VDC
+100 VDC
-500 VDC
6.3 VAC
225 KC TLM
+1000 V DC TLM
CATHODE CUR P A
TELEMETRY PROCESSOR-P A30 RSP-1140A
+1000 V
+70 V
-750 V TLM
P-TRANSMITTER PWR SUP RSP 1150A
A 21
6.3 VDC
+1000V DC
K1
K3
K2
K4
REG P
UNREG P
-750 VDC
-750 VDC
+100 VDC
-500 VDC
6.3 VAC
225 KC TLM
VIDEO COMBINER TLM
CAMERA TLM
SEQUENCER TLM
FROM A 34
UNREG P TLM
UNREG F TLM
REG P TLM
REG F TLM

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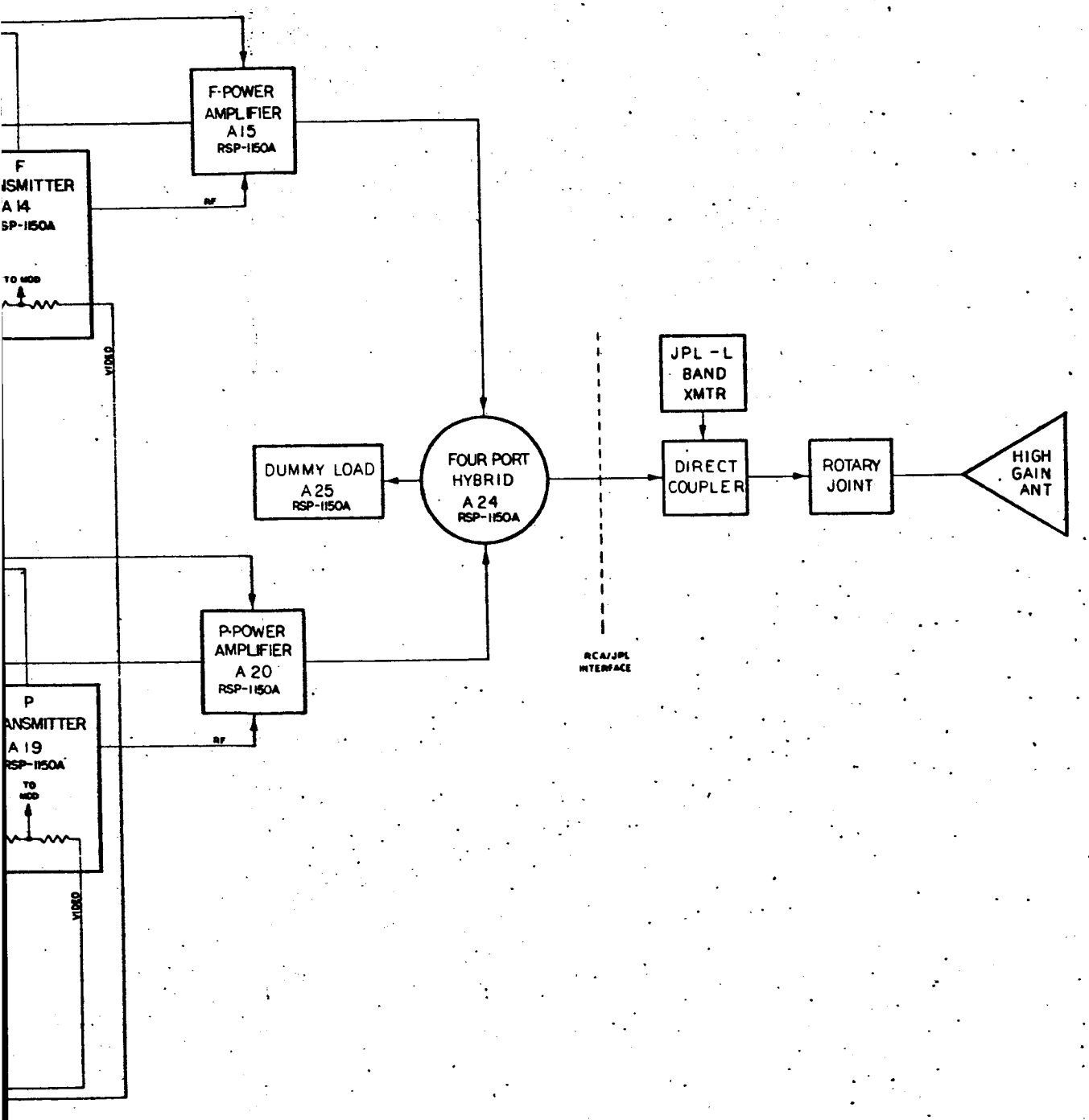

Figure 8-1. Modified Ranger TV Subsystem, logic diagram

104-6

TABLE 8-1

MAJOR DISADVANTAGES OF RA-6 COMMAND AND CONTROL CIRCUITRY

	Function	Disadvantages
A. SCR Desensitizing Circuitry		1. Circuitry Overly Sensitive a. No high- or low-frequency protection b. No continuous closure protection 2. Physically Removed from SCR's; Long Gate Leads a. Possible sensitivity to high-frequency noise
B. Clock-Start Command	Turns on clock at S+0 by energizing K1 relay in DCU	1. Clock and K1 relay control are operated from F-battery, while disabling function is operated from P-battery. Failure in either battery circuit prevents completion of entire function
C. CC&S Warm-up Command	Initiates warm-up mode by energizing K2 relay in DCU, grounding the two SCR's through 220-ohm resistance. Continuous presence inhibits turn-off of either channel	1. Momentary TV-2 closure turns on both channels; four RTC-7 commands required for turn-off 2. Failure of F-battery or K2 relay disables entire command function 3. TV-2 relay in JPL Bus is latching relay; inhibits turn-off 4. No command-inhibit provision during critical pressure of launch environment

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TABLE 8-1

MAJOR DISADVANTAGES OF RA-6 COMMAND AND CONTROL CIRCUITRY (Continued)

	Function	Disadvantages
D. RTC-7 Commands	1. Initiated warmup mode by stepping to Warm-up position on Command Switch 2. Provides for transmission of emergency telemetry in the event of loss of video 3. Provided for a return to normal operation 4. Provided for both channel turn-off	1. Required up to four Real Time Commands to execute turn-off function 2. Required a driver amplifier and mechanical switch in series with the command 3. Gain of driver amplifier may cause the circuit to be overly sensitive. Approximately 1 milliampere of current for 12 microseconds steps the switch. 4. No command-inhibit provision during critical pressure of the launch phase 5. P-battery powers all RTC-7 command circuitry; a battery failure would inhibit RTC-7 command function.
E. Clock-Output Command	Initiates warmup mode on F-channel only	1. No apparent disadvantage.
F. CC&S Full-Power Command	Activates full-power relays in F- and P-channel Transmitter Power Supplies	1. Back-up command is absent when terminal maneuver is not executed.
G. Full Power (Command Sequencer)	Output of Sequencer 5-minute timer initiates full-power turn-on	1. Back-up command is absent when terminal maneuver is not executed.

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TABLE 8-1

MAJOR DISADVANTAGES OF RA-6 COMMAND AND CONTROL CIRCUITRY (Continued)

	Function	Disadvantages
H. RTC-5 Command - Clock-Off Command	Provides Clock turn-off control	1. If cruise-mode relay is not actuated, the clock cannot be turned off. 2. This command appears to be wasteful in that its exclusive purpose is to inhibit a back-up command function.
I. Reduced Power (Ground Control)	Activates reduced-power relays in F- and P-channel Transmitter Power Supplies for test purposes	1. A short to ground on pin M of the TV Subsystem-to-Bus connector prevents full-power operation.
J. Channel Simulate (Test Control)	Turns on either channel for test purposes	1. Long SCR gate leads are required. 2. Potential source for shorting the SCR gates.
K. Channel Turn-Off (Test Control)	Turns off either channel after test	1. Carries unregulated bus to the connector ring on the Subsystem, thus is potential problem.

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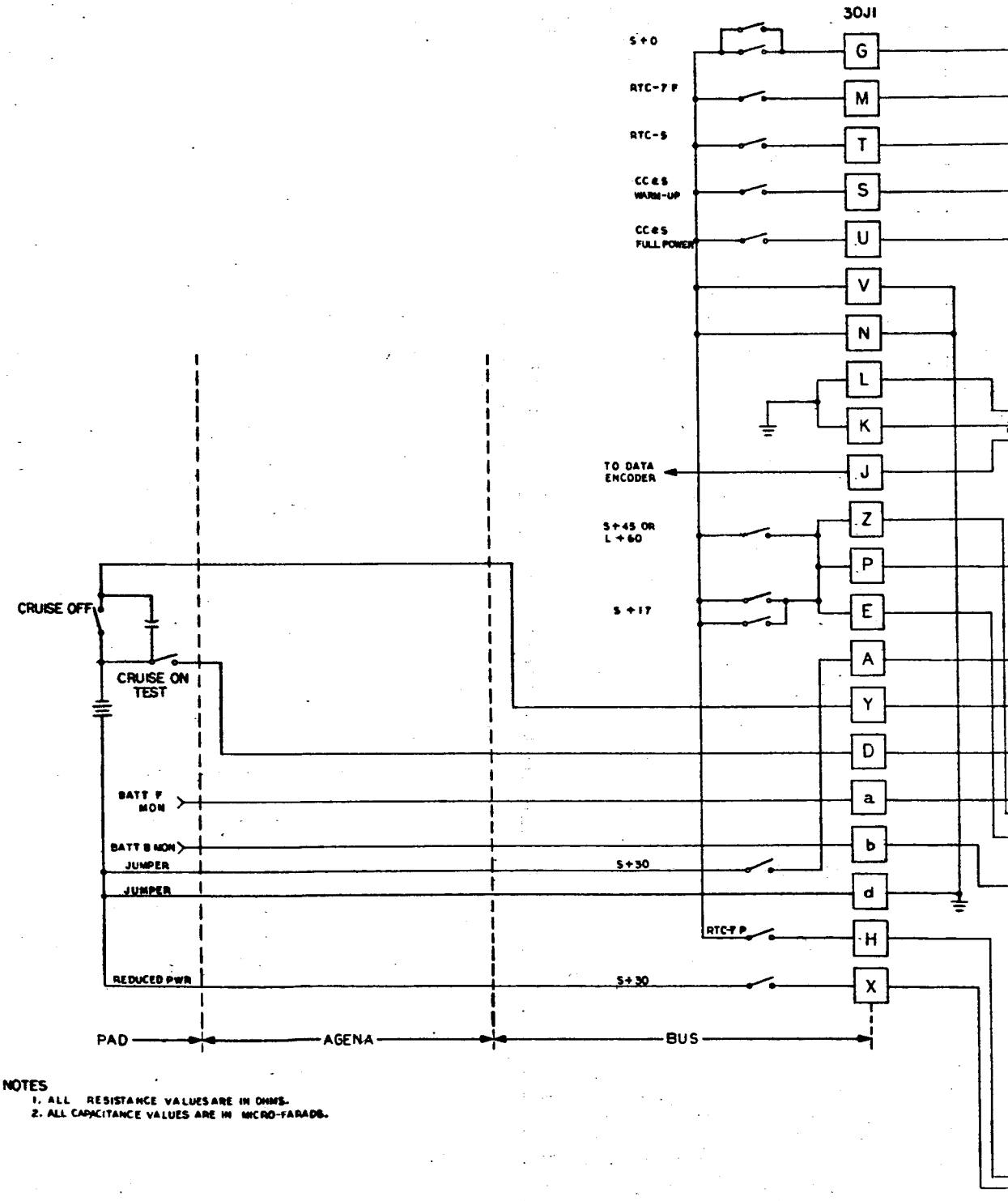
All of the revised command logic and circuits developed were analyzed for both real- and hypothetical-fault conditions. Each circuit was then analyzed in a worst-case condition to check analytically the choice of component parts.

a. Command Philosophy and Logic Revisions

The following changes were made in the philosophy and logic of the Command and Control Circuitry:

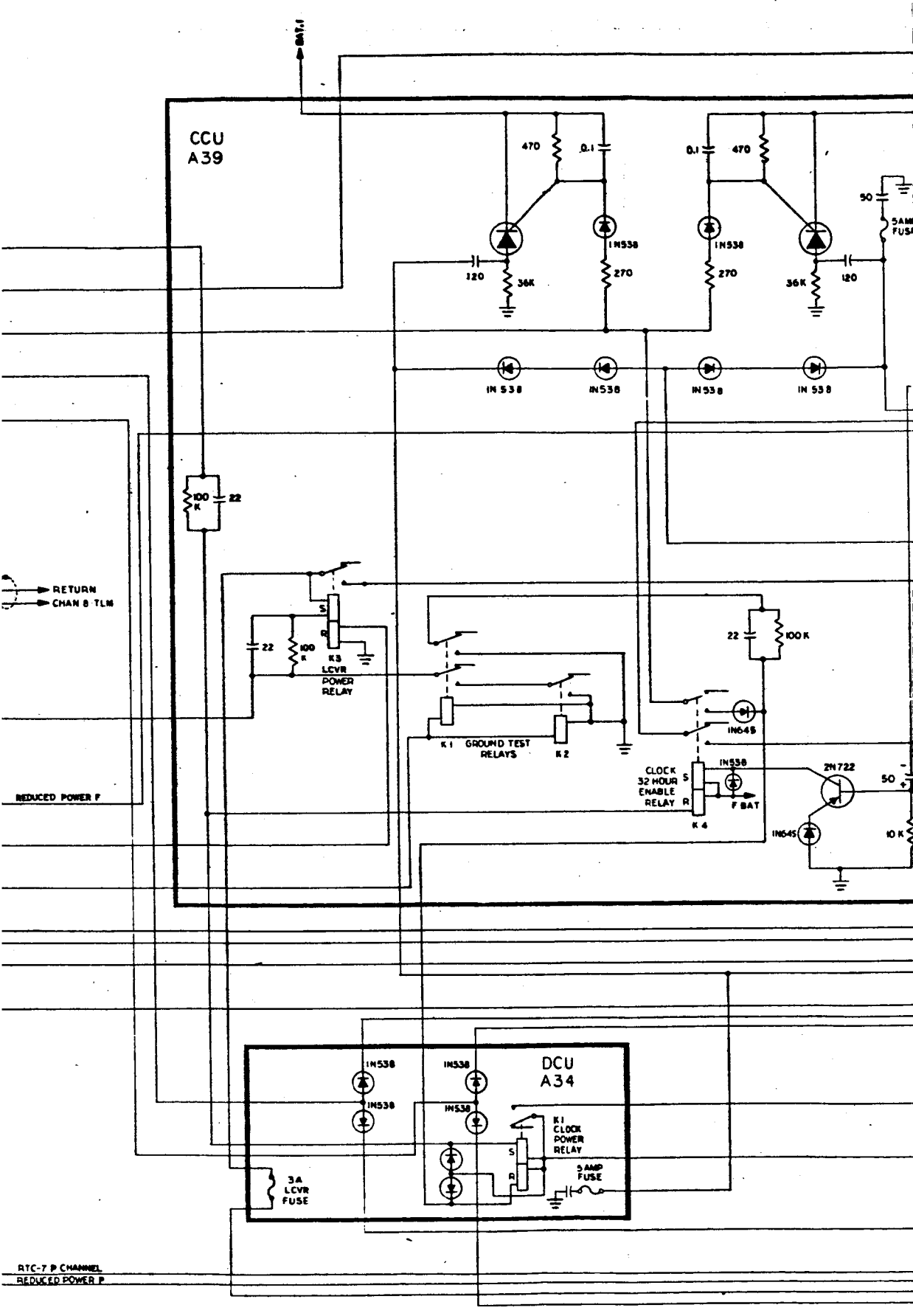
- Circuit effects on the battery SCR were minimized;
- Clock control was revised for single battery dependence;
- Inadvertent command initiation during launch was prevented;
- The continuous latching effect of the CC&S warmup relays was removed;
- The RTC-7 command system was revised for exclusive turn-on of both channels with complete channel redundancy;
- Clock-output command was retained;
- CC&S full-power command was retained;
- The time for the Sequencer full-power command was changed from 5 minutes to 80 seconds;
- The RTC-5 command was revised to incorporate the added function of turning off the Subsystem, if it becomes necessary to do so;
- The reduced-power command was revised so that it is inhibited during flight;
- All ground checkout commands from the blockhouse were eliminated, with the exception of one, which will be used to enable on-board commands. This command is to be isolated from a single fault mode.

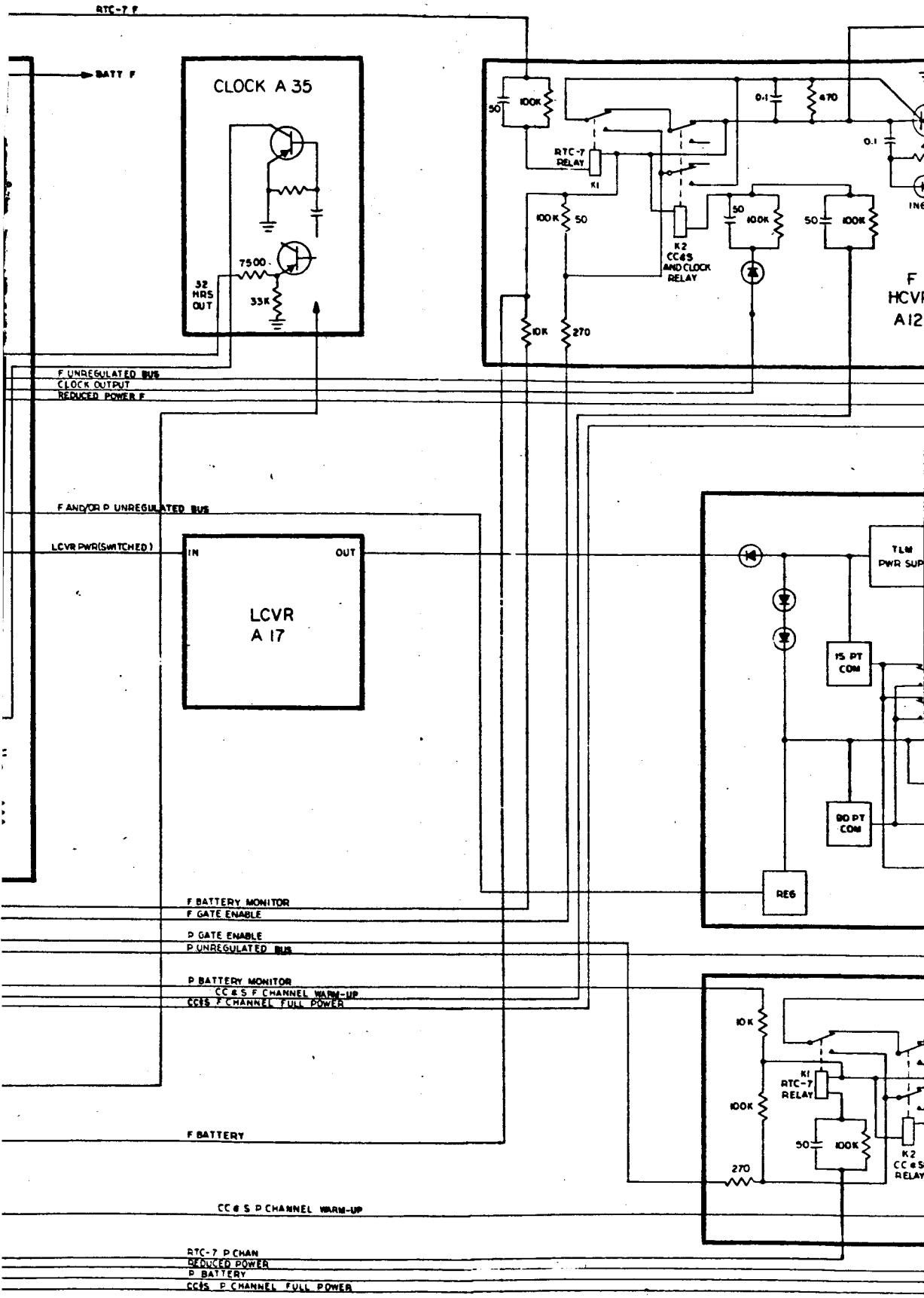
The revised Command and Control circuitry incorporating these logic modifications is shown in Figure 8-2.



NOTES

1. ALL RESISTANCE VALUES ARE IN OHMS.
2. ALL CAPACITANCE VALUES ARE IN MICRO-FARADS.


CCU
A39
470
0.1
IN538
270
36K
120
IN 538
100 K
22
RETURN
CHAN 8 TLM
K3
LCVR
POWER
RELAY
K1 GROUND TEST RELAYS K2
IN645
CLOCK
32 HOUR
ENABLE
RELAY
K 4
F BAT
2N722
50
10 K
REDUCED POWER F
DCU
A34
K1
CLOCK
POWER
RELAY
5 AMP
FUSE
3A
LCVR
FUSE
RTC-7 P CHANNEL
REDUCED POWER P


RTC-7 F
BATT F
CLOCK A 35
7500
32 HRS OUT
33K
50
100K
0.1
470
RTC-7 RELAY
K1
100K 50
K2 CC&S AND CLOCK RELAY
50 100K
50 100K
10K
270
F UNREGULATED BUS
CLOCK OUTPUT
REDUCED POWER F
F AND/OR P UNREGULATED BUS
LCVR PWR(SWITCHED)
IN
OUT
LCVR A 17
TLM PWR SUP
15 PT COM
80 PT COM
REG
F BATTERY MONITOR
F GATE ENABLE
P GATE ENABLE
P UNREGULATED BUS
P BATTERY MONITOR
CC&S F CHANNEL WARM-UP
CC&S F CHANNEL FULL POWER
10 K
100K
270
K1 RTC-7 RELAY
50
100K
K2 CC&S RELAY
F BATTERY
CC&S P CHANNEL WARM-UP
RTC-7 P CHAN
REDUCED POWER
P BATTERY
CC&S P CHANNEL FULL POWER

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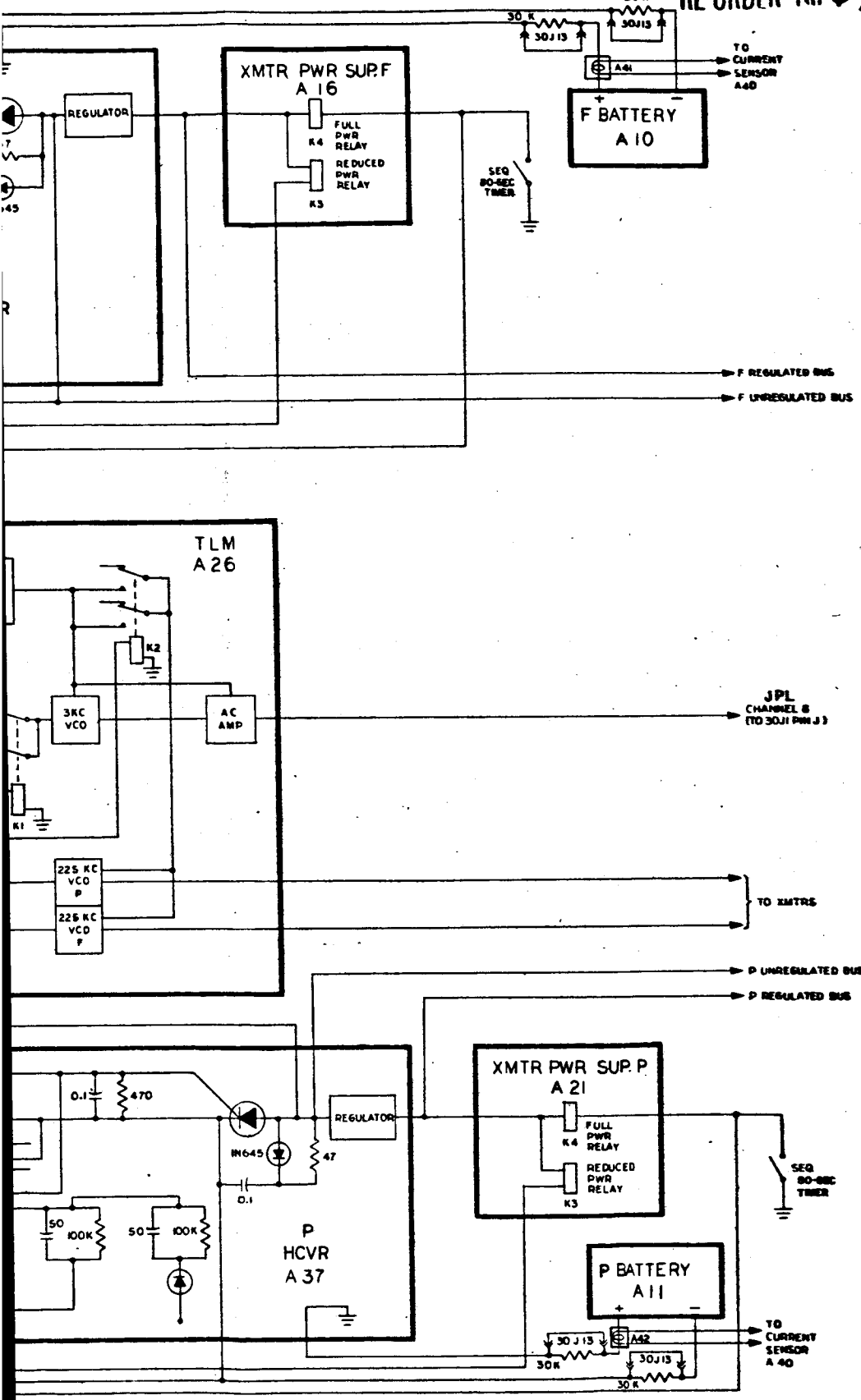

Figure 8-2. Block diagram of the Modified Command and Control circuitry

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3. *Analysis of Command and Control Circuitry Modifications*

a. SCR Desensitizer Circuitry

In the new design, the SCR gate desensitizer circuit consists of a 0.1-microfarad capacitor and a 470-ohm resistor shunted by two normally closed relay contacts. These components are located in the HCVR's as close as possible to the SCR gate. Figure 8-3 shows the new SCR desensitizer-circuitry design. The 30K-ohm resistors across the battery disconnect plug prevent a vibration of the plug from turning on the Subsystem. This method of SCR desensitizing has the following advantages over that employed in the RA-6 Spacecraft:

- Low-frequency protection is provided by normally closed relay contacts;
- High-frequency protection is provided by the same means. The addition of a 0.1-microfarad capacitor eliminates dry circuit closure problems;
- Short-circuit protection is provided by relay contacts;
- No actual SCR gate wires are located outside the HCVR; therefore, noise turn-on and accidental gate grounding is minimized; and
- If the battery disconnect plug is not properly seated, the resulting transients that may occur during periods of severe vibration will be filtered by the 30K resistors and the network across the SCR cathode to anode. The resulting displacement current will be minimized, thereby preventing the SCR from turning on.

b. Clock-Start Command (S + 0)

The clock-start command at S+0 latches relay K1 in the DCU. The contacts of this relay energize the clock. The clock-start command has been made momentary by the addition of an RC differentiating circuit in the CCU, thus permitting the command to be disconnected from the clock-start relay without requiring a change in the condition of the cruise-mode relay.

c. Hydraulic-Timer Command (S + 17)

This is a JPL Bus command which activates the cruise-mode relay if it had become unlatched during launch, and applies ground to the connector end of the

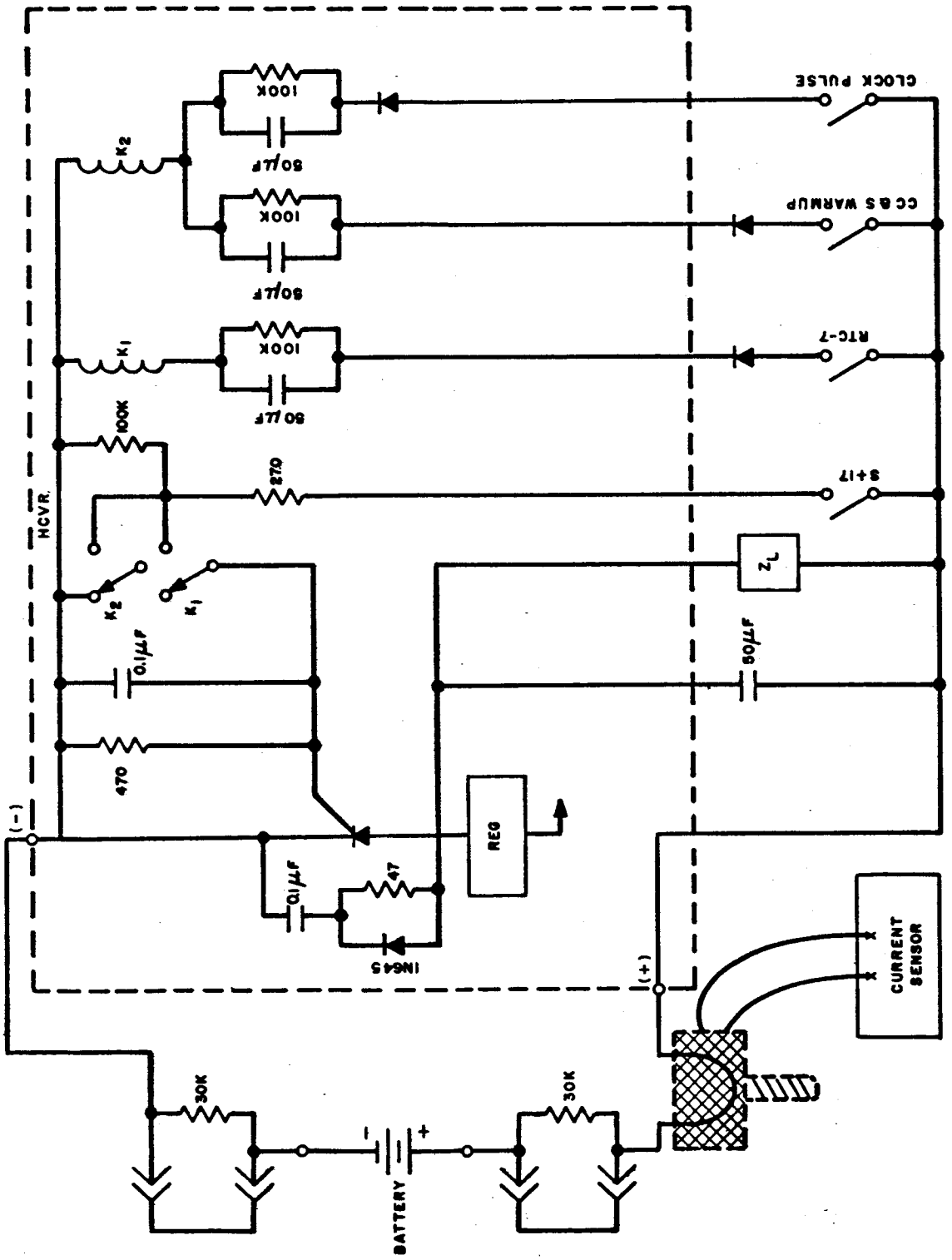


Figure 8-3. Single-channel SCR desensitizing circuit

111.

270-ohm resistors (gate current limiters) in the HCVR's, thus arming the SCR at this time.

This modification provides the following advantages over the RA-6 arrangement:

- The SCR gate resistor is not connected to ground until after the critical-pressure environment is passed;
- The high-power commands are disabled until after critical launch phase; and
- Minimum components are utilized between initiation and execution of the command function.

d. CC&S Warm-up Command

This is a continuous closure from the JPL Bus which momentarily activates the K2 relay in the High-Current Voltage Regulator through an RC differentiating circuit. The contact of the K2 relay removes the gate-to-cathode clamp from the SCR, permitting it to turn on by gate contact closure through the 270-ohm resistor to ground through the channel command-enable gates in the JPL Bus.

This modification provides the following advantages.

- Momentary or continuous closure of the CC&S warmup command in the JPL Bus will not turn on either channel before S+17 (Subsystem will not come on until critical-pressure phase of launch is completed);
- Continuous closure is made temporary by an RC differentiator, thus permitting subsequent turn-off of either, or both channels if they inadvertently turn-on by CC&S warmup command;
- SCR gate turn-on power is kept to a minimum;
- Isolation between the F- and P-Channels is maintained, in that a failure of a component in CC&S warmup P-Channel line will not prevent the F-Channel from being activated by the same command or any other turn-on command, and vice versa;
- Continuous closure of the CC&S TV-2 before S+17 dissipates itself before the command-enable gate is activated, and the Subsystem does not turn on when the ground bus is enabled.

e. RTC-7 Command

This is a momentary closure of 150 ± 50 milliseconds from the JPL Bus. Both contacts on the RTC-7 relay are utilized to provide F- and P-Channel turn-on. The momentary closure of the RTC-7 relay in the Bus energizes the K1 relays in the F- and P-Channel HCVR's momentarily through RC differentiating circuits. This removes the gate-to-cathode clamp from the SCR's, allowing them to turn on separately by grounding the gates to ground through 270-ohm resistors through the F- and P-Channel command-enable gates in the JPL Bus.

This design for F- and P-Channel turn-on by RTC-7 command has the following advantages over the method used in the RA-6 TV Subsystem:

- The use of two separate contacts now provided by the JPL Bus on the RTC-7 relay maintains complete isolation of channel turn-on at the command source. A failure along one of the RTC-7 command lines will not inhibit operation along the other line;
- No active elements are used between command initiation and execution;
- The RTC-7 command lines are not sensitive. A high resistance to ground will not activate the Subsystem. Approximately 7 milliamperes for 3.5 milliseconds is required per channel in the worst case;
- The RTC-7 command is inhibited during the critical-pressure environment of the launch phase;
- Momentary closure of the K1 relays in ths HCVR's minimizes gate power requirements;
- No single component failure in the TV Subsystem command reference will cause both channels to fail.

f. Clock-Output Command

The output command from the Clock, for turning on the F-Channel only, is now inhibited until S+32 hours. This is to allow for use of the RTC-5 command during mid-course maneuver, if necessary.

The 32-hour output from the Clock energizes the K2 relay in the F-Channel HCVR through a differentiating circuit, thus permitting the F-Channel only to turn on when the mission time is accomplished.

g. CC&S Full-Power Command

There is no change in this command function from the design used on the RA-6 Spacecraft.

h. Sequencer Full-Power

The full-power command from the Sequencer will be activated by an 80-second timer, rather than the 5-minute timer used on RA-6.

i. RTC-5 Command

The RTC-5 command is a momentary closure of 150 ± 50 milliseconds from the JPL Bus which turns off either or both channels if they are in warmup or full-power. This command is also utilized as the Clock override. However, the Clock turn-off or override function is inhibited for 32 hours after the clock start at S+0.

The advantages associated with the use of the RTC-5 command in the new Subsystem are as follows:

- No single component failure in one channel will prevent the other channel from being turned off.
- No active elements are used between command initiation and execution.
- The RTC-5 command input line is not sensitive. A high resistance to ground will not turn off either channel. (Approximately 140 milliamperes are required per channel.)
- Momentary closure of RTC-5 command minimizes gate power requirements.

j. Reduced-Power Command

The reduced power command now passes through the normally closed contacts of the clock start relay.

k. Ground Checkout Commands

Launch pad checkout is enabled by an external (ground battery) supply energizing relays in the TV Subsystem. These relays enable the Command ground bus and the cruise-mode-on relay. All other commands are given through the JPL Bus.

4. Command and Control Circuits—Modified Circuit Schematics

The schematic diagrams of Figures 8-4 through 8-7 indicate the design modifications incorporated into the Command and Control circuitry of the Ranger TV Subsystem as a result of this design study.

Figure 8-4 shows the circuits of the new Command Control Unit (CCU) design (RCA Drawing No. 1755337).

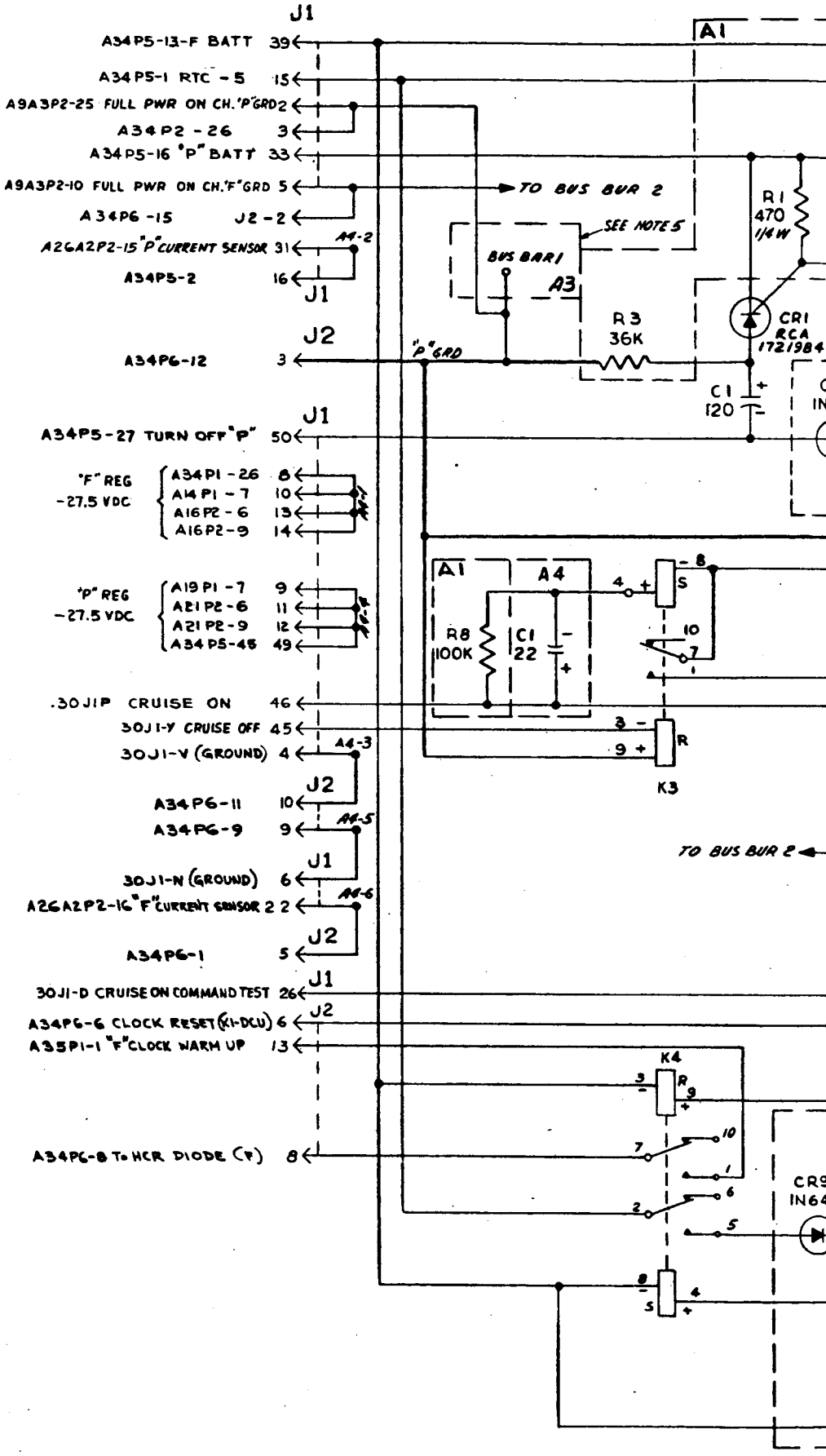
Figure 8-5 is a schematic diagram of the new Distribution Control Unit (DCU) design (RCA Drawing No. 1703981).

Figure 8-6 is a schematic diagram of the new High-Current Voltage Regulator (HCVR) design (RCA Drawing No. 1706631).

Figure 8-7 shows the schematic diagram of the new Clock design (RCA Drawing No. 1753325).

5. Normal Command Sequence of the CCU

This section analyzes the commands and describes their functions in the new Subsystem design by sequence. Prior to launch, the final cruise-on command is given from the ground to the TV Subsystem. This command is confirmed by the reception of Channel-8 telemetry.


J1
A34P5-13-F BATT 39
A34P5-1 RTC - 5 15
A9A3P2-25 FULL PWR ON CH."P"GRD 2
A34P2 - 26 3
A34P5-16 "P" BATT 33
A9A3P2-10 FULL PWR ON CH."F"GRD 5
A34P6 -15 J2 - 2
A26A2P2-15 "P" CURRENT SENSOR 31
A34P5-2 16
A4-2
J1
J2
A34P6-12 3
"P" GRD
J1
A34P5-27 TURN OFF "P" 50
"F" REG -27.5 VDC
A34P1 - 26 8
A14 P1 - 7 10
A16P2 - 6 13
A16P2 - 9 14
"P" REG -27.5 VDC
A19 P1 - 7 9
A21 P2 - 6 11
A21 P2 - 9 12
A34 P5-45 49
.30J1P CRUISE ON 46
30J1-Y CRUISE OFF 45
30J1-V (GROUND) 4
A4-3
J2
A34P6-11 10
A34P6-9 9
A4-5
J1
30J1-N (GROUND) 6
A26A2P2-16 "F" CURRENT SENSOR 2 2
A4-6
J2
A34P6-1 5
J1
30J1-D CRUISE ON COMMAND TEST 26
J2
A34P6-6 CLOCK RESET (X1-DCU) 6
A35P1-1 "F" CLOCK WARM UP 13
A34P6-8 To HCR DIODE (F) 8
TO BUS BAR 2
SEE NOTE 5
BUS BAR 1
A3
A1
R1 470 1/4 W
CR1 RCA 1721984
R3 36K
C1 120
A1
A4
R8 100K
C1 22
K3
K4
TO BUS BAR 2
CR9 IN64

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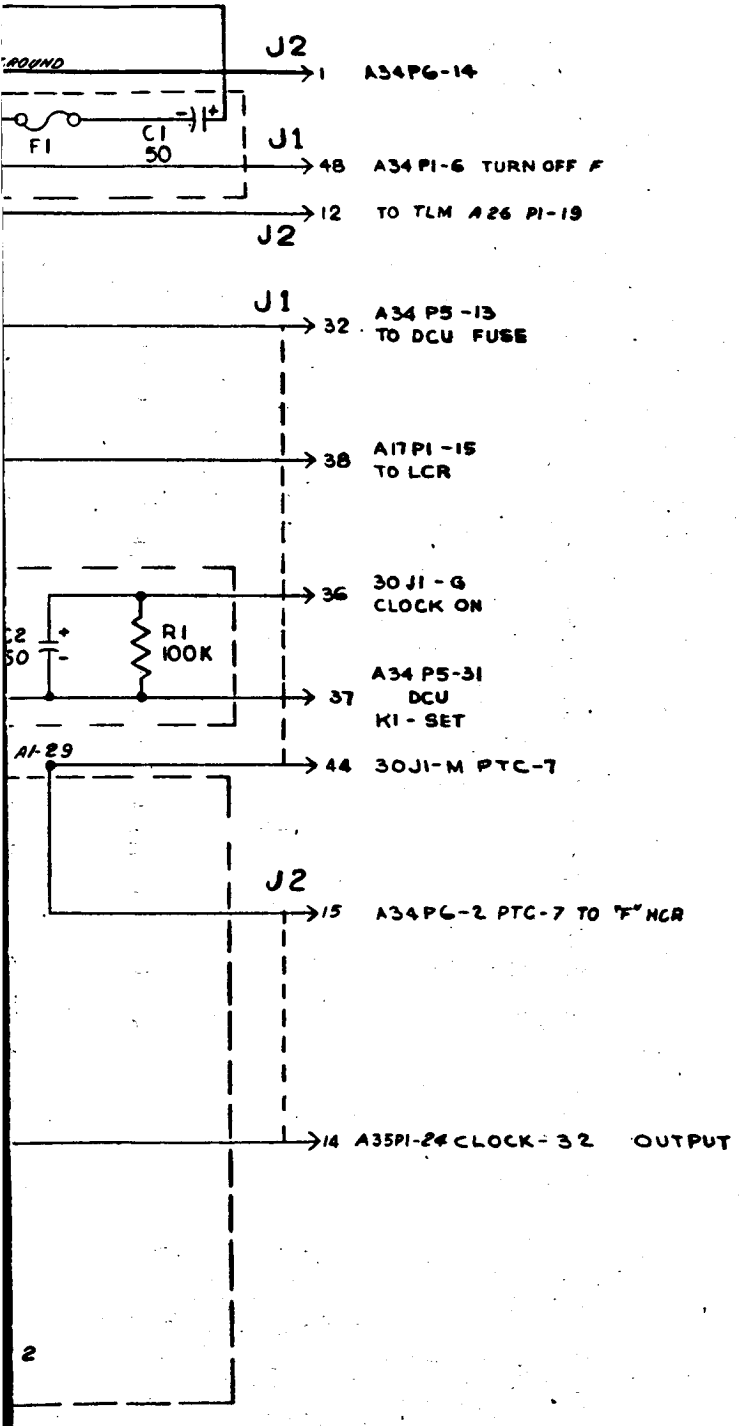
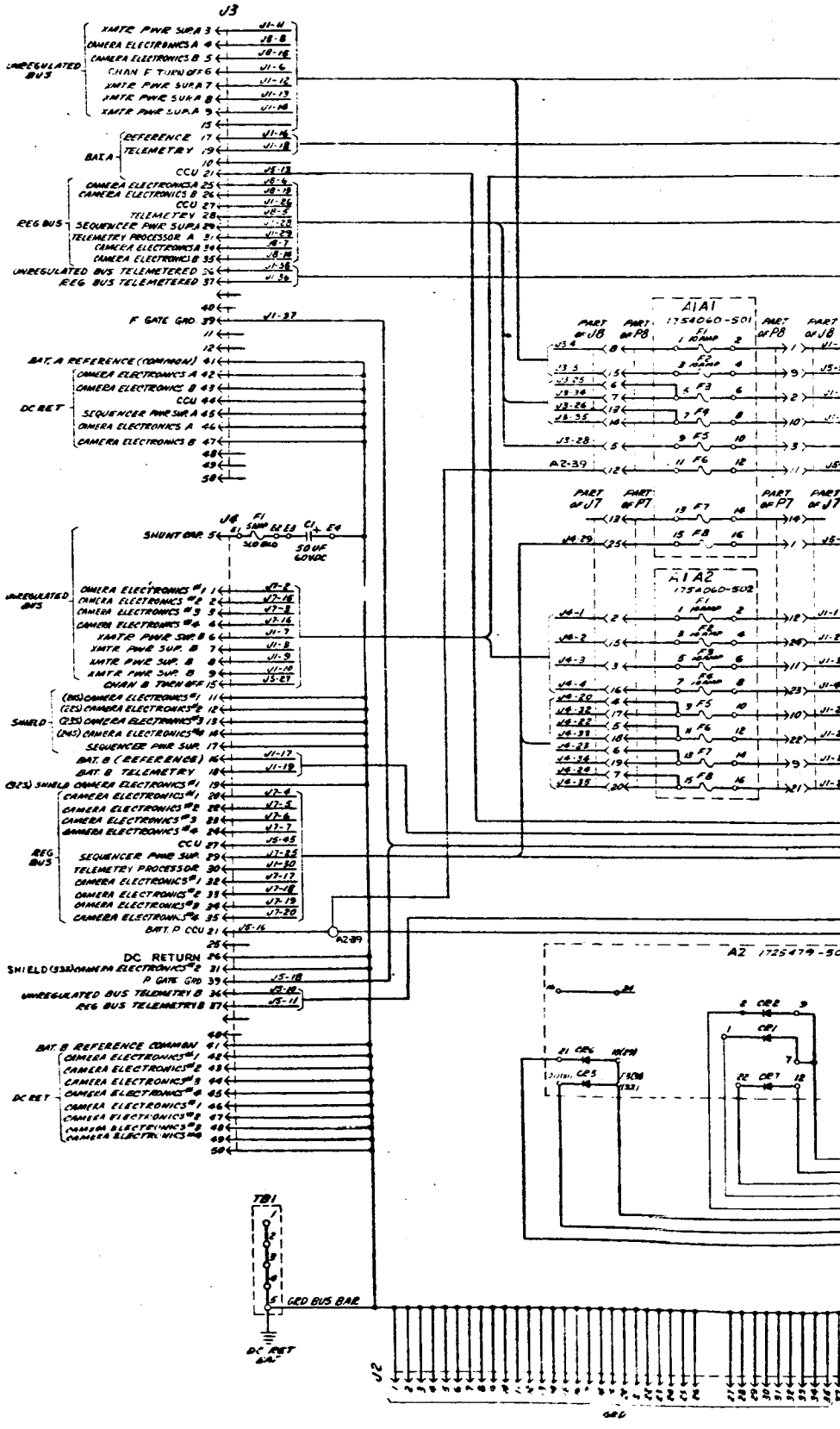
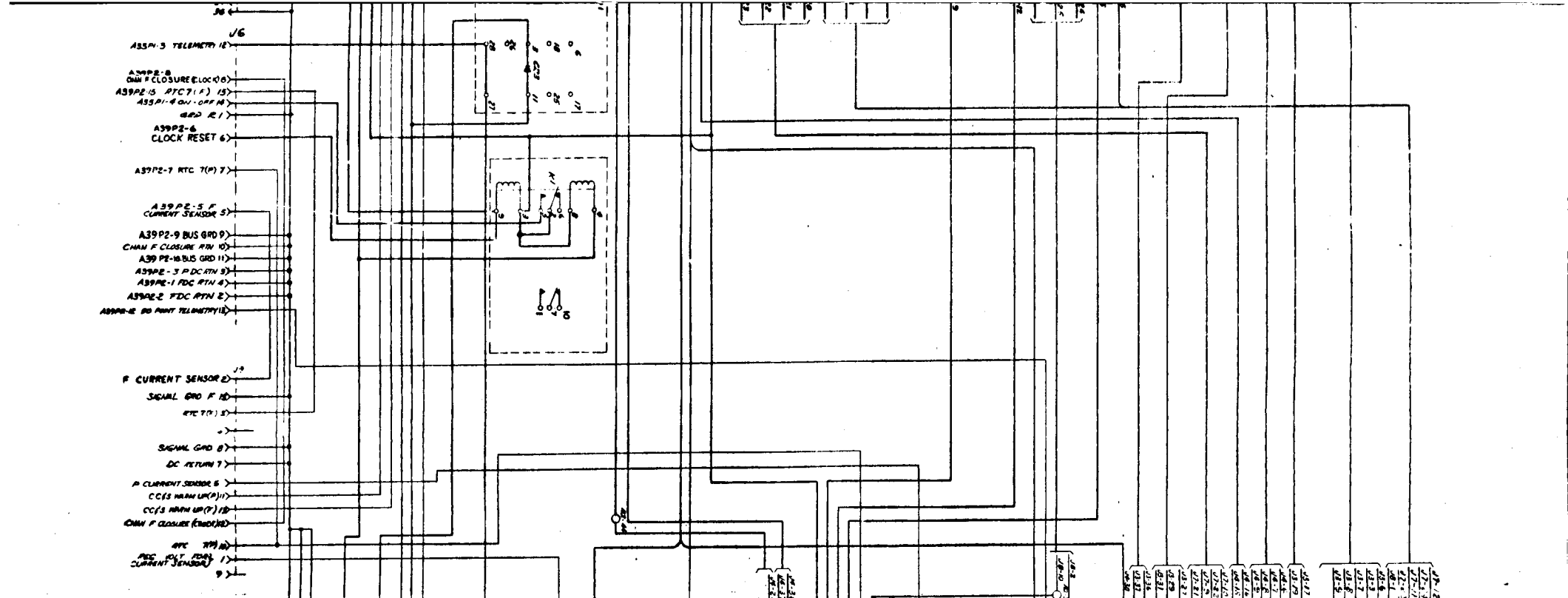
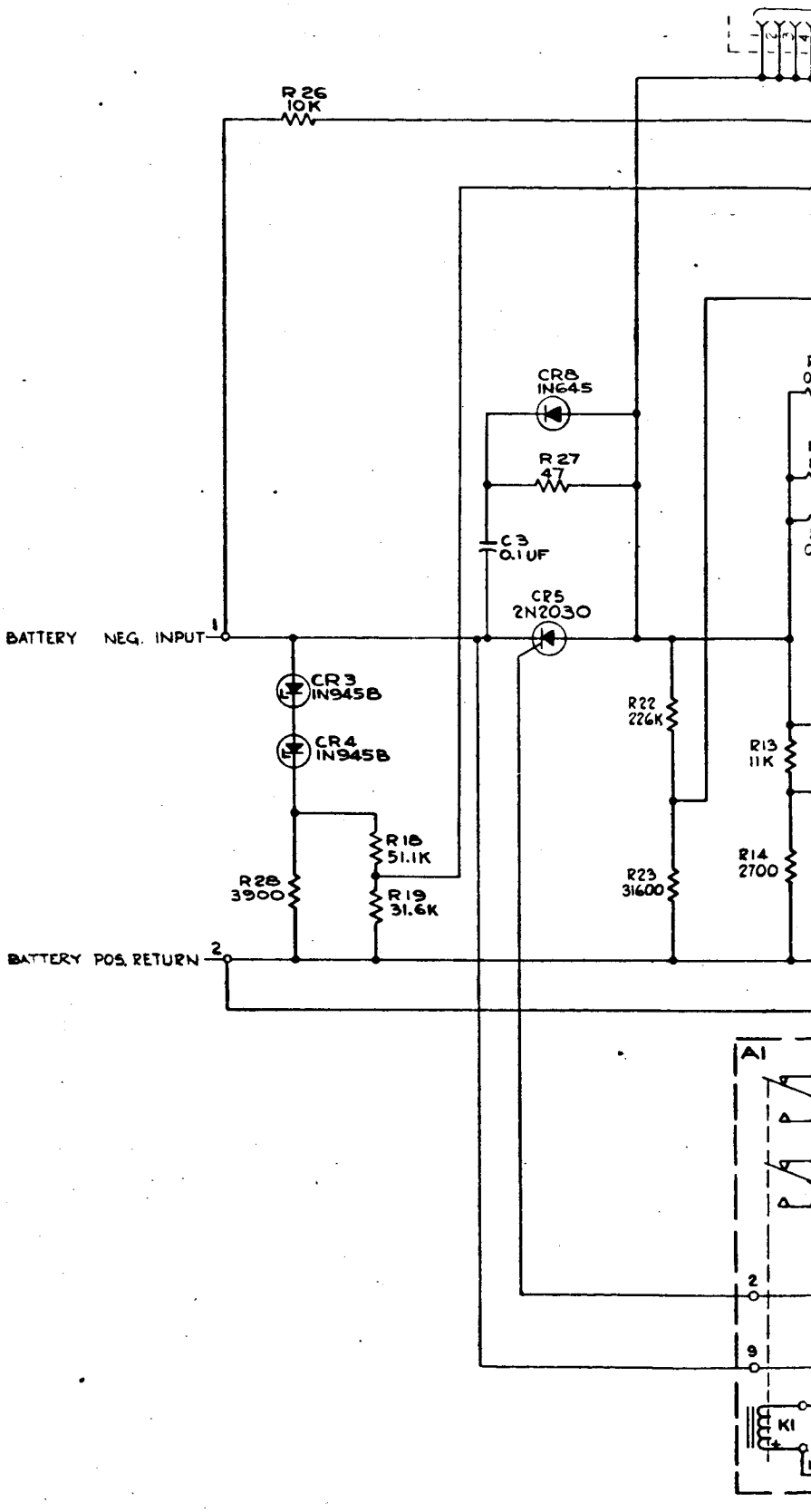


Figure 8-4. New TV Subsystem Command Control Unit (CCU), schematic diagram

116-2


J3
UNREGULATED BUS
XMTR PWR SUP A
CAMERA ELECTRONICS A
CAMERA ELECTRONICS B
CHAN F TURN OFF
XMTR PWR SUP A
XMTR PWR SUP A
XMTR PWR SUP A
BATA
REFERENCE
TELEMETRY
CCU
REG BUS
CAMERA ELECTRONICS A
CAMERA ELECTRONICS B
CCU
TELEMETRY
SEQUENCER PWR SUP A
TELEMETRY PROCESSOR A
CAMERA ELECTRONICS A
CAMERA ELECTRONICS B
UNREGULATED BUS TELEMETERED
REG BUS TELEMETERED
F GATE GRD
BAT. A REFERENCE (COMMON)
DC RET
CAMERA ELECTRONICS A
CAMERA ELECTRONICS B
CCU
SEQUENCER PWR SUP A
CAMERA ELECTRONICS A
CAMERA ELECTRONICS B
J6
SHUNT BAR
50 MILLIVOLT
50 UF 60VDC
UNREGULATED BUS
CAMERA ELECTRONICS #1
CAMERA ELECTRONICS #2
CAMERA ELECTRONICS #3
CAMERA ELECTRONICS #4
XMTR PWR SUP B
XMTR PWR SUP B
XMTR PWR SUP B
XMTR PWR SUP B
CHAN B TURN OFF
SHIELD
(BIS) CAMERA ELECTRONICS #1
(EES) CAMERA ELECTRONICS #2
(235) CAMERA ELECTRONICS #3
(245) CAMERA ELECTRONICS #4
SEQUENCER PWR SUP.
BAT. B (REFERENCE)
BAT. B TELEMETRY
(325) SHIELD CAMERA ELECTRONICS #1
REG BUS
CAMERA ELECTRONICS #1
CAMERA ELECTRONICS #2
CAMERA ELECTRONICS #3
CAMERA ELECTRONICS #4
CCU
SEQUENCER PWR SUP.
TELEMETRY PROCESSOR
CAMERA ELECTRONICS #1
CAMERA ELECTRONICS #2
CAMERA ELECTRONICS #3
CAMERA ELECTRONICS #4
BAT. P CCU
A2-39
DC RETURN
SHIELD (335) CAMERA ELECTRONICS #2
P GATE GRD
UNREGULATED BUS TELEMETRY B
REG BUS TELEMETRY B
BAT. B REFERENCE COMMON
DC RET
CAMERA ELECTRONICS #1
CAMERA ELECTRONICS #2
CAMERA ELECTRONICS #3
CAMERA ELECTRONICS #4
CAMERA ELECTRONICS #1
CAMERA ELECTRONICS #2
CAMERA ELECTRONICS #3
CAMERA ELECTRONICS #4
A1A1
1754060-501
A1A2
1754060-502
A2 1725479-50
TB1
REG BUS BAR
DC RET
J2


J6
A39P1-3 TELEMETRY (E)
A39P2-8 CHAN F CLOSURE (CLOCK) (8)
A39P2-15 PTC 7 (F) 15
A39P1-4 ON/OFF (A)
GRD (R) 1
A39P2-6 CLOCK RESET 6
A39P2-7 RTC 7(P) 7
A39P2-5 F CURRENT SENSOR 5
A39P2-9 BUS GRD 9
CHAN F CLOSURE RTN 10
A39P2-10 BUS GRD 11
A39P2-3 P DC RTN 3
A39P2-1 FDC RTN 4
A39P2-2 FDC RTN 2
A39P2-12 80 PAINT TELEMETRY (12)
J9
F CURRENT SENSOR 2
SIGNAL GRD F (1)
RTC 7(P) 5
SIGNAL GRD 8
DC RETURN 7
P CURRENT SENSOR 6
CCIS HARN UP(P) 11
CCIS HARN UP(P) 13
CHAN F CLOSURE (CLOCK) (12)
FDC FDC
CURRENT SENSOR 1
9


R26
10K
CR8
1N645
R27
47
C3
0.1UF
CR5
2N2030
BATTERY NEG. INPUT
1
CR3
1N945B
CR4
1N945B
R18
51.1K
R28
3900
R19
31.6K
BATTERY POS. RETURN
2
R22
226K
R23
31600
R13
11K
R14
2700
A1
2
9
K1

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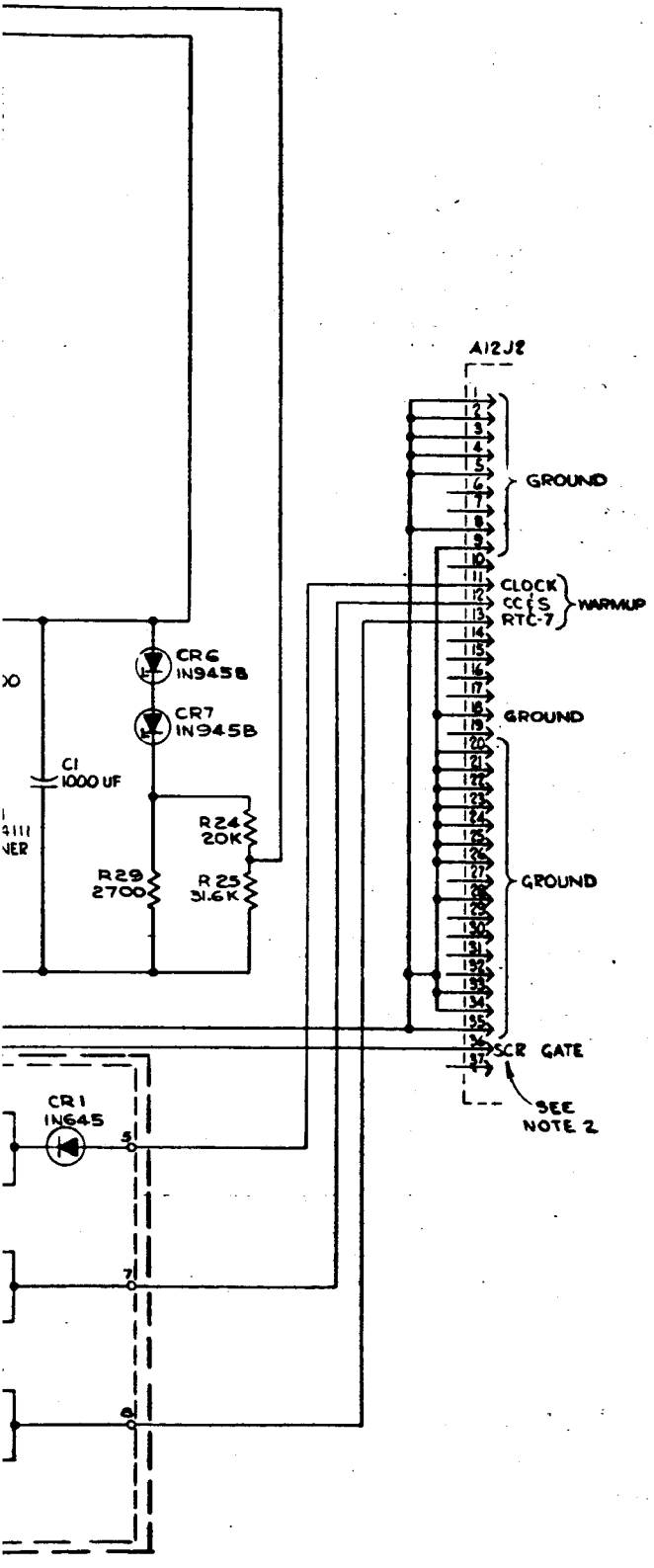
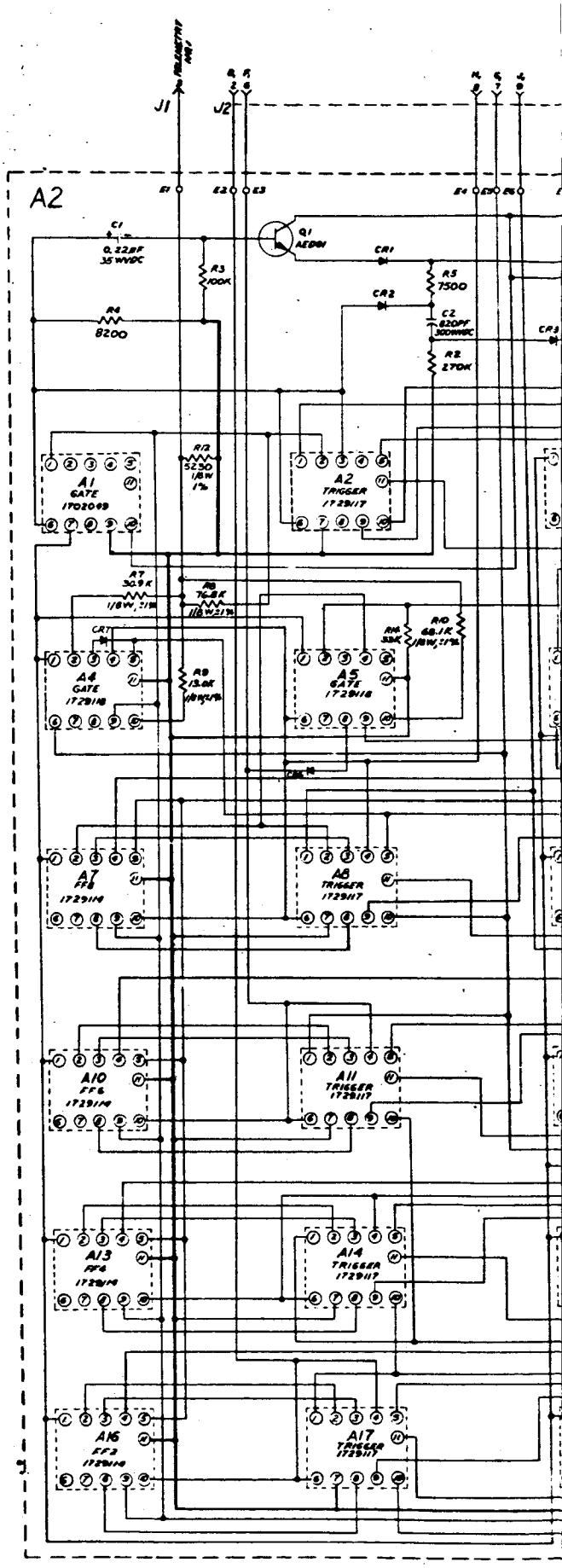
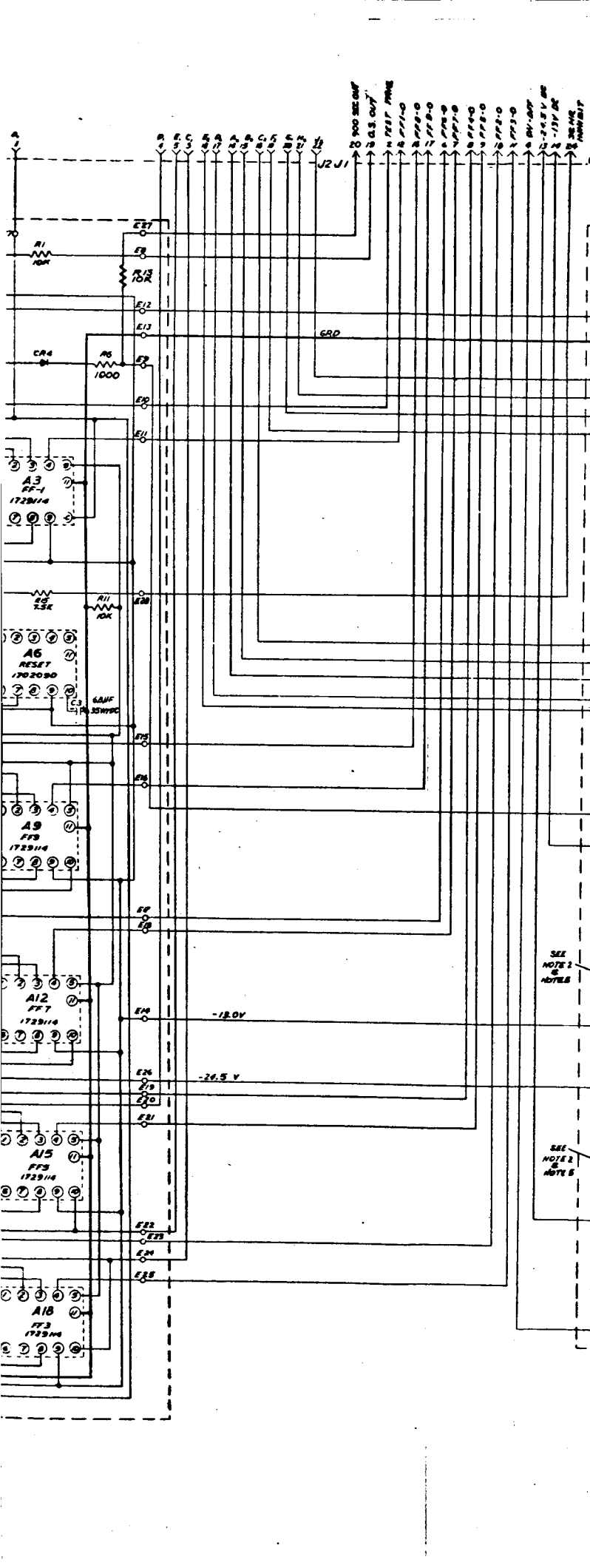


Figure 8-6. Modified TV Subsystem High-Current Voltage Regulator (HCVR), schematic diagram

118-2


A2
J1
J2
Q1
2N2894
CR1
CR2
CR3
R3
100K
R4
8200
R5
7500
C2
820PF
300WVDC
R2
270K
C1
0.22MF
35 WVDC
R12
52.3Ω
1/8W
1%
A1
GATE
1702069
A2
TRIGGER
1729117
R7
30.9K
1/8W, 1%
R8
76.8K
1/8W 1%
R10
68.1K
1/8W, 1%
R11
33K
CR4
A4
GATE
1729118
R9
13.0K
1/8W 1%
A5
GATE
1729118
A7
FF8
1729119
A8
TRIGGER
1729117
A10
FF6
1729119
A11
TRIGGER
1729117
A13
FF4
1729119
A14
TRIGGER
1729117
A16
FF2
1729119
A17
TRIGGER
1729117


J2 J1
R1 10K
R13 10K
CR4
R6 1000
GRD
A3 FF-1 1729114
R5 2.5K
R11 10K
A6 RESET 1702050
C3 .68UF 35 WVDC
A9 FF9 1729114
A12 FF7 1729114
-18.0V
-24.5 V
A15 FF5 1729114
A18 FF3 1729114
SEE NOTE 2 & NOTE 5
SEE NOTE 2 & NOTE 5

At Agena separation (S+0), the normally open set of contacts on a microswitch in the JPL Bus close. This closure grounds the "set" side of the clock-start relay and resets the 32-hour Clock-inhibit relay through a differentiating circuit consisting of 50-microfarad capacitor shunted by 100K-ohm resistor. At the same time, the hydraulic timer on the JPL Bus starts to operate.

At S+17 minutes, the hydraulic-timer plunger on the JPL Bus passes the S+17 minute wafer, closing a set of contacts that enable the command ground bus. This command function is backed up by a second S+17 contact on the same switch and also by a S+45 and L+60 minute closure.

At terminal mode, the following command functions can take place:

- A 200-millisecond pulse would actuate the K2 relay in the F-Channel HCVR grounding the SCR gate momentarily through a 270-ohm resistor. The F-Channel turns on in the warmup mode. Presence of the unregulated bus enables the 90-point telemetry commutator to be switched over to the Channel-8 VCO.

- RTC-7 Command. The 150-millisecond RTC-7 signals can be applied directly to the differentiating circuit in the F- and P-Channel HCVR's, energizing the K1 relays. This would fire the SCR's and turn on the F- and P-Channels in the warmup mode.

- CC&S Warmup Command (Continuous Closure). This signal is differentiated at the P- and F-Channel HCVR's and turns on both channels in the warmup mode.

- CC&S Full-Power Command (Continuous Closure). The CC&S TV-3 command is a backup for full-power turn-on of the Subsystem.

- RTC-5 Command (150 MS Pulse). The RTC-5 command performs one of two functions; it either turns off the TV Subsystem unregulated busses or disables the Clock.

6. *Circuit and Fault Analysis*

This section presents a detailed analysis justifying the new design approach. It describes as faithfully as possible the merits and drawbacks of this approach versus other schemes which have been suggested. It also analyzes various failure modes and proposes changes outside the Command and Control Unit, where deemed necessary.

