AD NUMBER
AD343093
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
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AUTHORITY
NRL ltr dtd 13 Dec 2007; NRL ltr dtd 13 Dec 2007

NRL Report 4890
Copy No. 1

PROJECT VANGUARD REPORT NO. 12

PROGRESS THROUGH DECEMBER 15, 1956

[UNCLASSIFIED TITLE]

Project Vanguard Staff

January 16, 1957

NAVAL RESEARCH LABORATORY
Washington, D.C.

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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 14, 1957

PROJECT VANGUARD REPORT NO. 12
Progress Through December 15, 1956

[Unclassified Title]

COORDINATION WITH OTHER SERVICES

Arrangements have been made with the White Sands Proving Ground to conduct vibration and firing tests of a third-stage solid-propellant motor from each subcontractor (ABL and GCR). These tests are part of the prequalification test program for the third-stage motor. (See page 6.)

In the SCEL program for development of a solar power system, the solar converters have been tested and are undergoing radiation damage experiments. Storage batteries are also being subjected to irradiation and tests for cycle life and vacuum operation. Power supplies for rocket tests have been designed; four clusters are scheduled to be ready in December 1956.

The design and construction of the Army prime Minitrack stations is progressing satisfactorily. The following events have occurred in this program:

1. The contract for the prefabricated administration buildings and guard shelters for the Latin American sites was let on 28 November to the Armco International Corporation.

2. On-site work has been advertised for quotation by 10 January for the Havana site and 27 December for the other Latin American sites.

3. Requirements have been placed on The Engineer School, Fort Belvoir, Virginia, for training motor generator operators for the stations.

4. The Army Map Service has been assigned the responsibility for the operation and maintenance of the prime Minitrack stations.

5. The Army Map Service is computing geodetic positions and azimuths to provide the IAGS the required control for establishing the stations. Computations are based on the international spheroid; the current geodetic control based on the Clarke Spheroid is being converted. Investigations are being made into the use of the geodetic reference at La Canoa, Venezuela. Data for all positions should be available by April 1957.

FIELD OPERATIONS

Test Vehicle 0 (Viking 13) was fired from the Vanguard launching complex at 0103 on 8 December 1956, after several delays due to operational difficulties and to a range obstruction (a ship which had to be cleared from the predicted impact area). Preliminary trajectory data indicate that powerplant burnout occurred at 104.8 seconds, that apogee was about 110 nautical miles, and that the impact range was 160 nautical miles.

Telemetry coverage during the rocket flight (both ppm/am and pwm/fm systems were used) was better than 90 percent complete. The T-11 DOVAP transponder operated satisfactorily except for the first 60 seconds when the signal was noisy; however, as the result of a range support error there was no DOVAP trajectory coverage from 150 seconds to 324 seconds. The two AN/ARW-59 command receivers met expectations. The S-band AN/DPW-1 radar beacon, employing an automatic gain control circuit, could not be easily interrogated by more than one radar, and finally failed altogether.

A transistorized Minitrack transmitter in a simulated satellite was ejected from the rocket at 119.8 seconds and the expected performance was realized. (See page 15.)

An aerodynamically stable nose cone, containing a ppm/am telemetering transmitter and a DOVAP transponder, was separated from the body of the rocket at 450.1 seconds. However, the data on turbulent heat-transfer coefficients and boundary-layer transition which were telemetered from the cone are of doubtful value owing to violent oscillations which occurred on re-entry. The rocket attitude control jets, intended to align the re-entering rocket with the flight path before nose-cone separation, did not operate. The ground command control system, intended as a flight-path trimming device in this and all subsequent Vanguard vehicles, could not be utilized because the radar feeding the velocity plotting board never acquired the rocket beacon.

Further data on the TV-0 launching will be presented in these reports as they become available in final form; a special report on the launching will also be published early in 1957.

THE LAUNCHING VEHICLE

CONFIGURATION AND DESIGN

Most of the finalized supersonic aerodynamic coefficient data have been received from NAMTC, Point Mugu.* Irregularities appear in the plots of drag coefficient versus angle of attack for several mach-number runs. These plots indicate that an increase in angle of attack results in a decrease in drag, but this is not likely the case. The data are being studied to determine what adjustments should be made before the supersonic aerodynamic parameters are released.

