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⑥ **PROJECT VANGUARD REPORT NO. 13**
PROGRESS THROUGH JANUARY 15, 1957

[UNCLASSIFIED TITLE] ⑧

Project Vanguard Staff

342883L

⑪ February 7, 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, ~~1956~~
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An administrative report is presented of
work progress on

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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 January 29, 1957

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PROJECT VANGUARD REPORT NO. 13
Progress Through January 15, 1957

[Unclassified Title]

THE LAUNCHING VEHICLE

CONFIGURATION AND DESIGN

Windtunnel tests have been concluded with the M. I. T. low-speed facility on several spoiler configurations to obviate the effect of the Von Karman vortex-shedding phenomenon on the launching vehicle during the prelaunch period.* The most satisfactory configuration tested consists of a spiral arrangement of rubber strips 1-1/2 inches high about the second-stage circumference. A complete spiral consists of 5 strips, each 51 inches long; there are two spirals, making 10 strips in all. This configuration is the only one tested which gave satisfactory performance for all angles of attack at the critical wind velocity. However, while it does prevent the buildup of vortices at the structural resonant frequency, it also adds to the flat plate area of the vehicle and therefore to the lateral force on the vehicle due to ground winds. The Glenn L. Martin (GLM) Stress Group is studying the new running loads as determined by the M. I. T. tests to ascertain the maximum ground winds which the vehicle can withstand: it is expected that the allowable launching wind velocities will be lowered somewhat. A new study of launch-stand clearance will be made to determine the effect of the spoilers in this problem.

Separation of the spoilers is accomplished by attaching rubber cups to the forward end of each spoiler. The cup is designed to create a drag at approximately 100 fps equal to the bonding power of the adhesive holding the cup and the spoiler to the vehicle. As the missile velocity increases beyond this point the spoiler should peel off.

Present plans call for these spoilers to be installed on TV-2, assuming that the ground wind limitation studies do not prove them to be undesirable.

NRL has conducted an investigation of a highly reflective white paint for use on the third stage of the launching vehicle to facilitate optical tracking. Tests have been conducted on both stainless steel and fiberglass of the types used by the third-stage subcontractors. An acceptable paint has been found that will adhere to the stainless steel, can be applied easily, and produces a reflectivity of 90 percent. The total thickness of the primer and paint is 2.5 mils, of which the primer undercoat is 1 mil and the paint outercoat is 1.5 mils, producing an estimated total additional weight of 0.8 pound on a surface area equal to that of the third stage. Initial tests of a coating on fiberglass have shown that additional work will be required to eliminate cracking after exposure of the specimens to the maximum environmental temperature of 250°F for 5 minutes. In order to obtain a true weight estimate and test of the paint's durability under firing conditions, samples of the primer and paint are being shipped to GCR for application to the rocket; the rocket will be weighed prior to and after application of the paint. Specimens of the case of the fired rocket will then be sent to NRL for measurements of the reflectivity of the coating.

*P.V.R. No. 12, p 3

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PROPULSION

First Stage

Five firings of production engine P-4 were conducted during this report period. Following two 50-second calibration runs of this series, a full-duration (150-second) firing was attempted but terminated in a premature shutdown at 105 seconds caused by a burn-through of the inner chamber wall. The injector and chamber were removed and replaced with new units which were immediately fired for full duration. A second full-duration firing was then attempted following this successful run, and although the test continued for the required 150 seconds, a burn-through of this second chamber was observed during a post-firing inspection. The records indicated that the failure occurred after 140 seconds. Following these failures of P-4, testing and fabrication at GE was stopped and GE was asked to submit proposals for preventing further chamber scoring and burnouts. A series of meetings were held subsequently to examine improvement proposals submitted by GE of which the most suitable are as follows:

1. Ceramic coating of the inner walls of the thrust chamber.
2. Testing of available backup hardware of overall design different from the present X-405 — mainly "spaghetti" type (tube bundle) thrust chambers.
3. Modification of the present chamber for better cooling by the addition of copper-cooling fins or wires within the present chamber wall tube helices.

Secondary proposals were: removal of plating from the inner chamber walls, addition of fuel-wetting agents for heat transfer improvement, and complete chamber redesign. These were discarded as not effective, untried, and/or time consuming. Following the second burnout of P-4 the GE proposals were reviewed and no. 3 was chosen as the approach with the most merit. No. 1 will be tried as a second-order approach pending more information. No. 2 was found to impose serious schedule delays.

Work has been initiated on these proposals, and design-modifying results are expected in February. Delivery of the first copper-fin-insert motor is anticipated in late January, and preliminary test results should be available shortly thereafter.

Modifications have been made on the tanks of test pit no. 3 at the GE Malta Test Station to allow thrust-chamber tests to be made for 150 seconds, thus providing a second pit capable of full-duration tests.

GE tests on oxidizer seals with 20-30 percent fluorine-oxygen mixtures* have been completed. All rotary-pump seal materials and most of the static seal materials which were tested proved satisfactory. One static lip seal made of Neoprene showed some erosion when exposed to the F_2 -lox flow at a pressure of 700 psi. However, the materials picture is encouraging and it is now known that the GE engine complex can be subjected to 20-30 percent F_2 -lox without any deleterious effect and without major changes of the seals. GE has submitted a proposal covering an advanced F_2 -lox program with the X-405 engine.

The NACA has completed about ten firings[†] during this report period, with 20-30 percent F_2 -lox in the 5000-pound (X-405 scaled version) thrust chamber. Specific impulses (at frozen equilibrium) of about 262 seconds were obtained at rather rich mixture ratios.

*P.V.R. No. 10 pp. 5-6; No. 11, p. 4; and No. 12, p. 5

†P.V.R. No. 10, pp. 5-6

At the stoichiometric ratio (about 2.6 - 2.8) the kerosene-F₂-lox propellant combination has a potential specific impulse of approximately 268 seconds. NACA was able to contain the heat flux developed by the F₂-lox combustion.