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TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-8 TV SUBSYSTEMS (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
2260 12/8/64 (Cont'd)						pins A1 and J1-1 indicated that relay K1 was open, which is normal. An operational check showed that when the power supply was switched to warmup, the +1000 volt supply appeared at the same instant. Visual inspection revealed no discrepancy. Leads 7 and 8 of transformer T1 were disconnected and an ohmmeter was placed across contacts 1 and 2 of relay K1. When the power supply was switched to warmup, the contacts remained open. When full-power was applied, the contacts closed; and in reduced-power mode, the contacts opened. This is normal operation. Leads 7 and 8 of Transformer T1 were reconnected, and the failure recurred. The contacts of relay K1 were disconnected again and an ohmmeter placed across contacts 1 and 2. This time the failure occurred. Relay K1 was found to be intermittent. A resistance check proved acceptable. However, when the relay was energized the contacts remained opened. Upon slight shaking of the coil, a rattling noise was heard, and when the coil was de-energized, the contacts closed and remained closed. The glass at the terminal weld was cut and the contact was viewed with a microscope. It was concluded that the weld between the terminal and the moving arm of the contact was improperly made and became loose in the glass capsule. This caused an intermittent-type failure. This is the second problem of this nature encountered with relay K1. It is attributed to a poor weld joint. The relay contacts were clean and not pitted, and exhibited no evidence of arcing. Evaluation of the inadvertent application of the 1000 volts to the power amplifier concluded that the tube was not damaged and is satisfactory for flight use. The relay K1 was replaced and the Transmitter Power Supply tested in accordance with RTRB No. 128A. The failure is felt to be an isolated instance; however, relays in stock and new procurements will be preconditioned for a minimum of 2000 cycles and a maximum of 3000 cycles of mechanical operation.
QC2262 12/10/64	High-Current Voltage Regulator, Serial No. 012, Flight Model III-3	Resistor R24, Type RN65E2002E	Output Voltage Not Within Specified Limit	Thermal-Vacuum (JPL)	Design	During thermal-vacuum testing at JPL, High-Current Voltage Regulator, Serial No. 012, was not operating within specified limits. Telemetry data indicated an output voltage of -26.0 volts, with an indication of one momentary drop to -23.0 volts. However, at no time did the communications or video output indicate an insufficient input-power condition. The assembly was returned to RCA, where troubleshooting revealed that resistor R24 in the regulated output telemetry circuit was changing resistance value. The component varied from 20 kohms normal to 15 kohms when heated. The resistor was replaced in the HCVR. High- and low-temperature tests were performed with no measurable change in the telemetry voltage after 30 minutes of operation. The resistor was then permanently installed, and the HCVR was acceptance tested. X-rays of the failed resistor revealed that one of the internal leads had separated from the resistive element. In resistors of this type, the leads are attached to a talon insert, which is bonded to the resistive element by a conductive cement. The cement is a mixture of silver and an organic binder, in

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TABLE C-1
DETAILED TABULATION OF FAILURES ON RA-8 TV SUBSYSTEMS (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
QC2262 12/10/64 (Cont'd)						which unseen cracks or voids occasionally occur during the curing process. This failure mode has occurred before. The previous failure was reported in Malfunction Report No. QC3593 and involved the same resistor R24 in HCVR, Serial No. 13. The vendor is aware of the failure mechanism and indicated that it is an unusual occurrence. In order to increase part reliability, construction of this type of resistor has been changed from the talon lead, which failed, to a capped-lead construction. New resistor procurements will be of the end-cap configuration. A review of the TV Subsystem design indicated that RN65-type resistors are also employed in the Video Combiner, Low-Current Voltage Regulator, and High-Current Voltage Regulator Circuits. In its application in the Video Combiner, the RN65-type resistor is in the common leg of the video-summing amplifiers, and a change in the resistance value would have a slight effect on the output. It is possible that it could result in a slight variation of the d-c level of the video output. However, the change would be too small to be noticed by monitoring this point. The application in the Low Current Voltage Regulator would affect only the telemetry reading of the -27.5 volt regulator voltage. This telemetry point is monitored and changes in value would be noticed. The applications in the High Current Voltage Regulator would affect the telemetry reading of the -27.5 volt regulated voltage and the unregulated bus voltages. Both of these telemetry points are monitored and changes in value would be noticed.
2268, 12/28/64	P3 Camera and Camera Electronics Assembly, Serial No. 040/037, Flight Model III-3	N/A	Shutter-Induced Noise Bursts	Ambient (JPL)	Design	Review of the 35-mm film from the SFOF Systems test revealed severe noise bursts in the P3 Camera video output. The noise was concentrated in the top one-third of alternate frames from the camera. The problem was only present during the terminal portion of the SFOF test when the TV Subsystem was mounted in a horizontal position. When the Subsystem was tested in the vertical position, the noise bursts were not present on the P3 Camera video output (similar situations have been noted with different cameras on every spacecraft). It appears that the electrostatic charge and discharge of shutter components contributes heavily to the appearance of white-level noise spikes in the video presentation. Substantial reduction of the noise has been demonstrated experimentally by ground conditions on all shutter parts. A limited number of spare shutters have been modified to eliminate the noise and are available as flight spares. Flight experience with the Ranger 7 Spacecraft indicates that the frequency of noise occurrence is significantly reduced with operation of the camera in a zero g environment.

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TABLE C-2
DETAILED TABULATION OF FAILURES REPORTED ON GSE

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
MR1581 10/19/64	Detector/ Amplifier, Unit 10 OSE (JPL)		Low Output Level	Ambient (JPL)	Nonconfirmed	During performance of the post-shipment electrical test on Flight Model III-3, the F-Channel detector/ amplifier of the TV OSE had a low output level. Normal operation was restored by tapping on a V-14 tube in the unit. The problem could not be made to reappear in test (Note: See MR 2144).
MR1579 10/19/64	Ground Power Supply, GSE		Circuit Breaker Tripped	Ambient (JPL)	Accident	At the start of the post-shipment electrical test of Flight Model III-3, the circuit breaker associated with the GSE ground power supply tripped. Investigation revealed that the GSE had been inadvertently connected to the wrong power plug. The plug was connected to a 20 amp circuit breaker on the main electrical power panel and immediately upon application of power, the breaker tripped. The GSE was then connected to the proper power plug which was connected to a 30-amp circuit breaker on the main electrical panel and normal operation was restored. Subsequent tests indicated that the failure did not affect the GSE or TV Subsystem. Test personnel have been alerted to scrutinize and check mating of all connectors before applying power. A decal was attached to the 20-amp circuit plug to indicate it was for use of test equipment only.
MR2145 QC4256 10/20/64	Monitor and Control Panel Serial No. 5 GSE	Transistor Q5 Module 206	Horizontal Tearing of Picture	Ambient (JPL)	Nonconfirmed	There was a horizontal tear in the picture at the monitor and control panel. It was found that the 4-second oscillator locking pulse was intermittent. Transistor Q5 was removed from MD206 for what was thought to be emitter-to-base breakdown. However, when the transistor was tested at AED, all breakdown voltages and other static characteristics fulfilled specified requirements. Transistor Q5 was replaced, and the equipment is operating satisfactorily.
MR2142 10/21/64	Sanborn Recorder, Serial No. 263, GSE	Drive Motor	Blown Fuse	Ambient (JPL)	Accident	During performance of System Test No. 2 of Flight Model III-3, the Sanborn Recorder in the GSE malfunctioned. The main drive motor was binding and eventually overheated, causing a fuse to blow. The motor was removed and the problem repeated after two hours of bench-test operation. The unit was disassembled and inspection revealed no apparent damage to the motor. The motor bearings were lubricated and the mounting assembly readjusted to alleviate bind on the motor shaft. The motor was then operated for 8 hours in bench test with no apparent rise in temperature or change in speed. The motor was reinstalled and operated normally.
MR2144 QC3648 10/21/64	Detector/ Amplifier, Unit 10, GSE, Serial No. 3	V-14 Tube Socket	Change in Gain and DC Level	Ambient (JPL)	Accident	During performance of System Test No. 2 of Flight Model III-3, there was a change in gain and a shift of d-c level of the F-Channel detector/amplifier of the GSE Unit 10. The problem was traced to a defective tube seocket V-14 in the detector/amplifier. The tube socket was replaced in the GSE and returned to AED where a pin-retention test was performed. Pin No. 2, the suppressor grid, was found to be loose. Pin No. 7 was also loose. It was concluded that the pins were loosened by the insertion of a tube with a bent pin. (See MR1581)

TABLE C-2
DETAILED TABULATION OF FAILURES REPORTED ON GSE (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
MR2146 10/21/64	Channel 8 Discriminator, Serial No. 650, GSE, Serial No. 3	Low Pass Filter	Excessive Noise on Filter RF Signal	Ambient (JPL)	Design	During the terminal maneuver portion of System Test No. 2 of Flight Model III-3, excessive noise was encountered on the RF signal containing the Channel-8, 90-point telemetry. The noise level was 400 to 500 millivolts while operating on RF at a threshold signal level of -130 dbm. Investigation revealed that the Channel-8 discriminator of the GSE was equipped with a 45-cps low pass filter. DSIF is equipped with a 25-cps low pass filter. The discriminator was replaced by a unit equipped with a 20-cps filter and the noise level was reduced.
MR2147 10/23/64	Film Recorder Serial No. 3, GSE		Lens Out of Focus	Ambient (JPL)	Accident	Analysis of the 35-mm film of the video output obtained during System Test No. 2 of Flight Model III-3 revealed that the lens assembly of the GSE Film Recorder was out of focus. The polaroid pictures taken during the test were in focus but the 35-mm film was defocused. Investigation traced the problem to a loose focus-retaining clamp in the optics for the 35-mm Film Recorder. The clamp was loose and was accidentally jarred in an attempt to correct the positioning of picture information on the 35-mm film. The focus was optically adjusted and the clamp tightened. Subsequent test results indicated that the problem was corrected. (1200 line resolution with scan lines visible on slow video).
MR2253 11/17/64	Directional Coupler, Serial No. 1778, GSE		Power Surge	Ambient (JPL)	Accident	The GSE power-output recorder indicated a power increase from 63 to 83 watts during the final 10 seconds of the Post Y-Axis Vibration Electrical Checkout of Flight Model III-3. The 90-point telemetry indicated normal transmitter performance during the malfunction. The power-amplifier cathode current was normal which indicated that the reflection to the F- and P-Channel power amplifiers, due to isolation between the power amplifiers and the problem area, was insignificant. The malfunction was isolated to a 10-db directional coupler external to the TV Subsystem. This component was installed for hardline operation because the RF test configuration limited installation of a Stoddard antenna. The 60-watt transmitter output caused the 10-watt coupler to overload and burn out. This, in turn, caused a mismatch at the coupler and some loss of the 10-db isolation, which resulted in the apparent power rise. The coupler was replaced by a 10-db pad of sufficient power. An identical test was performed and normal TV Subsystem operation occurred, which confirmed that the TV Subsystem incurred no damage as a result of the failed direction coupler.
MR2254 11/24/64	F-Channel 225KC Tape Demodulator, Serial No. 3 GSE	F-Channel Discriminator	Noisy and Erratic Telemetry	Ambient (JPL)	Nonconfirmed	During pre-thermal-vacuum checkout of Flight Model III-3, F-Channel 225 kc telemetry was erratic and noisy. This condition occurred only during tape playback. The problem was isolated to the F-Channel discriminator, and was eliminated when the defective unit was replaced.
MR2255 11/30/64	Blockhouse OSE		Indicator Illuminated	Ambient (JPL)	Design	The "No Sync" indicator on the Rate 4 of the Blockhouse Control Panel Checkout Unit (CPCU) illuminated when the "Cruise Test On" switch was reset. The "Cruise Test" switch induced a transient on the line between the spacecraft and the Blockhouse which caused interference on the JPL Data Monitoring System (DMS). The interference was supressed by the addition of a 1-megohm resistor and a diode in the blockhouse panel. All blockhouse panels have been modified in accordance with RCA drawing Nos. 1755346 Revision C, and 1756512 Revision B.

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TABLE C-2
DETAILED TABULATION OF FAILURES REPORTED ON GSE (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
MR2256 11/30/64	Vacuum Failure Protection Assembly, GSE		Circuit Failed to Operate	Ambient (JPL)	Accident	The GSE vacuum failure protection circuit failed to operate when loss of vacuum was simulated to checkout the circuit. Investigation revealed the circuit was not wired in accordance with supplied drawing, but with JPL drawing No. B3349659. Internal wiring change of the circuit has been performed. JPL drawing No. B3349659 must be revised to reflect wiring change.
MR2257	Clock Timer Serial No. 55033-M1, GSE, Unit 18		Clock Hands Stuck	Ambient	Workmanship	The new Clock Timer that was installed in Unit 18 of OSE, Serial No. 4 did not function properly during performance of Mission Verification Test No. 1 on Flight Model III-3. The minute and hour hands stuck and gave improper readings; however, the sweep second hand functioned normally. The clock was removed for repair and replaced by a spare clock.
2267 12/28/64	Channel-8 Telemetry, Unit 17 GSE, Serial No. 004	N/A	Loss of Telemetry	Ambient	Accident	During the SFOF test of Flight Model III-3, Channel-8 telemetry was lost at C+30 minutes for a period of 1 minute and 43 seconds, due to dropout of the P-Channel external power supply. The d-c power switch on Unit 17 of the GSE was accidentally bumped and turned-off. This switch is activated by rotating it 90 degrees to a mechanical detent. If care is not taken, this switch can be activated without engaging the mechanical detent. If this condition is present, it is possible that the switch can be disengaged by bumping or by interference from the coiled operator's headset cord. As soon as the problem occurred, the switch was reactivated and cruise-mode telemtry reappeared. This condition cannot cause any stress or abnormalities to the spacecraft. All GSE operators have been instructed to exercise care to ensure that the mechanical detent on the d-c power switch is fully engaged at turn-on when operating from external power.
2303 1/15/65	Kinescope, Unit 6, GSE, Serial No. 003	N/A	Incorrect Focus Voltage	Ambient (ETR)	Accident	The kinescope focus voltage was incorrectly set 0.5 volt low during the TV backup clock functional test of RA-8 at ETR. This situation occurred after initial calibration of the GSE at ETR, and was due to an operator recording the focus-voltage setting from a portion of data sheets marked void. The voltage was adjusted to the correct level and the focus of the kinescope was confirmed during a back-up system test.
2304 1/18/65	Display Equipment, GSE, Serial No. 003	Diode DEP 24	Displaced Horizontal Lines	Ambient (ETR)	Random	A review of the 35-mm film from System Test No. 1 on RA-8 at ETR revealed that approximately 30 percent of the frames of the P1 Camera Sync Disable had several displaced horizontal lines. The problem was isolated to a shorted diode in the vertical pump circuit. The diode is connected from the trailing-edge sync to the clamp circuit and was added to prevent pulses of approximately sync width from dropping vertical. The problem was only encountered in the sync disable mode because of the line length of 800 usec., while normal P-scan is approximately 555 usec. The problem has been classified as random. The problem cleared when the shorted diode was replaced.
MR2308 2/5/65	Monitor and Control Panel, Rack No. 5, OSE Serial No. 3	5K Potentiometer	Difficulty in Syncing During Sync Disable Mode	Ambient (ETR)	Workmanship	A review of the 35-mm film obtained during the Final System Test revealed difficulty in syncing the P1 Camera during the sync disable operation. The trouble was isolated to an open circuit in the 5K-ohm potentiometer used to vary the time constant of the trailing-edge sync circuit, which develops horizontal unblanking, horizontal drive, and clamp

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TABLE C-2
DETAILED TABULATION OF FAILURES REPORTED ON GSE (Continued)

MR NUMBER AND DATE	SUBASSEMBLY AND SERIAL NUMBER	COMPONENT PART	FAILURE MODE	TEST ENVIRONMENT	CAUSE OF FAILURE	ANALYSIS AND CORRECTIVE ACTION
MR2308 2/5/65 (Cont'd)						drive only during P1-Camera free-run mode. The potentiometer was replaced, and the problem was corrected.
MR 2309 2/9/65	960-Line RF Preamplifier Serial No. 382-1 OSE 3		Preamplifier Not Functioning Properly	Ambient (ETR)	Random	During full power checkout at ESF, the 960-line preamplifier, which was located on the roof of Hanger AO, was not functioning properly. The amplifier, permanently installed on the Hanger roof, is in a water-proof container designed to withstand atmospheric conditions. The amplifier was removed and returned to the hanger for analysis. The cover was removed. Approximately 6 ounces of water was found in the amplifier. An examination revealed that two leads to the electrolytic filter capacitor of the power supply were weakened by electrolytic action caused by the presence of water. The amplifier was replaced with Serial No. 382-2. The defective unit was thoroughly dried, and the leads were resoldered. The unit was then checked and found to be satisfactory. It was calibrated for gain and is to be used as a spare. The preamplifier installed on the roof has been protected with a plastic cover. Periodic mechanical and electrical inspections shall be performed. If the unit is still susceptible to atmospheric conditions, it will be installed prior to test and not left on the roof.
MR 2310 2/9/65	Film Recorder Serial No. 3	Switch A-14	Intermittent Video Signal	Ambient (ETR)	Workmanship	During a review of the 35-mm film obtained from the RA-8 full-power ESF checkout, it was noted that several frames of video were broken up due to what appeared to be intermittent operations of the OSE film drive unit. This unit was disassembled and lubricated, but the problem was not corrected. A further analysis isolated the problem to an intermittent operation in the a-c contacts of the Motor On switch in film recorder No. 1. The switch was replaced and 4000 frames of film were recorded with continuous turn-on and turn-off. There was no recurrence of the problem.

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a. SCR Desensitizing

(1) Design Modifications. In order to prevent an inadvertent turn-on of the Subsystem, the following design modifications have been made to the SCR desensitizing circuits:

- A 0.1-microfarad capacitor has been connected from gate to cathode on the SCR's to permit the cathode and gate to vary in unison to rapid external stimuli;
- Normally closed contacts of relays K1 and K2 in the HCVR's are connected in series between the gate and the cathode of the SCR's. With this arrangement, the cathode and gate are permitted to vary in unison at low frequencies without causing SCR turn-on;
- A 0.1-microfarad capacitor shunts the SCR, decreasing transients across the SCR; and
- Components of the SCR desensitizing circuits have been located in close proximity to the SCR's to increase the reliability of this circuit.

(2) Failure-Mode Analysis.

(a) SCR Short Out. A short out in the SCR would apply battery voltage directly to the unregulated bus and turn on the HCVR. If the short-out occurs during the critical-pressure environment of the launch phase, high-voltage arcing occurs, and the channel will burn out. If the conditions described by the new modifications are still in effect in the opposite channel, that channel will remain off.

If the SCR short-out occurs outside the critical-pressure environment, the on-board full-power commands would be actuated; that is, the Sequencer accumulator and CC&S full-power circuits would operate. When this occurs, the shorted channel cannot be turned-off. Ninety-point telemetry would be switched to the Channel-8 3-kc VCO. Finally, the battery would fully discharge, and the channel would be of no future value.

Replacement of the SCR with another component would not provide a solution, since any component would have the same potential failure mode.

One possible method of averting a short-out of the SCR is to place a turn-off switch in series with the SCR. Any series element used in this manner must be capable of carrying the full-load current, and of breaking it when a shorting situation occurs. It must also be able to close upon command; that is, it must be a contactor which may be actuated between separation and lunar impact.

A positive-acting, squib-firing contactor would not be resettable, and therefore would not be satisfactory for this application.

The failure of a series device to actuate upon command would destroy the ability of the channel to function altogether. Therefore, any series device used to increase the confidence that a channel will not turn on inadvertently by a short-out of the SCR merely presents new potential failure modes and at the same time, lowers confidence in the ability to turn on when desired.

It is concluded that the most reliable corrective action would be to take measures to prevent the short across the SCR from occurring. To eliminate external shorting across the SCR, all battery terminals in close proximity to the unregulated bus or other busses should be coated. This includes the anode and cathode of the SCR and all components directly connected to the battery line.

(b) SCR-Gate Grounded. Grounding of the SCR gate would produce the same effects as the short across the SCR, with the exception that the ground may burn out, and the channel would turn off. It is unlikely, however, that this would occur before the gate is destroyed.

A high-current contactor might be used in place of the SCR as a corrective measure against such a failure. However, if its control line (at the proper end) touched ground, it would produce the same effect as the SCR gate touching ground. The contactor would close and turn the channel on. However, if the Subsystem was not in the critical-pressure environment, and the relay was not of the latching type, the channel would turn off when the ground was removed. In order to be considered as a reliable replacement for the SCR, a contactor must have the following characteristics:

- It must be able to take a 16-ampere current load on each contact into a 50-microfarad capacitor.
- It must be able to carry 16-amperes for 1 hour and then break the 16-ampere from an inductive load (each contact).

This implies, for proper design, that each contact must be able to break 32 amperes if the 50 percent de-rating is to be followed.

- It must withstand Ranger launch-environment specifications (no closures during vibration).
- It must be able to be cycled many times (more than 100 during testing alone) and still be considered trustworthy for flight.
- It must have positive latching action in the "on" position to ensure battery connection if a failure should exist in the command circuitry after it is commanded on.

No contact examined was capable of meeting these requirements.

The recommended action for preventing grounding of the SCR gate is to coat all terminals and components of the gate in such a manner as to prevent their easy shorting. It is unlikely that a short on the gate will take place if this precaution is met.

(c) The 0.1-microfarad Capacitor opening or Shorting and the K1 and K2 Relay Contacts Not Transferring. Opening of the 0.1-microfarad capacitor thin lead breakage is unlikely, since the potting will prevent its mobility and a short on this value capacitor is not likely. Failure of the K1 and K2 relay contacts to transfer would require a double contact failure from two separate relays. This is very unlikely and extremely difficult to analyze. A dry-circuit condition could arise on either contact; but because of the 0.1-microfarad capacitor, high-frequency noise would be shunted around these contacts. Therefore, the possible problem caused by a dry circuit, if it did occur, would be minimized.

(d) Contact Bounce on K1 and K2 Relays. A recommendation has been made for preventing inadvertent turn-on due to contact bounce of the K1 or K2 relays. The equivalent circuit for this case is shown in Figure 8-8.

The stray capacity which exists on the enabling (S + X) wire provides a possible return path for the gate wire when and if the relay contacts bounce. Assuming 40 feet of wire and a stray capacitance of 10 $\mu\mu$farads per foot for a total of 400 $\mu\mu$farads, the voltage developed across the gate to cathode junction will have the characteristics shown in Figure 8-9.

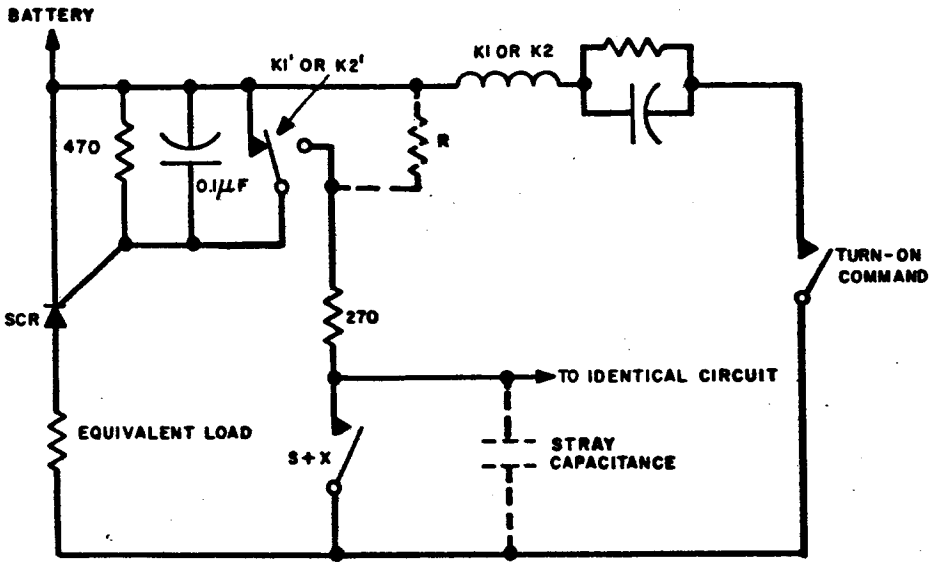
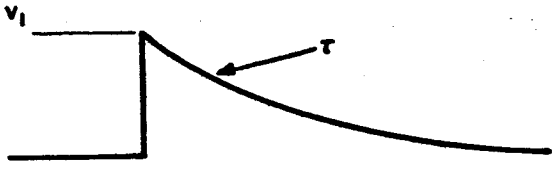


Figure 8-8. Single relay turn-on circuit



WHERE V_1 $36 \times \frac{400}{10,400} = 1.39$ VOLTS

AND $\tau = (470)(0.1)(10^{-6}) = 47\ \mu$ SECONDS

Figure 8-9. Pulse across gate-to-cathode junction

This possible inadvertent turn-on mode can be eliminated with the addition of resistor R. It is evident, however, that an additional failure mode is introduced in the event this resistor shorts. However, this failure mode seems remote if the recommendation of potting the gate components is observed. Therefore, this resistor has been incorporated in the SCR gate and appears as the 100K ohm resistor R3 in A1A1.

(e) dv/dt Desensitizing Circuit. To prevent a rapid dv/dt across the SCR where the battery voltage is applied, upon installation of batteries, a cathode-to-anode circuit on the SCR was proposed by the General Electric Company, the supplier of the SCR. This desensitizing circuit, shown in Figure 8-10, relies upon the time constant developed by the load inductance in the unregulated bus and the impedance developed across the 50-microfarad capacitor C2 at high frequencies. The resistance between the SCR anode and the capacitor is approximately 0.1 ohm.

The impedance of the 50-microfarad capacitor C2 between the anode of the SCR and ground is dependent upon the frequency component of the step voltage. (See Figure 8-11.) Because of this dependence, the dv/dt across the SCR becomes frequency dependent.

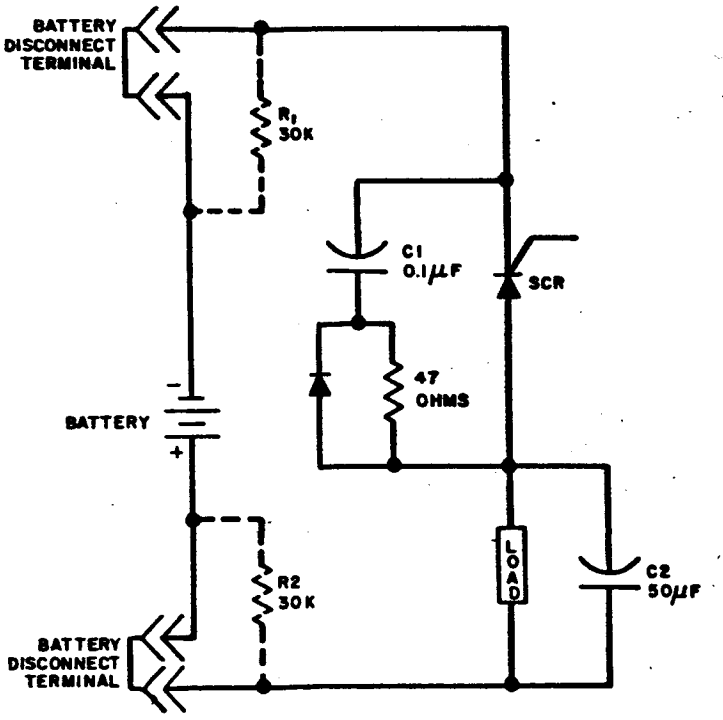


Figure 8-10. Noise suppression across the SCR

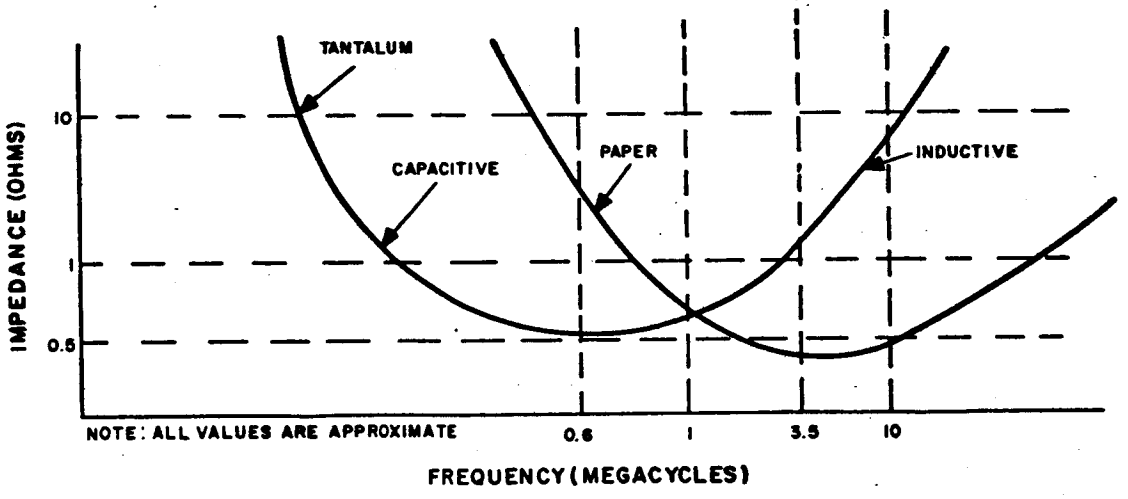


Figure 8-11. Typical Z versus frequency characteristics of tantalum and paper capacitors

The division C_1 and C_2 is such that, except for relatively high frequencies, the full voltage is across the SCR. This would occur when the battery disconnect plug was being applied. For this reason, the resistors R_1 and R_2 across the battery disconnect terminals are added, as shown in Figure 8-10. Insertion of the plug will not turn the SCR on because the battery voltage was previously applied through the two 30K-ohm resistors. The voltage dv/dt across the SCR is approximately 6 volts per millisecond.

Because of the impedance of the 50-microfarad capacitor to high frequencies, connector vibration will appear across it rather than across the SCR. The 0.1-microfarad capacitor will act as a short circuit to this variation. The 60K-ohm resistance between the battery and SCR limits the current through the SCR to less than the starvation current of the device. Therefore the disconnect plug is still effective.

b. Full-Power Back-up

The full-power control circuitry was analyzed and the following condition was made evident. If execution of a terminal maneuver is not necessary,

the RTC-6 command would not be sent and thus, the CC&S Full-Power command would not be sent to the Subsystem to provide full-power backup to the 5-minute accumulator of the Sequencer. Failure of the P-Channel Sequencer would disable the full power on that channel and the free running mode of camera P1 would be useless. Therefore, a circuit using RTC-7 commands was investigated and developed for assuring full-power backup to the Subsystem. However, JPL indicated that a pseudo-terminal maneuver would be available and would be initiated to enable the full-power backup command to be sent. Therefore, the need for this circuit was deleted.

c. Clock Inhibit Circuitry

The modified Clock inhibit circuitry has the following logic. At S+0, the clock-start command is capacitively coupled to the "set" side of the K1 relay in the DCU and "reset" of the K4 relay in the CCU. The "set" on the K1 relay in the DCU applies voltage from the F-battery to the clock. The "reset" on the K4 relay in the CCU opens the clock-relay reset line to RTC-5 and opens the clock-output line to the F-Channel SCR gate turn-on circuit.

The 32-hour output from the Clock is capacitively coupled to the base of Q1, causing relay K4 to set. This enables the Clock output pulse and enables the reset coil of the clock-control relay. Prior to this time, RTC-5 cannot be used to turnoff the Clock.

For ground test, the Clock control relay can be set by activation of K1 in the CCU.

The following are the worst-case design parameters of this circuit:

Impulse time at S+0

$$\underline{C} \times \frac{K_{\underline{3r}} \quad K_{\underline{1r}}}{K_{\underline{3r}} + K_{\underline{1r}}} = 40 \times 10^{-6} \times 510 = 20.5 \text{ msec.}$$

The maximum pickup time for both K1 and K3 is 3.5 milliseconds.

(1) Transistor Circuit Evaluation. The transistor circuit is shown in Figure 8-12.

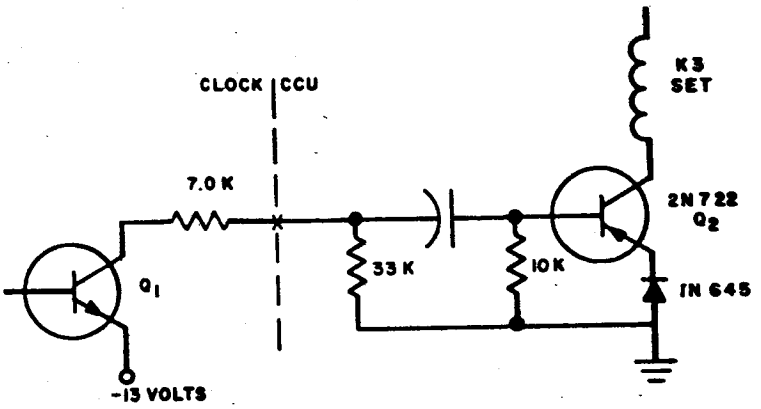


Figure 8-12. Clock-Transistor circuitry

Q_2 Max $\dot{Y}_{co}$ @ 55°C = 50 uA

V_{eb} = +.7 +.8 -.5

V_{eb} = +1.0 worst case

V_{CER} = 40 volts

R_B = 10K

Max V_{CER} = 39.5 Volts

Assume .5V drop across Diode

Min. B = 40 Max. B = 80

Assume IV drop on diode & .8 volt drop eb = +1.8 Volts

Assume -13 volt supply @ 11.0 Volts

$$\text{Eq gin} = \frac{-11}{7K + \underline{33K}} \times \underline{331C} = \frac{290 \times 10^{-3}}{8.4 + 26.4} = 9.55 \text{ Volts}$$

$$\underline{\text{Step}} \text{ on base} = -9.55 + 1.8 - 7.7 \text{ Volts}$$

$$I_b \text{ Shunt} = \frac{V_b}{\underline{10K}} = .225 \text{ ma}$$

Available $I_b = \frac{9.55 - 1.8}{7\ IC} = \frac{7.7}{8.4} = 0.92$ ma

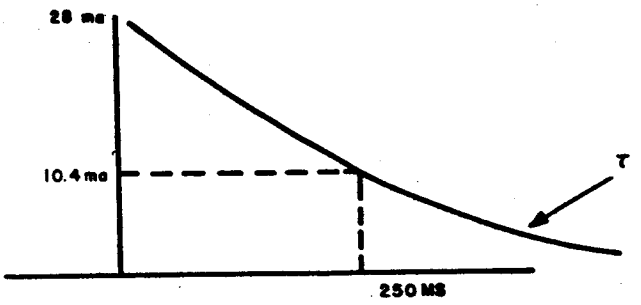
$i_b = .92 - .225 = 0.7$ ma

B = 40

$i_c = 28$ ma

discharge time IRC = 40 x 6.6 x $V0^3$ = 250 ms

Min I_{coil} for Set = 8.5 ma. @ 3.5 msec



d. Interface Connections

Table 8-2 summarizes the analyses of the effects of potential failure modes at the Pad/Agena and Agena/Bus interfaces.

TABLE 8-2
POTENTIAL FAILURE MODES AT INTERFACE CONNECTIONS

Potential Failure Mode	Effect on TV Subsystem
A. Failure at Umbilical Connector	
1. Pin D (Cruise On) shorts to Ground	a. No effect; K1 & K2 Relays in CCU are returned to ground
2. Pin D shorts to Battery Monitor	a. Maximum current taken is 4 ma; Insufficient to energize K1 and K2 relays in CCU

TABLE 8-2
POTENTIAL FAILURE MODES AT INTERFACE CONNECTIONS (Continued)

Potential Failure Mode	Effect on TV Subsystem
3. Pin D shorts to Pin Y (Cruise-Off)	a. No effect on mission
4. Pin D shorted to Battery Monitor	a. Same as Pin D shorting to ground (see 1.)
5. Pin D shorted to Pin X (Reduced Power P)	a. Channel P locked in Reduced-Power Mode. Capability of going to Full-Power Mode is inhibited. This fault should be cleared at Agena Separation when the Clock-control relay is energized
6. Pin D shorted to Pin A (Reduced Power F)	a. Same as Pin D shorted to Pin X (5.) except Channel F is affected.
7. Pin A shorts to Pin B	a. Slight drain on one battery due to 20K-ohm coupling. Probably no deleterious effect on over-all mission
8. Pin A or B shorts to Pin D	a. Slight drain on one battery (4ma maximum) should have no effect on mission
9. Pin A or B shorts to Pin Y	a. Will not reset Cruise-Mode relay in CCU. Current is limited to 4 ma.
10. Pin A or B shorts to Pins X or A	a. Reduced-Power relays will not activate. 10K-ohm resistors in monitor lines limit maximum current to 4 ma.
11. Pin Y shorted to Pin X or A	a. Possible reduced-power mode of operation in F- or P-Channel. This fault should be cleared at Agena separation.
12. All pins shorted together	a. The effect would be the same as for each pin individually shorted to ground since Battery Monitors are short-circuit limited.

TABLE 8-2
POTENTIAL FAILURE MODES AT INTERFACE CONNECTIONS (Continued)

Potential Failure Mode	Effect on TV Subsystem
B. Failures at Agena Separation	a. Analysis is the same for failure modes at the umbilical connector.

Note: In the analysis of the potential failure modes at the Agena umbilical connector, the pin designations used are those at the JPL Bus/TV Subsystem interface, since the umbilical connector contains the extensions of these lines.

e. Channel Turn-off Circuits

Table 8-3 summarizes the analyses of the potential failure modes that may occur in the F- and P-Channel turn-off circuits located in the CCU. Diodes CR3, CR4, CR7, and CR8 provide isolation of the F- and P-Channel turn-off circuits. Therefore, the analysis presented in Table VIII-3 effects either channel equivalently.

TABLE 8-3
EFFECT OF POTENTIAL FAILURE MODES IN THE P- AND F-CHANNEL TURN-OFF CIRCUITS

Potential Failure Modes	Effect on F- or P-Channel
A. SCR Short (SCR1 or SCR2)	
1. Anode-to-Cathode	a. If channel is on, it will be turned off. Channel can then be turned on again. b. If channel is off, unregulated bus will be present for approximately 460 μseconds max. Nothing actuates during this time. Channel can be turned on by command, but cannot be turned off.
2. Gate-to-Cathode	a. Channel Turn-on capability is still effective. b. Channel turn-off capability is lost.

TABLE 8-3
EFFECT OF POTENTIAL FAILURE MODES IN THE P- AND F-CHANNEL TURN-OFF CIRCUITS
(Continued)

Potential Failure Modes	Effect on F- or P-Channel
3. Gate-to-Anode	a. Channel turn-on capability is still effective. b. Channel turn-off capability is inhibited.
B. SCR Open (SCR1 or SCR2)	
1. Anode-to-Cathode	a. Channel turn-off capability is inhibited.
2. Gate-to-Cathode	a. Channel turn-off capability is inhibited.
C. 120-microfarad Capacitor (C1 or C2)	
1. Open	a. Channel turn-off capability is inhibited.
2. Shorted	a. Channel turn-off capability is inhibited.
D. 36K-ohm Resistor (R3)	
1. Shorted by grounding of SCR Anode	a. Channel will not turn off at RTC-5 command, and turn-off SCR will burn out. b. 120-microfarad capacitor (C1 or C2) will be charged up through a very low impedance and possibly be damaged. c. This failure mode can be prevented by potting all bare terminals around the SCR anode lines.
2. Open	RTC-5 turn-off command will not turn off the channel.

TABLE 8-3
EFFECT OF POTENTIAL FAILURE MODES IN THE P- AND F-CHANNEL TURN-OFF CIRCUITS (Continued)

Potential Failure Modes	Effect on F- or P-Channel
E. 470-Ohm Resistors (R1 and R4 in SCR Gate)	
1. Shorted	a. Same as gate-to-cathode short on SCR; Channel can be turned on but cannot be turned off.
2. Open	a. SCR gate circuit becomes more noise-sensitive because 0.1-microfarad capacitor in the SCR gate will not discharge.
F. 0.1 Microfarad Capacitor in SCR Gate	
1. Shorted	a. Same effect as gate-to-cathode short on SCR (See A2).
2. Open	a. Loss of SCR gate-to-cathode noise protection. b. Channel turn-off can still be accomplished.
G. 270-Ohm Resistors (R2 or R5 in RTC-5 command line)	
1. Short	a. Turn-off SCR will fire when commanded but will be damaged beyond further use.
2. Open	a. Channel turn-off capability is inhibited.

In addition to the potential failure modes analyzed in Table 8-3, another condition that represents a possible failure mode in the channel turn-off circuits is high SCR leakage current.

If the leakage current is high (approximately 1 milliampere), the voltage drop across the 36K-ohm resistor (R3 or R6 in the CCU) will not be negligible, and the turn-off step voltage will not be adequate for accomplishing channel turn-off. The leakage

current was tested on a typical SCR at ambient temperature and was found to be approximately 0.8 microamperes. This current through the 36K-ohm resistor developed 2.9 millivolts. These units (C35's) will be tested for leakage current with temperatures as high as the Ranger qualification limits.

f. Command Turn-on Circuit

These circuits are decoupled from one another at the high-current regulators. Each command is isolated from the other by diodes and coupling capacitors. A ground on any one of these lines does not negate the other command from functioning properly on that channel.

A typical command signal, taken through worst-case design, is shown in Figure 8-13.

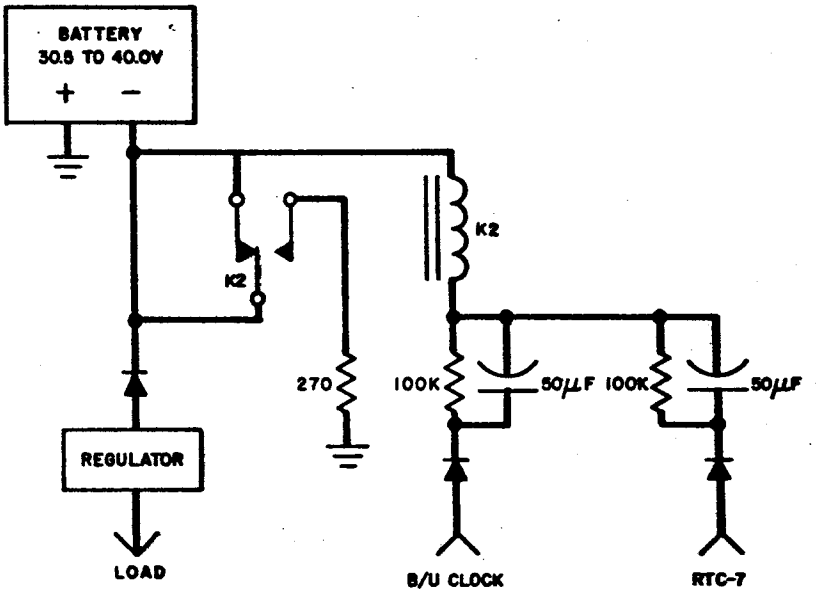


Figure 8-13. SCR turn-on circuitry for worse-case analysis

Worst case relay capacitor differentiator

Coil R = 1.25K forward, 20K Reverse ±10%

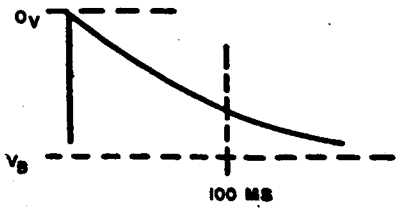
Capacitor = 50 μf $^{-15}_{+50}$

Coil dropout occurs at approximately 7 ma at 25°C.

Pickup time = 3.5 ms max.

Dropout time = 3.0 ms max.

Cap at max. and coil at max. and Battery @ max.



I min for dropout X $\overline{K}_r$ = dropout E

$7 \times 10^{-3} \times 1.37 \times 10^{3} = 9.6$ volts

V_b = 40.0 V @ IRC = 14.8 V @ 2 RC = 7.4 volts

$\overline{C} \times \overline{K}_r = 75 \times 10^{-6} \times 1.37 \times 10^{3} = 102$ msec.

RTC-7 operate time is 100 to 200 msec.

In worst case, the switch will break $\frac{14.8 \text{ volts}}{1.37}$ ma = 10 ma inductive

Nominal

Dropout @ 9.6 volts

$C \times K_r = 50 \times 10^{-6} \times 1.25 \times 10^{3} = 62$ msec.

Dropout occurs @ 1.5 RC

Therefore dropout is @ 90 msec. The pulse is gone before nominal RTC-7 opening.

Worst case minimum

$\underline{C} \times \underline{R} = 40 \times 10^{-6} \times 1.1 \times 10^{3} = 44$ msec.

Min holding voltage at V_{Bat} = 30.5 volts.

$7 \times 10^{-3} \times 1.1 \times 10^{3} = 7.7$ volts dropout

V_{Batt} @ 1 RC = 11 volts; @ 2 RC = 5.5

Therefore, dropout is approximately 1.5 RC.

Relay picks up in 3.5 ms and holds for approx. 30 msec.

g. SCR Gate Drive Resistor

Worst case SCR gate resistor

$$\frac{\overline{V}}{R\ ser} = \frac{40.0}{220} = 180\ ma$$

$$\frac{V_{nom}}{R3} = \frac{36.0}{270} = 133\ ma$$

$$\frac{\underline{V}}{R\ ser} = \frac{30.5}{325} = 94\ ma$$

Worst case SCR turn on current @ 0°C

= 90 ma

Worst case current through 4.7K @ V

$$\frac{V}{\underline{R}} = \frac{1.0}{375K} = 0\ ma.$$

With all conditions at their absolute worst, i.e., carbon resistors ±5% taken at a 20% duration for age, etc., there is a cushion of 4 ma for the SCR gate with the values shown.

At worst case, the RTC-7 command line draws 180 ma. Nominal is 133 ma.

h. Failure Mode Analysis of Diode "OR" Network Equivalent Circuit

The circuit of the diode "or" network is shown in Figure 8-14.

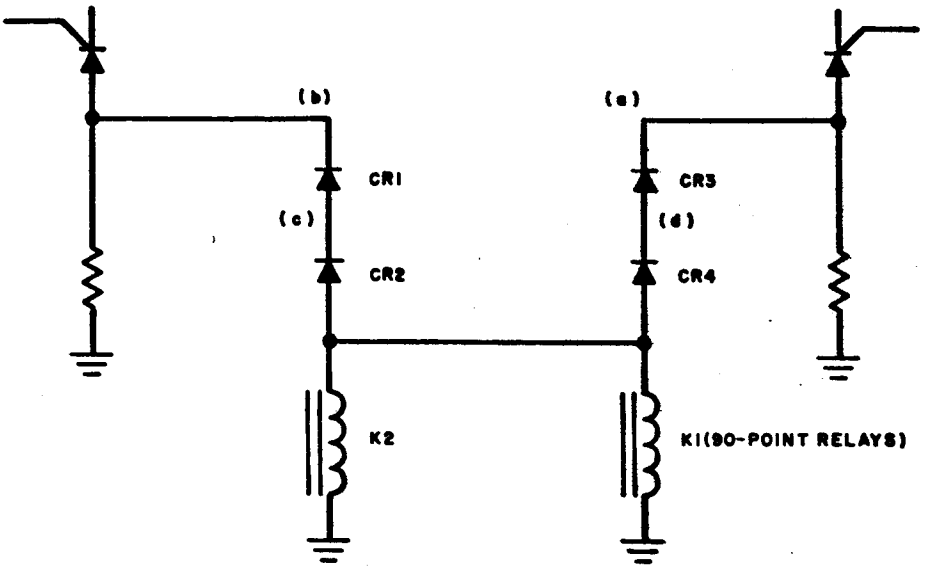


Figure 8-14. Equivalent diode "or" network

(1) CR1 or CR2 or CR3 or CR4 Short

(a) 90-point relays will energize if either channel is in warmup. This failure mode will have no effect on the system.

(2) CR1 or CR2 or CR3 or CR4 Open

(a) The channel associated with the open diode will not be able to operate the 90-point telemetry relays. (Failure of 90-point telemetry relays to activate requires that two failures occur. Namely, one channel does not come into warmup and the open diode associated with the other channel fails, or one diode in each leg fails.)

(3) Short Circuit (a) to (c) or (b) to (d)

(a) This failure mode can cause turn-off of the channel with the lowest unregulated bus voltage. (See comments under (4).)

(b) 90-point telemetry will be activated.

(4) Short Circuit (a) to (b) or (c) to (d)

(a) This failure mode can cause turn-off of the channel with the lowest unregulated bus voltage.

(b) 90-point telemetry will be activated.

Recommendation: The diodes shall be mounted in a straight-line configuration as shown in Figure 8-15, with all terminals coated to prevent the failure modes of paragraphs (3) and (4)

i. e.:

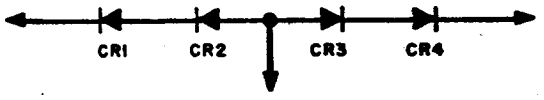


Figure 8-15. Straight line diode configuration

Worst case using 1N538 diodes

The Specification on 1N538 worst case is:

PIV = 200 v

I_F = 400 ma @ 150°C

= 15 amp Surge @ 25°C

V_{drop} max. + 1 Volt @ 500 ma @ 25°C

Nominal

PIV = 350 V

I_F = 750 ma @ 50°C

V_{drop} = 0.5 V @ 250 ma @ 150°C

The worst case voltage output to the input of the telemetry unregulated bus regulator is:

V_{Batt} = 30.5 volts

V_{drop} on SCR = 1.2 V Max. @ 16 amps

V_{drop} across diodes 2.0 Volts @ 500 ma

V_{output} = 30.5 - 3.2 = 27.3 volts min

V_{Bat} = 40.0 volts

V_{drop} on SCR = 0.7 volts @ 8 amps

V_{drop} across diodes 1.0 volts @ 250 ma

V_{output} = 40.0 - 1.7 = 38.3 volts

The current is limited by this telemetry regulator below 3.0 amps, depending upon the setting of output regulator potentiometer; therefore, fusing this line is of no use. Assume the short circuit current is drawn through the diodes. The higher unregulated bus will furnish this current and possibly short the series diodes. This eliminates the forward voltage drop through these diodes and raises the back bias on the blocking diodes for the opposite channel unregulated bus. Barring a second failure (these diodes also shorting), this failure does not harm the mission.

j. Command (Turn-on) Component Failure

(1) Gate Clamp Contacts (Series). Assume the CC&S warmup activates K2. Contacts K2' ground the gate of the SCR through K1', normally closed, and the

270-ohm resistor and S+17 normally open. Lack of proper contact on K1' negates this command. A possible corrective measure for this is to use the second set of normally open contacts on K1 and K2 in parallel between the SCR gate and the top of the 270-ohm resistor. However, this leads to the possibility of a failure due to the creation of wire congestion on the relay header. Congestion is undesirable in the area of the gate control components. This is the basic reasoning for not using these contacts for full-power backup. The same reasoning also holds for not jamming the header on the RTC-7 relay in the bus with wiring to the second set of contacts.

The likelihood of a dry circuit capable of holding up under the full battery voltage seems remote. Dry circuit is defined as a circuit contact incapable of passing 6 milliamperes. The contact resistance under these conditions would in the worst case be 5 megohms.

It would appear from comparing the likelihood of the fault versus the probable congestion on the header of the relays that the use of single contacts is preferable.

(2) Ground on Either the CC&S Warmup Line or the Clock Output Line. The isolation diodes on these lines prevent a failure of this type from interfering with the opposite command function. (See Figure 8-16.)

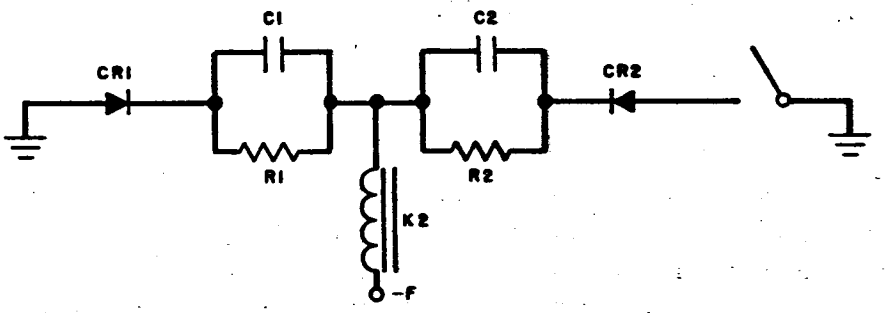


Figure 8-16. Isolation diodes

Assume the anode of CR1 is grounded and stays grounded prior to the time it is meant to be grounded. This sets up a charge across C1 of -F volts. C2 has a 0-volt charge across it. Grounding the anode of CR2 passes a ground through C2. The -F voltage across C1 now appears as a +F voltage on the cathode of CR1, back biasing this device. Therefore, the time constant for pick up of K2 is K2 R x C2. From previous analysis it is obvious that this relay will pick up.

(3) The De-sensitizing Circuit Cathode-to-Anode of the SCR is Analyzed Below

(a) Capacitor: 0.1 μf paper @ 100 volts (hermetically sealed)

(b) Screening tests:

- Seal test (100%) Static
- 72 hrs life test @ 1.4 times its rated voltage
- Insulation Resistance and dissipation factor are tested before and after shake test

(c) Failure mode: short

(d) 1N645 diode

- PIV: 225 volts
- Surge: 3A for 15 msec
- I continuous: 0.6 amp
- V_{drop}: 1 volt at .4 amp @ 150°C
- V_{nom}: 0.6 volt @ .6 amp @25°C
- Screening test: Not performed with PIV applied

Assume Capacitor shorts. The battery voltage is applied through the diode to 8 amp warmup load. This is in excess of the 3A surge current capability and the diode shorts. It is probable that the diode will open under the continuous current but if it doesn't, it will blow apart when the 16A full power current passes through it.

Assume Diode opens. The filtering action performed by the 0.1 f capacitor is no longer effective. It does not disturb the mission unless high-frequency noise is developed across the battery disconnect plug. This is a double fault condition and will not be analyzed here.

Assume Diode shorts. When the SCR is turned on, the capacitor (0.1 μf) discharges into the SCR internal junction. This condition may cause damage to the SCR. however, since the SCR was commanded on, it is not likely that the SCR will be turned on.

6. Conclusions

The following conditions have been met by the proposed command and control circuit:

- Insure as nearly as possible that turn-on will not take place until a real turn-on command is issued. This is accomplished by desensitizing the SCR and disabling all unnecessary commands during the launch phase.
- Insure as fully as possible that the Subsystem will turn on when intentionally commanded.
- Performed control switching for more meaningful telemetry.

C. Relay Circuitry Study for Replacing Silicon Control Rectifier

1. Initial Relay Studies

The circuits of Figures 8-17, 8-18 and 8-19 are the initial attempts to replace SCR's with electromechanical circuitry. The primary concept in the approach presented is to have a circuit with no possibility of inadvertent turn-on. The three circuits presented in their respective diagrams illustrate the basic approach. The diagrams as shown are for one channel only. The remainder of control circuitry has been omitted in order to most clearly show the SCR replacement circuitry.

Figure 8-17 is a "two-series switch" approach. The first switch is a squib which would not be allowed to close the circuit until after the critical pressure region (i.e., activate via midcourse, as an example). The second switch is either relay, K_1 or K_2, which is activated by one of the three (for F-Channel or two for P-Channel) turn-on commands. The relay does not require stringent environmental requirements with respect to "bounce", since during environmental stress the squib is open.

Relay K3 is the RTC-5 relay which allows the power to be removed from each channel. In this manner it acts exactly like the PCU of Flight Model III-1 in the SCR circuit.

The circuitry is redundant for maximum reliability. Common points are at the command inputs and HCVR input.

Figure 8-18 illustrates the same basic circuit as Figure 8-17. The major difference is the deletion of the squib in each battery line. This circuit presupposes a relay which cannot, under any expected or encountered environmental stress, exhibit relay bounce.

RE-ORDER No. 64-139

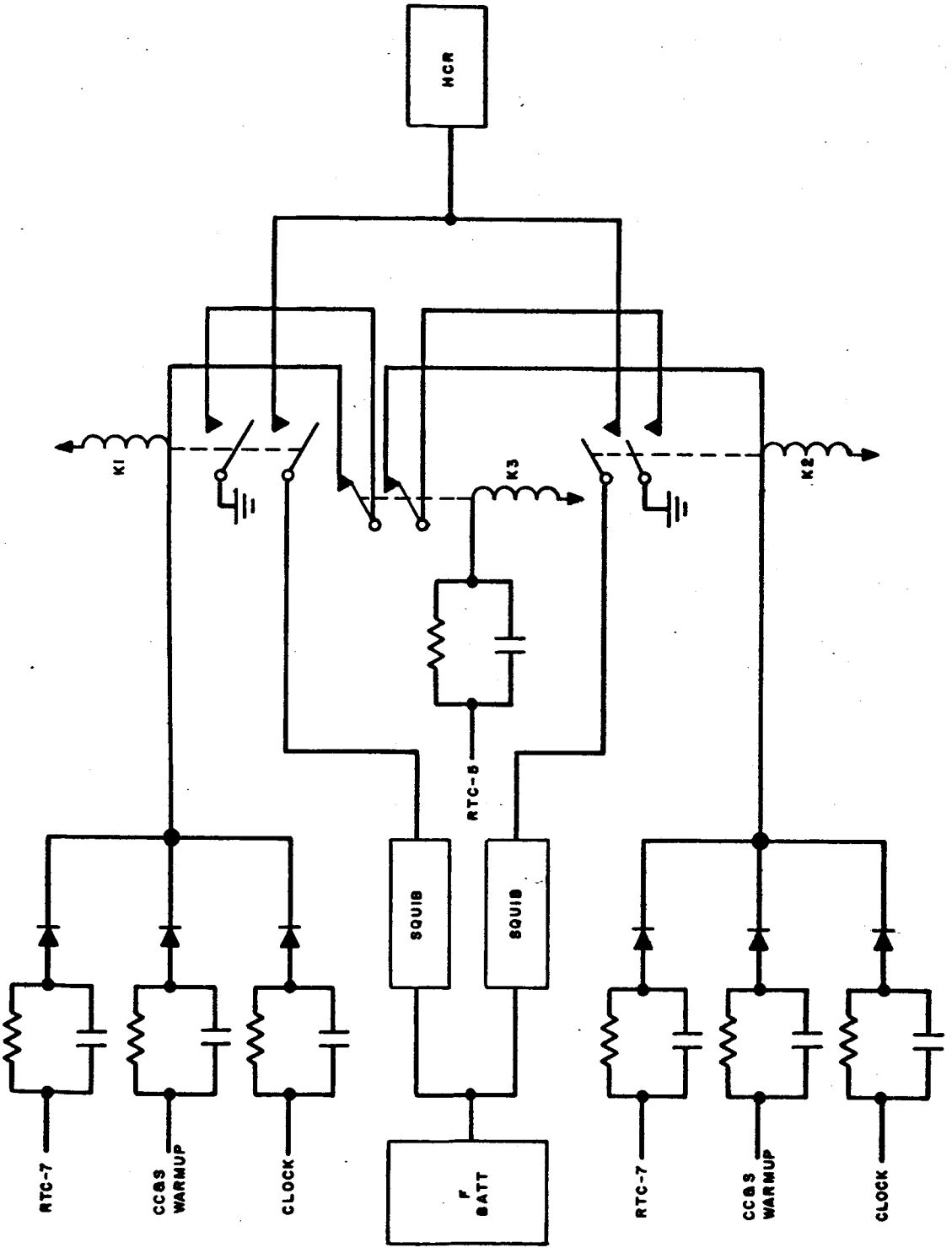


Figure 8-17. Circuit #1 two-series switches

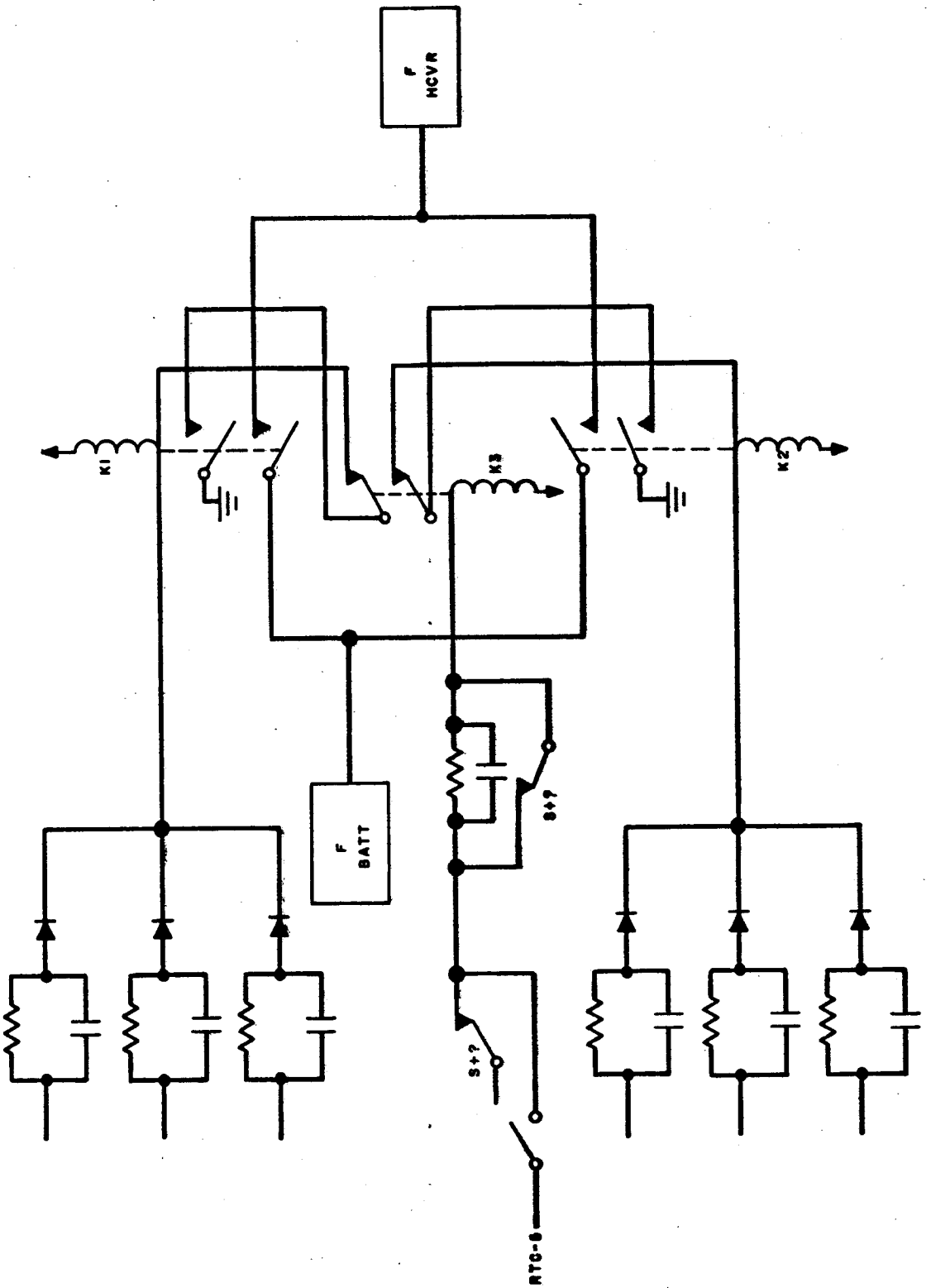


Figure 8-18. Circuit #2 one-series switch

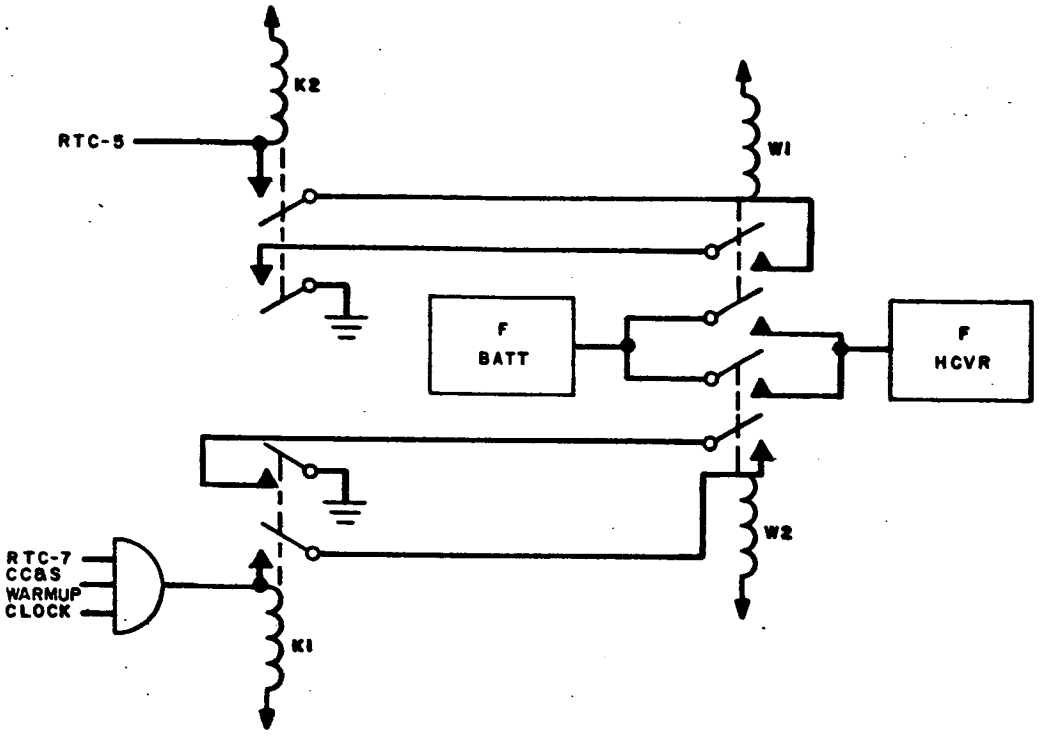


Figure 8-19. Circuit #3 motor driven switch

The other difference between Figures 8-17 and 8-18 is in the command circuitry for the relay K3. In Figure 8-18, an additional protective circuit is added to prevent the channel from locking "on" in the event power is inadvertently applied. A ground closure is applied during the launch phase which inhibits setting of relays K1 and K2. The circuit is redundant in the same manner as that in Figure 8-17.

Figure 8-19 represents an entirely different approach to the electromechanical switch. The device illustrated represents one similar to that used on the Ranger Bus to switch from external to internal power. The device is basically a number of normally open/normally closed switches driven by a reversible motor. W1 and W2 are motor windings used to drive the switches in their respective directions. K1 and K2 are used to properly direct the incoming commands.

Figure 8-20 represents the same basic idea as Figure 8-19. The only difference lies in the use of one latching relay rather than two holding relays.

Some preliminary discussions have been held between JPL and RCA to further specify and delineate a relay command circuit. Results of these discussions were rather inconclusive. For this reason, the three basic circuits are presented. Serious consideration of these devices would entail further investigation in order to narrow the choice down to the most desirable circuit.

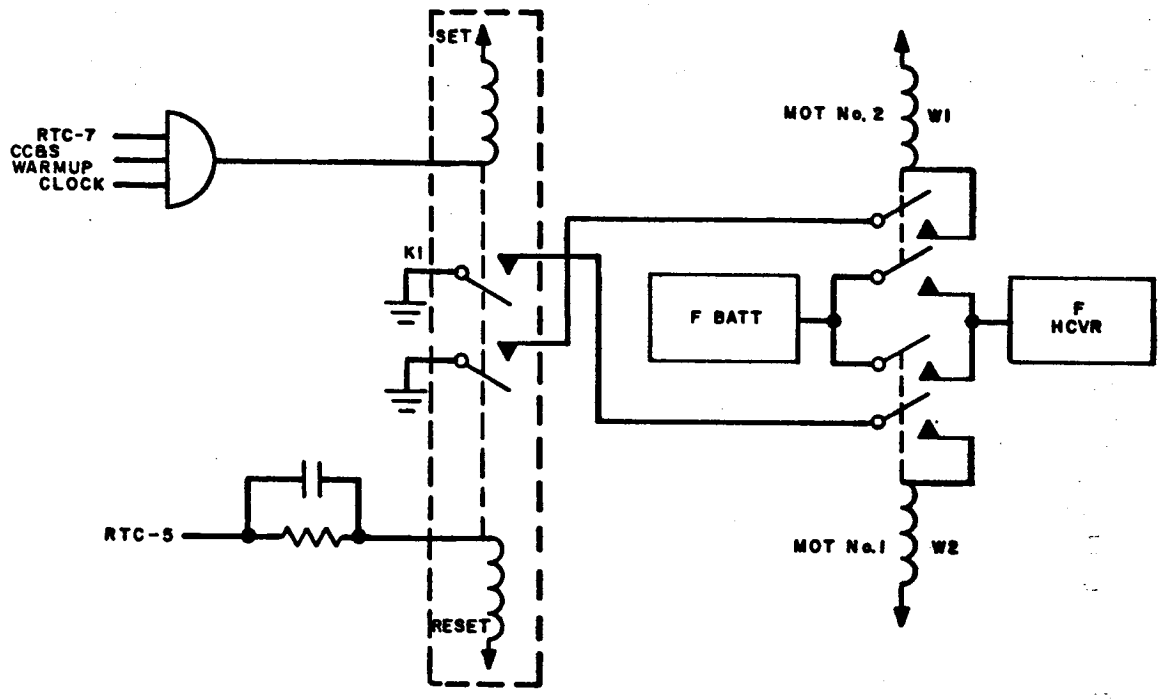


Figure 8-20. Circuit #4 motor driven switch

2. *Results of Relay Investigations*

The implementation of the relay studies employed a circuit as shown in Figure 8-21, which uses a relay as an electromechanical switch directly in the high-power line. The relay suggested for this application was the Babcock BR7X. Several of these relays were obtained and tested at RCA in a test circuit as shown in Figure 8-22.

- Test No. 1. Employing a bank of light bulbs as the 16-ampere load, relay serial number 198 was tested at 30 cpm with a 50% duty cycle. Contact No. 5 shorted after 10 operations.

- Test No. 2. Employing the same load, relay serial number 142 was tested at 30 cpm with a 50% duty cycle. Contact No. 5 shorted after 5 operations.

- Test No. 3. Relay serial number 142 was rewired as shown in Figure 8-23 to employ transfer contacting. This would prevent cooling-off of the lamp load and therefore reduce turn-on transients. The relay was tested at 12 cpm, with a 50% duty cycle and lasted over 1000 operations.

