

SECTION II

PLUM BROOK ROCKET SYSTEMS DIVISION

TEST OPERATIONS REPORT

FOR THE MONTH OF

JANUARY 1967

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
B-3	NUCLEAR ROCKET DYNAMICS AND CONTROLS FAC.	<p><u>NERVA</u> YPD2070(L.V.Humble)</p>	<p>NERVA engine propellant feed system tests.</p> <p>Most of the bootstrap test research piping and equipment has been disassembled. All of the research equipment except the KIWI reactor will be out of the test stand by February 15. Removal of the reactor will require opening the south roll-up door and use of the overhead crane. Present plans are to leave the reactor in place until May or June when weather conditions will be more favorable.</p> <p>We have started overhauling the facility subsystems.</p> <p>on monitored data, to either accept, reject or repair the vacuum jacketed piping.</p> <p>(2) Pressurization/Vent/Electrical (Valley Electric):</p> <p>The Government-furnished 4-inch diameter, high pressure gaseous hydrogen flexible manifold hoses were received and installed. The gaseous helium purge line had to be removed and reinstalled according to contract drawing. All pressure testing has been completed. A site inspection is scheduled for the week of January 30 to determine the completion and acceptability of the contract work.</p> <p><u>Status of Site Work:</u></p> <p>The following major jobs were completed or initiated during the month of January:</p> <p>The maintenance and repair of the major subsystems should be completed by the end of February.</p> <p>The research equipment installation design for the pump cavitation program has begun. Most of the research test requirements should be defined by February 15.</p>

SECTION II
 PLUM BROOK ROCKET SYSTEMS DIVISION
 TEST OPERATIONS REPORT
 FOR THE MONTH OF
 FEBRUARY 1967

SITE	SITE NAME	RESEARCH INSTALLATION	DESCRIPTION
B-3	NUCLEAR ROCKET DYNAMICS AND CONTROLS FAC.	<p><u>NERVA</u> YPD2070 (L.V.Humble)</p> <p>The liquid hydrogen run tank heat leak and temperature profile have been investigated and a summary of proposed procedures has been sent to the research group. A test will be performed with liquid hydrogen in the tank to define temperature gradients during chilldown. A rake is presently being designed to measure liquid hydrogen temperatures throughout the tank.</p> <p><u>NERVA</u> (Continued)</p> <p>Design calculations for the vapor bulb system are nearly complete. A design review meeting will probably be held within the next two weeks.</p>	<p>NERVA engine propellant feed system tests.</p>

SECTION II

PLUM BROOK ROCKET SYSTEMS DIVISION

TEST OPERATIONS REPORT

FOR THE MONTH OF

MARCH 1967

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-3	<p>NUCLEAR ROCKET DYNAMICS AND CONTROLS FAC.</p> <p><u>NERVA</u> YPD2070 (L.V.Humble) NERVA engine propellant feed system tests.</p> <p>A division level meeting was held on March 27 to resolve the final differences over the operating document. Following this meeting, the Cleveland and Plum Brook project engineers drafted a rewrite which should be ready for signatures the first week of April.</p> <p>Fabrication of the pump mount, turbine discharge lines, and tank temperature rake have begun. The pump inlet line is being designed and appears to be a critical lead time item. A design review meeting should be held within the next two weeks.</p>

SECTION II
 PLUM BROOK ROCKET SYSTEMS DIVISION
 TEST OPERATIONS REPORT
 FOR THE MONTH OF
 APRIL 1967

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
B-3	NUCLEAR ROCKET DYNAMICS AND CONTROLS FAC.	<u>NERVA</u> YPD2070(L.V.Humble)		NERVA engine propellant feed system tests.
		<p>The design of the new piping for the pump cavitation program is nearing completion. The purchase request for the pump inlet line should be ready to go to Procurement by the second week in May.</p>		
		<p>The vapor bulb design proposal was reviewed and accepted by Lewis-Cleveland.</p>		
		<p>A sketch of the total pressure rake has been sent to United Sensor for their comments and cost estimate.</p>		
		<p>Twelve (12) new pressure transducers are being procured to complete the requirements of the program.</p>		
		<p>The temperature rake for the liquid hydrogen tank is scheduled to be delivered the first week of May. Feed-thru connectors are being tested. The liquid hydrogen temperature test will probably be conducted the latter part of May.</p>		
		<p>The scram actuator for the turbopump speed control valve is scheduled to be shipped May 12. The analog computer simulation of the turbopump is still under consideration.</p>		
		<p>The pressure vent servo-controller has been modified with 0.1% input resistors to increase the accuracy of the pressure control system.</p>		
		<p>A procedure for removing the KIWI reactor and carriage has been written. All of the required equipment has been located and its condition checked.</p>		