With the first phase of the F₂-lox performance improvement program now completed, a review meeting will be held at the NACA on 23 January. This meeting will also determine the technically optimum future course.

NACA has submitted a research memorandum (R. M. E 56 × 28) entitled "Analysis of Fluorine Addition to the Vanguard First Stage." This report contains an elaborate analysis of the F₂-lox potential. It also emphasizes that JP-X fuel (45 percent JP4, or kerosene, and 55 percent unsymmetrical dimethyl hydrazine[§]) will yield a considerable improvement over JP4 at a mixture ratio close to the present first-stage oxidizer/fuel ratio of about 2.2 - 2.4.

Second Stage

During this report period the Aerojet General Corporation (AGC) continued firing tests with two units of the 72-pair impinging-jet injector which has been adopted as the production model.[†] This type of injector, incorporated in the first deliverable thrust chamber, had consistently exhibited C* (characteristic exhaust velocity) values in excess of 5000 fps; however, during this report period C* values obtained from the injectors tested were below that figure. The average performance values of 17 acceptance tests with 6 injector assemblies were: C*, 4850 fps; chamber pressure, 206 psia; mixture ratio, 2.76. Two tests were run using white inhibited nitric acid (WIFNA) to check performance, yielding the following values: chamber pressure, 207 psia; 4950 fps; mixture ratio 2.70. Five tests were made with a modified injector in an attempt to improve performance, and the following average values were obtained: chamber pressure, 207 psia; C*, 4890 fps; mixture ratio, 2.74.

Progress has been satisfactory in the fabrication of thrust chambers, with several thrust chambers completed during this report period; four of these were deliverable units.

Because of the repeated difficulties with tank assemblies reported in the last few months,[‡] a program of more rigid surveillance of welding and heat treating was instigated by AGC and the present opinion is that the tanks now in production will be satisfactory. Parts of the tank assembly for propulsion unit no. 1 have been satisfactorily hydrotested, and the propulsion units should be delivered in time to meet the launching schedules. In an effort to provide an alternate source, the A. O. Smith Co. will submit proposals for a parallel tank fabrication program; at the time of the initial discussions they expected to complete the first tank in April, if fabrication began immediately.

Tests on second-stage nozzle closure diaphragms** have been conducted, with favorable results from a chem-milled type; other designs have been eliminated. The chem-milled type is expected to burst at a pressure of 25-40 psig.

[§]The fuel now used in the second stage

[†]P.V.R. No. 10, p. 6; No. 11, p. 5; and No. 12, p. 5

[‡]P.V.R. No. 10, pp. 7-8, and No. 12, p. 5

**P.V.R. No. 12, p. 5

Third Stage

Allegany Ballistics Laboratory:

The Allegany Ballistics Laboratory (ABL) has fired both heavy-walled steel and light-walled fiberglass chambers. The heavy-walled steel chamber firings have served mainly for ballistic or combustion data. Run no. 14, at the end of this report period, was the first successful run of the series, with a duration of 37 seconds and the required total impulse. Some evidence of instability near burnout was noted. ABL hopes to cure this by eliminating the extra cellulose acetate insulation between the cast charge and the silica rubber insulation.

The ABL flight rockets will have two chamber-pressure sensing taps in the aft end; one will be active and useable for pressurizing the chamber, and the other will be a dummy for balance.

No difficulties have been encountered with the igniter-and-closure ignition system, and the 15-second delay is within the specification tolerance. No lengthy ignition or combustion delays and no undue starting transients have been observed: the durations of several "pips" observed on ignition starting records were too short to be considered deleterious. The igniter used with this system consists of boron and potassium nitrate, and weighs 145 grams. Tests of ignition in vacuo will be made shortly, with an exhausted Talos chamber as a receiving tank.

The dynamic balancing device is being serviced to correct some difficulties with the instrument transducers, but is expected to be operable shortly. The machine used for weighing the rockets before firing and immediately on cessation of chamber pressure to provide a realistic total impulse figure, was damaged in the explosion of a test chamber and is also undergoing repairs.

The duration of the prequalification test program is expected to be about 28 days, lasting until the 3rd week of February. ABL's vacuum specific impulse is still about 248-250 seconds.

Grand Central Rocket Company:

The Grand Central Rocket Company (GCR) began prequalification testing of their rocket in mid-December. To date two tests have been completed: the acceleration load test and the environmental (rain, salt, and humidity) test. The scheduled endurance vibration test has not been completed because of an ignition reliability problem which arose during the initial static tests of the first two prequalification rockets: a pressure peak appeared on the pressure-time trace. This was due to the fact that the propellant type igniter broke up before being consumed. Auxiliary igniter tests are being conducted to resolve the igniter problem before further prequalification tests are performed. Vacuum ignition tests are now planned, pending modification of the present igniter.

Inspection revealed a crack in the propellant grains after one of the low-temperature cycling tests. Two more cycling rounds are to be inspected for cracking, and if no cracks occur GCR will not be required to perform the cycling tests again.

Progress in static test instrumentation has been made by GCR with the help of the NRL instrumentation personnel. The latest static test data show correlation between measured static thrust and measured chamber pressure to within 1 percent.

GCR now anticipates completion of the prequalification tests in the last week of January.

FLIGHT CONTROL

Guidance

Reference System

Minneapolis-Honeywell has recently reported some difficulty in meeting gyro drift requirements in the presence of specified vibration even with the use of the matched shockmounts.* The vibration test specification now requires that the vibration be at a level of 0.9 g up to 60 cps, and at 4.2 g above that frequency. If the 0.9-g vibration were extended to 80 cps, the drift would probably be limited to an acceptable amount. In addition, Minneapolis-Honeywell has indicated that they require a relaxation of the overall pitch error requirement from 0.5 degrees to 0.75 degrees, at least for the first 4 units. They have requested a specification change covering the above items as well as several minor items. Qualification testing of the first production reference system has been completed and the unit will be delivered shortly.