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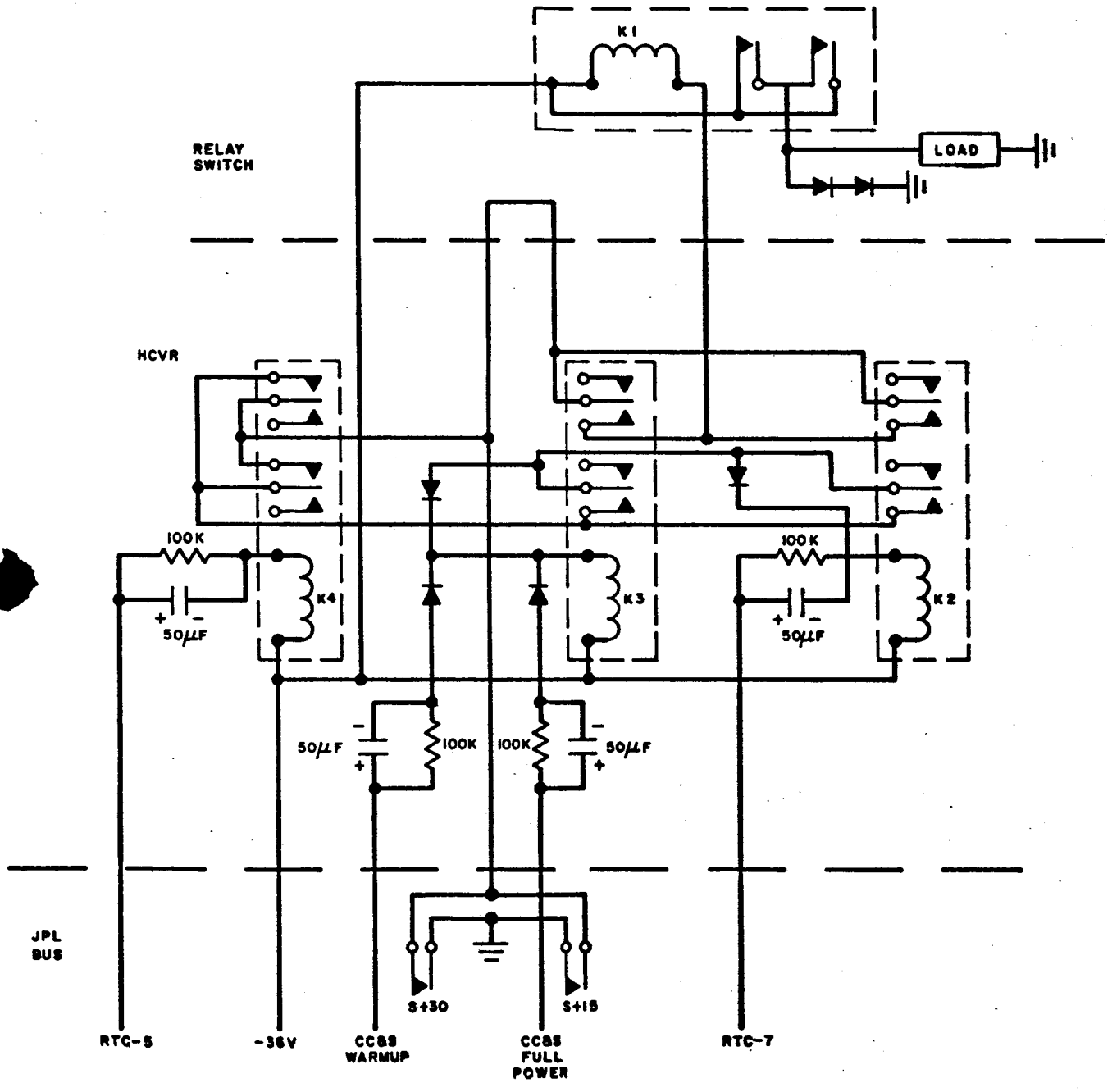


Figure 8-21. Schematic showing a relay as the main power switch

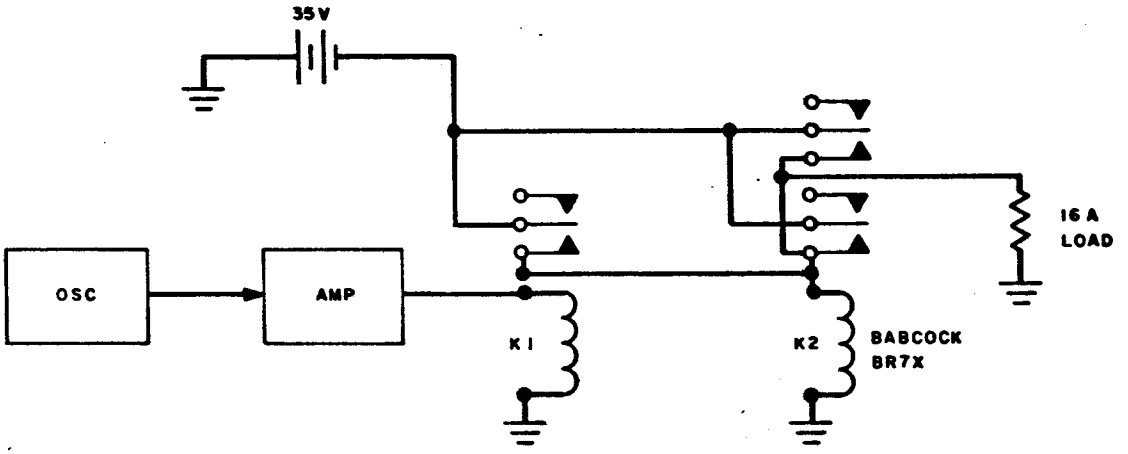


Figure 8-22. Relay test configuration with parallel contactors

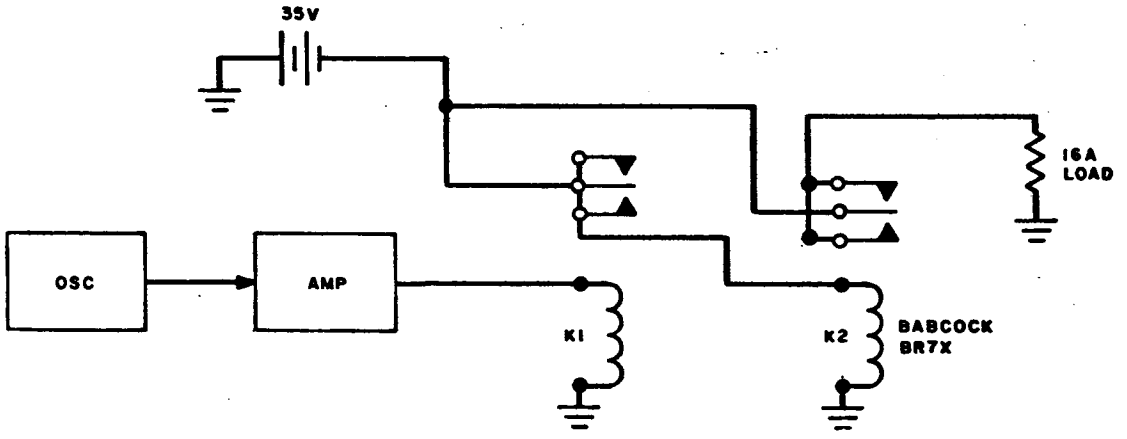


Figure 8-23. Relay test configuration with transfer contactors

- Test No. 4. Analysis of the circuit shown in Figure 8-23 showed that the relay was not being tested under the correct loading conditions. For this reason, relay serial number 17 was placed on test with a resistive load substituted for the lamp load. Contact No. 5 shorted after 156 operations.

- Test No. 5. Using a simulated Ranger TV Subsystem power load as shown in Figure 8-24a, relay serial number 179 was placed on test. The test was discontinued after 20 operations in order to add a diode to the load, as shown in Figure 8-24b, to simulate the series transistor in the TV Subsystem regulator circuit. The test was restarted at one cpm. After 60 operations contact No. 5 failed open. The test was allowed to continue overnight, using only contact No. 4. After 1000 operations the relay was still operating on contact No. 4. The test was then discontinued.

- Test No. 6. Employing the load shown in Figure 8-24b, relay serial number 221 was tested at one cpm. After 309 operations contact No. 5 became intermittent and after 340 operations the contact failed. Contact No. 4 became intermittent after 435 operations and the test was discontinued.

Upon completion of Test No. 6, the testing of a relay as the main power switch was concluded. The JPL-furnished relay logic was checked and found to be satisfactory with respect to all functions except the final switch relay.

3. *Results of Transistor Switch Investigation*

Upon the completion of the testing of the relay power switch it was decided to test a circuit which employed a power transistor as the actual switch and used a relay contact to provide the gating. The configuration shown in Figure 8-25, employing a manual switch, was assembled and tested with very good results. On the basis of this experience, the configuration shown in Figure 8-26 was assembled and tested. The room temperature measurements were:

- Transient load current: 40 amps.

- Transient base current: 6 amps.

The transistor was run at room temperature for over 1000 operations into the simulated load, at 12 cpm, and a 50% duty cycle, with no change in switching characteristics. The same test was run at -20°C, at 12 cpm, and at +60°C, at 6 cpm, with no change in switching characteristics. A check was made for troubles due to condensation by cycling between 0°C and +20°C, several times, with no change in switching characteristics.

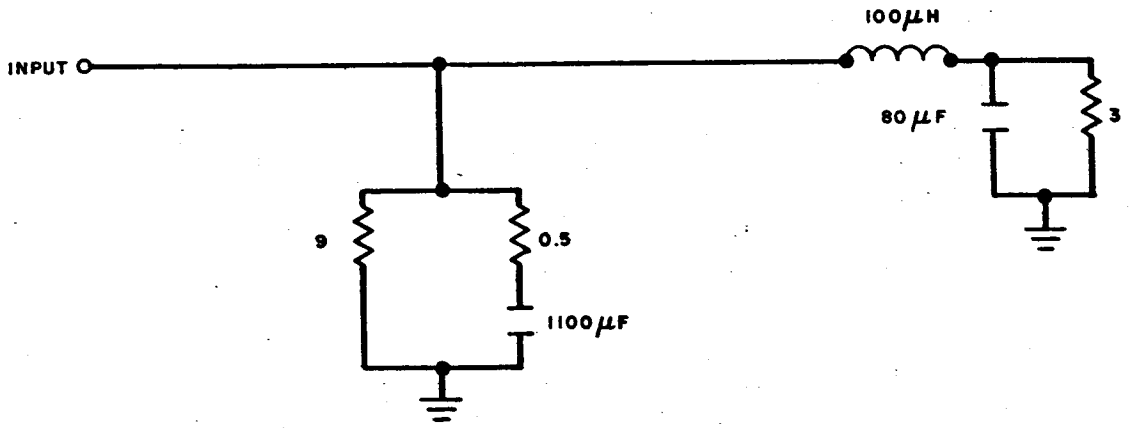


Figure 8-24a. Schematic showing equivalent to subsystem load

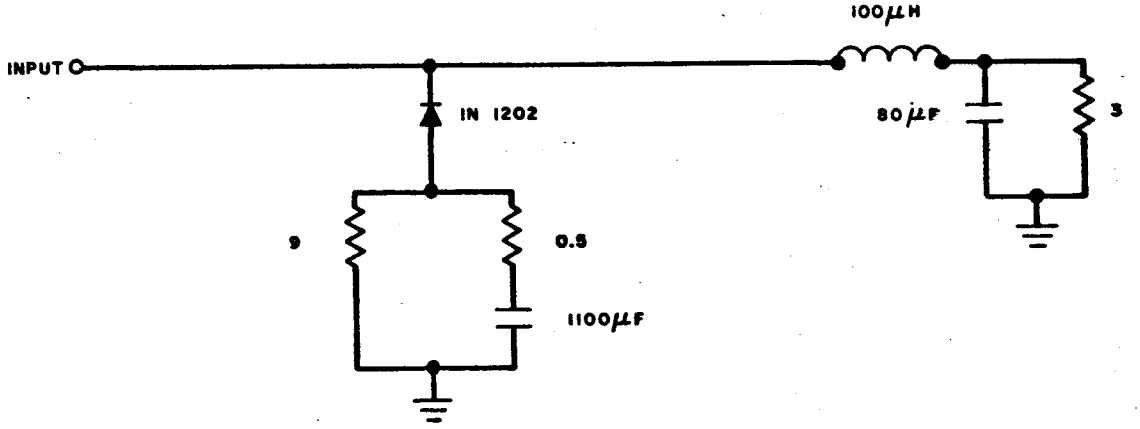


Figure 8-24b. Schematic showing equivalent to subsystem load (diode added)

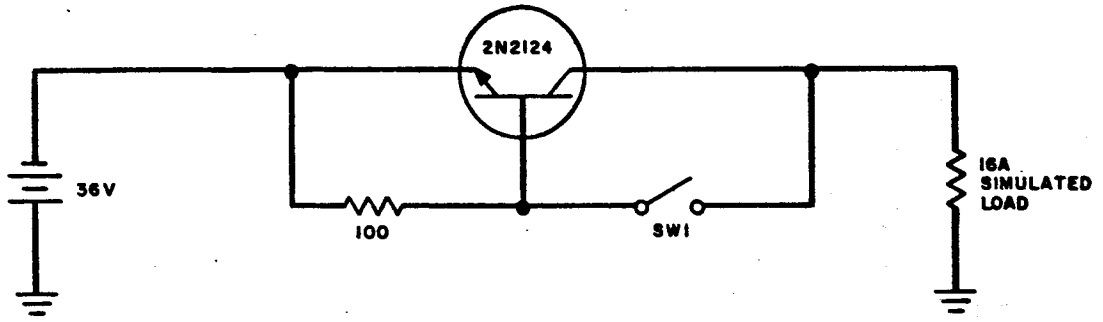


Figure 8-25. Circuit for test of a transistor as the power switch, gated manually

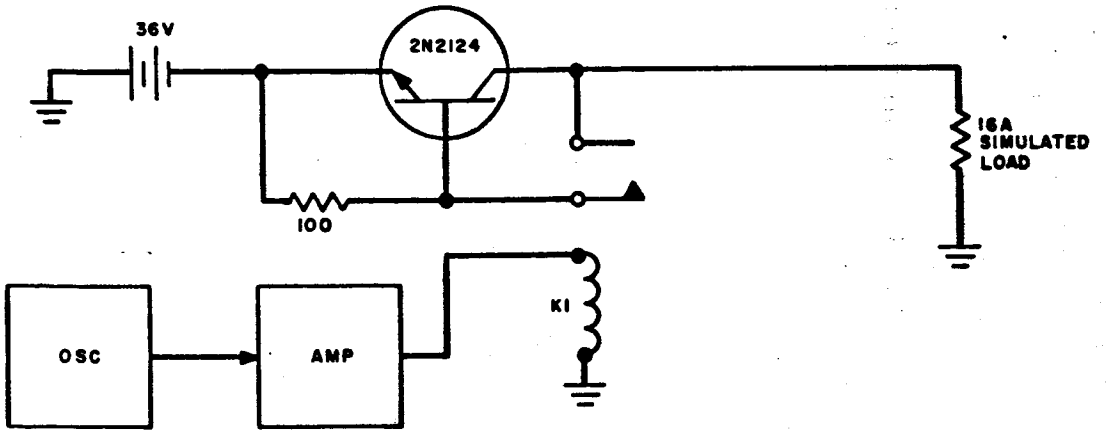


Figure 8-26. Circuit for test of a transistor as the power switch, relay gated

A computer analysis of the transistor switch circuit was made to determine if the transistor would be satisfactory under worst-case conditions. A total of 64 computer runs were made, at all possible operating conditions, and the worst transistor voltage drop was 1.55 V. The transistor power dissipation under these conditions is 24.5 watts, which is less than 10% of the rating of 250 watts.

4. *Conclusions*

The relays are rated at 10 amps with 50% derating recommended. The use of parallel contacts seems to help but the contacts will not open at exactly the same time, so one must carry the full load for a short period during the contact transfer. This period will vary with the specific unit.

Test Nos. 1, 2, 3, and 4 were performed with resistive loading. Tests 1 and 2 each employed double contacts to switch at a 30 cpm rate and the contacts welded after respectively 10 and 5 operations. Note that tests a, b, and c had incandescent lamp loading while d used a carbon resistor.

Tests Nos. 1 and 2 were conducted at a 30 operation per minute rate and failed in less than 10 operations. Test No. 4 was run at 1 operation per minute and the relay performed for 156 operations. It must be noted, however, that 1 and 2 used a lamp load while 4 used a cabron power resistor. The initial surge of current caused by the variable resistance of the lamps has not been measured and the limited availability of Babcock relays may not permit measurement of this surge in the required time.

Test No. 5 indicates that although the first contact may fail (after less than 60 operations), the second contact may survive over 1000 operations. Note that intermittent failures may have occurred during the unmonitored periods of operation.

On several occasions it has been noted that the relay contacts will short for a few operations and then open to continue with intermittent operation.

The transistor switch circuit will operate satisfactorily for more than 1000 operations at any temperature between -20°C and +60°C. The transistor is operated well within its ratings under these conditions.

The following conclusions are therefore felt to be in order:

- The JPL Relay Logic will operate satisfactorily to control the power switching element, with sufficient redundancy to prevent accidental operation.

- None of the Babcock relays tested operated for 1000 operations without failures. One of the five relays (serial number 179) would have performed satisfactorily, since the failure experienced was an open contact.
- Rapid operation adversely affects relay life.
- The simulated TV load greatly suppresses contact arcing.
- Contact welds tend to open after repeated operation.

D. Design Modifications to Telemetry Circuitry

Design modifications have been incorporated into the telemetry circuits of the Ranger TV Subsystem to ensure improved monitoring of the Subsystem during flight.

1. Telemetry Logic Modifications

In the modified Subsystem design, 15-point telemetry is available on the Channel-8 3-kc VCO prior to launch and/or during the launch phase through closure of the cruise-on as initiated from Ranger ground equipment. At S+17 minutes, the closure of a hydraulic timer relay in the JPL Bus will provide 15-point telemetry over the Channel-8 3-kc VCO during cruise mode, if this information was not commanded during the launch phase. At initiation of the warmup mode of operation, 15-point telemetry will be removed from the Channel-8 VCO and the 90-point telemetry will be transmitted over Channel 8 at this time (that is, when either unregulated bus is present). Simultaneously, 15-point and 90-point telemetry will be provided as inputs (225 kc) to the F- and P-Channel Transmitters, respectively, for transmission at full-power turn-on at the terminal mode. The logic for this operation is shown in Figure 8-2.

Further improvement in the telemetry operation is realized through an increase in the output-voltage scales, providing more accurate information from each telemetry point that is observed. The advantages associated with the revised telemetry logic are as follows:

- Transmission of 90-point telemetry is not dependent on the presence of the regulated current-limited bus for power.
- Presence of either unregulated bus starts the 90-point commutator and transfers the 90-point telemetry to the 3-kc VCO (Channel F) at the warm-up mode, thus providing two RF links when the P-Channel goes into full power.

- 90-point telemetry may be analyzed during the warm-up mode.
- 15-point telemetry is provided over the F-Channel Transmitter at full-power mode.
- 15-point telemetry is available during the launch phase.

2. *Telemetry Modifications*

a. High-Current Voltage Regulator

The High-Current Voltage Regulator was modified to improve the resolution of the telemetry outputs, both for the battery-voltage measurement and the regulated-output-voltage measurement. This modification entailed replacing a portion of the series-resistor network with zener diodes which act as a constant 22.5-volt source in series with the regulator sensor. There is a matched pair of temperature-compensated zener diodes in each circuit (see Figure 8-6).

In the former telemetry-readout circuit, the resistor chain consisted of a 150-kilohm and a 30-kilohm resistor in series. Consequently, with the 5 to 1 ratio between the series resistors, a 1-volt change in the 27.5-volt regulated voltage appeared as a 3.63 percent change in the telemetry readout.

In the modified telemetry readout circuit, all changes in the regulated output voltage appear as a change in the difference between the regulated output voltage and the zener-diode voltage. For example, where the difference between the regulated output voltage (27.5 volts) and the zener-diode voltage (22.5 volts) is 5 volts, a 1-volt change in the regulated output voltage appears as a 20 percent change in the telemetry readout. This represents a 5.5-to-1 improvement in the telemetry-resolution scale factor. Figure 8-27 is a graph showing the telemetry readout voltage as a function of the regulated output voltage using the modified circuit.

b. Low-Current Voltage Regulator

Only the regulated-output-voltage-measuring telemetry circuit of the Low-Current Voltage Regulator was being modified. This circuit is now identical to the regulated-output-voltage-measuring telemetry circuit used in the High-Current Voltage Regulator.

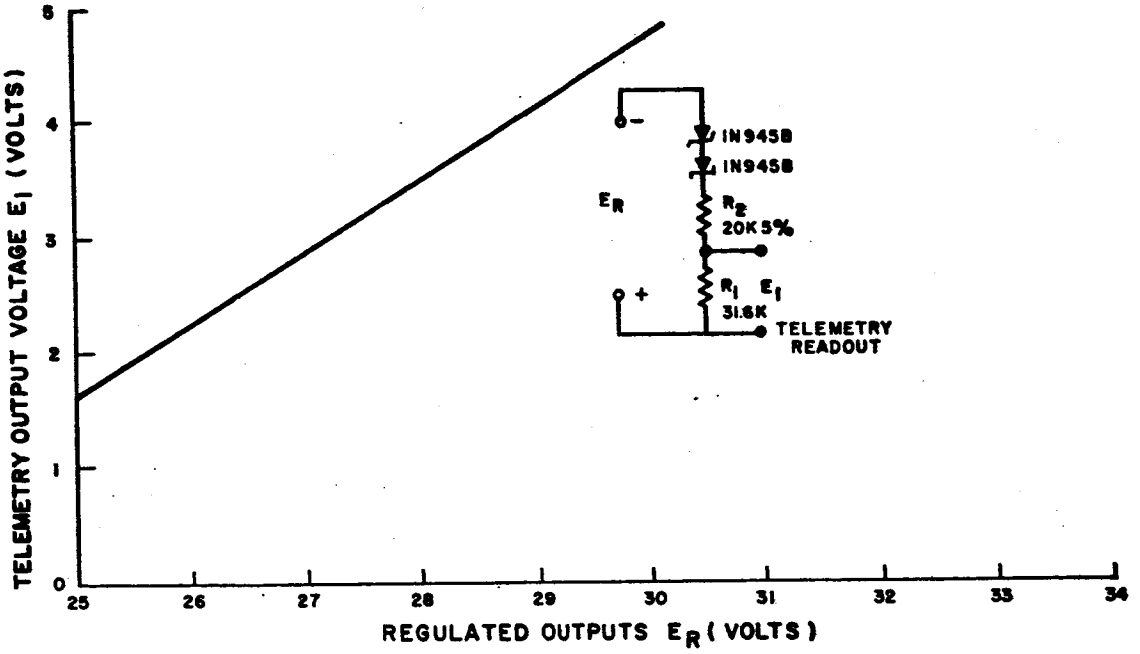


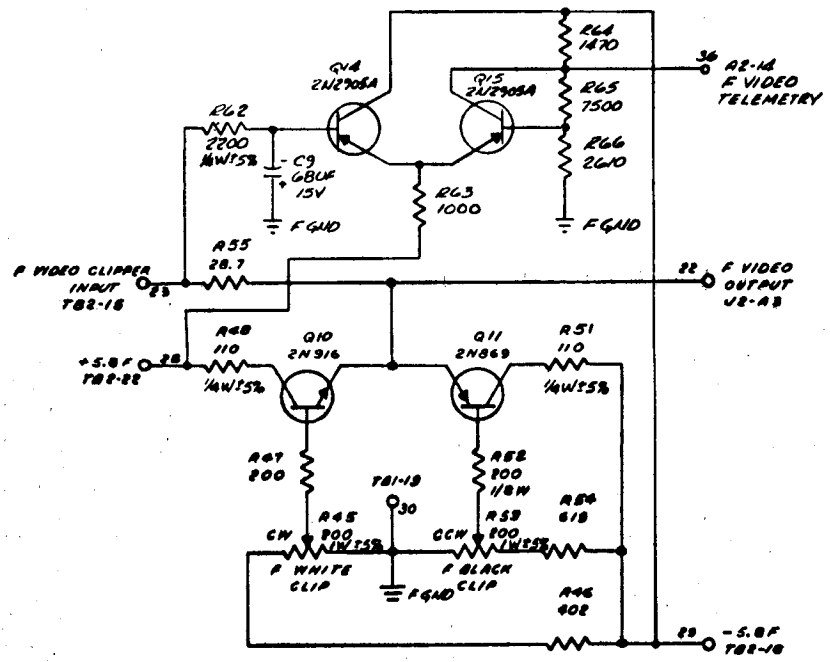
Figure 8-27. HCVR telemetry output as a function of the regulated-voltage output

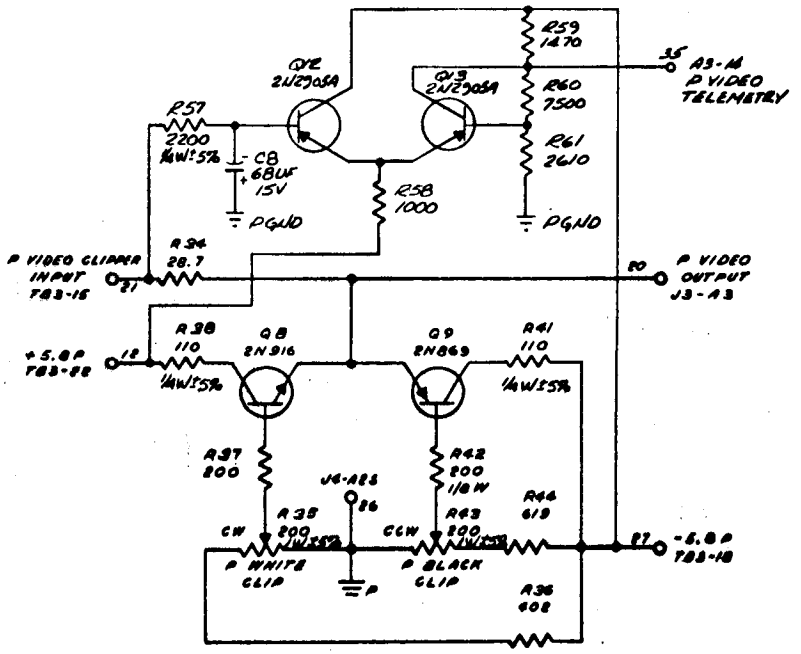
c. Video Combiner

The telemetry circuitry in the Video Combiner was modified to obtain more useful information from the telemetry points. Two d-c differential amplifiers are now used as peak detectors to monitor the level of the video outputs from the P- and F-Channel cameras. The circuit diagram of these differential amplifiers is shown in Figure 8-28.

d. Clock

The Clock design was modified to provide the revised telemetry outputs shown in Figure 8-29. The schematic diagram of the revised Clock design is shown in Figure 8-7.





NOTES:

1. ALL RESISTANCE VALUES ARE IN OHMS.
2. ALL RESISTORS ARE 1/8W ± 1% UNLESS OTHERWISE NOTED.
3 USED ON RANGE DTM, III-2, & SUBSEQUENT.

Figure 8-28. Telemetry amplifier and clipper circuits used in the video combiner

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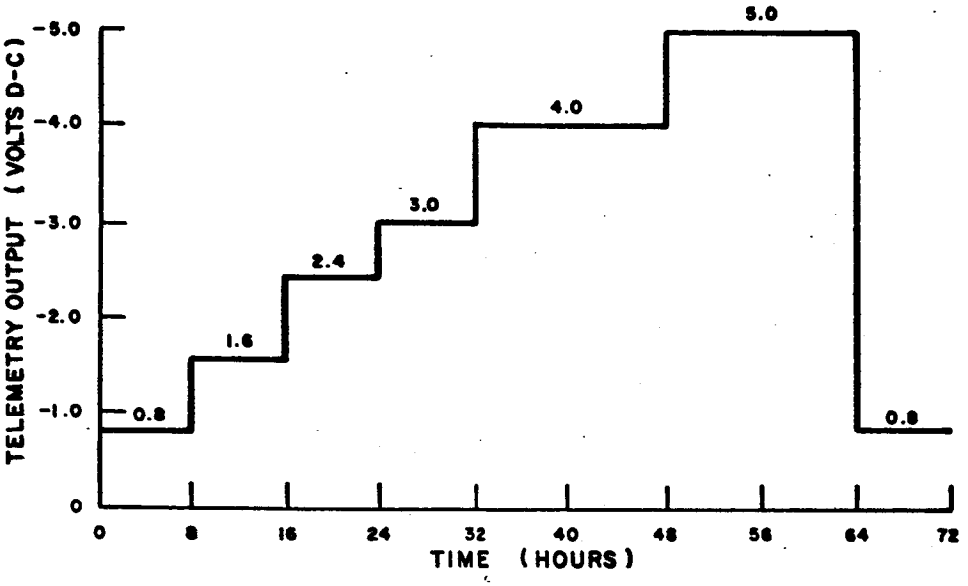
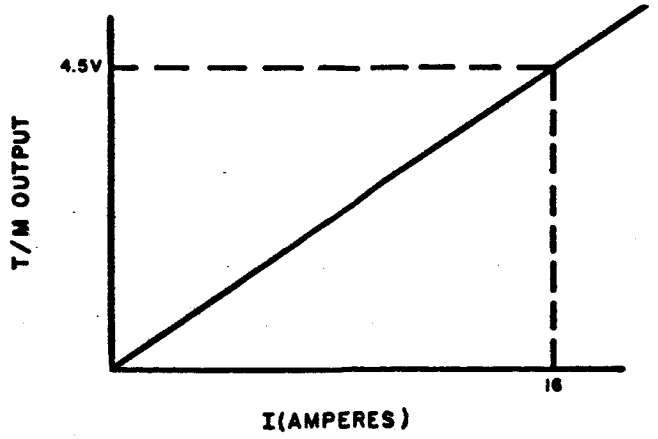
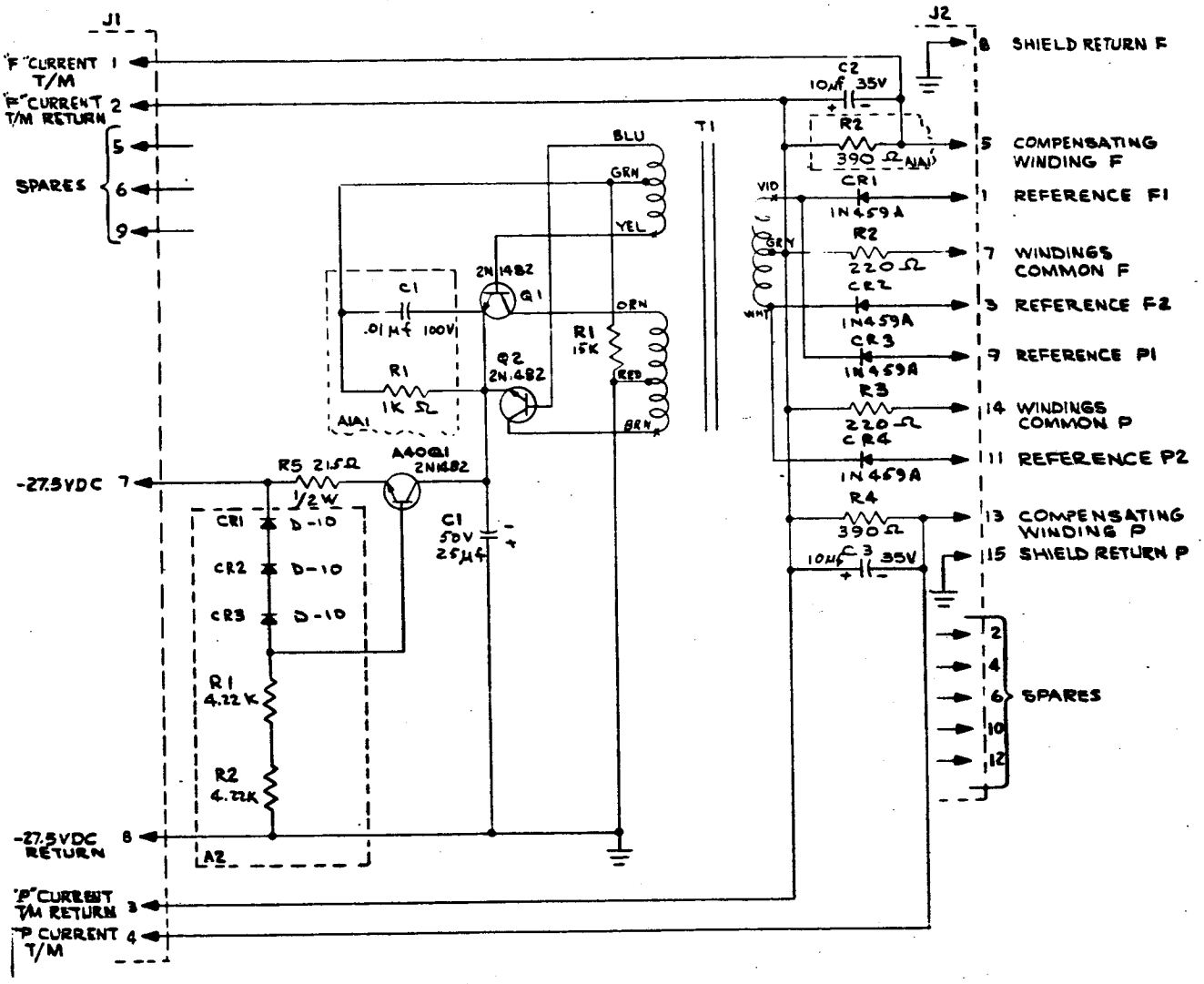


Figure 8-29. Revised telemetry outputs from clock

3. *Current Sensing Unit*

Provisions for monitoring both battery currents are being made by utilizing a circuit composed of a magnetic oscillator and Magnetic Amplifier. The schematic of this circuit is shown in Figure 8-30. A constant-current stage at the input will limit the drain from the Low Current Regulator to approximately 80 ma in the worst case failure mode. The input-output characteristics will be as follows:





NOTES

1. USED ON RANGER PTM III-2 & SUBSEQUENT
2. ⏚ -27.5V DC RETURN
3. RESISTORS ARE ¼W, EXCEPT WHERE NOTED.

Figure 8-30. Schematic diagram, current sensor unit

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4. *Control Programmer and Camera Sequencer and Sequencer Power Supply*

The redesign of the Control Programmer and Camera Sequencer has resulted in the following:

- The 5-minute warmup period has been shortened to 80 seconds;
- The telemetry circuit has been redesigned so that rather than telemetering the output of the flip-flops, the output of the relay and the relay driver are now sampled;
- The manual reset has been changed to a full-power command inhibit; and
- A set of redundant full-power command relay contacts has been added.

The above modifications are being incorporated into the assemblies during the Block III Rework Program.

5. *Communications*

Changes to the communications subsystem made for Ranger-7 consist of the following:

a. FM Modulator, 8314690 (Schematic, 8329135)

The relay contact on K1 which formerly switched to "emergency" conditions has been by-passed with a conductor. Although new circuitry external to this unit ensures that the coil of K1 is never energized under any conditions, this by-passing prevents any contact phenomena from influencing operation of the equipment.

b. Transmitter Power Supply, 1183569 (Schematic, 1183526)

Beryllium oxide wafers were placed between the transistors, Q1 and Q2, and the chassis and teflon sleeves were placed around the transistor monitoring studs where they pass through the chassis. These changes provide for insulation between the transistors and the chassis in the event of failure of or damage to

the insulating coating on the chassis. The wafer material also provides satisfactory heat conduction for the dissipation of power from the transistors.

The diode bridge assemblies CR1, CR2, and CR3 have been insulated from the chassis by the addition of strips of glass epoxy laminate. This addition is also for protection against imperfections in the insulating coating of the chassis.

Resistors R10 and R11 were changed from type RH10 to type RHM10. This new type provides better heat conduction between the element and the heat sink, thereby reducing the working stress level of the part.

c. Telemetry Chassis, 8314682 (Schematic, 8626007)

A voltage regulator was added to power the telemetry chassis from the unregulated bus, eliminating dependence on the high-current voltage regulator for this function. The new circuitry also permits either battery to act as the prime power source for the entire telemetry chassis.

6. *Harness Modifications*

The cable harnessing required several modifications in order to incorporate the command system and telemetry changes cut into the Ranger Block III system. The modifications to the main harness (30W1) were made on the premise that no new wires would be added into the potted connector, and all changes would delete wires; change functions of existing wires; or change destination of existing wires by using splices. Four connectors were deleted from the main cable harness and approximately thirty splices were added. Most of these splices were used to transfer points from the 90-point to the 15-point telemetry, from the 15-point to the 90-point telemetry, or to connect telemetry points to both commutators. The remaining splices were used to eliminate the use of connector contacts which are no longer functionally necessary.

In addition to the main cable harness, changes were necessary on five other smaller harnesses. The regulator harness (30W25) required the addition of two connectors, one to allow the use of a current sensor and a second to pick up the changes made in the two HCVR units. The clock harness required an additional connector which is being used to carry functions between the new CCU and the DCU. A new battery harness (30W29) is required to pick up the new current sensing transformers. Telemetry cables 30W14 and 30W15 are being rebuilt to incorporate new marking methods and permit potting of the selectro-connectors.

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Appendix A

Telemetry Bar Graphs for Various Modes of Operation

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Appendix A

Telemetry Bar Graphs for Various Modes of Operation

The following bar graphs show the range of values experienced at certain telemetry points during the listed modes of operation and conditions. These bar graphs indicate the values which could be expected during correct operation of the Subsystem under similar modes of operation and conditions. The extremes of each bar were derived from telemetry recordings made during testing of Flight Model III-1 at JPL and AMR. These extremes are applicable only to Flight Model III-1, and, since they are derived from a limited number of tests, they are not to be considered as changes to the specification limits. The specification limits of each telemetry point during normal operation are indicated by two small marks at the bottom of each graph.

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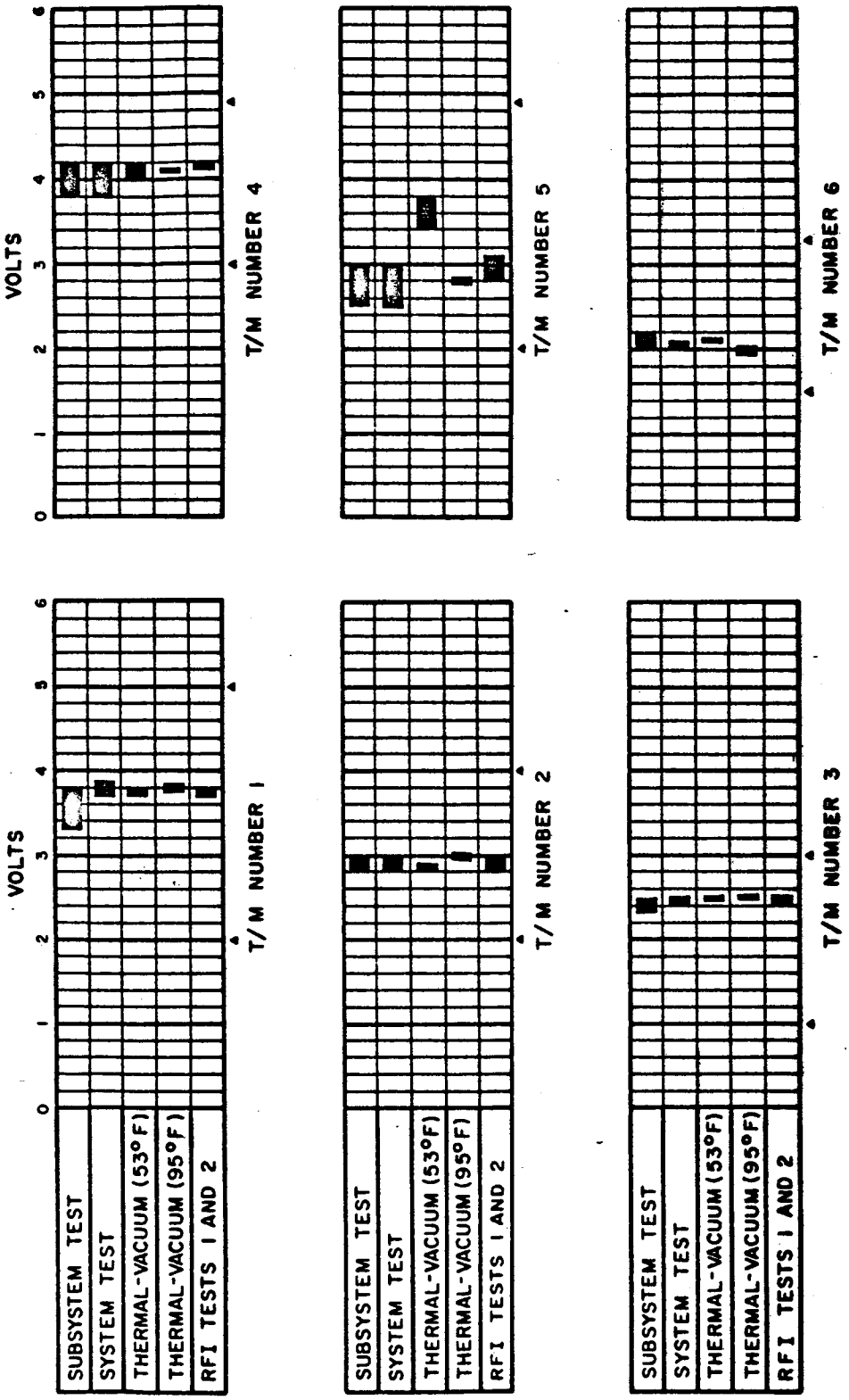

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry

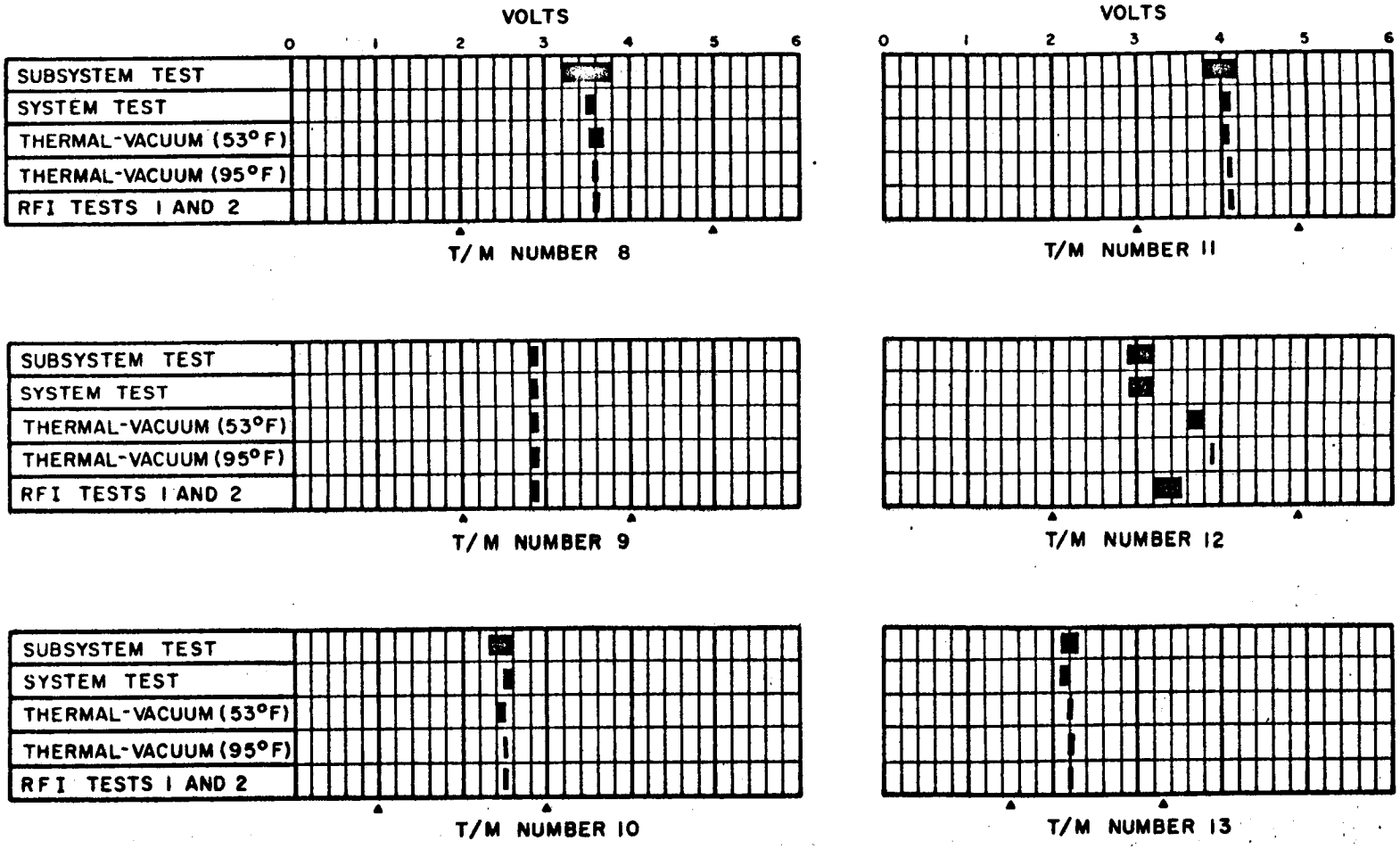

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry (Continued)

RE-ORDER No. 64-139-

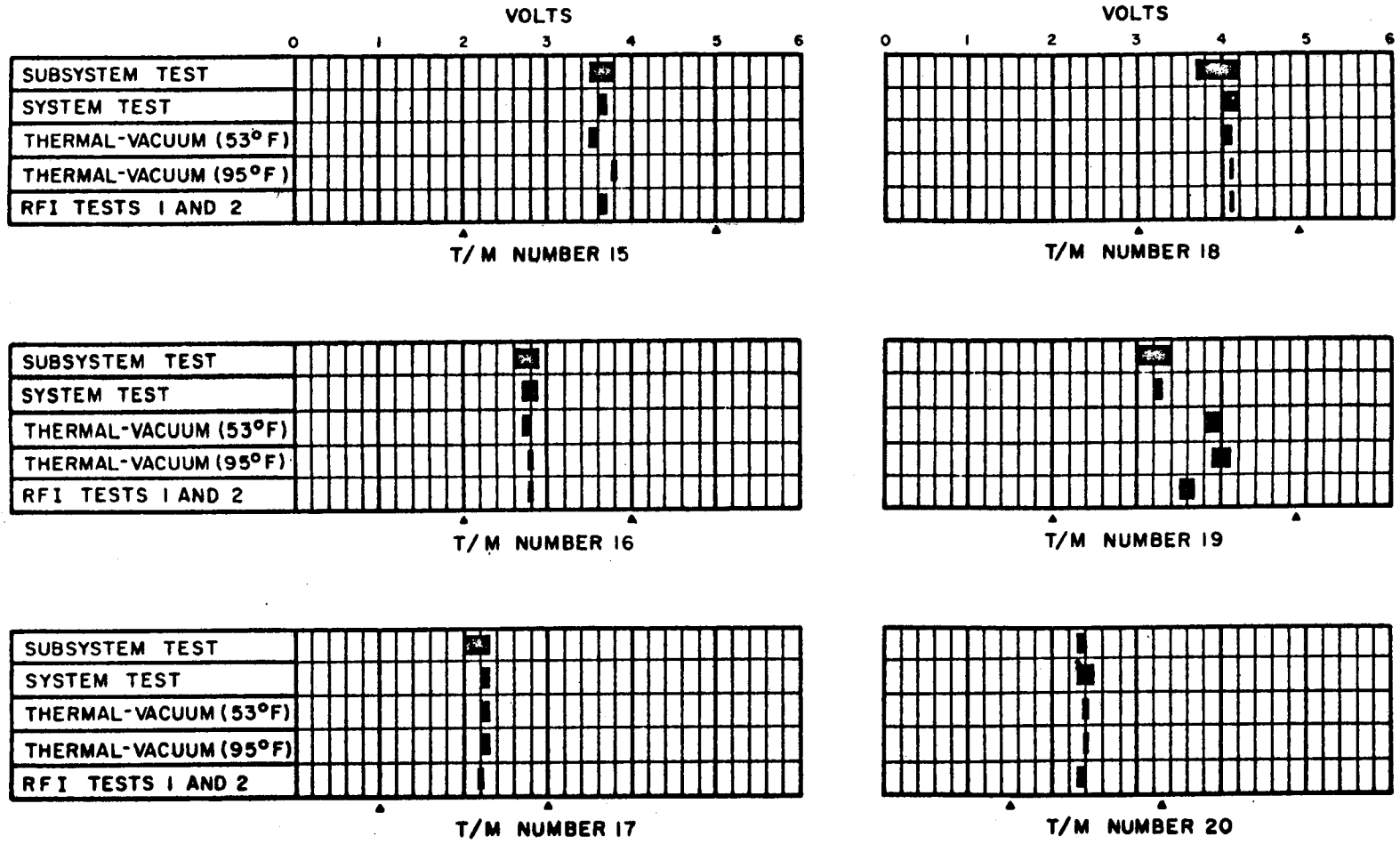

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry (Continued)

RE-ORDER No. 64-139

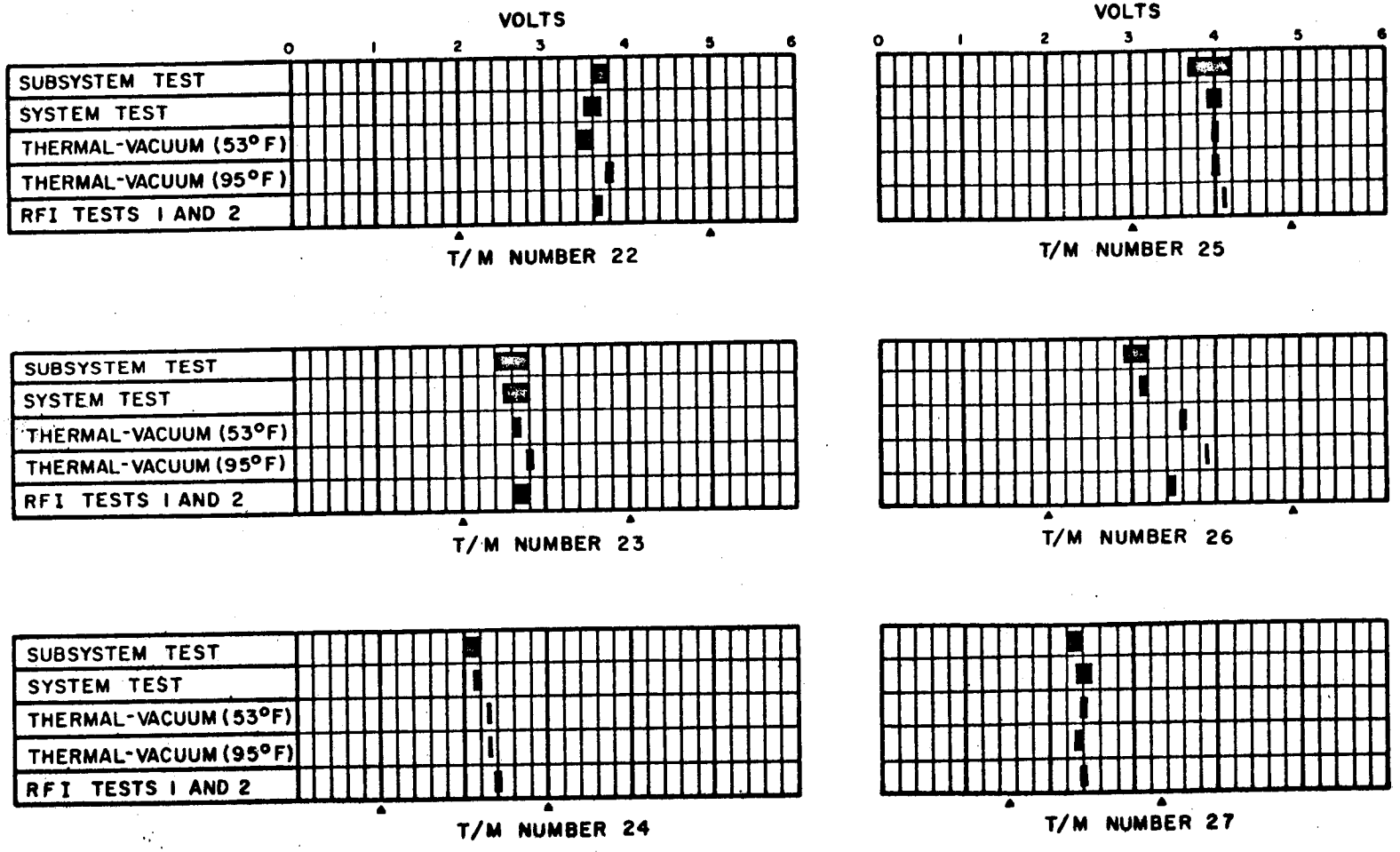

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry (Continued)

RE-ORDER No. 64-139

RE-ORDER No. 64-139

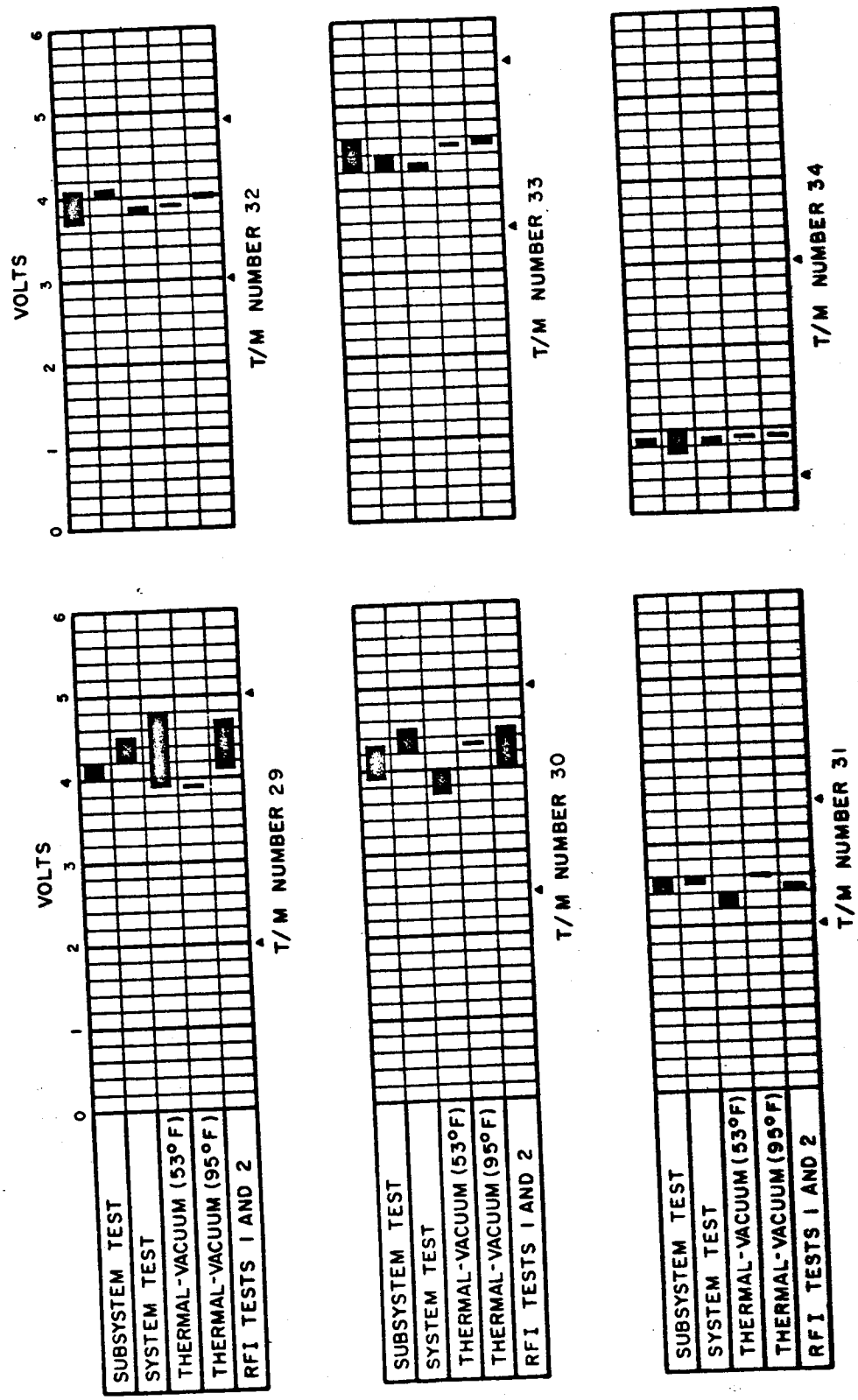

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry (Continued)

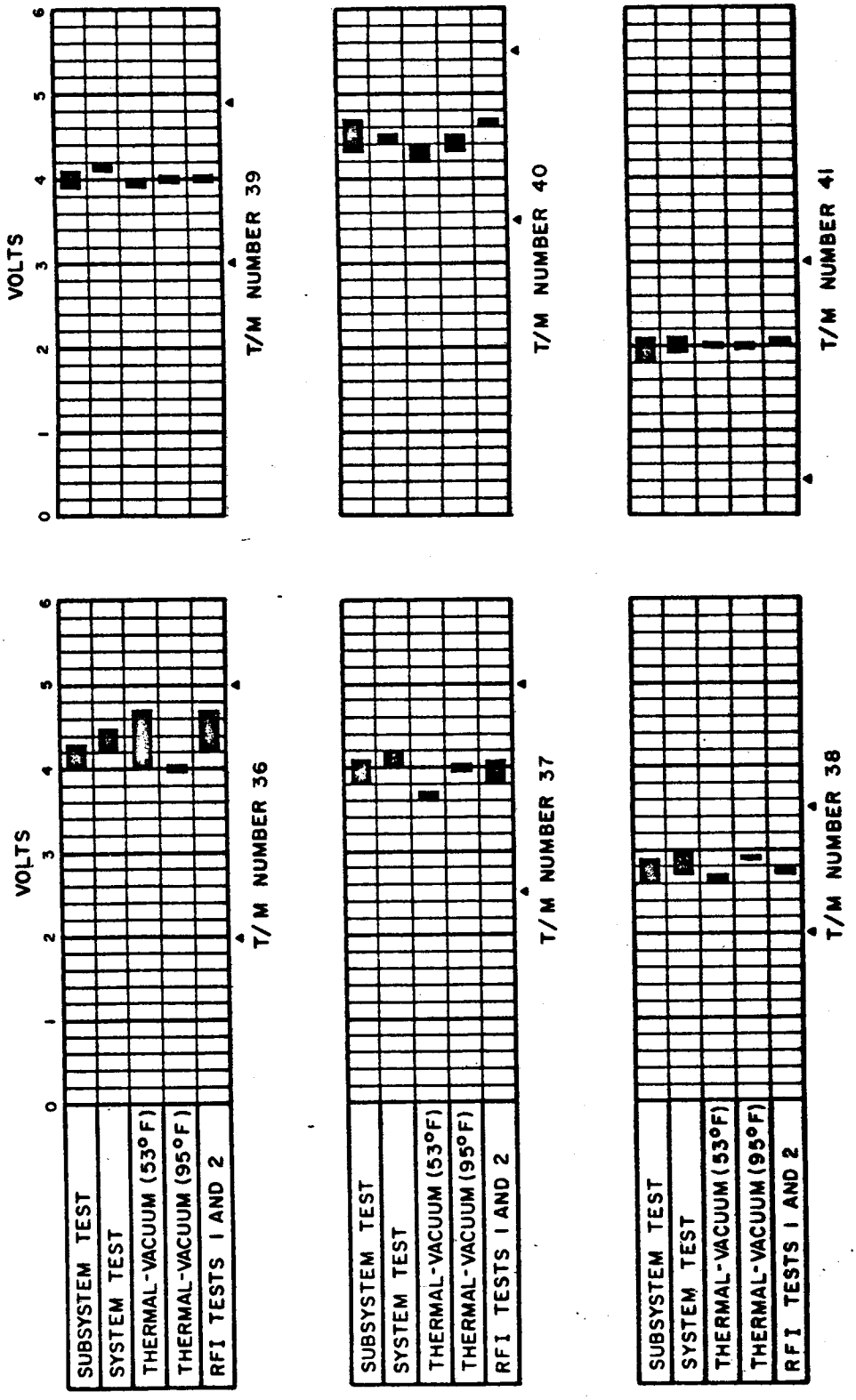

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry (Continued)

RE-ORDER No. 64-139.

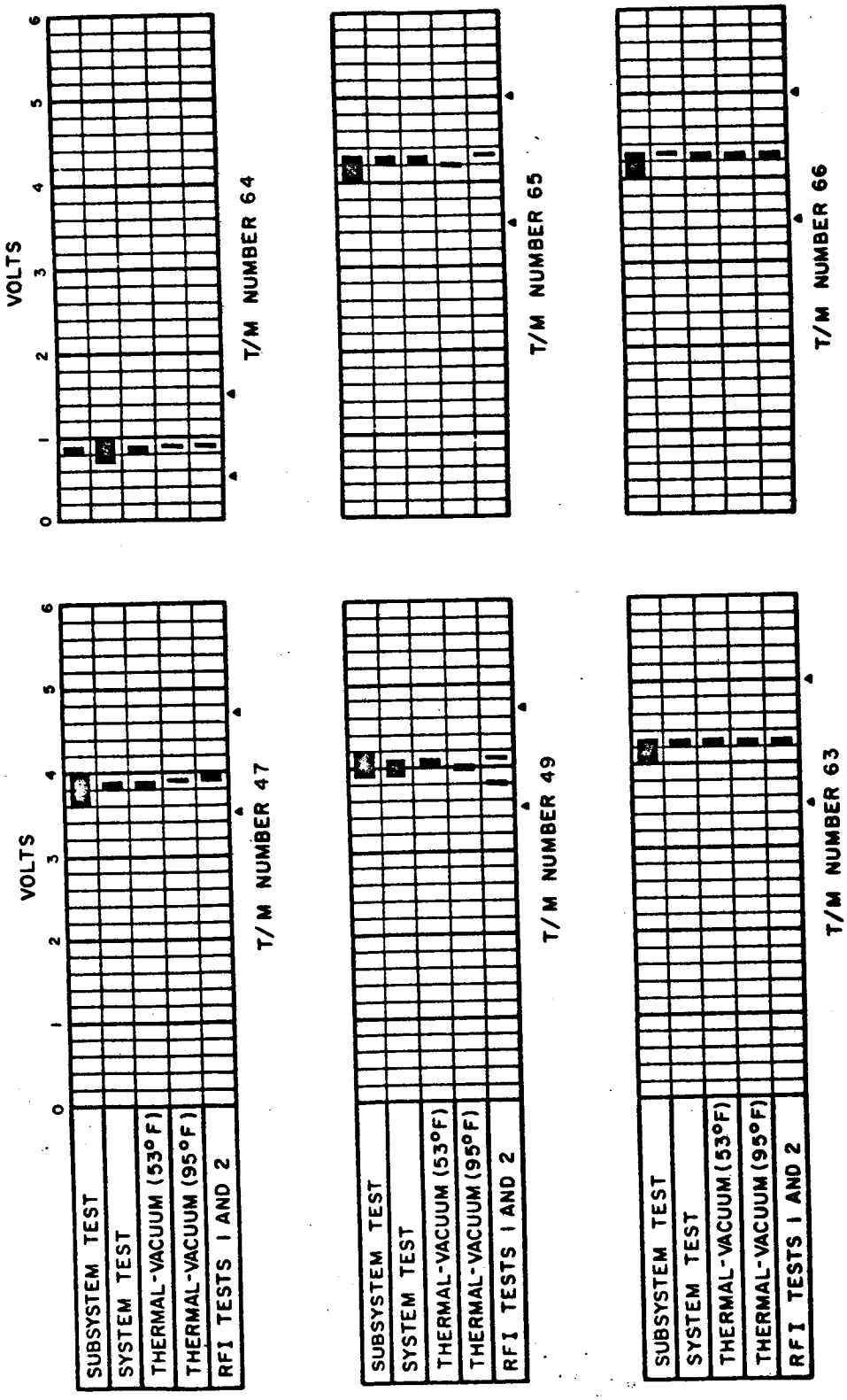

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry (Continued)

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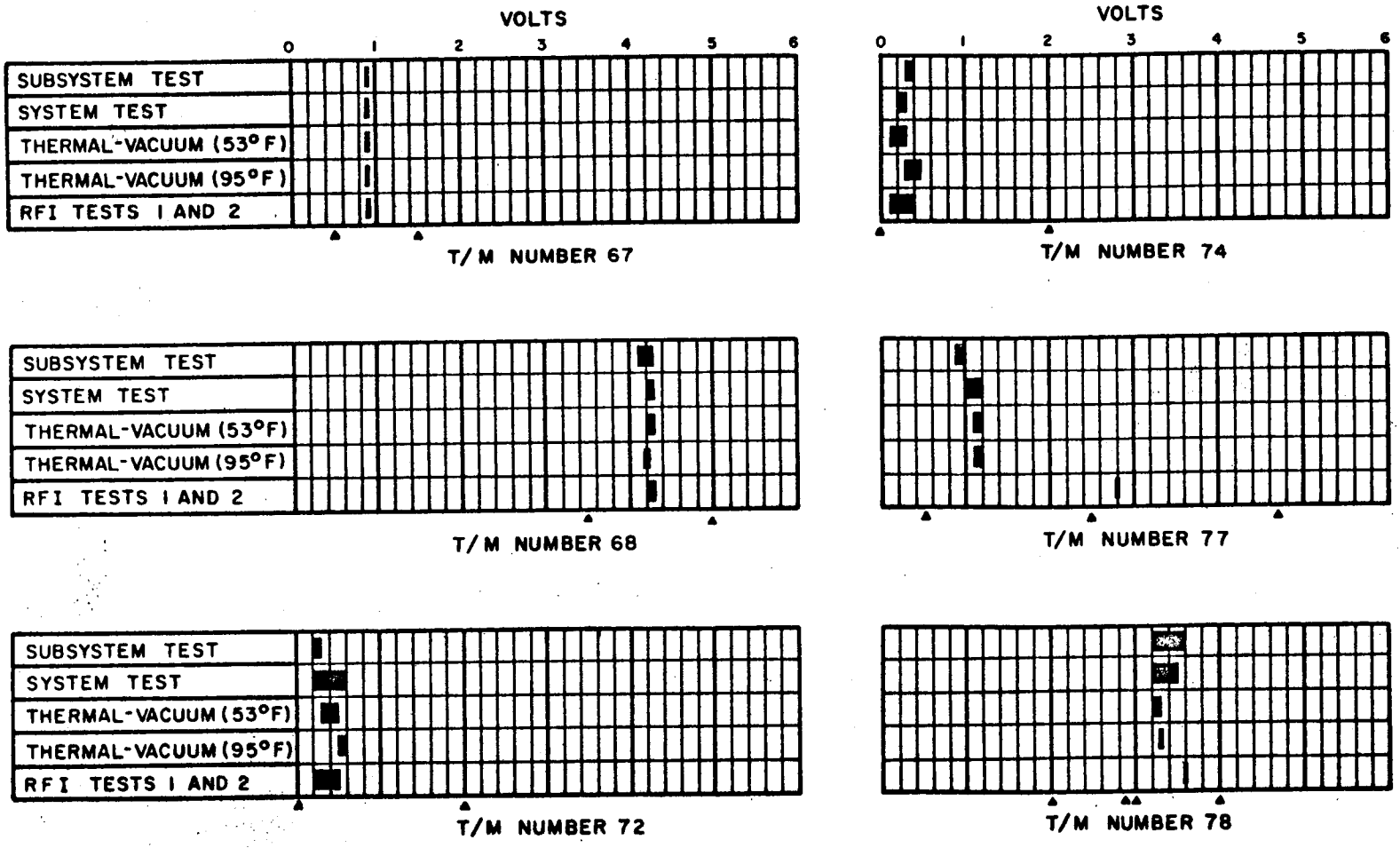

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry (Continued)

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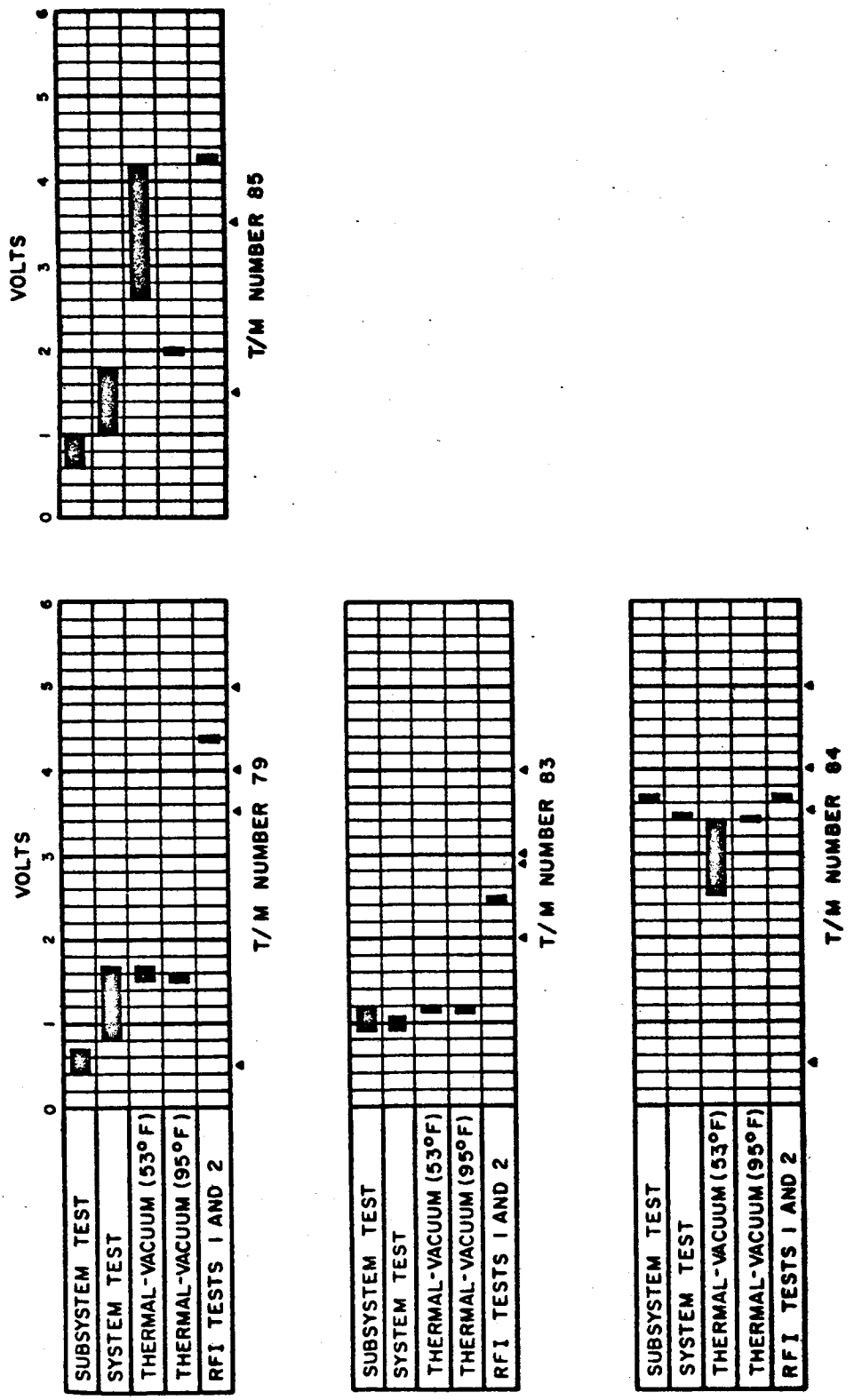

Figure A-1. Bar graphs of Flight Model III-1 90-point telemetry (Continued)

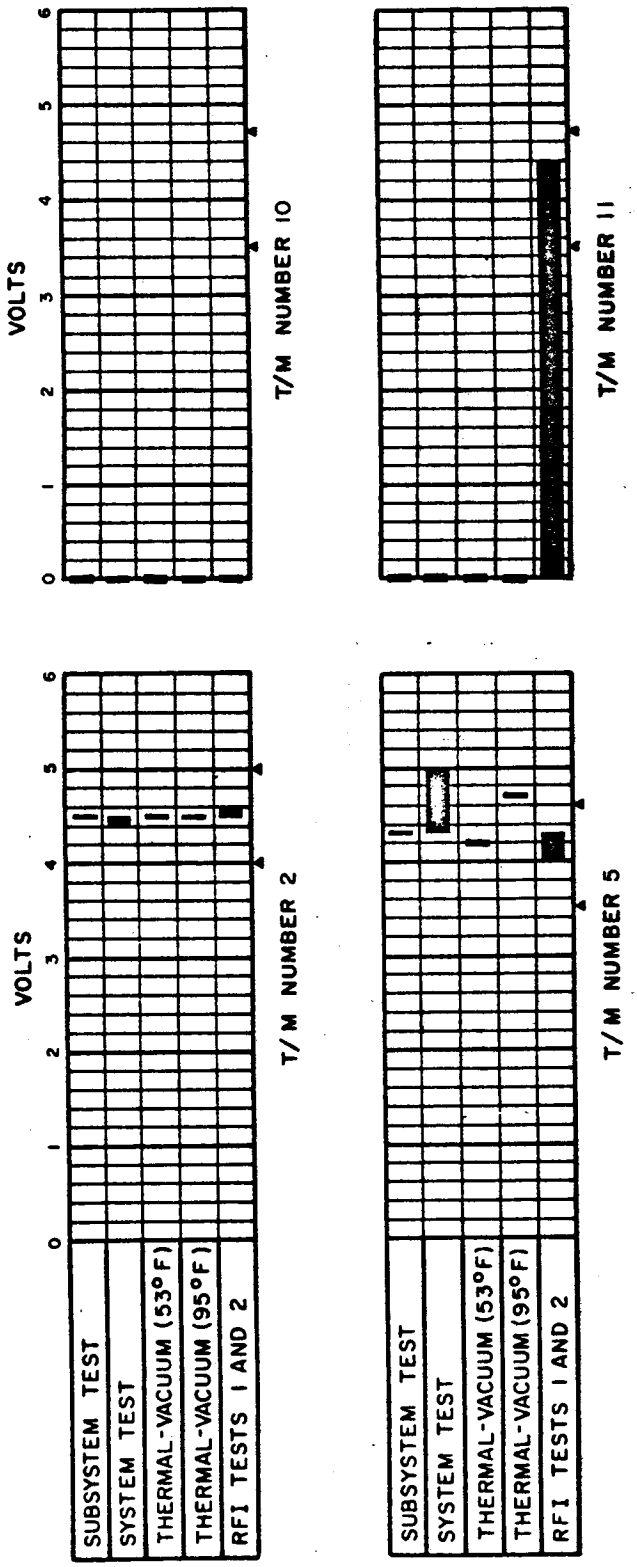

Figure A-2. Bar graphs of Flight Model III-1 15-point telemetry

RE-ORDER No. 64-139

Appendix B

Calibration Curves for Channel-8 Telemetry Points

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Appendix B

Calibration Curves for Channel-8 Telemetry Points

Figures B-1 through B-9 show the calibration of the outputs for the sensors used in the Channel-8 telemetry.

