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FINAL REPORT ON ENVIRONMENTAL TESTING OF IONOSPHERE EXPLORER SPACECRAFT

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GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

Final Report on Environmental Testing

of Ionosphere Explorer Spacecraft

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FINAL REPORT ON ENVIRONMENTAL TESTING OF IONOSPHERE EXPLORER SPACECRAFT

INTRODUCTION

The purpose of this report is to document the significant events of the Ionosphere Explorer environmental test program. Three spacecraft were involved in the test program: the prototype spacecraft and the flight Nos. 1 and 2 spacecraft (Figures 1 and 2). A summary of spacecraft operations at the Western Test Range (WTR) is included as well as a brief post-launch evaluation of the flight No. 1 spacecraft.

The environmental test specifications for the spacecraft are contained in references 2, 3, and 4. The project mission and spacecraft description are contained in references 1, 5, and 6.

The duration of the test program (May 1962 - June 1964) resulted mainly from a major addition made in January 1963 to the original scientific objectives. At that time the environmental testing of the original spacecraft had been virtually completed. However, data from the Alouette I satellite (launched September 30, 1962) showed that the scientific value of IE-A spacecraft could be substantially enhanced by the addition of an ion probe experiment. This addition was incorporated during the period January 1963 to August 1963, after which the complete series of environmental tests had to be repeated. The illustrations in this report show the spacecraft on its final configuration, i.e., with the ion probe added in 1963.

IE-A PROTOTYPE SPACECRAFT TEST HISTORY

The IE-A prototype spacecraft arrived at GSFC May 4, 1962, for design qualification tests. Balancing was completed May 8. The total balancing weight added was 382 grams. The total weight after balancing was 88.8 lbs. The residual unbalance was 8.3 oz-in static and 119 oz-in^2 dynamic. The center-of-gravity was determined to be 16.7 inches above the base of the payload. The spin test was successfully completed May 9.

The temperature test began May 9. On May 11, while checking out the payload at -15°C, the battery charging circuit did not function properly. It was necessary to use the override switch to prevent the battery-charging circuit from turning the payload off. Also at this temperature, the 3.72- and the 4.60-Mc sounders did not function. The sounder difficulty was traced to a bad solder joint. This was repaired and the temperature test was resumed on May 16. On May 19,