Attitude Control

Structural resonance is a major problem area.† Under this category fall two separate problems. One is the necessity of stabilizing the structural feedback loop; the present autopilot characteristics are inadequate to accomplish this, and a modification of the autopilot filter appears necessary. A presently proposed modification is the use of a double-notch filter tuned to approximately 60 and 100 radians per second to eliminate the high-frequency instability, plus a lag filter to eliminate the low-frequency instability. The second problem, which is much more serious, is the extremely low amplitude of engine oscillation that the present structure can safely withstand at the structural resonant frequency of 3.3 cps. The present estimate of the control-system noise at 3.3 cps is approximately 0.1 degree, which exceeds the structural limit. Some strengthening of the structure appears necessary to increase the allowable engine deflection at the resonant frequency. Additional control-system filtering may also be necessary to decrease the control-system noise.

Vickers, Inc. recently encountered a crosstalk problem in the magnetic amplifier which was solved by using two tripler supplies, one for the signal stages and one for the power stages. One remaining problem, which is not too serious, is a 10-percent variation in the jet amplifier static pull in-point (the point at which the jets will be fired) with specified variation in power-supply voltage and frequency. The specified tolerance is 5 percent.

Qualification testing of the autopilot should be finished by the end of January. The first production unit (not qualification tested) is being shipped. However, since the present filter is inadequate for correcting the structural instability discussed above, the magnetic amplifier units will have to be revised to include the required filter characteristics as soon as these are determined from studies of the structural transfer function on TV-2.

Flight Program and Staging

The results from the nose-cone jettison tests conducted at GLM during the last period‡ were not conclusive, owing partially to camera failure. A new series of tests is planned

*P.V.R. No. 11, p. 7

†P.V.R. No. 11, pp. 7-8

‡P.V.R. No. 12, p. 8

for evaluation of the jettison mechanism. It is planned to compare two jettison systems: explosive bolts combined with a spring, and explosive bolts alone. A spinup and separation test is planned at GLM to test third-stage separation for TV-1. The signal for ignition of the third stage in this separation is initiated by a centrifugal switch mounted on the spin table; this is necessary to insure spinup and therefore stabilization of the third stage before separation. A modified centrifugal switch has been tested and the results indicate that the switch is satisfactory for this application.

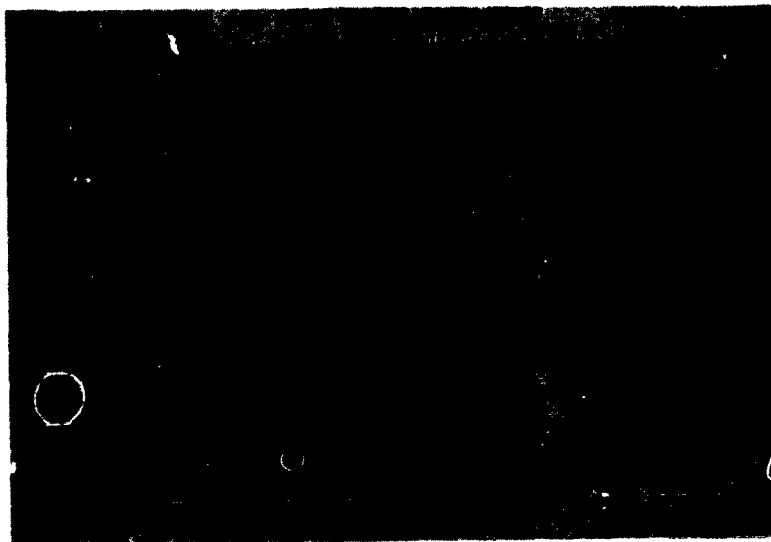
A test to evaluate the effects of separation of electrical connectors at low pressure (simulating first-stage separation) has been completed. The results of this test indicate that the consequent arcing might be sufficient to cause excitation of the first-stage destruct circuits. Additional tests and study in this area are proposed.

A test has been conducted by AGC to determine the effect of second-stage flame impingement on electrical connectors in the interstage structure. Complete information is not yet available but the preliminary results indicate that the fiberglass insulation was satisfactory.

The Atlantic Research Corporation (ARC) expects to complete the qualification testing of the spin and retro rockets (Fig. 1) by the second week of January. The problem of a pressure peak after ignition has been solved by modifying the ignition seal in the nozzle. Eight additional rockets are to be fired as a proof test to verify the seal. Approval of the qualification test program will be made by GLM during this report period. ARC is completing work on both the Model Specification and Inspection Procedure Manuals.

The aerodynamic cone for covering the retro rockets is approaching completion. The aerodynamic heating tests have been completed, with satisfactory results. A method of deflecting the cone at the time of firing of the retro rocket is still under development, but testing indicates a metal strip retained on the cone and covering body will deflect the cone sufficiently away from the vehicle. Pending additional development in this area, the final report on the aerodynamic cone is being completed.

Acceptance of the spin and retro rockets by the Navy for shipment to PAFB is anticipated by 21 January.



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Fig. 1 - ARC third-stage spin and second-stage retro rockets (ARC photo)

THE SATELLITE

CONFIGURATION AND DESIGN

The third and fourth 20-inch magnesium satellite shells and structures* have been received; however, neither unit could be considered acceptable. The greatest faults were in the polish and plating, but there also were small leaks in the pressure zones. Corrective measures have been outlined at Brooks and Perkins and the remaining units are expected to meet specifications. There will be a delay of one week until the next unit is received, but this delay is not serious since some of the equipment for installation in the satellite is not on hand.

The second 20-inch magnesium satellite is being instrumented completely with scientific equipment for testing purposes. All wiring, gages, skin-mounted equipment, batteries, and instrumentation modules will be included.

Information has been received from the State University of Iowa on their requirements for a cosmic ray experiment in a 20-inch satellite. NRL has nearly completed the design work on this satellite, and an aluminum model is complete except for the internal package and heat shield. The Geiger counter will be mounted on top of the internal package. The pressure zones are omitted in this satellite.