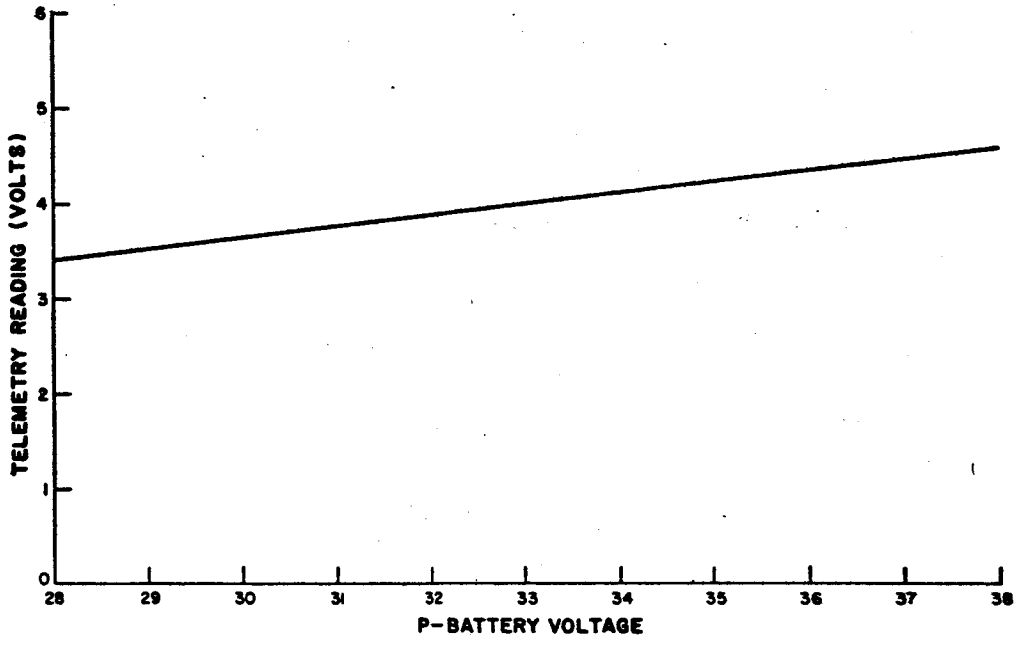

Figure B-1. Low-Current Voltage Regulator input (P-Channel battery) telemetry calibration curve

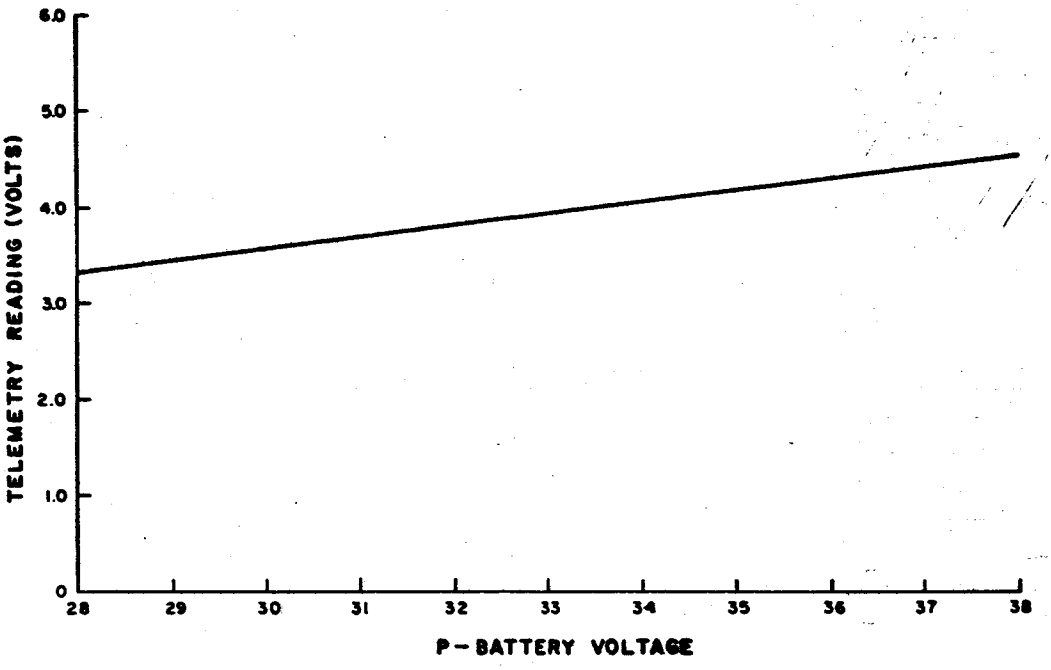

Figure B-2. RA-6, Channel-8 telemetry point 6, calibration curve, P-Battery voltage

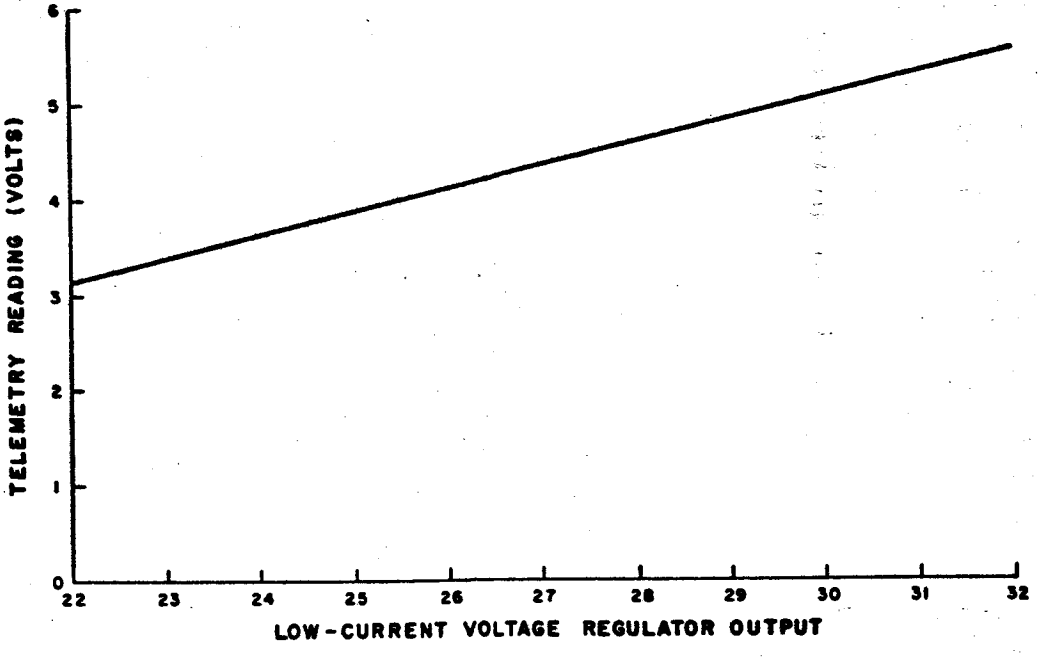

Figure B-3. RA-6, Channel-8 telemetry, point 2 calibration curve, Low-Current Voltage Regulator Output

RE-ORDER No. 64-139

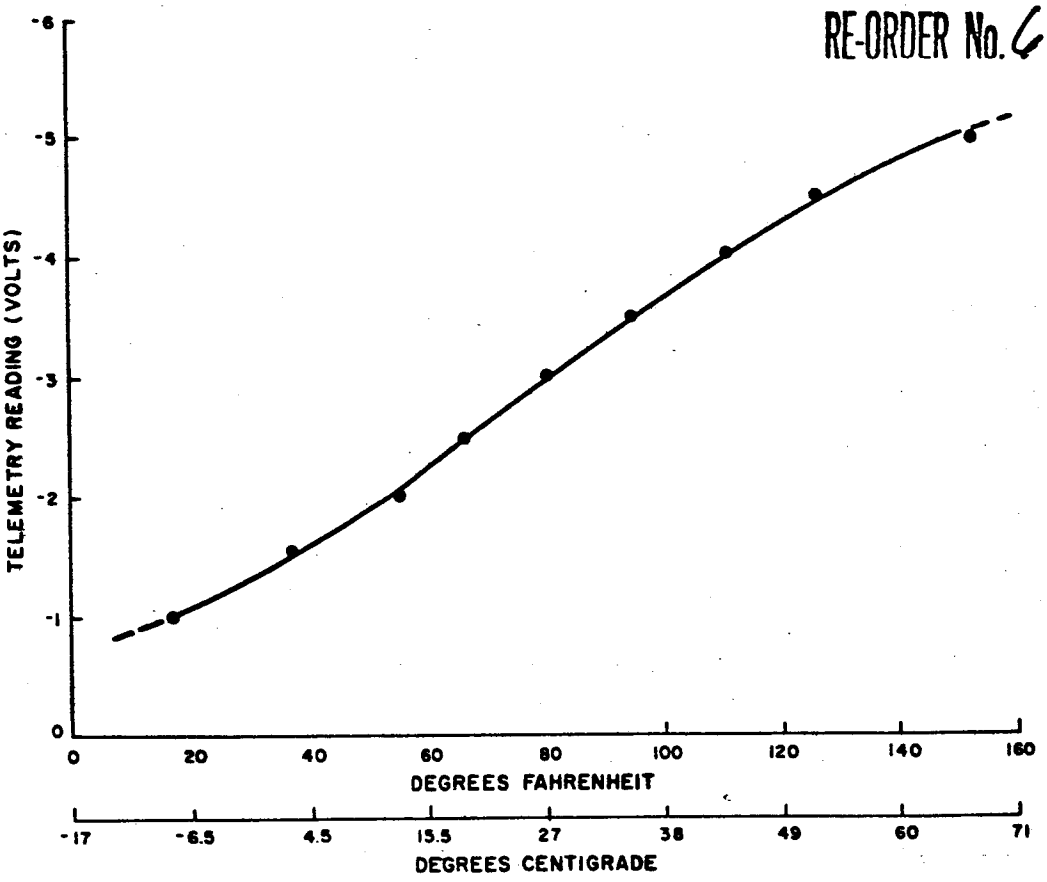

Figure B-4. RA-6, Channel-8, telemetry point 3, calibration curve, F-Battery internal temperature

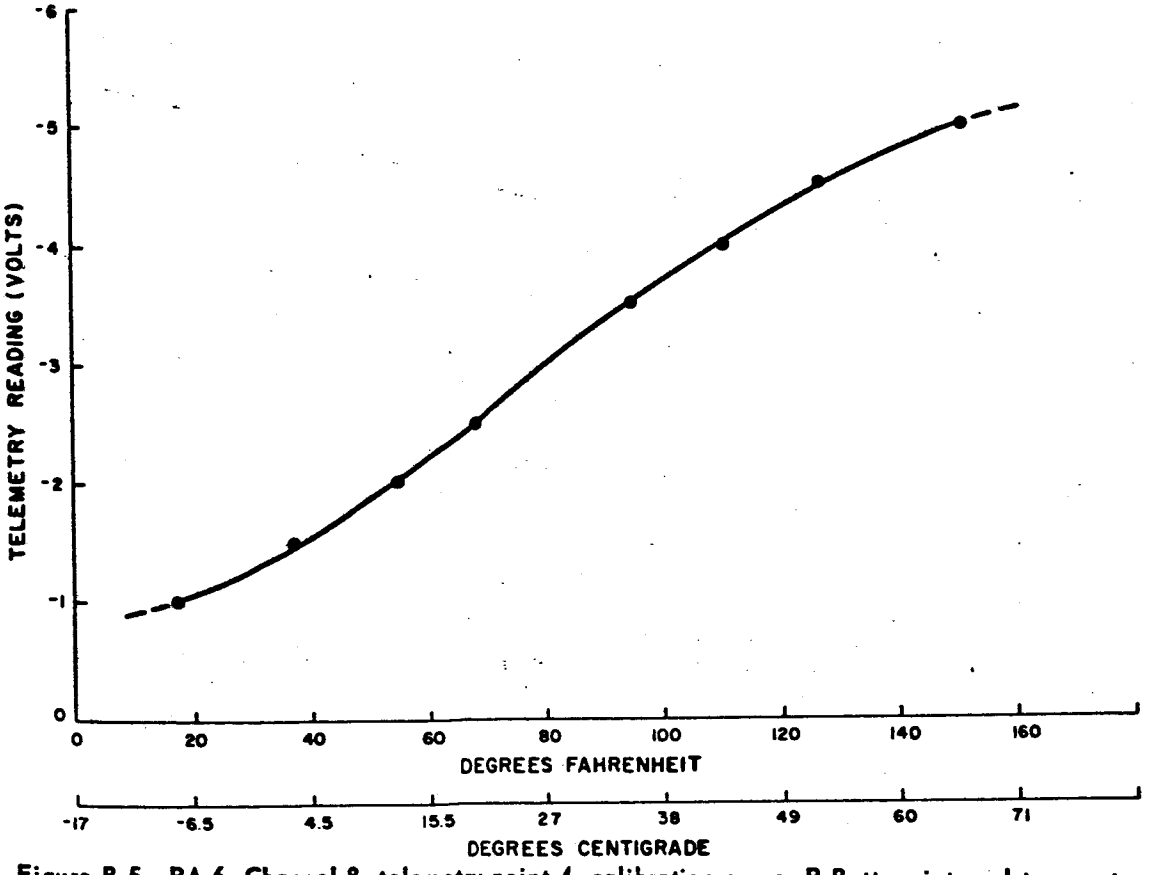

Figure B-5. RA-6, Channel-8, telemetry point 4, calibration curve, P-Battery internal temperature

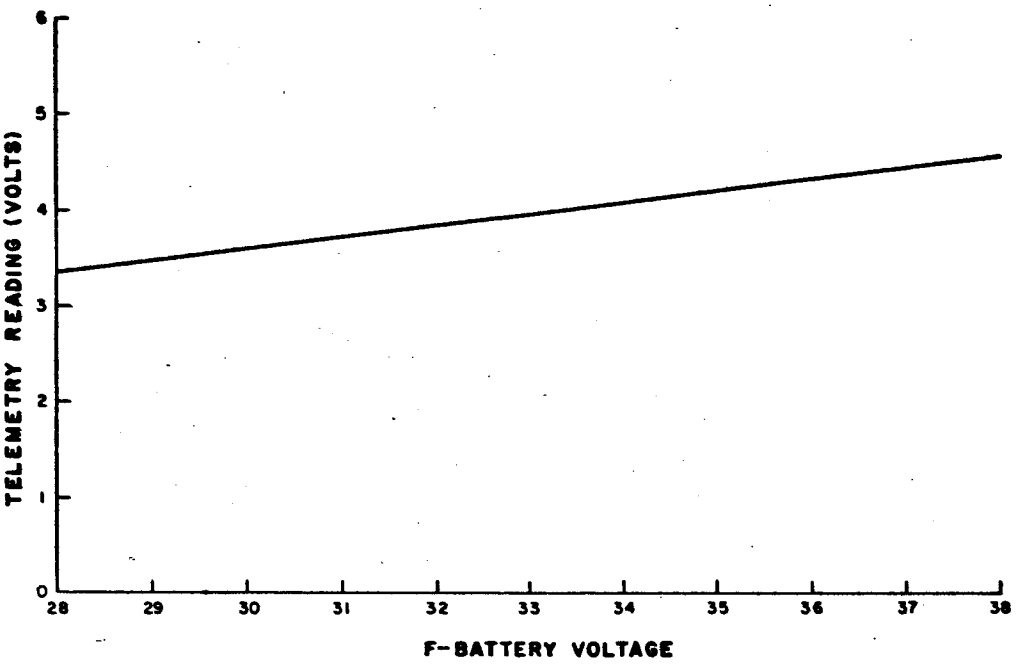

Figure B-6. RA-6, Channel-8, telemetry point 5, calibration curve, F-Battery voltage

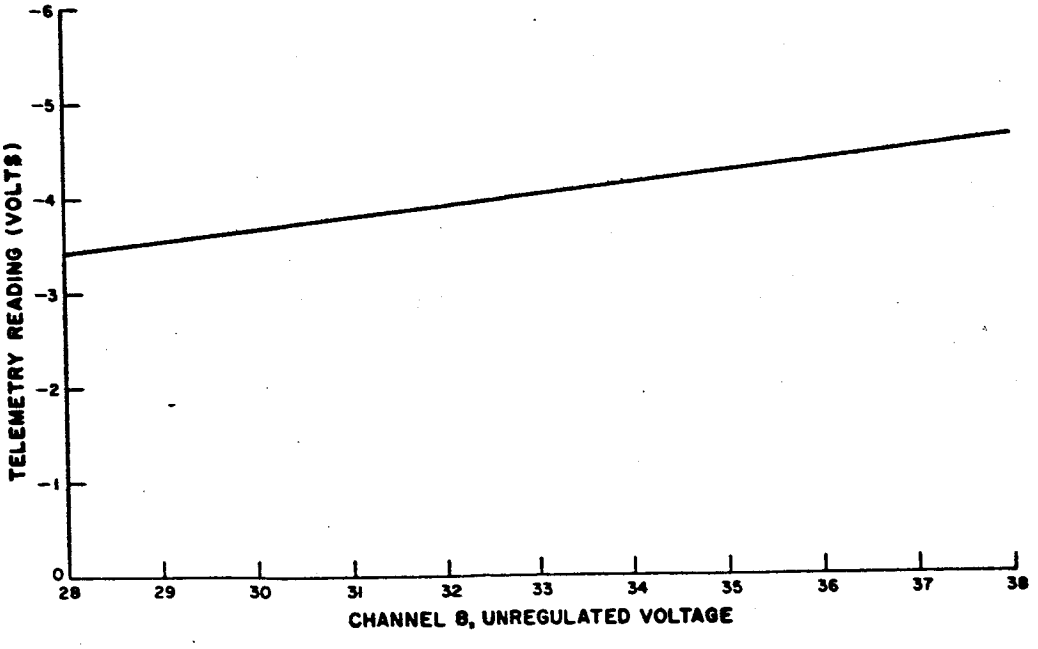

Figure B-7. RA-6, Channel-8, telemetry point 1, calibration curve, unregulated voltage

RE-ORDER No. 64-139

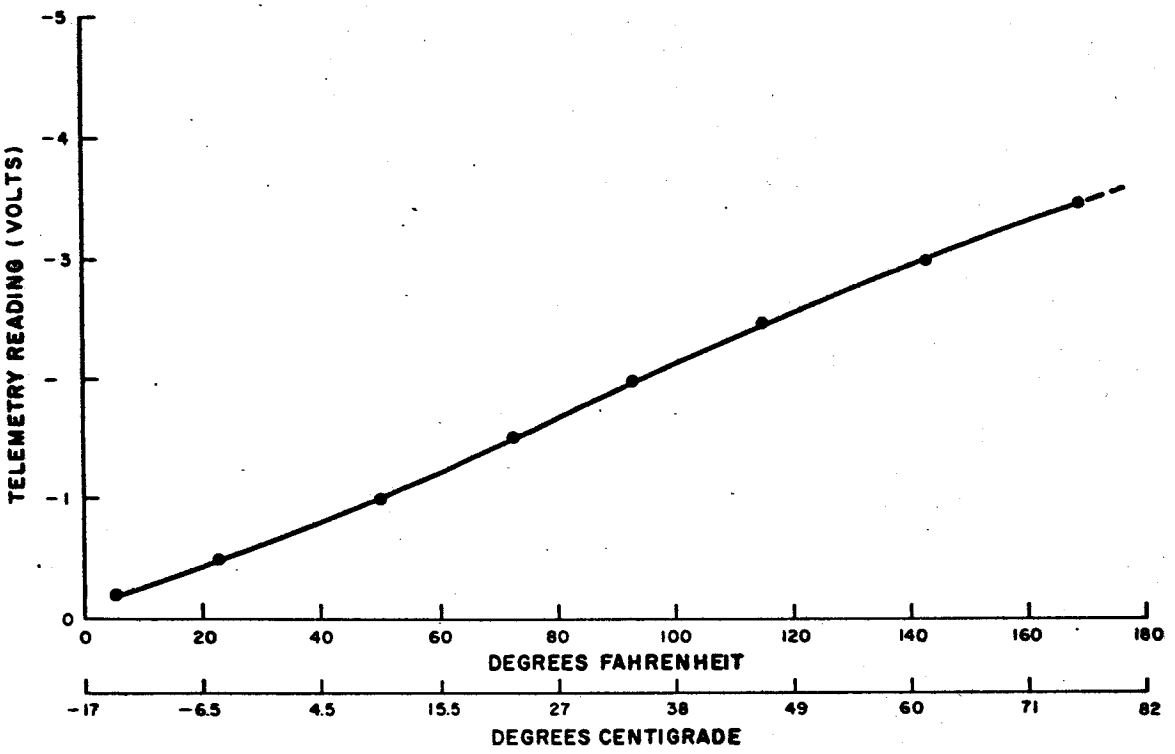

Figure B-8. RA-6, Channel-8, telemetry point 8, calibration curve, Shroud temperature

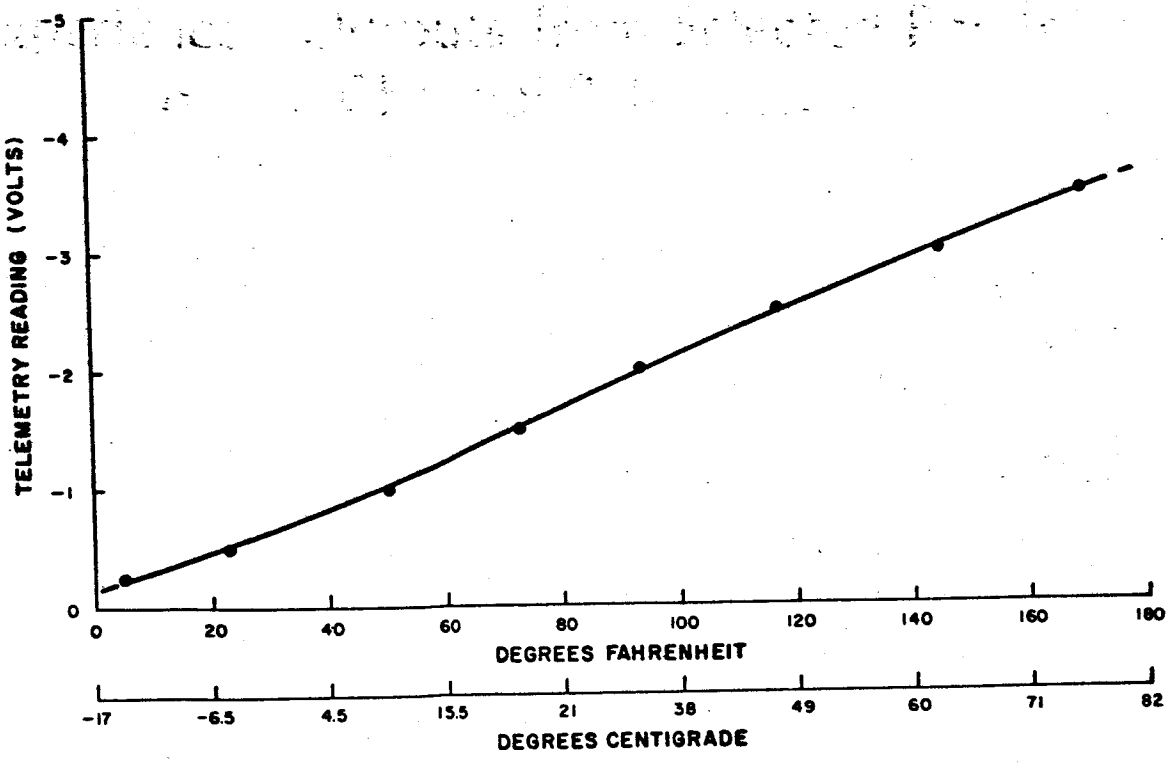

Figure B-9. RA-6, Channel-8, telemetry point 7, Calibration curve, Top Hat temperature (-Y axis)

RE-ORDER No 64-139

Appendix C

Experienced Outputs from Selected Points of the Channel-8 Telemetry

RE-ORDER No. 64-139

Appendix C

Experienced Outputs from Selected Points of the Channel-8 Telemetry

The following curves illustrate the outputs experienced from selected points of the Channel-8 Telemetry during the final tests at AMR.

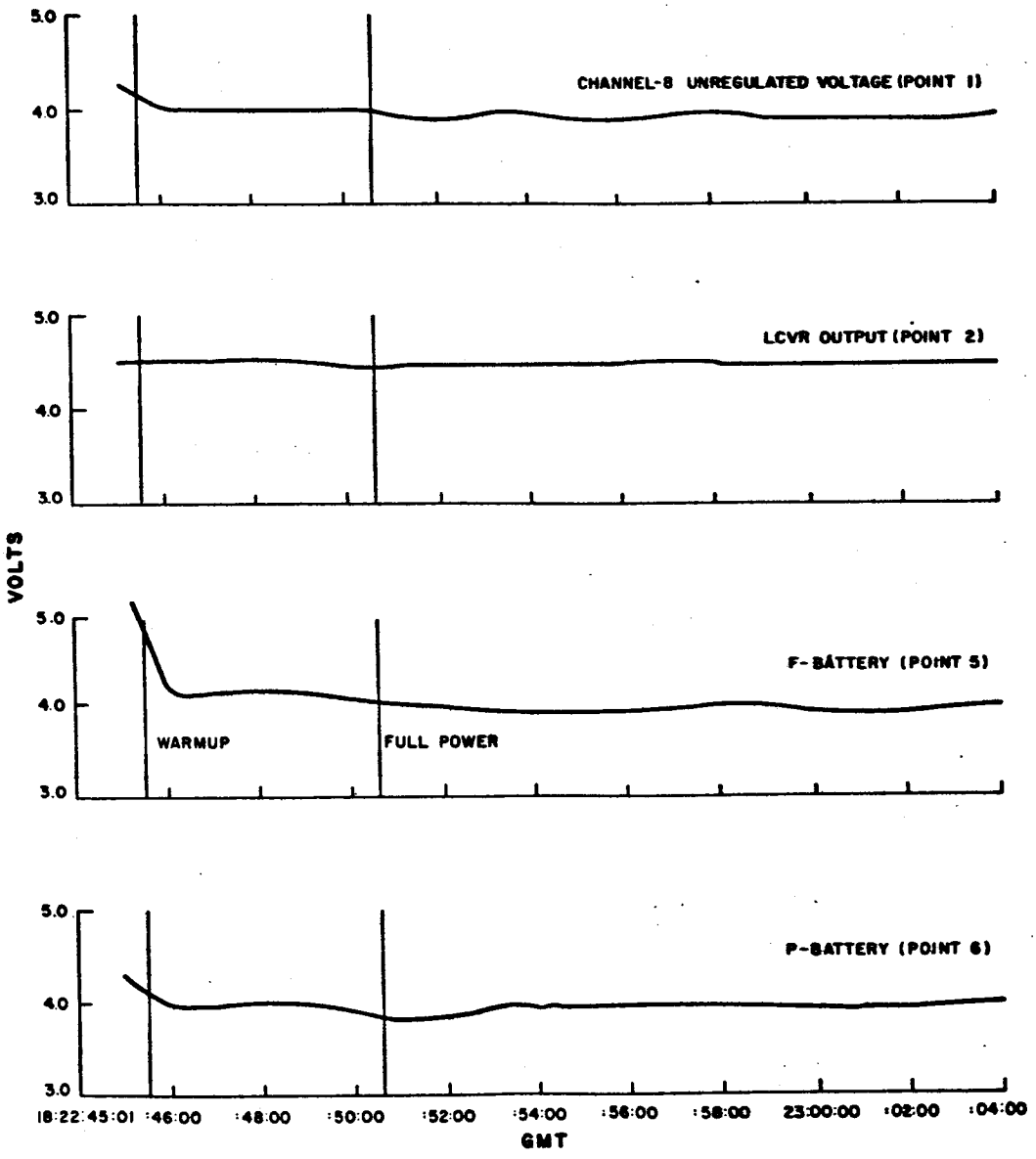

Figure C-1: RA-6 final system test, Channel-8 telemetry (at AMR, 1/18/64)

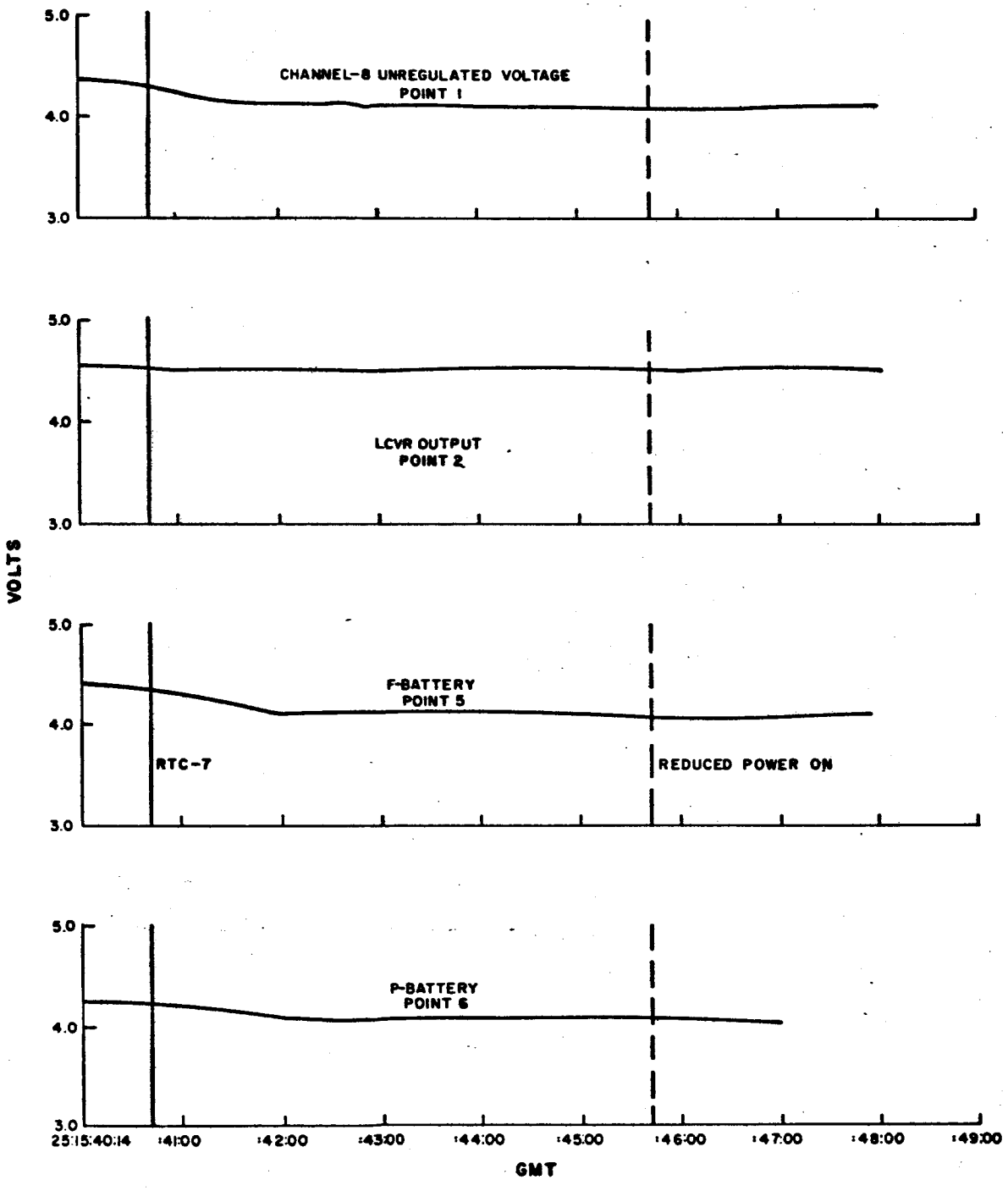

Figure C-2. RA-6, ESA checkout, Channel-8 telemetry (AMR, 1/25/64)

RE-ORDER No. 64-139

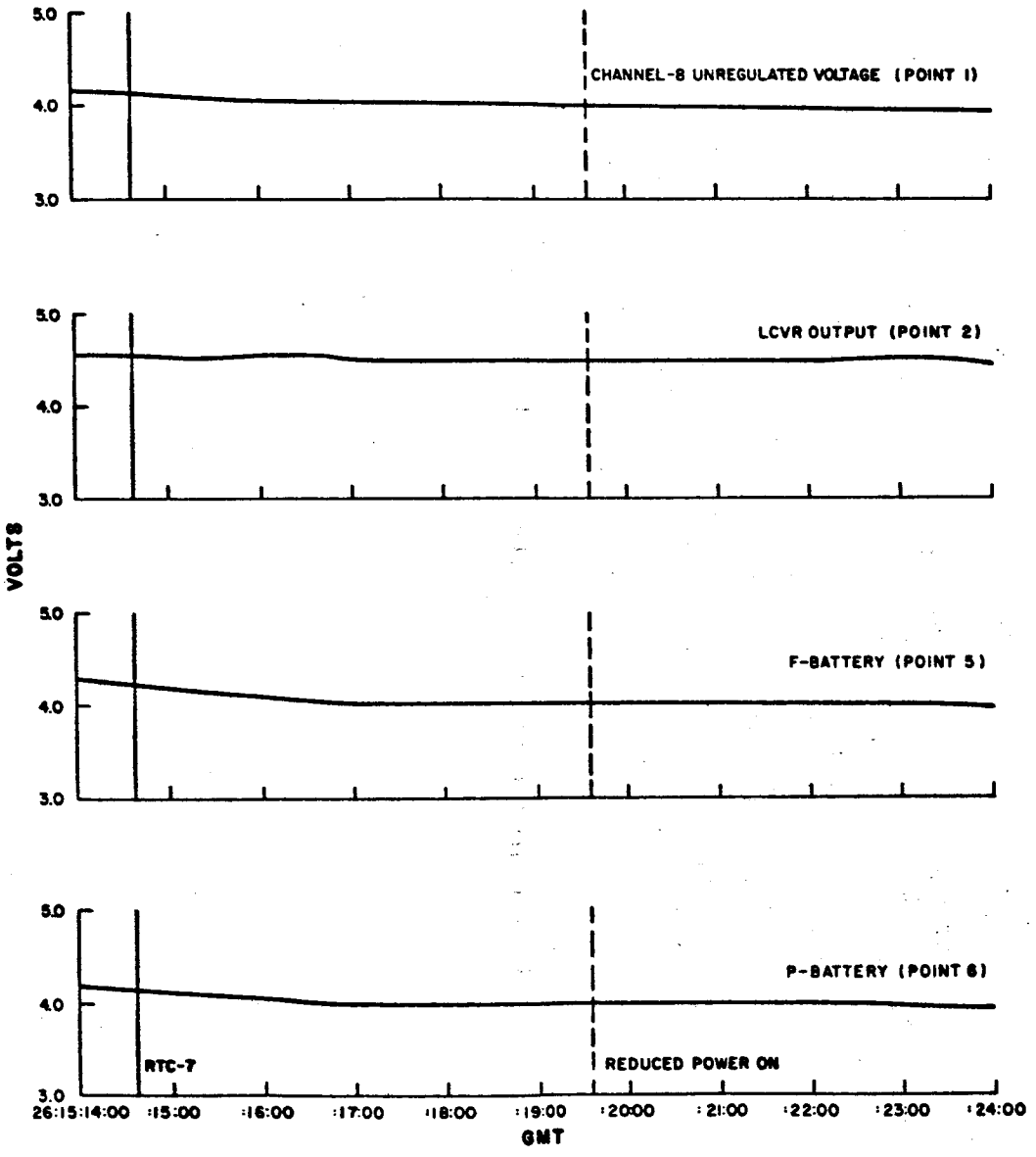

Figure C-3. RA-6, Channel-8 telemetry, pre-countdown test (AMR, 1/26/64)

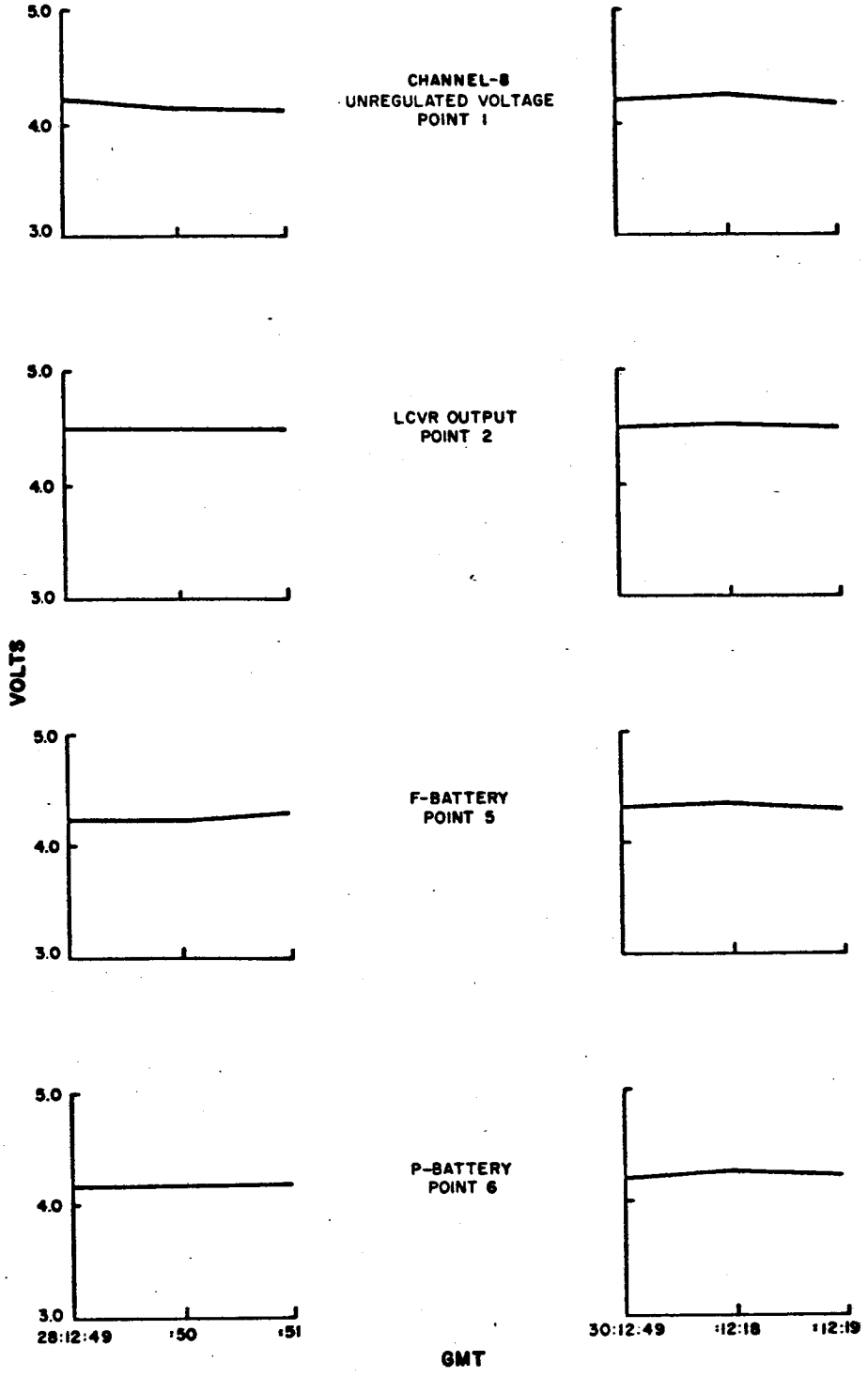

Figure C-4a. RA-6, Channel-8 telemetry simulated countdown (AMR, 1/28/64)

Figure C-4b. RA-6, Channel-8 telemetry countdown from T-128 (AMR, 1/30/64)

RE-ORDER No. 64-139

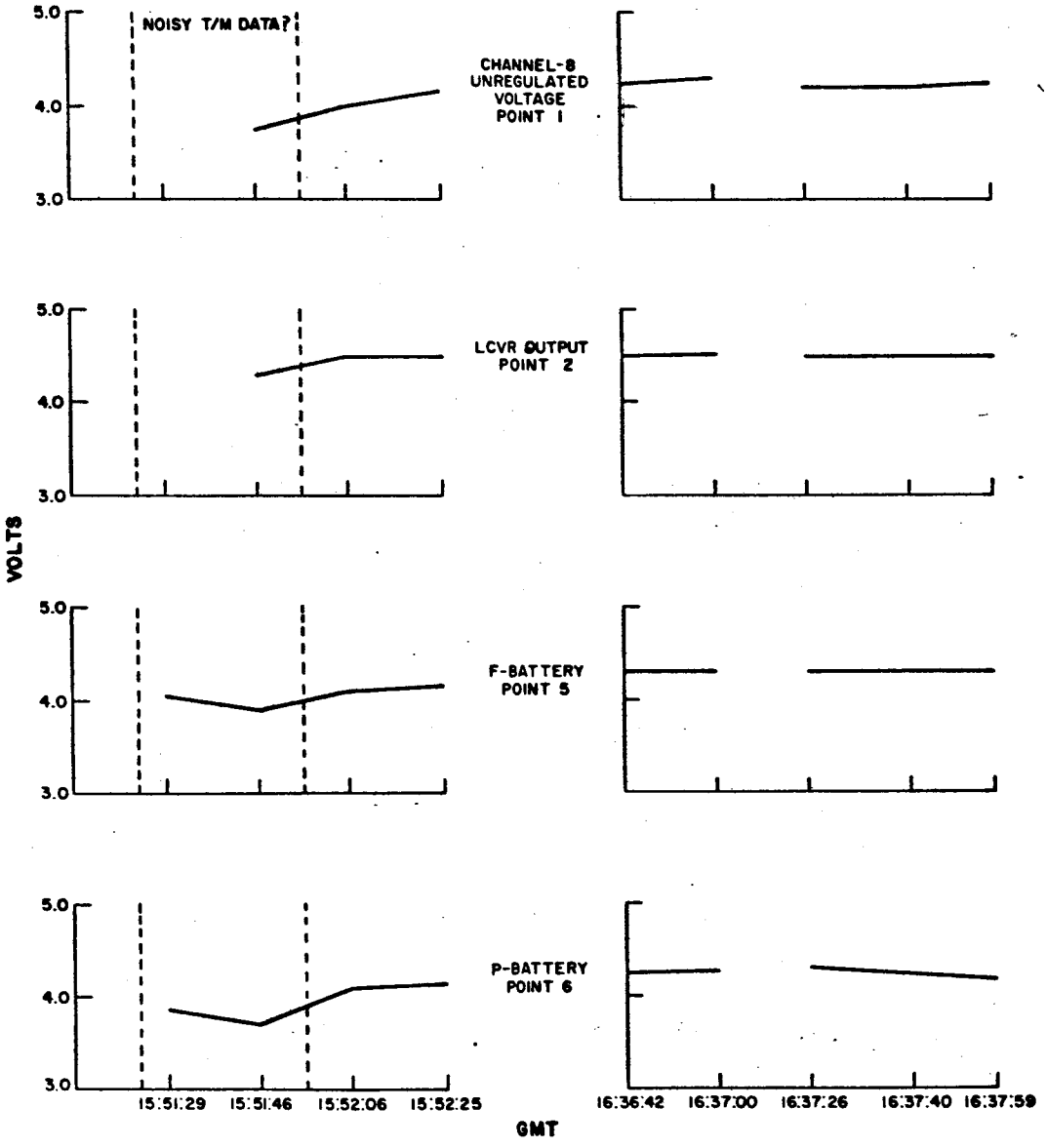

Figure C-5a. Channel-8 telemetry, inadvertent turn-on at booster ejection (1/30/64)

Figure C-5b. Channel-8 turn-on at S+17 min (Pick-up at Johannesburg (1/30/64)

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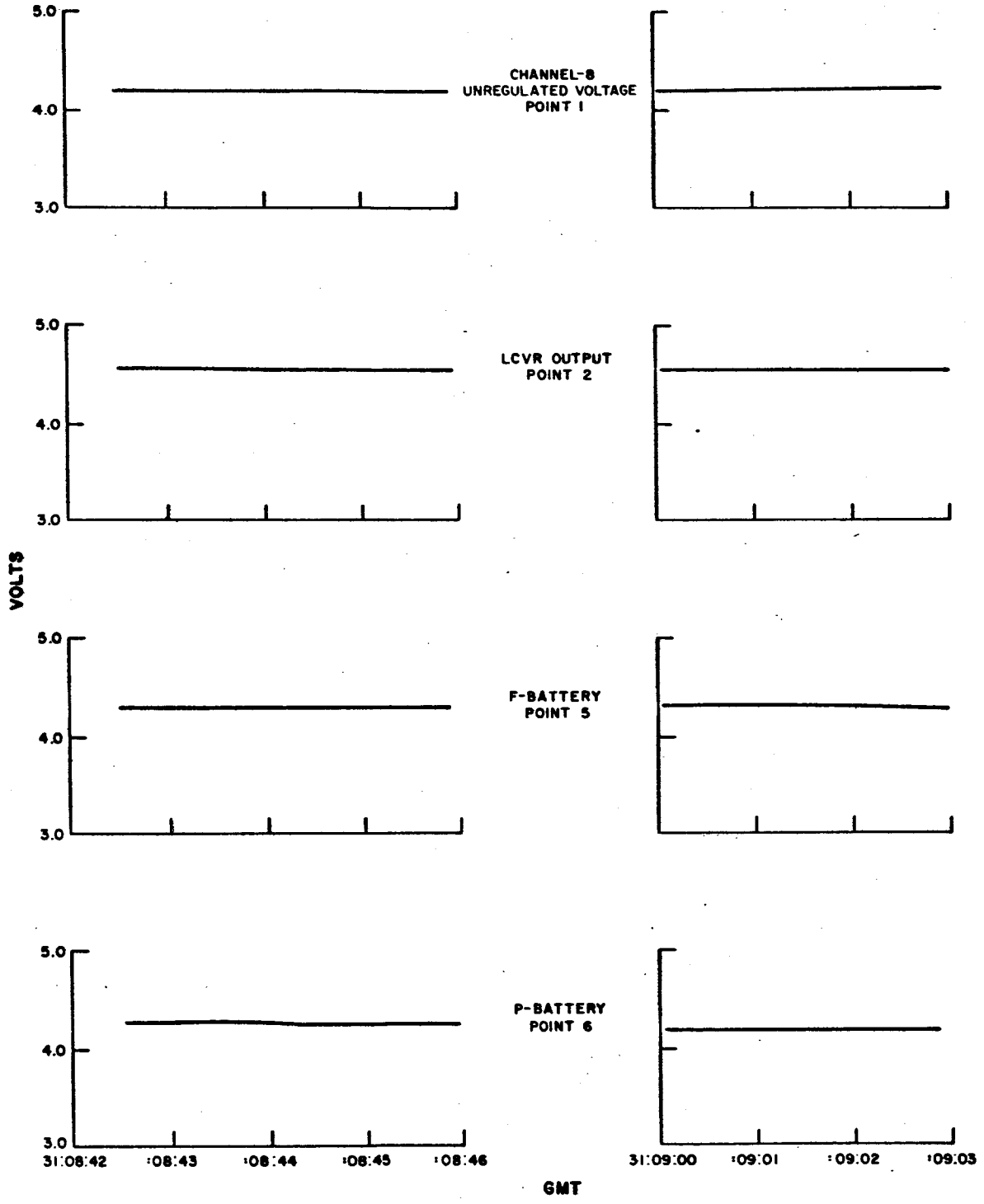

Figure C-6. RA-6, Channel-8 telemetry before and after midcourse maneuver

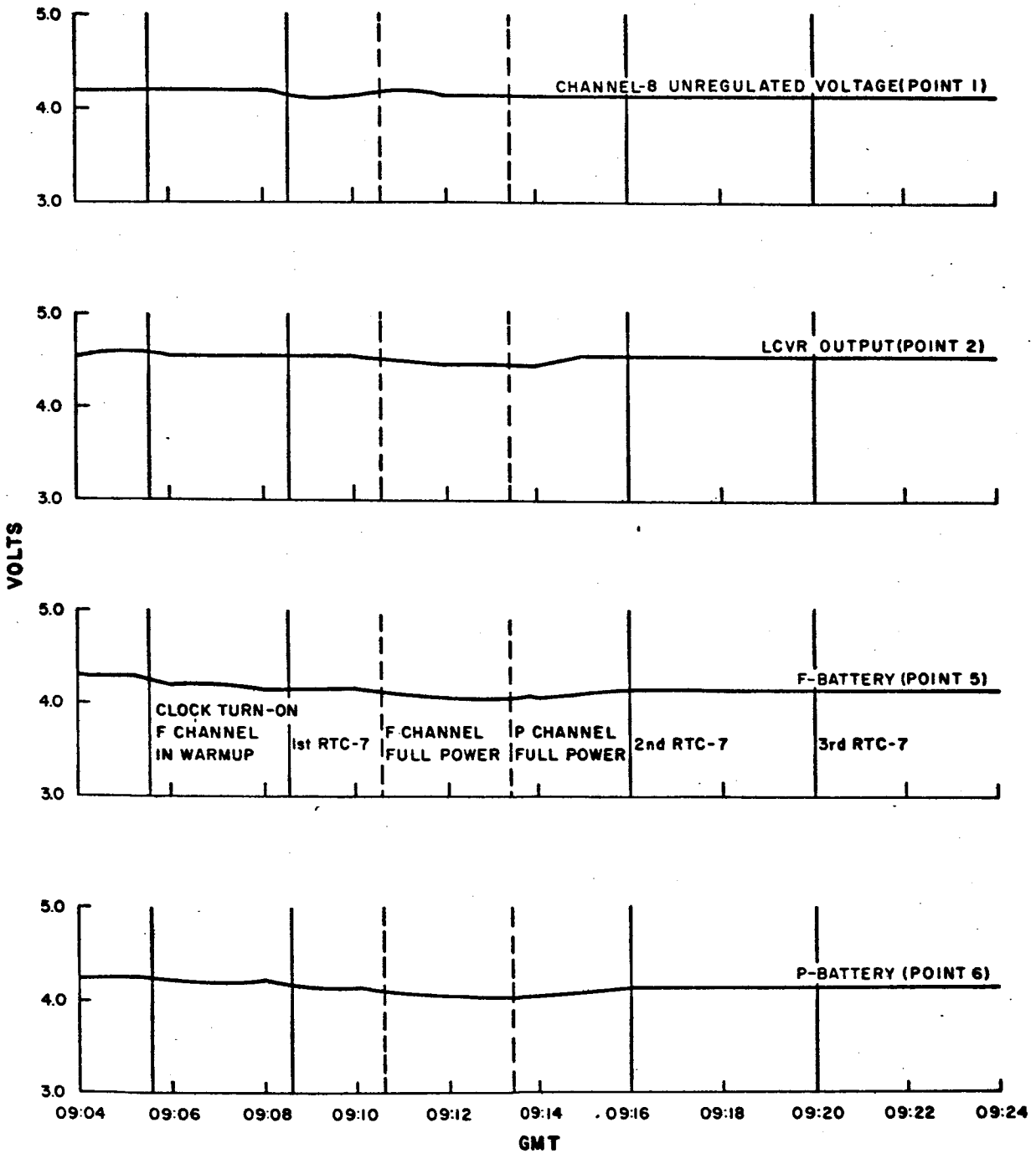

Figure C-7. RA-6, terminal mode to impact, Channel-8 telemetry (2/3/64)

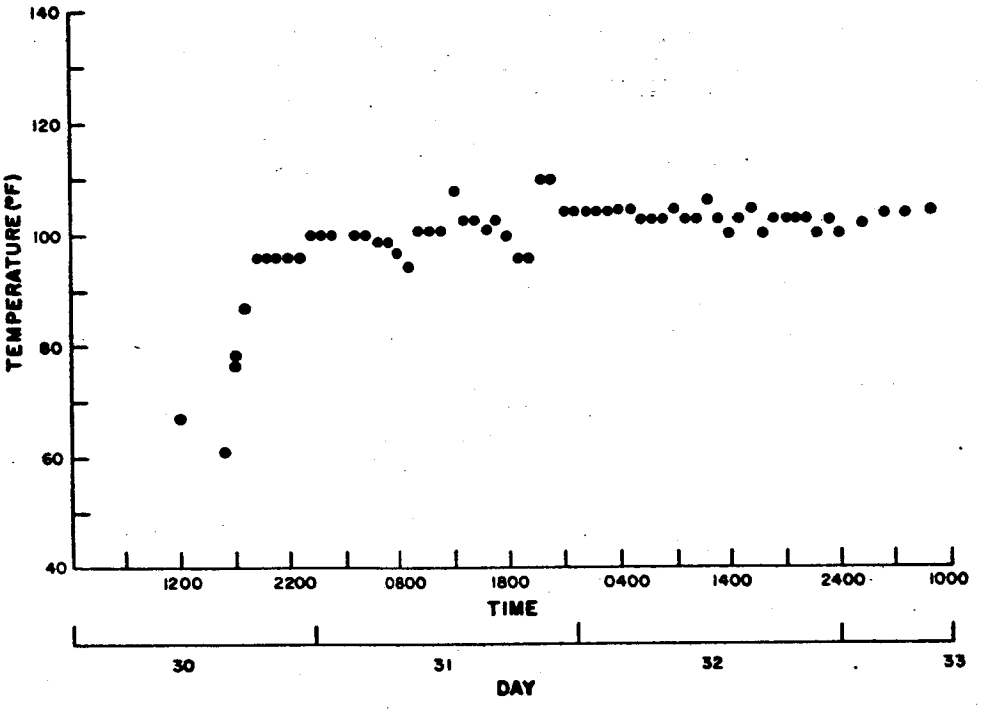

Figure C-8. RA-6 mission telemetry plot, Channel-8, point 7, Top Hat, temperature (-Y axis)

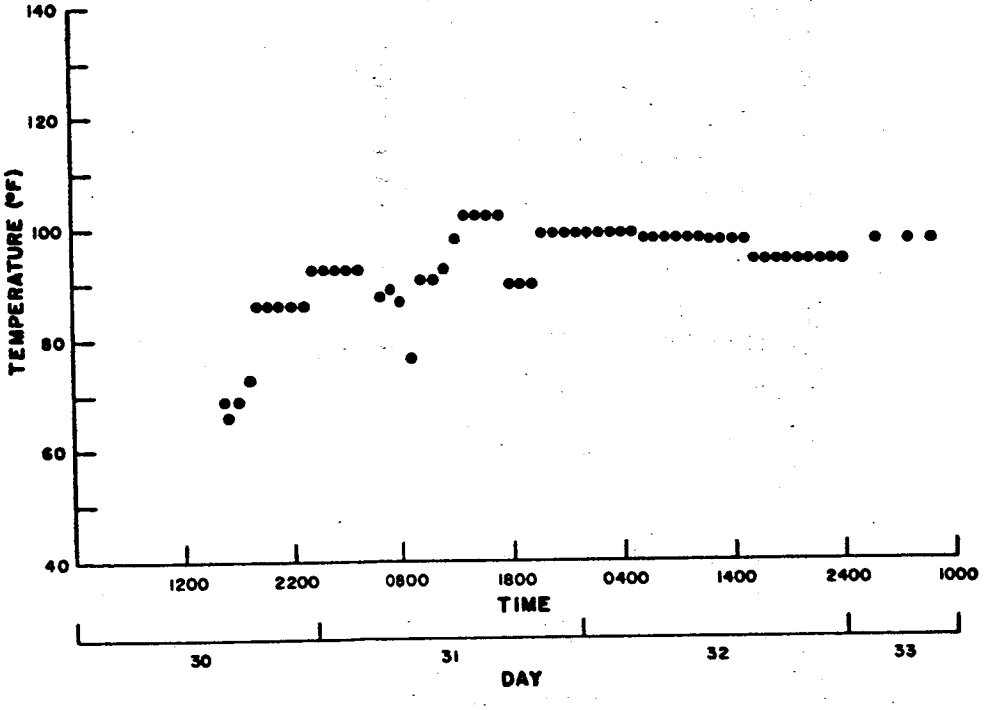

Figure C-9. RA-6 mission plot, Channel-8, point 8, Shroud temperature (-Y axis)

RE-ORDER No. 64-139

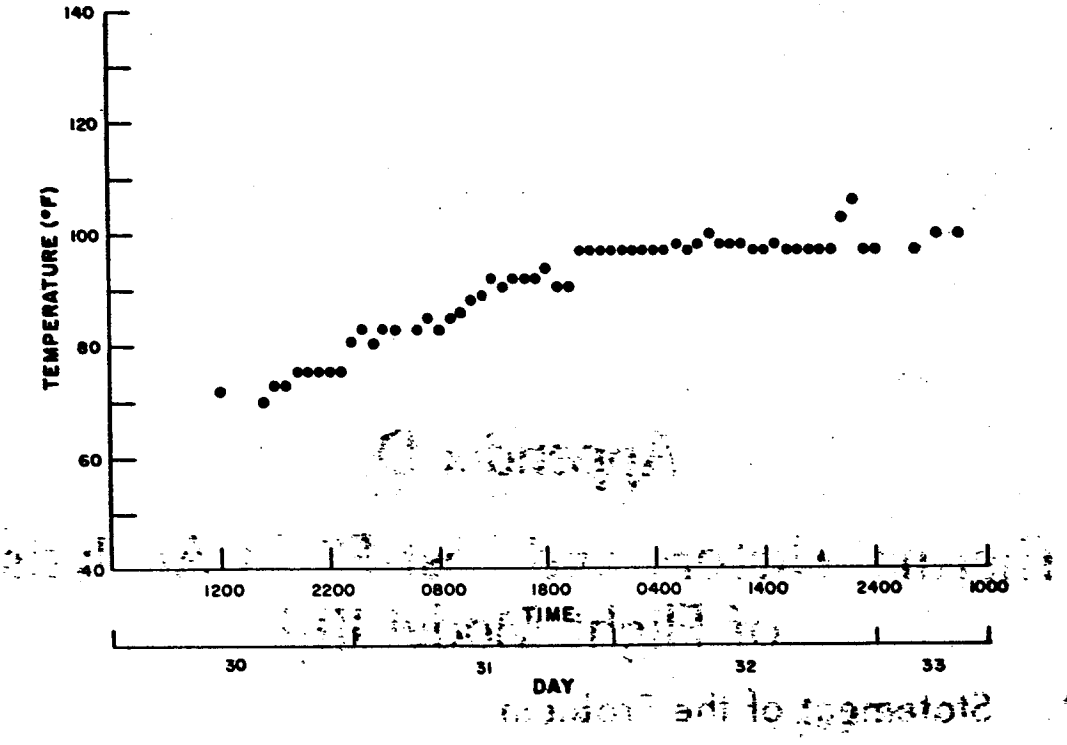

Figure C-10. RA-6, full mission telemetry plot, Channel-8, point 4, P-Battery internal temperature

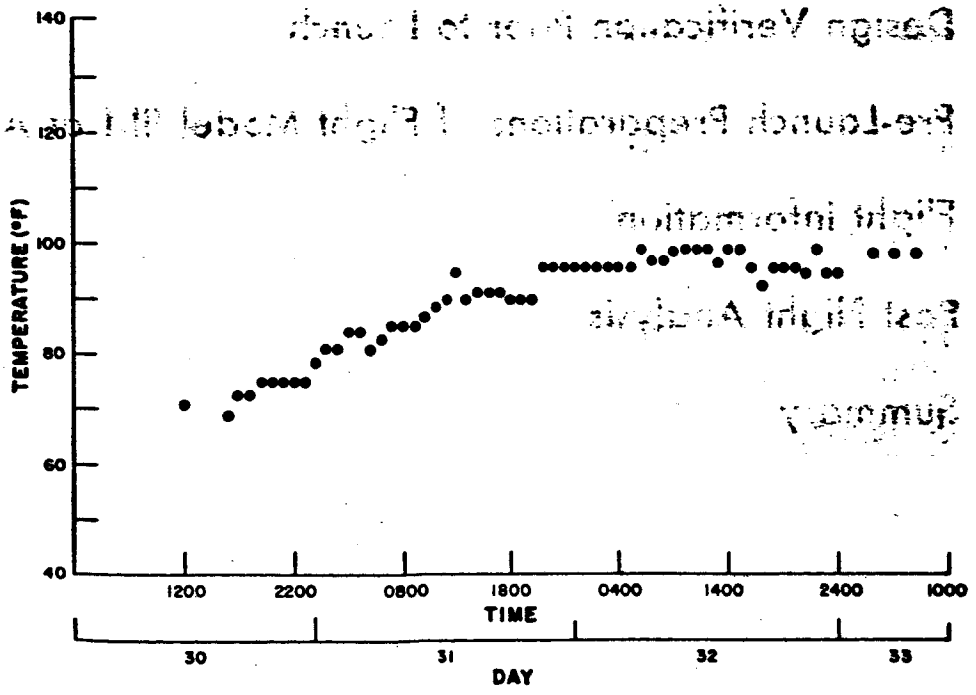

Figure C-11. Full mission telemetry plot, RA-6, Channel-8, point 3, F-Battery internal temperature

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Appendix D

Thermal History and Post-Flight Analysis of Flight Model III-1

A. Statement of the Problem

B. General Concepts of the Thermal Design

C. Design Verification Prior to Launch

D. Pre-Launch Preparations of Flight Model III-1 at AMR

E. Flight Information

F. Post Flight Analysis

G. Summary

RE-ORDER No. 64-139

Appendix D

Thermal History and Post-Flight Analysis of Flight Model III-1

A. Statement of the Problem

During the flight of the III-1 Ranger TV Subsystem, the temperatures recorded via telemetry were higher than those predicted prior to the flight. Generally, temperatures in the lower section of the Subsystem were 15 to 20 degrees C higher than predicted, while temperatures in the camera (upper) section of the Subsystem were 7 to 12 degrees C higher. An evaluation of the flight data and a review of the thermal analysis was undertaken to establish why the higher-than-expected temperatures were obtained. This appendix summarizes the results of the post-flight review.

B. General Concepts of the Thermal Design

The thermal configuration of the RA-6 TV Subsystem is shown in Figure D-1. Primary temperature-control surfaces are:

- Thermal shroud (polished aluminum vehicle skin)
- Thermal fins
- Thermal shields (insulators)

The construction of the shroud and fin assembly is such that solar energy striking the spacecraft parallel to its axis illuminates only the top surfaces of the fins, i.e., no direct sunlight is incident upon the thermal shroud. The flow of thermal energy with this condition is as follows:

- Sunlight strikes the fin surface at a normal angle of incidence and a portion is absorbed. The remainder is reflected to space and other parts of the spacecraft.

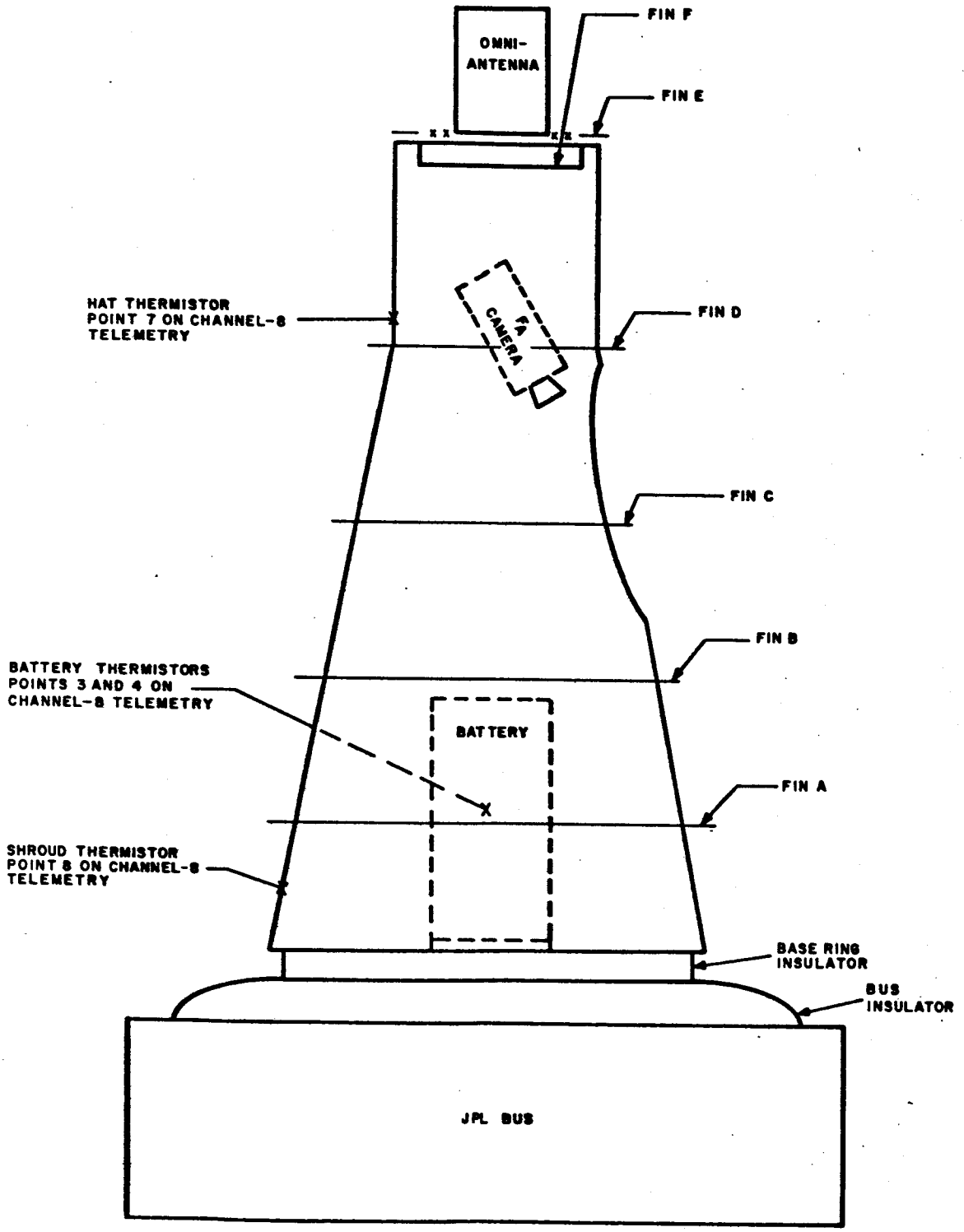

Figure D-1. Thermal configuration of the TV subsystem

- Part of the energy absorbed by the fin is radiated from the front and rear surfaces of the fin, the remainder flows into the thermal shroud.

- The energy flowing into the thermal shrouds from the fins is radiated from the shroud surface (polished aluminum), establishing a temperature field on the shroud surface.

- The temperature field established on the shroud is essentially isothermal; since the shroud envelopes all electronic equipment, the equipment will come to this same temperature at steady-state conditions. During full-power operation of the equipment, the temperatures of individual components are maintained below maximum temperature limits due to the "heat-sinking" properties of the spacecraft.

C. Design Verification Prior to Launch

1. *Thermal-Vacuum Tests*

Prior to thermal-vacuum tests, the model or spacecraft is thermally finsihed to flight conditions. The shroud is polished and washed and then covered with a strippable coating material to protect the surface during additional handling. The temperature-control fins are painted with a material of the same emissivity as used for flight and then covered for protection.

The spacecraft is instrumented with thermocouples capable of accurate detection of transient temperatures. Typical locations for 48 thermocouples are listed in Table D-1. Simulation of absorbed solar energy is accomplished by banding flat ribbon heaters to the underside illumination during flight. The inputs to these heaters are controlled by variable transformers.

Once the spacecraft is assembled, it is suspended in an environmental test chamber capable of maintaining pressures below 1×10^{-6} torr with wall shrouds at -180 to -190°C (LN_2). The Bus interface is simulated by an aluminum plate bolted to the base of the Subsystem and heated and sized to duplicate the JPL Bus. The strip coat is removed before the chamber door is closed.

Under simulated environmental conditions, electrical energy is applied to the heaters on the areas which will be solar illuminated during flight. The input is adjusted to provide a desired temperature distribution in the spacecraft, and an equilibrium condition is reached after approximately 40 hours of simulated cruise mode. The power inputs to the heated areas for the balanced condition are measured and recorded. These inputs are the basis for the determination of the absorptivity of the finishes to be applied to the solar-illuminated areas.

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TABLE D-1

RANGER FLIGHT MODEL III-4 THERMOCOUPLE LOCATION LIST THERMAL-VACUUM TEST AT RCA

Thermo-Couple No.	III-1 Flight Simulation	Nominal Test III-4	Revised Flight Test	Thermocouple Location
1	36.5°C	14.5°C	27.0°C	PA, -X side, unit (Cavity End) Ch. F
2	36.0	14.5	26.2	PA, -X side, mounting (3-7)
3	37.0	15.0	27.0	PA, +X side, unit Ch. P
4	36.5	15.0	26.5	PA, +X side, mounting (3-6)
5	38.0	16.5	26.5	Temp. Sensor Box, under deck 3, +Y side
6	36.0	15.0	26.2	Transmitter Ass'y X-12 unit, +Y side, Ch. P
7	38.0	15.5	26.2	Deck #4, -Y side (3-14)
8	37.5	16.0	26.5	Transmitter Ass'y X-12 unit, -Y side, Ch. F
9	38.0	16.5	27.6	Clock, -Y side
10	37.5	15.5	27.0	IPA Cavity, transmitter ass'y, -Y side, Ch. F
11	36.0	14.5	26.5	Dummy Load, +Y side
12	36.0	14.5	26.2	Deck #4, +Y side (3-15)
13	34.0	13.5	24.2	Sequencer, +Y side
14	32.5	13.0	23.0	Deck #5, +Y side
15	35.0	14.0	24.5	Comm. Pwr. Supply, -X side, Ch. F
16	35.5	14.5	25.5	Comm. Pwr. Supply, -X side, mounting
17	35.5	13.5	25.5	Battery (Internal) Ch. F (3-8)
18	37.0	16.0	24.0	Telemetry VCO, -Y side, (outer assembly)
19	37.5	16.5	24.0	Telemetry Power Supply Unit, -Y side
20	34.0	14.0	23.0	Deck #5, -Y side
21	34.5	14.0	24.0	Comm. Pwr. Supply, +X side
22	35.0	13.5	24.5	Battery All, Case (3-5) Ch. P

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TABLE D-1

RANGER FLIGHT MODEL III-4 THERMOCOUPLE LOCATION LIST THERMAL-VACUUM TEST AT RCA (Continued)

Thermo-Couple No.	III-1 Flight Simulation	Nominal Test III-4	Revised Flight Test	Thermocouple Location
23	32.5	10.5	24.0	Camera Electronics, +Y side, upper unit
24	37.0	14.5	27.0	Deck #3, +Y side, mounting
25	36.0	15.5	28.0	Sequencer Pwr. Supply, +X side
26	1.0	-13.5	- 5.0	Camera Electronics Thermal Shield, +Y side
27	37.0	15.5	27.0	IPA Cavity, -Y side, 1" below top, Ch. F
28	37.0	16.0	29.0	Video Combiner, -X side
29	35.0	13.0	27.0	Camera Electronics, -Y side, upper unit (3-2)
30	40.5	17.5	31.0	Deck #3, -Y side
31	36.0	15.0	26.7	IPA Cavity, transmitter ass'y, +Y side, Ch. P
32	38.0	16.5	26.5	Thermal Shield, -Y side (3-11), below Fin A
33	27.5	13.5	19.0	Camera F_a Lens Housing (3-1)
34	36.0	23.0	27.0	Camera Mounting Bracket, upper, (3-3)
35	35.0	14.0	25.0	Battery A10, case (3-8) Ch. F
36	47.0	42.0	38.0	Temperature Control Plate, Center (Fin F)
37	36.5	15.0	26.7	Battery (Internal) Ch. P (3-10)
38	36.0	14.0	26.0	Thermal Shield, +Y side (3-12) below Fin A
39	72.5	52.0	26.5	Antenna Ring, surface, -X side
40	38.5	26.5	29.5	Thermal Shield, hat, -Y side (3-9)
41	32.5	12.5	22.5	Hi-Current Regulator (Ch. F), -Y side

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TABLE D-1
RANGER FLIGHT MODEL III-4 THERMOCOUPLE LOCATION LIST THERMAL-VACUUM TEST AT RCA (Continued)

Thermo-Couple No.	III-1 Flight Simulation	Nominal Test III-4	Revised Flight Test	Thermocouple Location
42	48.5	44.5	47.0	Bus Simulation Plate, -Y side
43	32.0	12.5	23.0	Hi-Current Regulator (Ch. P), +Y side
44	40.0	17.5	29.0	Thermal Shield, -Y side, A-B
45	37.0	14.5	27.0	Thermal Shield, +Y side, A-B
46	41.0	18.0	32.0	Thermal Shield, -Y side, B-C
47	33.0	15.0	24.5	Thermal Shield, +Y side, B-C
48	42.5	20.5	34.0	Thermal Shield, -Y side, C-D

The level of fin input determined from the thermal-vacuum test as described above, has been found to provide reproducible temperatures, both on the same model and from model to model, provided no other factors have been altered. A comparison of models and vehicles tested in this manner is shown in Table D-2. The low levels of unaccountable energy on all of these tests is an indication of the reliability of the test method. What cannot be taken into account in these tests are solar reflections which in themselves are a rather abstract problem.

