AD NUMBER
AD343162
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution: Further dissemination only as directed by Director, U.S. Naval Research Laboratory, Washington, DC 20375, SEP 1956, or higher DoD authority.
AUTHORITY
NRL ltr dtd 13 Dec 2007; NRL ltr dtd 13 Dec 2007

NRL Report 4832
Copy No. 1

PROJECT VANGUARD REPORT NO. 8

PROGRESS THROUGH AUGUST 15, 1956

[UNCLASSIFIED TITLE]

Project Vanguard Staff

September 5, 1956

NAVAL RESEARCH LABORATORY
Washington, D.C.

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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 August 15, 1956" by the Project Vanguard Staff, NRL Report 4815 (Confidential), July 27, 1956

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PROBLEM STATUS

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

AUTHORIZATION

NRL Problem A02-90

Manuscript submitted August 28, 1956

PROJECT VANGUARD REPORT NO. 8
Progress Through August 15, 1956

[UNCLASSIFIED TITLE]

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.

COORDINATION WITH OTHER SERVICES

ARMY

The Department of the Army has advised that the first model of the AN/FPS-16 (XN-2) radar can be made available for use by Project Vanguard. This fills a crucial Vanguard requirement.

The program for establishing the Minitrack system under Army operation has been delayed pending settlement of funding arrangements. Since Army acceptance of the task was dependent on provision of funds, it must still be formally resolved that Army funding requirements will be met for their performance of the task. In order to avoid delaying the program, NRL has initiated a request to ASD (Compt) for construction funds to be made available to the Army immediately to get the program underway. Discussions will continue on funding requirements for equipment items and other phases of the Army program. However, despite the unsettled condition of the funding situation, the Army is proceeding with engineer design plans for the tracking stations.

AIR FORCE

The construction program for the launching complex is moving into the final stages. The original 15 August joint occupancy date, however, has slipped to 5 September. This slippage was caused by various factors such as the steel strike, interruptions due to range safety requirements, local labor strike, etc. An examination of the work remaining after 5 September indicates that by 1 October the following three items in the blockhouse will remain uncompleted:

1. The checkout of the air-conditioning.
2. The installation of electric light fixtures.
3. The Celotex installation on the ceiling of the blockhouse.

The availability of stainless steel tubing for the helium line installation can become a critical factor in the readiness date of the helium system. The contractor has been given no definite date on the availability of this tubing. Priority expediting action has been initiated.

The scheduled beneficial occupancy date for this launching complex was originally set for 15 October with the completion date to follow sometime later. The present construction status indicates that the completion date of the launching complex will be 9 October. This in effect means that the scheduled beneficial occupancy date has moved up 15 days from 15 October to 1 October. Provided nothing unforeseen occurs, it is expected that the launching complex completion schedule will not delay the launching date of TV-0.

According to the Jacksonville District Engineers the construction of the assembly building is on schedule. Construction of the foundation has been virtually completed.

The Minitrack construction schedule for Antigua, Grand Turk, and Mayaguana should be formulated by 1 September. At this writing, design crews are downrange, developing a final layout and construction design for each particular station. This is scheduled to be ready for review by the Air Force Missile Test Center, the Naval Research Laboratory, and the Bureau of Yards and Docks by 1 September.

THE LAUNCHING VEHICLE

CONFIGURATION AND DESIGN

Redesign has been started on the second-stage sleeve (which surrounds the third-stage bottle) in order to increase the clearance between the second and third stages during separation. This change will be effective on TV's 1 and 3 and subsequent vehicles. TV-2 will have a dummy third stage and, therefore, will not be changed. In accordance with these changes, modifications have begun on the second-stage dollies and handling equipment.

The current empty weight status of the launching vehicle is as follows:

Stage	Specification Weight (lb)	Target Weight (lb)	Current Weight (lb)
First	1782	1565	1441
Second	973	865	868
Third	89	89	82

The outer shell bracket of the first-stage thrust chamber has been resolved, and imposes only a seven-pound weight penalty which is not considered excessive. This arrangement, together with the center-of-percussion actuator alignment will result in the dual natural frequency of 38 and 44.5 cps, which has been accepted on the basis of current design study requirements. In accordance with needs dictated by earlier test results, the first-stage yoke, gimbal ring, and gimbal shaft bearing have been modified to eliminate completely the problems of shaft brinelling, yoke distortion, and gimbal ring-yoke interference.

The change to kerosene for the first-stage fuel, with its higher density as compared to gasoline, has dictated a 15-inch reduction in the length of the fuel tank. No adverse effects are anticipated from this change.

Aerodynamic transfer functions have been calculated for TV-3. Aerodynamic loads are being calculated at several flight times for the mission vehicles. These include running loads, roll moments, drag, and longitudinal and lateral accelerations.

The master wiring diagram and the wire and lug data book for TV-2 have been released. The ac power source (inverters) for TV-3 and for the mission vehicle electrical system test have been released for procurement. A static inverter has been received from the Electro-Solids Corporation for test evaluation. A considerable weight saving can be had in replacing the rotary units with this type of inverter if its performance is shown to be adequate.