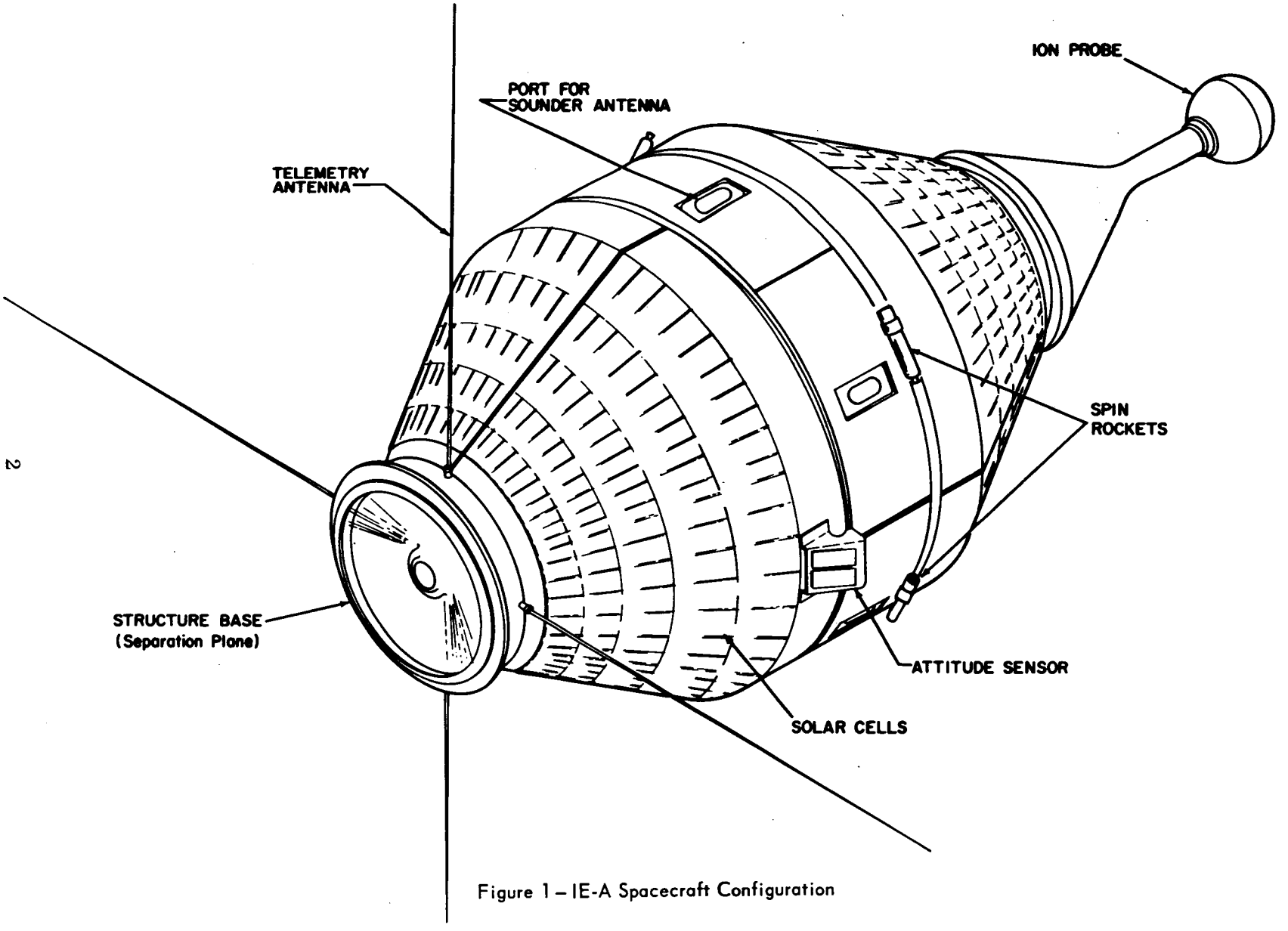

Figure 1 – IE-A Spacecraft Configuration

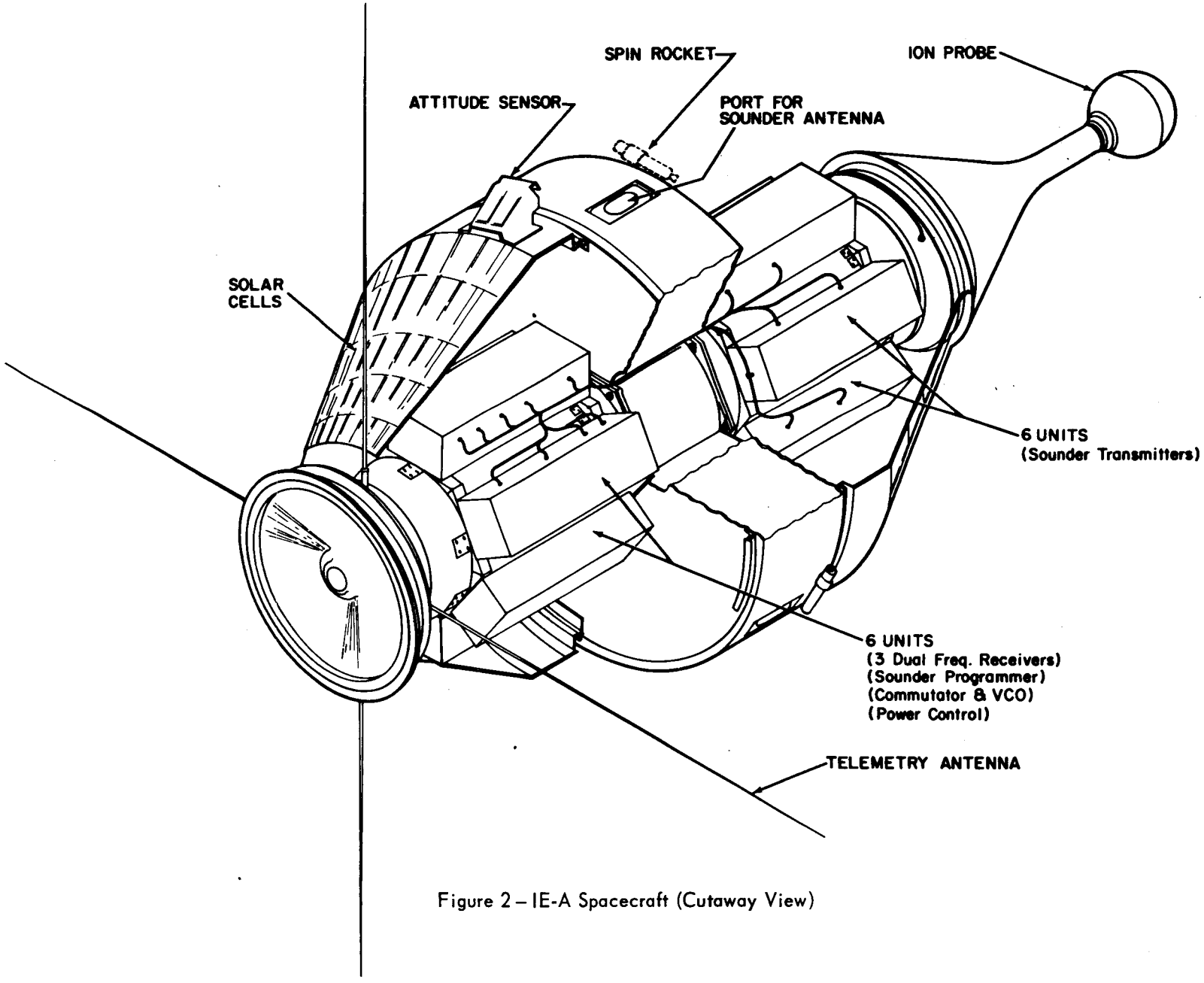

Figure 2 – IE-A Spacecraft (Cutaway View)

a checkout was made at 60°C, at which temperature the 4.60-Mc sounder malfunctioned. The difficulty was traced to a Bulova oscillator which was replaced May 22. The temperature test was then successfully concluded May 23.

The humidity, vibration, and acceleration tests were successfully completed on May 24, 26, and 28, respectively. The acceleration test was conducted at the Chesapeake Bay Annex of the Naval Research Laboratory. In the acceleration test, the spacecraft was actually subjected to 34.8 g's at the center of gravity as opposed to the specified 33 g's. Figure 3 shows the IE-A spacecraft in its final configuration on the vibration exciter.

On May 29, an improved Hughes FM telemetry transmitter was installed in the prototype spacecraft. The original transmitter was not acceptable to Airborne Instruments Laboratory (AIL), but it had been sufficient for making payload checkouts. In addition, the battery-charging circuit was modified to preclude using the override switch at -15°C. The spacecraft was then placed in the temperature chamber, and a satisfactory checkout was completed at -15°C without using the override switch.

After installing the improved Hughes telemetry transmitter, degradation of the transmitter power output was noted. On May 31, the difficulty was traced to one of the diplexers in the center tube. At first it was believed that the diplexer might have been damaged somewhat by the new transmitter or that the diplexer design was inadequate for the new transmitter. After investigating, however, AIL stated that the problem was one of tuning the diplexer to the new transmitter.

On June 2 the spacecraft was prepared for the thermal-vacuum test. Both the original and the new Hughes telemetry transmitters were installed. Before the test was begun, a faulty temperature transducer was detected inside the payload. The transducer apparently had been damaged in removing or installing the center tube. The transducer was repaired, and the test began that night.

During checkout on June 4 with the payload at -15°C and 2.2×10^{-5} mm Hg, difficulty was experienced with the Bulova clock (No. 2) which times the programmer. The payload was then checked out using clock No. 1, a redundant clock. The elapsed time for clock No. 1 to respond was about 30 seconds. After operating for awhile, both clocks functioned normally and responded immediately. Clock No. 2 also failed to function during checkouts made on June 5 and 6 at -15°C in a vacuum.

On June 10 during the solar simulation portion of the thermal-vacuum test, it was noted that the power output of the Hughes tracking transmitter was degraded from about 3.7 to 0.7 milliwatts in the high mode, and from about 1.0 to 0.5