2. *Solar-Simulation Tests*

The Thermal Control Model (TCM) and Proof Test Model (PTM) were tested under the solar simulator at JPL for purposes of design verification. The primary objective in the test of the TCM, however, was to evaluate the capability of the JPL 25-foot Space Simulator for verifying the thermal design of spacecrafts. These two objectives are complimentary and cannot be separated distinctly. The solar-simulation test preparation and instrumentation were influenced by the thermal-vacuum test results obtained from previous tests performed at AED. A complete description of the tests on the TCM and PTM and the conclusions drawn from them may be found in the 13th Bi-monthly Progress Report. (AED R-2113, issued October 8, 1963).

Tests on the PTM, which is of the same configuration and assemblage as Flight Model III-1, provided similar results to tests performed at AED. It can be assumed that

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TABLE D-2
RANGER THERMAL VACUUM TEST DATA

Subsystem	Test	Fin Input (watts)							Cruise Temperature, °C				
		A	B	C	D	E	F	Total	Hat	Vidicon	Shroud	Battery	Camera Electronics
TCM	JPL S.S.III	21.8	23	32.1	50.7	15.5	30.9	174	10	NA	-9	-9	-10
PTM	RCA 1A	30	36	43	52	13	32	206	22	12	17	14	18
PTM	RCA 1B	15	31.5	34	44.5	9	23	157	8	5	2	5	4
PTM	RCA 1C	51	49	6.2	68	17	37	284	36	27	30	22	28
PTM	RCA 2	30	36	48	52	13	36	215	22	14	17	16	15
PTM	JPL S.S.B	34.7	35.1	51.8	66.4	19.5	40.9	248	33	32	14	15	12
PTM	JPL S.S.D	30	36	48	52	13	36	215	24	24	11	12	9
FM III-1	RCA 1	31	36	48	52	13	36	216	23	13	13	12	11
FM III-2	RCA 1	31	36	48	52	13	36	216	21	10	10	10	10
FM III-2	RCA 2	31	36	49	53	13	37	219	21	10	11	11	9
FM III-2	RCA 3	33	41	53	57	14	38	236	26	14	15	14	14
FM III-3	RCA 1	33	41	53	57	14	38	236	29	18	18	16	17
FM III-3	RCA 2	33	49	53	57	8	38	238	27	16	18	17	18
FM III-4	RCA 1	48.5	60	71	71	20	32	303	39	28	38	36	35
FM III-4	RCA 2	34.5	42	51.5	55	17	38	237.5	27	14	16	14	13
FM III -4	RCA 3	38	56	66	64	10	32.5	267	29	19	27	26	27

Flight Model III-1 would have acted the same as the PTM under solar simulation since this was true in tests in which heaters were used to simulate the solar input. The reflection characteristics of both were the same so as to provide a like input due to this source of illumination.

The question left unanswered by the solar-simulation test program is just how much error lies between the system in the JPL chamber and actual solar illumination. For a spacecraft of low profile, this error can be shown to be reasonably small, but for a configuration such as the Ranger TV Subsystem, not only does the intensity diminish from top to bottom, but the collimation error becomes acute. Direct solar inputs are distorted and when "sunshades" are used to limit the angular illumination, other factors are affected, such as intensity levels and reflection errors.

3. *Absorptivity and Emissivity Measurements*

The values of the optical properties of the finishes for the Ranger TV Subsystem flight models are determined from test data obtained during the thermal-balance tests. Paints are mixed, blending PV-100 white paint with black Mil-E-5557 III, to provide the desired absorptivity values (gray paint reference, RCA Drawing No. 1758619). The shrouds are kept cleaned and polished to maintain a low value of emissivity.

Measurements of the optical properties of the paints are made using sample slugs painted at the time the finish is applied to the shrouds of the flight models. The same procedure and specifications are used to paint the sample slugs as is followed in the painting of the shrouds.

The absorptivity of the finish is determined by spectrophotometric analysis at AED. Samples are submitted to JPL and a check on the absorptivity is determined by STL. Comparative results from AED and STL are listed in Table D-3.

D. Pre-Launch Preparations of Flight Model III-1 at AMR

1. *Flight Preparations of Thermal Surfaces*

At AMR prior to systems assembly of Flight Model III-1 Ranger TV Subsystem, all unpainted aluminum surfaces of the thermal shroud were repolished. The shrouds were washed down with detergents dissolved in distilled water, thoroughly rinsed, and allowed to dry.

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TABLE D-3
COMPARATIVE RESULTS ON SOLAR ABSORPTIVITY MEASUREMENTS BY RCA/JPL/STL

Sample Finish	Solar Absorptivity Value Measured			
	RCA	JPL/STL	STL Range Over Many Samples (14)	Measured on III-1 at AMR by RCA
Gray No. 1 (353-1116)	0.33	0.36	0.36/0.43	0.39/0.41
Gray No. 2 (353-1120)	0.60	0.63	0.63/0.65	0.63/0.65
Gray No. 3 (353-1124)	0.80	0.85	0.83/0.85	0.80/0.82

NOTE: Samples obtained from batches of Gray paint supplied by RCA to JPL. These paints were used on the PTM and FM III-1.

The fins of the thermal shroud were covered with protectors and then masked. Strippable coating developed by the Goddard Space Flight Center of NASA was applied to maintain the cleanliness of the polished surface and to limit the oxidation effect. The coating leaves no film, thereby causing no alteration in the optical properties of the surface. The strip coat was not removed until final assembly.

2. *Verification of Absorptivity*

After cleaning the thermal shrouds, the absorptivities of the painted surfaces were verified using a portable reflectometer manufactured by the Lion Research Co. This equipment is standardized and calibrated using painted samples evaluated by spectrophotometric analysis at AED. Checks were made at many points on each fin to assure that handling and aging had not caused a change in the absorption value. Favorable results were obtained from this verification test and no repainting was considered necessary. (See Figure D-2.)

3. *Recalibration of Temperature Sensors*

During systems checkout at AMR, it was found that the Temperature Sensor Assembly (Serial No. 7) had two damaged diodes. The unit was replaced with Serial No. 4 assembly. All fifteen thermistor circuits were recalibrated prior to the launch and this information sent to the SDAT team. The final calibration of Flight Model III-1 temperature telemetry points are given in Figures D-3 through D-17.

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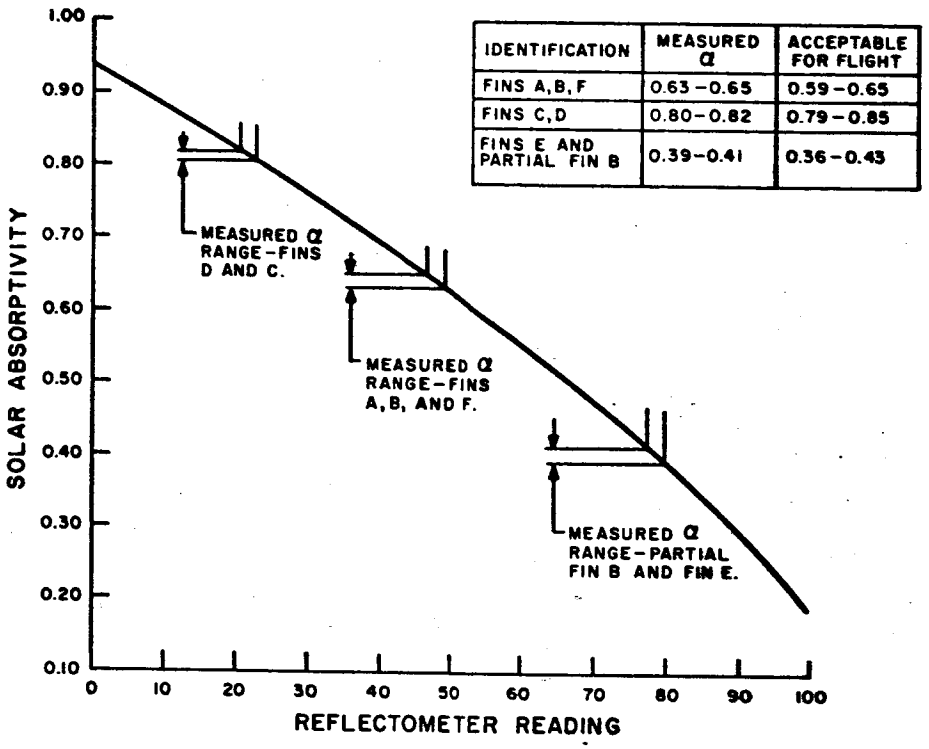

IDENTIFICATION	MEASURED α	ACCEPTABLE FOR FLIGHT
FINS A, B, F	0.63 – 0.65	0.59 – 0.65
FINS C, D	0.80 – 0.82	0.79 – 0.85
FINS E AND PARTIAL FIN B	0.39 – 0.41	0.36 – 0.43

Figure D-2. Solar absorptivity measured on Ranger TV Subsystem Flight Model III-1 at AMR prior to launch

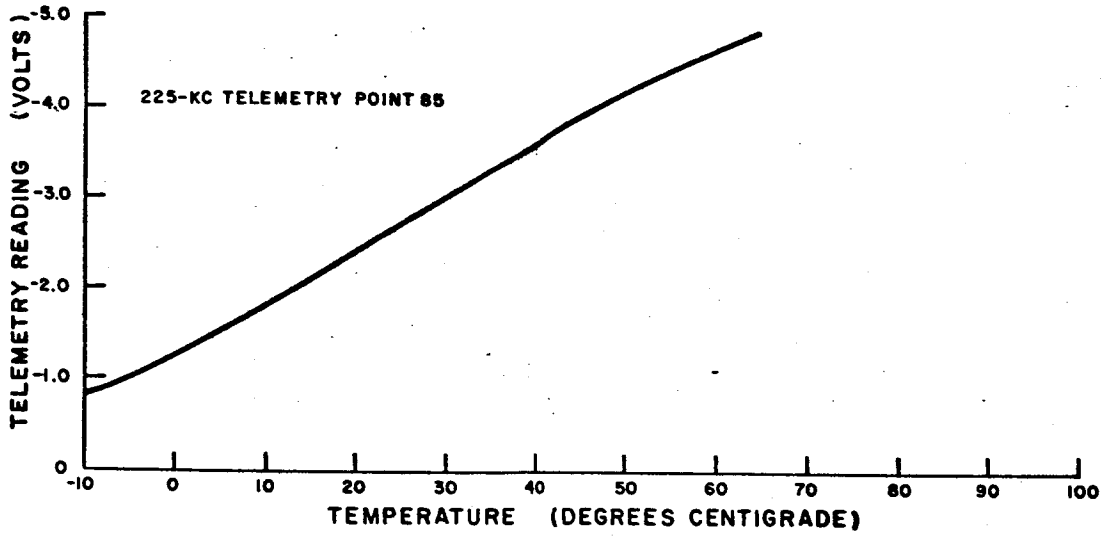

Figure D-3. Calibration curve for thermistor 1-1, front housing of F_a camera

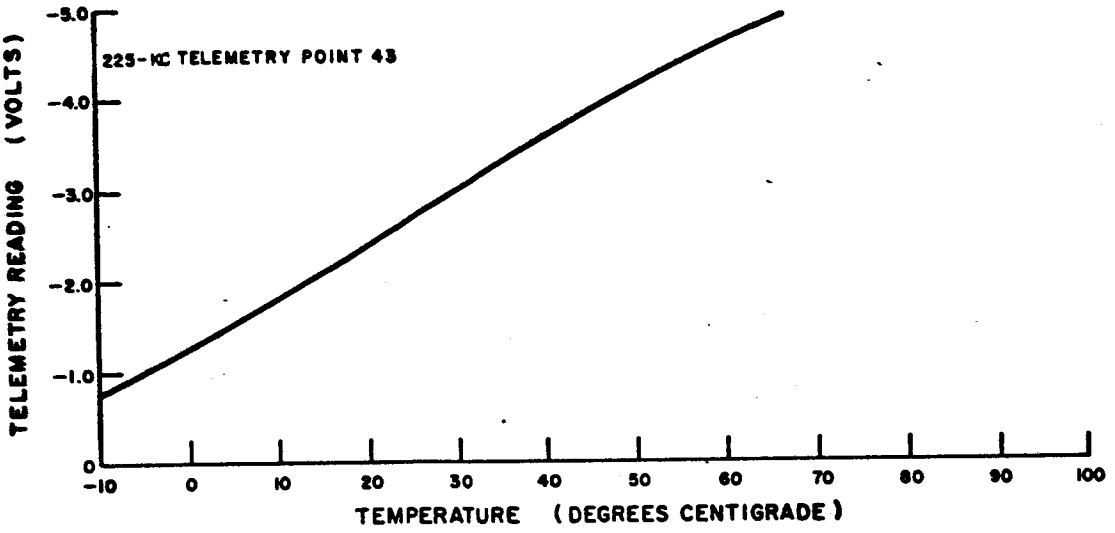

Figure D-4. Calibration curve for thermistor 1-2, frame 2 of F_b Camera Electronics, -Y side

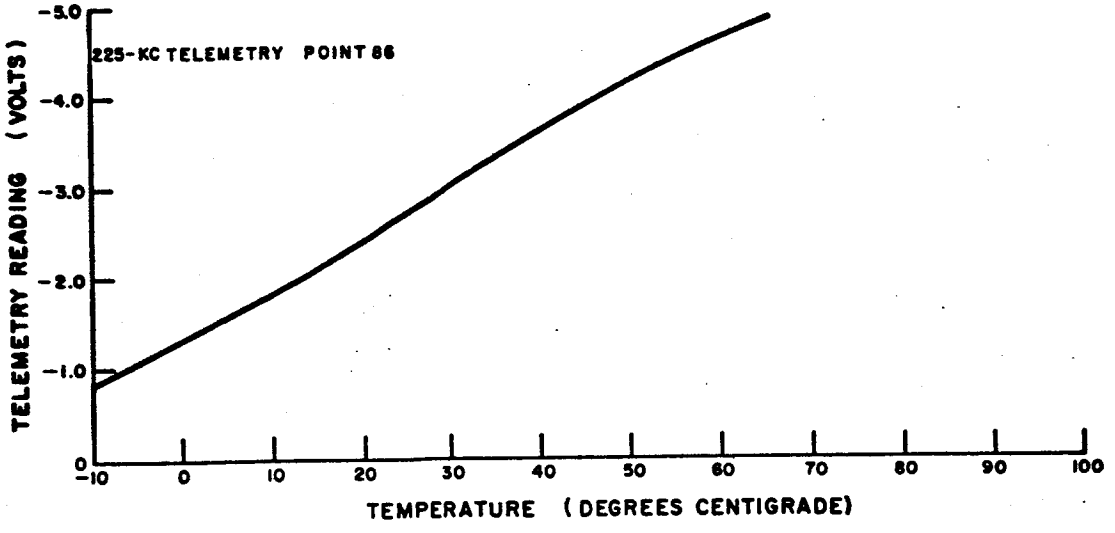

Figure D-5. Calibration curve for thermistor 1-3, Camera Mounting Bracket

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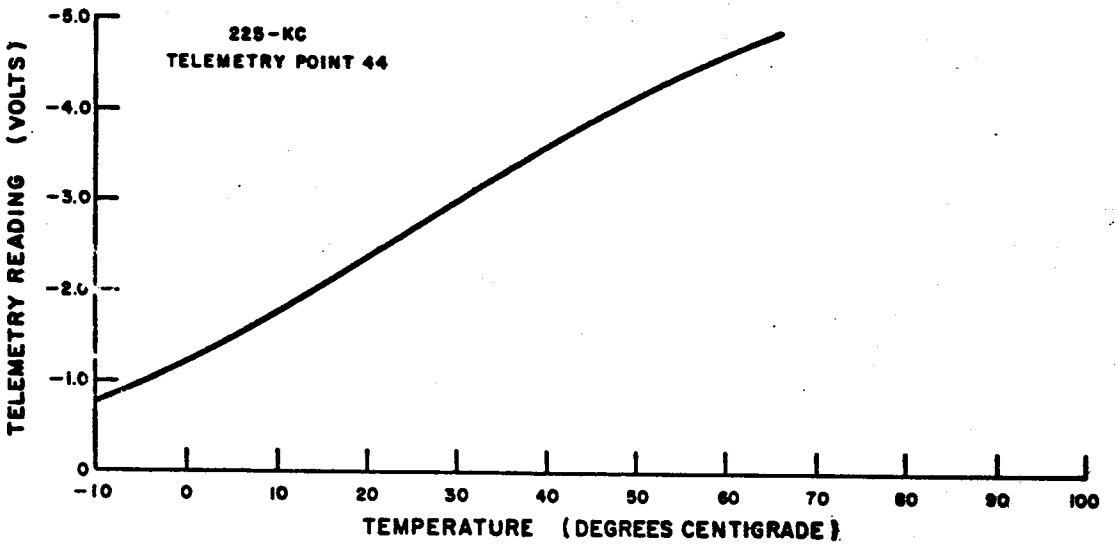

Figure D-6. Calibration curve for thermistor 1-4, F-Channel Battery case, -X side

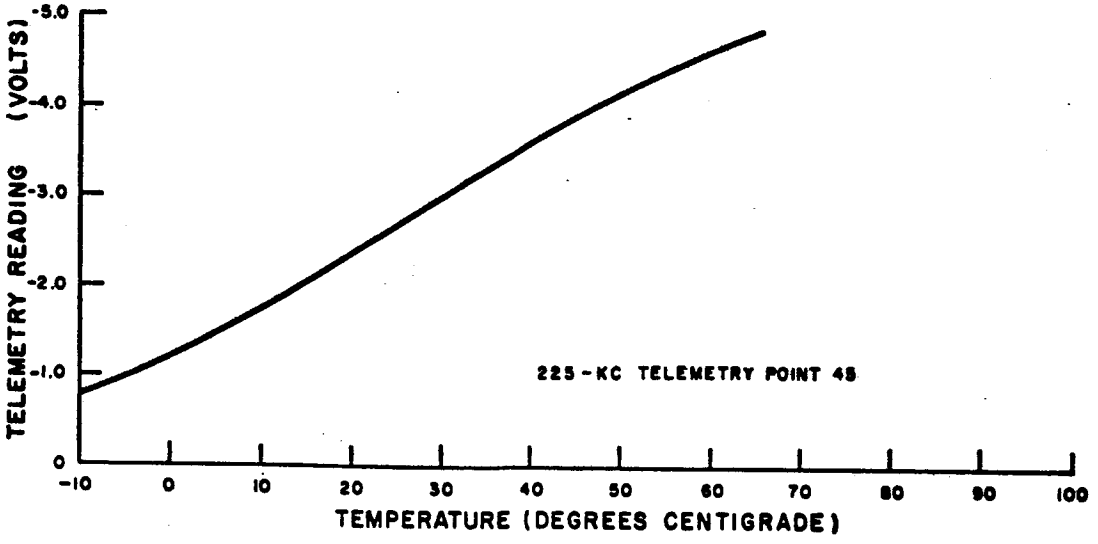

Figure D-7. Calibration curve for thermistor 1-5, P-Channel Battery case, -X side

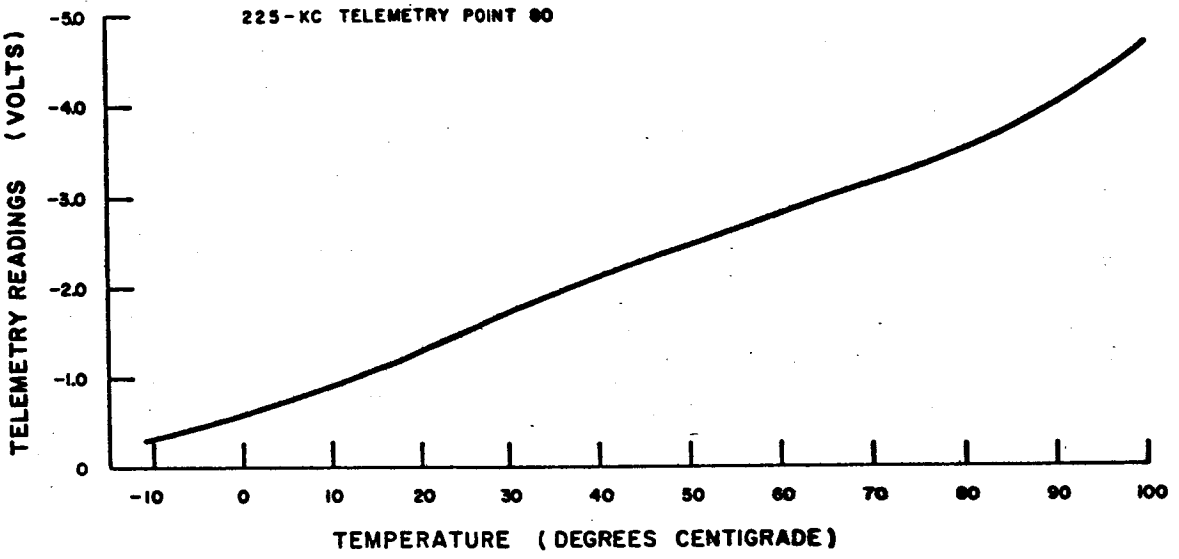

Figure D-8. Calibration curve for thermistor 1-6, P-Channel Power Amplifier mounting, -X

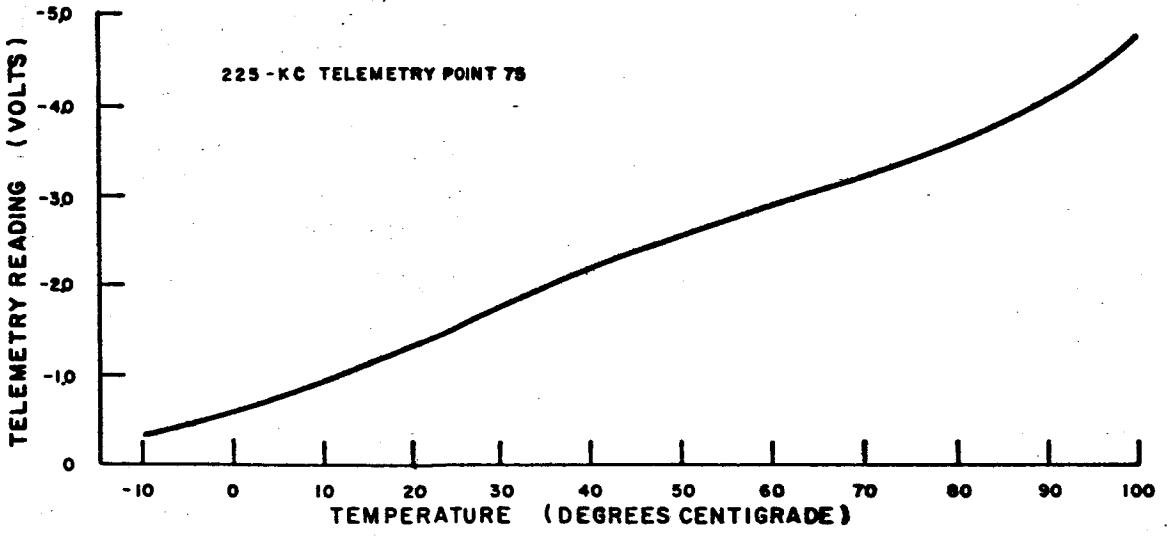

Figure D-9. Calibration curve for thermistor 1-7, below Dummy Load, + Y

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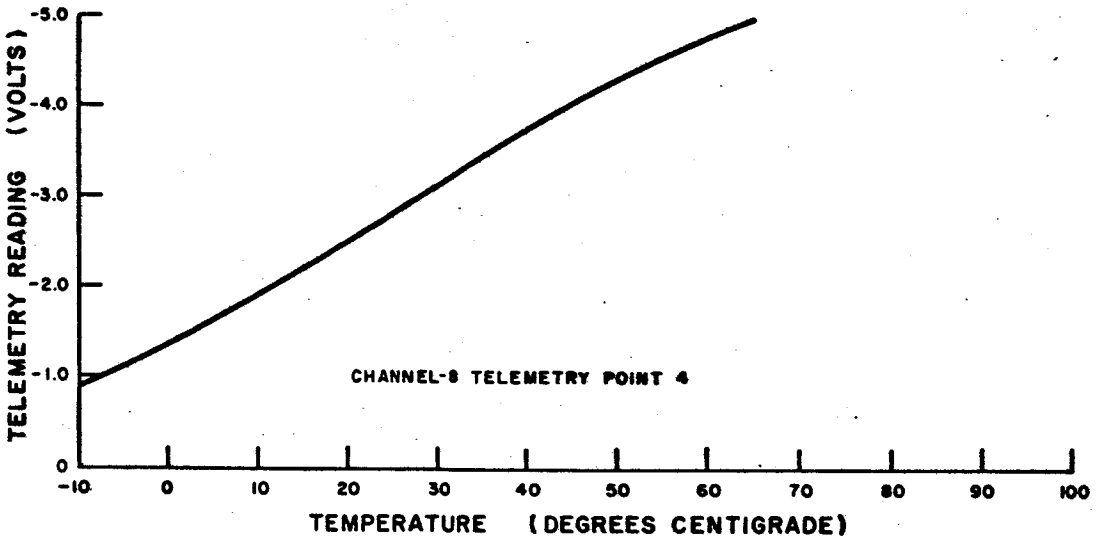

Figure D-12. Calibration curve for thermistor 1-10, P-Channel Battery, inside

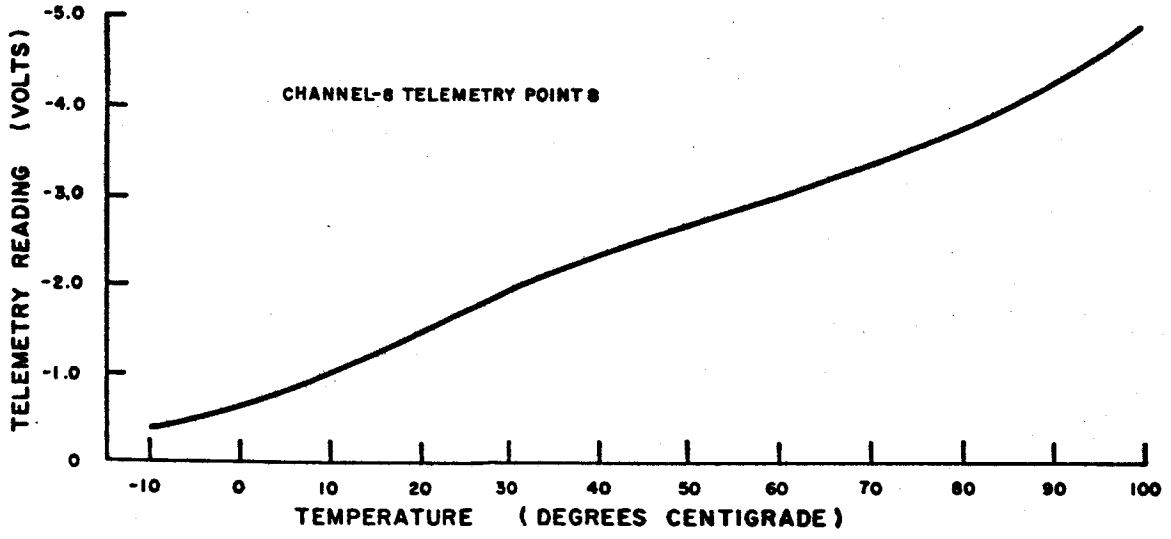

Figure D-13. Calibration curve for thermistor 1-11, Thermal Shroud, Bottom, -Y

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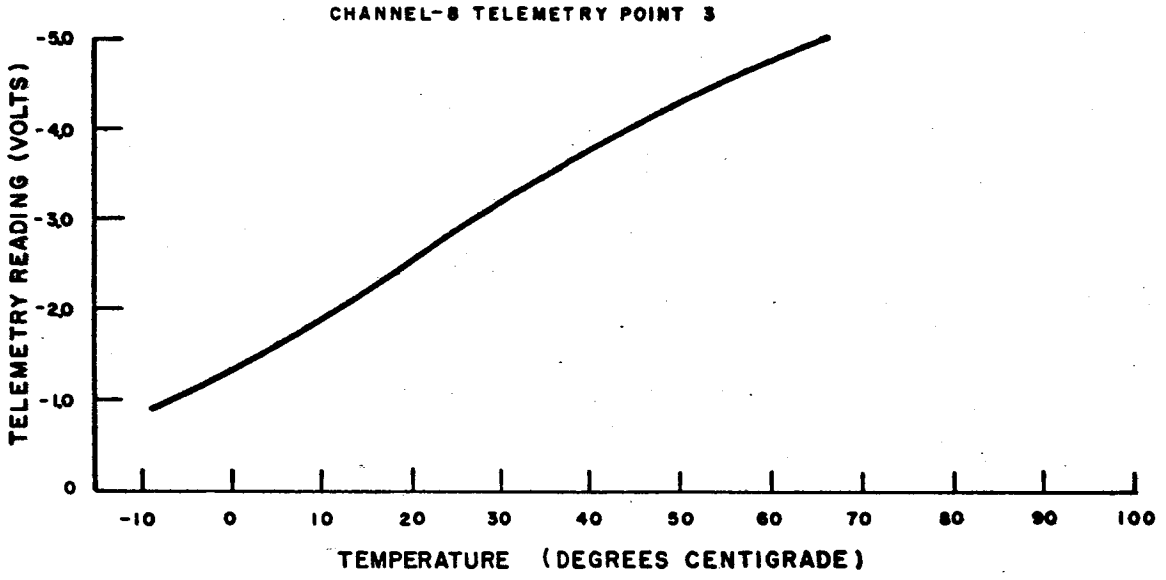

Figure D-10. Calibration curve for thermistor 1-8, F-Channel Battery, inside

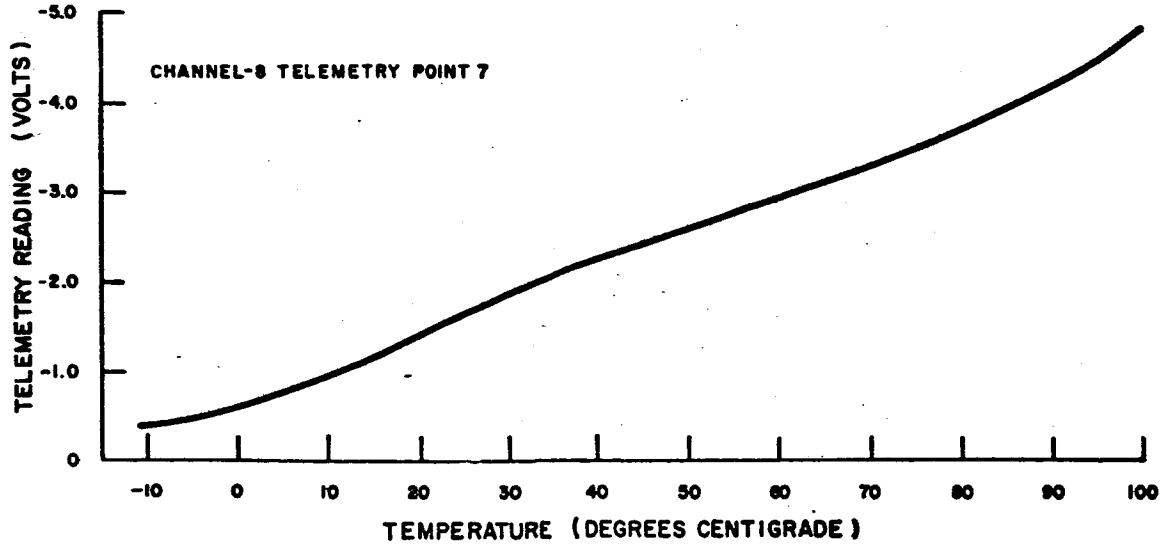

Figure D-11. Calibration curve for thermistor 1-9, Top Hat, -Y

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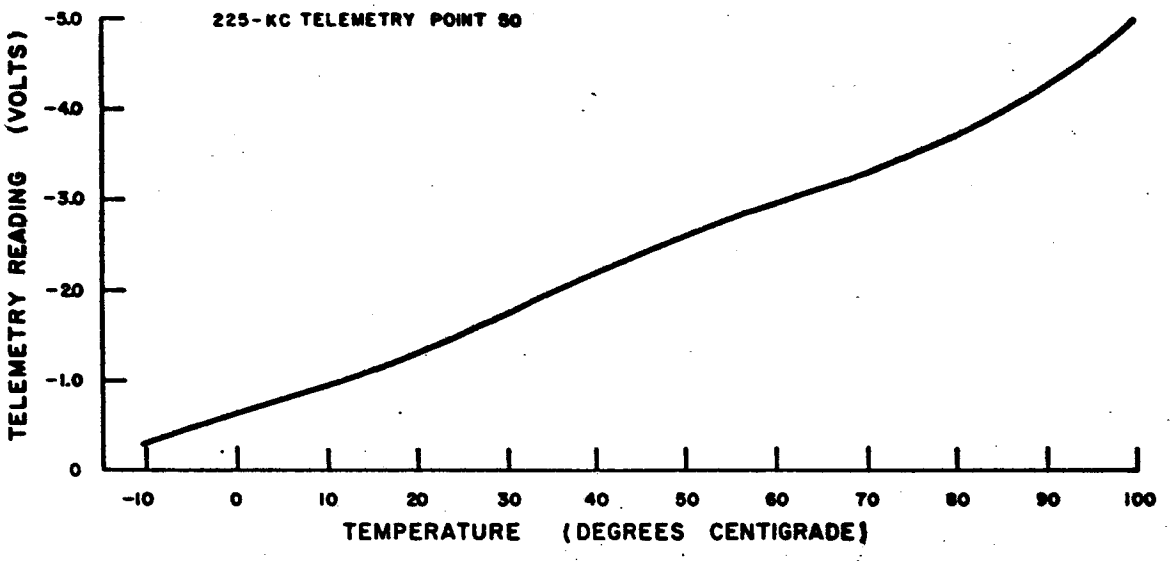

Figure D-14. Calibration curve for thermistor 1-12, Thermal Shroud, Bottom, + Y

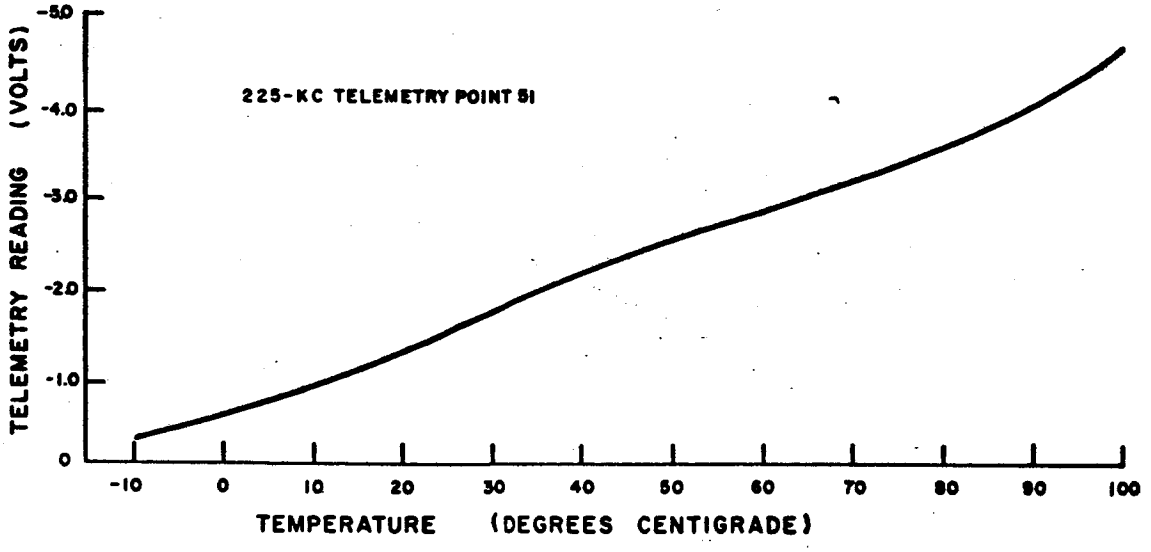

Figure D-15. Calibration curve for thermistor 1-13, Transmitter Power Supply mounting, -X, -Y

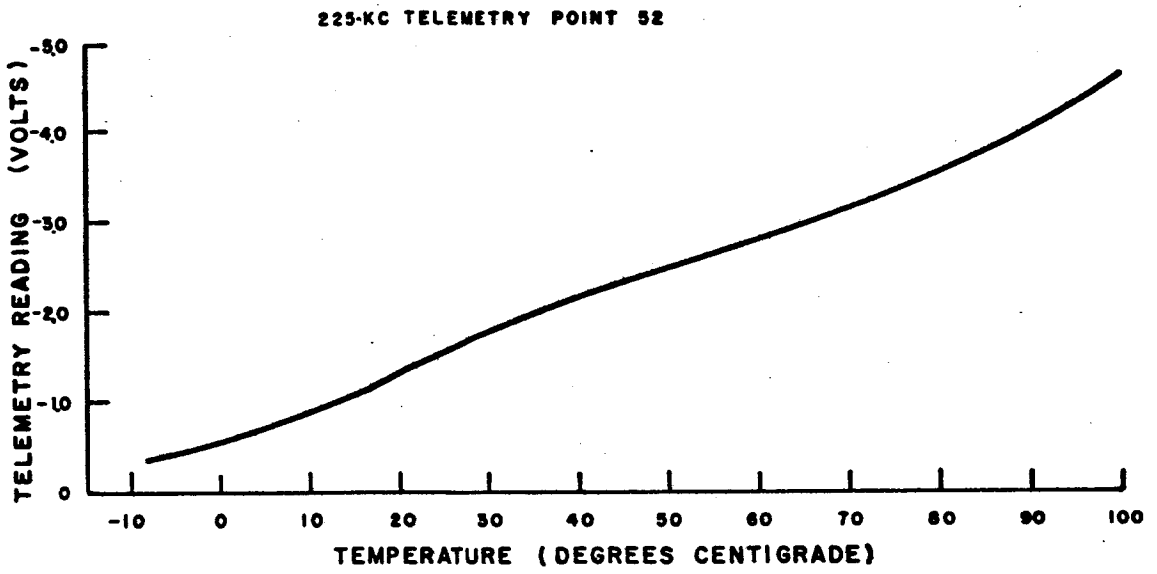

Figure D-16. Calibration curve for thermistor 1-14, second bulkhead, -Y

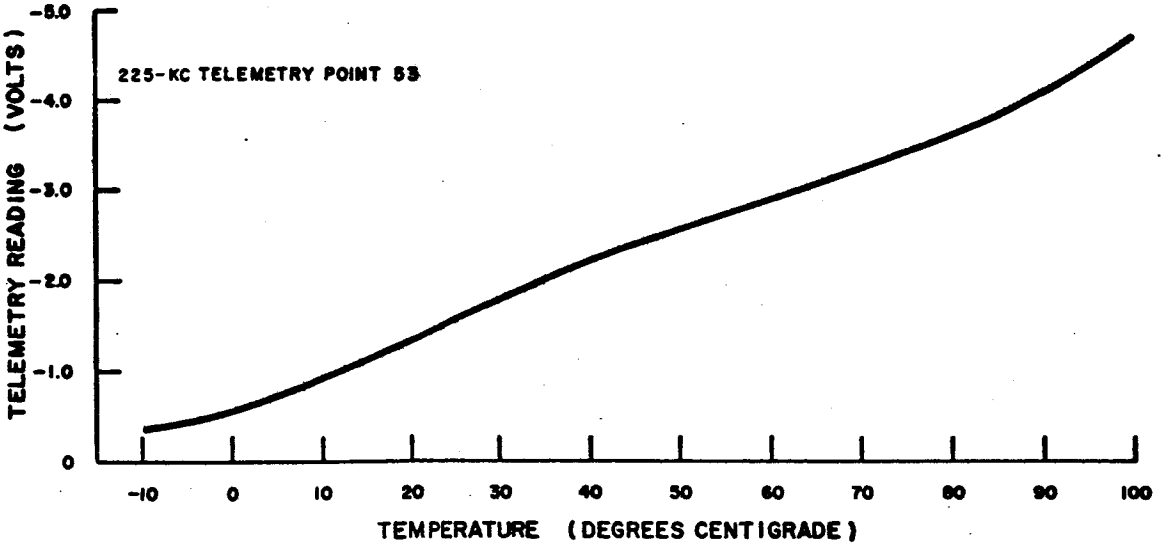

Figure D-17. Calibration curve for thermistor 1-15, second bulkhead, +Y

4. *Cruise-Mode Temperature Predictions*

Prior to the flight of RA-6, predicted temperature curves for the cruise-mode telemetry points were plotted using data obtained during solar-simulation testing of the Block III PTM. These curves are shown in Figures D-18 through D-20.

E. Flight Information

1. *Telemetry Data Received*

Channel-8 telemetry data received during the flight of the RA-6 Spacecraft provided temperatures of each battery, the thermal shroud below fin A on the -Y side, and the temperature of the thermal-shroud hat on the -Y side. Figures D-21 through D-23 are plotted curves of the reduced data from the RA-6 cruise-mode telemetry.

F. Post Flight Analysis

1. *Thermal-Vacuum Tests*

Immediately following the flight of the RA-6 Spacecraft, preparations were made to perform the following thermal-vacuum tests on Flight Model III-4 TV Subsystem at AED:

(a) A test duplicating the real-time flight of the RA-6 Spacecraft. Temperature curves obtained from the RA-6 telemetry were used as a guide for inputs to the fin heaters (the inputs unknown at this point). The fin inputs were adjusted in such a manner as to cause the test-vehicle temperatures to follow the above mentioned curves and at the same time, where possible, maintain the usual ratio of inputs to the fins. This temperature-time duplication is shown by Figures D-24 through D-26. The resulting fin heater input energy for this test is shown in Table D-4.

(b) A test establishing "nominal" temperatures on the vehicle using the pre-flight calculations for the fin inputs. This test verified that the III-4 Subsystem was thermally akin to the RA-6 Spacecraft. The temperatures obtained were those previously called "nominal". The fin energy input is shown in Table D-4.

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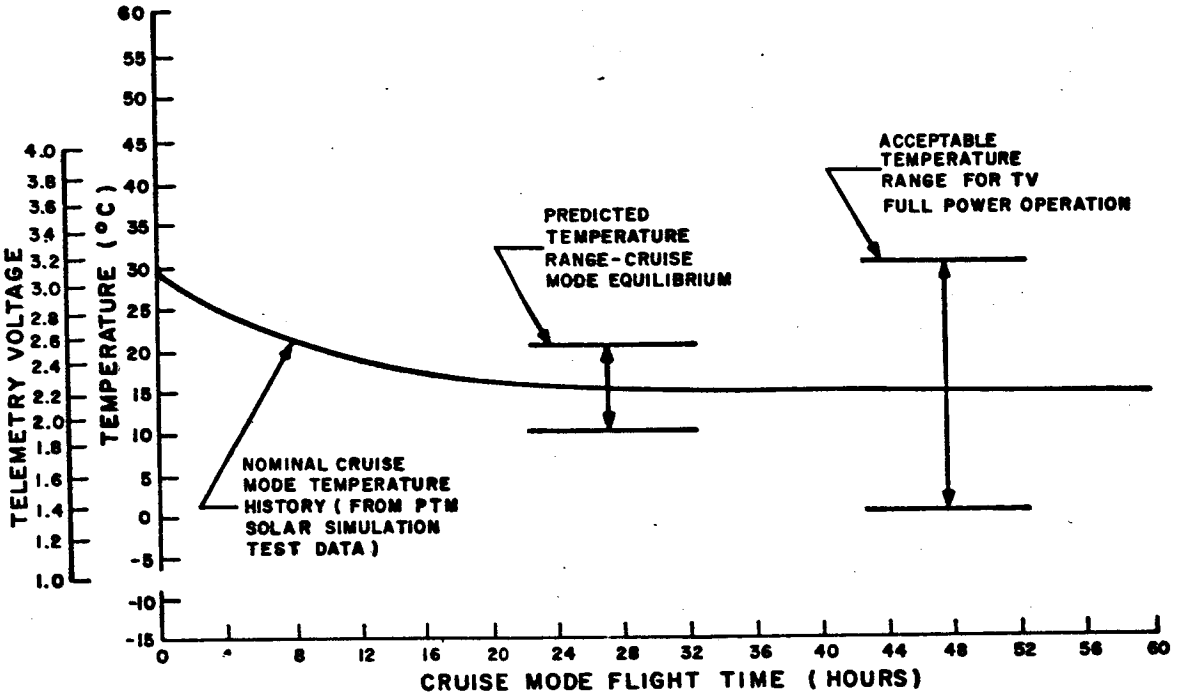

Figure D-18. Flight Model III-1, 15-point telemetry, points 8 and 10

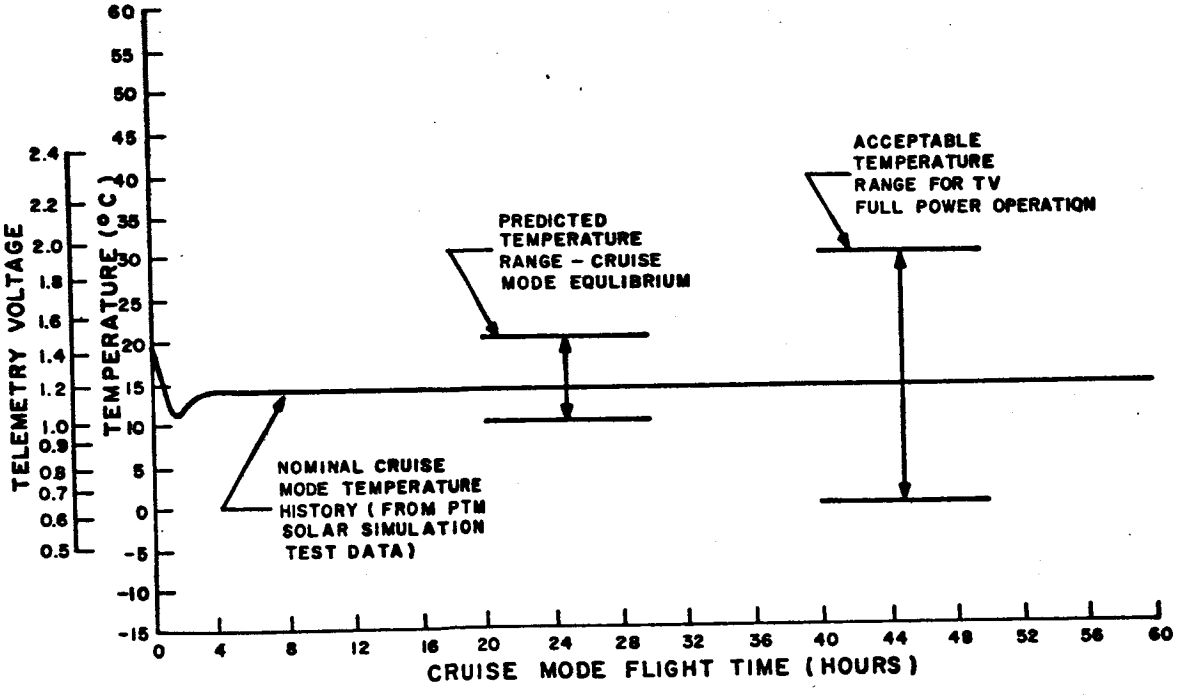

Figure D-19. Flight Model III-1, 15-point telemetry, point 11

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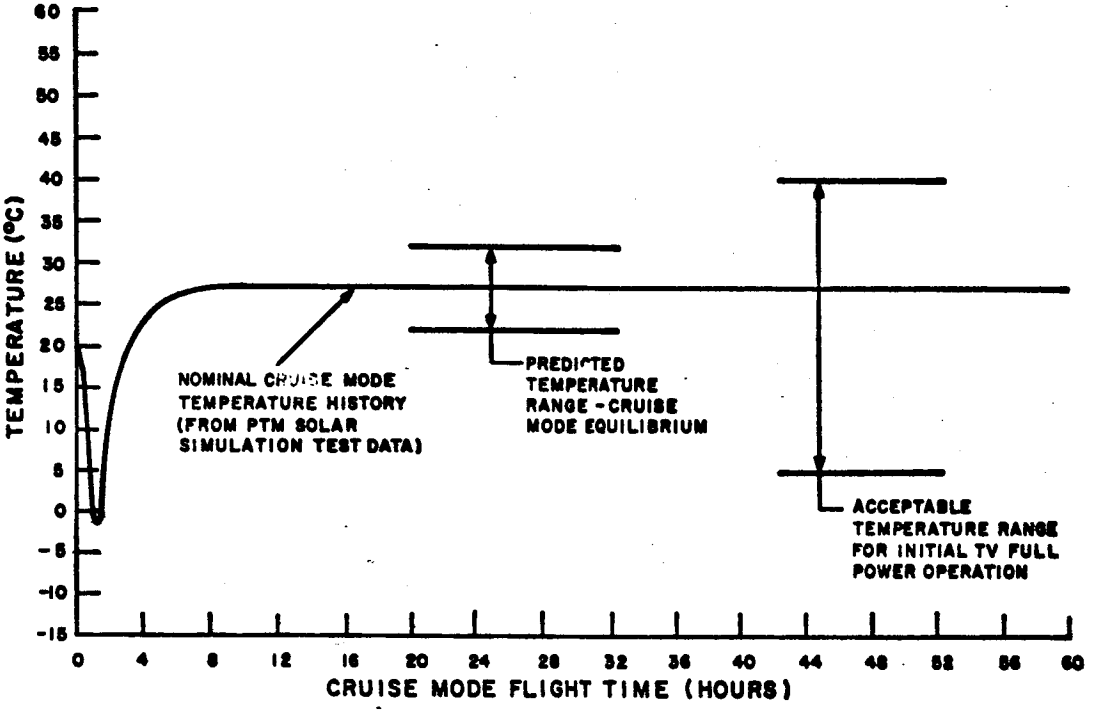

Figure D-20. Flight Model III-1, 15-point telemetry, point 9

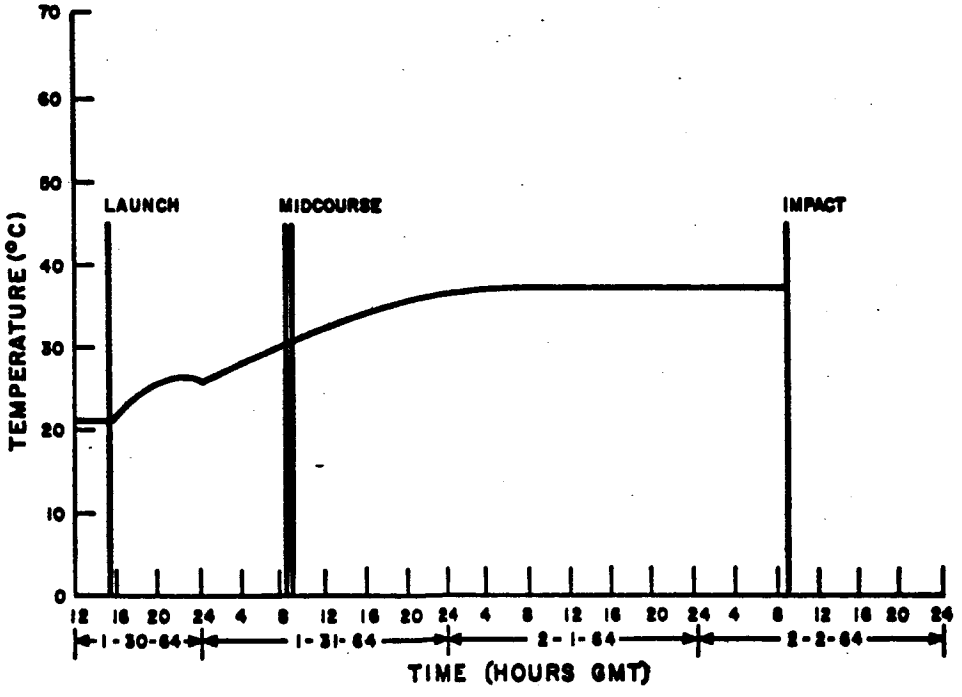

Figure D-21. Flight Model III-1, F-Channel Battery, internal temperature history

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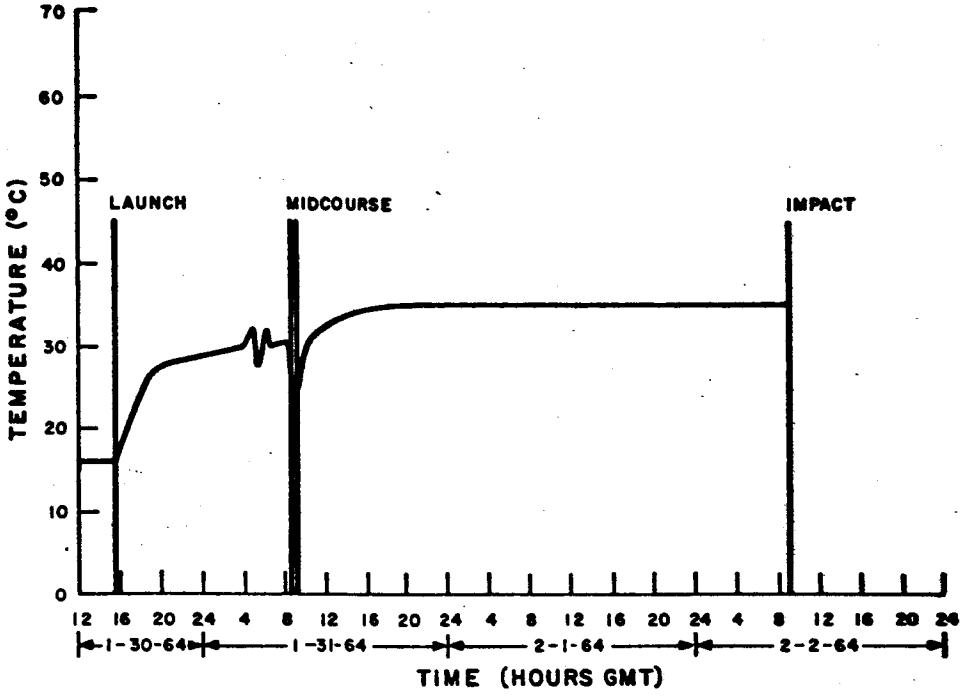

Figure D-22. Flight Model III-1, Thermal Shroud, -Y axis below fin A, temperature history

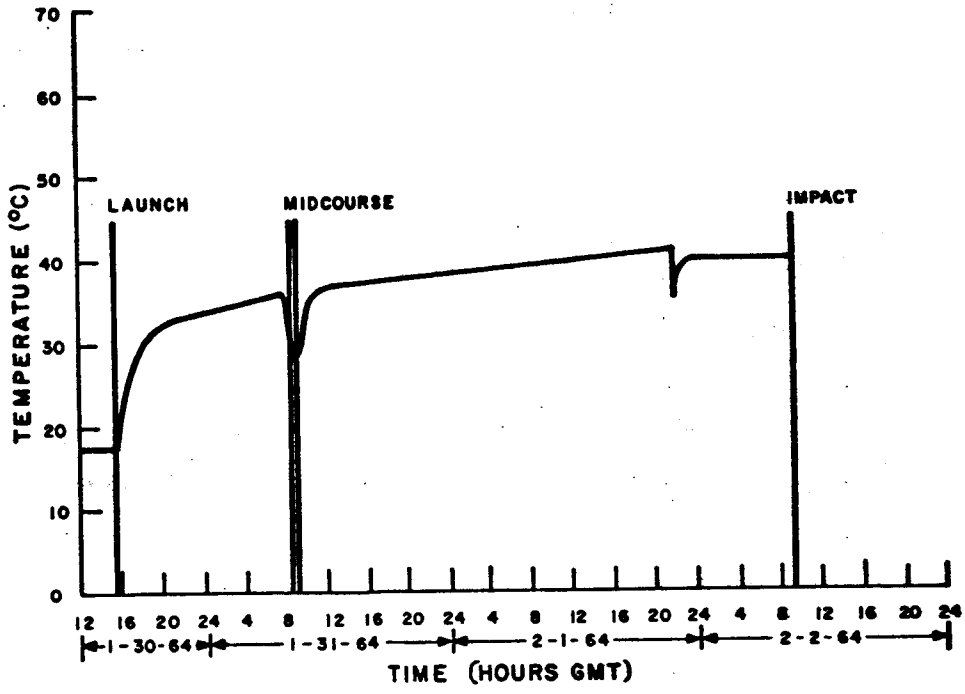

Figure D-23. Flight Model III-1, Top Hat, -Y axis, temperature history

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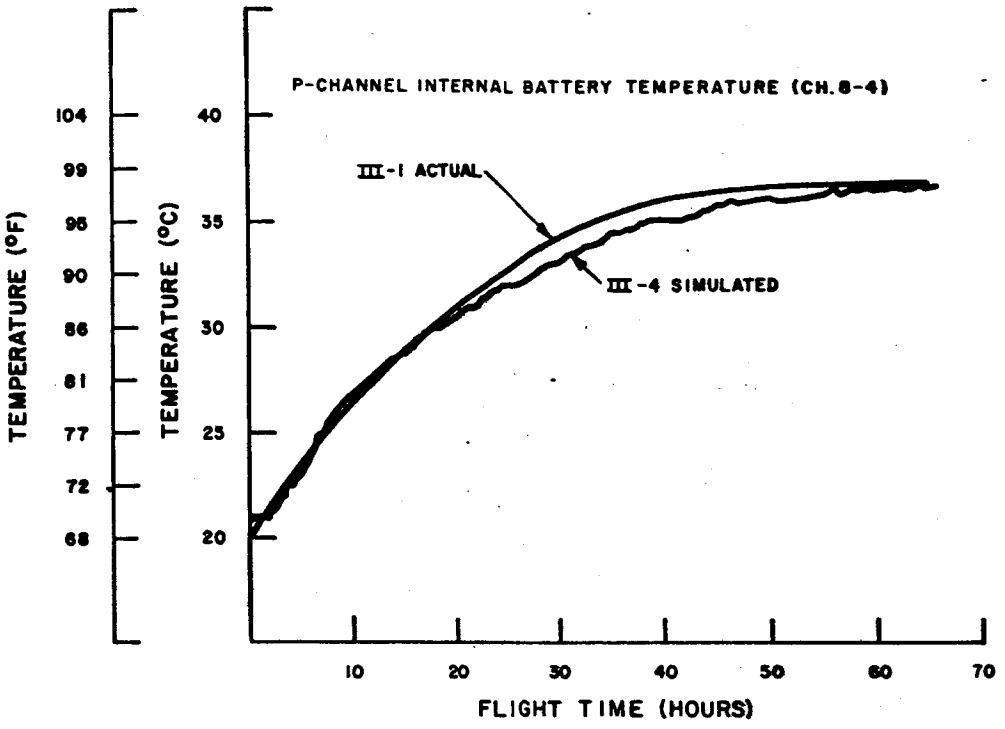

Figure D-24. Actual versus simulated temperature profile, P-Channel Battery, internal

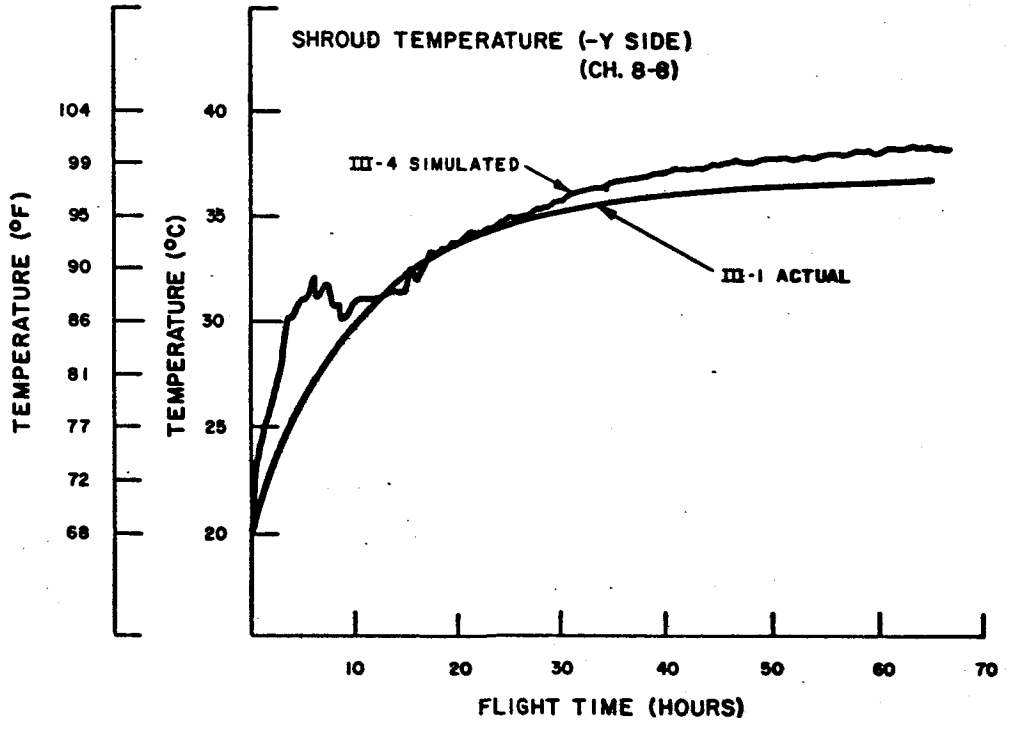

Figure D-25. Actual versus simulated temperature profile, Thermal Shroud, -Y axis

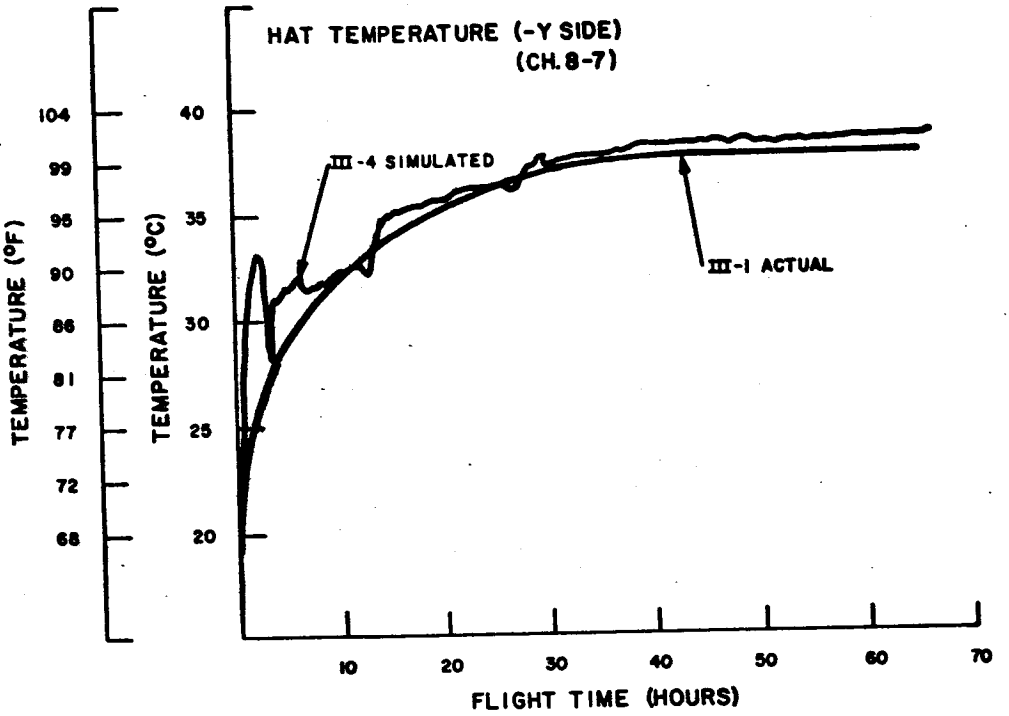

Figure D-26. Actual versus simulated temperature profile, Top Hat, -Y axis

(c) A test establishing a temperature field on the Subsystem 10 degrees C lower than the temperatures obtained from the flight duplication test. This test was called the revised flight test. Table D-4 indicates the fin energy input for this test. The equilibrium temperatures obtained for these tests are given in Table D-1. Energy loss calculations are presented in Tables D-5 through D-7. A calculation of the average radiation coupling factor (K) from the Subsystem surface to the chamber wall is given at the bottom of these tables. The agreement in the calculated values of K for the three tests (880, 887, 887 in^2) indicate that good energy balances were achieved.

The key thermal information obtained from these tests can be summarized as:

(1) Flight Duplication Test — Provided the values of input energy that may represent the energy absorbed during the flight of the RA-6 Spacecraft.

(2) Nominal Test — Verified that the Flight Model III-4 was thermally the same as Flight Model III-1 (RA-6).

TABLE D-4
THERMAL INPUT ENERGY

		Calculations for Ranger III-1				Calculations for Ranger III-2			Test Data (From III-4 Tests)			Comparisons		
												(m-k)	(m-n)	(e-h)
	a	b	c	d	e	f	g	h	k	m	n	p	r	s
Finish Ident.	Proj. Finish Area	α Value	Original Input Calculation S = 0.9	Input Without Reflection S = 0.93	Input With Reflection S = 0.93	α Value	Input Without Reflection S = 0.87	Input With Reflection S = 0.87	Nominal Input Test	III-1 Flight Duplication Test	Revised Flight Test	Increase Nominal to III-1 Flt.	Decrease III-1 Flt. to Revised	Calculation Decrease III-1 to III-2
			Watts	Watts	Watts		Watts	Watts	Watts	Watts	Watts	Watts	Watts	Watts
A	58.5 IN^2	0.65	34.3	35.4	44.7	0.58	29.5	38.9	34.4	48.5	37.9	14.1	10.6	5.8
B*	53.2	0.65	31.1	32.2	45.0	0.58	26.9	43.0	42.0	60.3	56.1	18.3	4.2	2.0
B**	16.4	(0.65) 0.41	9.7	10.0		(0.93) 0.58	13.3							
C	68.4	0.82	50.5	52.2	54.4	0.77	45.8	48.1	51.4	70.7	66.3	19.3	4.4	6.3
D	74.7	0.82	55.1	57.0	58.6	0.77	50.0	51.9	55.1	71.0	64.0	15.9	7.0	6.7
E	45.2	0.41	16.7	17.2	17.2	0.20	7.9	7.9	16.7	19.9	10.1	3.2	9.8	9.3
F	50.1	(0.84) 0.65	37.9	39.1	39.7	(0.81) 0.58	35.3	36.0	37.8	32.3	32.4	-5.5	-0.1	3.7
Totals	366.5	—	353.3	243.1	259.6	—	208.7	225.8	237.4	302.7	266.8	65.3	35.9	33.8

( ) — Indicates Effective Absorption Value. S = Solar Constant ($WATTS/IN^2$)

Corresponding

Component	c	d	e	g	h	k	m	n
Battery	15	18	23	7	14	14	36	26
Near Vidicon Face Plate	16	19	20	6	8	14	28	19
Thermal Shield — Hat (-Y)	27	30	31	16	18	27	39	30
Thermal Shield Below Fin A (-Y)	16	19	25	9	15	16	38	27
Camera Electronics	15	18	23	7	15	14	35	27
	Calculated Temperatures					Measured Test Temperatures		

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TABLE D-5

TEMPERATURE BALANCE AND ENERGY LOSS FLIGHT DUPLICATION TEST

Item	A Area In^2	B Effective Σ	AXB In^2	Temp. T °C	σT^4 Watts/In^2	Energy Loss Watts
Fin F	48.1	0.98	47.14	47	.383	18.1
Fin E	45.24	0.89	40.26	72	.518	20.9
Hat Skin	666.	0.05	33.30	38	.342	11.4
Flange D	33.1	0.88	29.13	40	.350	10.2
Fin D	149.4	0.89	133	40	.350	46.6
Skin C — D	491.	0.05	24.6	37	.337	8.3
Camera Holes	151	0.98	148	37	.337	49.9
Electronics Shield	67	0.94	63	1	.206	13.0
Flange C	31.3	0.88	27.54	42	.360	9.9
Fin C	139.2	0.89	123.9	42	.360	44.6
Skin B — C	714	0.05	35.7	37	.337	12.0
Flange B	43.7	0.88	38.46	38	.342	13.2
Fin B	139.2	0.89	123.9	38	.342	42.4
Skin A — B	550	0.05	27.5	38	.342	9.4
Flange A	49.3	0.88	43.38	38	.342	14.8
Skin Below A	579	0.05	28.9	37	.337	9.7
Base Ring	160	0.02	3.2	32	.316	1.0
Legs	129	0.30	38.7	32	.316	12.2
Fin A	117	0.89	104.1	38	.342	35.6
			$\Sigma AXB = 1113.7$		Total Energy Loss	383.2

$Q_{IN} = 302.7$

$K' = \frac{302.7}{.344} = 880\ In^2$ $\quad (\sigma T^4)_{Avg.} = \frac{383.2}{1113.7} = 0.344$ $\quad T_{Avg.} = 38.5°C$

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TABLE D-6
TEMPERATURE BALANCE AND ENERGY LOSS NOMINAL TEST

Item	A Area In^2	B Effective Σ	AXB In^2	Temp T °C	σT^4 Watts/In^2	Energy Loss Watts
Fin F	48.1	0.98	47.14	42	.360	17.0
Fin E	45.24	0.89	40.26	52	.407	16.4
Hat Skin	666	0.05	33.30	26	.292	9.7
Flange D	33.1	0.88	29.13	23	.280	8.2
Fin D	149.4	0.89	133	23	.280	37.2
Skin C — D	491	0.05	24.6	18	.262	6.4
Camera Holes	151	0.98	148	18	.262	38.8
Electronics Shield	67	0.94	63	-13.5	.164	10.3
Flange C	31.3	0.88	27.54	20	.269	7.4
Fin C	139.2	0.89	123.9	20	.269	33.3
Skin B — C	714	0.05	35.7	17	.258	9.2
Flange B	43.7	0.88	38.46	17	.258	9.9
Fin B	139.2	0.89	123.9	17	.258	32.0
Skin A — B	550	0.05	27.5	16	.255	7.0
Flange A	49.3	0.88	43.38	16	.255	11.1
Skin Below A	579	0.05	28.9	15	.251	7.3
Base Ring	160	0.02	3.2	12	.241	0.8
Legs	129	0.30	38.7	12	.241	9.3
Fin A	117	0.89	104.1	16	.255	26.5
			$\Sigma AXB = 1113.7$		Total Energy Loss	297.8

$Q_{IN} = 237.2$

$K = \frac{237.2}{.267} = 887\ In^2$ $\quad (\sigma T^4)_{Avg.} = \frac{297.8}{1113.7} = 0.267$ $\quad T_{Avg.} = 19.4°C$

TABLE D-7

TEMPERATURE BALANCE AND ENERGY LOSS REVISED FLIGHT TEST

Item	A Area In^2	B Effective $\epsilon \Sigma$	AXB In^2	Temp. T °C	σT^4 Watts/In^2	Energy Loss Watts
Fin F	48.1	0.98	47.14	38	.342	16.1
Fin E	45.24	0.89	40.26	26.5	.292	11.8
Hat Skin	666	0.05	33.30	29	.304	10.1
Flange D	33.1	0.88	29.13	32	.316	9.2
Fin D	149.4	0.89	133	32	.316	42.0
Skin C — D	491	0.05	24.6	30	.308	7.6
Camera Holes	151	0.98	148	30	.308	45.6
Electronics Shield	67	0.94	63	-5	.188	11.8
Flange C	31.3	0.88	27.54	34	.324	8.9
Fin C	139.2	0.89	123.9	34	.324	40.1
Skin B — C	714	0.05	35.7	28	.300	10.7
Flange B	43.7	0.88	38.46	28	.300	11.5
Fin B	139.2	0.89	123.9	28	.300	37.2
Skin A — B	550	0.05	27.5	28	.300	8.3
Flange A	49.3	0.88	43.38	28	.300	13.0
Skin Below A	579	0.05	28.9	26	.292	8.4
Base Ring	160	0.02	3.2	20	.269	0.9
Legs	129	0.30	38.7	20	.269	10.4
Fin A	117	0.89	104.1	28	.300	31.2
			$\Sigma AXB = 1113.7$		Total Energy Loss	334.8

$Q_{IN} = 266.8$ $\qquad Q_{IN} = K\delta [T^4]$

$K' = \frac{266.8}{.301} = 887\ In^2$ $\qquad (\sigma T^4)_{Avg.} = \frac{334.8}{1113.7} = 0.301$ $\qquad T_{Avg.} = 28.2°C$

(3) **Revised Flight Test** — Indicated the amount of energy input reduction required to reduce the temperatures of the flight duplication test by approximately 10 degrees C.