The first- and second-stage destruct systems will employ four strands of Primacord laid longitudinally the length of the fuel and oxidizer tanks, and two E-81 type detonators with a delay of 1.5 seconds.

Manufacturing and modification have been completed for TV-0. Modification of TV-1 to meet its test objectives is underway and on schedule, and TV-2 and subsequent vehicles are in the tooling phase.

PROPULSION

First Stage

The second GE demonstrator first-stage engine has successfully completed further full duration (150-second) tests with no adverse effects. A test program for performance characteristics under adverse conditions has been initiated and several runs have been made on this demonstrator with both long and short duration firings. In this series, such tests were included as: (1) low fuel suction pressure to the turbopumps; (2) heated fuel and tail can (over 120°F); (3) canted thrust chamber (7 degrees maximum off axis); (4) varied propellant valve sequence times; (5) varied reactant ratio; and (6) oxidizer exhaustion shutdowns. All tests were completed without incident and performance was within specifications.

The improved quality control of thrust-chamber liners seems to have rectified the chamber burning problem; no burnouts have been reported recently. Problems of injector scoring have arisen and they are currently attributed to delivery of obsolete hardware; resolution of these problems depends on delivery of the proper hardware. Development testing of the aluminum injector has been suspended for the present, because of repeated explosions. This is attributed to "aging" of the material which causes the injector to burst under operating conditions after only a few runs. The problem will continue to be studied, but only as a secondary effort.

Life testing of the production prototype X-405 turbopump is continuing with one pump having operated satisfactorily 10 times and another 8 times, including demonstrator engine operation. Cavitation limits of the pump unit are being determined in the second demonstrator engine tests and these values are considered adequate for the vehicle.

Second Stage

Assembly drawings of experimental and prototype second-stage thrust chambers employing the inpinging-type injector have been completed. "Marbrazing" and hand welding will now be used for aluminum chamber fabrication to replace the unreliable machine welding procedure. Four experimental chambers have been completed and fabrication has started on three welded prototype divergent nozzle sections. Tests with fiberglass-wound aluminum test sections indicate that fiberglass is a suitable alternate for the steel wire wrapping of chamber tubes.

Several modifications of the basic showerhead injection pattern have been made, and improved steady-state performance has been realized. Six experimental injectors, including aluminum and stainless steel showerhead, and aluminum one-on-one inpinging stream types, have been completed. The combustion stability of the one-on-one injector was satisfactory over a mixture-ratio range of 2.2 to 3.2 with a chamber pressure range of 175 to 220 psia.

The weight of the heated helium (restricted grain) second-stage gas-pressurization unit utilizing AISI 410 stainless steel for tankage material has been calculated to be considerably below the maximum weight allowed by the GLM Specification 925. Service fittings have been designed and drawings initiated for vents, drains, valve bleeds, and vent plugs. The configuration of the solid propellant grains for the helium pressurization heat generator has tentatively been established as: two grains 14.15 inches long and 1.9 inches in diameter with a restrictor thickness of 0.18 inch. Their burning rates have been reduced from 0.18 in./sec to 0.12 in./sec at 100 psia. The grain case outside diameter has been increased from 2-1/4 inches to 2-3/8 inches. Evaluation testing dictates a cast-molded grain restriction technique. Water expulsion tests indicate satisfactory performance of the system.

Eight helium tank hemispheres and three fuel tank heads have been fabricated, and the first helium test sphere is nearly completed. The fuel tank outlet was relocated to reduce fuel outage and to facilitate fabrication procedures. The oxidizer tank bottom was modified to take into account redesigning of the thrust-chamber actuator support mounting. Hydraulic acceptance test procedures have been prepared for the prototype assembly and for final leak testing of the complete second-stage propulsion system.

The direct fuel actuation of the oxidizer valve has been replaced with a closed hydraulic-oil actuated circuit. Detailed design layouts of this system are currently being prepared. Experimental fuel and oxidizer thrust-chamber valves have passed acceptance tests and prototype oxidizer valves are being fabricated. All pilot valves for development testing have been received and four pressure switches for thrust-chamber development testing have been fabricated. The pressure regulating system is performing satisfactorily with no adverse effects from heat-generator combustion products. Design of the first experimental electrical harness assembly has been completed and one assembly has been installed in the subcontractor's static firing facility.

Third Stage

The Allegany Ballistics Laboratory has conducted a total of twelve full-scale propellant grain firings. Eleven of these utilized a heavy-walled steel test chamber and one a fiberglass chamber. All twelve static firings employed fiberglass aft end closures and steel sea-level type nozzles. The main objective of the firings to date has been to finalize the

propellant grain configuration, reduce the resonance suppressor weight, and test the fiberglass aft closure attachment method. The thrust-time and pressure-time curves were neutralized by removing the inhibitor from the aft surface of the propellant. The chamber pressure has been reduced to 250 psi over the operating cycle. By increasing the throat diameter slightly, nozzle erosion was curtailed; this eliminated the necessity for coatings on the graphite throat.