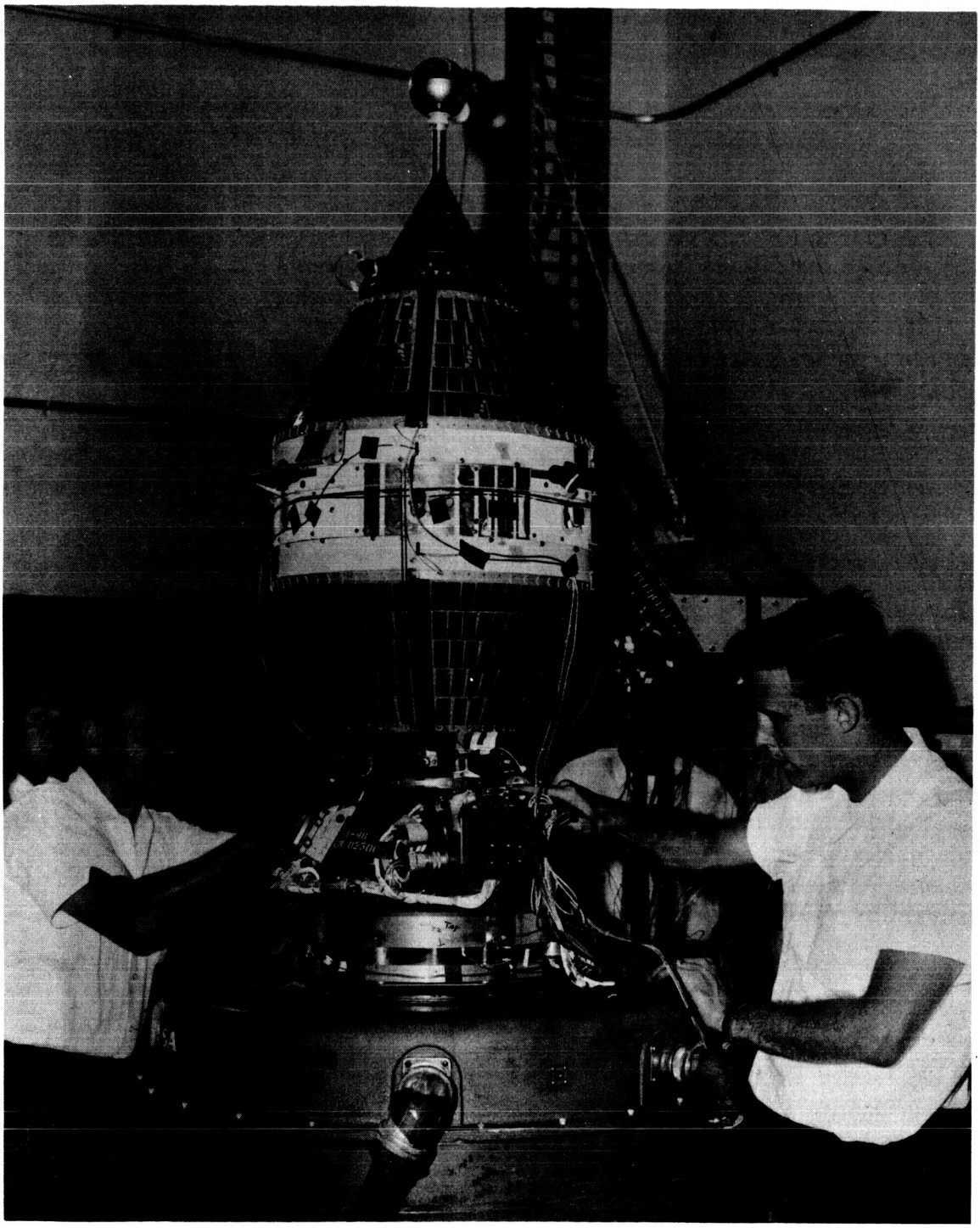

Figure 3 – IE-A Prototype Spacecraft on Vibration Exciter

milliwatts in the low mode. During checkouts on June 12 through 18, the Hughes tracking transmitter was down to 0.05 and 0.07 milliwatts in the high and low modes, respectively.

During checkout on June 15, it was noted that one dummy antenna (not part of the spacecraft) was not functioning properly. However, all sounders functioned normally.

The thermal vacuum-test was successfully concluded June 18 (except as noted) after the sounding antennas were partially extended.

It was agreed that the following components were to be requalified at a later date in temperature, vibration, and thermal vacuum:

- Hughes FM telemetry transmitter
- Hughes tracking transmitter
- A Bulova clock

Spacecraft moments of inertia were determined June 19.

A prototype Bulova clock and a prototype Hughes tracking transmitter successfully completed temperature and vibration tests during August 17-22, 1962. A prototype Hughes FM telemetry transmitter successfully completed a temperature test during this period but malfunctioned as a result of a vibration test on August 21. The transmitter was repaired at AIL by a Hughes representative and returned to GSFC for additional testing. The temperature retest was successfully completed August 30-31. The vibration retest was conducted on August 31; the transmitter again malfunctioned as a result of the test. The transmitter was returned to Hughes for repairs.

The radiation caused by the high-altitude nuclear explosion on July 9, 1962, over the Pacific Ocean was too intense to permit proper functioning of the spacecraft solar cells for the desired period of time. Therefore, it was decided to postpone the launch and to suspend environmental testing of the IE-A spacecraft. It was also decided to procure new FM telemetry transmitters from another source (RCA, Canada) during this period.

The prototype spacecraft arrived at GSFC October 23, 1962, for a thermal-vacuum test to check the performance of the tracking transmitter and Bulova clock in the system. The test began October 23, and was successfully completed October 31.

In November 1962, it was determined that GSFC did not have sufficient manpower to complete environmental testing of the IE-A spacecraft at GSFC. Accordingly, arrangements were made to shift environmental testing to Bendix Systems Division in Ann Arbor, Michigan. Bendix, in conjunction with AIL, prepared a new test plan which was approved by GSFC.

The new FM telemetry transmitters for the prototype and flight No. 2 spacecraft arrived at Bendix, Ann Arbor, Mich., in early January 1963, from RCA, Montreal, Canada. The prototype transmitter successfully completed environmental testing at RCA prior to being shipped to Bendix. During initial checkouts at Bendix, it was discovered that the polarity was reversed on the transmitters, thus producing an inverted wave form. Two RCA representatives made minor modifications to the transmitters at Bendix to correct the polarity. Preliminary indications were that the prototype transmitter was satisfactory. However, the two flight transmitters were returned to RCA for repairs and adjustments, primarily to correct a mismatch problem with the spacecraft.

The thermal-vacuum retest of the prototype spacecraft to qualify the new FM telemetry transmitter began January 10 and was successfully completed January 18, 1963.

At the Director's meeting at GSFC January 14, 1963, it was announced that the IE-A launching would be postponed until the fall to provide time for some major modifications to the spacecraft. Accordingly, environmental testing at Bendix was terminated after completion of the thermal-vacuum retest on the prototype spacecraft. The spacecraft modifications consisted mainly of incorporating an ion probe experiment, lowering the frequencies of three of the six fixed-frequency sounders, and replacing two of the six 30-foot antennas with 60-foot antennas.

The modifications were made to the spacecraft during the first half of 1963, and spacecraft environmental testing was resumed August 1, 1963. The prototype spacecraft was balanced during August 1-7, 1963. The residual static and dynamic unbalance were 3.2 oz-in and 35.6 oz-in^2, respectively. The spacecraft weight was 96.2 pounds, including approximately 0.9 pound of balancing weight. The spacecraft's center of gravity was 17.3 inches above the interface. On August 8 the spin test was successfully completed and measurements were made to determine the moments of inertia of the spacecraft about the spin, pitch, and yaw axes. The resulting moments of inertia were as follows: spin axis - 0.62 slug-ft^2, pitch axis - 1.52 slug-ft^2, yaw axis - 1.53 slug-ft^2.

The ion probe electronics card (University College, London) for the prototype spacecraft was modified August 10 (capacitor added).

The prototype spacecraft completed the vibration test August 13-14. The test results were: (1) the insulation on one small wire in the matching network, pinched during installation in the spacecraft, was aggravated by vibration causing an RF short; (2) a few screws were loosened and a few others backed out; and (3) a capacitor in the ion trap programmer was not properly epoxied and vibration caused one small wire lead to the capacitor to sever.

The pinched wire in the matching network was repaired August 14 before vibration in the lateral axes. Loctite sealant was applied to screws on the flight spacecraft prior to launch. The capacitor with the severed wire was replaced August 15 after vibration and was properly epoxied.

On August 16 either during disassembly or reassembly of the spherical probe for the ion probe experiment, one small pin in the spherical probe was broken. The prototype spherical probe was replaced with the flight No. 2 spherical probe.

The thermal-vacuum test on the prototype spacecraft began August 16. Figure 4 shows the spacecraft in the thermal-vacuum chamber. Three days of satisfactory operation at -15°C in vacuum were completed August 20; 3 days of operation at 60°C in vacuum were completed August 24. During the hot portion of the test, the 5.47-Mc sounder (one of six) did not function, and the FM telemetry transmitter degraded from 1.5 to 1 watt. Otherwise, the spacecraft performed satisfactorily. The transmitter degradation was normal for this temperature. The 5.47-Mc sounder functioned normally after the test at ambient conditions.

Investigation of the 5.47-Mc sounder difficulty by AIL personnel on September 5 revealed that the difficulty was caused by a transistor in the spacecraft programmer; at 60°C the transistor failed to generate a pulse needed to turn on the 5.47-Mc sounder. The transistor was replaced.

During the hot portion of the test, a small quantity of unidentified fluid condensed in the chamber port. Although the source of the fluid is not definitely known, a chemical analysis indicated that the fluid was plasticizer from polyvinyl chloride tubing used on cables between the spacecraft and the chamber feed-through plate.