2. *Analytical Calculations*

The thermal control of the Subsystem during cruise mode is almost entirely dependent upon the external environment; the internal power dissipation is so small as to be an insignificant input during normal cruise operation. However, a large internal power dissipation during the cruise phase would cause a large temperature increase on the Subsystem due to the "semi-insulated" design configuration. One postulation that would explain the higher flight temperatures of the RA-6 Spacecraft was that there was abnormal internal power during cruise mode. This theory is discounted since the dissipation would have to occur for the entire flight; battery telemetry did not indicate this to be true. Therefore, if unusual internal power dissipation effects are discounted, the higher temperatures must be due to external effects. Another assumption is that the unknown cause of the discrepancy may be isolated to energy inputs, that is the energy-loss parameters (emissivity, surface area) did not change from those determined via thermal-vacuum testing. Many precautions are taken to see that the emissivity of the large polished aluminum skin area does not change from testing to flight, including frequent repolishing to remove oxides and residue and using strip coat as a protective cover.

Thus, the cause of the discrepancy was placed in the area of external energy input. This input is due to the solar energy available at the vehicle surface, the energy composed of two components:

(1) Solar energy arriving at the surface directly.

(2) Solar energy arriving at the surface indirectly, i.e., reflected from other surfaces.

A calculation of total energy absorbed is required. This is a simple task for the case of directly incident solar energy, since the absorbed amount is given by:

$$Q_{D_i} = \left[SA_p \alpha \right]_i$$

where:

Q_{D_i} = direct solar energy absorbed by surface i

S = solar intensity constant

A_p = projected area of surface i to the solar field

α = solar absorptivity of surface i

The energy absorbed for the indirect or reflected solar energy case can be computed by:

$$Q_{R_{ij}} = \left[SA_p(1-\alpha)\right]_i C_{ij}$$

where:

$Q_{R_{ij}}$ = direct energy reflected by surface i that is absorbed by surface j.

C_{ij} = solar reflection coupling factor.

This expression is no more complex than that written for the direct input if C_{ij} is known. However, obtaining the value of C_{ij} is a complex calculation which requires use of the IBM 7090 computer. This solar reflection coupling factor is a complex function of the absorptivities of the reflecting surfaces, and the configuration factors relating the reflecting surfaces. Values of C_{ij} from computer analysis are given for selected vehicle absorptivity values in Figures D-27 through D-36. The configuration factors (ϕ_{ij}) used to obtain these values are shown in Table D-8. Table D-9 gives computer values for the I.R. coupling factors (K_{ij}) for the vehicle. These factors are used for energy loss calculations and are computed in the same manner as C_{ij} except emissivities are substituted for solar absorptivities.

Computations of the absorbed energy during flight were performed for the III-1 vehicle as shown in Table D-4. Prior to launch column (b) absorptivity values were verified with the reflectometer at AMR. Column (c) represents the original (before flight) input based upon these α values. For this set of calculations, a nominal solar constant of 0.90 watts/in^2 was used, and reflection inputs were assumed to be minor and neglected. This was done for "safety" reasons since the primary thermal concern was for maintaining the battery temperature above 10°C. The reasoning was that the calculation would indicate a conservative cruise temperature and the reflection input in flight would be additional insurance against a cold battery. Calculations based on this input yield a battery temperature of 15°C and a vidicon housing temperature of 16°C.

Column (d) of Table D-4 indicates the input for Flight Model III-1 for a solar constant of 0.93 watts/in^2 (the actual value for the January launch). The yearly variation in the solar constant is approximately ±3.3%. Column (e) indicates the input for the higher solar constant, and includes the effect of solar reflections. It can be seen that reflections account for 16.5 watts additional input, while the higher solar constant yields about 8 additional watts input. Accounting for the higher solar constant and solar reflections in the input calculation results in predicted battery and camera housing temperatures of 23 and 20°C respectively. Table D-10 gives a comparison of the maximum input

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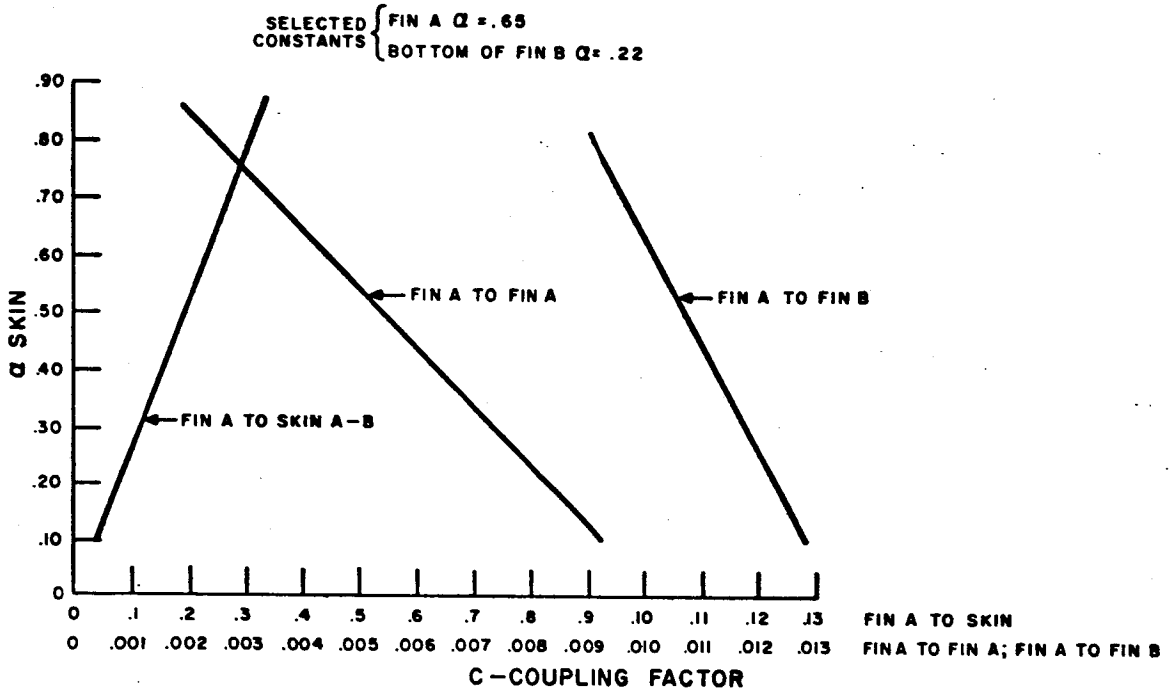

Figure D-27. Solar coupling factors, section between fin A and fin B

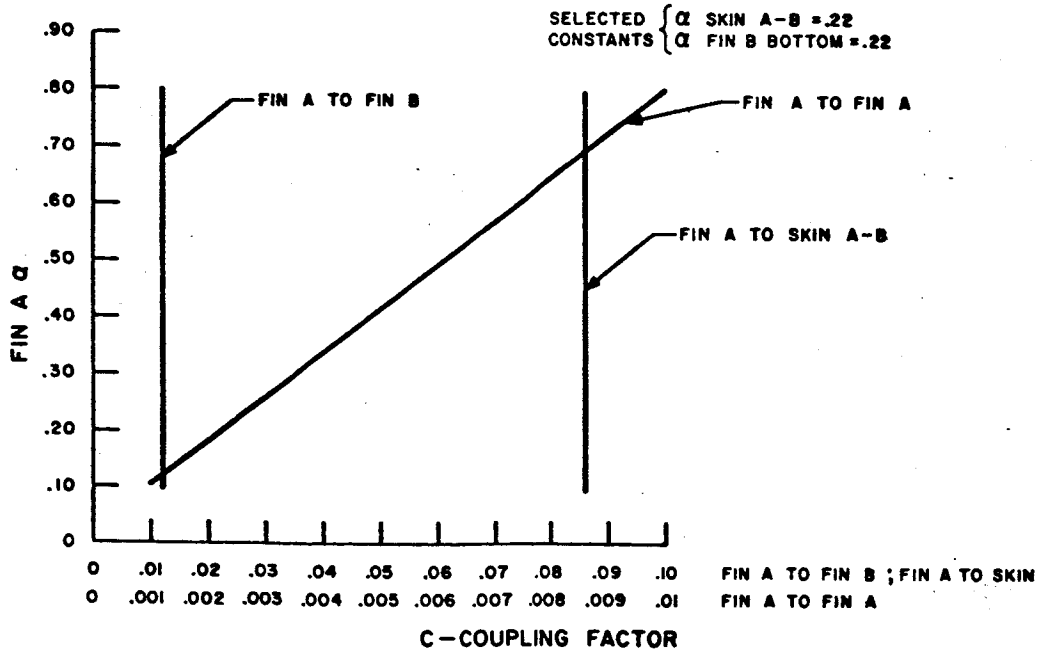

Figure D-28. Solar coupling factors, section between fin A and fin B

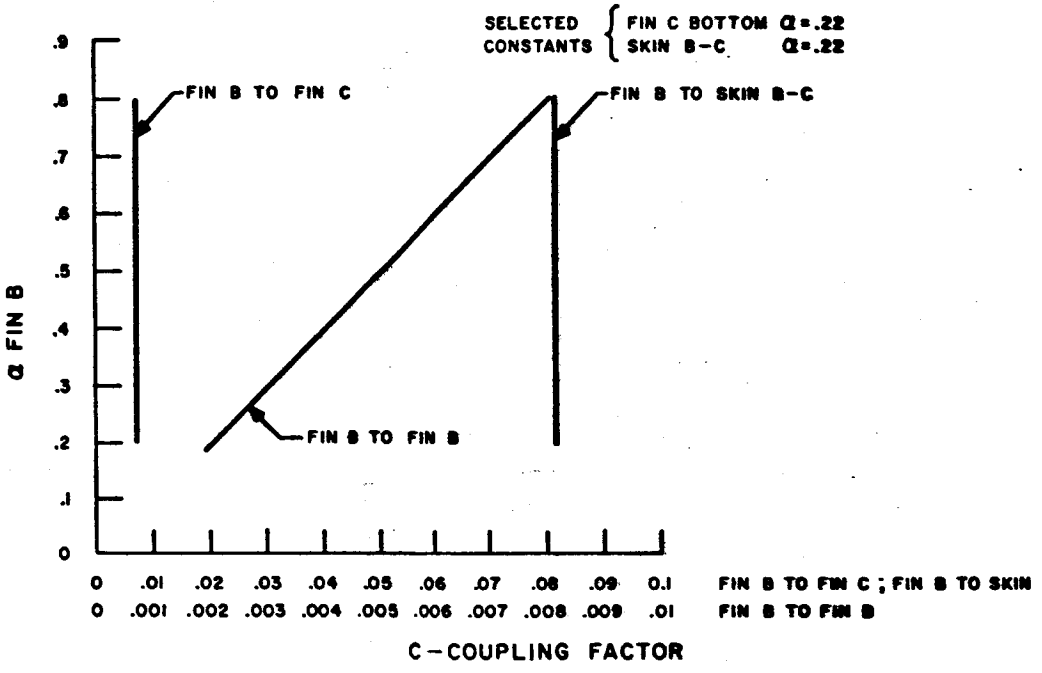

Figure D-29. Solar coupling factors, section between fin B and fin C

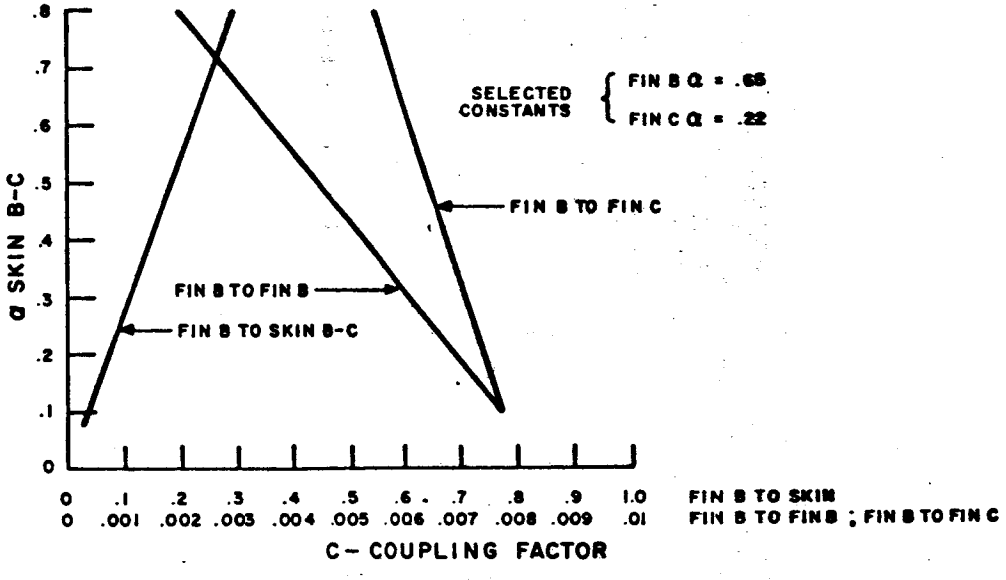

Figure D-30. Solar coupling factors, section between fin B and fin C

Figure D-31. Solar coupling factors, section between fin B and fin C

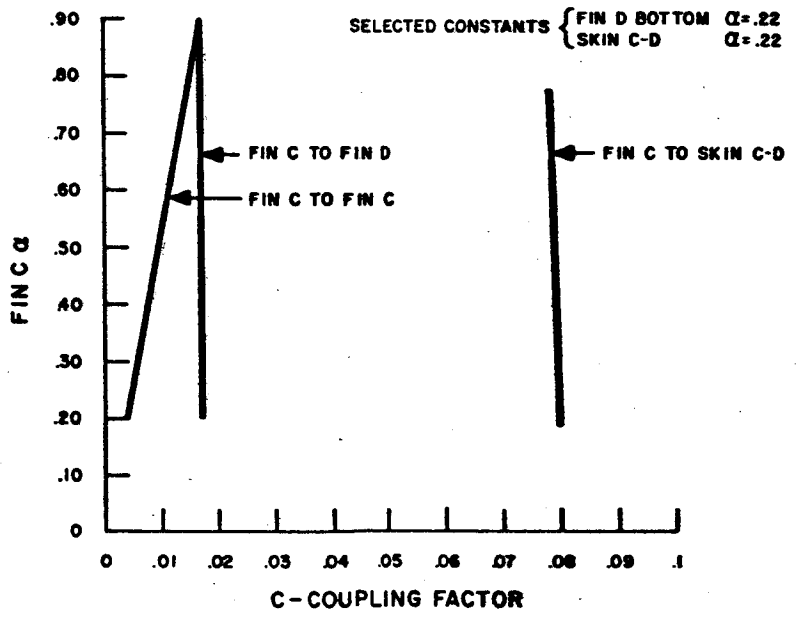

Figure D-32. Solar coupling factors, section between fin C and fin D

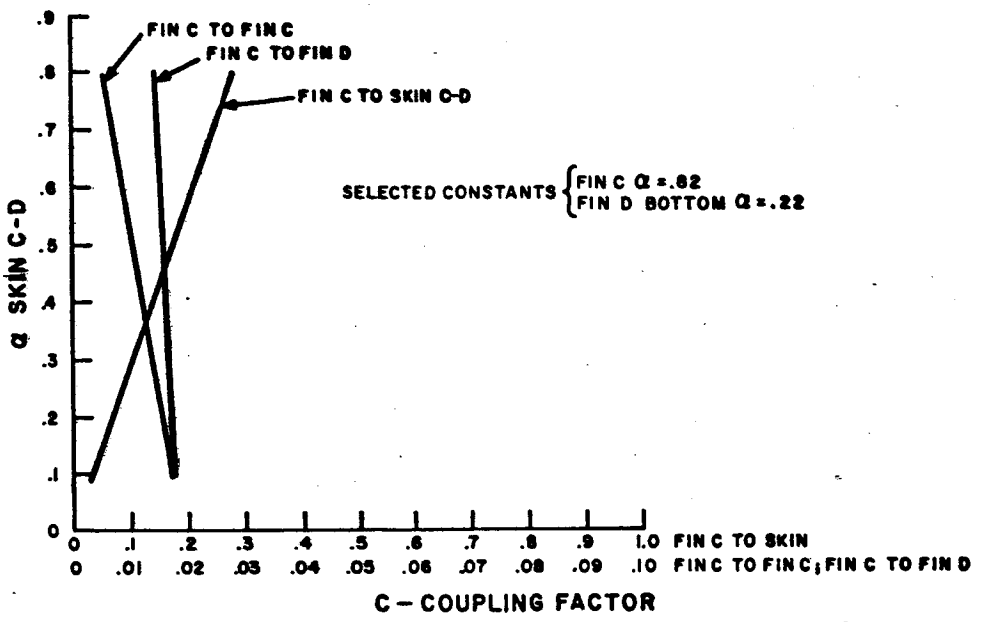

Figure D-33. Solar coupling factors, section between fin C and fin D

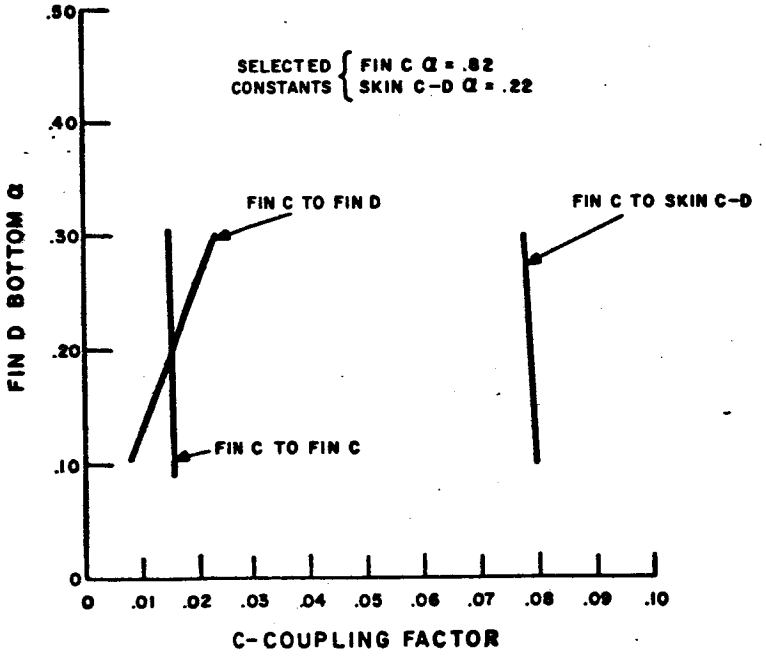

Figure D-34. Solar coupling factors, section between fin C and fin D

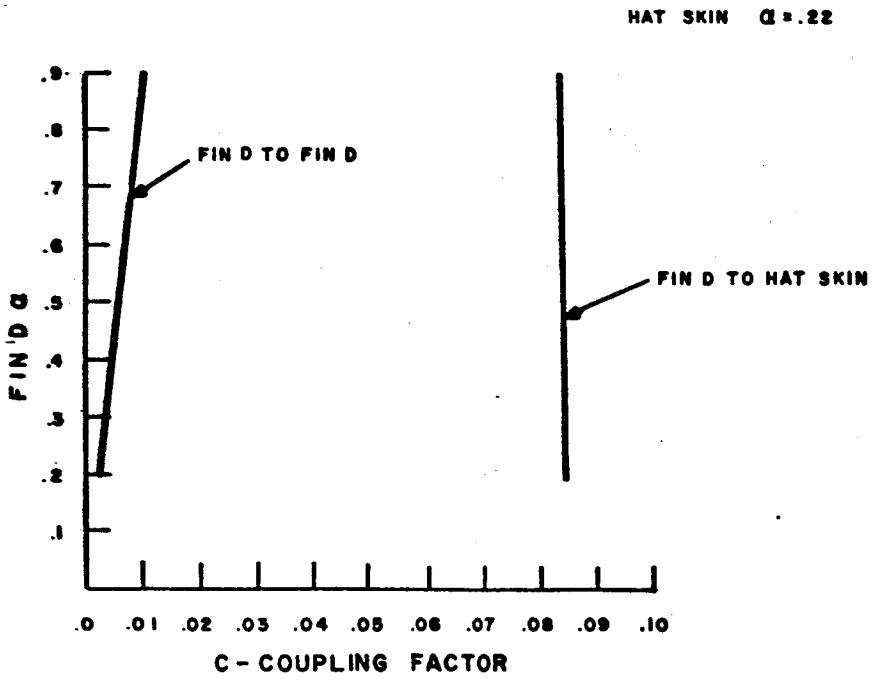

Figure D-35. Solar coupling factors, section between fin D and Top Hat

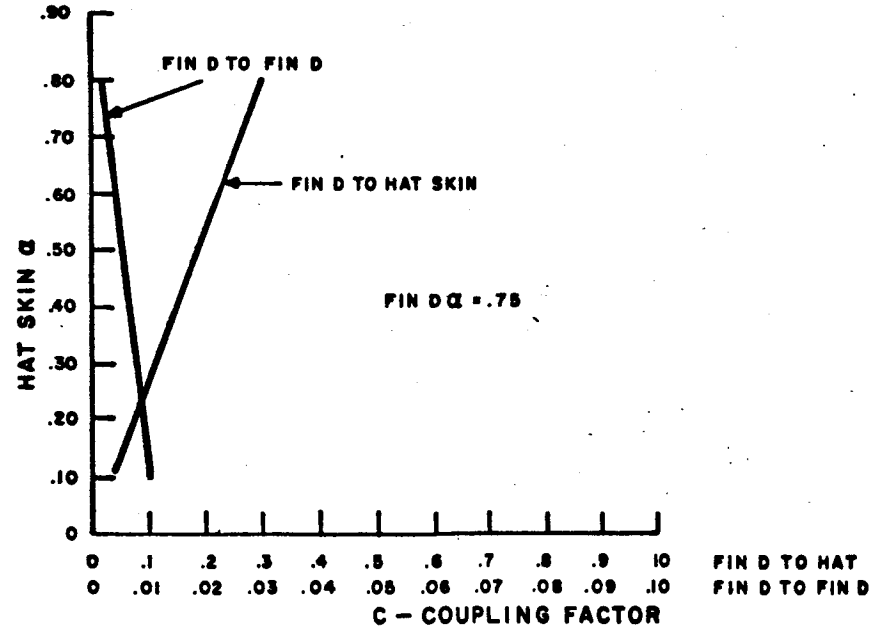

Figure D-36. Solar coupling factors, section between fin D and Top Hat

TABLE D-8
RANGER CONFIGURATION FACTORS (ϕ_{ij})

From \ To	Fin D Top	Fin Flange C	Hat Skin	Space
Fin D Top	0	0.250	0.130	0.620
Flange D	0.565	0	0	0.435
Hat Skin	0.014	0	0	0.986

From \ To	Fin C Top	Fin D Bottom	Flange C	Skin C to D	Space
Fin C Top	0	0.060	0.210	0.120	0.610
Fin D Bottom	0.060	0	0	0.430	0.510
Flange C	0.470	0	0	0	0.530
Skin C to D	0.017	0.065	0	0	0.918

From \ To	Fin B Top	Fin C Bottom	Flange B	Skin B to C	Space
Fin B Top	0	0.022	0.260	0.100	0.618
Fin C Bottom	0.022	0	0	0.440	0.538
Flange B	0.415	0	0	0	0.585
Skin B to C	0.010	0.040	0	0	0.950

From \ To	Fin A Top	Fin B Bottom	Flange A	Skin A to B	Space
Fin A Top	0	0.040	0.290	0.080	0.590
Fin B Bottom	0.030	0	0	0.510	0.460
Flange A	0.350	0	0	0	0.650
Skin A to B	0.010	0.065	0	0	0.925

From \ To	Fin A Bottom	Skin Below A	Space
Fin A Bottom	0	0.480	0.520
Skin Below A	0.048	0	0.952

ϕ_{ij} ≡ Percent of the Thermal Energy leaving i surface that arrives at surface j.

TABLE D-9
I.R. COUPLING FACTORS FOR RANGER (K_{ij})

From \ To	Top Fin D	Flange D	Hat Skin	Space
Fin D Top	~0.012	0.220	0.006	0.762
Flange D	0.502	~0.014	0	0.484
Hat Skin	0	0	0	1.000

From \ To	Top Fin C	Bottom Fin D	Flange C	Skin C to D	Space
Fin C Top	~0.012	0.054	0.194	0.006	0.734
Fin D Bottom	0.021	~0.024	0	0.021	0.934
Flange C	0.394	0	~0.010	0	0.596
Skin C to D	0.015	0.060	0	0	0.925

From \ To	Top Fin B	Bottom Fin C	Flange B	Skin B to C	Space
Fin B Top	~0.012	0.019	0.230	0.005	0.734
Fin C Bottom	0.019	~0.016	0	0.021	0.944
Flange B	0.370	0	~0.010	0	0.620
Skin B to C	0.009	0.036	0	0	0.955

From \ To	Top Fin A	Bottom Fin B	Flange A	Skin A to B	Space
Fin A Top	~0.012	0.037	0.258	0.004	0.689
Fin B Bottom	0.027	~0.030	0	0.026	0.917
Flange A	0.310	0	~0.010	0	0.780
Skin A to B	0.008	0.058	0	0	0.930

From \ To	Bottom Fin A	Skin Below A	Space
Fin A Bottom	~0.019	0.023	0.960
Skin Below A	0.043	0	0.960

Where: K_{ij} = Percentage of the energy radiated by body i that is absorbed by body j

Energy from i absorbed by j (net) = $q_{ij} = A_i \Sigma_i K_{ij} \delta \left[T_i^4 - T_j^4\right]$

Values of emissivity used to calculate above factors:

$\Sigma_{\text{top of fins}} = 0.89$ $\Sigma_{\text{flanges}} = 0.88$

$\Sigma_{\text{bottom of fins}} = 0.90$ $\Sigma_{\text{skin}} = 0.05$

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TABLE D-10
INPUT ENERGY NOT ACCOUNTED FOR RANGER III-1

Fin Indent	Actual energy Input for III-1 (from test data)	Maximum Input Calculation for III-1	Input energy not Accounted for
	Watts	Watts	Watts
A	48.5	44.7	3.8
B	60.3	45.0	15.3
C	70.7	54.4	16.3
D	71.0	58.6	12.4
F	32.3	39.7	-7.4
Totals	302.7	259.6	43.1

Possible Cause of Discrepancy	Comment
Incorrect solar absorptivity values	Measurement error can be ±5% however good agreement on values between RCA/JPL/STL.
Oscillation of capsule about z-axis	Variation ≈ 0.2° per JPL. Thus not significant.
Solar reflections from bus, solar panels, and fin surfaces	Accounted for in part but values could be higher due to the large areas of polished aluminum on capsule
Yearly variation in solar constant	Accounted for in above calculation (normal variation ± 3.3%)
I.R. inputs from bus and solar panels	Accounted for in thermal-vacuum testing
Errors in measurement of temperatures during T/V testing	Not significant since error ≅ 1 → 2°C
1/2° sun angle decollimation	Not significant since intensity is low in decollimated areas.
Solar panels not locked in 90° position	Would cause solar reflections to capsule - but did not occur per JPL.
Incorrect temperature telemetry	Estimate max. error ± 5°C.
Equipment operating during cruise inside capsule	Theoretically would cause higher temperatures - however battery telemetry discounts this source.
Solar constant much higher than stated by literature	Not true since bus and solar panel temperatures normal.
Errors in values of emissivity of fins or polished skin	Little effect as long as the values do not change after the thermal-vacuum verification test. Every effort made to protect the surfaces via strip coat and covers.

calculation for Flight Model III-1 and the data obtained from the flight duplication test. A total of 43 watts of energy remain unaccounted for. Possible sources of this differential are indicated in this table.

In selecting the thermal finish to be used for Flight Model III-2, a "compromise" design modification was selected as a solution to the problem. Values of solar absorptivity will be applied that reduce the energy input only enough to produce a temperature field of approximately 10°C lower than that obtained during the RA-6 Mission. However, the approach of not accounting for reflection is perhaps overconservative, thus, reflections will be accounted for in selection of the surface finishes. Also the value of the solar constant for the Flight Model III-2 launch date (0.87 watts/in^2) will be utilized. Table D-4, column (f), indicates the approximate values of absorptance to be used on Flight Model III-2. Note that only two gray paints are now required. The calculated energy inputs are shown in columns (g) and (h) for these values. The input of column (g) represents a "worst condition" low-temperature situation (no reflections accounted for) which is very unlikely, based upon the III-1 flight. Column (h) represents what might be called the lower bound of the nominal temperature range. The values are computed using the same techniques as for Flight Model III-1 computation. If the RA-7 external environment is similar to the RA-6 environment, a discrepancy in input will again occur and the Flight Model III-2 will cruise at a higher temperature than indicated by calculations. Thus, an upper bound upon the nominal range is required.

This upper temperature bound can be obtained as follows:

- Test data exists on the input required to duplicate the RA-6 flight.
- Test data exists on the input required to establish a temperature balance at 10°C below the level of RA-6 flight; and
- The difference in input between the two tests can easily be determined. This difference can be directly related to the amount of reduction in the value of solar absorptivity required on the respective fin surfaces.

Column (r) of Table D-4 indicates the difference in input between the two tests to be 36 watts. Column (s) indicates the difference between Flight Models III-1 and III-2 calculated inputs to be 34 watts. Therefore, the upper nominal temperature bound will be as indicated by the results of the revised flight test.

At the bottom of Table D-4, temperature values are indicated for the components which will have cruise-mode telemetry for the RA-7 flight. These values represent the equilibrium temperatures (achieved after approximately 40 hours of cruise-mode flight). The values in columns (c) through (h) are calculated while those in columns (k) through (n) are measured test data. The temperature calculations are obtained by utilizing the equations given in Table D-11. These equations were obtained by fitting thermal-vacuum test data of Block III vehicles to a straight line approximation using the technique of "least squares". Accuracy of these equations is on the order of ±3°C over the temperature range of 15°C to 35°C.

TABLE D-11

EQUATIONS TO CALCULATE TEMPERATURES OF SELECTED COMPONENTS FOR RANGER

Component	Equation
BATTERY	$5T^4 = (1.1025 \times 10^{-3})\ X + (-0.1208 \times 10^{-3})\ Y \left(\frac{\text{WATTS}}{\text{IN}^2}\right)$
VIDICON HOUSING (F_a)	$5T^4 = (0.9697 \times 10^{-3})\ X + (0.4767 \times 10^{-3})\ Y$
CAMERA ELECTRONICS (-Y)	$5T^4 = (1.107 \times 10^{-3})\ X + (-0.157 \times 10^{-3})\ Y$
THERMAL SHIELD, HAT (-Y)	$5T^4 = (1.106 \times 10^{-3})\ X + (0.662 \times 10^{-3})\ Y$
THERMAL SHIELD, BELOW FIN A (-Y)	$5T^4 = (1.1286 \times 10^{-3})\ X + (-0.1638 \times 10^{-3})\ Y$

Where:

$X = Q_A + Q_B + Q_C + Q_D + Q_E + Q_E$ (Total heat input via fins) WATTS

$Y = -2Q_A - Q_B + Q_D + 2\left[Q_E + Q_F\right]$ WATTS

Q_i = Energy absorbed by fin i (WATTS)

T = Temperature in °K

5 = Stefan-Boltzman's constant = 3.657×10^{-11} $\frac{\text{WATTS}}{\text{IN}^2\ °\text{K}^4}$

NOTE: Above equations obtained from applying least squares method to thermal vacuum test data. The equations represent an approximation of the true solution.

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G. Summary

Flight Model III-2 will differ thermally from Flight Model III-1 only by the gray paints applied to the fins. The number of gray paints required has been reduced from three to two. The approximate required values of solar absorptivity for the two paints are 0.58 and 0.77. These surface finishes will produce a predicted design temperature envelope (equilibrium values) for the cruise thermistor points as follows:

	Nominal Temperature Range	
Thermistor Location	Lower Bound	Upper Bound
Battery (Internal)	14°C	26°C
Rear Vidicon Face Plate	8°C	19°C
Thermal Shield — Hat (-Y)	18°C	30°C
Thermal Shield Below Fin A (-Y)	15°C	27°C
Camera Electronics	15°C	27°C

These values are thermal calculations and include no tolerance for telemetry inaccuracy (possible ±5°C).

The Flight Model III-2 design is based upon the following items:

- That the input energy obtained for the flight duplication test was similar to the actual Flight Model III-1 flight input. This test was performed with only 3 temperature readings available as a guide.
- Internal energy dissipation within the Spacecraft during the Flight Model III-1 cruise mode was normal.
- Discrepancies between calculated input and actual input were due to uncertainties in the external input parameters. This discrepancy could not be pinpointed as caused by any one parameter, but more reasonably is the additive effect of many parameters.
- The degree of uncertainty in the post flight analysis was such that a complete compensation for the input discrepancy was not attempted.

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Appendix E

Search of Magnetic Tapes for RA-6 Signal

A. Conclusions

B. Search for RCA RF Signals from TV Subsystem During Boost Phase

C. Analysis

D. Expected Signal Levels in Warmup and Reduced Power

Appendix E
Search of Magnetic Tapes for RA-6 Signal

A. Conclusions

It may be stated with confidence that:

- No in-band incoherent (noise modulation) transmission exists at an input power level to the maser of -120 dbm or higher.
- No in-band video modulation exists at a level of -150 dbm or higher.
- No in-band emergency mode modulation exists at a level of -160 dbm or higher.

Our failure to find any signal at these levels is a positive indication that the transmitter was not in reduced power. All evidence points to the conclusion that no L-band signal was present in the television transmitters.

B. Search for RCA RF Signals from TV Subsystem During Boost Phase

The search for RF radiation from the payload was broken into two parts. First, it was necessary to determine if DSIF-71 at AMR was capable of observing and saw TV signals from the payload during the boost phase. The second part was to determine if any AMR receiving stations monitored the spectrum in the vicinity of the RCA signals and if they saw any signals. DSIF-71 reports that no signals other than those emanating from the JPL transponder were observed during the 478-second tracking period. The transponder signal was monitored on a panelyzer with a sweep width probably adjusted such that only the RCA Channel P (Figure B-1) could have been seen had it been on. The operators did monitor the panelyzer when the RCA Channel 8 was reported on and at various times until loss of signal. They report that no TV signal was seen. The path loss of the RCA signal while under the shroud is not known; however, using estimates, it would probably have been possible to see the RCA signal on

the DSIF-71 panelyzer had the P-transmitter been in full power. It is also probable that signals could not have been seen had the P-transmitter been in warmup. The F-transmitter signal could not have been seen, since the panelyzer was probably not set for this observation.

Reports from the Cape stations about observation of signals other than JPL signals are all negative with one exception. A telemetry ship, the Twin Falls Victory, reported seeing one carrier about 150 kc below the JPL frequency. This ship was stationed north of Ascension Island. The time of this observation is not known, nor is a level of confidence on this observation known. The spacing of 150 kc below the JPL frequency is not a normal frequency for RCA video transmission. It is possible that the signal seen was a receiver or spectrum analyzer spurious signal, or possibly another signal present on the range. Investigation of this report is continuing.

C. Analysis

During the time that transmission should have been received from the RA-6 television transmitter, trained observers were monitoring the two redundant RCA receivers at DSIF-12 and the receivers at DSIF-11. In addition to this, four independent spectrum analyzers were intently observed, two at DSIF-11 and two at DSIF-12. Absolutely no television signals were observed at either receiving site.

Immediately following impact, a search of the magnetic tapes was instituted at DSIF-12 for any indication of emergency mode signals. None were found. In the following day, while a further narrow-band search was continuing at DSIF-12, flight dub tapes were analyzed at JPL under the supervision of George Tetsuka. Several replays of the FR 800 rotary head predetection tape through a panoramic analyzer were made at DSIF-12 to determine if spurious signals were present, and 16-mm motion picture film was taken of this display for permanent record. Again nothing was found.

A final attempt was made on February 8, 1964 by replaying FR 1400 flight dubs and FR 800 flight dubs through the correlation detection equipment at the Venus Site. To the best of our knowledge, this is the most sensitive equipment of this type available in the world. There was absolutely no indication of any signal from the TV Subsystem in RA-6.

If the reported background noise increase was indeed a noise-modulated transmission, its level is unfortunately too low to be observed on replay of the spectrum-preserving FR 800 magnetic tape. Since the -118 dbm of the JPL transmitter is clearly seen on the FR 800 tape, a ninety per cent confidence was established for -120 dbm noise modulation with a thirty per cent confidence for -125 dbm.

D. Expected Signal Levels in Warmup and Reduced Power

Since the JPL received signal strength was close to the theoretical nominal, it will be assumed that the total path loss at lunar distance was nominal. The value of the loss from the output of the 60-watt power amplifier to the maser input is 144.5 db. During the first 30 seconds of warmup, the output power builds up rapidly and reaches a maximum of +3 to +8 dbm. Following this time, the power output drops off and, after one minute of warmup, is in the range of -5 to -20 dbm. From this point on, the spread between transmitters continues, the lowest of 3 transmitters tested being -25 dbm. Thus, the received signal level could vary from -136.5 to -169.5 dbm if the transmitters were in warmup during the terminal mode of the RA-6 mission.

In reduced power, the output of the power amplifier is greater than +17 dbm. Thus, the received signal level if the transmitters were in reduced power at lunar distance would be greater than -127.5 dbm.

Various techniques were tried to recover a signal from the tape, but no signal was found. The capabilities of the various methods (as reported in a memo by R. Heyser dated 2/11/64 were sufficient so that one may conclude that:

- The transmitters were definitely not in reduced power.
- The transmitters were most probably not in a normal warmup mode.

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Appendix F

Failure-Potential Analysis of the Various Equipment Groups of the Ranger TV Subsystem

A. Camera Group

B. Command Group

C. Power Group

D. Communications Group

E. Telemetry Group

F. Demated Connectors

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Appendix F

Failure-Potential Analyses of the Various Equipment Groups of the Ranger TV Subsystem

This appendix presents the results of a series of failure analyses performed on the various equipment groups of the Ranger TV Subsystem. The purpose of the analyses was to determine the possibility of the occurrence of a single fault that can be isolated within any particular equipment group causing the failure of the RA-6 mission. The various equipment groups thus analyzed were:

- Camera Group
- Command Group
- Power Group
- Communications Group
- Telemetry Group
- Demated Connectors

A. Camera Group

The TV Camera Assembly of the Ranger TV Subsystem comprised four Partial (P-) Scan Cameras and two Full (F-) Scan Cameras. Each Camera operated in conjunction with its associated Camera Electronics Assembly. The four P-Camera and two F-Camera Subassemblies were to obtain high-quality, high-resolution television pictures of the lunar surface during the terminal mode of the Ranger Spacecraft.

The P-Cameras were to have begun operation with the reception of the warmup command and were to be ready to provide video signals to the modulator of Transmitter Assembly (A19) via the Video Combiner Assembly after the completion of the 5-minute warmup period. Sync and control signals for the Cameras were to be

provided by the Control Programmer and Camera Sequencer Assembly. The control signals were to provide sequential operation of the cameras; for example, while one of the Cameras was being read out, the remaining three Cameras were to be erased and prepared for subsequent exposure. The video signals derived from the readout of the Cameras were to be amplified by the associated Camera Electronics Assembly, and were to be sent serially to the Video Combiner Assembly. The picture-taking function of all Cameras was to continue until impact.

The four P-Camera Subassemblies, designated as P1, P2, P3, and P4, were to focus the lunar image on their respective vidicons through the lenses, and the vidicons were to convert image to video signals. A slit-type shutter was to be used in each Camera Subassembly to expose the vidicon-faceplate photoconductive layer to the lunar-surface image received through its optical lens.

The four P-Camera Electronics Assemblies, designated as P1, P2, P3, and P4 corresponding to their respective cameras, were to amplify the video signals and supply them serially to the Video Combiner Assembly. Each P-Camera Electronics Assembly was also to supply the necessary operating voltages, sweep signals, and focus signals for the vidicon and yoke assembly of its associated P-Camera Subassembly. Additional circuitry was included in the P1 Camera Electronics Assembly to provide a free-running capability. That is, Camera P1 was to be capable of operating without the external timing signals normally supplied by the Camera Sequencer.

The F-Cameras were to begin operation with the reception of the Warmup command and be ready to provide video signals to the modulator of Transmitter Assembly (A14) via the Video Combiner Assembly after the completion of the 5-minute "Warmup" period. Sync and control signals for the Cameras were to be provided by the Control Programmer and Camera Sequencer Assembly. The control signals were to provide alternate operation of the two Cameras. For example, while the F_a Camera was being read out, the F_b Camera was to be erased and prepared for subsequent exposure. Conversely, while F_b was being read out, F_a Camera was to be erased and prepared for subsequent exposure. The video signals derived from the readout of the Camera were to be amplified by its associated Camera Electronics Assembly and sent to the Video Combiner Assembly. The picture-taking functions of both Cameras were to continue until impact.

The two F-Camera Subassemblies, designated as the F_a and F_b Cameras, were to focus the lunar image on the vidicon through the lens of each Camera Subassembly, and the vidicon then converted the image to video signals. A slit-type shutter was to be used in each Camera Subassembly to expose the vidicon-faceplate photoconductive layer to the lunar-surface image received through its optical lens.

The two F-Camera Electronics Assemblies, designated F_a and F_b corresponding to their respective Cameras, were to amplify the video signals and supply them serially

to the Video Combiner Assembly. In addition, the F-Camera Electronics Assembly was to supply the necessary operating voltages, sweep signals, and focus signals for the vidicon and yoke assembly of the associated F-Camera Subassembly.

Failure of any or all of these assemblies would not have affected the outputs from the Transmitters. Either an unmodulated signal or an output modulated by the telemetry indications would still have been received.

One possible failure mode, high-voltage arcing, should be mentioned as a reason for the lack of a 30-second pulse from the P-accumulator during the early turn-on of the Channel-8 telemetry. If the turn-on of the cameras is attempted in a partial-pressure condition, high-voltage arcing will occur in the 1000-volt supply in the Cameras. If only one camera arced or shorted, the subsequent load required would result in the blowing of the 3-ampere slow-blow fuse associated with that camera. However, if more than one camera in a particular channel arced, then the load on that High-Current Voltage Regulator would limit the current so that each fuse would not see more current than it could handle. This load would also result in the regulated -27.5 volts rising above -20 volts d-c, the minimum voltage required for operation of the 5-minute P-Accumulator circuit.

The Filter Assembly (A38) comprised four inductors and four capacitors arranged as two separate low-pass choke-input filters. The schematic diagram of the circuit is shown in Figure F-1. The Filter Assembly was designed to reduce 15-kc noise on the 27.5-volt, d-c regulated lines to the Full-Scan (F_a and F_b) Camera Electronics Assemblies (A6 and A7).

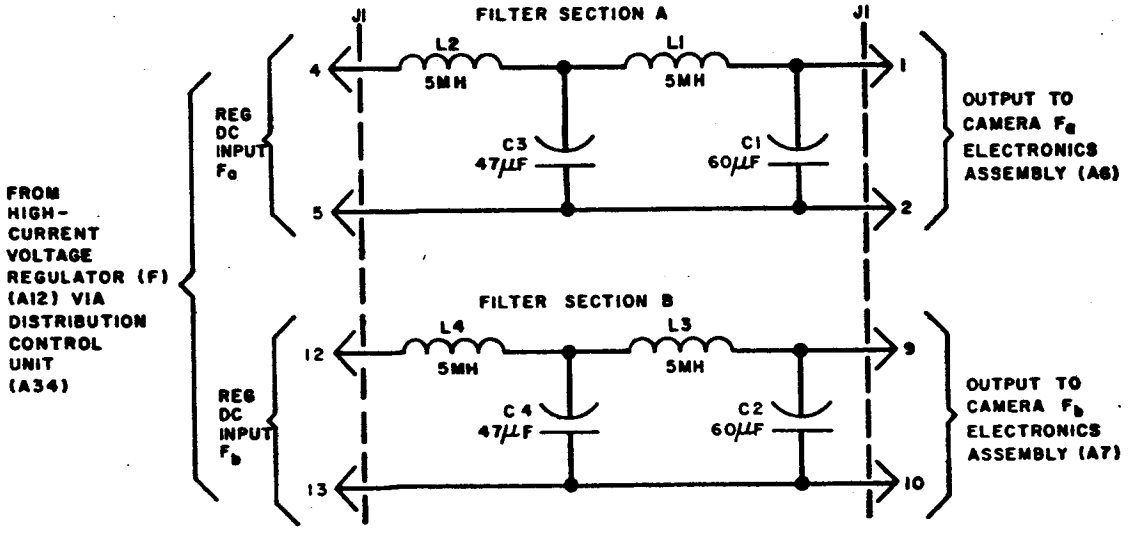

Figure F-1. Filter assembly, schematic diagram

If this assembly had failed in any way, only the output from the F-Cameras would be affected.

The Camera Sequencer Group comprised three assemblies: the Control Programmer and Camera Sequencer Assembly; the Video Combiner Assembly; and the Sequencer Power Supply Assembly. The Camera Sequencer Group was to generate synchronizing signals for the Full-Scan (F-type) and Partial-Scan (P-type) Cameras of the Ranger TV Subsystem. Video signals from the Cameras were to be combined with sync and tone-code signals and then supplied to the applicable Transmitter Assembly as composite video. The tone-code signal identified the F- Camera. Telemetry and test functions were provided for Subsystem testing and pre-launch checkout.

The loss of any of these assemblies would affect only the picture-taking capability of the Subsystem and would not result in the loss of some manner of transmitted signal. A synopsis of the analysis of the information returned by the Channel-8 telemetry indicated that the Sequencer operated normally during terminal mode; the 30-second pulse from the 5-minute accumulator was generated at the proper time.

During the inadvertent turn-on of the Channel-8 telemetry, there was no indication of a 30-second pulse being generated. This could have been caused by either the loading down of the output of the HCVR by arcing in either the cameras or the transmitters or by turn-off of the Subsystem for a period longer than 10 milliseconds.

The normal operation of the P-accumulator is illustrated in Figure F-2. The output of the 3.36-second flip-flop is summed with the output of the 26.88-second flip-flop in an adder circuit which gates on an SCR. Under normal operation, this pulse will then remain until the power supply for the Sequencer is turned off.

A test was performed to determine the characteristics of this accumulator circuit under conditions of unusual voltage inputs. The input to the Sequencer Power Supply was varied. It was determined that reliable accumulator start and production of an accumulator pulse would require an input of -20 volts d-c or less. Starvation of the accumulator initiation and pulse storage by the SCR will occur if the power-supply input voltage is reduced to less than -5 volts d-c for a period of 10 milliseconds or more.

B. Command Group

The Command Group of the Ranger TV Subsystem included an accurate, solid-state timer designated as the Electronic Clock Assembly. The Electronic Clock Assembly was to provide an emergency source for the energization of the F-Channel portion of the Ranger TV Subsystem in the event of a failure of both the CC&S and the RTC-7 links. The Electronic Clock Assembly began operation at booster separation.

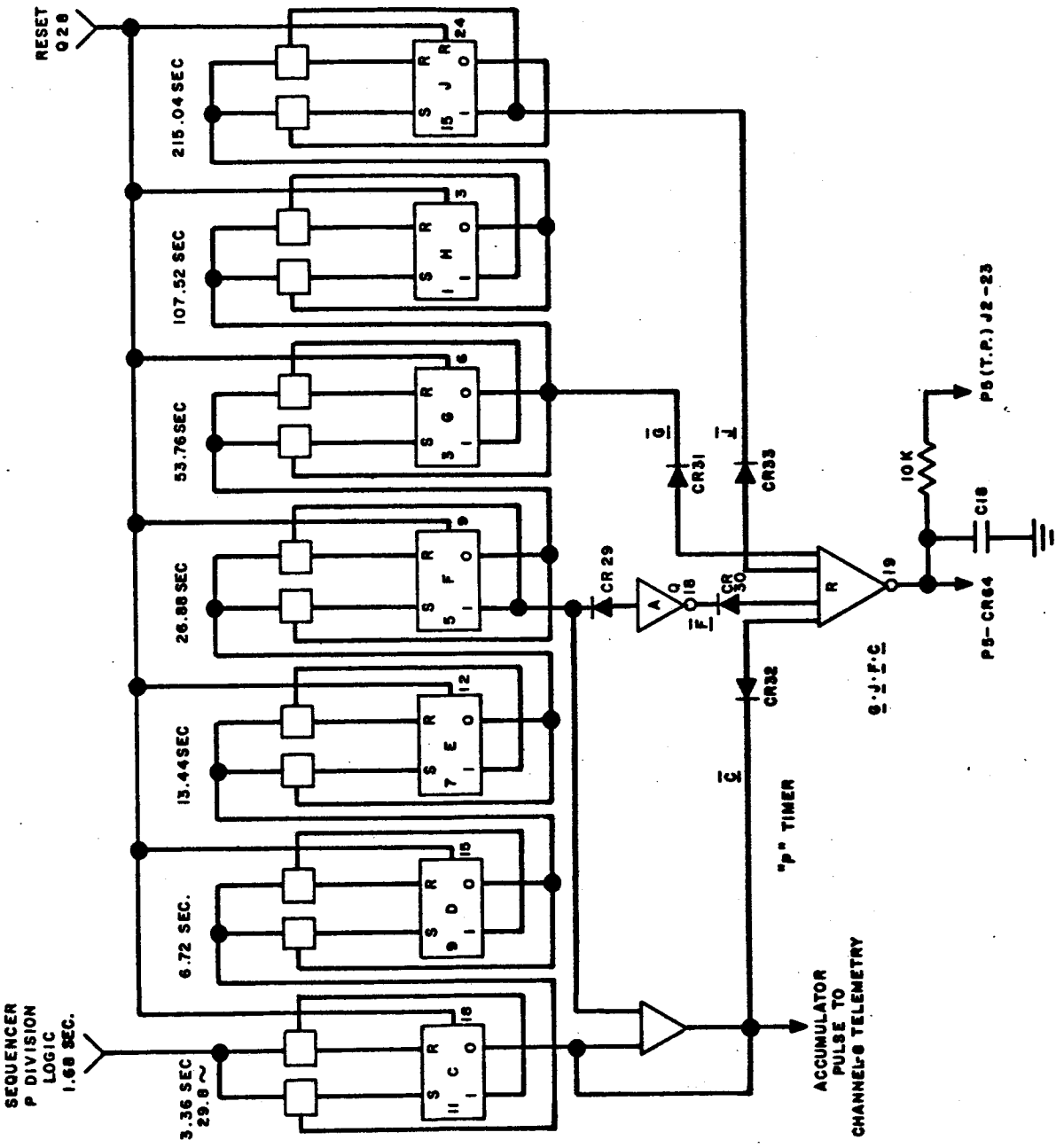

Figure F-2. P-Channel 5-minute accumulator, logic diagram

Should the Electronic Clock Assembly function not be required, the assembly was to be disabled by an RTC-5 command. However, it was decided to allow the Clock to turn on the F-Channel. A block diagram of the Electronic Clock Assembly is shown in Figure F-3.

As shown in Figure F-3, the oscillator portion of the oscillator-counter generates 100-cps pulses which are divided in the counter portion to provide pulses at 10-second intervals and further divided to provide pulses at 900-second (15-minute) intervals. The 10-second pulses are used during testing of the Electronic Clock Assembly to provide a means of checking over-all clock operation within a reasonable amount of time. The 900-second pulses are used to trigger a one-shot multivibrator. The output of the one-shot multivibrator triggers a flip-flop counter chain and the time-decode gate.

The 16-, 32-, and 64-hour outputs of the flip-flop counter chain are provided to the digital-to-analog converter which provides an analog output to the telemetry equipment. The telemetry output is equal in amplitude to the counted time in 16-hour increments. The zero output of each flip-flop of the counter and the zero output of the one-shot multivibrator are available as inputs to the time-decode gate circuit. A prewired connector plug selects the inputs of the flip-flop counter chain to be used to open the time-decode gate.

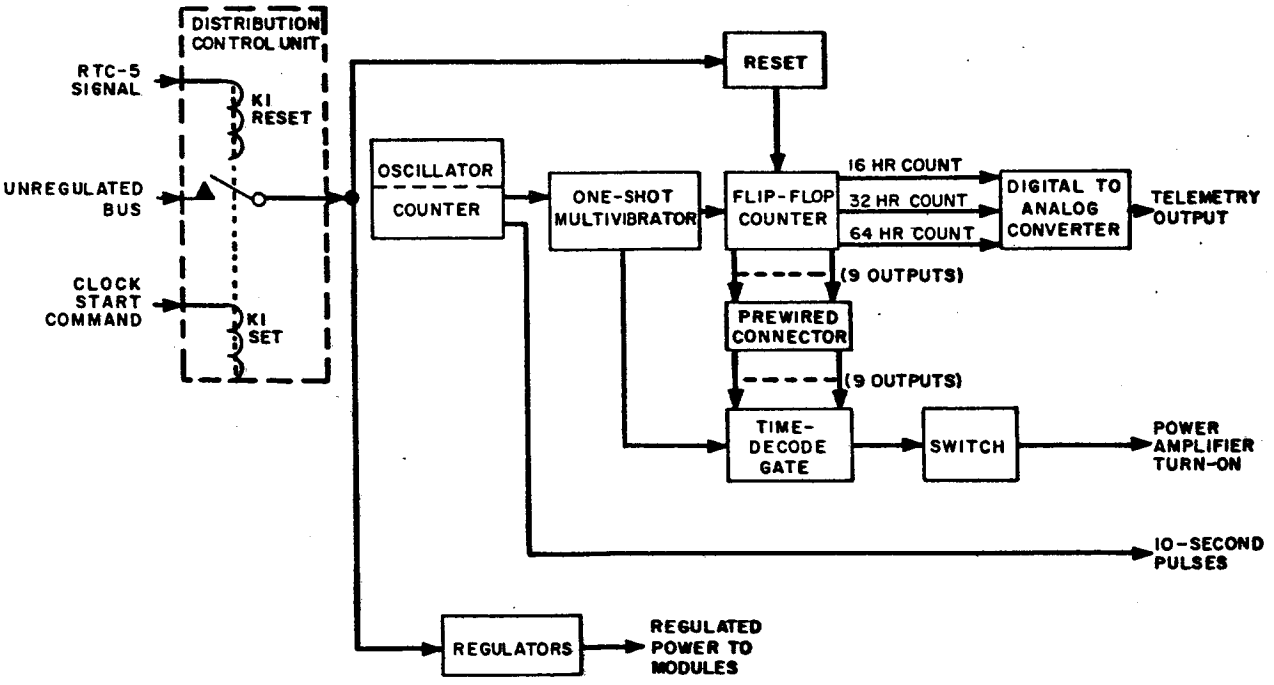

Figure F-3. Electronic clock assembly, block diagram

When the counted time is equal to the time wired into the connector, the time-decode gate generates a signal which closes the electronic switch. The output of the electronic switch, is sent to the Distribution Control Unit (DCU) to be used to energize the F-Channel of the Ranger TV Subsystem. Primary power for the Electronic Clock Assembly is obtained from the unregulated bus through the contacts of the "clock start" postion of relay K1 of the Distribution Control Unit. The regulator circuits of the Electronic Clock Assembly use the unregulated bus to develop the minus 13- and minus -24.5-volt operating potentials required by the remaining circuits of the Electronics Clock Assembly.

As indicated by the Channel-8 telemetry, the reliability and operability of the Electronic Clock Assembly were proved by the generation of all required pulses by that assembly at the time required and in fact the Clock did turn on the F-Channel of RA-6.

The Power Contro[illegible] (PCU) was provided to turn off power in the F- and P-Channels of the Ranger TV Su[illegible]stem, if necessary. This turn-off control was to be provided by two silicon controlled rectifiers (SCR's), one for F-Channel and one for P-Channel, which were connected to the Subsystem SCR's in the High-Current Voltage Regulators for F-Channel and P-Channel, respectively, and by relay circuitry which was connected to the Command Switch. If the Command Switch were stepped by successive RTC-7 commands, the relay-circuitry logic in the PCU would first prime the turn-off circuit and then turn on both of the SCR's in the PCU. This turning-on of the SCR's would result in negative-going pulses being transmitted to the anodes of the Subsystem SCR's in the High-Current Voltage Regulators; these pulses would be of sufficient amplitude to turn off the Subsystem SCR's. Figure F-4 illustrates the operation of the PCU.

The operation of this assembly during the early turn-on of the Channel-8 telemetry could account for the abrupt turn-off of the Subsystem at that time. During the terminal mode, this assembly would not be operated, and the Channel-8 telemetry indicated that the SCR's in the High-Current Voltage Regulators were turned on until impact.

The Distribution Control Unit (DCU) was designed to fulfill the following four-fold purpose:

- The DCU was to function as a distribution and isolation point for regulated and unregulated voltages in the split-system configuration of the Ranger TV Subsystem;
- It contained fuses that protected each power source from failure of an individual unit;
- It contained circuitry providing power, command, and telemetry power redundancy; and
- It contained isolation diodes to prevent shorts in one area of operation from affecting operation in other areas.

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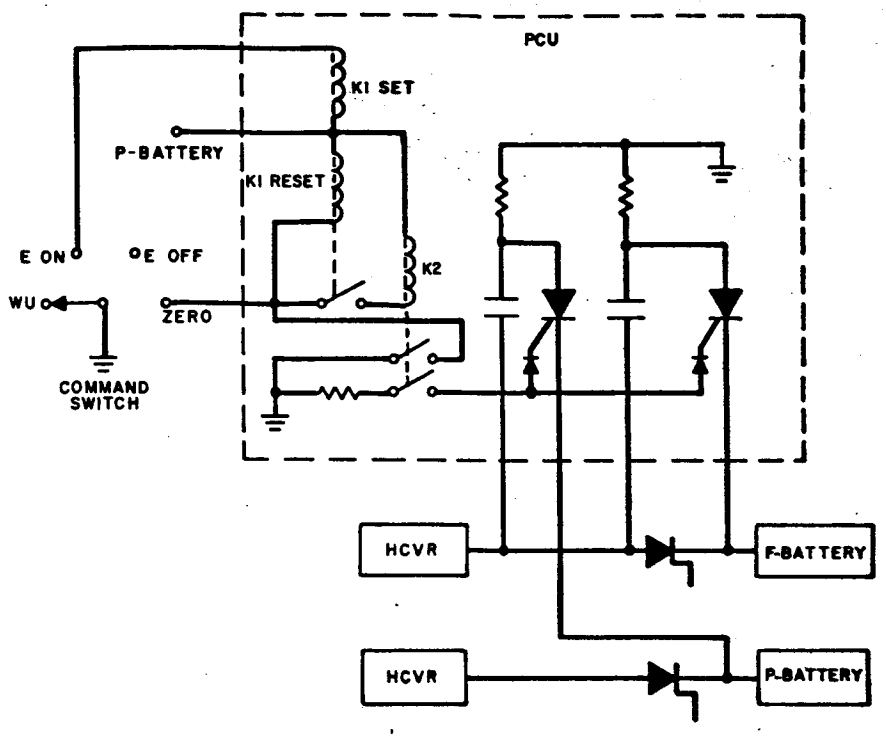

Figure F-4. System turn-off mechanism, block diagram

Investigation of the Channel-8 telemetry indicated that the DCU was operational because all signals routed through the DCU to the Channel-8 telemetry were received and were normal.

The Command Switch was designed to fulfill the following purposes:

- It consisted of a 4-position rotary-solenoid stepping switch with six separate sets of contacts at each position and also included circuitry for the processing of various TV Subsystem commands;
- It contained monitoring circuits to indicate the status of unregulated power;
- It contained relay circuitry for processing "Cruise Mode" commands; and
- It was to transfer RTC-7 to the Ranger TV Subsystem during the operational mission.

The Channel-8 telemetry indicated that the Command Switch operated normally. It showed that the first RTC-7 command issued during the terminal mode resulted in the turn-on of the P-Channel as indicated by the voltage drop of the P-Channel Battery.

Special tests were performed on both a spare flight-qualified Command Switch and on the PTM to determine the sensitivity and speed of operation of the Command Switch. From test data utilizing the flight-qualified spare, it was shown that the Command Switch would step if the stepper amplifier was grounded through a 40-kilohm resistance. The schematic diagram of this test is shown in Figure F-5. It was also determined that increasing this resistance to 150 kilohms would turn the transistors off, conditioning the stepper switch for another advance; reduction of the resistance once again to 40 kilohms would cause the switch to step once more. A combination of four such varying high-resistance shorts at the input of the driver amplifier would cause the Command Switch to step from "zero", into "Warmup", through "Emergency," "Emergency Off", and back to "zero."

It was determined that the stepper motor could maintain a speed of 40 steps per second. The specifications on the stepping relay requires that the switch be stepped if a pulse of 12.0 milliseconds or less is applied.

The coil in the Command Switch, S1, has a limited dissipation capability. Full-drive current continuously applied for 5 minutes or more will cause the coil to overheat and eventually impair the ability of the stepping switch to operate correctly.

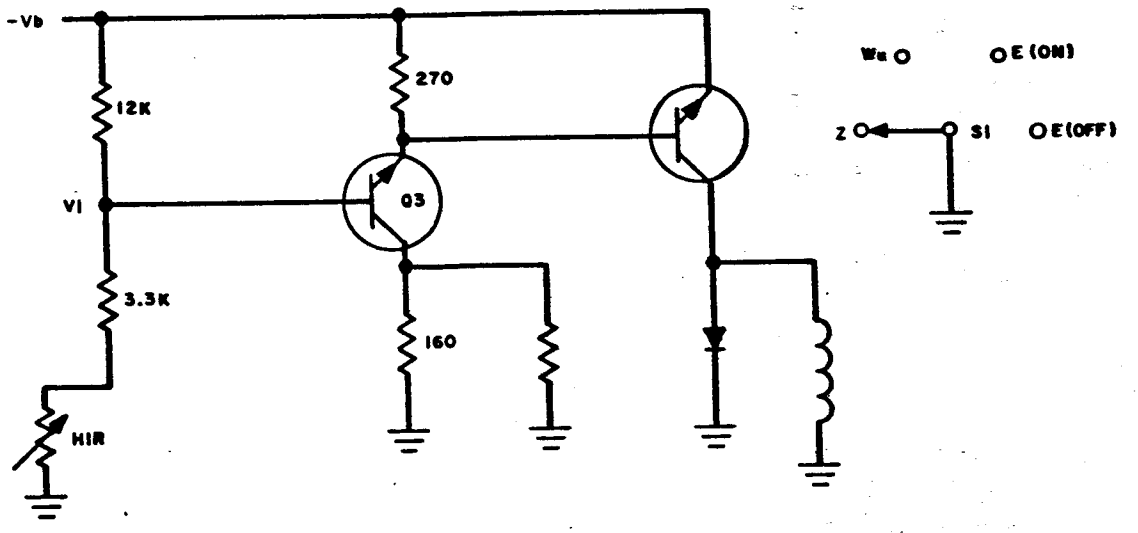

Figure F-5. Special test of command switch, schematic diagram

During the second of a series of tests performed using the PTM TV Subsystem, it was determined that the Subsystem could be switched through the four positions of warm-up to zero in 1.8 seconds. A test run on a stepping relay as a component showed that it could be stepped at a rate of 40 steps per second after it had been brought up to speed.

The purpose of these tests was also to verify the operation of the TV Subsystem with all external cabling removed and without the turn-on command from the CC&S.

Three special tests were performed on the PTM TV Subsystem on 5 February 1964.

With the Subsystem operating on batteries, all ground cabling (including the grounding strap) was removed. The TV back-up clock microswitch (S+0) was actuated (15-minute clock installed). The Channel-8 telemetering was activated by simulating the mechanical back-up timer switch closure. The Spacecraft telemetering was monitored (including Channel-8) by RF link. Channel-8 telemetering indicated that F-Channel warmup was initiated by the TV back-up clock. RTC-7 was transmitted by RF link and the initiation of P-Channel warmup was observed on Channel-8. Observation of the output of the Subsystem as indicated by the GSE verified that the F-Channel was at full power 5 minutes after the back-up clock initiated warm-up and that the P-Channel operated at full power 5 minutes after warmup was activated by RTC-7. Three more RTC-7's were transmitted to turn off the TV.

The TV operated normally with all ground cables removed and without a CC&S commanded warmup.

The purposes of these tests were as follows:

- Test No. 1 — To determine if the TV Subsystem Command Switch could be stepped from a zero position through warmup, emergency on, emergency off, and return to zero in less than 30 seconds;

- Test No. 2 — To determine if points 1 and 2 of the TV Subsystem Channel-8 telemetry would be present if the TV Subsystem was brought directly into warmup by RTC-7 without prior operation of the Channel-8 telemetry; and

- Test No. 3 — To determine if points 1 and 2 of the TV Subsystem Channel-8 telemetry would be present if the TV Subsystem was brought into warmup by a simulated CC&S command without prior operation of the Channel-8 telemetry.

The following results were obtained:

- Test No. 1 — The TV Subsystem was turned on by simulated RTC-7 command and the Command Switch was advanced back to zero by a total of four simulated RTC-7 commands. The total elapsed time from initiation of the first simulated RTC-7 command to turn-off of the TV Subsystem by the fourth RTC-7 command was 1.8 seconds. The TV Subsystems turned off upon actuation of the fourth RTC-7 command;

- Test No. 2 — With Channel-8 telemetry off, the TV Subsystem was placed into warmup by a simulated RTC-7 command. Channel-8 telemetry was recorded during the warmup operation at the GSE. Telemetry points 1 and 2, the regulated P-Channel voltage, and the Low-Current Voltage Regulator output were obtained on the Channel-8 telemetry during this test. Figure F-6 shows one frame of telemetry obtained in this test; and

- Test No. 3 — With Channel-8 telemetry off, the TV Subsystem was placed into warmup by a simulated CC&S command. Channel-8 telemetry was recorded at the GSE. Points 1 and 2 were not present on the telemetry during this test. One frame of telemetry in this test is shown in Figure F-7.

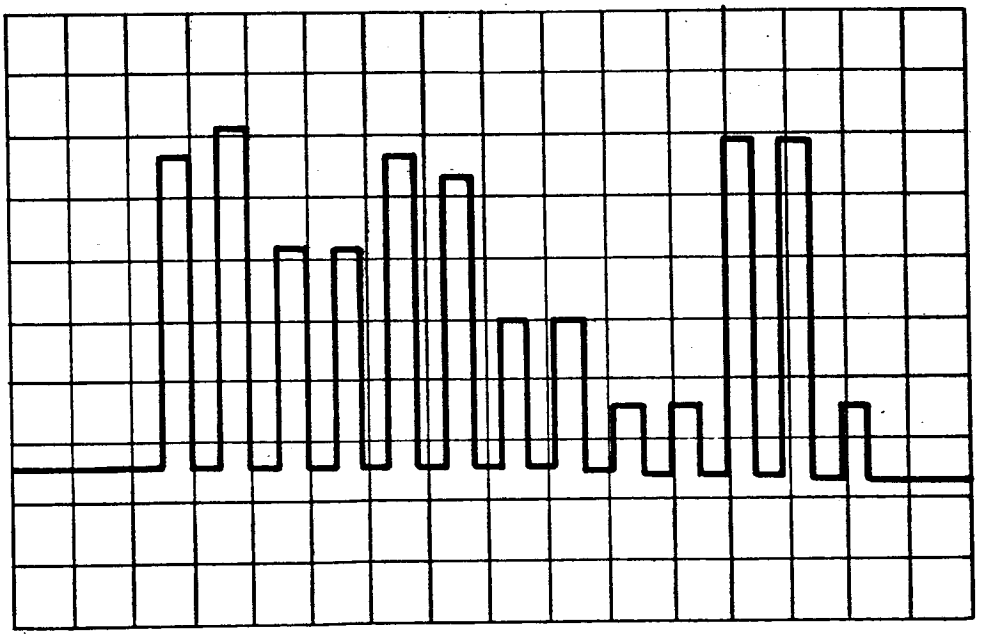

Figure F-6. Channel-8 telemetry frame by RTC-7 warmup

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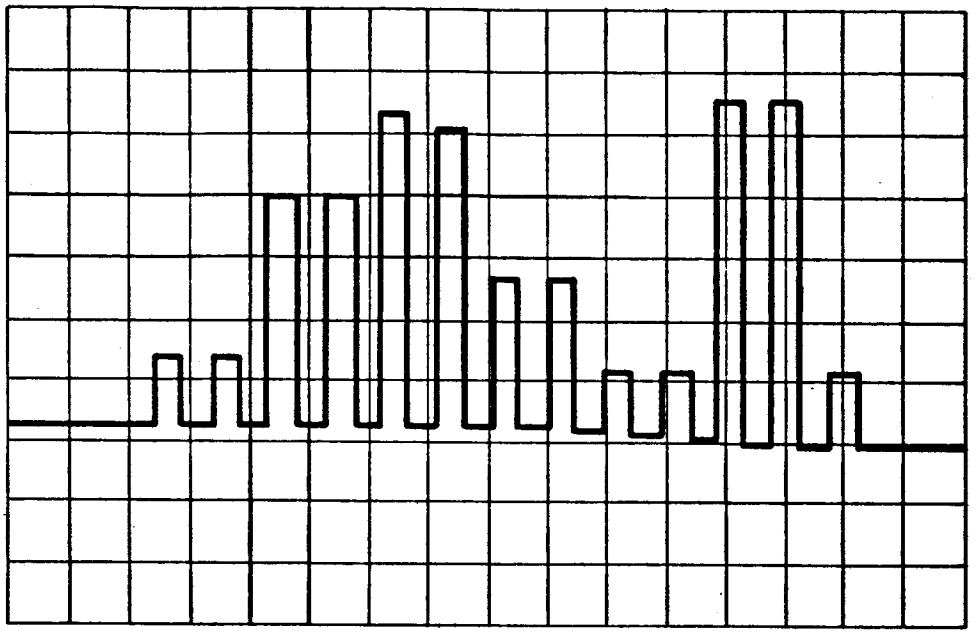

Figure F-7. Channel-8 telemetry frame by CC&S warmup, SCR induced turn-on, or K2 (DCU) closure

C. Power Group

The Batteries were designed to provide all necessary power to operate the Ranger TV Subsystem during a Subsystem Test in the launch area, a checkout in the explosive safe area, a pre-launch checkout, and an ensuing lunar mission of approximately 66-hour duration.

The Batteries were of a silver-zinc composition, hermetically-sealed, and rechargeable with a low discharge rate. Each Battery consisted of 23 series-connected cells and two temperature transducers; a 37-pin connector and two output studs were provided on each Battery.

The Channel-8 telemetry indicated that these Batteries were operational and performed properly throughout the mission.

Two High-Current Voltage Regulators (HCVR) and one Low-Current Voltage Regulator (LCVR) were to supply minus 27.5-volts regulated d-c to the equipment of the Ranger TV Subsystem.