A preliminary air load distribution for an angle of attack of 5-1/2 degrees at maximum "q" has been made from recently reduced transonic windtunnel data, and is being studied to determine whether or not critical stress levels will be produced in the launching vehicle under these conditions. These air loads were calculated from WADC pressure data and are felt to be quite accurate; however, the transonic force coefficients do not correlate well with the highest subsonic windtunnel data nor with the lowest supersonic data. This discrepancy is thought to be due, at least in part, to the effect of varying the base-pressure drag on the different scale models and "sting" configurations used for the various speed ranges. Base-pressure drag estimates are only approximate, and a recalculation of this effect may decrease the discontinuities in the force coefficients between the three speed ranges, subsonic, transonic, and supersonic.

A low-speed windtunnel test is soon to begin as a part of the investigation to determine a spoiler configuration for the launching vehicle, which will prevent the formation of von Karman vortices† at frequencies on or near the vehicle resonant frequency. It is felt that the problem is not just to find an effective vortex spoiler but also to avoid a configuration which will add excessive flat plate area to the vehicle with consequent prohibitive air loads at low ground wind velocities. The 5 × 7 foot low-speed M.I.T. windtunnel is being used for the spoiler test, which began on 10 December 1956, with a 1/4-scale cylindrical model of the vehicle second stage. The duration of the tests will depend on the amount of modification of the spoilers required before the optimum configuration is determined. These modifications will be made as needed, with M.I.T. shop facilities.

An additional radio cutoff relay is being incorporated in the cutoff and destruct circuitry for TV-1 at the request of AFMTC. This results in two independent systems for cutoff and destruct. One system is powered from the 28-volt telemetering battery and the other from the 28-volt vehicle battery.

A reliability review of the components in the Vanguard vehicle electrical system has begun at the Glenn L. Martin (GLM) plant. A brief report summarizing the results of this review indicates that the probabilities of failure would be in the following order:

1. Wire breakage
2. Inverter malfunction
3. Relay malfunction
4. Battery malfunction

*P.V.R. No. 10, p. 4
†P.V.R. No. 9, p. 3

NRL will extend this review to a reliability study of all relays and controls components involved in the flight of the vehicle.

Modification and testing of three rotary inverters* to determine which is the more suitable dc power supply for the Vanguard controls indicates that a unit manufactured by the Leland Electric Company is preferable.

Instrumentation plans for all test and satellite vehicles have been reviewed and additions and changes specified. The major changes involve the installation of an angle-of-attack instrument, measurement of vibration in the vicinity of the gyros, flares for optical tracking, and measurement of propellant flow rates on TV-5 and the SLV's. All of these items are being investigated.

PROPULSION

First Stage

The final performance figures for the production first-stage engine P-2 as stated in the last report† have been found to be in error. An unrealistic thrust correction factor had been employed which indicated higher performance than was actually achieved. This discrepancy was noted during the final data-reduction analysis and this engine now is "sub-performance" with specific impulse figures of 248.4 and 248.6 seconds for the first two test firings. The acceptance of this engine was based on the higher figures and discussions are currently in progress to resolve this situation.

A failure of the thrust structure and a chamber burnout occurred early in the calibration testing of production engine P-3. The thrust-structure failure was attributed to an excessively hard start which caused three structural compression members to fail in tension. A new starting procedure has been devised which consists of "wetting" the chamber by filling the jacket to the level of the inlet fittings at the aft end of the motor; this eliminates hard starts, and the operation is being verified during the regular testing program. The thrust structure, the rocket engine, and the faulty turbopump† were replaced, and the acceptance test series was completed without further mishap. The performance of this engine was found to be slightly below specification: specific impulses of 249.9 and 249.5 seconds were reported. The engine was dried and cleaned in preparation for packaging and then removed from the stand; it will remain at the GE Malta test station until the low performance and hardware deviation problems are resolved. The fourth production engine, P-4, has been assembled and mounted in the test pit for calibration testing. Because of added costs and the delay caused by the P-3 structure failures, the prequalification engine (PQ-1)† has not been tested. Testing of this unit is anticipated as soon as prevailing schedules and budgets are reviewed.