After the launch was postponed in March 1964, it was decided to use an X-258 rocket motor as the fourth stage of the Scout vehicle. Because of the anticipated higher acceleration levels, an additional acceleration test was conducted on the prototype spacecraft (less ion probe electronics) on June 18, 1964 at the Naval Ordnance Laboratory, White Oak, Maryland. The spacecraft successfully completed the test which consisted of accelerating the spacecraft to 46.5 g's for 1 minute.

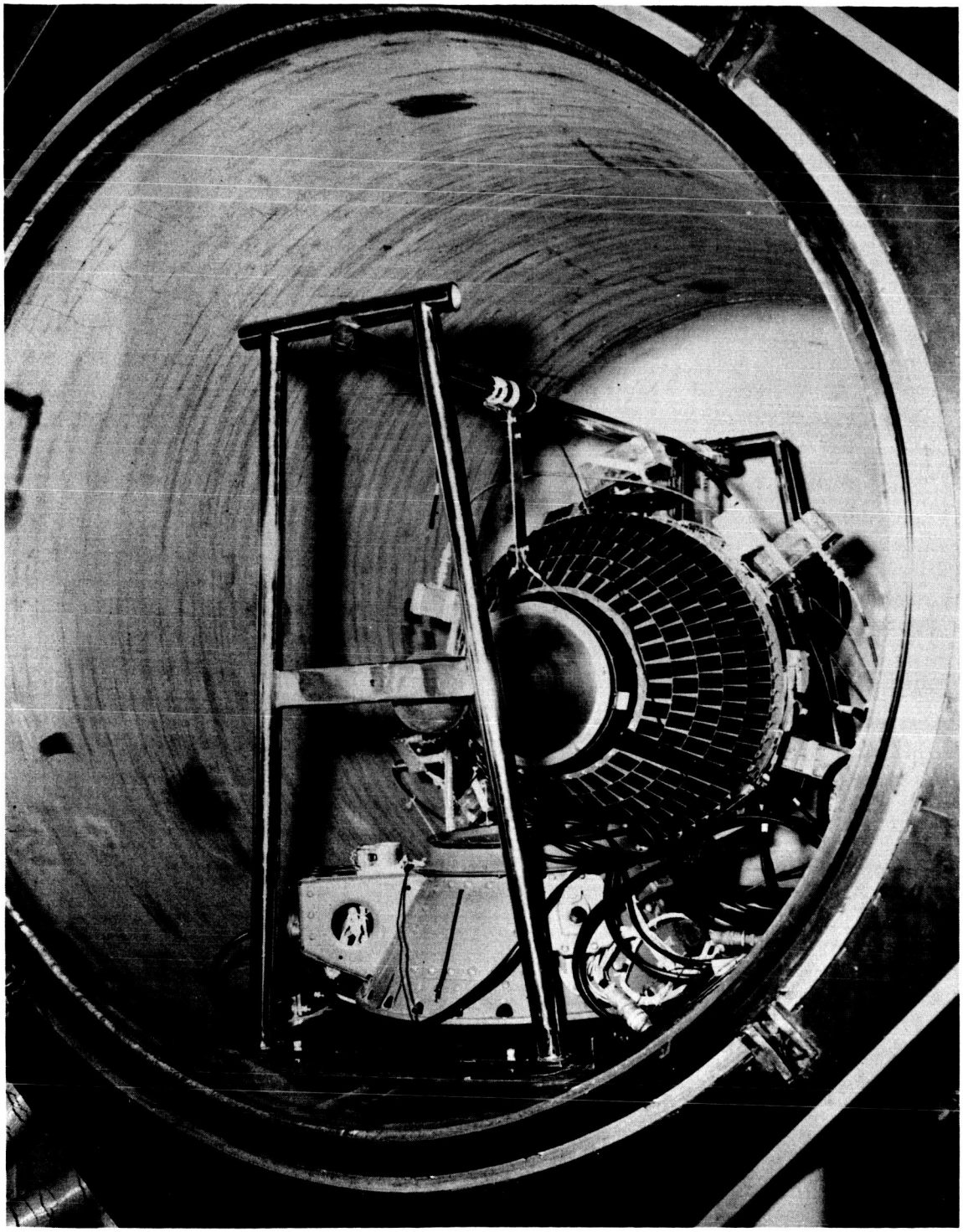

Figure 4 – IE-A Prototype Spacecraft in Thermal-Vacuum Chamber

On June 16, 1964, the prototype spacecraft attach fitting successfully completed load tests of 4500 pounds for 1 minute and 5000 pounds for 1 minute.

Table I summarizes tests conducted, dates of tests, and various problems and malfunctions which occurred during the testing program on the IE-A prototype spacecraft.

IE-A FLIGHT NO. 1 SPACECRAFT TEST HISTORY

Flight No. 1 spacecraft arrived at GSFC August 2, 1962, for environmental testing. Balancing was accomplished during August 3-9 (see Figure 5). The residual unbalance was 2.82 oz-in static and 31.3 oz-in^2 dynamic. The payload weight was 91.22 pounds, which included 0.77 pound of balancing weight. The center of gravity of the payload was 16.47 inches forward of the separation plane.

The spin test was successfully completed on August 10. The vibration test was successfully completed on August 13 and 14.

Flight No. 1 spacecraft successfully completed the thermal-vacuum test during August 15-24. At -5°C in vacuum, the 2.85 and 3.72-Mc sounders were slightly degraded. On August 19 during checkout at 50°C in vacuum, it was noted that one command channel was degraded somewhat. The observed degradation was attributed to a bad connection outside the payload.

Spacecraft moments of inertia were determined August 28, 1962.

It is significant to note that the flight No. 1 spacecraft successfully completed all environmental tests without malfunctioning.

Because of changes and modifications to the flight No. 1 spacecraft, environmental retests were conducted at GSFC starting August 12, 1963.

Flight No. 1 spacecraft was initially balanced during the period August 12-15, 1963. A final balance was conducted September 13 and 16. The residual static and dynamic unbalance were 1.7 oz-in and 11.2 oz-in^2, respectively. The spacecraft weight was 97.65 pounds, which included 0.87 pound of balancing weight. The center of gravity of the spacecraft was 17.5 inches above the interface. The spin test was successfully completed on August 15. On August 16 and 19 measurements were made to determine the moments of inertia of the spacecraft about

Table I

ENVIRONMENTAL TESTING OF IE–A PROTOTYPE SPACECRAFT

	ITEM	1 Balance	2 Spin	3 Temperature	4 Humidity	5 Vibration	6 Acceleration (At CBA)	7 Temperature	8 Thermal-Vacuum	9 Moments of Inertia	10 Thermal-Vacuum	11 Thermal-Vacuum (At Bendix)	12 Balance	13 Spin, Moments of Inertia	14 Vibration	15 Post-Vibration Checkout	16 Thermal-Vacuum	17 Acceleration (At NOL)
		May 1962 5–8	May 9	May 9–23	May 23–24	May 24–26	May 28	May 29	June 2–18	June 19	Oct. 23–31	Jan. 1963 10–18	Aug. 1963 1–7	Aug. 8	Aug. 13–14	Aug. 16	Aug. 16–24	June 1964 18
A	Battery charging circuit			■				[M]										
B	3.72 and 4.60 Mc sounders			■ [R]														
C	Bulova oscillator			■ [C]														
D	Original Hughes telemetry transmitter			◪					■									
E	Improved Hughes telemetry transmitter							[C]	◪		◪							
F	Diplexer							[I]										
G	Temperature transducer								■ [R]									
H	Bulova Clock No. 2								■		[C]							
I	Hughes tracking transmitter								▬		[C]							
J	New RCA telemetry transmitter											[C]						
K	Small wire pinched, loose screws, Broken capacitor lead														[I] [R]			
L	Broken pin in spherical probe															[I] [R]		
M	At 60°C transistor failure in 5.47 Mc sounder																■ [R]	