Preliminary design work on the NRL magnetometer satellite has begun, but no schedule for completion has been set as yet. This satellite will probably be cylindrical in shape instead of spherical, and of adequate size to accommodate the standard internal package at one end, and the magnetometer sensing head at the other. The skin will be made of a nonconductor, such as plastic. No magnetic materials are permissible, and nonmagnetic antennas are now being built. This required a minor modification in the joint components.

A Calidyne Model C44 vibration table has been purchased to act as a standby for the present NRL vibration equipment, which cannot meet all of the requirements for the satellite tests.

The sinusoidal vibration test equipment now in use at NRL is capable of handling loads of up to 20 pounds at the peak acceleration of 12 g from 15 to 2000 cps, and may be used in the range 10-15 cps if the peak-to-peak displacement is limited to one inch. With loads of 3 pounds or less, acceleration to 15 g may be obtained from 10 to 2000 cps, and with very small loads, up to 20 g may be obtained from 700 to 2000 cps. The new equipment, which should be operative by 15 February, can provide random vibration of loads up to 89 pounds at a root-mean-square acceleration level of 20 g.

A special horizontal vibration table has been designed and constructed at NRL for use with the existing MB-C5H shaker, as well as the MB-C25H at DOFL; this device will simulate the horizontal vibration environment of the satellite.

As of 1 January, over 125 initial-design vibration tests have been made at NRL on Vanguard satellites, satellite components, and launching vehicle components; in addition, use has been made of outside facilities such as DOFL when the requirements exceeded the capabilities of the NRL equipment.

*P.V.R. No. 12, p. 9

To meet the satellite acceleration test requirements, an adaptation has been made of a large whirling arm at the Chesapeake Bay Annex of NRL. The small vertical centrifuge at NRL can produce a constant acceleration of up to 75 g on small loads which do not exceed the dimensions of a 6-inch cube: this is adequate for certain preliminary component tests, but the overall requirement for the 6-inch and 20-inch satellites is for a horizontal centrifuge capable of accelerations up to 100 g. The CBA device, which has been available since 10 December, more than meets this requirement. A modified wingtip fuel tank, acting as a wind screen, effectively prevents aerodynamic drag on the item under test.

Developmental work has been completed on the pressure-and-temperature environmental chamber, which has been in operation since October.* Pressures as low as 0.1 micron of mercury can now be produced within this chamber.

SCIENTIFIC EXPERIMENTS AND INSTRUMENTATION

Assembly of the various satellite instrumentation circuits into a unit has been started and will be completed shortly. The instrumentation cards or "modules" are being placed in the following order beginning at the bottom of the package: large battery pack, small battery pack, Lyman-alpha electronics, meteor collision counter, telemetry encoder, orbital peak reader, and Minitrack transmitter.

Because of the possibility of high-temperature operation if the satellite orbit is entirely in the sun, a change is being made in the encoder transistor: the high-temperature transistor is larger and slightly heavier.

During this period one of the subminiature pressure gauges was vibrated to the design test levels recommended by the Environmental Studies Subcommittee. A pressure calibration after the test showed that the gauge had not changed either in sensitivity or zero level.

A set of satellite erosion gauges have been bombarded for the first time with small high-speed splash particles from the ballistic gun.† Erosion was noted as an increase in resistance, in some cases as high as 100 percent.

The final layout of the electrometer circuit for the Lyman-alpha instrumentation has been made. Ten units have been constructed, and six of these potted and subjected to tests. The operational life tests and the temperature test both yielded satisfactory results. A contract for 100 Lyman-alpha ionization chambers‡ has been awarded to the Anton Laboratories of Brooklyn, N. Y. Fifteen of these units are to be delivered on 15 February, and the remainder within 90 days thereafter. Meanwhile, additional chambers are being constructed at NRL for test purposes.

The amplifiers and pulse stretchers for the meteor collision detection equipment have been constructed and delivered for Aerobee-Hi flights 40 and 41. These rockets, to be flown at WSPG in March and April, will flight-test the complete Lyman-alpha and environmental satellite package, including Minitrack, but without the external sphere.

Preparations are underway for a telemetry recording test in connection with these two rocket flights: the modulated Minitrack signal and a constant-frequency timing signal

*P.V.R. No. 10, p. 16

†P.V.R. No. 5, p. 17, and No. 10, p. 17

‡P.V.R. No. 5, p. 18, and No. 10, p. 17

will be recorded on a two-channel magnetic tape recorder. The assembly of operational materials and spare parts for distribution to the telemetry ground stations is now in progress.

A transistorized receiver has been developed for satellite installation, to turn on high power-consuming instruments upon ground command.* The electrical characteristics which had to be met are:

1. Satisfactory closure of the output relay for a period of 1 minute, after application of a 1-second audio-modulated rf pulse with a strength of -120 dbw at the receiver input.
2. Minimum receiver rf and audio bandwidth with good skirt rejection, to discourage unauthorized turn-on.
3. Minimum size and weight mercury battery for at least 2 weeks of operation.
4. Use of circular 5-1/2-inch-diameter chassis.

The receiver employs ten Texas Instrument Co. transistors which have good temperature characteristics. The 108-Mc crystal-controlled Minitrack oscillator serves as the first local oscillator; only a small portion of its power is required. A crystal-controlled second converter is employed for stability. The recovered audio-modulated signal is passed through a narrow-passband filter (± 2 percent of the center frequency) to reject frequencies other than the turn-on frequency. The filtered audio signal is then detected and the resulting dc voltage trips a multivibrator which operates the output relay. At least 20-percent modulation of the rf carrier is required to operate the receiver at any level of received signal power. Assuming a 1-percent duty cycle for the relay, the total receiver weight including the power supply is 11.6 ounces for 18 days lifetime, or 20.0 ounces for 65 days. Temperature and vibration tests have been satisfactorily made on most of the critical components, and further tests will be made on the final printed-circuit configuration.

Radiation damage tests by SCEL on p-n type solar energy converters and Ni-Cad storage batteries for the proposed satellite solar power supply† are continuing and the results so far have been favorable. Clusters of the converters will be flight tested in Aerobee-Hi flights 40 and 41 (five clusters in each rocket), in March and April respectively; these clusters were delivered to NRL on 15 January.