The low performance of all X-405 engines to date has been attributed to the erroneous propellant flow data obtained in rocket motor tests in pit 3, upon which the original assumed performance was based. The nominal test specific impulse now seems to be slightly below the minimum value currently required, and performance improvement studies are underway. The pit-3 flow devices have been replaced with turbine type flowrators and the results of preliminary tests now show an improved correlation with production engine data.

*P.V.R. No. 10, p. 4
†P.V.R. No. 11, p. 4

Tests of oxidizer seals with 20-percent mixtures of fluorine and oxygen* have started, and testing has progressed smoothly with results indicating that several materials show promise as turbopump running seals. The neoprene grease seal currently being used behind the lox running seal shows signs of decomposition, but several solutions are possible, including material substitutions, which should resolve this problem. The testing is up to schedule and no delays are foreseen.

Second Stage

During this period the Aerojet General Corporation (AGC) has encountered considerable difficulty with tank failures. After a 10-second checkout firing, a small leak was discovered in an oxidizer tank weld; this leak was repaired and the tank, upon being hydrostatically tested, failed at 360 psi. The reason for the tank failure was not determined, but was expected to be a faulty weld. Pressure testing of a completed propellant tank assembly at 340 psig disclosed a leak between the helium tank and the fuel tank. Only four of the 37 helium tanks drawn passed inspections and one of these tanks installed in a completed tank assembly failed during a hydraulic test after 90 seconds at 1900 psig. An oxidizer tank damaged during proof testing is being repaired, helium hemispheres are in the process of being welded, and with the available fuel tanks a complete tank assembly will be fabricated. The pacing times in meeting schedules are the helium hemispheres, which are expected to be completed 17 December. A closer quality control is being maintained in an effort to produce reliable tanks, and a record of the status of each tank in fabrication is being distributed by AGC. The tank failures have resulted in a delay of several weeks in the engine system delivery schedule.

AGC has continued firings of its aluminum thrust chamber with the modified 72-pair impinging-jet injector† to check performance. Attempts have been made to improve injector performance by adding fuel orifices, varying the oxidizer pressure, and using white inhibited fuming nitric acid (WIFNA) as an oxidizer. All of these tests give results which are in the range required by the Vanguard specifications.

Nozzle closure tests have been conducted and from the information obtained a new closure has been designed and released for fabrication. This closure has a central 8-inch diaphragm section designed to rupture at pressures between 25 and 42 psi, and an outer ring designed to fail at the glue line at 65 psi.

Third Stage

Allegany Ballistics Laboratory

The Allegany Ballistics Laboratory (ABL) has performed additional tests to verify the adequacy of the silica-rubber insulator and the dummy casting powder to retard burning around the slotted sections of the propellant.‡ The results indicate that the silica-rubber insulator is adequate but a sharp pressure rise was indicated near the end of burning in one test, which could be caused by separation of the propellant from the dummy casting powder. Tests will be made with propellant at the slotted sections rather than the dummy casting powder.

*P.V.R. No. 10, pp 5-6 and No. 11, p. 4
†P.V.R. No. 10, p. 6, and No. 11, pp. 4-5
‡P.V.R. No. 11, p. 6, and No. 10, p. 8

Since the last report, ABL has encountered several failures of the fiberglass parts, attributed to the lack of post-cure time on the phenolic portions or to their thickness. Additional post-curing and increased thickness of the phenolic portions have remedied the deficiencies.

The problems of fabrication and supply of the Durestos-fiberglass altitude and sea-level expansion cones have been solved. Tests performed with the sea-level cones indicate satisfactory performance. The fully expanded altitude expansion cones are to be tested during the coming weeks.

Further tests are now planned by ABL to verify that the thickness of the altitude nozzle is sufficient to withstand the long-duration firing. Tests will be undertaken on a nozzle employing a cylindrical section with a cone-shaped diffuser at its exit. A back-pressure will cause the issuing jet to flow full, thereby testing the greatly expanded cone at sea level. The initial tests will employ a Terrier sustainer and an under-expanded nozzle; upon successful proof testing with this system the ABL third-stage motor will be tested.