LEGEND

■ SUBASSEMBLY FAILURE OR MALFUNCTION
◪ QUESTIONABLE OPERATION
▬ MARGINAL SUBASSEMBLY OPERATION
[I] SPECIAL PROBLEMS
[R] SUBASSEMBLY REPAIRED
[C] SUBASSEMBLY CHANGED
[M] SUBASSEMBLY MODIFIED

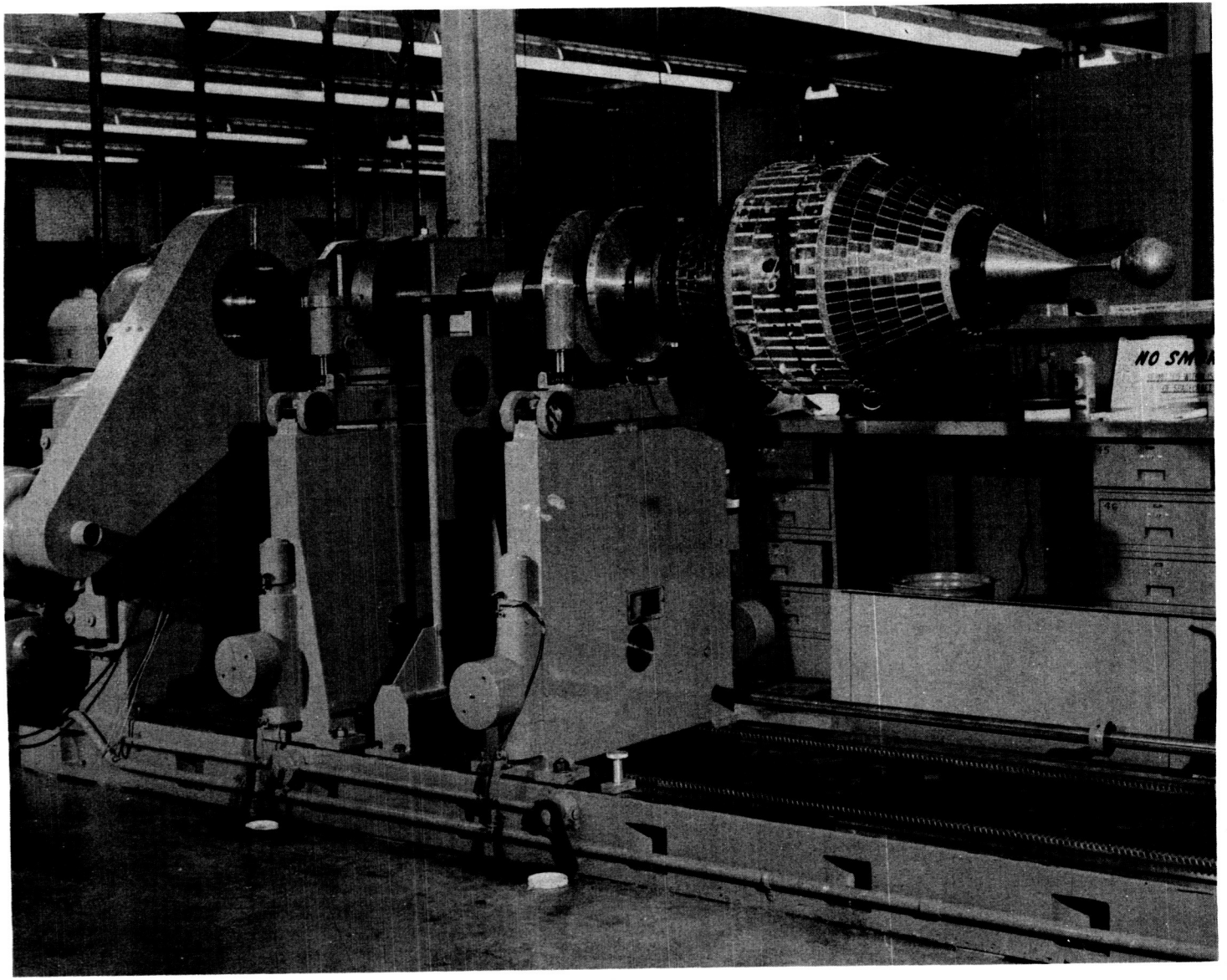

Figure 5 – IE-A Flight No. 1 Spacecraft on Dynamic Balancing Machine

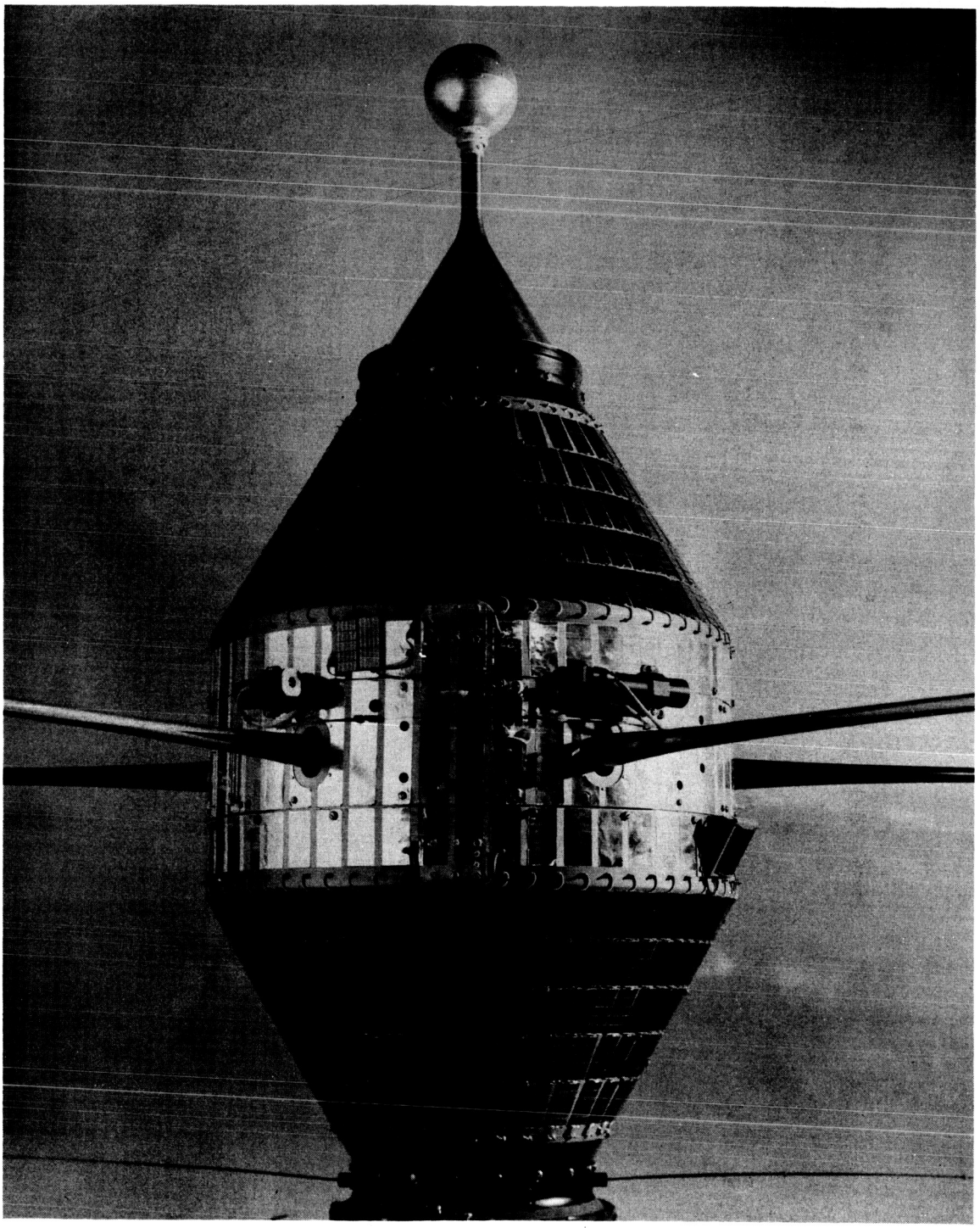

Figure 6 – IE-A Flight No. 1 Spacecraft with Antennas Extended

the spin, pitch, and yaw axes with and without the separation device. The resulting moments of inertia were as follows:

- Flight No. 1 spacecraft —

Spin axis	0.62 slug-ft^2
Pitch axis	1.62 slug-ft^2
Yaw axis	1.62 slug-ft^2

- Flight No. 1 spacecraft with the separation device attached —

Spin axis	0.77 slug-ft^2
Pitch axis	2.78 slug-ft^2
Yaw axis	2.78 slug-ft^2

The spacecraft successfully completed the vibration test August 20-21.

On August 22 it was noticed that one of the small pins in the spherical probe for the ion probe experiment was broken. The cause was attributed to vibration or handling. A similar pin was broken in the prototype spherical probe as mentioned previously. The prototype probe was repaired at GSFC by August 24 with a new gold plated stainless steel pin and a teflon sleeve to provide additional support for the head electronics. After successfully completing a vibration test at prototype levels August 26, the modified probe was installed on the flight No. 1 spacecraft. Similar modifications were made to the spherical probes of the two flight spacecraft.

The thermal-vacuum test of the flight No. 1 spacecraft began August 27. The spacecraft operated satisfactorily for 3 days at -5°C in vacuum; the test was concluded August 31. The spacecraft operated satisfactorily for 3 days at 50°C; the test was successfully concluded September 6.

On November 6, 1963, measurements were made to determine the moments of inertia of the spacecraft about the yaw and pitch axes and an axis midway in-between. The resulting moments of inertia are presented below. Also shown are lateral moments of inertia determined on August 16 and 19.

Axis	Moments of Inertia, Nov. 6, 1963 (slug-ft^2)	Moments of Inertia, Aug. 16 & 19, 1963 (slug-ft^2)
Yaw	1.6142	1.6156
Yaw + 45°	1.5940	Not measured
Pitch	1.6076	1.6156

After the launch postponement in March 1964, all three spacecraft were again subjected to some additional environmental retests. These retests were conducted at GSFC during the period June 2-19, 1964. The retests were abbreviated and were conducted because of changes made in the spacecraft and because of the elapsed time since completion of the previous series of tests in September 1963.

The flight No. 1 spacecraft was balanced during the period June 3-5, 1964. The residual unbalance was 3.87 oz-in static and 27.6 oz-in^2 dynamic. The spacecraft weighed 98 pounds, including 0.84 pound of balancing weight.

The spacecraft successfully completed a 1-minute flight-level random vibration test in the thrust direction on June 5.

During June 9-12, the spacecraft successfully completed a thermal-vacuum test; satisfactory spacecraft checkouts were made at -5°C and 50°C in vacuum.

Flight battery package, serial No. 5-8-4, successfully completed a flight-level vibration test on July 7, 1964. The battery package, installed in the flight No. 1 spacecraft at WTR, was used to extend the sounding antennas after launch.

