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PROGRESS THROUGH AUGUST 31, 1957

[UNCLASSIFIED TITLE]

Project Vanguard Staff

October 4, 1957

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PREVIOUS PROJECT VANGUARD REPORTS

Project Vanguard Report No. 1, "Plans, Procedures, and Progress" by the Project Vanguard Staff, NRL Report 4700 (Secret), January 13, 1956

Project Vanguard Report No. 2, "Report of Progress" by the Project Vanguard Staff, NRL Report 4717 (Confidential), March 7, 1956

Project Vanguard Report No. 3, "Progress through March 15, 1956" by the Project Vanguard Staff, NRL Report 4728 (Confidential), March 29, 1956

Project Vanguard Report No. 4, "Progress through April 15, 1956" by the Project Vanguard Staff, NRL Report 4748 (Confidential), May 3, 1956

Project Vanguard Report No. 5, "Progress through May 15, 1956" by the Project Vanguard Staff, NRL Report 4767 (Confidential), June 2, 1956

Project Vanguard Report No. 6, "Progress through June 15, 1956" by the Project Vanguard Staff, NRL Report 4800 (Confidential), June 28, 1956

Project Vanguard Report No. 7, "Progress through July 15, 1956" by the Project Vanguard Staff, NRL Report 4815 (Confidential), July 27, 1956

Project Vanguard Report No. 8, "Progress through August 15, 1956" by the Project Vanguard Staff, NRL Report 4832 (Confidential), September 5, 1956

Project Vanguard Report No. 9, "Progress through September 15, 1956" by the Project Vanguard Staff, NRL Report 4850 (Confidential), October 4, 1956

Project Vanguard Report No. 10, "Progress through October 15, 1956" by the Project Vanguard Staff, NRL Report 4860 (Confidential), November 4, 1956

Project Vanguard Report No. 11, "Progress through November 15, 1956" by the Project Vanguard Staff, NRL Report 4880 (Confidential), December 3, 1956

Project Vanguard Report No. 12, "Progress through December 15, 1956" by the Project Vanguard Staff, NRL Report 4890 (Confidential), January 16, 1957

Project Vanguard Report No. 13, "Progress through January 15, 1957" by the Project Vanguard Staff, NRL Report 4900 (Confidential), February 7, 1957

Project Vanguard Report No. 14, "Progress through February 15, 1957" by the Project Vanguard Staff, NRL Report 4910 (Confidential), March 12, 1957

Project Vanguard Report No. 15, "Progress through March 15, 1957" by the Project Vanguard Staff, NRL Report 4930 (Confidential), April 2, 1957

Project Vanguard Report No. 16, "Progress through April 15, 1957" by the Project Vanguard Staff, NRL Report 4950 (Confidential), May 1, 1957

Project Vanguard Report No. 17, "Progress through May 31, 1957" by the Project Vanguard Staff, NRL Report 4980 (Confidential), July 10, 1957

Project Vanguard Report No. 18, "Minitrack Report No. 1: Phase Measurement" by C. A. Schroeder, C. H. Looney, and H. E. Carpenter, NRL Report 4995 (Unclassified), July 26, 1957

Project Vanguard Report No. 19, "Progress through June 30, 1957" by the Project Vanguard Staff, NRL Report 5010 (Confidential), August 6, 1957

Project Vanguard Report No. 20, "Progress through July 31, 1957" by the Project Vanguard Staff, NRL Report 5020 (Confidential), September 16, 1957

Project Vanguard Report No. 21, "Minitrack Report No. 2: The Mark II Minitrack System," by Roger L. Easton, NRL Report 5035 (Unclassified), September 12, 1957

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PREFACE

This report is intended as a general summary of the progress on Project Vanguard ~~during the indicated period~~. Hence, minor phases of the work are not discussed to a great extent, and technical detail is kept at a minimum. It is hoped that the information ~~here~~ presented will be of assistance to administrative and liaison personnel in coordinating and planning their activities, and as a guide to the current status of the project. ~~Material of a more technical~~ nature will be published from time to time in separate reports which will be announced in subsequent monthly progress reports.

PROBLEM STATUS

This is an interim report; work on the problem is continuing.

AUTHORIZATION

NRL Problem A02-90

Manuscript submitted September 30, 1957

THE LAUNCHING VEHICLES

DESIGN, STRUCTURE, AND ASSEMBLY

The TV-2 backup vehicle has been accepted and delivered to the field on 5 August.

Several design changes have been made in the TV-3 and TV-3 backup vehicles as a result of the requirements of the revised test program.* The heavy instrumented nose cone which was to remain attached to the third stage in flight will be replaced by a 6.44-inch satellite package; this will provide Minitrack data from which the third-stage performance can be inferred. The change required that an SLV-type peel-away nose cone be employed; therefore the forward nose-cone support frames of both vehicles have been revised accordingly. Since one half of the peel-away cone is to carry an angle-of-attack meter, the other half must be counterweighted. The housing and "spider-arm" attachment on the third-stage nose have been modified to accommodate the satellite package. Some of the equipment from the original nose cone has been relocated in the second stage, and some, including the optical tracking flare installation, has been eliminated. The net reduction in the weight of the composite vehicle is about 200 pounds.

The TV-3 spin rockets have been canted outward 20 degrees to reduce the acceleration of the spin table (see Flight Program and Staging, p. 5).

The completely assembled TV-3 has been erected at The Martin Co. plant and the final acceptance tests are underway. Horizontal tests on the TV-3 backup vehicle are still going on; the first-stage electrical, telemetering, and hydraulic system tests are completed, and controls tests have begun; the second-stage telemetering tests are completed, and electrical, instrumentation, and controls tests have begun.