SECTION II

PLUM BROOK ROCKET SYSTEMS DIVISION

TEST OPERATIONS REPORT

FOR THE MONTH OF

JUNE 1967

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
B-3	NUCLEAR ROCKET DYNAMICS AND CONTROLS FAC.	<p><u>NERVA</u> YPD2070(L.V.Humble)</p>		<p>NERVA engine propellant feed system tests.</p> <p>Most of the month of June was spent in making calibration dip tests with Rosemount's temperature probes and in installing the liquid hydrogen tank temperature rake. The installation of the tank temperature rake will be completed early in July. A tank temperature test is scheduled for July 22. The new tank vent valves will be installed for this test.</p> <p>Bids for the pump inlet line were opened June 23. The contract will be awarded July 3. This appears to be the critical item on the schedule.</p> <p>Set-up of the analog simulation control system for the cavitation tests is scheduled to begin July 10.</p> <p>The redesign of the turbine speed control valve scram actuator has not been completed by the manufacturer. Alternate methods of speed control and fast shutdown are being investigated.</p>

SECTION II
PLUM BROOK ROCKET SYSTEMS DIVISION
TEST OPERATIONS REPORT
FOR THE MONTH OF
AUGUST 1967

B-1

HIGH ENERGY
ROCKET ENGINE
FACILITY

CENTAUR
YOV2273 (E.R. Jonash)

Advanced Centaur tests.

B-1 Facility is currently scheduled to commence testing of the improved Centaur in mid-November. The Centaur test tank has been moved from General Dynamics and installed in B-1 Facility. Installation of facility systems to accommodate tank out-flow and tank pressurization tests is as follows:

- (1) Pressurizing gas conditioning system: Design is complete and pressurization skid has been assembled. Checkout of this system is scheduled for the second week of September.
- (2) Liquid oxygen systems: A 13,000 gallon dewar has been installed at the facility. The existing vacuum-jacketed transfer line is being used for LOX. Fabrication of this system is completed. A contract for cleaning the system is to be awarded by October 1, 1967.
- (3) Liquid hydrogen system: Vacuum jacketed transfer line from AF Plant #74 is scheduled for delivery to Plum Brook by the first of October. Foundations for the transfer line from the storage dewar to B-1 are designed and a contract for their installation should be awarded the first week of September.
- (4) Instrumentation systems: A new patchboard and digitizer are being installed in the test facility. This work is being done "in house" and should be completed by mid-October.
- (5) Hydrogen burnoff and LOX dump line: A combination burnoff and dump line has been designed and a contract for its installation should be awarded the first week of September. This system is scheduled for completion the third week of October.

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
B-1	(Continued)	<u>CENTAUR</u> (Continued)	<p>(6) High pressure helium supply: Trailer #47 will be used to provide the facility with high-pressure helium to charge the Centaur storage bottles. The temperature conditioning bath for the storage bottles has been designed and is currently being installed.</p>
C	TURBOPUMP	<u>BOILING FLUIDS RIG</u> YQF0553 (I.I.Pinkel)	<p>The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.</p> <p>The research gear and hot air turbine were installed during August and a series of checkout tests were made. The pump was checked out in liquid nitrogen to 6,000 RPM on August 30. The research gear was disassembled and inspected. A liquid hydrogen cold shock is scheduled for September 7. A data test is scheduled for September 14.</p>
E	DYNAMICS STAND	<u>ATLAS-CENTAUR</u> YOV0774 (E.R.Jonash) YOT2043 (H.M.Henneberry)	<p>Static and dynamic tests for Atlas-Centaur vehicle.</p> <p>Two runs were accomplished during August in the "bulkhead dynamics" test series. Data was inconclusive as it did not clearly indicate a change in damping due to the fuel tank bulkhead effect. Data is still under discussion.</p> <p>A leak in the Atlas fuel tank developed during the past month. Location of the leak is around the fuel tank level probe boss. X-rays indicate a crack in the doubler. The need for, and method of, repair are currently under study in conjunction with LeRC-Cleveland structures personnel.</p> <p>Status of both the "duct dynamics" and "bulkhead dynamics" future programs is unknown at this time.</p>