After firing, the fiberglass chamber was only moderately warm on the exterior surface. A compression test made on an empty fiberglass chamber showed that it would withstand a 5000-pound load. The backup 4130 steel chambers are presently being fabricated and will be delivered prior to and during the prequalification test program. A "styrofoam" nozzle closure has been successfully tried in an attempt to develop a pressure seal to aid ignition in vacuo. A vacuum type ignitor is in the development stage and will be tested during the month of August.

The Grand Central Rocket Company has fired four lightweight 410 stainless steel chambers for performance evaluation. The previous heavy-walled steel chambers tested with both 91LD (phenolic resin) and Rockide A (aluminum oxide) coatings showed the latter to be a sufficiently good insulator to permit elimination of polysulphide rubber inhibitor. All firings made by Grand Central were for full duration, but an ignition delay problem has been encountered. A technique of reducing the content of the igniter and utilizing a nozzle closure to build up ignition pressure is being tested. A rather progressive pressure-time curve has been shown with some ten seconds of "tailoff." Tests are planned to reduce the progressive burning. Altitude-type nozzles have been used in every test in order to evaluate temperature resistant coatings using Rockide A in various thicknesses at critical temperature areas.

Static test stands are being finalized by both subcontractors in order that vibration measurements may be made during prequalification testing. The prequalification testing phase will begin the first week in September and extend into the first week of November. The prequalification tests have been formulated and are being submitted to the third-stage subcontractors.

FLIGHT CONTROL

Guidance

Reference System

Minneapolis-Honeywell has recently completed random vibration tests of the gyro units. Preliminary evaluation of test data basically substantiates the theory used to correlate random and sinusoidal vibration, which will be used in qualification tests. Development work on the reference package shockmounts is continuing.

The HIG-6 single-axis rate-integrating gyro, three of which are used in establishing the vehicles three reference axes, is shown in Figs. 1 and 2. The gyro wheel has an angular momentum of 500,000 gm-cm^2/sec, half of that of the standard HIG-6 unit. This modification was made to reduce gyro sensitivity. The gyro is suspended on its spin axis in the gimbal casing which is in turn neutrally floated in the gyro case. In Fig. 3 the gyro reference system is shown without covers and before wiring. The view is of the bottom, with the corner on the downrange face of the vehicle toward the observer. Shown are three hermetic integrating floated gyros (HIG-6's) which sense vehicle angular rotations

in roll, pitch and yaw; three isolation amplifiers, which couple the error signals sensed by the gyros to the autopilot amplifiers; three gyro temperature controllers; and a frequency-compensated direct-current converter, which compensates for power supply variations.

Attitude Control System

Evaluation tests of the autopilot magnetic amplifier breadboard have indicated a failure to meet the specified frequency response characteristics although static gains are satisfactory. Vickers is working on this problem in close liaison with Glenn L. Martin engineers. The subminiature tube amplifier breadboard is presently being used in the first-stage dynamic controls mockup. This mockup has shown some inner loop instability characteristics. However, it is expected that the introduction of a small amount of artificial leakage in the hydraulic actuators will correct this condition.

A Nyquist study has been made of the pitch-yaw motor control system for TV's 0-2 and the mission vehicles. New missile dynamic equations were derived from more up-to-date weight data. The results of this investigation reveal that no changes are required in the control systems of these vehicles.