TV-4 is slightly behind schedule because of difficulties in the arrangement of electronic instrumentation in the second-stage forward section. This section is about to be spliced to the newly delivered Aerojet Propulsion Unit No. 3. The first stage of this vehicle is complete. Electrical and mechanical installations have begun in the TV-4 backup second stage which has been assembled with a temporary splice. The manufacturing of TV-5 and the SLV's is proceeding on schedule.

A destruct test has been conducted by The Martin Co. on a first-stage liquid oxygen tank filled with water. The destruct system, employing detonators and four strands of primacord next to the tank, gave complete cutting action with longitudinal opening of the tank.

PROPULSION

First Stage

Two more General Electric X-405 first-stage powerplants, S/N-11 and S/N-12, have been accepted and delivered to The Martin Co. No deviations from the specifications were necessary for S/N-11, but a deviation was required to cover the specific impulse of S/N-12, which was two seconds low on the average. Preliminary tests on S/N-13 have been completed, and acceptance of this engine during September is anticipated.

*P.V.R. No. 20, p. 1

Four rated-pressure propellant expulsion tests have been completed on the first-stage pressurization mockup.* As a result of these tests, additional orifices have been made in the peroxide tank pressure inlet to minimize detrimental effects due to surges, and investigations are underway to resolve some problems with the main regulator which fails to prevent overpressurization.

Second Stage

Second-Stage Propulsion Units 3 and 4 have been accepted and delivered to The Martin Co. with no deviations from the specifications. There will be a delay of about two weeks in the delivery of Propulsion Units 5 and 6 owing to difficulties with the tank assemblies: the fuel tank for Unit 5 has been rejected because of a 25-degree rotational misalignment of the head, and the helium sphere in the tank assembly for Unit 6 failed during hydrostatic testing.

Several specimens, including weld, from a sectioned helium sphere have been used for test purposes during this report period. A specimen tempered at 825°F and subjected to working conditions failed in less than 60 minutes. Then the tank assembly which was being used for qualification tests was loaded with propellants and pressurized to working pressures, and a similar failure of the helium sphere occurred after 8 hours, 45 minutes. The failures in both cases occurred in the heat-affected zone adjacent to the weld that was in acid (the second-stage oxidizer, white inhibited fuming nitric acid). Two additional sphere sections then were tempered at 600°F and tested under working conditions. These did not fail after 8 hours, and a decision was therefore made to temper all future units at 600°F.

Second-stage thrust chamber C-10, which was to be anodized* along with chamber B-27 in an effort to increase the operating lifetime, was damaged during the anodizing process and has been discarded. Chamber B-27, renumbered C-12, was anodized and fired for 10, 60, 115, 15, 10, and 60 seconds, or a total of 270 seconds. Some leaks developed and repairs were made with Epoxy resin impregnated with aluminum powder. The chamber was fired again and failed in five seconds owing to burn-through; it was assumed that the aluminum powder ignited and overheated the tubes. Inspection of the tubes disclosed that they were eroded to paper thinness, and it was concluded that anodizing did not appreciably increase the lifetime of the chamber.

Thrust chamber C-11 was coated with Epoxy resin impregnated with a ceramic material. A firing of the chamber to evaluate this material was prevented by a malfunctioning fuel valve which necessitated immediate shutdown. It was noted that acid had attacked the coating.

The present lifetime of the second-stage engine appears to be adequate, though marginally so, for the mission. However, NRL desires a greater margin of safety. To that end, small-scale experiments will be conducted at NRL to determine the suitability for Vanguard of various known successful methods of coating and plating thrust chambers.

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* P.V.R. No. 20, p. 2

Third Stage

Grand Central Rocket Co.

The Grand Central Rocket Co. has continued the qualification firings of their third-stage rocket motor. The first firing was made in July* with a motor which had been temperature-conditioned to 30° F, and the data indicated an altitude specific impulse of 240 seconds. Another firing at the same temperature has yielded the same specific impulse, and two firings at 130° F have yielded 241 seconds. Two firings at 80° F have yielded between 237 and 238 seconds. A vacuum-ignition firing has also been conducted, and the altitude specific impulse was below 240 seconds. An investigation is underway to determine the causes of specific impulses below 240 seconds; for example, errors in calibration of the test instruments could be a factor. However, no change is expected in the qualification firing schedule.

The Nigg Engineering Company now has the first two altitude nozzles ready for delivery to GCR, and two stainless steel chambers should be delivered by the Western Way Co. about 12 September. Thereafter, delivery rates of three or four units per week are expected from each of these suppliers.

Two GCR third-stage motors have been cast and processed for delivery to the field by 12 September for TV-3; they are now being balanced and aligned.

Allegany Ballistics Laboratory

The Allegany Ballistics Laboratory has continued research toward resolution of the resonant burning problems which have hampered development of their third-stage rocket. Two approaches† have been followed: One utilizes a baffle system immobilized at the chamber inner wall into which the propellant is cast, and a paddle-type resonance suppressor in the ported area of the propellant. The other involves the dispersal of a chemical additive in the propellant during mixing to act as a suppressor. Small-scale (8-inch diameter) versions of the ABL third-stage configuration have been tested with both systems, and both have yielded satisfactory results as resonance suppressors; the successful additive was aluminum oxide. Two full-scale prototypes, one employing each system, are now being prepared for static testing. Both will be evaluated as the potential ABL third-stage prototype, and if either is successful, several additional firings will follow as a prequalification evaluation program.

FLIGHT CONTROL

General

The ballast loading for TV-2 has been established as water fill of the second-stage propellant tanks to the normal ullage to simulate fuel slosh in later vehicles. No ballast is to be added to the helium sphere, and as a result the vehicle is 300 pounds light. The stability of the vehicle has been examined for this condition and a very small improvement was evident.