The dynamic-balancing machine* has been installed and calibrated and is ready for the prequalification test rockets. The mechanical alignment machine to measure concentricity of component parts is also ready for the prequalification tests. Assuming that the remaining development problems are solved during the next group of firings, ABL plans to start prequalification tests on 26 December, to be completed by 19 January. According to performance estimates, ABL will be able to realize a vacuum specific impulse of 250 seconds with a total loaded weight of 433 pounds and an empty weight of 53 pounds, producing an incremental velocity of 14,300 feet per second.†

Grand Central Rocket Company

The Grand Central Rocket Company (GCR) has now finalized the propellant configuration using the propellant GCR 201C.* Further tests at the 20°F conditioning temperature have not resulted in the propellant cracking noted earlier. In recent static firings, however, the measured pressures did not correlate with the measured thrust. Investigations revealed that an excessively large pressure line diameter could be contributing to low pressure readings, and corrective measures were taken. A delay in the schedule was caused by some metal parts which did not meet the specification approval drawings. Adjustments were made to assure uniformity of these parts for the prequalification tests.

The acceleration tests of the GCR third-stage rocket were made on the NOTS "Snort" track on 28 November. Two sled runs were made, subjecting the rocket to the required longitudinal acceleration of 7 g and normal acceleration of 2 g. The rocket was then returned to GCR for static firing to complete the test. Endurance vibration tests of the GCR rocket will be made by the Army Ordnance Test Facility at White Sands Proving Ground; the vibration test and subsequent static firing are scheduled for the week of 17-21 December.

Testing of nozzle closures and igniters is in progress with a dummy rocket employing a half-inch propellant web to simulate the ignition and early burning phase. One vacuum test has been made, but owing to a leak in the pump system, a vacuum sufficient to give a real test of the ignition and initial burning was not realized.

*P.V.R. No. 11, p. 6

†The current specification requirements are: loaded weight, 433 pounds; empty weight, 53 pounds; and incremental velocity, 14,182 feet per second.

Because of the delay imposed by development problems and alterations of metal parts, GCR anticipates starting the prequalification testing on 15 December to be completed by 12 January. Static firing tests of the prototype prequalification rocket indicate that GCR may have a vacuum specific impulse of 242 seconds with a total weight of 433 pounds and an empty weight of 53 pounds, producing an incremental velocity of 13,700 feet per second (see footnote on page 6).

FLIGHT CONTROL

Guidance

The qualification test and model specifications for the Minneapolis-Honeywell reference system have been approved by NRL, and delivery of components to GLM, is expected in the near future.

The substitution of 28-volt heaters with increased capacity to assure satisfactory temperature control of the gyros will probably call for a revision in the count-down to allow earlier starting of the heaters.

Attitude Control

During this reporting period a preliminary investigation was initiated into the use of a periodic control system as an alternate to the proportioning system for stabilization of the Vanguard vehicle in the pitch plane during first-stage powered flight. This study was started to determine whether or not resonant frequencies due to structural feedback could be attenuated by interruption of the continuous proportioning system.

The first production unit of the Vickers autopilot magnetic amplifier is scheduled for shipment on 17 December. REAC studies of the breadboard magnetic amplifier with the first-stage dynamic mockup in pitch and yaw have been satisfactorily run. System performance studies with the modified preamplifier,* in roll, have also be successfully run; satisfactory response was obtained by adjusting the forward loop parameters.

Flight Program and Staging

Model, qualification-test, and acceptance-test specifications for the Designers for Industry, Inc., programmer have been reviewed and approved. The approval was subject to submission of the manufacturer's certificate of compliance with respect to current-carrying and interruption capacity of relay contacts. The first production unit of the timer is scheduled for shipment on 30 December, and qualification testing of a second unit will start on this date.

A qualified production unit of the Air Associates, Inc. coasting time computer is scheduled for shipment on 15 January. As indicated previously,† delays in the delivery of integrating accelerometers to Air Associates for these units was a problem. At present three units are in various stages of construction, and delivery of three accelerometers is expected before the end of December.

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*P.V.R. No. 11, p. 7
†P.V.R. No. 10, p. 11

Tests have been conducted on the nose-cone jettison and third-stage spinup and separation procedure at the GLM plant. Analysis of the test data has not been completed but preliminary results indicate that the mechanism for nose-cone jettison will work successfully. The spinup and separation test was successful except for the fact that the second-stage mockup did not move clear of the spinning third stage; the cause has not yet been determined.

A mockup test of first- and second-stage separation is planned for early in 1957.