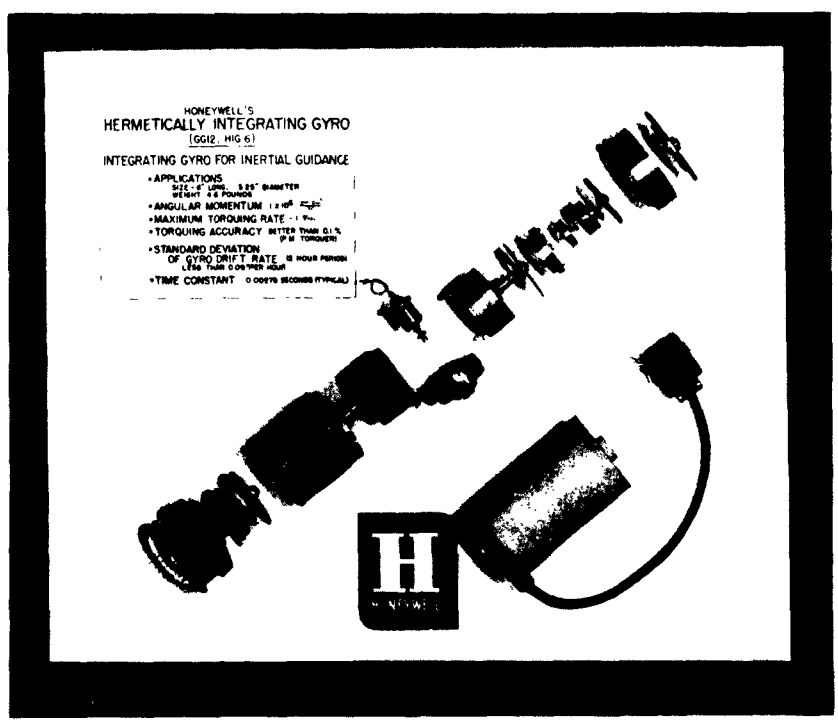

Fig. 1 - Major components breakdown of HIG-6 gyroscope: (left to right) signal pickoff, gimbal assembly and gyro wheel, torque generator, and the assembled gyro below in a can about the size of a large can of peas (Minneapolis-Honeywell photo)

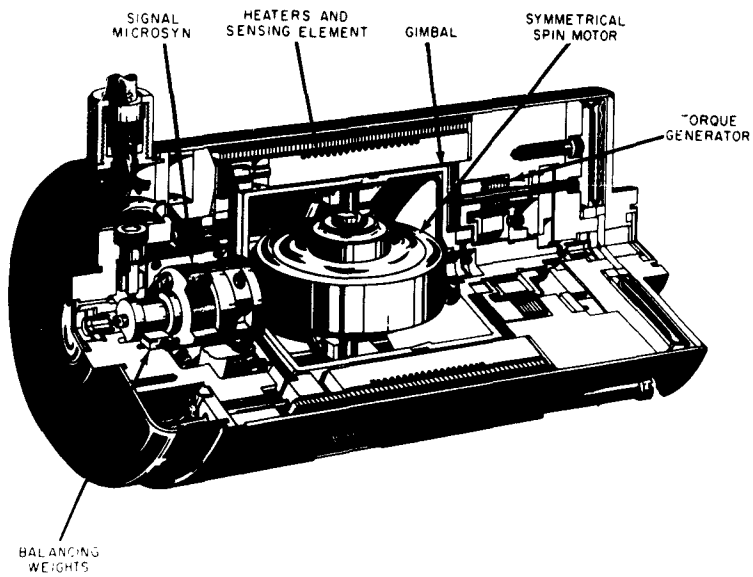

Fig. 2 - Cutaway of HIG-6 showing arrangement of major sections of "floated" gyroscope (Minneapolis-Honeywell photo)

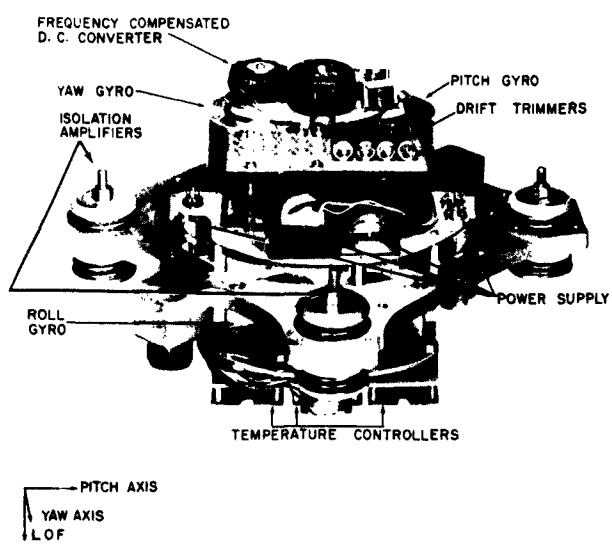

Fig. 3 - Three-axis gyro reference system for Vanguard launching vehicle (Minneapolis-Honeywell photo)

Preliminary control system tests were completed on the first Aerojet second-stage engine mockup. The frequency response tests, and in general all test results, were satisfactory. All of the preliminary tests were performed with the breadboarded subminiaturized electronic amplifier. Additional tests will be performed on the final Aerojet engine mockup upon delivery to the Martin Company. The preliminary engine mockup structure was damaged during controls test and is no longer operable. No delay is expected in the completion of the dynamic controls testing schedule.

A study has been made of the energy of the compressed helium in the second-stage propellant tanks and helium sphere available for coasting flight roll and pitch-yaw control. The study indicated that sufficient energy was available to allow at least a 25 percent margin of safety in the total impulse requirements of the auxiliary jet systems.

All detail and assembly drawings of the TV-5 controls can and shelf structure (for both the subminiature and magnetic amplifier assemblies) have been completed and checked. Details for the can installation are also complete.

Hydraulic System

Drawings of the second-stage hydraulic pump motor have been supplied to Vickers, Incorporated. It is expected that a contract for delivery of the pumps will be completed by this firm in the near future. The first-stage pump is to be supplied by the New York Air Brake Company and will be driven by the rocket engine turbopump assembly.