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* P.V.R. No. 20, p. 3

† P.V.R. No. 20, p. 4

New trajectory and guidance system parameters have been established for the revised (4-pound) payload of TV-3. A complete analysis was necessary since both aerodynamic and structural transfer functions have changed as a result of the 200-pound weight reduction. The analysis has shown, as yet, no large change in the stability of the vehicle. A somewhat steeper trajectory was achieved to take advantage of the increased third-stage velocity increment. The revised pitch program contains three rates, and the program timer settings have been established for these. New constants have been derived for the coasting time computer and a study has been made to determine the effect of a fixed firing time for the third stage. The results of this study indicate that some advantage might be gained for a vehicle with less than the minimum performance expected from TV-3. At present, the third-stage firing time for TV-3 is based on an active coasting time computer.

An analysis has been started to derive a transfer function for the Vanguard vehicle including propellant sloshing effects and aerodynamic terms. An improved correlation of the theoretically derived and experimentally measured first-stage frequency responses has been achieved by revising the gimbaled-engine inertial term and deriving a representative induced-hydraulic-leakage coefficient. A preliminary analysis has been made of the damping of gimbaled engine motion by the engine exhaust stream, and the results indicate that the terms are negligible for both first and second stages.

During the combined controls and electrical systems mockup test, which now has been completed, it was found that the shutdown of the second-stage hydraulic pump motor* introduced a transient in the controls system. However, the transient was of short duration and analysis showed that the jet system could effect the necessary correction. The shutdown of the pump motor is necessary to conserve the second-stage battery power.

Guidance

The use of modified shockmounts on the fifth gyro reference unit has proved unacceptable owing to excessive drift rates at vibration frequencies between 38 and 42 cps. It is planned, therefore, to continue use of the type of shockmounts employed on the first four units. One of the two units returned to the supplier† has now been accepted and the second is still undergoing laboratory checkouts. The unit for TV-4 is scheduled to be delivered to The Martin Co. before 6 September.

Attitude Control

Since the Vickers magnetic amplifier autopilot is still unqualified,† the electronic autopilot built by The Martin Co. as a backup has been released to manufacturing and the present plan is to use it in all satellite launching vehicles. Electronic autopilots are now on hand for all vehicles through TV-5. Two magnetic amplifier autopilots are also on hand, but no test program will be initiated until this equipment has been completely qualified.

The seal material for the first-stage roll-jet assemblies has been changed from stainless steel to aluminum bronze. These assemblies have been requalified, and an improvement in their response time was noted.

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* P.V.R. No. 20, p. 4

† P.V.R. No. 20, p. 5

A re-evaluation has been made of the requirement for helium augmentation of the first-stage roll control system at engine cutoff. This was desirable because the second-stage separation time and sequence had been shortened to conform to recent first-stage thrust-decay information obtained from G.E., and a possibility therefore existed that the helium requirement could be eliminated. However, since the loss of roll control would coincide with the maximum disturbing moment from turbine deceleration, the helium augmentation is still considered necessary during separation.

A "live" test of the first-stage gimbaled-engine hydraulic servos has been conducted during a static firing of the engine. Analyses of the results showed that the control system performed satisfactorily.

The roll control test on the second-stage dynamic mockup is now scheduled to begin on 10 September. The major delay has been the shortage of proper propane gas handling equipment.

Flight Program and Staging

A total of four launching vehicle program timers has now been accepted and eight others have been returned to Designers for Industry, Inc. for reworking. Delivery of three timers every two weeks has been promised, starting 3 September.

In the flight of TV-1 (1 May 1957), an excessively high spin acceleration was imparted to the prototype third stage (employed as a second stage in TV-1). This resulted in the completion of two revolutions prior to the end of spin-rocket burning. At two revolutions the third stage is freed to move longitudinally off the spin table. In TV-1, the third stage was connected to the instrumented nose cone by an upper bearing assembly which employed a spring to compensate for thermal stresses, and this spring would tend to pull the freed third stage off the spin table. In point of fact it is not known whether (or when) this occurred in TV-1, and thus the spin rate of the third stage is uncertain; only the spin rate of the table is telemetered.

In subsequent vehicles, including the satellite launching vehicles, no instrumented cone and spring device will be employed. Thus under normal conditions the freed third stage should not leave the table until the retro rockets are ignited by the separation signal, after the end of spin-rocket burning. However, unforseeable forces conceivably could cause it to leave prematurely; the table, if still under acceleration, might thus impart tip-off movements to the third stage. Such disturbances could cause a damaging collision during separation, or could deviate the third-stage trajectory, or both.

To solve this problem the spin rockets of TV-3 are being canted 20 degrees outward from their original tangential orientation. This reduces their torque enough to bring the final spin rate down to the design value and to ensure that third-stage release (at 2 revolutions) will not occur until the end of spin-rocket burning.

Analysis of the results from the first-second stage separation mockup test* indicates that no excessive impulses are to be expected from explosive bolt action during separation. Equations and programming have been completed and computer runs have been started on a study of first-stage separation based on delayed ignition of the second-stage engine. In light of recent information from G.E. on the thrust decay of the first-stage engine at shutdown, the first-stage separation sequence has been altered to provide a reduced separation interval.

*P.V.R. No. 20, p. 6

THE SATELLITES

DESIGN, STRUCTURE, AND ASSEMBLY

Group 1 Satellites

All testing on Group 1 prototype Satellite B has been completed. Satellite C, the final Group 1 prototype, is now undergoing vibration tests.

The three Group 1 flight satellites have been coated with silicon monoxide. However, some undesirable discolorations have appeared beneath the coating, particularly on the first satellite coated; an example is shown in Fig. 1. These spots are apparently due to some step in the electroplating process. The problem of removing and avoiding them is under study.