Table II summarizes tests conducted, dates of tests, and results of acceptance testing of the IE-A flight No. 1 spacecraft.

IE-A FLIGHT NO. 2 SPACECRAFT TEST HISTORY

The flight No. 2 spacecraft arrived at GSFC August 21, 1962, for environmental testing. Balancing was accomplished during August 22-27. The payload weight was 90.3 pounds, including 0.6 pound of balancing weight. The residual unbalance was 1.94 oz-in static and 40.2 oz-in^2 dynamic. The spin test was successfully completed August 27.

During checkout of the payload prior to the vibration test, it was noted that the frequency of one of the Hughes FM telemetry transmitters had shifted excessively. Testing was suspended at this point pending resolution of the transmitter problem, and also because of the enhanced radiation belt discussed previously.

Environmental tests were resumed at GSFC September 4, 1963, after several modifications to the spacecraft.

The flight No. 2 spacecraft was again balanced during September 4-6, 1963. The residual static and dynamic unbalance were 1.4 oz-in and 15 oz-in^2,

Table II
ENVIRONMENTAL TESTING OF IE–A FLIGHT NO. 1 SPACECRAFT

	ITEM	1 Balance	2 Spin	3 Vibration	4 Thermal-Vacuum	5 Moments of Inertia	6 Balance	7 Spin, Moments of Inertia	8 Vibration	9 Post-Vibration Checkout	10 Thermal-Vacuum	11 Balance	12 Moments of Inertia	13 Balance	14 Vibration 1-Minute Thrust Random	15 Thermal-Vacuum
		Aug. 1962 3–9	Aug. 10	Aug. 13–14	Aug. 15–24	Aug. 28	Aug. 1963 12–15	Aug. 15–19	Aug. 20–21	Aug. 22	Aug. 27 Sept. 6	Sept. 13, 16	Nov. 6	June 1964 3–5	June 5	June 9–12
A	Broken pin in spherical probe									[S][R]						

LEGEND [S] SPECIAL PROBLEMS
[R] SUBASSEMBLY REPAIRED

respectively. The spacecraft weighed 97.5 pounds, including 0.82 pound of balancing weight. The center of gravity of the spacecraft was 17.3 inches above the interface. The spin test was successfully completed September 6.

On September 9 measurements were made to determine the moments of inertia of the spacecraft about the spin, pitch, and yaw axes. Measurements were also made to determine the moments of inertia of the spacecraft with the separation device attached about the spin axis. The resulting moments of inertia were as follows:

- Flight No. 2 spacecraft —

Spin axis	0.63 slug-ft^2
Pitch axis	1.60 slug-ft^2
Yaw axis	1.60 slug-ft^2

- Flight No. 2 spacecraft with the separation device attached —

Spin axis	0.77 slug-ft^2

During checkout of the spacecraft on September 10, a short piece of cable in the telemetry circuitry was found to be defective. The cable and two associated connectors were replaced.

The vibration test was conducted September 11-12. Before the test was begun, it was noted that two monitoring points were open on one attitude sensor. After completion of the thrust-axis vibration test on September 11, investigation revealed that one small wire was attached to a wrong pin in a connector; this was corrected and the vibration test was resumed September 12. During random vibration in the first lateral direction, it was noted that the spherical probe for the ion probe experiment was partially unscrewed. The unit was removed, Loctite was applied, and the probe was screwed down firmly. Vibration in the second lateral direction was then conducted. Post-test checkout was satisfactory, and the spacecraft was considered to have successfully completed the test.