Flight Program

The Ampatco, Incorporated, design for the vehicle programmer was selected over competing proposals, and contract negotiations had proceeded for the delivery of the units. However, Ampatco was divorced from its parent company and absorbed by another firm, and the contract was cancelled. Designers For Industry, Incorporated, have taken Ampatco's proposal and made a satisfactory proposal on it, and have been given a letter of intent by the Martin Company. Ampatco's drawings and a partial breadboard unit of their punched-tape programmer have been delivered to Designers For Industry.

Staging

To simulate separation of the first and second stages, Primacord has been detonated at a distance of eight inches from a 0.020-inch-thick aluminum plate. The aliminum plate, simulating the second-stage thrust chamber, was penetrated by fragments. Tests were then conducted using Primacord at a distance of eight inches from a magnesium plate, and perforation of the plate was again observed. A redesign of the separation area is in progress which utilized explosive bolts. No delay in the schedule is anticipated, but a weight penalty, estimated at 28 pounds, will be involved.

The Atlantic Research Corporation has been developing a solid-propellant rocket to deliver a 50-pound thrust for a 1-second duration. Two of these rockets are to be used for spinup of the third stage prior to launching, and two are to be used as retro-rockets to decelerate the second stage at third-stage launch. Heavy-walled test motors have been utilized during development firings in order to finalize propellant ballistics and charge configuration. A total of 90 development firings have been made with the heavy-walled test motor at 20°F, 70°F, and 130°F.

A lightweight motor has been fabricated from 4130 steel with a wall thickness of 0.030 inch. The nozzle is machined from 4130 steel and a carbon insert is placed in the nozzle throat. The nozzle is then welded to the chamber. The fully loaded lightweight rocket motor weights 260 grams or 0.6 pounds.

A prequalification test program is underway by Atlantic Research to demonstrate reproducibility and reliability of the spin and retro rockets. Vacuum ignition tests have been successfully performed. Eight dummy units to be used in the mockup program and eight live units to be used in captive spinup and third-stage retro separation have been delivered to the Grand Central Rocket Company.

Air Associates has completed a breadboard layout of the transistor amplifier and has started on a working model of the integrating accelerometer time computer for third-stage launch. It is not expected that prelaunch cooling of this system will be required. Preliminary qualification and test specifications have been received.

Criteria have been furnished AFMTC to establish the location of the high-powered amplifier for ignition of the third stage by ground command. This command, derived from AN/FPS-16 (XN-2) radar data, would start the timer in the rocket. Comparison data would be available from the integrating accelerometer, and ground command would be used only if the deviation of the accelerometer data exceeds a prescribed amount.

GROUND EQUIPMENT

The Polarad Company has completed the schematic design of all ground test units except the unit tester, and breadboarding is nearly completed. Detailed design is underway and the manufacture of consoles has commenced.

THE SATELLITE

CONFIGURATION AND DESIGN

The design of the 20-inch satellite is complete except for the heat switch installation; the results of structural tests have been satisfactory and a final model is being fabricated in aluminum. Drawings have been prepared for the contractor, and it is anticipated that the manufacture of magnesium 20-inch satellites will begin by late August. Design evaluation tests are continuing in order to determine the structural capabilities of the satellite for possible future requirements.

The "6-inch" satellite will actually have an inside diameter of 6.400 inches, the shell to be of magnesium alloy FS-1, 0.020 inch thick. Structural tests indicate the design is adequate. A heat switch has been installed and the entire unit is now under test.

Experiments are still in progress to determine a suitable compound for potting the spring-actuated antennas for the satellites. The manufacture of 72 antenna assemblies is underway; 24 of these are scheduled for delivery on 1 September and the remainder on 21 September.

INSTRUMENTATION

Work is progressing satisfactorily on the telemetry coding system. A first attempt has been made to fabricate circuitry in a form which utilizes near-optimum circuit components and approaches a practical satellite configuration. The present status would indicate that the complete coding system, exclusive of batteries, can be readily accommodated in a cylinder 3-1/4 inches in diameter and 1-1/2 inches high. Current discussions indicate that the initially contemplated twelve-channel system may not be adequate and consideration is being given to an eighteen-channel system with no change in the basic circuitry. Preliminary tests under laboratory conditions have shown a signal reproducibility of the order of one part in five thousand. A study is underway to derive techniques for measuring the system reproducibility under varying ambient conditions and for determining interchannel interference.

An investigation is being completed on the problem of maintaining an adequate signal-to-noise ratio at the ground recording stations under various conditions. It was found that the galactic noise which will be recorded for a period of several hours each day at some of the stations will amount to a decrease in power of the Minitrack transmitter by a factor of four. Solar noise, occurring once each day, yields approximately this same effective decrease in transmitter power at all locations. The telemetry coding system is being tested by mixing various amounts of noise with its signals to simulate the actual recording conditions and determine the readability of the signal.

Problems involved in the accurate photographic reproduction of telemeter signals have been further studied. A special three-tube oscilloscope has been designed, and construction has started on one element of the system for photo-reproduction.