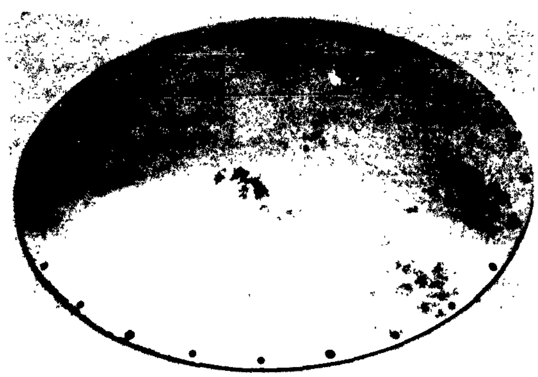

Fig. 1 - Disclorations under silicon monoxide coating on cover plate of Group 1 flight satellite

The pressurized internal instrument container for the Group 1 satellite has been tested to determine its ability to withstand the pressure buildup due to battery gasses. The initial pressure of the sealed container at room temperature was 14.1 psig. Then, during approximately 500 hours in an oven at 64.5°C, the pressure in the container increased from 20.3 psig to 26.3 psig. When the container was returned to room temperature the pressure was 18.5 psig, or 4.4 psi above the initial pressure. From the results it was concluded that the container will withstand the anticipated flight conditions without a pressure relief valve.

Group 2 Satellites

Additional vibration tests have been performed on the fully instrumented aluminum Group 2 prototype satellite. The separation mechanism, however, was replaced by a stainless steel sleeve. No failures occurred when the satellite was vibrated through the first two test levels,* but during the horizontal vibration at the third level (20 g) failures of the Kel-F base, all four Kel-F side supports, and the tubular internal structure of the satellite occurred (Figs. 2 and 3). At this time there was some uncertainty as to the level of vibration applied by the vibration table; moreover the satellite structure had previously undergone much vibration in the Group 1 testing with probable fatigue resulting, and the internal instrumentation package was about a pound overweight. A fatigued structure would of course not be used for a flight unit; nevertheless thicker structural and Kel-F members will be employed in future Group 2 satellites.

Group 3 Satellites

Drawings and specifications for the nonmetallic parts of the Group 3 satellite have been completed. These parts will be fabricated of Spiralloy by the Young Development Laboratories of Rocky Hill, New Jersey. Delivery of the first group of parts, which includes the top and bottom hemispheres, magnetometer support tube, and satellite base hub, is expected during the first week of October. The metallic components, such as the internal instrumentation container, antennas, etc., will be made at NRL.

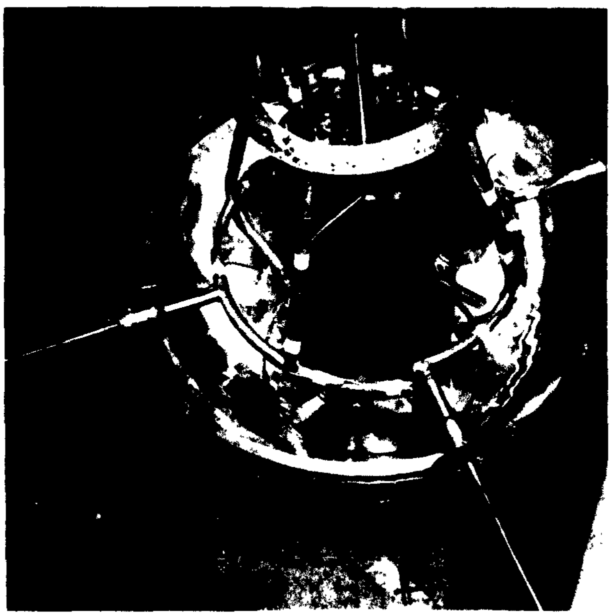

Fig. 2 - Failure of tubular structure and Kel-F side supports in Group 2 aluminum prototype satellite

* P.V.R. No. 17, Appendix A

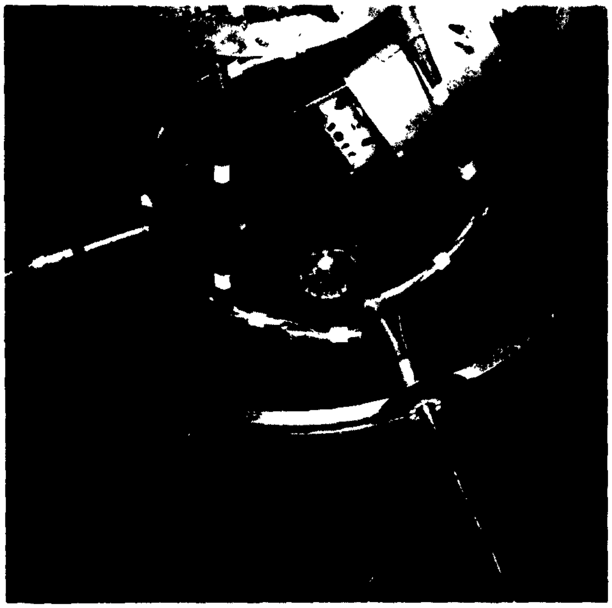

Fig. 3 - Failure of Kel-F base support in Group 2 aluminum prototype satellite

6.44-Inch Satellites

The six test models of the 6.44-inch satellite, and three of the planned six flight units, have been completed. The latter are still to be coated with silicon monoxide at Fort Belvoir. Production of these satellites is on schedule.

Further vibration tests on the 6.44-inch satellites have produced no structural failures. Acceleration tests will begin early in September with shortened antennas loaded to simulate the full-length antennas, which will not fit into the centrifuge.

Effects of Spin Rocket Exhaust

A second test has been performed to determine the amount of contamination of the satellite shell by the spin rocket exhaust products. This test employed the same arrangement and procedures as the original test conducted in June,* and the resulting deposit on the satellite and antennas was much the same. However, infrared spectral analysis of the antenna deposit did not disclose the silicone oil which was found in the first instance. It is presumed that the 300° F baking of the third-stage rocket case (which is coated with a silicone-base paint) precluded silicone oil deposition. Nevertheless, the weak emission spectrum of the deposit suggests an organic composition. Microscopic examination of the contaminated antennas disclosed a black substance in which small white crystals were dispersed. This deposit appears to be principally carbonaceous. Separate tests will be conducted to determine the composition of the satellite deposit, since it is not as dark as the antenna deposit.