SECTION II
 PLUM BROOK ROCKET SYSTEMS DIVISION
 TEST OPERATIONS REPORT
 FOR THE MONTH OF
 SEPTEMBER 1967

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-1	<p>HIGH ENERGY ROCKET ENGINE FACILITY</p> <p><u>CENTAUR</u> YOV2273(E.R.Jonash)</p> <p>Advanced Centaur tests.</p> <p>Centaur tank pressurization and outflow tests are scheduled to start in mid-November. Installation of facility systems to accomplish these tests are proceeding on schedule.</p> <ol style="list-style-type: none"> <li>(1) Pressurizing gas conditioning system: The skid has been checked out. The skid is scheduled for installation in the stand in mid-October. <li>(2) Liquid oxygen system: The liquid oxygen transfer line is complete except for cleaning. Cleaning contract is to be awarded October 2 with completion within three weeks. <li>(3) Liquid hydrogen system: The vacuum jacketed transfer line from AF Plant #74 has been received at Plum Brook. Contract for the installation of foundations has been awarded with completion expected by October 26. <li>(4) Instrumentation systems: The patchboard and digitizer are currently being installed in the test stand terminal room. Installation of the instrumentation on the research package will be started in October. <li>(5) Hydrogen burnoff and LOX dump line: All government furnished equipment for this line, except the gimbals, have been received. The gimbals are due October 19. The installation contract has been awarded with completion expected by November 5. <li>(6) High pressure helium supply: The temperature conditioning bath has been installed. A problem of water causing corrosion of the titanium bottles has temporarily halted this job. An investigation into this problem is currently underway.

SECTION II
 PLUM BROOK ROCKET SYSTEMS DIVISION
 TEST OPERATIONS REPORT
 FOR THE MONTH OF
 OCTOBER 1967

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY	<p style="text-align: center;"><u>CENTAUR</u> YOV2273 (E.R. Jonash)</p> <p>Centaur tank pressurization and outflow tests have been rescheduled to start the first of December. Contract and in-house work has required more time than expected. Since we have been unable to procure flight weight vehicle vent valves which are self-regulating in the open position, a back-pressure control system is being designed by the Plum Brook controls group.</p> <p>Installation of the facility systems is as follows:</p> <ol style="list-style-type: none"> (1) Pressurizing gas conditioning system: After checkout at "D" Site, the skid has been installed in the B-1 facility and the majority of mechanical and electrical connections have been completed. (2) Liquid oxygen system: The 13,000 gallon dewar has been cleaned. Cleaning of the Centaur LOX tank and transfer line by the contractor is expected to be completed by November 10. (3) Liquid hydrogen system: The contractor has completed the foundations. Transfer Line A frame supports are presently being installed, with completion expected by November 10. Transfer line sections have been vacuum checked. Vacuum-jacketed flex sections have been fabricated in-house and installation of 	<p style="text-align: center;">Advanced Centaur tests.</p>

(Continued on Page 24)

SITE	SITE NAME	RESEARCH INSTALLATION	ε	DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY (Continued)	<p>the transfer line in the test facility is near completion.</p> <p>(4) Instrumentation system: The patchboard and digitizer installation has been completed. Instrumentation on the research package is about 70% completed.</p> <p>(5) Hydrogen burnoff and LOX dump line: Burner is in place and 90% of line has been installed. Contract completion date is November 5.</p> <p>(6) High pressure helium supply: The remaining high pressure spheres required for this system were received October 30. All bottles will be hydrostatic pressure tested prior to installation.</p> <p><u>CENTAUR 5-C TANK:</u></p> <p>Inspection of Centaur 5C tank has progressed as follows:</p> <p>(1) Tank pressure test was completed October 18, 1967. This test qualified the tank for the following conditions:</p> <p>(a) Maximum pressure differential between LH₂ tank and ambient pressure - 30 PSID</p> <p>(b) Maximum pressure differential between LO₂ tank and ambient pressure - 48 PSID</p> <p>(c) Maximum pressure differential between LO₂ tank and LH₂ tank - 25 PSID</p> <p>(d) Minimum pressure differential between LO₂ tank and LH₂ tank - 2 PSID</p> <p>(e) Maximum pressure differential between LO₂ tank and intermediate bulk-head cavity - 48 PSID</p> <p>(2) A cryogenic test will be performed at "F" Site. The site and the tank are being readied for this test. Expected test date is mid-December.</p>		