Magnetic materials received for development of a means of nondestructive readout of information stored in magnetic memory units have been incorporated in circuits for laboratory study. Satisfactory operation has been achieved with extremely lightweight (about 3/4 gram) cores, shielded from the earth's magnetic field. Larger cores (about 10 grams) are relatively immune to errors from this source.

A solar switch is being developed to reset periodically (on each orbit) one of two memory units. A binary scaler switches as the satellite passes from dark to light, first switching in one memory unit to store information while the other is being read out and then, on the next orbit reversing the process. The present design will accommodate a damping of the satellite spin down to one revolution per hour; however, the time constant will be shortened to one revolution per minute to increase reliability.

The first samples of Clevite Research Center type PZT-2 ceramic transducers for the meteor collision detector have been received. Laboratory tests indicate an adequate sensitivity from these samples, for which the supplier claims a permissible operating temperature "conservatively rated at 200°C" and characteristics unimpaired by storage at temperatures above the Curie point of 385°C. Favorable results have been obtained from temperature tests of this transducer. This should permit close acoustical coupling to the satellite skin without damage due to aerodynamic heating. Various means for suitably mounting the transducer on the skin are being investigated.

THEORY AND ANALYSIS

SATELLITE ORBIT COMPUTATION

The plans for the satellite computation program have considered first of all the situation in which the flight is completely successful. In this case the perturbation produced by the earth's equatorial protuberance is more important than the effects of atmospheric drag. This results in a regression of the node of the orbit plane, and an advance of the perigee of the ellipse in the orbit plane. To avoid the ambiguity and uncertainty concerning the location of the perigee in a nearly circular orbit, and to allow for large inclinations to the equator, the method of Hansen's lunar theory has been adopted. In these studies the earth's potential field is represented by

$$V = \frac{-1}{r}\left[1 + \frac{k_2}{r^2}(1 - 3S^2) + \frac{k_4}{r^4}(3 - 30S^2 + 35S^4) + \frac{k_6}{r^6}(5 - 105S^2 + 315S^4 - 231S^6)\right],$$

where

$$S = \sin \beta .$$

The numerical values of the k's have been deduced from the following adopted value of g:

$$g = 978.034\ (1 + 0.0052884 \sin^2 \phi - 0.0000059 \sin^2 2\phi)\ \text{gals.}$$

The adopted unit of mass is the mass of the earth, the unit of length is the earth's radius, and the natural unit of time is 806.42 seconds of mean solar time (in 2π units of time a massless particle would complete one revolution in a circular orbit of unit radius).

The theoretical developments of the differential equations needed in Hansen's method have been completed, and the Fourier series with actual numerical coefficients will be developed next. After this, it is proposed to test this method of development to see how well it could be adapted to include the drag effects. It would appear that a time must arrive when the drag forces completely dominate the satellite trajectory; thus it will be necessary, for the last few hours of the flight, to change to methods of step-by-step integration.

VEHICLE TRAJECTORIES

Trajectories for TV's 3 and 4 have been computed on the basis of revised weights and the same pitch attitude program currently used for the mission vehicle.

ELECTRONIC INSTRUMENTATION

TELEMETERING

New telemetering frequencies have been assigned to Project Vanguard by PAFB, as follows:

System	New Frequency (Mc)	Vehicles Affected
ppm/am	238.5	TV-2 and subsequent vehicles
pwm/fm	234.5	TV-1 through TV-3 backup
pwm/fm	231.5	TV-3 and subsequent vehicles
fm/fm	228.5	TV-1 through TV-4 backup

Steps are being taken to initiate the changeover partially in TV-1 and completely by TV-3. An investigation was conducted to assure satisfactory operation of the ppm/am components at 238.5 Mc prior to acceptance of the new assignments.

PPM/AM Systems

The prototype ppm/am telemetering transmitter has been completed on schedule and is undergoing tests for conducted and radiated noise. Two AN/DKT-7 (XN-1) transmitters have been borrowed from AFCRC as spares for emergency use.

The second Elsin Electronics ppm/am ground station and three camera magazines have been accepted; the ground station has been readied for shipment to PAFB. It is expected that the third and fourth Elsin ground station units will be accepted about 1 September.

A prototype ppm/am signal simulator for checkout of ground stations has been completed by NRL, and duplicates are being produced.

The van for the mobile ppm/am ground station has been received and is being outfitted.

PWM/FM Systems

Vibration tests have been conducted on the pwm/fm transmitter components for TV-1. The results of the first runs were unfavorable, owing to a poor choice of components by the manufacturer. Replacement of these components resulted in a definite improvement.

The installation of the pwm/fm ground station in the trailer has been completed.

FM/FM Systems

Hoover Electronics has received all subcarrier oscillators needed for the TV-1 prototype fm/fm transmitter, with the exception of the strain gauge oscillator. The Electro-Mechanical Research Corporation expects to deliver this unit posthaste, and it appears that no further difficulty will be encountered in this area.