The thermal-vacuum test on the flight No. 2 spacecraft began September 16. Three days of operation at -5°C in vacuum were completed September 20. At -5°C in vacuum some difficulty was experienced with the ion probe experiment. Indications were that the first derivative voltages were lower than normal. Spacecraft operation, otherwise, was satisfactory. (In a subassembly test on a flight-spare ion probe experiment, the problem at -5°C in vacuum was duplicated and was proved to be associated with the dummy load.) Three days of satisfactory spacecraft operation at 50°C in vacuum were completed September 25.

Additional tests were conducted on the flight No. 2 spacecraft during June 2-19, 1964. The tests consisted of thermal vacuum, temperature, vibration, and a final balance check.

The thermal-vacuum test on the Flight No. 2 Spacecraft began June 2, 1964. The spacecraft checked out satisfactorily June 3 at -5°C in vacuum. During spacecraft checkouts on June 4 at 50°C in vacuum, it was noted that Bulova clock No. 2 was slow in responding. The time required to respond was about 15 seconds as opposed to a normal time of 1.7 seconds. On June 5, spacecraft checkouts were conducted at 45°C and 40°C in vacuum. The corresponding times for Bulova clock No. 2 to respond were about 7 seconds and about 4 seconds. At 25°C in vacuum, the clock response was normal. Spacecraft performance was otherwise satisfactory throughout the thermal-vacuum test.

The test was discontinued June 5, and the spacecraft was removed from the chamber. Investigation indicated that the Bulova clock had probably malfunctioned. The clock was removed from the spacecraft, and a spare Bulova clock was installed on June 11. The spare clock had successfully completed a flight-level vibration test June 11 before being installed in the spacecraft.

A temperature test was conducted on the spacecraft on June 11, and the spacecraft including the new Bulova clock checked out satisfactorily at 60°C and 40°C.

On June 12, the spacecraft successfully completed a 1-minute flight-level random vibration test in the thrust direction.

In a thermal-vacuum retest, June 15 - 17, the spacecraft checked out satisfactorily at -5°C and 50°C in vacuum.

The spacecraft unbalance, checked on June 19, was determined to be 1.94 oz-in static and 10 oz-in^2 dynamic. The spacecraft weight was 97.3 pounds.

Table III summarizes tests conducted, dates of tests, and results of the acceptance testing of the IE-A flight No. 2 spacecraft.

FLIGHT SPARE ION PROBE EXPERIMENT

A flight-spare ion probe electronics card successfully completed a flight-level vibration test September 20, 1963.

A thermal-vacuum test was then conducted on the spare ion probe experiment. The test began September 23. During checkout on September 24 at -5°C

Table III
ENVIRONMENTAL TESTING OF IE–A FLIGHT NO. 2 SPACECRAFT

	ITEM	1 Balance Aug. 1962 22–27	2 Spin Aug. 27	3 Pre-Vibration Checkout Aug. 28	4 Balance Sept. 1963 4–6	5 Spin Sept. 6	6 Moments of Inertia Sept. 9	7 Pre-Vibration Checkout Sept. 10	8 Vibration Sept. 11–12	9 Thermal-Vacuum Sept. 16–25	10 Vibration at Pt. Mugu Feb. 1964 19	11 1-Minute Thrust Random June 1964 2–5	12 Thermal-Vacuum June 11	13 Temperature June 12	14 Vibration 1-Minute Thrust Random June 15–17	15 Thermal-Vacuum Balance June 19
A	Hughes telemetry transmitter			■ R												
B	Short piece of cable, two connectors							◫ R								
C	Small wire attached to wrong pin							◫	R							

LEGEND

■ SUBASSEMBLY FAILURE OR MALFUNCTION
◫ SPECIAL PROBLEMS
R SUBASSEMBLY REPAIRED

in vacuum, it was noted that the first derivative voltages were lower than normal — similar to the problem with the ion probe experiment on flight No. 2 spacecraft operating at -5°C in vacuum. The problem was believed to be associated with the dummy load on the experiment. The test was temporarily stopped September 24, and the dummy load on the experiment was disconnected. Another dummy load was attached outside the chamber, and the test was resumed that day. Operation of the experiment at -5°C and 50°C in vacuum then proved to be satisfactory, and the test was concluded September 27.

During subsequent checkout of the experiment, it was noted that the electronics card was not functioning properly. The unit was shipped to University College, London, repaired, and returned to GSFC for environmental retests.

The electronics card successfully completed a vibration retest November 12, 1963; the spare ion probe experiment successfully completed a thermal-vacuum retest November 18-21, 1963.

SUMMARY OF OPERATIONS AT WTR

First Phase

Spacecraft prelaunch operations began at Western Test Range (WTR) on January 23, 1964. The prototype spacecraft and the two flight spacecraft were kept in the Missile Assembly Building clean room which was temperature- and humidity-controlled.

Initial checkouts of the ground station and the flight spacecraft were satisfactory except that the flight No. 2 spacecraft had a problem in the power control unit — a relay which functioned intermittently. The relay was replaced January 29.

The center tube of the flight No. 1 spacecraft was removed January 31, and batteries for extending the sounding antennas were replaced. A similar battery change was made February 3 on the flight No. 2 spacecraft. The ion probe experiments were integrated January 31 and February 3 on flight Nos. 1 and 2 spacecraft, respectively. All four Miller 1-year timers on both flight spacecraft were rendered ineffective February 4.

Two Bendix arming connectors successfully completed flight-level vibration tests at GSFC February 6. One of these connectors was installed in the flight spacecraft prior to launch to arm the circuit connecting the sounding antennas and the antenna batteries.

The flight No. 1 spacecraft was initially selected for launching because of its slightly better electrical characteristics and history. However, because of

No. 1 spacecraft's intermittent signals from the modulated beacon into the FM telemetry system, the No. 2 spacecraft was selected for launching.

At a meeting on February 7 concerning the spin-balance operation with the X-248 rocket motor, it was stated that small cracks had developed in the fiber glass around eight of the 24 shoulder studs on the X-248 rocket motor.

Two telemetry antennas were replaced on the flight No. 1 spacecraft February 7.

A 30-foot spare sounding antenna was extended February 7. A 60-foot sounding antenna on the prototype spacecraft and all six sounding antennas (four 30-foot and two 60-foot) on the flight No. 1 spacecraft were extended February 10. Satisfactory electrical continuity checks were made on all antennas. Two antennas on the flight No. 2 spacecraft were also extended and checked.

Three small wires were installed in the flight No. 2 spacecraft February 14 to provide parallel electrical paths around three fuses.

The flight No. 2 spacecraft successfully completed a 1-minute thrust-axis random vibration test at flight levels at the Naval Missile Test Facility, Point Mugu, February 19. The test was conducted as a quality assurance measure because of changes made in the spacecraft at WTR. Point Mugu responded very quickly to the request for this test made February 18. The spacecraft was transported to Point Mugu, tested, and returned to the Naval Missile Facility, Point Arguello, February 19. Satisfactory spacecraft checkouts were made February 20.

One spin rocket failure occurred in a series of tests conducted at Bulova Research and Development Laboratories in Woodside, New York. The failure occurred at 110°F in vacuum when the nozzle end of the rocket blew out.