In addition to providing regulated voltage, the Voltage Regulators were to perform the following functions:

- Distribute some of the unregulated voltages to various units;
- Send scaled outputs to the Telemetry Assembly so that the Battery voltage and the regulated and unregulated output voltages could be telemetered;
- Provide inputs for charging the Batteries (HCVR only); and
- Control the regulated and unregulated outputs in response to external "On" and "Off" commands. This control was accomplished by silicon-controlled rectifiers.

The Channel-8 telemetry indicates that these Regulators operated as designed. However, it is believed that they did turn on during launch because of the receipt of a command from the Command Switch.

A test was performed on a flight-qualified High-Current Voltage Regulator to determine its current-carrying capability. For a nominal unregulated voltage of -31.2 volts, the regulator maintained a minus 27.59-volt output up to a load 5.8 amperes. With the input voltage kept at minus 31.2 volts, the output voltage dropped to minus 18.8 volts as the load was increased to 7.5 amperes. Loading the HCVR to 10 amperes drove the output to zero volts.

A second test was performed with the load maintained at 5.8 amperes. It was determined that the HCVR output would follow the input voltage.

Table F-1 lists several of the readings recorded during these tests.

TABLE F-1
VOLTAGE AND CURRENT READINGS RECORDED DURING OPERATIONAL TESTING OF A HCVR

Battery Input (volts)	Regulated Output (volts)	Load (amps.)
20.61	18.09	5.8
31.20	27.59	5.8
31.20	18.8	7.5
34.0	18.8	7.5

The Low-Current Voltage Regulator (LCVR) can be powered by stepping the Command Switch to warmup. During a normal mission, the K1 relay in the Command Switch is reset for the last time by a switch on the blockhouse panel which momentarily connects the P-Battery to the reset coil of relay K1. At Agena separation plus 17 minutes (S+17), the hydraulic timer actuated by Agena separation closes a set of contacts pulling the K1 relay into its set condition. (This is the Cruise-Mode-On Command.) As relay K1 is set, it provides P-Battery voltage directly to the input of the Low-Current Voltage Regulator resulting in a regulated -27.5 v d-c to power the Channel-8 telemetry components. (See Figure F-8.)

The K1 relay will also provide power to the LCVR when it is set, by the driving of the Command Switch to its warmup position. This mechanization is intended as a back-up mode in the event the Cruise-Mode-On command is not properly initiated at S+17. The previous stepping of the Command Switch from Emergency-Off to Zero causes the K1 relay to be reset. A subsequent advance of the Command Switch to Warmup sets the K1 relay with Channel-8 telemetry initiated. Three additional, or any integral combination of four, Command-Switch advances will return the switch to Zero, resetting relay K1 and turning the Channel-8 telemetry off. The two telemetry points, point 1 (P-Channel unregulated voltage taken at the input to the LCVR) and point 2 (LCVR output voltage), were present in the inadvertent Channel-8 telemetry presentation. This is the indication that the Channel-8 telemetry circuitry received its power from the LCVR. The actuation of relay K1 put P-Battery voltage into the LCVR and also actuated relay K3 of the Distribution Control Unit (DCU), transferring the Channel-8 telemetry drive to the output of the LCVR. These events are the same as those which occurred during the RA-6 flight.

These are several failure mechanisms which will cause the P-Battery power to be applied to the LCVR and hence to the Channel-8 telemetry, and one failure mechanism which can momentarily close the contacts of relay K-1. These failure mechanisms, however, do not account for all of the events as they occurred. The LCVR will receive power if the transfer contacts of relay K1 can be effectively shorted, such as, a short circuit between pins 38 and 39 of A13J1, a Cannon connector in the Command Switch; or if the K1 relay contacts can remain closed for 67 seconds without the relay latching. The stopping of Channel-8 telemetry for these situations would depend, in the first case, on the short lifting and, in the second case, on the acceleration of the Spacecraft, causing the closure to be removed. These possible cases are considered unlikely as being the specific reasons for the RA-6 failure.

Still, a third possible failure mechanism would be the shorting of the warmup tab (located on the outside wafer of the Command Switch) to the mounting stud; this would set the K1 relay. Subsequent shaking loose of this contact and touching the off or zero contact to a spot on capacitor C would reset relay K1, removing Channel-8 telemetry power. It is also necessary that the insulation covering the case of capacitor C, which carries P-Battery voltage, be cut through to supply the voltage pulse to reset relay K1.

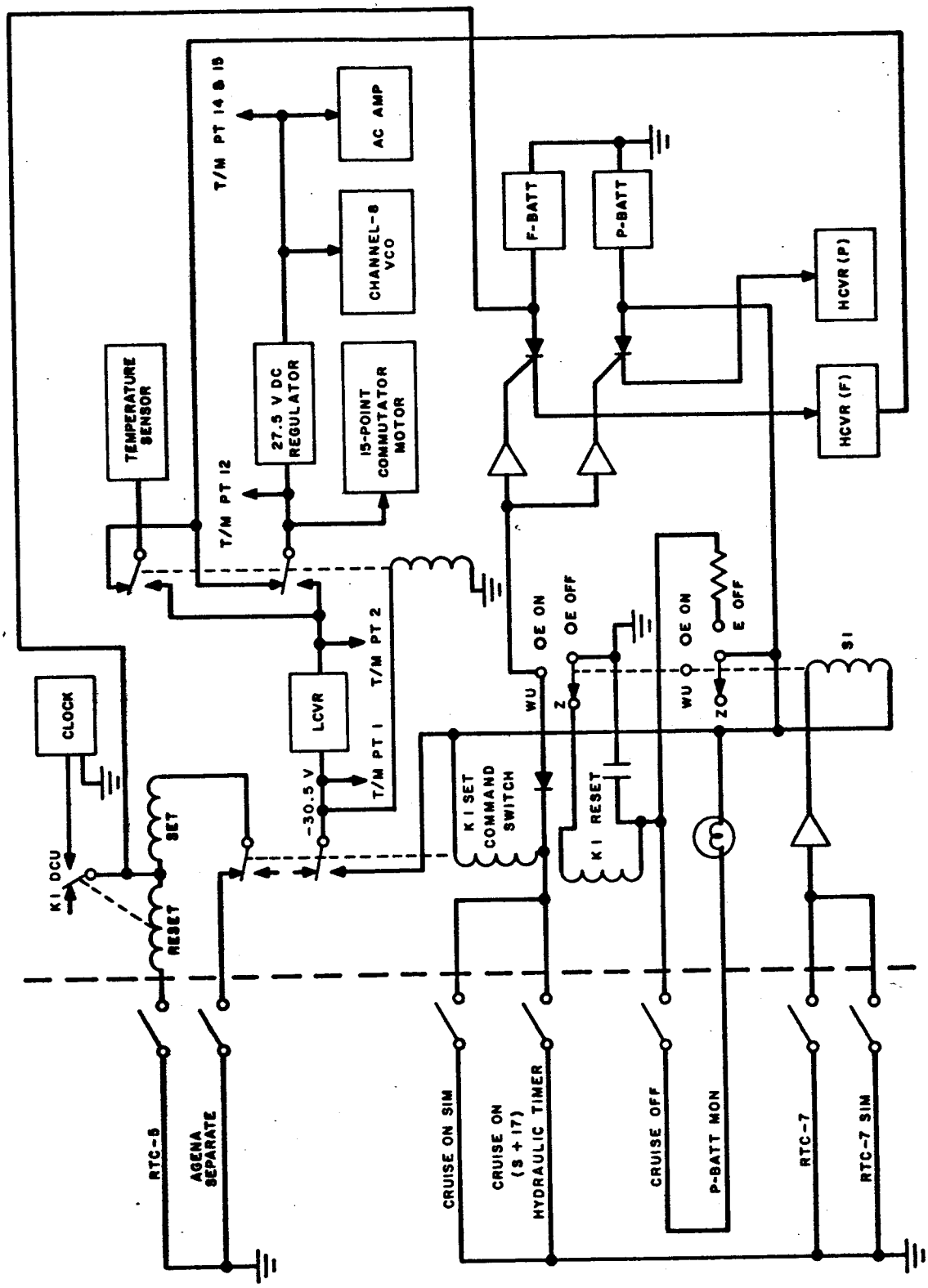

Figure F-8. Low-Current Voltage Regulator and Channel-8 telemetry connections, schematic diagram

The Channel-8 telemetry events would then have been duplicated, having required a very special sequence of time-separated failures. Had the connection to the capacitor remained, the relay would still have operated at S+17, which did occur, because the voltage applied to the reset coil would have been on the order of 15 volts; the set voltage of about 30.5 volts would have overcome it and the relay would have set.

D. Communications Group

The Communications Group of the Ranger TV Subsystem consists of two similar transmitting channels and one RF combining section. Each transmitting channel comprised the following assemblies:

- An L-Band, FM Transmitter consisting of the following subassemblies:
  - (1) an FM modulator,
  - (2) a X12 multiplier,
  - (3) a X4 multiplier, and
  - (4) an intermediate power amplifier (IPA);
- a 60-watt Power Amplifier;
- a Transmitter Power Supply; and
- a Telemetry Processor.

The RF combining section comprised the following units:

a. A Stripline, 4-Port Hybrid Assembly; and

b. A Dummy Load.

The Communications Group was to receive the telemetry outputs from the Telemetry Assembly (A26) and the composite video outputs from the Video Combiner Assembly (A8) and convert these inputs to the required frequency and amplitude for combination in the RF combining section and application to the JPL Equipment (see Figure F-9). Also, telemetry signals from the Communications Group were to be properly scaled at the telemetry processors and supplied to Telemetry Assembly (A26).

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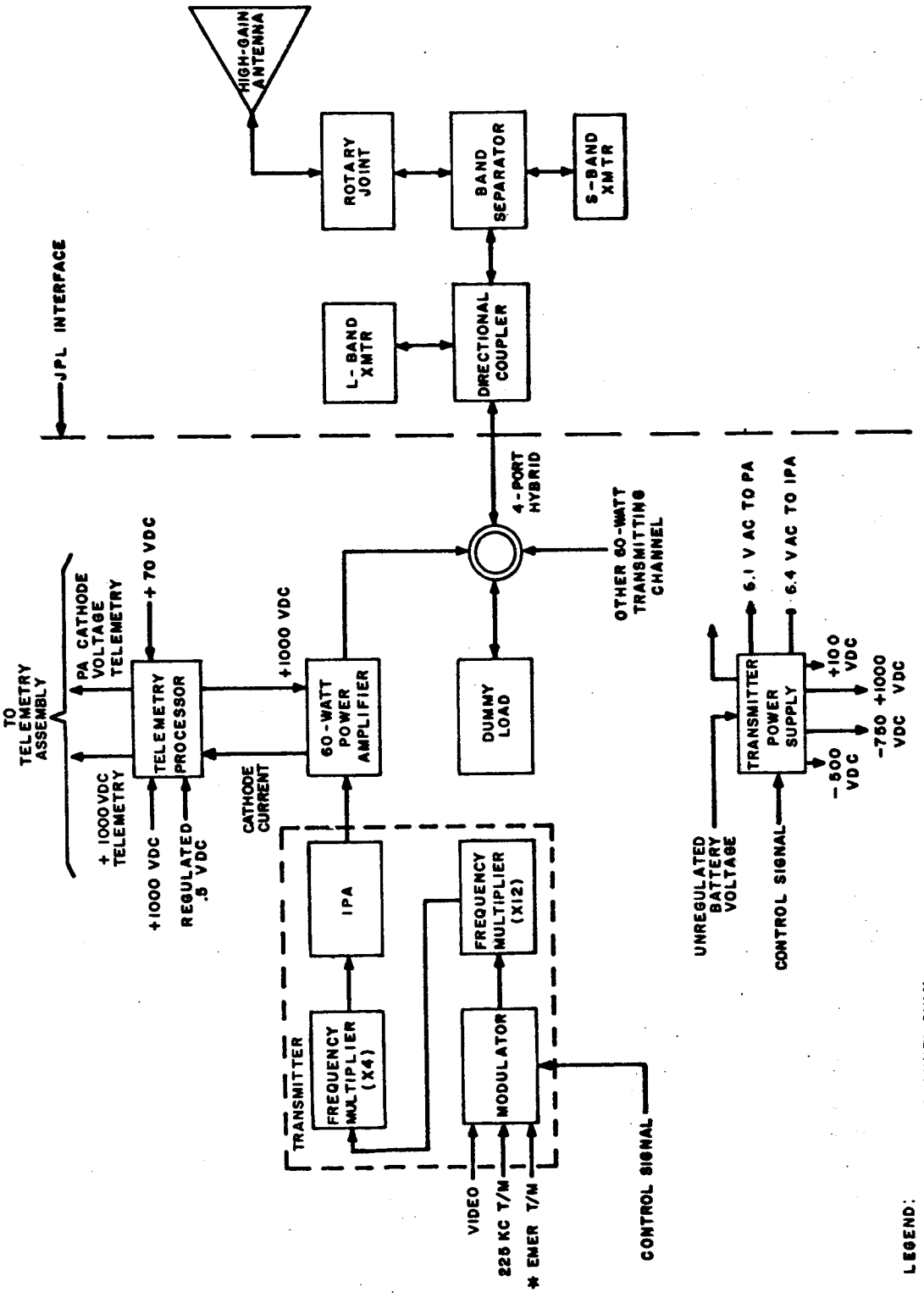

Figure F.9. Communication equipment, block diagram

The loss of either one of the transmitting channels would not affect the operation of the other channel. Therefore, it must be assumed that because no output was received, both channels were inoperative.

Only the loss of all the high voltages to the Transmitters and Power Amplifiers would result in no output being transmitted, provided all power connections were intact. If no video information were supplied to the Transmitters, the unmodulated signal or telemetry information would be transmitted. Even if the crystals in both transmitting channels were fractured, the oscillators would continue to oscillate at some frequency close to the nominal value. The loss of any of the plate voltages to the Transmitters or Power Amplifiers would still result in the generation of noise.

Neither the Transmitters nor the Power Amplifiers were designed to operate in partial-pressure conditions. If TV Subsystem turn-on had taken place during the inadvertent turn-on of the Channel-8 telemetry, arcing in either the Transmitters, Power Amplifiers, Power Supplies, or any combination of these assemblies would cause the destruction of components resulting in shorting of the output from the Power Supply (if the short burned free, some voltage outputs should result) and loading down of the remaining output voltages so that the voltage inputs to the Transmitters and Power Amplifiers would appear to be nonexistent. Under this condition, the current required by each Power Supply would be limited to about 5 amperes or the normal warm-up current.

There are no known probable failure modes that could occur in the Stripline 4-Port Hybrid to cause the loss of output from both transmitting channels; the design for this Hybrid was tested under many varying conditions (see Bimonthly Progress Reports Nos. 12, 13, and 15) and has satisfactorily operated even with double the power input experienced in the Ranger TV Subsystem.

The loss of the Dummy Load Assembly would not result in the loss of all output power from the 4-Port Hybrid. Because this assembly is a passive device, it may be assumed that it was operable.

The effect of possible Transmitter crystal fracture on RA-6 mission was schematically analyzed. Analysis of the FM modulator schematic discloses that the element most likely to be damaged by excessive shock is the frequency-determining crystal. Even this supposition is unlikely, because the JPL crystal was able to survive launch environment without the slightest change. However, should such a shock actually fracture the Subsystem crystals, it is evident from the schematic that the oscillators would continue to oscillate at some frequency close to the nominal value. This follows because the oscillator is a tuned-base, tuned-collector type. Furthermore, the frequency-modulating varactor would now be able to deviate the oscillator over an extremely wide range, which would most assuredly encompass a portion of the normal frequency spectrum that would have been evident during the search for RF described in Appendix E.

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E. Telemetry Group

The Telemetry Assembly was operated during both cruise mode and terminal mode. After Agena separation, the Central Computer and Sequencer (CC&S) started the cruise mode, causing the LCVR to supply regulated power to the Cruise-Mode section of the Telemetry Assembly. Critical telemetry inputs were sampled, processed, and applied on the Jet Propulsion Laboratory (JPL) transponder for transmission to the ground station.

Terminal mode was to be started by the warmup command. This command is normally supplied by the CC&S. However, it was supplied by both the ground station (via the "RTC-7" command) and the Electric Clock Assembly in the TV Subsystem. During a normal terminal mode, the HCVR and the LCVR provide power for the Telemetry Assembly. The 90-point telemetry was to sample and process detailed diagnostic telemetry inputs, and provide two identical data outputs to the P-Channel and F-Channel Transmitters. Two emergency-type outputs, of less-sophisticated form, were also to be available for direct application to the transmitters.

The Telemetry Assembly, as shown in Figure F-10, was designed to perform as follows:

- It was to convert 15 bits (channels) of parallel-input telemetry information into a serial, scaled-frequency-deviation telemetry output during both cruise mode and terminal mode; the 15 bits included full-scale, zero, and frame references. Conversion components were isolated from load effects;

- It was to perform an additional conversion, identical to that described above, for a 90-channel input during terminal mode. The 90 channels were to include all required references. Two parallel and independent outputs were to be provided;

- It was to process the 90-channel input to provide two serial, scaled-voltage-deviation telemetry outputs which were suitable for emergency operation; and

- It was to convert input power, as necessary, to operate the components.

The Telemetry Assembly comprised the following subassemblies and circuits:

- 15-Channel Commutator (A1);

- 90-Channel Commutator (A2);

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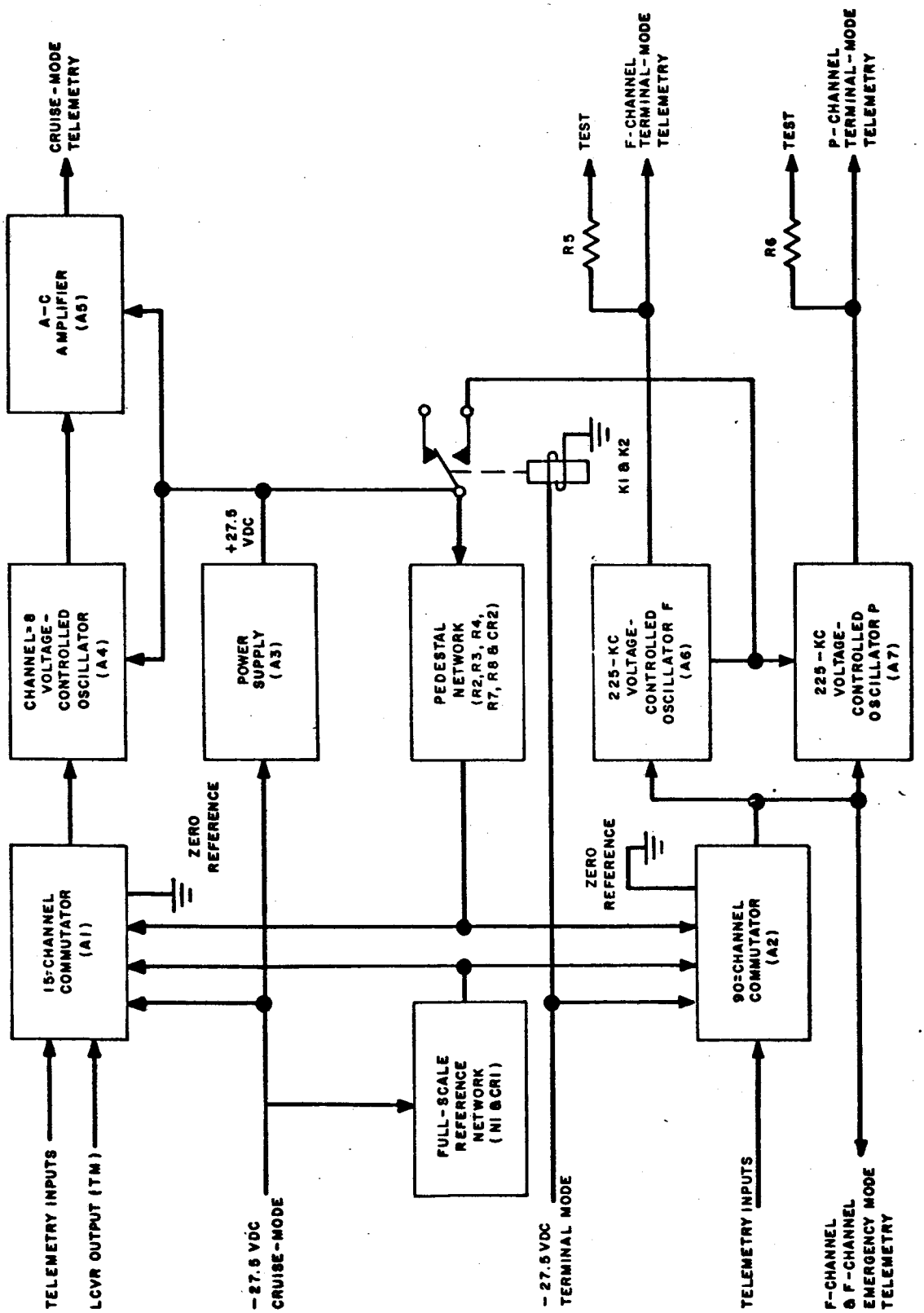

Figure F-10. Telemetry Assembly, block diagram

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- Power supply (A3);
- Channel-8 voltage-controlled oscillator (VCO) (A4);
- A-C amplifier (A5);
- 225-kc VCO P (A6); and
- 225-kc VCO F (A6).

The Channel-8 telemetry received during the mission indicated normal operation of that portion of the Telemetry Assembly associated with the 15-point telemetry.

Because no 90-point telemetry was received, no evaluation of the operation of that portion of the Telemetry Assembly can be made. It should be noted that malfunctioning of the 90-point telemetry could in no way seriously interfere with the over-all operation of the Subsystem.

The Temperature Sensor contained 23 thermistors and associated circuitry for the detection of the temperature within the Subsystem at 15 preselected locations. The Temperature Sensor consisted of seven low-range (-10°C to +65°C) and eight high-range (-10°C to +100°C) temperature-measuring circuits.

The low-range temperature-sensor circuit consisted of a thermistor and a diode-resistance circuit. The diode-resistance circuit was to perform two functions: detect any thermistor-resistance change; and supply the telemetry system with a voltage representative of temperature.

The high-range temperature-sensor circuit consisted of two thermistors and a resistive network. The resistive network was to perform two functions: detect any thermistor resistance change; and supply the telemetry system with a voltage representative of temperature.

The operation of those thermistors associated with the Channel-8 telemetry was normal throughout the mission. The only deviation from normal was that the temperatures indicated by these thermistors stabilized at temperatures higher than those expected.

A test was performed at AED to determine the commutator speed versus input voltage of a 15-point commutator. A Brush recorder was used for time calibration and the input voltage was measured with a digital voltmeter. The results are listed in Table F-2.

TABLE F-2

SPEED-VERSUS-INPUT-VOLTAGE CHARACTERISTICS OF A 15-POINT COMMUTATOR

Input Voltage (volts)	Frame Time (seconds)
27.5	14.5
24.9	16.7
26.02	15.6
26.5	15.1
27.01	14.7
28.01	14.0
29.0	13.3
30.02	12.6
27.5	14.3

The commutator was stopped during a pulse after 430 milliseconds. The pulse was stretched an additional 270 milliseconds; the nominal pulse width was 490 milliseconds. An investigation was made into the possibility of a decreasing frame time during a mission. It is believed that, as the commutator wears during the mission, the frame time will gradually decrease.

Another test was performed at AED to determine the effect of the input voltage to output voltage of the telemetry voltage regulator. The test was terminated at an input voltage of -30 volts to prevent overstressing of the VCO; no change was noted in the operating characteristics of the VCO during the test. The results of the test are listed in Table F-3.

TABLE F-3
EFFECT OF INPUT CURRENT AND VOLTAGE ON VCO OUTPUT VOLTAGE

Input (volts)	Input Current (ma)	Output (volts)
-27.46	137	+27.12
-24.99	127	+26.90
-26.00	132	+26.97
-27.00	135	+27.07
-28.00	140	+27.16
-29.00	143	+27.28
-30.00	147	+27.38

F. Demated Connectors

An investigation was made into the possible demating of any one connector in the Subsystem which would result in the loss of both transmitting channels. The investigation was based on the following facts:

- The Channel-8 telemetry functioned properly. This indicated that the Low-Current Voltage Regulator, 15-point commutator, and all 15 telemetry points functioned properly;
- The F-Channel SCR was turned on by the warmup pulse from the Clock. This was indicated by the drop in the telemetered F-Battery voltage;
- The P-Channel SCR was turned on by the Command Switch being stepped by the RTC-7 command. This was indicated by the drop in the telemetered P-Battery voltage immediately after receipt by the Spacecraft of the RTC-7 command;
- The P-Channel Sequencer started counting on a 5-minute countdown. This was indicated by the receipt of the 30-second accumulator pulse from the telemetry; and

- The Clock was turned on and counting. This was indicated by both the operation of the F-Channel SCR and by the receipt of the timing pulses on the telemetry.

Table F-4 lists the connectors which contain connections critical to the operation of both channels.

TABLE F-4
CRITICAL CONNECTORS

Assembly	Connector	Command or Function
A-12 HCVR (F)	J-1	Channel-8 - F-Battery voltage telemetry point.
	J-2	F-Channel - SCR on gate
A-13 Command Switch	J-1	Clock on.
A-28 Sequencer P.S.	J-1	P-Channel sequencer power to start counter.
A-29 Sequencer	J-2	Channel-8 - P sequencer accumulator pulse telemetry points.
A-17 LCVR	J-1	15-point commutator power.
A-34-DCU	J-1	Can not confirm - if demated, would only disable F-Channel, not P-Channel
	J-2	P-Channel and F-Channel SCR on gates
	J-3	F-Channel - SCR gate on and F-battery T/M
	J-4	P-Channel - SCR gate on and P-battery T/M
	J-5	P-Channel - sequencer power to start counter
	J-6	Clock start
A-35 Clock	J-1	Clock start
A-37 HCVR (P)	J-1	P-Channel sequencer regulated voltage to start counter.
	J-2	P-Channel - SCR gate on.

The camera connections were not analyzed, because the demating of them would not result in the complete loss of the Transmitter outputs.

The individual F- and P-Channel Transmitter connections were not analyzed because the demating of a connector in one channel would not affect operation in the other channel.

It can be concluded from this investigation that all connectors critical to the operation of both channels were mated from lift-off to impact during the flight of RA-6.

A review was also made of the connections which interface with the JPL Bus and on through to the umbilical connector. These connections are listed in Figure F-11.

If the RTC-7 simulate line is accidentally grounded, it will cause the Command Switch to step into Warmup. The RTC-7 simulate and d-c return are connected to adjacent pins in the umbilical connector (pins 4X and 4Y) as well as in the Agena separation connectors (pins K and E). A short across these pins, which are male pins in the umbilical connector, at booster ejection could have accounted for the Subsystem being stepped into Warmup.

After the final check on the pad during the launch countdown, a Channel-8 telemetry was turned on by the GSE Cruise On command. Following two to three minutes of Channel-8 telemetry recording, the Cruise-Mode Off command was initiated at the GSE. This, in effect, momentarily connected the P-Battery monitor line to the K-1 relay reset coil in the Command Switch. If, following this exercise, the Cruise-On command was accidentally shorted to ground, it would have turned the Channel-8 telemetry on. This is considered unlikely because the Cruise-On connection (pin 3F) in the umbilical is not near any d-c returns. In addition, the Subsystem would have had to fabricate a Cruise-Mode Off command to reset relay K1, in order to account for the normal operation which occurred after Agena separation.

The wires labeled F-Channel turn-off A and F-Battery monitor A, as well as a similar pair for P-Channel, were suspect. The circuit is shown in Figure F-12. It is believed that if the Battery monitor line could be shorted to the Subsystem turn-off line, the TV Subsystem would be in warmup. The fuse in the Battery monitor line is a 5-ampere, slow-blow fuse. A test was performed on this fuse during which a normal 8-ampere warmup load was placed on two samples of the fuse. One sample blew in 47 seconds; the second blew in 52 seconds. When these pins are located in the umbilical connector, it is found that they are quite distant from each other. In addition, to result in damage to both transmitting channels, both sets of Battery monitor leads would have to be shorted to the turn-off leads. Also, the fuse could not have blown for 67 seconds. The latter is unlikely because the loads would have been considerably higher if the Subsystem had been turned on in warmup in a critical-pressure environment. These high-current loads coupled with the likelihood that the fuses would have blown earlier than those tested in an ambient-pressure environment, reduce the

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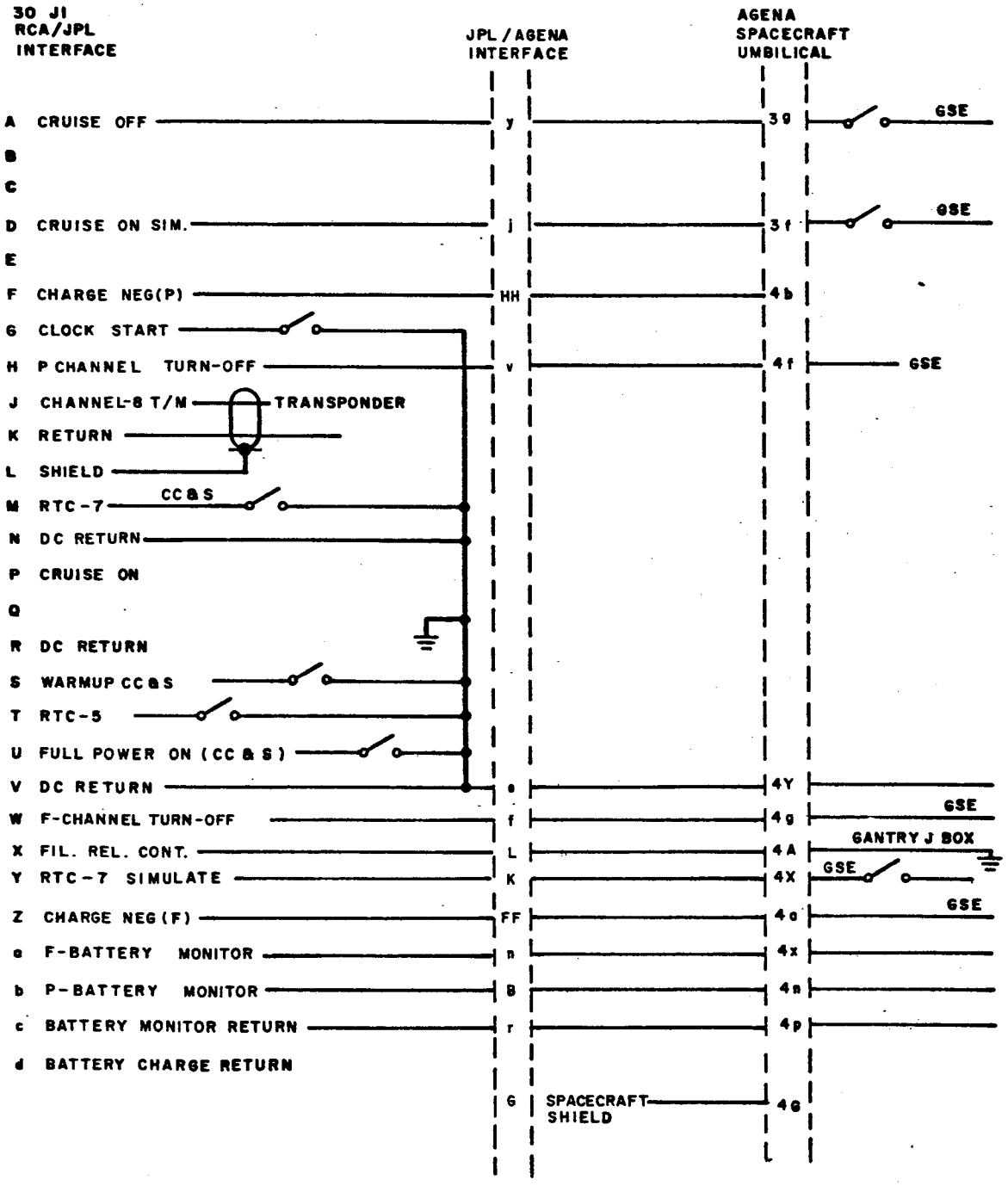

Figure F-11. Umbilical wire connections

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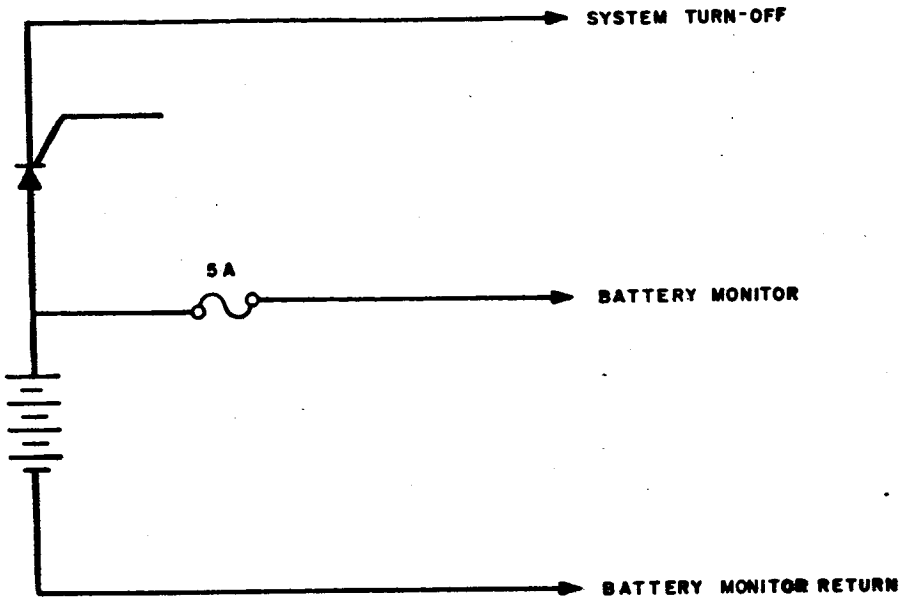

Figure F-12. Possible subsystem turn-on mechanism, schematic diagram

probability of this mode of malfunction. The shorting of the Battery monitor lines to the Subsystem turn-off lines is analogous to a Central Computer and Sequencer (CC&S) warmup command. This method of warmup would have the Channel-8 telemetry operating from the HCVR, and points 1 and 2, the unregulated voltage for F-Channel and the LCVR output voltage, would have read zero in the telemetry readout. This condition did not exist.

There is only one connection that interfaces with JPL Bus and the TV Subsystem which, if it was demated, would result in the loss of the outputs from the transmitting channels. This is the connection from the 4-Port Hybrid (A26) of the Subsystem to the Directional Coupler (Case No. 2) of the JPL Bus.

An investigation was performed at JPL which resulted in the conclusion that this cable could not have become demated from the period of Agena separation until impact. There is also proof that the cable was properly mated prior to launch. It does not appear that the environment necessary to destroy this connection was present from the time of launch to Agena separation.

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Appendix G
Agena Shroud Pressures

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Appendix G

Agena Shroud Pressures

A report on the pressure in the spacecraft compartment of the Agena Shroud was made by Lockheed. In summary, it stated that the space is very near the ambient at a time corresponding to the inadvertent Channel-8 telemetry turn on.

TABLE G-1
SUMMARY OF PRESSURES INSIDE AGENA SHROUD

Time	Altitude (ft)	Pressure
	40,000	1.85 psi (95.5 mm Hg)
	128,000	0.05 psi (2.58 mm Hg)
L +136.5	136,500	0.01 psi (5.17×10^{-1} mm Hg)
L +136.5	178,000	0.008 psi (4.12×10^{-1} mm Hg)

The lag between ambient and the spacecraft compartment from the 128,000 foot altitude is nil (Figures G-1 through G-3).

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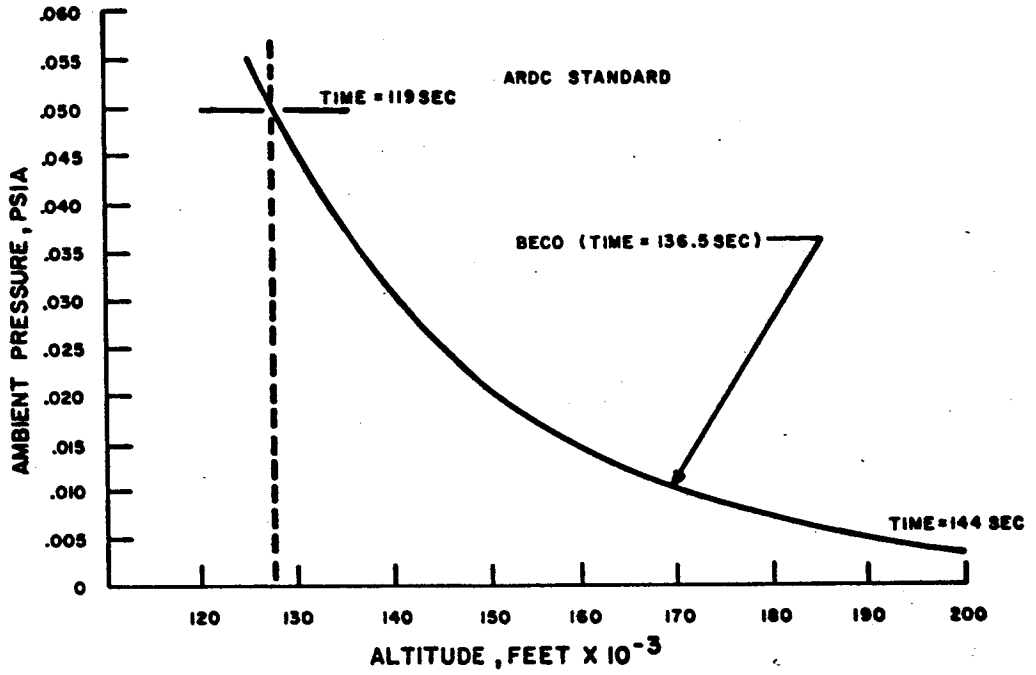

Figure G-1. Ranger-6 (calculated) pressures

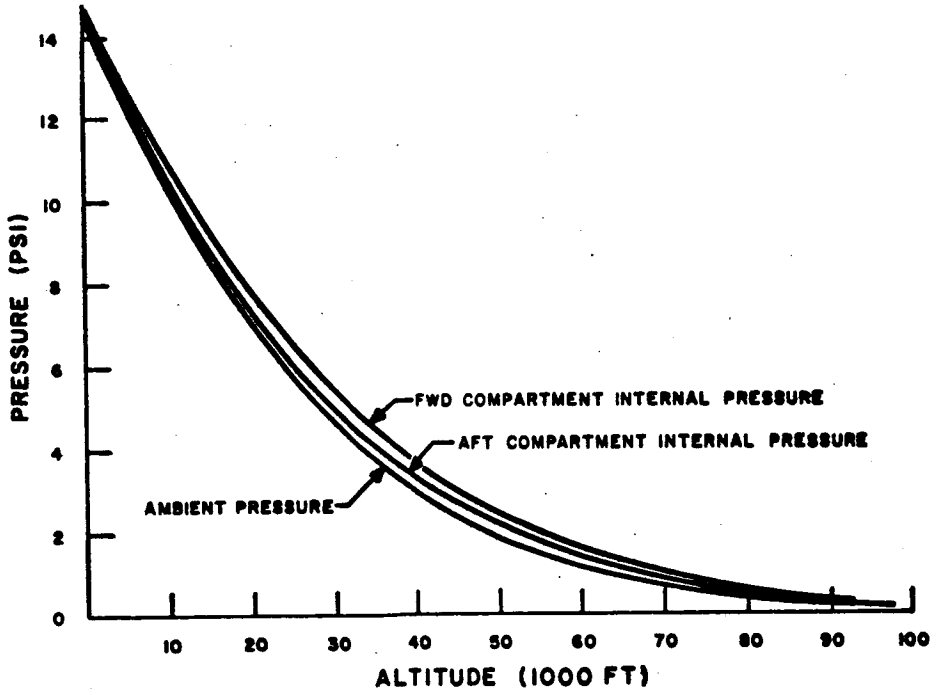

Figure G-2. Pressure vs altitude (data from Thor-Agena Test)

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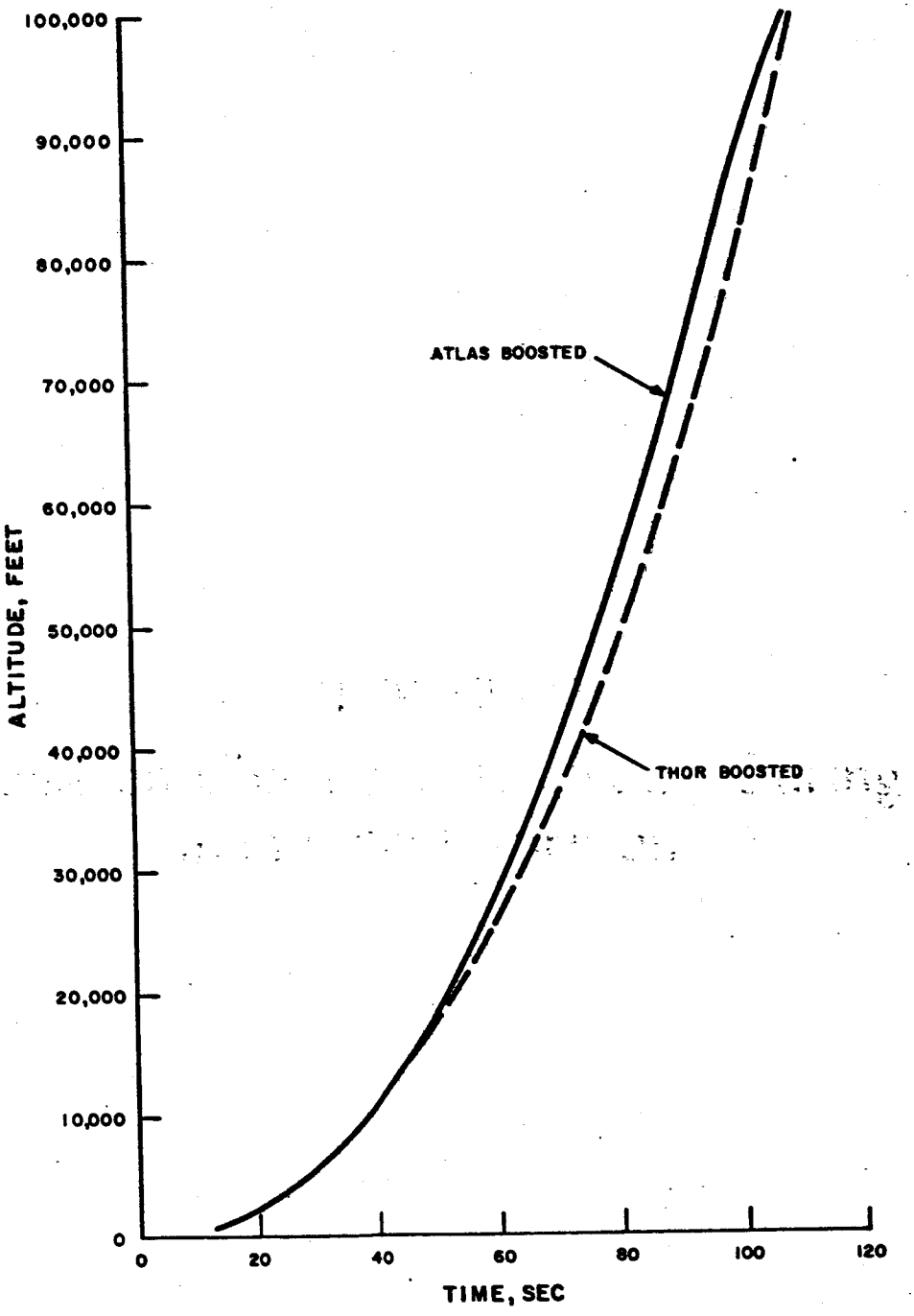

Figure G-3. Comparison of Atlas-Boosted and Thor-Boosted Agena pressures

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Appendix H

Noise on Channel-8 Telemetry During Inadvertent Turn-on

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Appendix H

Noise on Channel-8 Telemetry During Inadvertent Turn-on

The following facts were noticed during the first two frames of Channel-8 telemetry received from the 67-second inadvertent turn-on during the launch phase of RA-6.

- All points were noisy, with the peak-to-peak noise on the points varying randomly from 4 to 10 percent of the peak-to-peak deviation.
- There was a distinct shift of all points toward a higher frequency (pedestal end of the Channel-8 data).
- The noise cleared up abruptly during the tenth data point of the second frame, at which time the frequency shifted down to its normal value. Channel 8 performed normally for the remainder of the flight.
- Points 1 and 2 were present and normal, indicating that the low-current regulator (LCR) was operating and thus powering the telemetry chassis (Figure H-1). The frame time of the Channel-8 telemetry during the inadvertant turn-on was 19.4 seconds and constant. This frame time is in the same range as the prelaunch and normal cruise data for RA-6.
- The noise was the same for both the Agena and JPL bus RF links.

The following facts summarize the typical characteristics of a telemetry chassis and the Channel-8 VCO (Figure H-2).

- Channel-8 VCO Deviation and linearity
  +1.25 vdc (pedestal): 3050 ±2 cps
  -5.00 vdc (full scale): 2950 ±2 cps
  All points must lie within ±2 cps of the "best-fit" straight line. Typically, all points lie within ±1 cps of the "best-fit" straight line under all environmental test conditions.
- 15-point commutator speed characteristics
  In the range of 27.5 ±2.5 volts the relationship of frame time to input voltage is approximately linear (provided temperature is constant).

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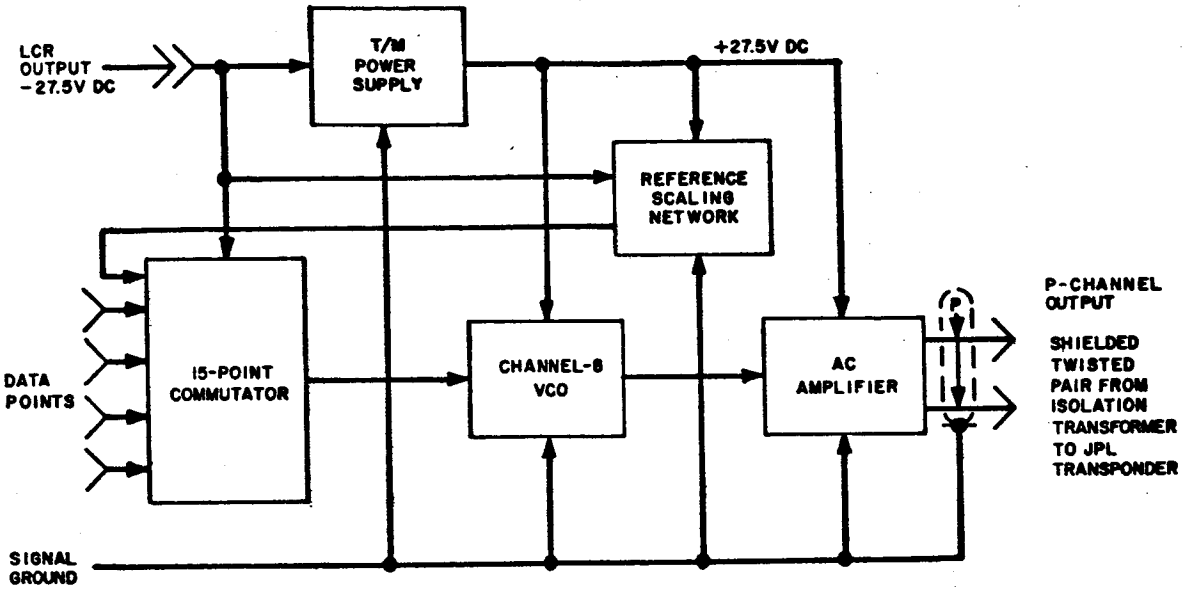

Figure H-1. Block diagram – telemetry chassis cruise mode

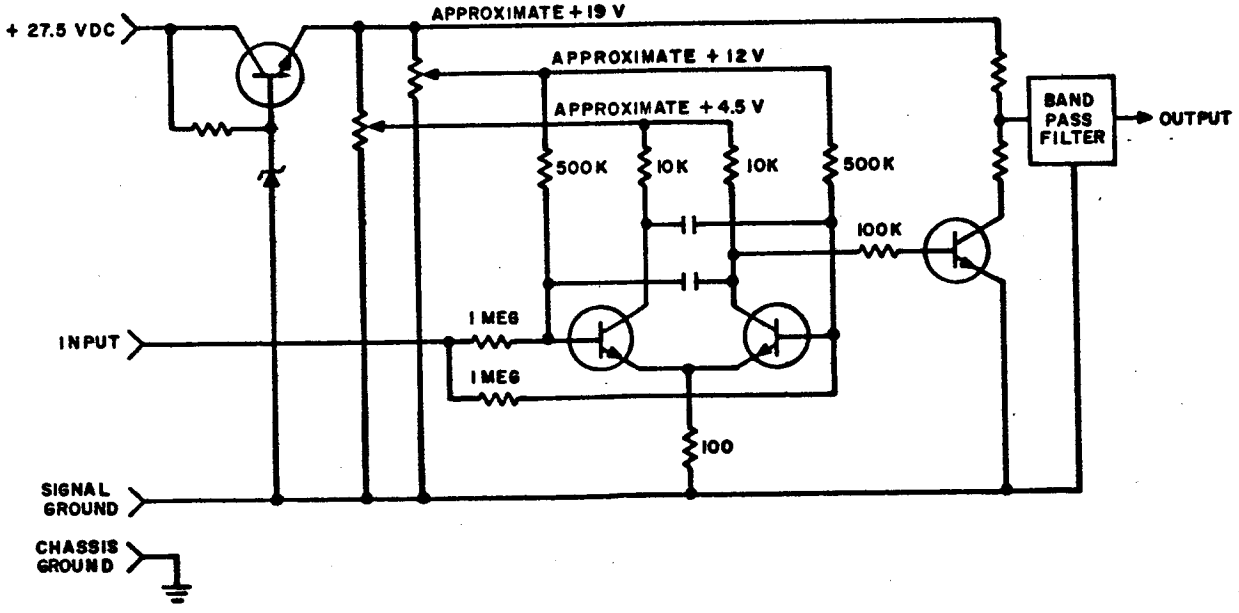

Figure H-2. Simplified schematic Channel-8 VCO

The frame time increases approximately 0.8 second for a decrease of 1 volt in the supply voltage.

- Variation of Channel 8 characteristics with input voltage.
  The output of the DC-DC converter on the telemetry chassis will change 0.1 volt for a 1-volt change in the input. The overall effect of varying the input voltage in the range of -27.5 ±2.5 vdc on the Channel-8 VCO frequency was unobservable. (Resolution of the frequency monitoring set-up was ±1 cps.)

- Operational Vibration Test on Flight 1 Spare
  A telemetry chassis was set up and operated in the cruise mode during special vibration tests at JPL during the week ending February 9, 1964. The noise observed on the data points in this test was several orders of magnitude lower than that present in the inadvertent turn-on of RA-6. In addition, there was not shift in frequency of the Channel-8 VCO.

From all of the above data the following conclusions can be drawn:

- The noise and frequency shift of the VCO was not due to variations in the B+ supply voltage to the telemetry chassis.

- The noise was not due to pickup, since the zero, full scale, and pedestal points were as noisy as the data points. The zero, full scale, and pedestal voltages are generated within the telemetry chassis and have no long cable runs before reaching the VCO. These points are all referenced to the same signal ground (within 6 inches) as the VCO. The zero point is a direct short to this signal ground.

- The noise was not due to RF link problems, since the noise was identical for the telemetry transmitted over the Agena and JPL RF links.

- The noise was not due to contact noise of the commutator under vibration.

The mechanism believed responsible for the noise on Channel-8 is arcing in the rest of the TV Subsystem which would cause a large noise voltage to exist on signal grounds in the telemetry chassis with respect to the chassis ground. For low frequency noise, the +28 vdc, signal grounds, and all other points in the Channel-8 VCO would ride up and down together with respect to chassis ground. At higher frequencies, this would no longer be true because of stray capacitance to chassis ground. This is particularly important in the base and emitter circuits of the multivibrator of the Channel-8 VCO. The emitter circuit is connected to signal ground by 100 ohms; the impedance of the off transistor base is several hundred kilohms regardless of the data point being

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sampled. Thus, there would be a difference in the noise potential present on the emitter and base of the off transistor caused by stray capacitances to chassis ground. This would cause the transistor to switch sooner thus accounting for the increase in frequency. The random nature of the noise in both amplitude and time would account for the noise on all telemetry points.

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Appendix J
Command Switch Tests

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Appendix J

Command Switch Tests

A test series, consisting of two tests at ambient conditions and three at partial-pressure conditions, was performed to determine if the Command Switch could be stepped by electrostatic discharges. The first test at ambient conditions was performed with the equipment connected as shown in Figure J-1. The LTM Command Switch was mounted on a steel plate and 10-foot leads for the RTC-7 command and the ground return for the Switch were coiled on the plate. The following attempts were made to step the Command Switch:

- A 4000 uf capacitor was charged to 132 volts and discharged near the lead for the RTC-7 command. The Command Switch did not step;
- The high-voltage power supply was discharged at 20,000 volts and 5 milliamperes near the lead for the RTC-7 command. The Command Switch again did not step; and
- The high-voltage power supply was discharged at 2,000 volts and less than 5 milliamperes into the end of the lead for the RTC-7 command. This time the Command Switch stepped readily.

The second test at ambient conditions was made with the equipment connected as shown in Figure J-2. The interface signals of connector J1 of the LTM Command Switch were terminated in a 50-pin, type D connector manufactured by Cannon. The other side of the connector was faced toward a metal plate that was connected to the positive output of the high-voltage power supply. The voltage output of the supply was increased until arcing occurred across the 1/4-inch gap located between the metal plate and the connector. The first arcs appeared between the P-Battery Monitor pin and the metal plate at approximately 9,500 volts. Arcs then occurred between the metal plate and the RTC-7 command and ground return pins. The Command Switch stepped whenever an arc occurred between the metal plate and the RTC-7 command pin.

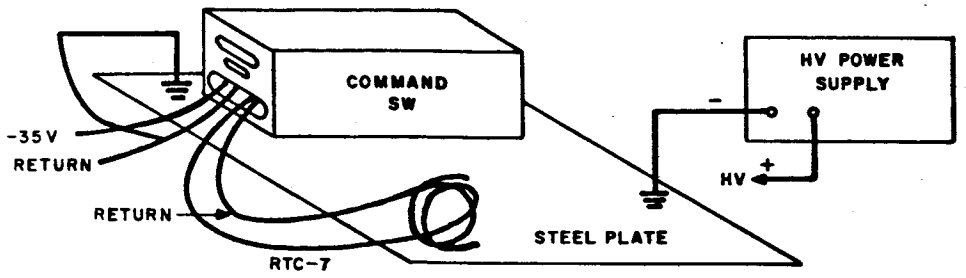

Figure J-1. Ambient test configuration

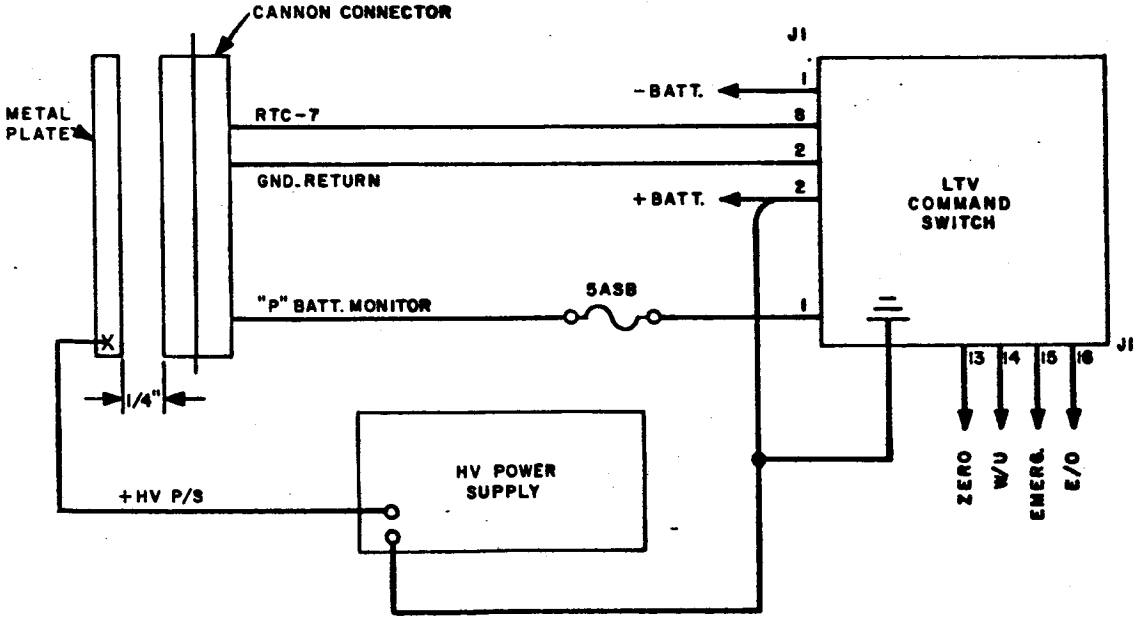

Figure J-2. Ambient test set-up using Cannon connector

The first test at partial-pressure conditions was performed with the equipment connected as shown in Figure J-3. The equipment was mounted in a bell jar with the LTM Command Switch connected to an Agena Adapter harness which included the umbilical connector as shown in Figures J-4, 5, and 6. The following signal leads were connected:

- RTC-7 simulate to JPL Spinoff connector J2, pin K to umbilical connector pin 4X;
- D-C Return to JPL Spinoff connector J2, pin e to umbilical connector pin 4Y;
- F-Battery Monitor to JPL Spinoff connector J2, pin n to umbilical connector pin 4x; and
- P-Battery Monitor to JPL Spinoff connector J2, pin B to umbilical connector pin 4n.

A lead destined to carry a variable d-c voltage was connected to the housing of the umbilical connector. This was to provide a variable potential on the housing with respect to the d-c return and thus possibly result in an arc between the housing and some other point.

The bell jar was then evacuated to 3×10^{-1} Torr and +500 volts was applied to the housing of the umbilical connector. The Command Switch did not step. Following this, several changes, as noted in Table J-1, were made to the conditions of the test with the listed results.

The pressure in the chamber was then returned to ambient and the voltage turned off. An attempt was made to step the Command Switch by applying an RTC-7 simulate command, however, the switch would not step. The chamber was then opened and the equipment was examined. The results were as follows:

- Arcs had occurred between the RTC-7 simulate connection of the Command Switch connector and three adjacent pins. These pins were severely burned and a layer of carbon was deposited in the vicinity of the connector (see figure J-7);
- There was evidence that a minor amount of arcing had occurred between the RTC-7 simulate and the d-c return leads at the JPL Spinoff connector J2; and
- A slight discoloration was observed at the door latch of the umbilical connector adjacent to the RTC-7 Simulate pin 4X.

The LTM Command Switch was replaced with Command Switch, Serial No. 008. The cannon connector was also replaced. The second test at partial-pressure conditions was performed with the equipment again connected as shown in Figure J-3 and a 300-volt potential difference. No arcing resulted.

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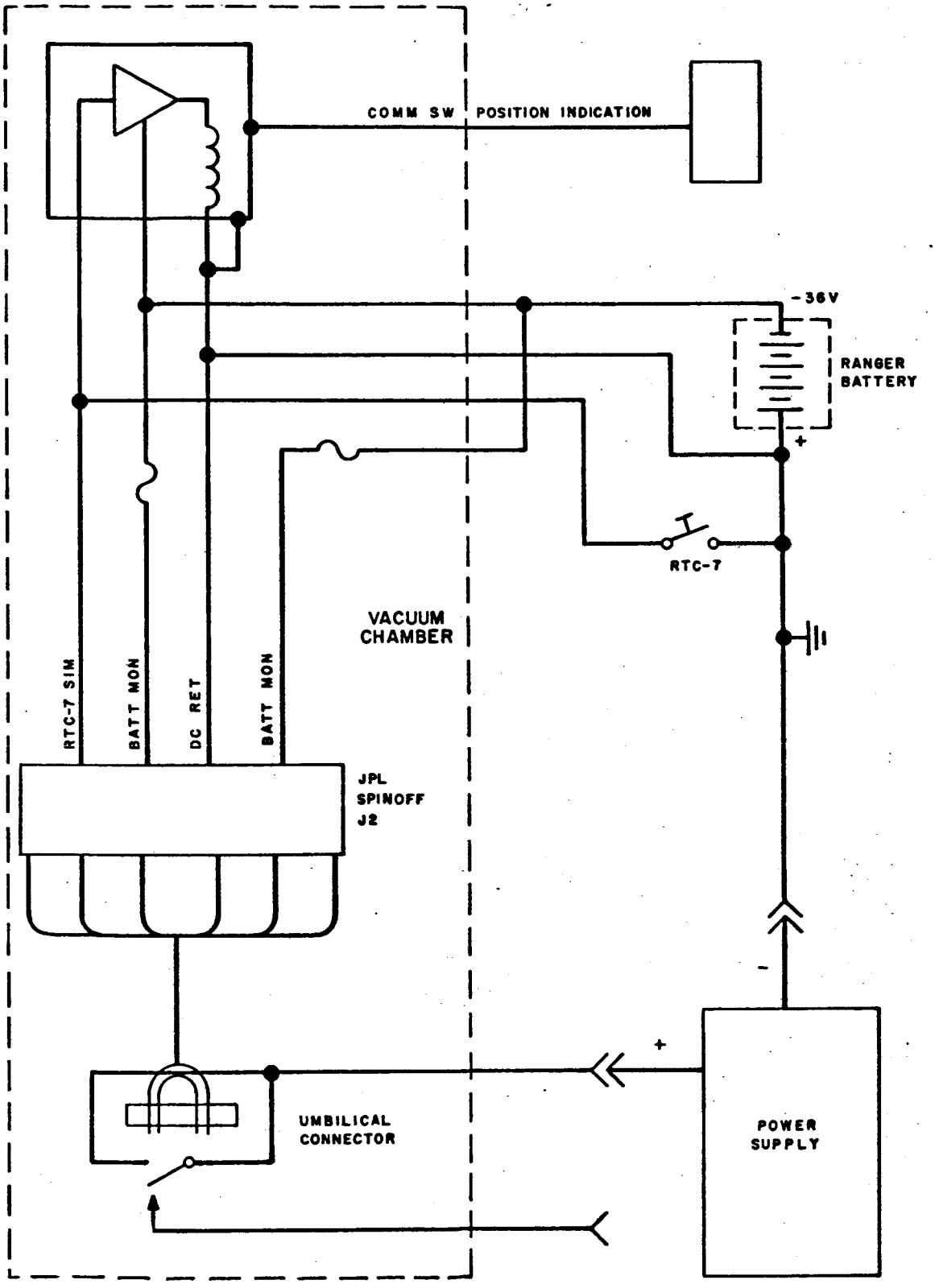

Figure J-3. Vacuum test configuration

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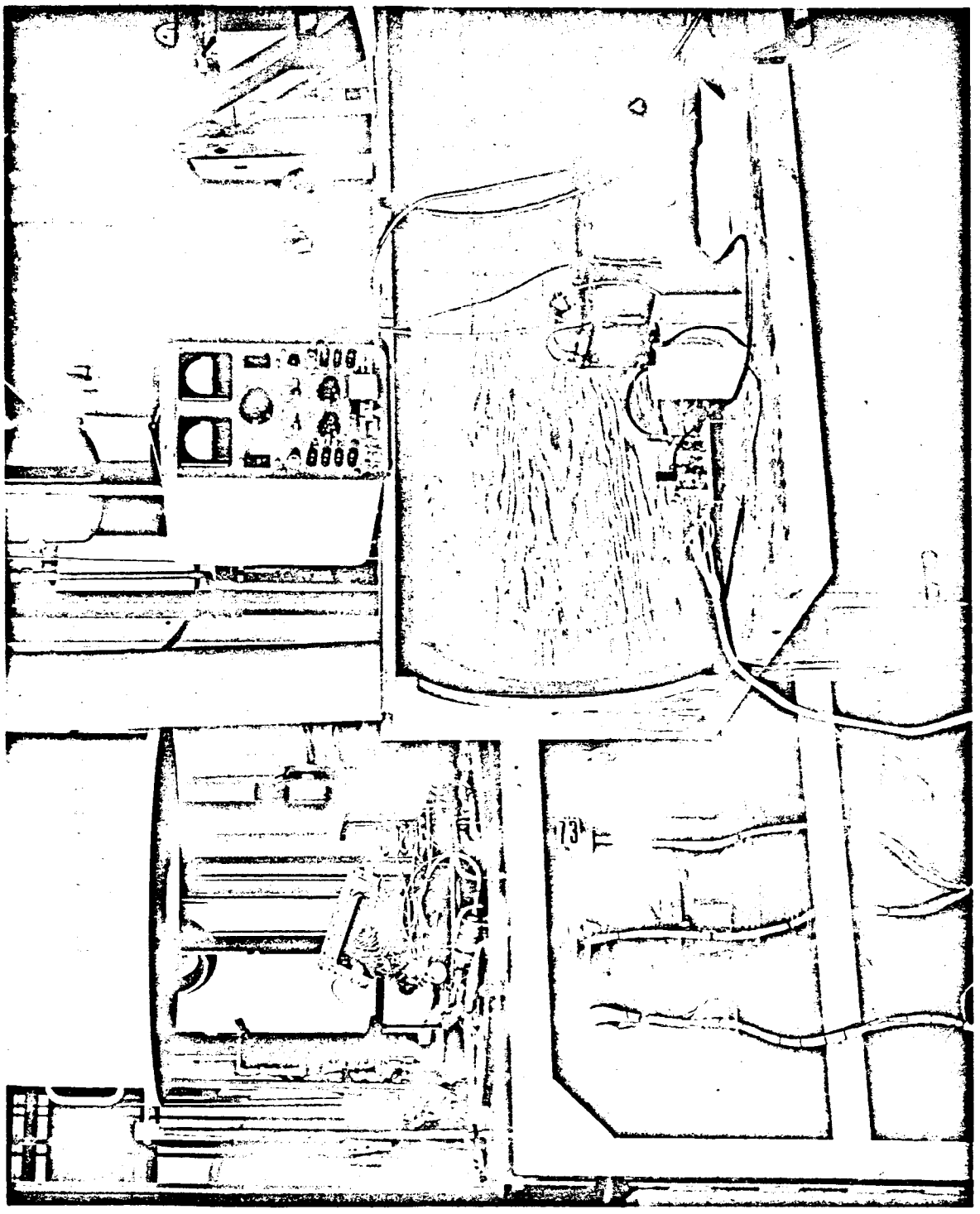

Figure J-4. Photograph of vacuum test configuration

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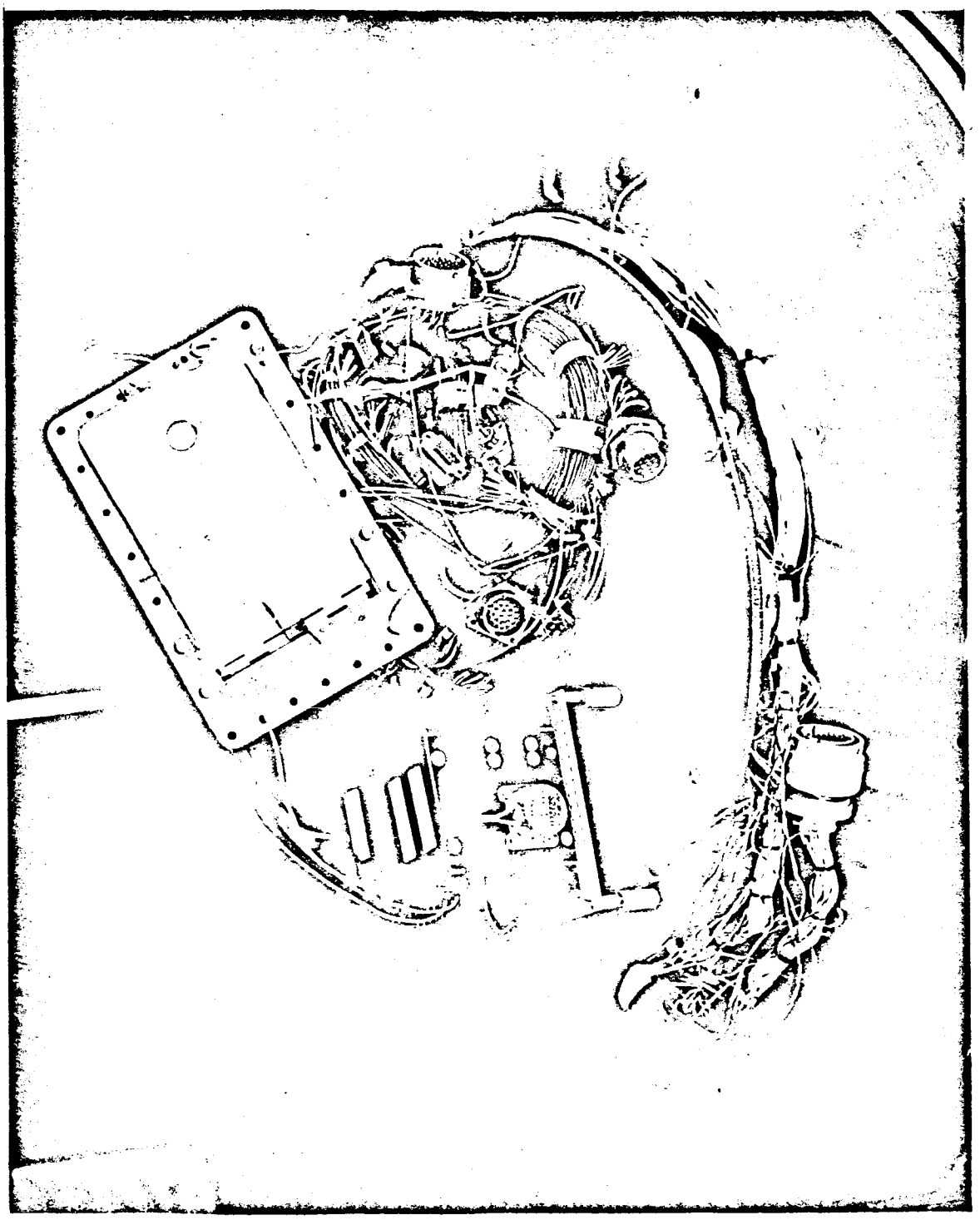

Figure J-5. Umbilical connector and Command Switch in vacuum jar

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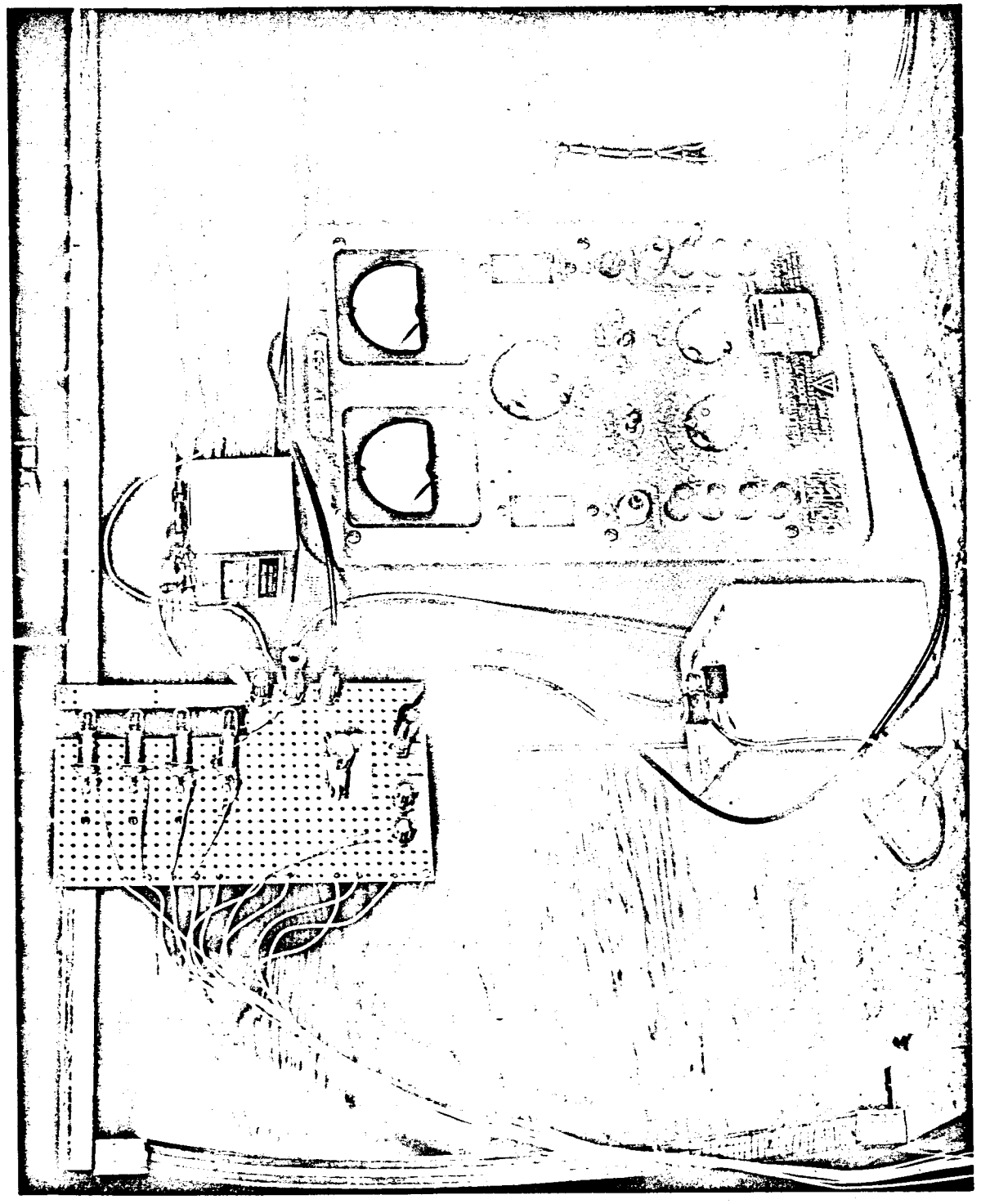

Figure J-6. Vacuum test power supply and step indicator

TABLE J-1
RESULTS OF THE FIRST TEST OF THE COMMAND SWITCH AT PARTIAL-PRESSURE CONDITIONS

Pressure (Torr)	Voltage applied to Umbilical Housing	Arcing Indications	Stepping of Command Switch
Reduced from 3×10^{-1} to 1×10^{-1}	+500V	few sporadic	None
Reduced from 1×10^{-1} to 5×10^{-2}	+500	None	None
Raised from 5×10^{-2} to 1×10^{-1} and held	+500	at first sporadic, then sustained	12 steps at irregular intervals
Reduced from 5×10^{-1} to 5×10^{-1} (rough pumping at 1×10^{-1})	+500	at first sustained, then sporadic	None
Raised from 1×10^{-1} to 5×10^{-1}	+250	None	None
Held at 5×10^{-1}	+500	Sustained	None

Another series of tests were made that were similar to those of Table J-1 except that only 350 volts was applied to the housing of the umbilical connector. These tests did result in arcing and stepping of the Command Switch. The results of these tests are included in Table J-2. A similar test was performed with 300 volts applied to the housing of the umbilical connector with no evidence of arcing.