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*P.V.R. No. 19, p. 8, and No. 20, p. 10

Satellite Separation Mechanisms

A vibration test has been conducted to establish the separation strap load needed to hold the 6.44-inch satellite in position. It was found that a load of 125 to 150 pounds at each end of the strap was sufficient to keep the sphere properly seated on the separation mechanism sleeve. Other vibration tests have been performed in which various separation mechanism designs were tested.

On the basis of the tests, analyses, and weight estimates, it was decided to have the Raymond Engineering Laboratories (REL) proceed with fabrication of one prototype and six flight units designed on the following basis:

1. Modification of the standard separation mechanism used for the 20-inch satellites, to reduce weight by removing unnecessary components.

2. Modification of the internal mechanism to prevent the explosive caterpillar motors from buckling.

3. Employment of a new strap arrangement for releasing the sphere.

4. Installation of small leaf springs, located at each of the three satellite-locating pins, to accomplish separation. If further tests prove this method is not sufficiently reliable, space is available for a coil spring.

The delivery schedule was agreed to by REL as follows:

1. The prototype will be delivered by 31 August.

2. The six flight units will be delivered by 18 September.

3. All explosive motors will be delivered by the end of August.

SCIENTIFIC EXPERIMENTS AND INSTRUMENTATION

Group 1 Experiments

The cadmium sulfide photosensitive type erosion gage has passed vibration, temperature, and vacuum tests without damage. Its response was decidedly sluggish at -20°C but returned to normal at room temperature. The time constants of the gage have been lengthened* to about 2 seconds for the transition from darkness into light and about 5 seconds for the transition from light into darkness. These time constants are long enough to give an integrated output which can be calibrated as a function of the size of the light-admitting holes. The response of a cadmium sulfide gage monitored through the telemetry system in Satellite C was satisfactory, and exact calibration of this gage is underway. Both the cadmium sulfide and chromium strip erosion gage will be used on the flight satellites. Chromium strip gages are now on hand for all satellites, and cadmium sulfide gages are on order.

The differential pressure gages for the meteor penetration experiment were received at NRL in the spring of 1957 and passed the preliminary design thermal and vibration tests at that time. However, the pressure gages mounted in Satellites A and B failed during the

*P.V.R. No. 17, p. 13

vibration tests on those satellites, and another gage failed during a special vibration test at an rms acceleration of 20 g. The gage manufacturer has been apprised of this situation and steps are being taken to improve the design. Meanwhile, a test of the vibration transmissibility through the satellite stem on which the gage is mounted has revealed very high resonant levels. The feasibility of mounting the gages on shock-absorbing springs is being studied, but it may be simpler to relocate the gage on the central structural ring, where less violent resonance obtains. The latter solution is being tested in Satellite C.

Temperature gages (thermistors) are now on hand for all of the Group 1 satellites.

The Minitrack transmitter in Satellite C failed during the vibration tests, and the failure was traced to the power amplifier transistor. Although this transistor is of an older type and is less rugged than the transistors being used for the flight units, it had previously passed a more severe vibration test. There is no apparent prevention of this type of failure. It has been agreed, however, that since two identical transmitters, i.e., those in Satellites B and C, have withstood the second level of the vibration test program,* the design is qualified for satellite use.

The Minitrack transmitter for the first Group 1 flight satellite is complete, and transmitters for the second and third are under construction. The telemetry encoder, Lyman-alpha peak memory, and meteor collision detector electronic modules for the first flight unit are complete and are now undergoing electrical tests. These tests include temperature runs in which calibration curves are taken for each transducer at various temperatures from 0° to 60°C. Erosion and temperature gages have been installed in the first flight unit.

Group 3 Experiments

Electrical tests have been conducted on prototypes of the Group 3 satellite magnetometer by the manufacturer, Varian Associates. The signal-to-noise ratio exceeded expectations, and good proton-precession signals were obtained with the sensing head in a field as low as that believed to exist 1500 miles above the geomagnetic equator. However, with the sensing head located 1 foot from the electronics, as planned, a relay causes an error of about 15 gammas. Since a reading accuracy of less than 5 gammas is desired, steps are being taken to eliminate the interference. Checks of the overall system including the satellite transmitters and command receiver will begin about 20 September.

Environmental and lifetime tests have continued on the Zn-AgO batteries for the Group 3 instrumentation. The results to date indicate excellent reliability over the temperature range from -30° to 60°C at low drain rates, and from 0° to 60°C at the 7-ampere drain rate used for polarization power. The battery characteristics have been unaffected by vibration. Tests of the pressurized battery can have demonstrated that a pressure relief valve must be employed.

The first ground station magnetometer system has been completed except for installation of the sensing head, which will be delivered by 6 September.

A developmental model of the rf system for the magnetometer satellite has been completed. The 10-milliwatt tracking transmitter will be powered by silver cells, and the frequency-controlling crystal will have a temperature coefficient of minus one part per million per degree centigrade to provide a measurement of the temperature of the satellite

*P.V.R. No. 17, Appendix A

internal package. The 80-milliwatt telemetering transmitter will be turned on by ground command. The command receiver, the two transmitters, and the network which connects both transmitters and the receiver to the turnstile antenna array have been constructed on a chassis 8-1/2 inches in diameter and 1-1/4 inches thick. The unit has been tested over a wide temperature range and is now ready for the magnetometer system tests which will take place in September.

The preliminary antenna design tests indicated that a 25-1/2 inch antenna on the magnetometer can would provide a 50-ohm antenna impedance without matching circuits. More detailed tests and a final design will be completed when a mockup of the magnetometer can becomes available.