The NRL magnetometer satellite system (for geomagnetic studies) is now designed to the extent that the satellite contents, structure, and theoretical capabilities can be described without anticipation of major changes. Briefly, the satellite will contain a proton processional magnetometer, a command receiver, the Minitrack transmitter, and an Ag-Cd battery pack which will be charged by solar cells.‡ The magnetometer instrumentation, consisting of an amplifier, programmer, and sensing head, will weigh 3 pounds or less. The battery pack is to provide 3 weeks operation without charging; with solar-cell charging designed to equal the discharge rate, the active life of the satellite will be extended until a component fails or the satellite re-enters the atmosphere. Measurements will be taken by ground command in such a manner that the number per orbit can be controlled. Plans now include a measure of the battery voltage during the polarizing cycle of the magnetometer.

*P.V.R. No. 6, p. 16, and No. 10, p. 20

†P.V.R. No. 7, p. 2; No. 11, p. 1; and No. 12, p. 1

‡This should not be confused with the satellite solar power supply under development by SCEL.

This feature will give information on the orbit-by-orbit condition of the batteries, and will thus determine how many magnetic field measurements can or should be taken during each crossing. This not only permits efficient use of power but also provides a safeguard against continual excessive overcharge of the batteries.

Magnetometers will also be located at each Minitrack receiving station. The absolute total scalar field will be measured on the ground with a proton precessional magnetometer. A second instrument will measure variations in the field components. If tests now in process demonstrate adequate stability, the component instrument will be of the electron beam type that NRL has used for obtaining rocket aspect. If negative results are obtained in these either a commercial variometer will be used to measure components or the proton precessional magnetometer will be adapted to measure the total field plus two angles, thus providing a vector representation.

At present, a Geiger counter manufactured by the Anton Laboratories appears to be the best available sensing element for the cosmic ray experiment proposed by the State University of Iowa. The experiment as presently contemplated would consist of comprehensive observations of the total charged-particle cosmic ray intensity as a function of latitude, longitude, altitude, and time. Although mercury batteries are presently planned, silver cells are under consideration because of their better low-temperature characteristics. The output of the Geiger counter will be recorded on magnetic tape, and read out upon ground command. Studies are also in progress to see if a suitable apparatus can be devised to measure the relative abundance of primary He, Li, Be, B, C, N, and O nuclei.

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ELECTRONIC INSTRUMENTATION

VEHICLE TELEMETERING

PPM/AM Systems

One AN/DKT-7 (XN-2) vehicle telemetering transmitter has been rejected after the bench inspection at NRL, reworked by James S. Spivey, Inc., and returned to NRL along with three additional transmitters. This contractor has now delivered 6 transmitters on the contract for 25, and is meeting the delivery schedule. Transmitters for TV-3 and backup are now ready at NRL for shipment to GLM. The spare transmitter for TV-1 was damaged at the GLM plant through accidental application of 28 volts to the 6-volt filament circuit; it has been repaired and is satisfactory. The transmitter which was on hand as a spare for the TV-0 nose cone has been modified by the incorporation of an RF transmitting head to meet the TV-2 requirements, and delivered to GLM for use as the TV-2 spare.

Studies of miniature vacuum tubes and transistor circuits are continuing in preparation for miniaturizing the AN/DKT-7 transmitter. The present unminiaturized unit is shown in Fig. 2. A typical ppm/am recording ground station is shown in Fig. 3.

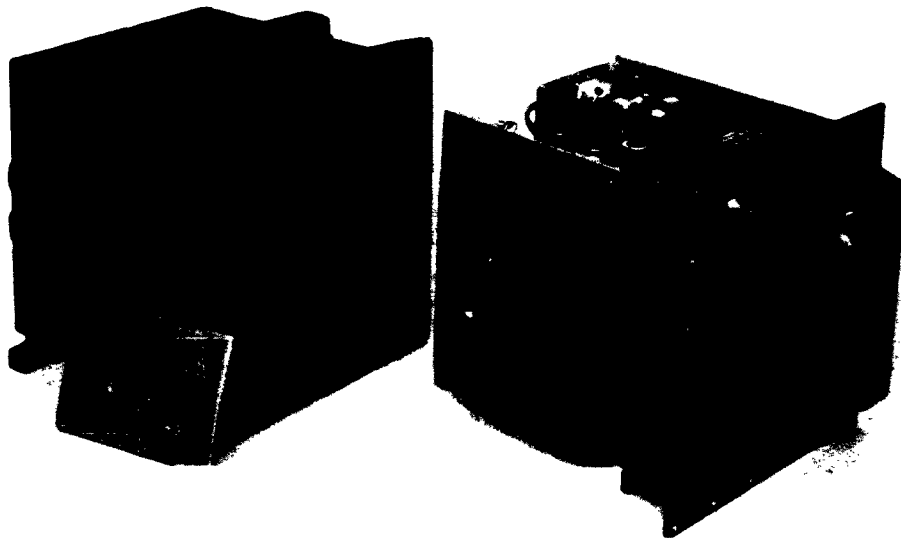


Fig. 2 - The AN/DKT-7 ppm/am telemetering transmitter

The ppm/am calibrators for TV-2 and backup have been delivered to GLM; one other calibrator has been rejected and returned to the contractor, Leemath, Inc., for reworking. Leemath has promised to deliver 10 additional calibrators by 1 February.