SECTION II
 PLUM BROOK ROCKET SYSTEMS DIVISION
 TEST OPERATIONS REPORT
 FOR THE MONTH OF
 NOVEMBER 1967

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY	<u>CENTAUR</u> YOY2273(E.R.Jonash) (CPO - A.J.Stofan; RSD - J.E.Sholes)		<p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellents (LH₂,LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test, LN₂ being substituted for non-flowing propellant.</p> <p>Liquid hydrogen tests are scheduled to commence in mid-December. System checkout has been started. The following major items were completed in November:</p> <ol style="list-style-type: none"> (1) Installation of 16" burnoff and LOX dump line. (2) Installation of LH₂ transfer line supports. (3) Vacuum check, cleaning, and installation of 3" vacuum jacketed LH₂ transfer line. (4) Cleaning of Centaur LH₂ tank. (5) Cleaning of LOX supply dewar, transfer line, and Centaur LOX tank. (6) Pressure check and installation of high pressure GHe spheres. (7) Installation of pressurizing gas conditioning system. (8) Installation of LOX dewar and Centaur LOX tank vent lines. (9) Installation of pressurizing diffuser to Centaur LH₂ tank forward door. (10) Installation of the majority of facility and research instrumentation.

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
B-1	(Continued)	<u>CENTAUR</u> (Continued)	<ul style="list-style-type: none"> (2) Insulation of natural gas line running beneath 16" burnoff line. (3) Thermocouple instrumentation on GHe spheres. (4) Cold-shock and pressure-checks of Centaur tank system. (5) Insulation of Centaur LH₂ discharge line.
C	TURBOPUMP	<u>BOILING FLUIDS RIG</u> YQF0553 (I.I. Pinkel) (FSCD - P.R. Meng; RSD - W.D. Pack, Jr.)	<p>The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.</p> <p>A test run was made on November 28. Three speed survey runs were made from 0 to 27,000 r.p.m. These tests were made to check for critical speeds and to check the modifications made to the turbine. Because of progressively higher vibration readings during the three runs, the testing was terminated.</p> <p>The pump and the turbine were disassembled and inspected. The turbine bearings showed only a slight amount of wear; however, the pump booster had some unidentified metallic material plated to its casing. The turbine has been reassembled and is being installed. The pump has been repaired, rebalanced, and is being reassembled.</p> <p>The next scheduled run is December 7.</p>

SECTION II
 PLUM BROOK ROCKET SYSTEMS DIVISION
 TEST OPERATIONS REPORT
 FOR THE MONTH OF
 DECEMBER 1967

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-1	<p>HIGH ENERGY ROCKET ENGINE FACILITY</p> <p><u>CENTAUR</u> YOV2273 (CPO - A.J.Stofan; RSD - J.E.Sholes)</p> <p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellents (LH₂/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test, LN₂ being substituted for non-flowing propellant.</p> <p>During the first two weeks of December all facility systems were checked out.</p> <p>On December 13 and 14, the Centaur BPTV LH₂ and LOX sections were coldshocked with LN₂.</p> <p>On December 20, an LH₂ boiloff test on the Centaur BPTV was conducted. The tank was filled to 100% liquid level and the boiloff rate was monitored while maintaining 5.29 psig back-pressure. All of the LH₂ was boiled off in 7 hours and 48 minutes. The boiloff rate was nearly constant in the cylindrical section of the tank at approximately 12#/min.</p> <p>On December 21, five pressure rise tests were made on the Centaur BPTV LH₂ tank. These tests were made at five different liquid levels and consisted of closing the vent system and monitoring tank pressure rise from 5.3 to 15.0 psig. Also, the first series of helium burp tests were made. Four burp tests were made at 87% LH₂ tank ullage with 60 seconds of outflow at 1.5#/sec. Five burp tests were made at 60% LH₂ tank ullage and zero outflow. In all tests LH₂ tank pressure was increased from 5.3 psig to 12.8 psig and pressure maintained at 12.8 psig.</p> <p>The next series of Centaur BPTV LH₂ tank helium burp tests is scheduled for January.</p>