The AN/UKR-5A recording fm/fm and pwm/fm ground station has been checked out by a representative of the New Mexico College of Agriculture and Mechanic Arts. Test recordings indicate satisfactory linearity of response in the descriminators, with the exception of one malfunctioning unit. A magnetic tape recorder has been ordered for use with this ground station.

VEHICLE TRACKING

A contract has been awarded the Hazeltine Electronics Company for the conversion of three AN/DPN-31 radar beacons from S-band to C-band.* One S-band beacon and a C-band magnetron have been supplied to Hazeltine to expedite completion of the first C-band unit.

Modification of the AN/DPN-19 radar beacons is progressing satisfactorily.

The T-11 DOVAP transponders from BRL are not satisfactorily passing environmental tests: chattering has occurred in the internal-external power relay. This relay will probably be replaced. In addition, late deliveries are endangering the schedule. Efforts are being made to hasten delivery of the transponders and to incorporate modifications at NRL: the control relays are being revised, and transistorized power supplies have been designed and manufactured which will be integrated into the transponders as soon as more of the latter are received. NRL has also begun design work on an experimental transponder.

RANGE INSTRUMENTATION

Tests are being conducted on weatherproofing paint for the 3-element helix antennas. The preliminary results show a decrease in gain of about 0.5 db due to a coating of Plascite 7133 (with a titanium dioxide pigment).

The S-band beacon antennas for the blockhouse and hanger have been received, as well as the antennas for monitoring command signals. The DOVAP and telemetry antennas for the blockhouse are being produced by the New Mexico College of Agriculture and Mechanic Arts.

Transformers and coaxial cable have been shipped to PAFB for the Vanguard telemetry site. The readiness date has been reset to 25 August 1956.

The utility trailer and two photographic trailers, with test equipment and supplies, have been shipped to PAFB.

Plans are being formulated for the establishment of a field group to be responsible for range instrumentation installation and checkout, and preparations have begun to initiate the field installations during the latter part of August.

RANGE SAFETY

Two AN/ARW-59 command receivers have been aligned and shipped to the Martin Company for TV-1. Invitations to bid have been extended for the manufacture of standard AN/ARW-59 receivers in order to assure meeting the time commitments. The proposals are to include a transistorized power supply to complement the receiver. A breadboard

*P.V.R. No. 7, p. 13

model of a transistorized decoder designed by NRL has passed laboratory and environmental tests and is in the process of being repackaged; this decoder may be produced by NRL or may be included in the contract. Use will be made of the BuAer-sponsored developmental receiver and decoder later in the program if they are available.

THE MINITRACK SYSTEM

A contract for the construction of eleven Minitrack ground station units has been awarded to the Bendix Radio Division of the Bendix Aviation Corporation. Two of these units will be shipped to NRL where they will be installed in special trailers for use at the Mayaguana and Grand Turk stations. The other nine will be installed in trailer vans now on contract from the Warner-Fruehauf Company of Baltimore, for use at the other stations; all but two of these stations are overseas.

The Blossom Point Test Facility has been in operation since about mid-July, the trailer-mounted ground station having been shipped to Blossom Point for installation on 19 July. Evaluation tests of the equipment and final alignment of the complete antenna configuration have been proceeding successfully since this time. Personnel from the Bendix Radio Division have been in attendance at many of these tests since about 8 August.

An item of interest on the operation of this station is that the system sensitivity is adequate to receive the radio signals emanating from the sun and from several radio-stars; records from Cygnus and Cassiopeia have been obtained. A section of a typical record made during the passage of the sun through the antenna pattern, showing several solar flares, is shown in Fig. 4. This record, made on 14 August, was obtained from three antenna pairs on an east-west baseline only. It is interesting to note that addition of the north-south baseline would provide the approximate position of the solar flare on the surface of the sun. It is questionable whether these signal sources can be used as calibration sources for the Minitrack system, because of their relatively large size and low signal level, but they will certainly provide a daily check of system operation, as well as some basic radio astronomy data simultaneously from at least eight Minitrack stations.

The sensitivity of the system to solar and stellar radiation introduces problems. The principal of these is the possible error in the Minitrack data during simultaneous reception from the sun and the satellite. This would decrease the accuracy of the Minitrack data depending on the strength of the solar radiation and the range of the satellite from the ground station; it is expected, however, that the effect would only be troublesome in satellite passages within 30 minutes of local noon.

The Minitrack transmitter for the minimum satellite has been life tested utilizing a Philco transistor. In the single test run so far, the transmitter output power has deteriorated about 20 percent after three weeks of operation, and 50 percent after six weeks. This transistor deterioration is the most serious problem encountered to date in using transistors for the minimum satellite package. Transistors were selected in preference to subminiature tubes in view of their much greater power efficiency in this low-power application.

Western Electric transistors have been tested for high-power operation (100-milliwatts output) as modulated transmitters to provide continuous telemetering from the satellite. A life test at this power level is being started also. Since relatively light tapping on these transistors has produced changes in their electrical characteristics, a vibration test set-up is being constructed, and a vacuum tube transmitter with a 100-milliwatt output will be built and tested.