The delay in delivery of video recorder film magazines from the Wilkes Precision Instrument Co.* has been due to difficulty in obtaining necessary metals and small parts;

*P.V.R. No. 12, p. 12

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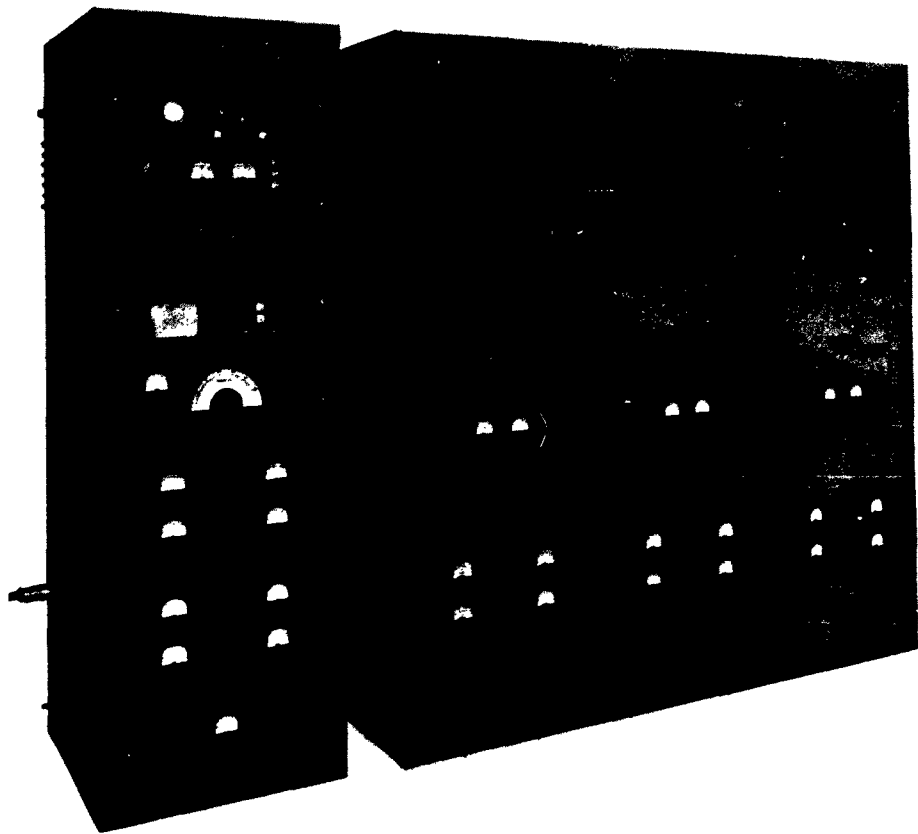


Fig. 3 - Typical ppm/am telemetry ground station

Wilkes now expects to deliver four magazines by 1 February. DuPont Lino-flex film has been tested for ppm/am ground station recording and found useable but not as sensitive as Eastman Verichrome* or Ansco Plenachrome.

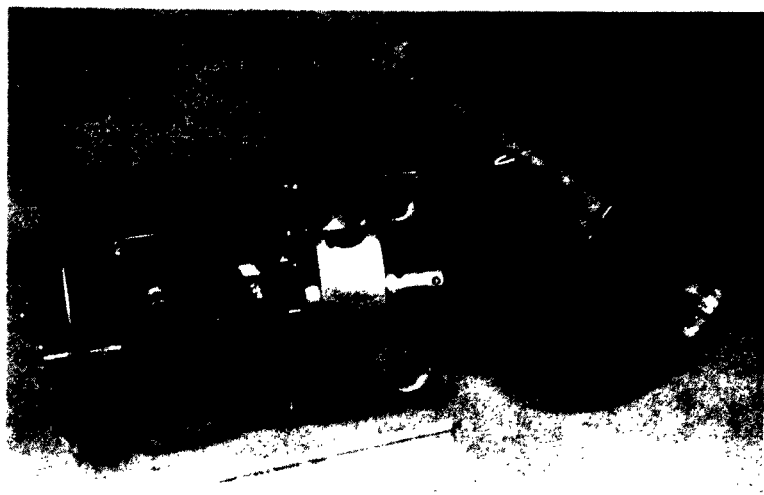
PWM/FM Systems

Development of a new can and a transistorized power supply for the pwm/fm vehicle telemetering transmitter† is progressing satisfactorily. Considerable improvement and reduction in size has already been made in the transmitter for TV-3: this transmitter and the transmitter flown in TV-0 are shown for comparison in Fig. 4. The transmitters for subsequent vehicles will be smaller still, and lighter by about 8 pounds than the TV-0 transmitter. In addition to the weight saving, the new transmitter and power supply yield a decrease in primary power consumption and a large decrease in turn-on surge current. Final electrical and environmental tests of this unit are to be undertaken in the near future.

A typical pwm/fm ground station, like the one used in the trailer at the AFMTC Vanguard telemetry pad, is shown in Fig. 5.

*The manufacture of this film in the required size has been discontinued.

†P.V.R. No. 12, p. 12



(a)



(b)

Fig. 4 - Comparison of pwm/fm telemetering transmitter for TV-3 (a) and transmitter flown in TV-0 (b)