Group 4 Experiments

A bench model of the rf system for the Group 4A (radiation balance of the earth) satellite has been completed and tests are now being conducted to integrate the telemetering transmitter with the sample premodulator circuit received from the University of Wisconsin. This equipment will soon be shipped to the University for system tests in their laboratory.

6.44-Inch Satellite Experiments

During August five solar-powered and seven battery-powered Minitrack transmitters for the 6.44-inch satellites were constructed. Each of these was adjusted for optimum performance, and a temperature-frequency curve for each was obtained over the range from -20° to +80° C in a laboratory environmental chamber. The temperature coefficient of frequency is approximately minus one part per million per degree centigrade for all 12 transmitters. About 40 antennas for these satellites, employing lightened Teflon supports for the spiral matching coils, have been matched to 50 ohms ±1 ohm. The antennas for the first two flight units have been completed.

The antenna phasing network consists of a matched lumped-constant phase-shift circuit built up on a fiberglass terminal board, potted for mechanical stability, and mounted inside the sphere behind the three lower solar cell patches. These circuits provide a voltage standing-wave ratio of about 1.04 for the battery-powered transmitter and about 1.06 for the solar-powered transmitter. Networks have been completed for the first two flight units.

Solar cell deliveries are on schedule, and the solar cells for the first two flight units are on hand.

Preliminary design vibration tests have been run on a fully equipped developmental model of the 6.44-inch satellite with a photoflood light energizing the solar-powered Minitrack transmitter. Both transmitters performed satisfactorily during and after vibration through the third level of the recommended vibration test procedure.*

The first prototype 6.44-inch satellite has undergone the required design tests. The operation of the solar-powered transmitter during the thermal tests was satisfactory over the temperature range from -20° to 60° C. The accuracy of the temperature measurement obtained from the transmitter frequencies was well within the required ±20° C, producing an excursion of about ±2°C in the internal package. The measured thermal-lag

* P.V.R. No. 17, Appendix A

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6.44-Inch Satellite Experiments

During August five solar-powered and seven battery-powered Minitrack transmitters for the 6.44-inch satellites were constructed. Each of these was adjusted for optimum performance, and a temperature-frequency curve for each was obtained over the range from -20° to +80°C in a laboratory environmental chamber. The temperature coefficient of frequency is approximately minus one part per million per degree centigrade for all 12 transmitters. About 40 antennas for these satellites, employing lightened Teflon supports for the spiral matching coils, have been matched to 50 ohms ±1 ohm. The antennas for the first two flight units have been completed.

The antenna phasing network consists of a matched lumped-constant phase-shift circuit built up on a fiberglass terminal board, potted for mechanical stability, and mounted inside the sphere behind the three lower solar cell patches. These circuits provide a voltage standing-wave ratio of about 1.04 for the battery-powered transmitter and about 1.06 for the solar-powered transmitter. Networks have been completed for the first two flight units.

Solar cell deliveries are on schedule, and the solar cells for the first two flight units are on hand.

Preliminary design vibration tests have been run on a fully equipped developmental model of the 6.44-inch satellite with a photoflood light energizing the solar-powered Minitrack transmitter. Both transmitters performed satisfactorily during and after vibration through the third level of the recommended vibration test procedure.*

The first prototype 6.44-inch satellite has undergone the required design tests. The operation of the solar-powered transmitter during the thermal tests was satisfactory over the temperature range from -20° to 60°C. The accuracy of the temperature measurement obtained from the transmitter frequencies was well within the required ±20°C, producing an excursion of about ±2°C in the internal package. The measured thermal-lag

* P.V.R. No. 17, Appendix A

time constant of the internal package is about 1/2 day. Therefore the effects on this package of aerodynamic heating during ascent will be negligible. The doppler shift of the battery-powered transmitter will give a correction for the temperature of the heated shell as well as a measure of the final velocity of the third-stage rocket.

The measured absorptivity-to-emissivity ratio of the assembled satellite is approximately unity when the emissivity is 35 percent for the sphere and 25 percent for the antennas. This should provide a colder-running satellite than the Group 1 scientific satellite. Since the lower temperature requirement is no longer determined by the mercury batteries, advantage can be taken of the -20° C lower limit of the solar-powered transmitter. Good agreement has been obtained between calculated and measured values of the satellite thermal parameters; therefore the flight units will be coated to provide an emissivity of 35 percent for the sphere and 25 percent for the antennas. The temperature measurements of this test sphere in orbit can be used to predict more closely the equilibrium temperature of the 20-inch scientific satellites.

Vibration tests on the first prototype were run with the coated sphere secured by a strap to the first prototype separation mechanism. The vibration caused variation in the output of the solar-powered transmitter, and when the sphere was opened for inspection no output was obtainable from this transmitter. It was found that the transistor had failed, presumably from the vibration. This transmitter and all antennas were replaced and the test was continued without further difficulties through the second level of the vibration test procedure; sinusoidal tests were also included. Another prototype must pass this same vibration test to qualify the design of the test sphere.

The original schedule provided for the completion of the prototype test program before assembly of flight units so that corrections necessitated by prototype failure could easily be incorporated in the flight units. Delays have been encountered in every phase of the testing of the first prototype and at present it is about two weeks behind schedule. The assembly of flight units was begun on schedule even though the prototype tests had not been completed. The first flight unit is now complete and it is expected that acceptance tests of the flight units can be completed as scheduled.

ELECTRONIC INSTRUMENTATION

GENERAL

The elimination of the instrumental nose cone from TV-3 has removed the necessity for some instrumentation, while the remainder has been relocated. The attitude-sensing gyro unit has been deleted. A pwm/fm transmitter which would have monitored the attitude as well as various performance and environmental functions, is therefore not needed; the regular pwm/fm transmitter is still required in the second stage, however. A longitudinal accelerometer which was to sense the third-stage acceleration has been relocated in the second stage and will be monitored there through the pwm/fm system. The T-11 Dovap transponder has been relocated in the second stage, which also carries a C-band AN/DPN-48(XE-1) radar beacon.