A test has been conducted on the "peel-away" nose cone for the Vanguard vehicle with a spring-loaded double-ended explosive bolt. Testing showed adequate performance of ordnance components and no interference during the "peel-away" sequence that might cause damage to the satellite or vehicle.

The Atlantic Research Corporation has begun the qualification program of the spin and retro rockets. Test firings at 130°F showed a high ignition peak and rocket case bulging after several units were tested. Investigation revealed improper igniter fabrication compared to previous methods and "over-conditioning" of the rockets in excess of 140°F. These problems were overcome and further testing is underway. The scheduled completion date of the program is 21 December. Meanwhile tests performed by AGC on the spin and retro motors in a vacuum chamber have shown satisfactory performance.

THE SATELLITE

20-INCH SATELLITE

No further changes in configuration or design have been made in the 20-inch satellites. The present schedule for delivery of the 20-inch satellite structures is as follows:

Unit No.	Intended Use	Shipping Date	Arrival Date (NRL)
1	Structural Tests	12-1-56	12-4-56
2	Structural Tests	12-14-56	12-17-56
3,4	Thermal Tests	12-29-56	1-3-57
5,6,7	TV-4	1-14-57	1-17-57

Unit no. 1 was received on schedule, and the assembly of the internal package and antennas is complete; vibration and acceleration tests will be performed on this unit. The pressure zones leaked badly at the welds and at the pressure gage connection. In order to meet the schedule, however, it was decided to accept units 1 and 2 with leaks and without polishing or plating; all subsequent units must conform to specifications. There were several other unacceptable deviations on unit no. 1 which will be corrected on unit no. 2.

The weight of the magnesium unit as received was 5.81 pounds, which is 0.1 pound less than the estimated weight; such weight deviations are expected, because of material thickness variations, manufacturing tolerances, etc.

6.44-INCH SATELLITE

The final 6.44-inch satellite units are being fabricated. The approximate delivery date for the magnesium components is 5 February 1957. The Kel-F parts and the heat switches are due for completion on 4 January.

The acceptance tests uncovered a flaw in the submitted design of the separation mechanism* which only appears on the centrifuge with the third-stage acceleration-vs-time curve programmed in; hand operation had been satisfactory. The mechanisms were returned to the Raymond Engineering Laboratories for modification. Unit no. 1 has been returned to NRL and now works satisfactorily. The operation of the modified separation may be described as follows:

1. If an acceleration of approximately 12 g or more is applied for over 2 seconds, the clock will be allowed to run for 12 seconds more, to the stop on the "g-weight" arm. If the duration of the 12-g acceleration is less than 2 seconds, the unit will reset.

2. When the acceleration is subsequently reduced to below 12 g the timer will start and run for approximately 26 seconds.

3. At the end of this period the timer arm will close the electrical circuit and the caterpillar motors will expand, pulling the locking pins and rotating the spring release.

*P.V.R.No. 11, p. 13

THEORY AND ANALYSIS

Consideration is being given to the relocation of the prime Minitrack station originally planned for Panama* to Australia, probably at the Woomera range. Two sets of reasons for such a move have been adduced which are directly related to the orbit determination program. First were the following arguments in favor of moving a prime Minitrack station to Australia from a western hemisphere location near the equator:

1. The observations of the orbit from the prime Minitrack fence array will be made at approximately the same longitude, hence they will be separated by approximately equal intervals of time. The existence or nature of any phenomena whose periods happen to correspond to this observational period might go undetected. Accordingly, it would be better to make some observations at a significantly different longitude and hence at times which are significantly different from those of the main quasi-periodic sequence of observations from the primary fence. A station located near an antipodal point would permit observations at opposite sides of the orbit as rapidly as possible, i.e., after about half a revolution of the satellite, rather than after about half a day.

2. The shape of the earth could be more readily studied if data were available from an Australian station as well as from the prime Minitrack fence.

3. The number of observations from an Australian station would be greater than the number from a station near the equator.

In addition, the following factors are related specifically to the moving of such a prime Minitrack station to Australia from Panama rather than from elsewhere in the fence.