Langley Research Center (LRC) decided to proceed with the original X-248 rocket motor which as of February 20 had 35 small cracks (19 forward, 16 aft) in the fiber glass around the mounting studs. Scout personnel reported that three worse-case studs successfully completed a 1,000-pound static load test February 20. A second X-248 rocket motor had been considered until the dome was damaged slightly when the separation device was torqued down on the motor. LRC then considered the second motor unsuitable for flight.

Composite spin and balance of the X-248 rocket motor, upper D-section, flight No. 2 spacecraft, and separation device was conducted March 1 and 2. The total weight added was 1158 grams. The spacecraft and separation device were

then removed and returned to the clean room to await remating with the vehicle on R-4 day.

Spin and balance was delayed approximately 1 week pending resolution of the stud problem with the X-248 rocket motor. After removing all 48 studs twice and re-epoxying twice (the second time with the proper mix), only five studs backed out when the prescribed 25 inch-pounds of torque was applied to the studs. These studs were then removed and re-epoxied in place. After the 24-hour curing period, the studs successfully passed the torque check.

Additional 1,000-pound static load tests were then successfully conducted on three studs on the forward shoulder of the X-248 rocket motor. A torque test was again conducted on the 24 studs on the aft end of the motor. Twenty-two studs successfully passed the test, one stud failed, and one stud was accidentally broken loose.

The flight No. 2 spacecraft and separation device were remated to the Scout vehicle March 6, somewhat ahead of schedule to provide additional continuous time to resolve a problem which appeared March 5 in the Scout guidance system. Indications were that the problem was unbalanced deadband in the guidance system, most likely in the D-section of the Scout. At first it was believed that the Poppet valve electronics unit (PVE) in the D-section was not functioning properly, but this possibility diminished when a spare PVE unit was substituted and the problem remained. Ground support equipment (GSE) and external cabling were also suspected. The external cabling was later ruled out as a possible cause; and after many hours of checking, the GSE was all but ruled out as a cause.

Other possible causes considered were vehicle wiring problem, shielding problem in D-section, system compatibility problem, and component(s) failure somewhere in the system. As of March 7, range personnel believed that the problem was most likely in the vehicle. However, LRC personnel thought that the problem was in the GSE and decided to proceed with the launch with evidence of a possible guidance problem.

Meanwhile, the spacecraft and heat shield remained attached to the vehicle awaiting resolution of the possible guidance problem or rescheduling of the launch. Dry air (74°F) was pumped inside the heat shield.

On March 6, after installation of the spacecraft on the vehicle, the spacecraft was commanded several times with the heat shield off and on to ensure command capability and a vehicle-spacecraft RF-compatibility check was made. It was reported that no RF interference occurred.

Both timers were removed from the separation device on March 6. It was reported that the timers did not function properly and that small pins in the timers were shortened to permit proper operation.

Mock countdown was conducted March 16. On March 17 final spacecraft preparations were made. Solar cells were cleaned. Spin rockets and the antenna arming plug were installed. One screw, one of the three used to attach the ion probe spherical ball to the spacecraft, was partially drilled out and replaced by a shortened screw. The screw head had previously been sheared.

On March 17, 1964 (R-1 day) the IE-A launch was postponed indefinitely pending resolution of the Scout vehicle guidance problem. Launch preparations were terminated about 6:30 p.m.

The prototype spacecraft and the flight No. 2 spacecraft were placed in storage at WTR. The flight No. 1 spacecraft was returned to Airborne Instruments Laboratory for checkout and repairs. In June 1964, all three spacecraft were returned to GSFC for additional tests.

Second Phase

All three spacecraft were returned to WTR on June 24, 1964. The difficulty encountered in March with the Scout vehicle proved to be in the vehicle wiring harness. A different Scout vehicle was used to launch the spacecraft.

While in transit to or at Los Angeles aboard a TWA airplane, the flight No. 2 spacecraft was apparently toppled over, causing some damage to the shipping container and minor damage to the spacecraft. An external mounting bracket for a despin rocket motor was bent. Although the spacecraft later checked out satisfactorily electrically, project management no longer considered the spacecraft flightworthy because of the unknown factors involved.

Composite spin and balance of the X-258 rocket motor and the flight No. 1 spacecraft was conducted during August 5-7.

During the second phase, prelaunch operations proceeded well. No difficulty was encountered with the spacecraft.

Launch Operations

The flight No. 1 spacecraft, designated Explorer XX, was successfully launched August 25, 1964. The Scout vehicle performance was near nominal. The orbital parameters were: apogee, 1011 km; perigee, 865 km; inclination, 79.9 degrees; and period, 103.8 minutes. The spacecraft spin axis was 7 degrees from perpendicular to the plane of the ecliptic.

All postlaunch events occurred on schedule. Spacecraft separation occurred as planned, the four telemetry antennas released properly and assumed the radial position, the tracking transmitter switched from the low-power mode to the high-power mode, the spinup and despin rockets performed satisfactorily, the six sounding antennas (four 30-ft. and two 60-ft.) extended fully, and the tracking transmitter switched back to the low-power mode, thus indicating that the spacecraft was ready for experiment operation. The final spin rate obtained was 1.5 rpm.

EARLY ORBITAL PERFORMANCE

Initial indications are that the spacecraft is performing well and as planned. Five and one-half hours of telemetry data were received the first day of operation. The six fixed-frequency sounders are functioning well, and the ion probe experiment is operating properly. Spacecraft "housekeeping" data are near nominal.

Some interference has been detected during operation of the 5.47-Mc and the 7.22-Mc sounders. Signals from ground-based transmitters apparently cause some of the interference. Operation of the tracking transmitter also causes some of the interference with the 5.47-Mc sounder. However, good echoes are being obtained using the 5.47-Mc and the 7.22-Mc sounders when the tracking transmitter is not operating and when the critical frequency of the ionosphere is sufficiently high to shield interfering signals originating from the ground. To minimize the interference, spacecraft operation procedures have been modified somewhat in that the tracking transmitter is kept inoperative except for being commanded on periodically from selected locations to provide "housekeeping" data for determining spacecraft status.

Some difficulty has also been experienced in commanding the tracking transmitter on to acquire "housekeeping" data. Two or three commands are sometimes required to acquire satisfactory data.

The spacecraft was launched into 100 percent sun, and achieved a nearly perfect orientation with respect to the sun. The spin axis of the spacecraft is nearly perpendicular to the plane of the ecliptic. In addition, degradation of the solar cells has been less than expected. Because of optimum conditions and conservative design, the system voltage has been excessively high. To maintain the system voltage within normal operating limits, the sounding time has been increased from a nominal 4 to 5 hours to as much as 8 hours per day. This situation was alleviated somewhat in mid-September when the spacecraft began entering partial shade. Minimum sun conditions of about 65 percent are expected about October 10, and a return to 100 percent sun is expected about November 10. The temperatures of the spacecraft as it enters minimum sun conditions are

somewhat lower than anticipated, thus resulting in less generation of power than anticipated. Spacecraft operation is therefore being held to a maximum of about 3 hours per day during minimum sun conditions.

CONCLUSIONS

Sufficient data have already been received from the spacecraft to consider the mission successful. Although the designed lifetime of the spacecraft is 1 year, the actual lifetime is unpredictable and may even exceed 1 year.

In view of the success of Explorer XX, it is concluded that the environmental test program was adequate.

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