An electronic instrumentation Operations Manual is being prepared. It will include the following:

1. Physical configuration drawings and weights of all vehicle-borne electronic equipment.
2. Schematics and wiring diagrams.
3. Specifications and operating descriptions.
4. Test procedures.
5. Inventory and block diagrams of all ground stations under the auspices of the Vanguard Electronic Instrumentation Group.
6. Complete list of all test equipment.

TELEMETERING

PPM/AM Systems

Three more AN/DKT-7 ppm/am telemetering transmitters have been delivered by the James Spivey Co., making a total of 19 to date. Six more will complete the contract.

Two AN/DKT-7 transmitters have been returned to NRL from the field for the structural modifications which are being made in all of these transmitters. The modifications are the result of vibration tests.

PWM/FM Systems

Two additional pwm/fm telemetering transmitters have been completed and are now undergoing environmental tests. The flight transmitters for all vehicles through SLV-1 have now been delivered to The Martin Co.

An ac filament-power supply for the pwm/fm transmitters has been successfully tested in open-loop operation with a pwm/fm ground station. The use of this device will eliminate a diode rectifier and several other components and reduce the power loss in the transmitter.

The first transistorized main power supply for the pwm/fm transmitter has performed satisfactorily in horizontal vehicle instrumentation tests by The Martin Co. If all pre-flight tests of this unit show favorable results, the unit will be flown in TV-3, providing an earlier flight evaluation than had been planned.

FM/FM Systems

Four additional transistorized power supplies are being fabricated for the fm/fm telemetering transmitters. The success of this lighter and more efficient power supply has led to a decision to use it in all flight fm/fm transmitters.

A trailer has been wired and will shortly be shipped to the field to house the second fm/fm ground station obtained from the Bureau of Aeronautics. The station will be located at the Vanguard telemetry pad at AFMTC.

VEHICLE TRACKING

Two additional S-band and one C-band AN/DPN-48(XE-1) radar beacons have been delivered to NRL by Melpar, Inc.

A proposal has been submitted to Melpar for the following changes in procedure:

1. Melpar would provide a service engineer for the beacons.
2. All acceptance tests would be conducted at the plant under the surveillance of an NRL representative.
3. All S-band beacons would be converted to C-band at the plant before delivery.

RANGE SAFETY

The contract with the Connecticut Telephone and Electric Co. for AN/ARW-59 command receivers and transistorized decoders has been terminated because that firm could not meet the required delivery schedule. Arrangements are being made for production of these equipments at NRL.

THE MINITRACK SYSTEM

The Blossom Point Minitrack Station is now complete and calibrated.

The Fort Stewart Station is complete and checked out and will be calibrated early in September; a complete Army crew is on board. Diesel generator trouble at this station requires replacement of some units.

The Havana Station will be complete, including antenna installation, by the second week in September. Alignment of the antennas is scheduled for late September, and system calibration for early October. The electronic checkouts have been completed and radio-star tracking operations are scheduled for mid-September. An additional diesel generator is required at this station to provide power for the building air conditioner. All station personnel are on board.

The Quito Station is complete, including electronic checkouts and antenna alignment. The initial radio-star tracking operations were carried out on 24 and 25 August; this is believed to be the first radio astronomy ever undertaken in South America. All personnel are on board, and communications are expected by the latter part of September. Frequent earthquakes are felt at this station, which is located on the slopes of Mount Cotopaxi, an active volcano.

The Lima Station is complete including electronic checkouts. Alignment of the antennas will be completed by the first week in September, and radio-star tracking operations will begin at that time. All personnel are on board, and communications will be established by about 1 October.

The Antofagasta Station is nearly complete. The antenna installations will be finished by the second week of September, and alignment by the third week. The electronic check-out team from NRL will arrive about mid-September. Temporary living arrangements (this station is located on the Chilean desert nitrate region) are very adequate. All personnel are on board and communications will be established by about 1 October.

The Santiago Station is incomplete pending the return of the erection crew from Antofagasta to replace some rf feed lines crushed during shipment. The schedule presently calls for electronic unit operation by mid-September, and complete station operation by 1 October. All personnel are on board, and communications will be established by about 1 October.

The San Diego Station is complete, and an initial calibration was made on 11 August. A final calibration must still be made. Communication will be established by 1 September.

The Antigua Station is complete including electronic checkouts. Final alignment of the antennas, which is being delayed while an accurate survey is completed by the Army Map Service, is scheduled for mid-September. Seven Yagi antennas looking west of north (338 degrees true) and four looking east of north (25 degrees true) will be installed during September to increase the coverage provided by the regular Minitrack antennas and to provide triangulation with the Grand Turk Station in place of the cancelled Mayaguana Station.*

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*P.V.R. No. 20, p. 15

The Grand Turk Station has been modified to provide two 7-Yagi antenna fields aimed respectively at 354 and 55 degrees true. The construction of the final antennas and the arrival of the electronics trailer are scheduled for early September.

Transportation difficulties are hampering operations at all the South American stations and the Cuban station. This problem should be eliminated by the arrival of Army Map Service vehicles at these sites by mid-September.

The equipment for the Woomera, Australia Station (to be operated by that country) arrived at Woomera on 14 August. All operations there are progressing satisfactorily and an operational date of 1 October is being sought. The communications link will be provided by the U.S. Navy from Washington, D.C. to Hawaii, but the link from Hawaii to Australia has not yet been arranged.