1. The fence character of the western hemisphere prime Minitrack array will be preserved much more completely if the Panama station is removed than if another station is removed. This is due to the fact that the two off-fence stations at Antigua and San Diego would go a long way toward closing the gap which would be left by the removal of the Panama station. Many orbits would be observable during the same revolution both from Panama and from one or the other of these two off-fence stations. In such cases the satellite would be observed at least once, even if the Panama station were removed. The same kind of compensatory coverage would not be available if another station were removed.

2. The establishment of an Australian station supplementing the primary Minitrack fence would open up the possibility of improving and increasing the telemetering reception by reading out telemetered data at an antipodal location on many orbits.

3. The Panama station is relatively near the equator, hence it would be expected to yield fewer readings than either another fence station or the Australian station; on the other hand, it is not actually the equatorial station of the main fence. Thus, moving the Panama station would not entail any of the disadvantages associated with the absence of a station at the equator.

*P.V.R. No. 11, p. 23

4. The local situation at Rio Hato, Panama, does not now appear to be especially conducive to the establishment of a Minitrack station for various reasons including, for example, the level of electrical noise.

ELECTRONIC INSTRUMENTATION

TELEMETERING

PPM/AM Systems

Three AN/DKT-7 ppm/am telemetering transmitters have been delivered to date on the contract for 25 transmitters with the James Spivey Co.; the deliveries are on schedule. The transmitter for the TV-2 backup vehicle has been delivered to GLM.

Development work which was underway on a miniaturized ppm/am transmitter and a transistorized power supply had to be discontinued during this report period as a result of the preparations for the TV-0 firing. This work will be resumed shortly.

Several ppm/am calibrators from the Lemath Co. were found unacceptable and returned to the company for reworking; one of these has been redelivered and the other two are expected shortly.

A contract for 12 ppm/am video recorder film magazines has been awarded to the Wilkes Precision Instrument Co: a prototype unit scheduled for delivery on 10 December has not been received as yet.

PWM/FM Systems

The pwm/fm transmitter package has been redesigned and environmentally tested with satisfactory results; this package is intended for use in TV-3. A still newer design, utilizing a transistorized power supply, a smaller commutator motor, and a new rf power amplifier, is being constructed. The overall unit is smaller and lighter by 8 pounds than its predecessor. Environmental tests will be performed on this unit in the near future.

FM/FM Systems

The fm/fm telemetering transmitter and spare for TV-2 have been delivered to GLM.

Further work on the fm/fm transmitter can has reduced its leakage, and other faults in the transmitter which were revealed by vibration tests have been corrected. Input signal voltage limiters have been added to the transmitter, and a transistorized power supply, developed to replace the vibrator type used previously, is being redesigned and tested.

VEHICLE TRACKING

A second C-band AN/DPN-31 radar beacon has been received from the Hazeltine Electronics Co., and will be delivered to GLM for the TV-2 backup.

The S-band AN/DPN-48 (XE-1) radar beacons manufactured by Melpar are still undergoing environmental tests. The i-f amplifier was found to be regenerative at high temperature, and work is going on to remedy this situation. The crystal mixer has been redesigned for better efficiency: an increase in gain of approximately 5 db has been achieved. This S-band beacon is now almost two months late. Work is progressing on the first C-band unit.

A special DOVAP transponder has been received from the ABMA for study as a possible alternative to the T-11 transponder. It is smaller and lighter than the T-11 but has less power output and contains no internal power supply.

RANGE SAFETY

Bids have been received for the production of a transistorized decoder developed by Project Vanguard to replace the KY-55/ARW decoder currently used with the AN/ARW-59 command receiver for cutoff, destruct, and ground control commands.

THE MINITRACK SYSTEM

TRANSMITTER DEVELOPMENT

Temperature cycling tests (0° to 70°C) have been completed on four units of the 10-milliwatt Minitrack transmitter for the minimum (6.44 inch) satellite.* This transmitter utilizes the Philco type SBDT-12 transistor. The slopes of the frequency-temperature characteristics of three of these units were almost the same as those of their associated frequency-control quartz resonators, indicating that the transmitter characteristic is determined primarily by the quartz crystal. Frequency-bias voltage characteristics at 25°C for all four of these units show negligible frequency deviation at bias voltages as low as 70 percent of normal. The small effect of changes in bias voltage on frequency, together with the correlation of frequency-temperature characteristics of the transmitter and the quartz crystals, suggest the possibility of determining the approximate temperature of the transmitter from measurements of its frequency.