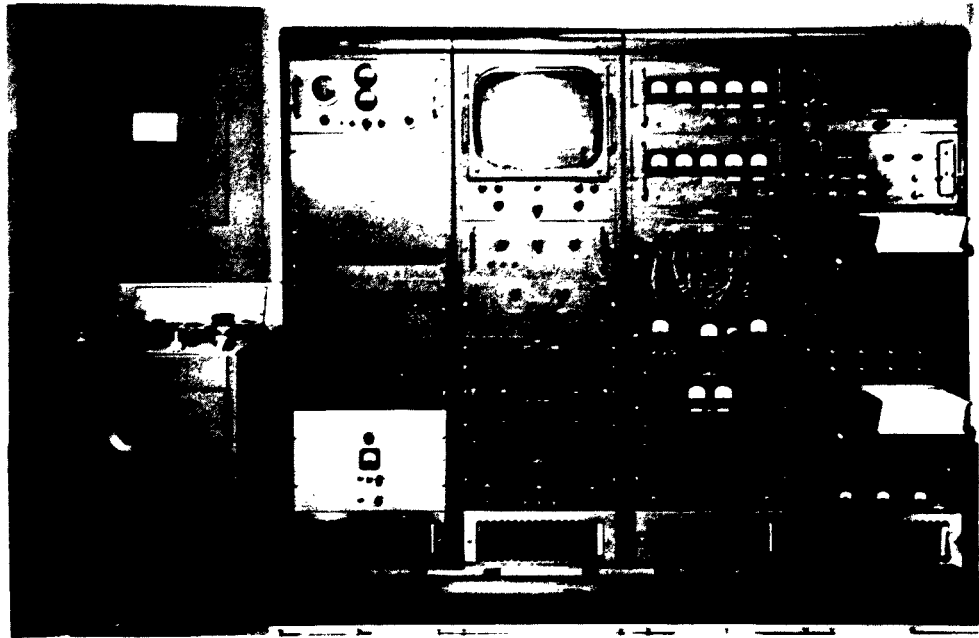


Fig. 5 - Typical pwm/fm ground station

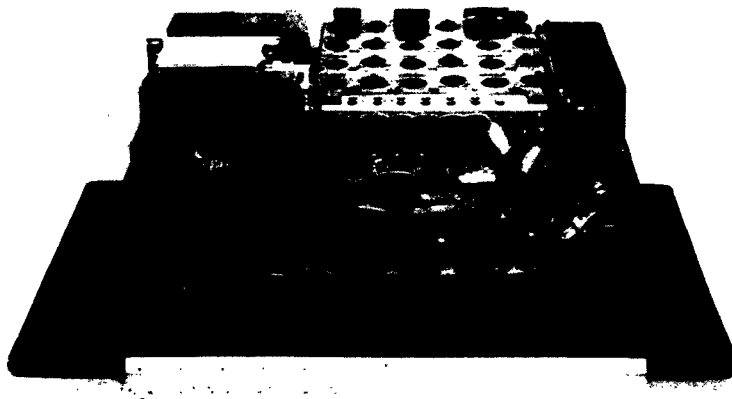


Fig. 6 - Typical fm/fm telemetering transmitter

FM/FM Systems

The Hoover Electronics Company has now delivered four fm/fm vehicle telemetering transmitters which are acceptable. Three of these have been shipped to GLM for TV-1, TV-2, and the TV-2 backup, and the fourth, as the TV-1 spare, will be shipped forthwith. Two other transmitters, which were being used as electrical prototypes but did not have pressurizable cases, have been returned to Hoover for modification. A typical transmitter is shown in Fig. 6.

A transistorized power supply* has now been used successfully with the fm/fm transmitter, and units are being packaged to replace the vibrator supplies currently in use.

VEHICLE TRACKING

The first Melpar S-band AN/DPN-48(XE-1) radar beacon (Fig. 7) now has passed all environmental and bench tests† and has been accepted at NRL. The first C-band unit is now undergoing bench tests and delivery of this beacon is scheduled for 18 January. The second S-band and C-band units are scheduled for delivery on 25 January and 1 February respectively. As a result of the acceptance of the first S-band beacon, production of the remaining units has been started. The production units will be structured in magnesium and thus will be about 5 pounds lighter than the first units, to insure that they will meet the specification requirement of 25 pounds. Delivery of three to five units is expected about 1 April.



Fig. 7 - The first S-band AN/DPN-48 radar beacon

The second of the three AN/DPN-31 radar beacons converted from S- to C-band by the Hazeltine Electronics Company has been received at NRL and allocated to GLM for the TV-2 backup. The third unit, and a fourth unit built by Hazeltine, have been delayed by late deliveries of C-band magnetrons.‡

*P.V.R. No. 12, p. 12, and No. 11, p. 21

†P.V.R. No. 12, p. 13, and No. 11, p. 21

‡P.V.R. No. 11, p. 21

A voltage regulator and line filter developed for use with the AN/DPN-19 radar beacon have corrected a power dropoff formerly experienced with supply voltages below 28 volts. The line filter also eliminates certain problems of interference between the beacon and other rocket-borne electronic equipment. All of the AN/DPN-19 beacons are being modified to incorporate these items.

Additional modification of the T-11 DOVAP transponder (Fig. 8), consisting of replacement of the 6AK5 tube by the Western Electric 408A, have improved the unit's overall efficiency and sensitivity, and reduced the heat dissipation. Full output power is now obtained at 15 microvolts as compared to the previous 30 microvolts, and a saving of 15 watts of 28-volt filament power is effected. The modified transponder has been successfully tested in the Vanguard vehicle vibration environment.

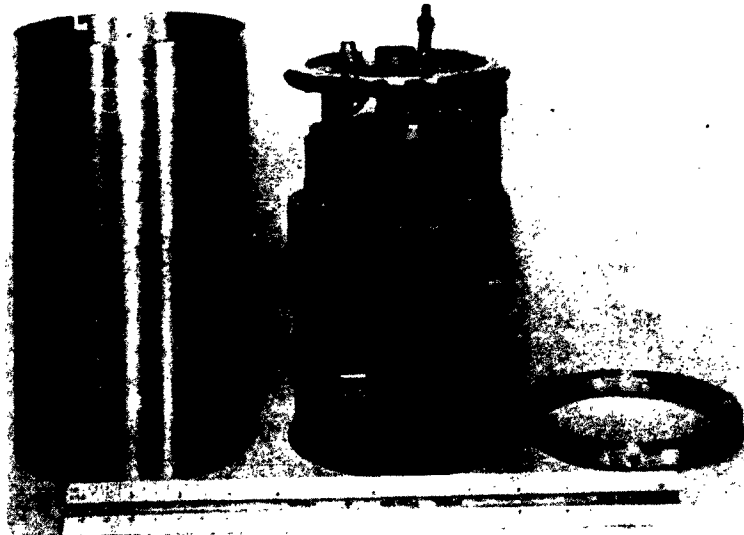


Fig. 8 - Modified T-11 DOVAP transponder

RANGE SAFETY

Final testing is underway on ten units of the transistorized decoder (Fig. 9) developed at NRL to replace the KY-55/ARW decoder currently used with the AN/ARW-59 command receiver. The replacement will be made in the TV-2 backup and all subsequent vehicles. Bids for the production of these decoders have been reviewed.