DATA PROCESSING

TELEMETERED DATA

Radiation, Inc. (Orlando) delivered the Digital Data Recording System van of the Automatic Recording and Reduction Facility (ARRF) to the NRL Telemetry Pad at Cape Canaveral on 10 August. Various difficulties were encountered both in the recording system and in connecting it to the telemetering ground stations there. A number of ppm/am digital data recordings were made during pre-static tests of TV-2, although there was some difficulty in obtaining suitable subcommutator synchronization signals, which are essential for ppm/am subchannel selection in the data reduction process.

With the exception of the linearizer and its associated paper tape punch and decimal printout equipment, the Digital Data Reduction System was placed in operation at Orlando during August. New sense amplifiers have been built and installed in the linearizer, but additional equipment faults must be corrected. Replacement of mechanical stepping switches is expected to eliminate most of the faults apparent at present. The RCA engineers working on the linearizer estimate that the linearizer will be operational by October 1957.

ORBITAL DATA

Whenever real-time orbit calculations are to be made, the Vanguard Computing Center (Washington, D.C.) will use the facilities of the IBM Research Computing Center (Poughkeepsie, New York) for standby purposes. The primary IBM 704 computer in Washington will be connected to the secondary IBM 704 computer in Poughkeepsie by transceiver link. It is planned to use the secondary computer only in case of failure of the primary system.

The IBM mathematicians have continued work on various subroutines to complete a satisfactory program for orbit computations by the middle of October 1957. It is expected that these programs will be checked out with simulated observations before the flight firing of TV-3.

THIRD-STAGE FIRING PREDICTION

On 13 August 1957 the AN/FPS-16(XN-1) radar at Patrick Air Force Base tracked the TV-2 vehicle beacon successfully. Final radar antenna alignment cannot be accomplished until the boresight tower installation has been completed. Owing to delays caused by the weather and mechanical problems, only the first half of the boresight tower was erected by the end of August. Permanent power to the XN-1 site was installed the last week in August. The optical digital encoder which was damaged during shipment of the XN-1 has been replaced; the radar will be ready for tracking TV-2 when launched.

The radar synchronizer chassis has been added to the AN/FPS-16(XN-2) radar at Grand Bahama Island so that both the XN-1 and XN-2 radars can track the C-band beacon in the vehicle without mutual interference. The XN-2 radar has been given its final checkout by the RCA (Moorestown) engineers and is ready for the operational acceptance tests to be conducted by AFMTC early in September. The temporary target assembly installed on the XN-2 boresight tower will be replaced by the permanent equipment in the first part of September to complete the whole XN-2 system installation. It is expected that this radar will be accepted by AFMTC prior to 1 October.

Despite the delay in the launching of TV-2 (see Range Operations), it does not appear that digital impact prediction will be available for this firing. At the end of August, the scheduled completion date for the data transmission cable from the XN-1 site to the IBM 704 computer at Cape Canaveral was the middle of September. The planned completion date for installation of all equipment associated with digital impact prediction and the third-stage firing system is early October.

The Milgo Electronic Corp. (Miami) delivered the digital data transmitter for the XN-1 radar in the middle of August. The equipment was operated with the radar on a temporary basis, and a satisfactory magnetic tape record was made of the output of the radar. The transmitter was returned to the contractor's plant to facilitate checkout of the digital data receiver to be installed at the IBM 704 site.

The impact prediction program set up by AFMTC for possible use with the XN-1 radar during the TV-2 firing was checked at the end of August by running it on the 704 computer at Cape Canaveral with simulated radar data obtained from AZUSA data recorded during a missile firing. The impact-prediction plot obtained on the plotting board for the simulated data was very nearly superimposed on a plot obtained from the AZUSA data run through the computer immediately beforehand. Simulated data are now being prepared for checking the impact-prediction program for the expected TV-2 trajectory with simulated XN-1 radar tracking errors present.

An alternate approach to the third-stage firing prediction is being programmed and will be compared with the first method, now being completed at AFMTC, to determine which program will be used for the launching of TV-3. The comparison will be made by using simulated radar input data to represent a vehicle firing.

RANGE OPERATIONS

Owing to a series of difficulties in the field, it has been necessary to postpone the launching of TV-2.

At the beginning of August the operational schedule called for a propulsion pressurization system test on 6 August with liquid nitrogen in the liquid oxygen tank to simulate the required temperature conditions. This test had to be rescheduled for 7 August because a lack of ground equipment prevented acceptable drying of the tanks. On 7 August the test was run but a failure of the main helium regulator cancelled all pressurization aspects of the test, and it was rescheduled for 10 August. On that date the test was run again, but the hydrogen peroxide system check had to be deleted because the peroxide vent valve failed to close. It was then decided to incorporate the entire test into the static firing operation.

The static firing had been scheduled for 14 August, but owing to the accumulated delays it was rescheduled for 22 August, and the combined pre-static instrumentation and vertical functional test was performed on 14 August. The attempt to static-fire on 22 August was cancelled after 7 hours of delays due to an inoperative liquid oxygen vent valve, and rescheduled for 26 August. On that date an operational error resulted in a flow of liquid oxygen into the thrust chamber and down into the flame deflector tube in the firing stand. The flame deflector was cracked and it was considered highly probable that the engine had been damaged as well; therefore it was decided to replace the engine. Fortunately, engine S/N-6 was on hand as a replacement engine for the TV-2 backup vehicle, and the installation of this engine in TV-2 was completed on 28 August. The static firing was then scheduled for 3 September; repairs to the flame deflector were already underway. The launching operation can be carried out about 10 days after a successful static firing.

The TV-2 backup vehicle was shipped to the field on 5 August, and the hanger check-outs on this vehicle are underway so that, if necessary, it can be erected on the firing stand immediately after the flight of TV-2. Another X-405 engine is being shipped to replace the present engine in this vehicle, since it has a leaky liquid oxygen system. The replacement will be made by the first week in September.

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