Two of the 10-milliwatt transmitters have been potted in foam plastic and vibration tested. In both cases there was a steady decrease in 108-Mc output power when the orientation of the unit was changed by 90 degrees from the initial orientation. The power eventually dropped to zero, but could be restored to its original value by adjustment of the collector tank circuit capacitance. Investigation indicated that the trouble could be attributed to the change in position within the transistor case of a heat-conducting compound of aluminum flake in a viscous silicone. Measurements on several Philco transistors of this type showed an output capacitance variation of 10 to 25 percent. Philco was apprised of this situation and is trying to eliminate the difficulty. Delivery of two non-aluminum filled units is scheduled for 18 December.

A 10-milliwatt transmitter has been constructed with the Western Electric type GA 53233 transistor and operates with a battery efficiency of 30 percent as compared to the 20 percent obtained with the Philco SBDT-12 transistor. In a temperature test of this unit, the same correlation was found between frequency-temperature characteristics of the transmitter and the quartz crystal as was found with the units employing the Philco transistors. However, the variation in power output over the range 0° to 70°C was found to be 1.5 db, as compared with the 3-db variation with the Philco transistors. The unit has been potted in foam plastic, and temperature and vibration tests on it will be completed shortly. Similar tests will be made on units employing the modified Philco transistors.

Two modulated Minitrack transmitter† chassis have been subjected to vibration and acceleration tests and temperature cycling from 0° to 75°C; neither unit suffered any mechanical damage. The power output of one unit was reduced about 7 percent at 0° and about 15 percent at 75°C, and the total frequency variation over that temperature range was 7 Kc; the frequency at room temperature was about 2 Kc below 108 Mc. The power output of the other unit was reduced about 30 percent at 0°C and about 8.8 percent at 70°C, and the total frequency variation was 4 Kc; the frequency at room temperature was 1.2 Kc above 108 Mc. The overall efficiency of these two units at room temperature is about 20 percent. On the basis of the foregoing data, a minimum lifetime of two weeks may be expected for the modulated transmitter at 15°C.

*P.V.R. No. 11, p. 22

†These transmitters are intended for the 20-inch satellites and will be used for telemetering as well as tracking.

One battery pack for the modulated transmitter has passed vibration, acceleration, and temperature tests; a second pack is soon to be tested and a third is under construction.

MINITRACK EXPERIMENT IN TV-0

The purpose of the Minitrack experiment in TV-0 was to confirm the Minitrack system calculations in a field test and to flight-test a transistor type Minitrack transmitter.

The receiving antennas used had a gain of 12 db less than the 8-element Minitrack array and this loss in signal-to-noise ratio was made up by using a transmitter power of 105 milliwatts. Therefore, the signal-to-noise ratio should closely duplicate the conditions for a 10-milliwatt transmitter 150 miles above a Minitrack station. The signal in flight was very close to the calculated level and the noise on the output was negligible.

The transmitter used consisted of a crystal-controlled 108-Mc oscillator employing a Western Electric type GA 53233 transistor. The oscillator was powered by 18 Mallory type RMI cells in a series package. At ejection, there was about 1000 cps of frequency modulation due to whipping of the spring antennas as they unrolled; this condition was damped out in 7.5 seconds. Frequency modulation was again apparent at 430 seconds when the antenna whipping was probably caused by re-entry into the atmosphere. There was no measureable frequency modulation during the burning period when the transmitter was subjected to the mechanical vibration of the rocket motor.

The Minitrack sphere with four spring antennas forming a turnstile array was housed in a box on the South side midsection door. At 120 seconds, a signal from the NRL timer exploded two "Caterpillar" motors, releasing a spring-operated mechanism which ejected the sphere from the rocket with a separation velocity of about 10 feet per second. At this time, the rocket was out of the drag of the atmosphere and the trajectory of the ball should have been essentially the same as that of the rocket. The duration of the signal received was within 30 seconds of the duration of the telemetry signals, providing a rough indication that the trajectories were indeed similar.