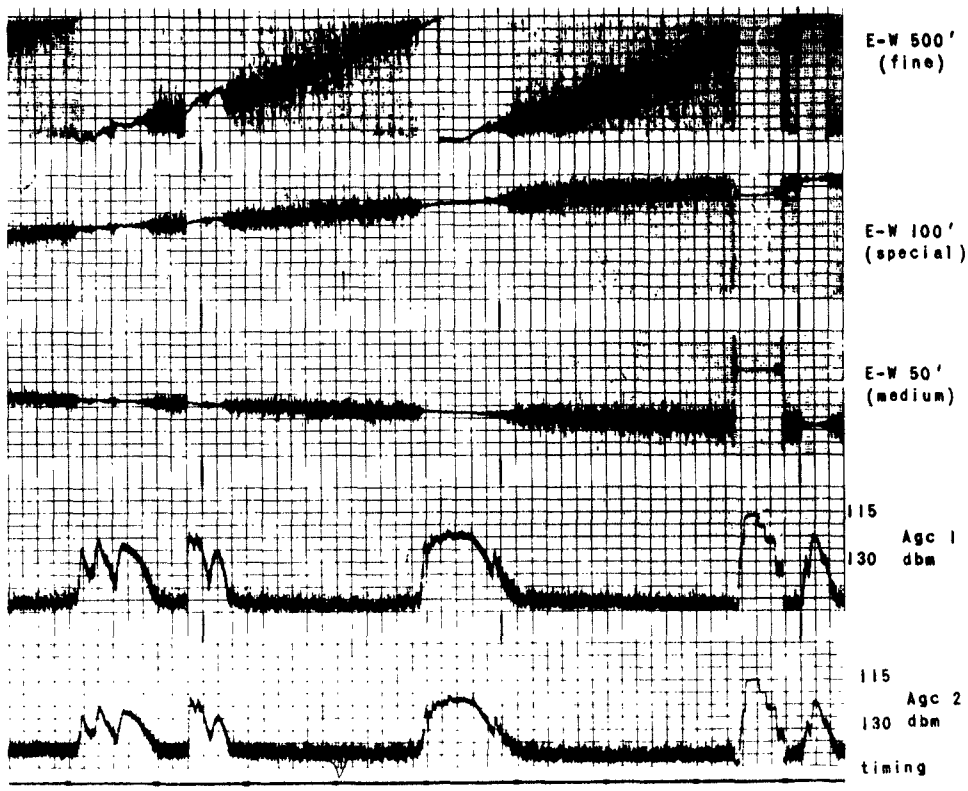

Fig. 4 - Minitrack record of the sun

On the whole, the Minitrack system is on schedule. The next items to be disposed of are the selection of the final ground station antenna type and the negotiation of a contract for its production, the testing of the prototype telemetering receiver and command turn-on units, the testing of the prototype calibration camera and polar mount, and the determination of the overall calibration procedure.

DATA PROCESSING

TELEMETERED DATA

The contract negotiations with Radiation, Incorporated for the automatic recording and reduction facility for telemetered data have continued. The contract will probably be signed by both parties before the end of August. The Contract Division of ONR advised Radiation that the contract would have a beginning date of 23 July 1956 so that costs incurred after that date for this work would be reimbursed in the event a contract resulted from the negotiations. The company is proceeding on this basis in order not to delay final delivery of the equipment. A government-furnished trailer has been transported to the company for modification and installation of the data quantizing and recording equipment.

ORBITAL DATA

Two conferences have been held at NRL to brief the representatives of the International Business Machines Corporation on the programming requirements for the orbit computations. IBM mathematicians are programming the 704 computer to calculate a Fourier series in literal form from the product of two given Fourier series, each having five indices. This program is the first step in the development of the orbit computational procedure by means of the mathematical approach described in the section of this report entitled Theory and Analysis.

SECOND-STAGE APOGEE PREDICTION

It is planned to install the AN/FPS-16 (XN-2) radar on Grand Bahama Island for tracking the second stage of the launching vehicle. A study conducted by AFMTC has indicated that it is feasible to transmit the radar tracking data in digital form over the submarine cable to Cape Canaveral and to use the IBM 704 Computer located there for predicting the second-stage apogee. The computer will actually calculate the time for firing the third stage and present this information at a control console in Central Control at Cape Canaveral. The firing time as given by the integrating accelerometer mechanism in the vehicle will be telemetered for display on the control console so that a decision can be made as to whether or not a ground command need be transmitted to fire the third stage. AFMTC will make a technical proposal for the equipment needed for the digital data transmission to the computer. NRL and GLM will jointly propose the design for the control console. Vanguard personnel will operate the control console and have the responsibility for firing the third stage.

According to present plans, the AN/FPS-16 (XN-1) radar will be installed at PAFB. Thus both this equipment and the XN-2 on Grand Bahama Island will be available for use as part of the AFMTC range safety system for Project Vanguard.

* * *

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