Fig. 9 - Transistorized decoder for use with
the AN/ARW-59 command receiver

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THE MINITRACK SYSTEM

All significant Minitrack system contracts have now been made, with the exception of those pertinent to the analysis of the calibration plates and the telemetering ground antenna mounts, and a possible contract for field service personnel. The Minitrack training course, to be conducted at NRL and the Blossom Point Minitrack Test Facility starting about 18 February, is now being put on a firm schedule with all groups preparing tests, components, and test equipment as required.

A complete report on most phases of the Minitrack system is in preparation; rough copies are to be available to the NAS-IGY committees by about 1 February for inclusion in an overall satellite report. Test specifications have been prepared separately from this report and have been furnished the Bendix Radio Division of Bendix Aviation Corporation for their guidance in the production and test of the Minitrack ground station units.

Calibration airplane flights are now being made, employing the special calibration camera built at NRL. Although instrumentation difficulties have developed, the method of "conning" the plane into the desired position by means of a radio link from the ground (to furnish the pilot with a meter indication of his angular position as measured by the ground Minitrack system with a medium baseline) has proved very feasible.

The Army program for six prime-Minitrack stations continues satisfactorily. Contracts for generator sets and other government furnished material have been awarded and initial shipments are enroute to terminals for oversea movement. The contracts for on-site work at the Latin-American stations are scheduled for award during January 1957 and the Fort Stewart site contract is scheduled to be awarded in March 1957. Discussions have been held between the Army Signal Corps and NRL to resolve the make-up of data messages and the requirements of the Vanguard control center for leased lines for receiving data.

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DATA PROCESSING

TELEMETERED DATA

The nose-cone data (ppm/am) from the TV-0 flight are being reduced by the Physical Science Laboratory of the New Mexico College of Agriculture and Mechanic Arts; the results should be available by the middle of February 1957. The pwm/fm data reduction requested of AFMTC for this flight has been completed and a report on it is expected shortly. GLM has completed its reduction of the TV-0 telemetered data (ppm/am and pwm/fm) from the vehicle and is sending copies of the reduced records to NRL.

The automatic recording and reduction facility (ARRF)* for telemetered data is continuing under development at Radiation, Inc. and at NRL. To make the earliest possible use of the digital data recording portion of this system, it is planned to use an interim transistorized ppm/am quantizer developed at NRL, until the final quantizer becomes available. This interim quantizer will be subjected to test under simulated operating conditions before being sent to Radiation, Inc. early in February 1957. Modifications of the sub-channel selector to provide automatic gain control have also been made at NRL.

ORBITAL DATA

The Commission of Fine Arts rejected the sketch and drawings of the front of the Vanguard computing center first submitted by the International Business Machines Corporation for the building at 615 Pennsylvania Avenue, N. W., Washington, D. C. A new sketch and drawings in accord with the Commission's recommendations have now been presented to the Commission.

Programming of various subroutines for use in orbital calculations on the IBM 704 computer has been continued by the IBM mathematicians. In addition to further test of the three-observation subroutines, test calculations have been made for the four-observation elliptic orbit subroutines on the 704 computer at IBM world headquarters in New York City.

THIRD-STAGE FIRING PREDICTION

The RCA Service Company at AFMTC has signed a contract with the Milgo Corporation for the design and construction of the digital data transmission system between the AN/FPS-16 radars at Grand Bahama Island and Patrick Air Force Base, and the IBM 704 computer at Cape Canaveral. The receiver at the computer site and the transmitter at the PAFB radar site are to be delivered by the middle of May and the transmitter for the GBI radar site is to be delivered by the middle of June 1957. Bids on the data transmission system between the IBM 704 computer and the third-stage firing control console to be located in Central Control (Cape Canaveral) will be invited very shortly so that they can be opened by about the middle of February 1957.

*P. V. R. No. 11, p. 26

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FIELD OPERATIONS

Viking 14 (TV-1) arrived at AFMTC on 14 January and the preliminary results of the receiving inspection indicate that the vehicle was in fair condition. As a result of the late firing of TV-0 (8 December 1956) and accumulated small delays, TV-1 will probably be launched early in March instead of on the scheduled date of 29 January.

The purposes of the TV-1 launching are to test the spinup, separation, and firing of a live Vanguard third stage, and to continue equipment evaluation. The delivery of two third-stage rockets from each subcontractor, as well as inert cases for test purposes, is scheduled for 12 February. The delivery of the instrumented nose cone, which will remain attached to the third stage during its flight, is scheduled for 30 January. This nose cone will house a T-11 Dovap transponder and an AN/DPN-19 radar beacon for tracking purposes, and a pwm/fm telemetering transmitter to monitor the performance of the third stage.

Since the AN/DPN-19 radar beacon does not employ an automatic gain control circuit, there should be no repetition of the difficulty in multiple interrogation experienced with TV-0.*

The flight azimuth of TV-0 was about 105 degrees instead of the predetermined 100 degrees. It has been reported also* that the coasting-flight attitude control jets on TV-0, intended to align the rocket with the flight path prior to nose-cone separation, did not operate. Since it is known that the control system proper functioned normally, it is believed that the failure must have been due, in large measure, to some malfunction in the peroxide system, or to valve deterioration, or both.

The following steps have been taken to prevent a recurrence of these difficulties in the TV-1 and subsequent launchings:

1. The count-down procedure has been modified to include a hot test of the roll and attitude jets.
2. The contractor has been asked to obtain new Futurecraft solenoid valves for the TV-1 jet system.
3. The liquid-oxygen topping line in TV-1 will be insulated to minimize chilling of any nearby parts of the peroxide system.
4. A critical review has been made of the procedure of aligning the rocket on the launch stand, and GLM is reworking this procedure.
5. Parallel investigations are underway at NRL and GLM to determine what factors in addition to jet system failure may have contributed to the overall azimuth error, such as: gyro precession errors due to resolver inaccuracy; launch-stand misalignment, etc.

*P. V. R. No. 12, p. 2

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PROJECT VANGUARD REPORT NO. 13 - PROGRESS
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