The significant data from the test are as follows (all times refer to takeoff, which occurred about 13.6 seconds before base timing zero):

Ejection time: 119.8 seconds
Signal level at +130 seconds: 91 dbm
Calculated signal level: 92 dbm
Time required for antenna motion to damp out: 7.5 seconds
Ball roll-period: 2.6 seconds (constant throughout flight)
Re-entry time: 446.2 seconds
Last signal time: 468.6 seconds
Frequency at takeoff: 108.0036 Mc

BLOSSOM POINT TEST FACILITY

The new time standard and phase measurement equipments for the prime Minitrack station have been installed at Blossom Point and checked out both individually and in overall system tests; they are now ready for station calibration. The time standard chassis for the Mark II installation has been received and is being tested prior to incorporation in the system.

It is planned to conduct calibration tests on the Mark II installation at Blossom Point utilizing radio stars as sources. If the radio stars in Cygnus and Cassiopeia are used, a calibration accuracy of 10 to 30 seconds of arc appears probable. The Mark II system has also observed Taurus and Virgo, but at greatly reduced amplitude which limits their utility as calibration sources.

The equipment for the Minitrack operator training course at Blossom Point is now being checked out, and the various racks are being assembled.

DATA PROCESSING

TELEMETERED DATA

Reduction of priority telemetered data (both ppm/am and pwm/fm), consisting largely of propulsion and control information required for the field report on the TV-0 flight, was completed by GLM and NRL personnel using the Oscar Model J equipment installed in Hangar C at Cape Canaveral. AFMTC has been requested to reduce some additional pwm/fm data. One copy of the pwm/fm magnetic tapes and two copies of the ppm/am oscillograms have been given to GLM for further analysis in Baltimore. The nose-cone data (ppm/am) will be reduced by the Physical Science Laboratory of the New Mexico College of Agriculture and Mechanic Arts under contract Nonr-2158(02), which was executed early in December.

Manual reduction of telemetered data will be continued for each flight until the automatic recording and reduction facility (ARRF) being procured from Radiation, Inc. is ready for use. It is expected that the ARRF trailer (data recording system) will be sufficiently complete to permit digital recording of the ppm/am data at the NRL telemetry pad at Cape Canaveral for the flight firings of TV-2 and subsequent vehicles. In addition, every effort will be made to complete this trailer installation so that pwm/fm and fm/fm data can also be recorded in digital form for all of these flights. The digital data reduction system, without the linearizer, will probably be available for these flights so that nonlinearized Teledeltos records can be produced automatically. The complete ARRF system should be ready for operation for the flight during firing of TV-3.

Previously only ten channels of the pwm/fm data were to be digitally recorded in real time at the NRL telemetry pad, while the remaining data would be played back after the flight to produce a digital magnetic tape record. Now it is planned to record all 45 channels digitally in real time through minor modifications to one of the ten translators of the pwm/fm ground station and use of its output exclusively for encoding by the ARRF system. Nine channels of the pwm/fm ground station will continue to be available to provide nine of the conventional analog outputs.

ORBITAL DATA

Drawings and a sketch of the front of the building for the Vanguard computing center at 615 Pennsylvania Avenue, N. W., Washington, D. C. have been presented by the International Business Machines Corporation to the Commission of Fine Arts for approval. Preliminary drawings of the internal building remodeling have also been presented to the District of Columbia Building Department.

The IBM mathematicians have continued the programming of various subroutines for Fourier series computations on the 704 computer. Additional test calculations have been made with the three-observation elliptic orbit subroutines on the 704 computer located at IBM world headquarters (590 Madison Avenue, New York City).

THIRD-STAGE FIRING PREDICTION

The RCA Service Company at AFMTC has completed the detailed specifications for the digital data transmission equipment required for the information link between the AN/FPS-16 radars (at Grand Bahama Island and at Patrick Air Force Base) and the IBM 704 computer (at Cape Canaveral). Bids have been requested from prospective suppliers and will be opened 26 December 1956. The RCA Service Company has also completed the specifications on the data transmission link between the IBM 704 computer and the third-stage-firing control console to be located in Central Control (Cape Canaveral); bids on this equipment will be invited shortly.

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Naval Research Laboratory. Report 4890 (CONF.)
PROJECT VANGUARD REPORT NO. 12 - PROGRESS THROUGH DECEMBER 15, 1956 (Unclassified Title). by Project Vanguard Staff, 18 pp., January 16, 1957.

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