Inspection of the equipment following these two test series revealed no new evidence of arcing other than at the door latch of the umbilical connector. The Command Switch was stepped to the ZERO position by applying the RTC-7 Simulate command.

For the third test at partial-pressure conditions, the equipment was modified so that the arcing would be produced between an isolated screw and the portion of the door of the umbilical connector near the latch. The connections of the equipment remained as shown in Figure J-8. Although arcs could be produced at pressures from 1 to 3×10^{-1} Torr, even sustained arcing did not result in the stepping of the Command Switch. However, spikes of 4-volts amplitude were observed in the RTC-7 Simulate lead.

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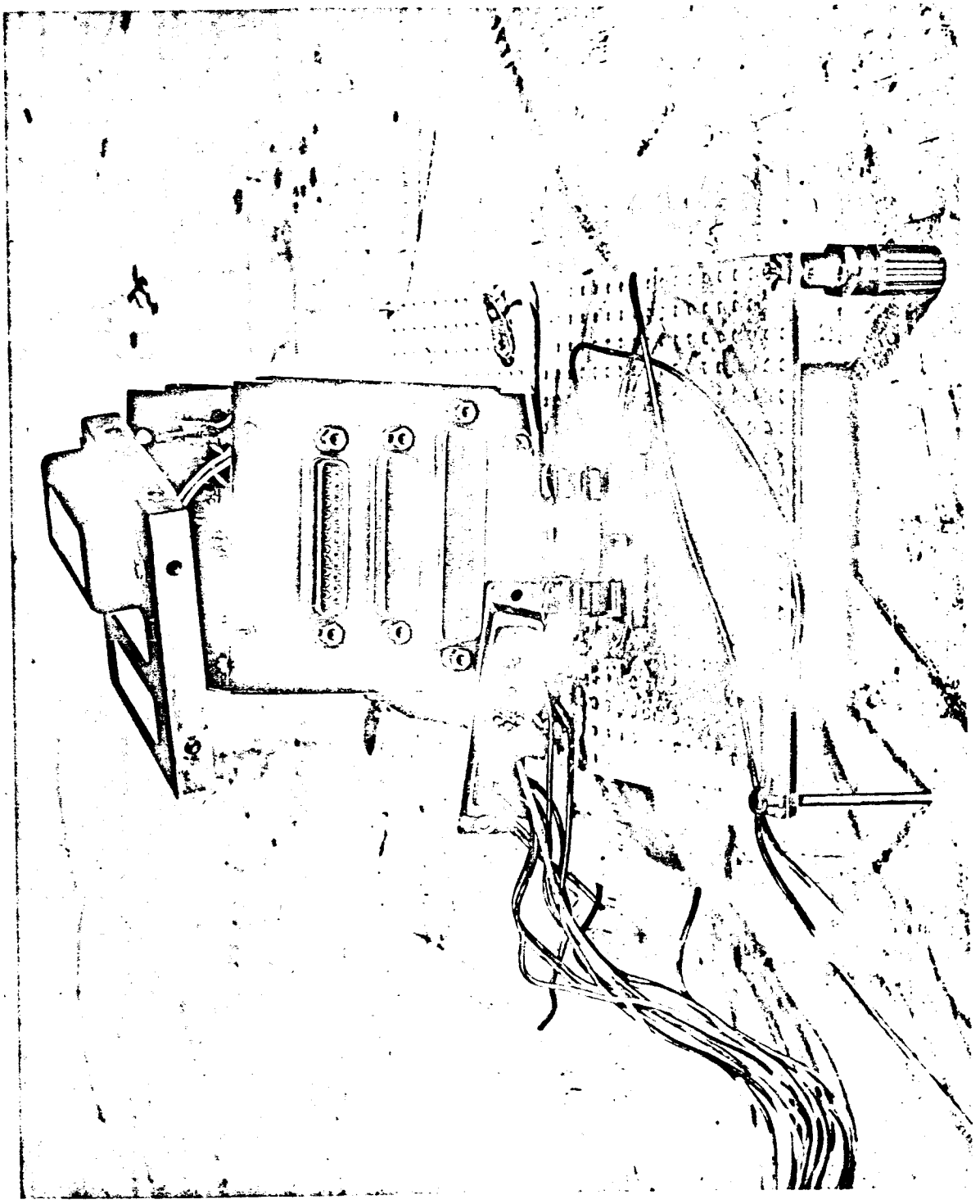

Figure J-7. Command switch destroyed during test

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TABLE J-2
RESULTS DURING THE SECOND TEST OF THE COMMAND SWITCH AT PARTIAL-PRESSURE CONDITIONS

Time (seconds)	Pressure (Torr)	Voltage applied to Umbilical Housing	Arcing Indications	Stepping of Command Switch
0	Ambient to 1	+350	Sporadic	Stepped to Warm-up
10	8×10^{-1}	+350	Sporadic	Stepped to Emergency and then to Emergency Off
20	6×10^{-1}	+350	Sporadic	Stepped to Zero
30	4×10^{-1}	+350	None	None
60	Rapidly Raised to 1	+350	Sporadic	Stepped to Warm-up

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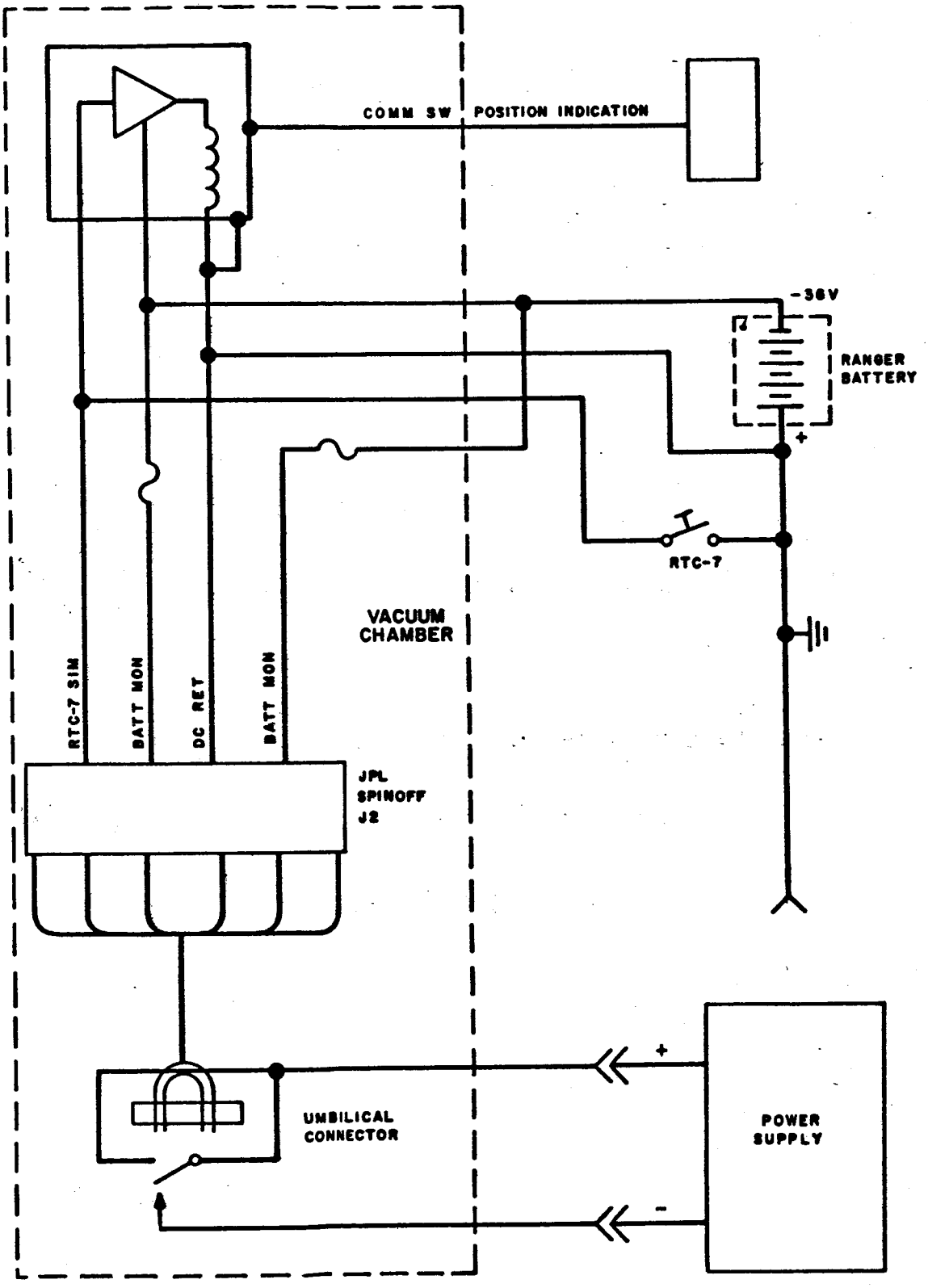

Figure J-8. Vacuum test configuration

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Appendix K

Testing of Command and Control Circuitry

A. Introduction

B. Testing of SCR Actuating and De-Sensitizing Circuits

C. Testing for False Turn-on of the SCR Circuitry

D. Testing for the 32-Hour Clock-Enable Circuitry

Appendix K

Testing of Command and Control Circuitry

A. Introduction

Individual circuits that have been proposed for use in the command and control circuitry were breadboarded in the laboratory and tested under ambient conditions to evaluate (1) their reliability in performing their normal functions and (2) their immunity against functioning in any possible abnormal mode. These tests were carried to extremes in order to establish the highest possible confidence that the command and control circuits would perform normally even under the most severely adverse conditions.

The tests that were performed are as follows:

- Tests of the functional operation and reliability of the SCR actuating and de-sensitizing circuits;
- Tests of the immunity of the SCR circuitry to any mode of false turn-on; and
- Tests of the functional operation of the 32 hour Clock enable circuitry and of the suitability of the parts applications used in this circuitry.

Satisfactory results were obtained in all three categories of testing. The tests and test results are described in detail in the paragraphs that follow.

B. Testing of SCR Actuating and De-Sensitizing Circuits

1. SCR Actuating Circuits

Empirical tests were performed on the proposed SCR-firing circuit and relay controls to demonstrate, on a functional basis, the performance of the circuits. A schematic

diagram of the circuit is shown in Figure K-1. Power was supplied by a battery having an open-circuit voltage of 39.5 volts and a voltage of 34 volts when connected to a 10-ampere load.

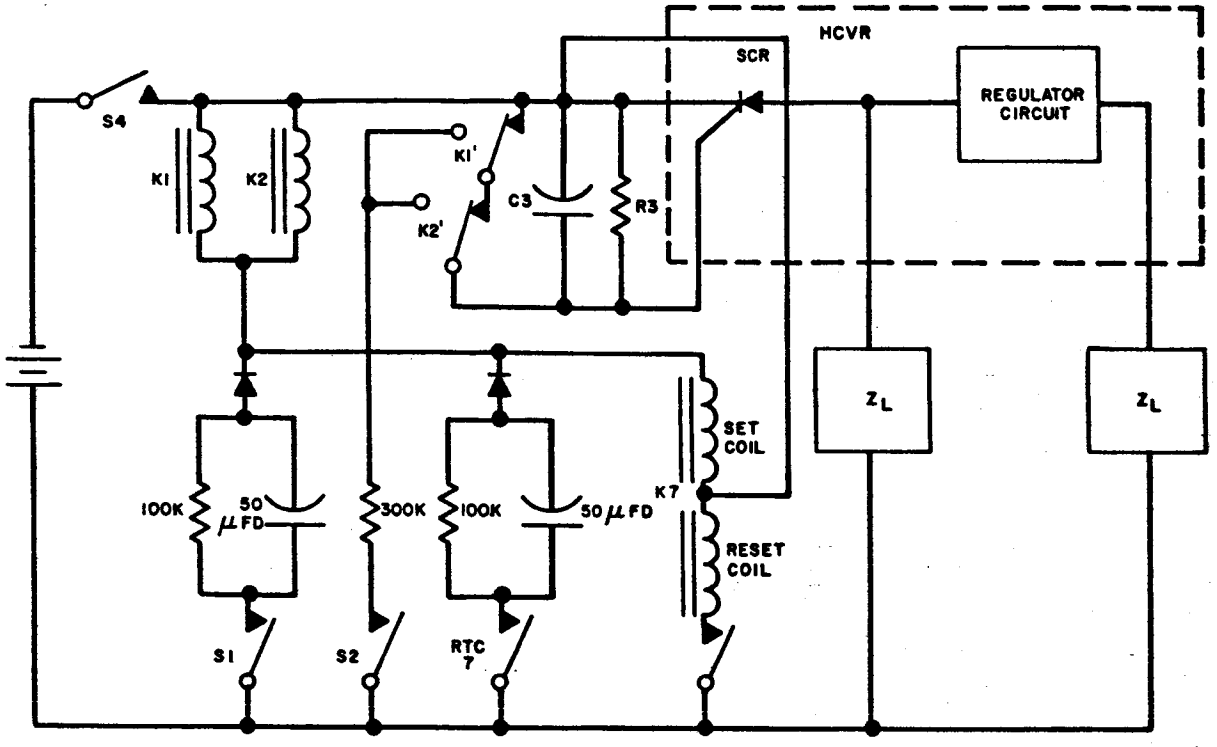

Figure K-1. SCR firing circuit and relay controls, schematic diagram

a. Test No. 1

This test was performed to measure the time delay between the closure of switch S1 and the firing of the SCR when gate current is supplied through switch S2. The delay is a function of the reaction times of relays K1 and K2 and is not affected appreciably by the very fast switching time of the SCR.

The delays observed varied from a maximum period of 3.0 milliseconds to a minimum of 2.35 milliseconds; the "on" time of the relays was 50 milliseconds.

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b. Test No. 2

This test measured the same delay as in test No. 1. Switch S1 was closed and gate voltage was applied through switch S2. The SCR was fired by closure of the RTC-7 switch. The maximum and minimum delays of firing of the SCR were the same as observed during test No. 1.

c. Test No. 3

This test was performed to attempt a turn-on of the SCR by opening and closing switch S4 with different values of capacitor C3 placed in the circuit and with the gate-shorting contacts of relays K1 and K2 open-circuited. The value of capacitor C3 was varied from 0.01 to 0.001 microfarad in steps of 0.001 microfarad. The SCR was not observed to turn on during more than 20 cycles of operation of switch S4.

These three tests were performed on the circuit before the concept of separating the coils of relays K1 and K2 had been implemented. Separation of the relay coils will approximately double the on-time of the SCR gate.

2. SCR De-sensitizing Circuitry

Three tests were performed on the circuit provided for anode-to-cathode de-sensitizing of the SCR. These tests were performed to demonstrate the functional operation of the circuitry under unfavorable conditions.

The SCR de-sensitizing circuit shown in Figure K-2 was constructed and used to perform this series of tests to determine the effect on the 1N645 diode of surge currents produced by repeated voltage applications and by short circuiting capacitors C1 and C2.

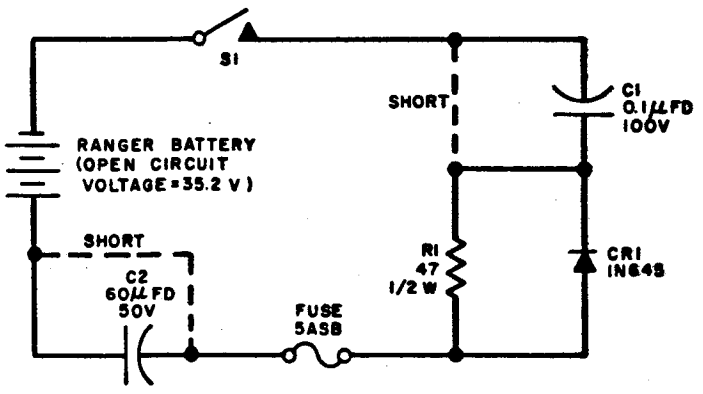

Figure K-2. Test configuration of SCR Anode-to-cathode de-sensitizing circuit

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a. Test No. 1

During this test, the battery voltage was applied fifty times to the circuit by opening and closing switch S1. Capacitors C1 and C2 were discharged between each application of voltage. The forward and reverse resistances of diode CR1 were measured before and after the test. No change in resistance was found. Figure K-3 illustrates the voltage transient which appeared across diode CR1 when S1 was closed.

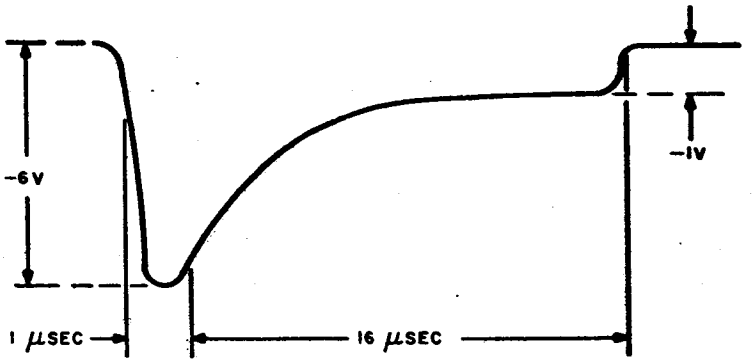

Figure K-3. Voltage transient across CR1 following voltage application to SCR de-sensitizing test circuit during test No. 1

b. Test No. 2

This test was performed to determine the effect on diode CR1 when capacitor C2 was short circuited. A short circuit was placed across capacitor C2. The battery voltage was applied twenty times to the circuit by opening and closing switch S1. Capacitor C1 was discharged between each operation. Again, the forward and reverse resistances of diode CR1 were measured. No change was noted.

c. Test No. 3

This test was performed to determine the effect on diode CR1 of short circuiting capacitor C1. The short circuit which had been placed across capacitor C2 for the preceding test was removed and placed across capacitor C1. The battery voltage was applied ten times to the circuit by opening and closing switch S1. Capacitor C2 was discharged between each operation. The forward and reverse resistances of CR1 were then measured. The forward resistance was 3 kilohms, rather than the 9 ohms

measured previously, and the reverse resistance was 8 megohms rather than infinity. These values indicated diode failure. Figure K-4 illustrates the voltage transient which appeared across diode CR1 when voltage was applied.

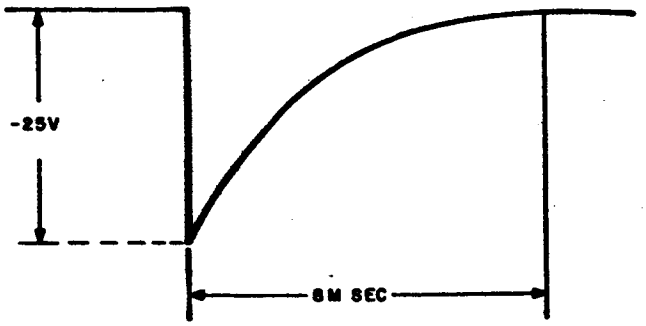

Figure K-4. Voltage transient across CR1 following voltage application to SCR de-sensitizing test circuit during test No. 3

C. Testing for False Turn-on of the SCR Circuitry

Exhaustive testing was performed on the SCR test circuitry with the intent of discovering any possible mode of falso turn-on.

1. Test No. 1

An audio noise voltage was applied across the SCR from anode to cathode to attempt a turn-on by noise. An audio generator was coupled across the type C60A SCR from anode to cathode using a 22-microfarad capacitor. The frequency of the audio generator was varied and the a-c voltage across the SCR was monitored with an oscilloscope. Because of the a-c voltage drop across the capacitor, it was difficult to maintain a constant voltage across the SCR. The test was also performed with a 100-microfarad capacitor used as the coupling capacitor. The SCR was not observed to fire during the noise voltage applications at the amplitudes and frequences shown in Table K-1.

TABLE K-1 GENERATOR OUTPUT VOLTAGE AND FREQUENCY FOR TEST NO. 1		
Peak-to-Peak Voltage	Frequency (cps)	Coupling Capacitor (mfd)
1	600,000	22
1.05	1	100
4	600,000	100

2. *Test No. 2*

This test was conducted to investigate the gate-to-anode capacitance required for turn-on during a rapid application of voltage to the SCR cathode. Figure K-5 illustrates the circuit used during the test. The values of C1 and C2, the gate-to-anode and gate-to-cathode capacitances, respectively, that were placed in the circuit for the nine steps of the test, and the results of each step of the test, are given in Table K-2. Switch S1 was opened and closed rapidly to apply voltage to the cathode of the SCR.

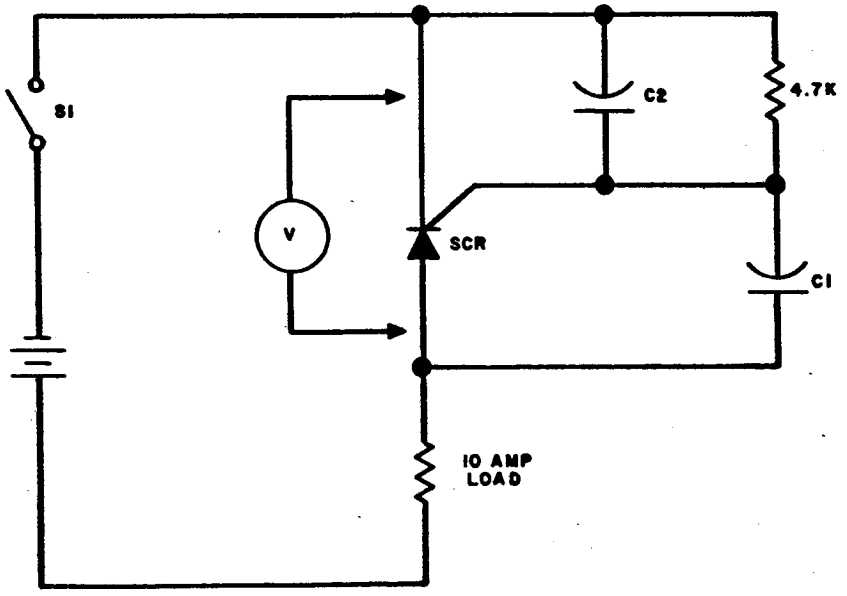

Figure K-5. Test circuit for test No. 2

TABLE K-2 RESULTS OF TEST NO. 2			
Step	Capacitance (mfd)		Test Result
	C1	C2	
1	0.002	none	SCR fired when S1 closed
2	0.002	0.01	SCR did not fire
3	0.003	0.01	SCR fired occasionally
4	0.002	0.22	SCR did not fire
5	0.003	0.22	SCR did not fire
6	0.004	0.22	SCR did not fire
7	0.005	0.22	SCR did not fire
8	0.02	0.22	SCR did not fire
9	0.03	0.22	SCR did not fire

3. *Test No. 3*

The circuit illustrated in Figure K-6 was constructed to produce a capacitive discharge into a ground plane. The circuit was utilized during the four parts of this test to attempt a simulated noise turn-on of the SCR by discharging capacitors into the 12- by 24-inch steel plate connected to the return side of the circuit.

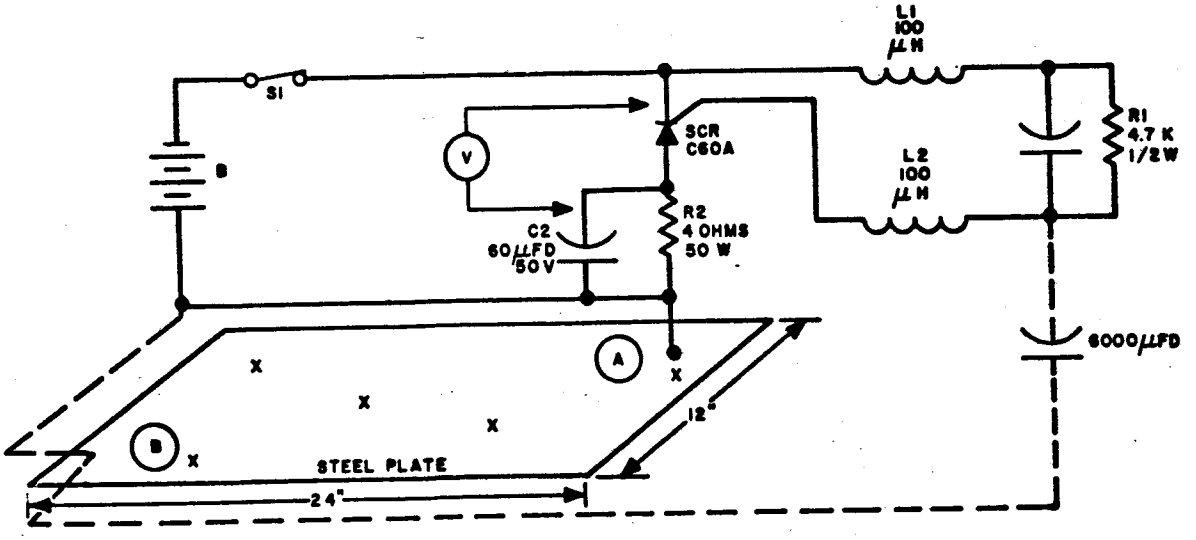

Figure K-6. Test circuit for test No. 3

a. Part a

This part of the test was performed by charging a capacitor to battery potential and then discharging it at various points on the steel plate. The test circuit included only the solid lines shown in Figure K-6. Capacitors of three different values, 0.1-, 10-, and 60-microfarads, were discharged on the steel plate at the points indicated by X's in Figure K-6. The SCR did not fire during this part of the test.

b. Part b

This part of the test was performed in the same manner as part a, except that the positive lead of the battery was moved from point A to point B on the steel plate, as indicated by the dashed line. The test results were the same as in part a.

c. Part c

This part of the test was performed in the same manner as part b except that a 6000-micromicrofarad capacitor was placed between the junction of choke L2 and resistor R1 and point B on the steel plate. The test results were the same as in the preceding two parts.

d. Part d

Choke L2 was laid on the metal plate; a 90-microfarad capacitor charged to 90 volts was then discharged near the choke. The SCR fired.

Following test No. 3, the SCR was replaced by another type C60A unit. This unit was found to be extremely sensitive and more rigorous tests were performed on it in an attempt to find a de-sensitizing method which would minimize the possibility of turn-on by spurious signals.

The circuit shown in Figure K-7, was constructed using a type C60A SCR. Relay K and the wiring were placed on the metal plate. When the distance "X" was 6 inches and a 90-microfarad capacitor charged to 90 volts was discharged between points a and b and c and d, the SCR turned on.

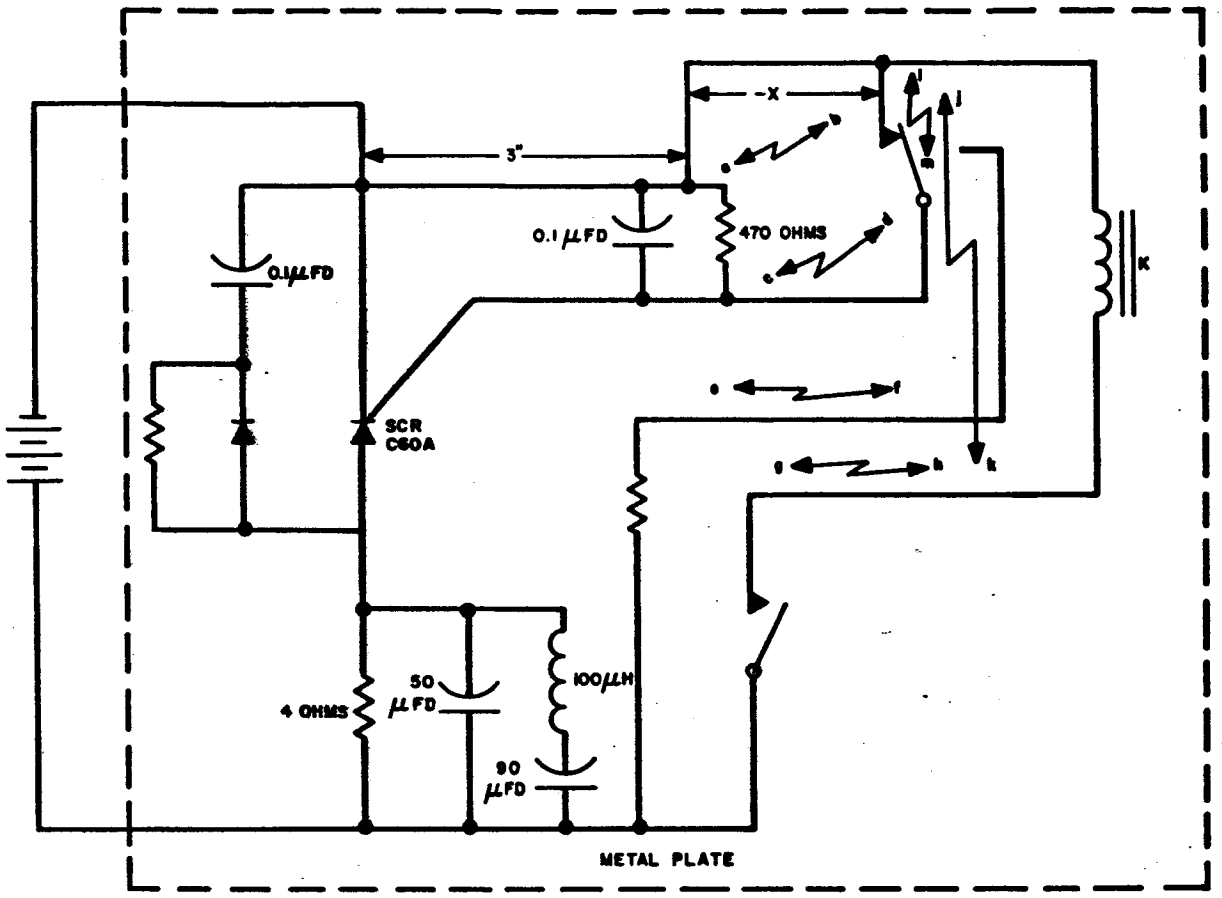

Figure K-7. Test circuit used in test No. 3

4. *Test No. 4*

In the circuit of Figure K-7, the type C60A SCR was replaced with a type C60DX308 SCR. The tests summarized in Table K-3 were performed with the results shown in the table.

The relay shown in Figure K-7 was then replaced, in turn, with loops of wire of three different diameters. Discharges were introduced on the ground plane near the wire loop with the results shown in Table K-3.

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TABLE K-3
SUMMARY OF TEST NO. 4

Distance "X" (inches)	Capacitor Value (mfd)	Capacitor Charge (volts)	Discharge Path From	Discharge Path To	Condition of SCR After Discharge of Capacitor
8	90	90	a	b	Off
			c	d	On
			e	f	Off
			g	h	Off
			j	k	Off
			l	m	Off
6	90	90	a	b	On, however this occurred only once and could not be repeated.
			c	d	Off
			e	f	On only once; could not be repeated.
			g	h	Off
			j	k	Off
			l	m	Off
					In addition, the SCR was turned on for 1 minute at 8 amperes to heat the junction. Then each discharge was repeated 3 times with no turn-ons. Then discharge path a-to-b was spread away from path c-to-d by 3 inches and the discharge was introduced between c and d. The SCR turned on.

TABLE K-3
SUMMARY OF TEST NO. 4 (Continued)

Distance "X" (inches)	Capacitor Value (mfd)	Capacitor Charge (volts)	Discharge Path From	Discharge Path To	Condition of SCR After Discharge of Capacitor
3	90	90	a	b	Off
			c	d	Off
			e	f	Off
			g	h	Off
			j	k	Off
			l	m	Off
					In addition, the SCR was turned on for 1 minute at 8 amperes. Then 20 discharges were introduced in the vicinity of the wires. No turn-ons occurred.
9.5 (loop diameter)	90	90	a	b	On
			c	d	On
19.0 (loop diameter)	90	90	a	b	On
			c	d	On
14.0 (loop diameter)	90	90	a	b	On
			c	d	On

The following additional arcs were caused to occur, with no turn-on's noted:

- Arc on anode heat sink;
- Arc on case of relay; and
- Discharge of 120 microfarad capacitor charged to 150 volts across each pair of points.

The 9.5-inch loop was then inserted in the circuit and 4 amperes were passed through the ground plane near the loop; the SCR did not turn on. Twelve amperes were passed through the ground plane near the loop; the SCR did not turn on.

The 9.5-inch loop was twisted together so that the wires were in close proximity to one another. Arcing into a wire that was twisted together with the loop wires did not cause the SCR to turn on.

5. Test No. 5

The SCR was connected as shown in Figure K-8.

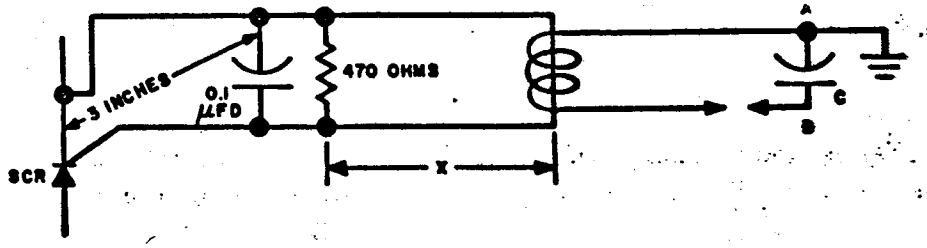

Figure K-8. Test circuit used in investigation of high-energy coupling into the SCR circuit

The following steps were performed to determine the effects of coupling high energy into the gate-to-cathode circuit of the SCR:

- With the distance "X" in Figure K-8 adjusted to 3 inches, and with 4 turns in the loop, a 90-microfarad capacitor, charged to 90 volts, was discharged into the loop. When point A was negative, there was a turn-on. When point A was positive, no turn-on resulted;
- With 2 turns of wire in the loop and with point A negative, the same discharge caused the SCR to turn on intermittently; and
- With 4 turns of wire in the loop and with 10 amperes of current flowing through the 4 turns, the SCR did not turn on.

The last series of tests indicated that when the SCR did turn on it was because of capacitive coupling. If the turn-on's that occurred in the preceding steps were the result of transformer action, then the turn-on's would occur when point A was positive

and point B was negative. (The polarity reversal across the transformer would make the gate positive with respect to the cathode.) However, this was not the case. When point A was negative and point B was positive, the SCR turned on. The way in which capacitive coupling could theoretically cause turn-on is illustrated in Figure K-9.

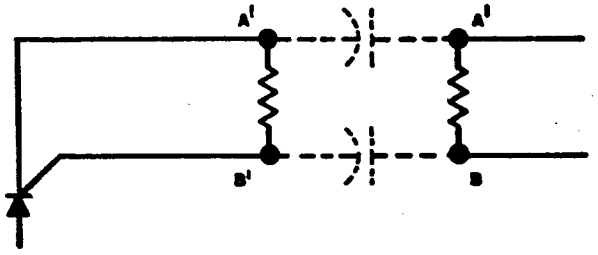

Figure K-9. Hypothetical circuit showing how capacitive coupling could cause SCR turn-on

In order to test the above theory, the 3-inch wires between the SCR and the R-C network were twisted together as shown in Figure K-10. The length of wire "X" was also twisted.

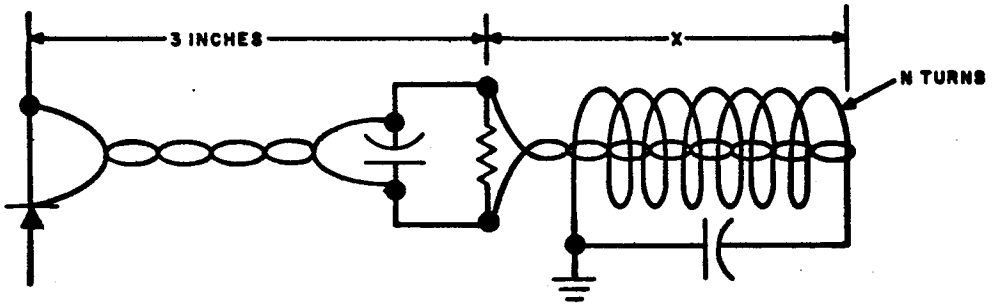

Figure K-10. Test circuit with twisted gate-to-cathode wires

The following steps were performed:

- With 7 turns of wire in the loop and using a 90-microfarad capacitor charged to 90 volts, an arc of either polarity would not turn the SCR on;
- With an "X" distance of 6 inches, with 14 turns of wire, and using a 15-microfarad capacitor charged to 500 volts, the discharge energy was equal to $1/2\ CV^2$ or 1.75×10^6 joules. An arc of either polarity would not turn the SCR on;

- The SCR was turned on for 1 minute at 8 amps to heat the junction. The two steps described above were then repeated with no turn-on; and

- A 15-microfarad capacitor charged to 500 volts was discharged near the cathode of the SCR. No turn-on resulted.

It was concluded from the above steps that the leads must be kept short and must be twisted to prevent turn-on when a high-energy discharge is coupled into the gate-to-cathode leads.

6. *Test No. 6*

Next, the prototype control module was connected to the breadboard circuit as shown in Figure K-11. (The wires between the relays and between relay K2 and the module were too short to twist.)

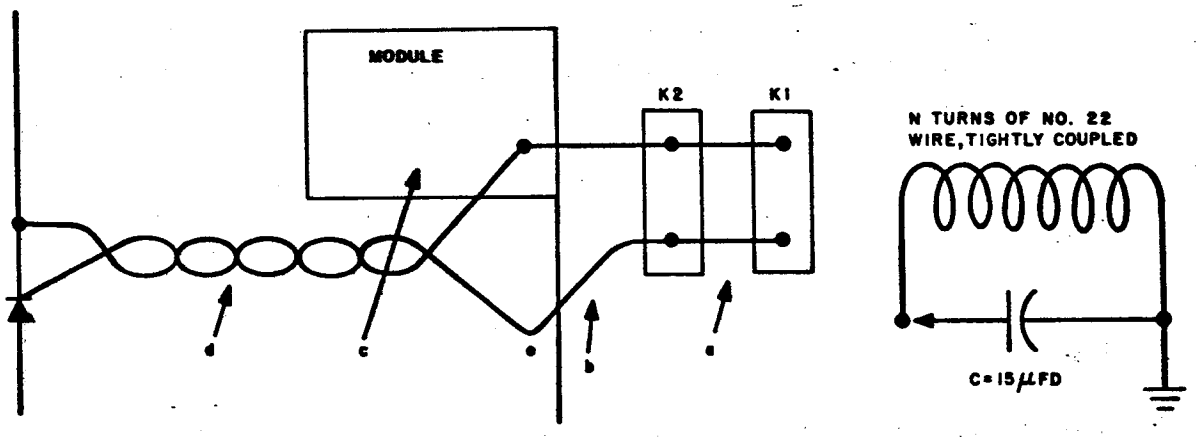

Figure K-11. Test circuit with SCR connected to the Prototype Control Module

The following steps were performed:

- With 2 turns of wire around point "a" and 2 turns around point "b", capacitor C was charged to 150 volts and discharged through the loop. The SCR did not turn on. However, when capacitor C was charged to 200 volts and discharged through the loop, the SCR did turn on.

- With 2 turns around point "a", capacitor C was charged to 500 volts and discharged through the loop. The SCR did not turn on.

- With 2 turns around point "b", capacitor C was charged to 250 volts and discharged through the loop. The SCR did not turn on. However, when capacitor C was charged to 300 volts, the discharge did turn on the SCR.

- With 4 turns around point "c" and with capacitor C charged to 200 volts, the discharge did not turn on the SCR. However, when capacitor C was charged to 250 volts, the discharge did turn on the SCR.

- With 4 turns around point "d" and capacitor C charged to 500 volts, discharges of either polarity did not turn on the SCR.

Points "a", "b", and "c" in Figure K-11 were enclosed in a metal box and the following steps were performed:

- A 15-microfarad capacitor was charged to 500 volts and discharged across the surface of the box in many places (side-to-side, etc.). The SCR did not turn on.

- Four turns of wire were placed at point "d" of the circuit in Figure K-11. A 15-microfarad capacitor, charged to 500 volts, was discharged several times, but the SCR would not turn on.

- Finally, twenty turns of wire were wrapped around the metal box. The SCR could not be turned on either by capacitive discharge or by high-current flow through the wire.

7. *Test No. 7*

This test was performed to determine the effect of a-c coupling through the contacts of relay K2. An external signal generator was connected to the circuit as shown in Figure K-12. The a-c coupling was measured at the SCR gate with an oscilloscope. The signal generator frequency was varied from 9 cps to 10 Mc. The SCR did not turn on. Table K-4 lists the a-c voltages on the SCR gate at the different frequencies.

A 15-microfarad capacitor, charged to 500 volts, was discharged into point "a" in Figure K-12. No turn-on occurred.

8. *Test No. 8*

The circuit shown in Figure K-13 was constructed and used to perform a series of steps in which a turn-on of the SCR was attempted by simulating voltage transients in the SCR circuitry.

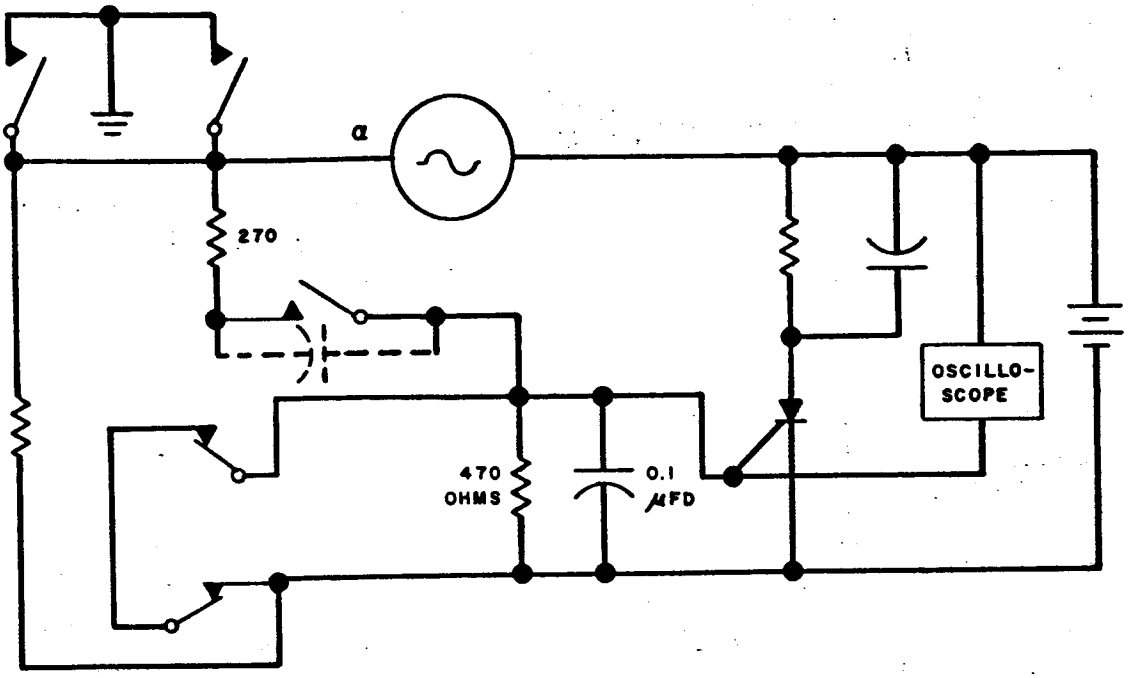

Figure K-12. Circuit for testing the effect of false coupling of relay control noise to the SCR gate

TABLE K-4
SCR GATE VOLTAGES AT DIFFERENT GENERATOR FREQUENCIES

Frequency of Signal Generator	Input Voltage (peak-to-peak)	SCR Voltage (peak-to-peak)
9 to 500,000 cps	30	0
1 Mc	24	0.03
2 Mc	18	0.1
5 Mc	9	0.23
8 Mc	6	0.25
10 Mc	4	0.33

a. Part a

This test was performed to determine the effect on the SCR when switch S1 was opened and closed rapidly to simulate relay-contact bounce. Following several operations of switch S1, the SCR had not turned on. After removing capacitor C1 from the circuit, this was repeated. The SCR did not turn on. Resistor R1 was removed and the test was repeated. The SCR still did not turn on.

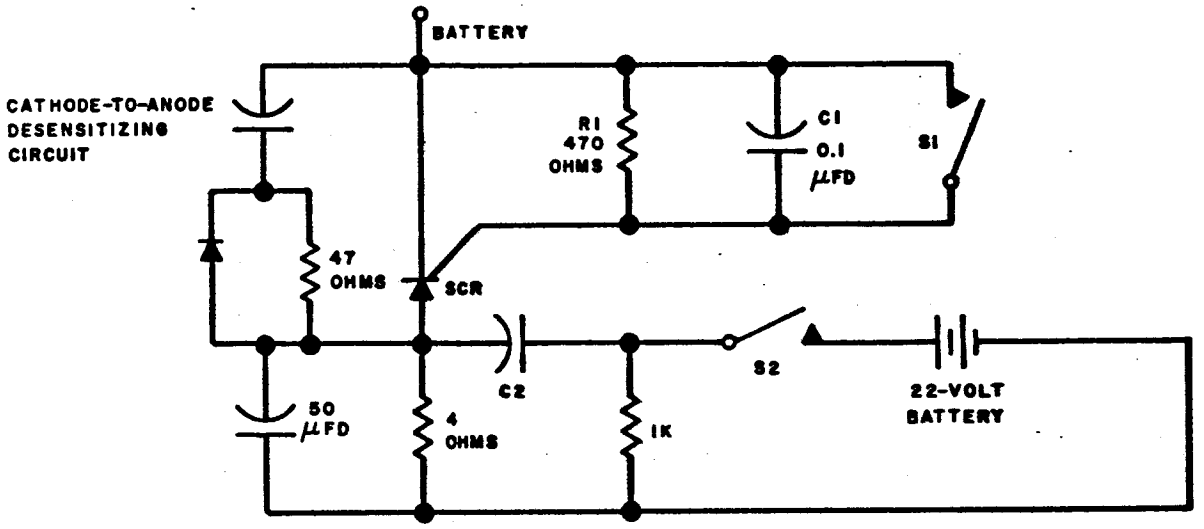

Figure K-13. Test circuit for simulating voltage transients in the SCR circuit

b. Part b

This step was performed to determine the effect of voltage transients in the anode circuit of the SCR. The step was accomplished by coupling a 22-volt battery through capacitor C2 by means of switch S2. Switch S2 was opened and closed several times, but the SCR failed to turn on. Resistor R1 and capacitor C1 were put back in the circuit. Switch S1 was left open and the test was repeated. The SCR again did not turn on. With switch S1 closed, another test was performed with the same result.

c. Part c

The cathode-to-anode desensitizing circuit was connected and steps a and b above were repeated. The SCR remained off during all tests.

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9. Test No. 9

This test was performed in an attempt to turn on the SCR by electromagnetic or electrostatic coupling. The test was performed using the circuit shown in Figure K-14. Fifty turns of No. 18 wire were wrapped around the twisted wires connected between the gate and cathode of the SCR.

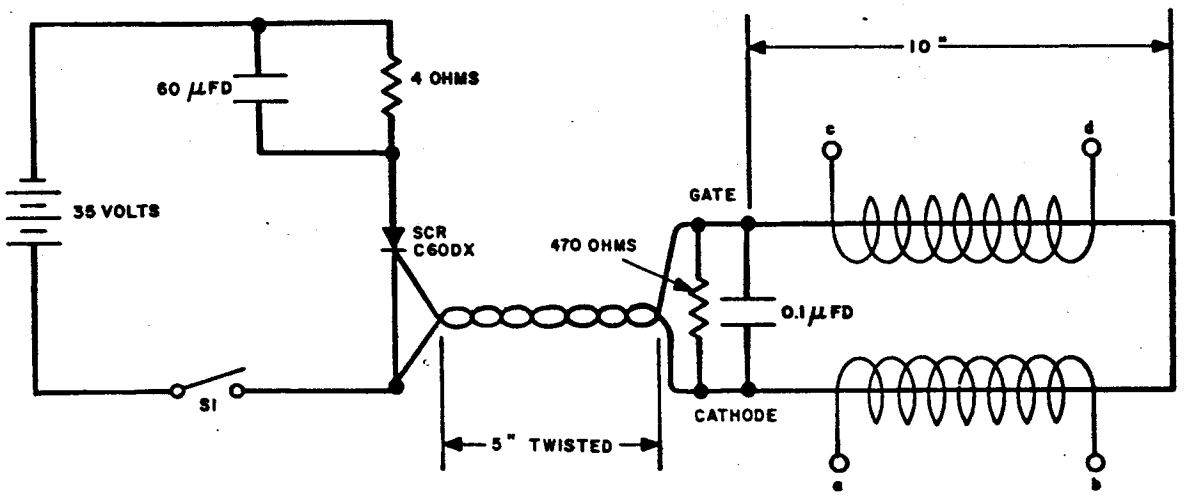

Figure K-14. Test circuit for test No. 9

A current of six amperes at 90 volts d-c was made to flow through the coil between points a and b. Regardless of the polarity of the applied voltage, the SCR did not turn on. Next, a 90-microfarad capacitor, charged to 90 volts, was discharged through the coil between points a and b. The SCR did not turn on, regardless of the direction of the discharge. A source of 45 volts d-c at 15 amperes was then connected between points a and b. The SCR did not turn on, regardless of the polarity of the potential applied between points a and b.

The circuit shown in Figure K-14 was tested with 50 turns of No. 18 wire wrapped around the cathode side (points a and b) of the short circuit across the SCR desensitizing circuit. When a source of 90 volts at 6 amperes was connected between points a and b, the SCR did not turn on, regardless of the polarity of the connections. Discharging a 90-microfarad capacitor, charged to 90 volts, across points a and b caused the SCR to turn on when the polarity was such that the negative side of the capacitor was connected to point a and the positive side was connected to point b. However, using the same capacitor charged to 90 volts, but with the polarity reversed, the SCR would not turn on.

A source of 45 volts d-c at 15 amperes was connected between points a and b. The SCR did not turn on, regardless of the polarity of the connections.

Next, a source of 90 volts at 6 amperes was connected to a 50-turn coil of No. 18 wire wrapped around the gate side of the short circuit (between points c and d in Figure K-14). The SCR did not turn on, regardless of the polarity of the connections.

The discharge of a 90-microfarad capacitor, charged to 90 volts, between points c and d caused the SCR to turn on when the polarity of the discharge was such that the negative side of the capacitor was connected to point c. When the polarity was reversed, the same test did not turn on the SCR.

When a 45-volt source at 15 amperes was connected between points c and d, the SCR did not turn on, regardless of the polarity of the connections.

The steps in test No. 9, described above, demonstrated that the coupling by which the SCR would be turned on was capacitive, establishing a high degree of confidence that if the SCR circuit were enclosed in a metal box, it would not turn on except in response to a genuine turn-on signal.

10. *Test No. 10*

The circuit shown in Figure K-15 was constructed to test the immunity of the SCR to noise generated at the gate and cathode of the SCR.

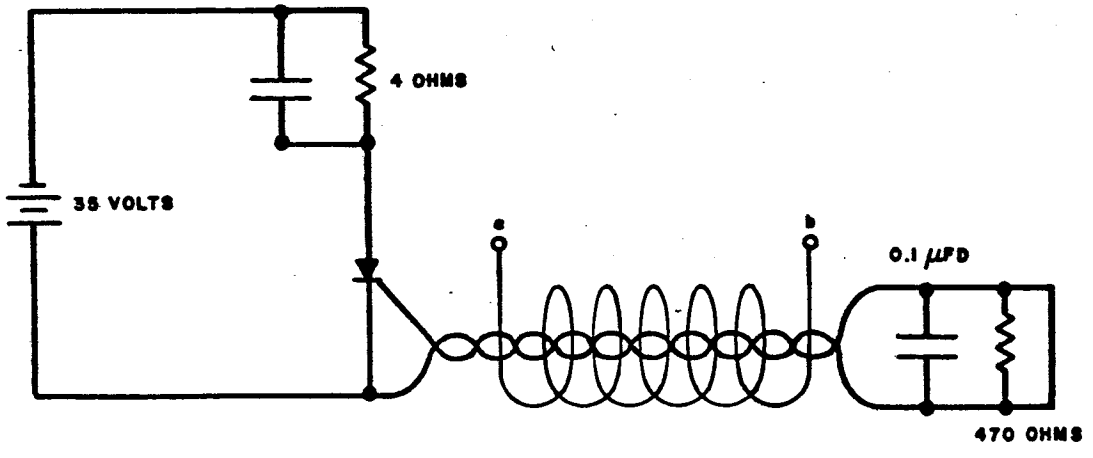

Figure K-15. Circuit for testing noise immunity of the gate and cathode of the SCR

Fifty turns of No. 18 wire were wrapped around the twisted gate and cathode leads. The following steps were performed:

- A source of 90 volts d-c at 6 amperes was connected between points a and b. The SCR did not turn on regardless of the polarity of the connections.
- A 90-microfarad capacitor charged to 90 volts was discharged between points a and b. Regardless of the polarity of the discharge, the SCR did not turn on.
- A source of 45 volts d-c at 15 amperes was connected between points a and b. The SCR did not turn on, regardless of the polarity of the connections.

11. Test No. 11

The SCR circuit was connected in a simulated RA-6 configuration and also in the proposed command and control system configuration and tested for immunity to turn-on by spurious signals. The test circuit for testing of the RA-6 configuration is shown in Figure K-16. A 10-foot length of wire was connected between the SCR and the desensitizing network and was placed on a steel plate to simulate the configuration of the RA-6 command system.

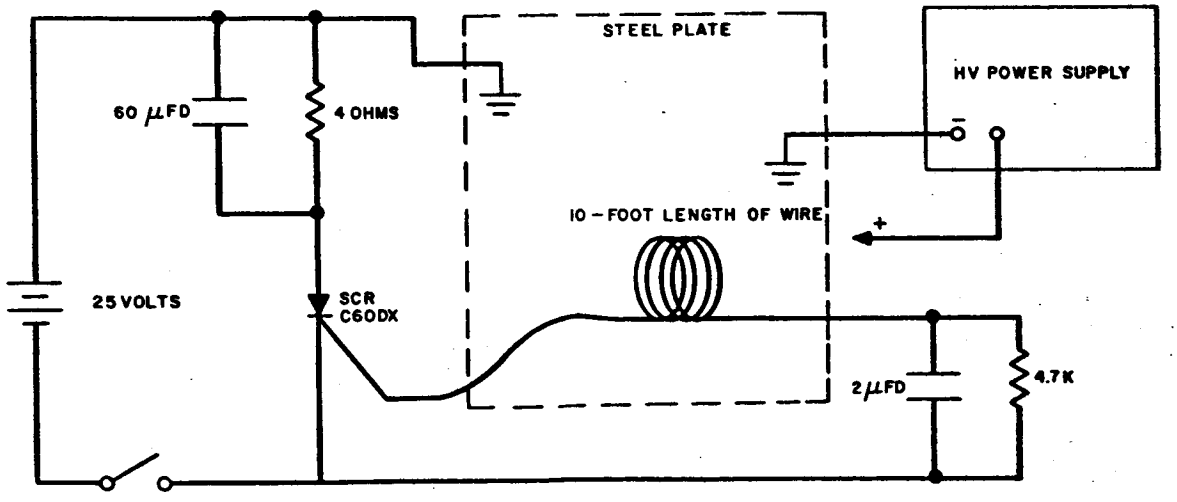

Figure K-16. Simulated RA-6 command circuit configuration

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The following steps were performed:

- Twenty kilovolts at 5 milliamperes was discharged into the steel plate near the 10-foot length of wire. The SCR did not turn on.
- A 90-microfarad capacitor charged to 90 volts was discharged near the loop of wire. The SCR turned on.

The desensitizing network was then installed in a metal box as shown in Figure K-17. While the network was being placed in the box, the SCR gate lead was inadvertantly grounded and the SCR was destroyed by excessive gate current. The SCR was replaced with a unit of identical type and the test was continued. The high-voltage power supply was grounded to the metal plate.

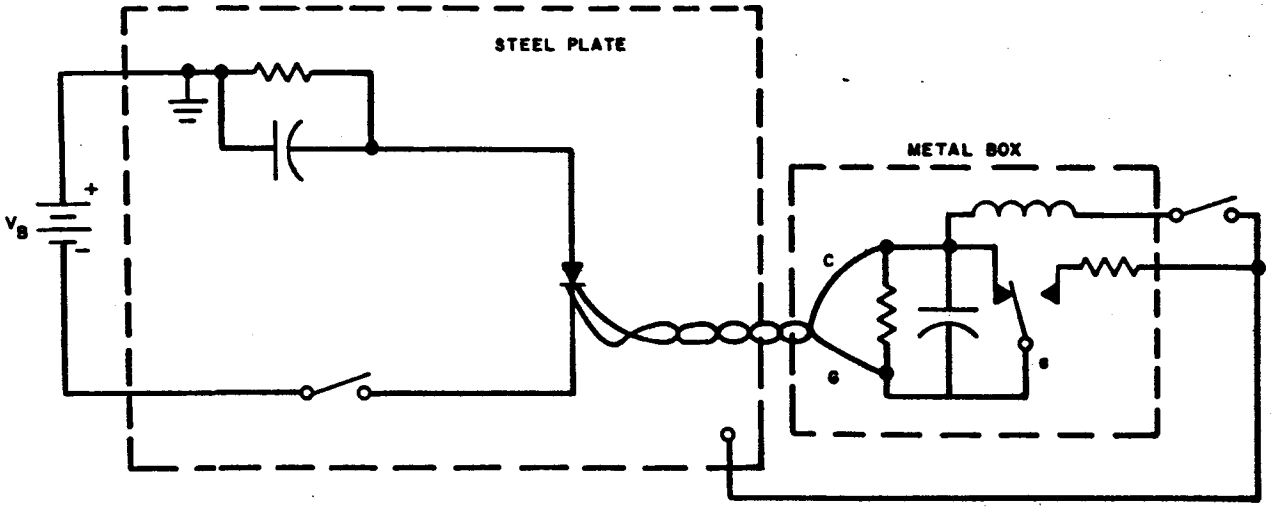

Figure K-17. Test circuit with de-sensitizing network installed in a metal box

Twenty kilovolts at 5 milliamperes was discharged into the metal box several times. The box was then opened and it was found that the connection to the relay armature (point a in Figure K-17) was burned so that it no longer touched the armature terminal. This was apparently the result of arcing between the metal box and the armature. The 20-kilovolt discharge into the ungrounded metal box had followed the shortest electrical path to ground on the steel plate, passing through the SCR gate lead and causing the SCR to turn on. The specified breakdown potential of the relay is 1400 volts.

The SCR was found to be unharmed after this test. If the armature terminal had been burned off by battery current, the SCR gate junction would have been destroyed. Since the gate junction was not destroyed, the armature terminal could only have been burned by the high-voltage arc.

Next, the proposed command circuit configuration was constructed, as shown in Figure K-18. The entire circuit was enclosed in a metal box.

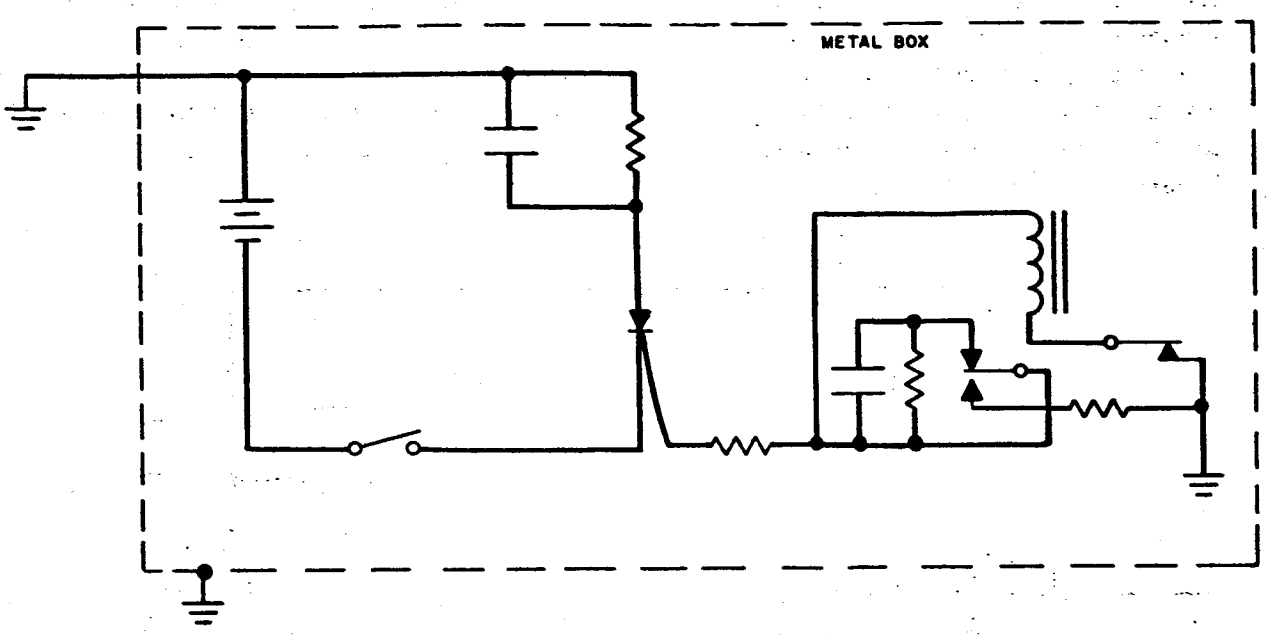

Figure K-18. Test circuit simulating the proposed command circuit configuration

Twenty kilovolts at 5 milliamperes was discharged onto the surface of the metal box. The SCR did not turn on. The arc was applied near the negative and then the positive terminal of the battery, with no adverse effect on the SCR.

A 4000-microfarad capacitor was charged to 132 volts and discharged onto the surface of the metal box, with no adverse effect on the SCR.

It is concluded from the preceding tests that, with the wiring between the SCR and the control circuitry twisted, and with the control circuitry enclosed in a metal box, it is very unlikely that the SCR will be inadvertently turned on by stray noise or by high-energy discharges. The tests verified that energies in excess of 1 million joules, discharged near the SCR and its associated circuitry, will not turn on the SCR.

D. Testing of the 32-Hour Clock-Enable Circuitry

A series of tests was performed on the 32-hour relay, K4, and the associated drive circuitry. These tests were performed to demonstrate proper functional operation and to investigate circuit applications. The following paragraphs include the descriptions and results of these tests:

1. Test No. 1

This test was performed to investigate the effect of coupling to the "set" coil of relay K4 when the "reset" coil was energized. The circuit shown in Figure K-19 was constructed. The "reset" coil was energized by closing switch S2. The voltage across the "set" coil increased to +0.7 volt for 7 milliseconds when the "reset" coil was energized. When the "reset" coil was opened, the voltage across the "set" coil decreased to -35 volts for 60 milliseconds. The observed waveform across the "set" coil is illustrated in Figure K-20.

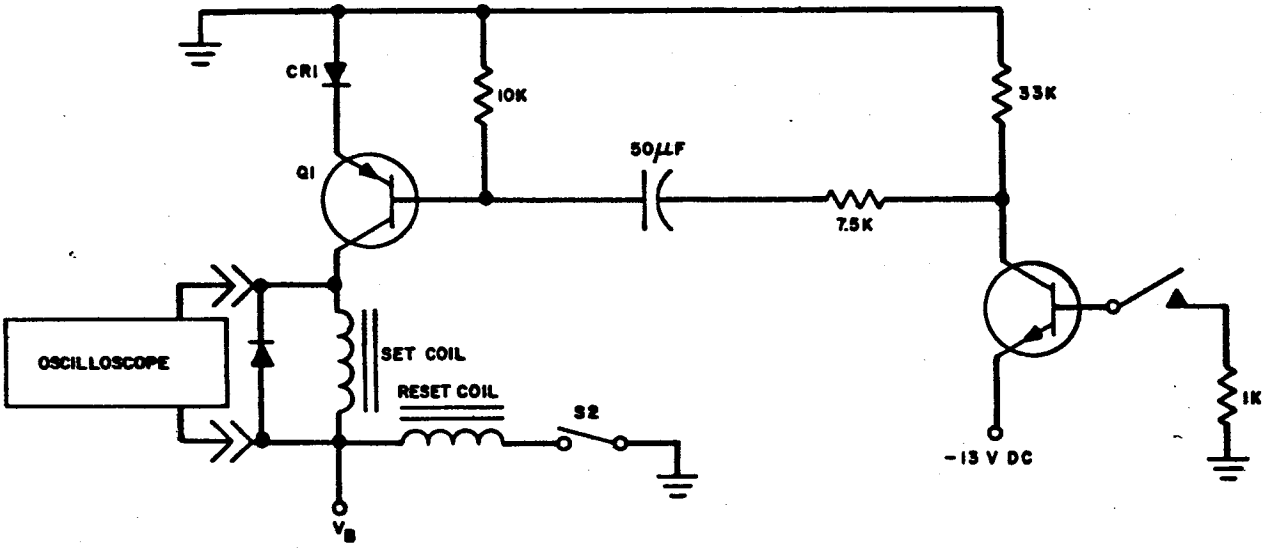

Figure K-19. Circuit for testing operation of the 32-hour clock-enable circuitry

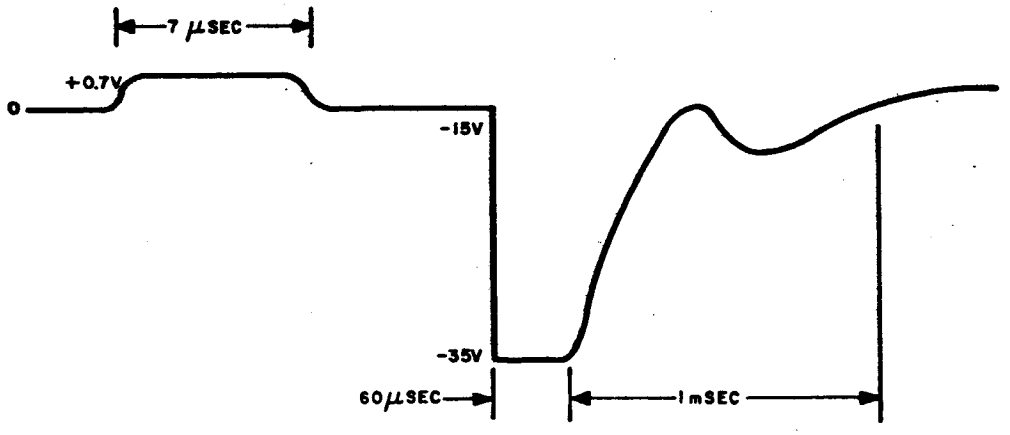

Figure K-20. Waveform appearing on oscilloscope during test No. 1

2. *Test No. 2*

This test was performed to verify that the BV_{cbo} of transistor Q1 was sufficient for its application in this circuit. The measured voltage on the base of transistor Q1 when switch S1 was closed was -1.5 volts when switch S1 was opened, the base voltage was +2.5 volts. The observed waveform at the base of transistor Q1 during switching is shown in Figure K-21.

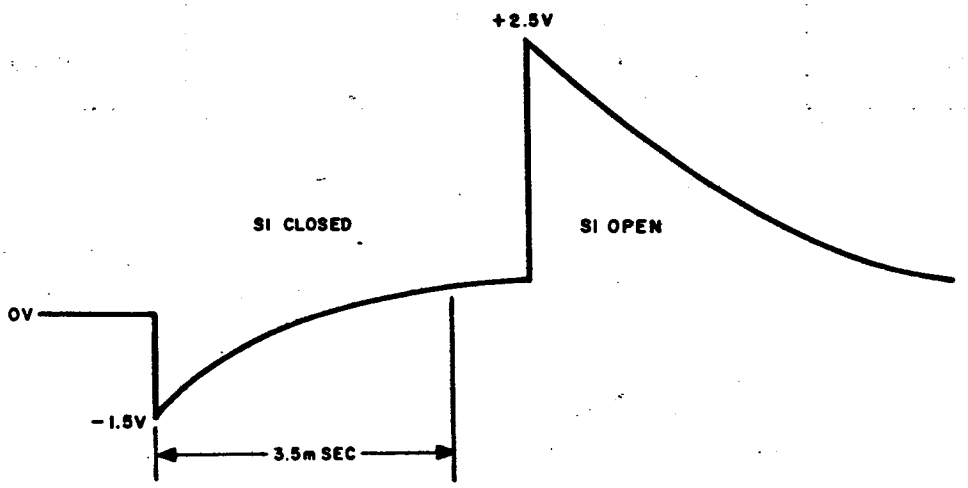

Figure K-21. Waveform at base of Q1 during switching

The maximum BV_{cbo} measured in this circuit application was 42.5 volts. The maximum specified BV_{cbo} of this transistor is 50 volts.

3. *Test No. 3*

This test was performed to determine the actual voltage drops across transistor Q1 and diode CR1 when transistor Q1 was in a cut-off condition. The circuit was placed in a thermal oven and the temperature was varied from -10°C to +65°C. The measured voltage drops across diode CR1 and transistor Q1 (V_{EB}) are listed in Table K-5.

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TABLE K-5
VOLTAGE DROPS ACROSS CR1 AND Q1(V_{EB}) AT DIFFERENT TEMPERATURES WITH Q1 CUT OFF

V_B (volts)	Temperature (°C)	CR_1 (volts)	V_{EB} (volts)
40.2	25	+0.08	-0.09
40.5	0	+0.075	-0.08
40.2	-10	+0.08	-0.08
40.5	+65	+0.08	-0.09