

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 JANUARY 1968

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-1	<p><b>HIGH ENERGY ROCKET ENGINE FACILITY</b></p> <p><u>CENTAUR</u>            YOY2273 (CPO -            A.J.Stofan; RSD -            J.E.Sholes)</p> <p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellents (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test, LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>Five series of Centaur LH<sub>2</sub> tank GHe burp tests were made, three on January 18 and two on January 24. Each series consisted of four separate test runs. A larger orifice plate was used to control burp pressure for these tests. The variable parameters were tank ullage volume, starting GHe bottle pressure, and outflow rate. Analysis of the test data from both run days indicated that the tank insulation had not reached a steady state chilled condition. Because the tank insulation temperature was still decreasing during the burp tests, the LH<sub>2</sub> boiloff rate was higher than normal and the test results were not valid. As a result of this situation, the test operation plan was modified for the next run.</p> <p>On January 31, the Centaur LH<sub>2</sub> tank was filled and allowed to chill down overnight. The LH<sub>2</sub> boil-off rate and a tank insulation thermocouple reached a steady-state condition approximately 12 hours after the tank was filled. On February 1, ten series of GHe burp tests were made. A total of 36 test runs was conducted successfully, completing the GH<sub>2</sub> burp test program.</p> <p>The Centaur LH<sub>2</sub> tank outflow tests are scheduled to begin on February 14.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 FEBRUARY 1968

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-1	<p>HIGH ENERGY ROCKET ENGINE FACILITY</p> <p><u>CENTAUR</u> YOV2273 (CPO - AJ Stofan; RSD - JE Sholes)</p> <p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellents (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test, LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>On February 1, ten series of GHe burp tests were conducted. They covered thirty-six test conditions. These tests complete the GHe burp test program.</p> <p>(Continued on Page 24)</p>

SITE	SITE NAME	RESEARCH INSTALLATION	DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY (Continued)	<p><u>CENTAUR</u> (Continued)</p> <p>On February 29 the tank was filled and allowed to chill down overnight prior to the March 1 tests. These tests were originally scheduled for the week of February 11, but were delayed because the GH<sub>2</sub> temperature conditioning system did not adequately cool the gaseous hydrogen. The original conditioning system consisted of three parallel coils of 3/8 inch copper tubing, 30 feet long, immersed in a LN<sub>2</sub> bath. Three changes were made that improved its operation to a successful level -- (1) the number of parallel coils was doubled, which increased the available surface area; (2) the outside of the coils was coated with carbolyne self-priming vinyl which acted as an insulating material. The effect is to increase the coil wall <math>\Delta T</math> and shift the outside heat transfer process from the film-boiling to the nucleate-boiling regimes, which greatly increases the overall heat transfer rate; (3) the LN<sub>2</sub> inlet line was modified to create a swirling action in the bath. This somewhat increased the liquid velocity and further improved the outside heat transfer coefficient. The three changes were separately evaluated. The increased coil lengths and the swirl were not particularly effective without the tube-wall coating.</p> <p>The March 1 tests will complete the testing on the Centaur LH<sub>2</sub> tank. (NOTE: March 1 testing was successfully completed.) The next series of tests will consist of Centaur LOX tank outflow tests. The LOX system was inspected and found to be contaminated. A contract to clean the system is being written. Testing is estimated to resume within four to six weeks.</p>	

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 MARCH 1968

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY	<u>CENTAUR</u> YOY 2273 <i>L. Review</i> (CPO - Ad Stofan; RSD - JE Sholes) <i>6.11.68</i>		<p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellents (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test, LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>Research test runs were conducted on March 1, 14, and 19.</p> <p>All Centaur LH<sub>2</sub> tank outflow tests were conducted on March 1. Three one-burn and seven two-burn outflow tests were made, completing this phase of the program.</p> <p>As indicated in last month's report it would be near the end of April before Centaur LOX tank testing could be started. To utilize this time a series of Centaur LOX tank tests using LN<sub>2</sub> were planned. These tests were conducted on March 14 and March 19. A total of six burp tests and five outflow tests were made. It is hoped this data can be used to possibly lower the number of Centaur LOX tests required.</p> <p>Modifications are presently being made to ready the test facility for Centaur LOX tank testing. It is anticipated that the contract for cleaning the LOX system will be awarded the first week of April.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 APRIL 1968

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY	<u>CENTAUR</u> <u>YOV2273</u> (CPO - RF Lacovic; RSD - EF Gustke)	Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellants (LH <sub>2</sub> /LOX) from a battle-ship type Centaur tank. Only one propellant will be outflowed in any one test; LN <sub>2</sub> being substituted for non-flowing propellant.	<p>On April 3, a Centaur LOX tank LN<sub>2</sub> boiloff test was performed. This test substantiated heat leak data obtained on Centaur LOX tank LN<sub>2</sub> tests of March 14 and March 19.</p> <p>The integrity of the six high-pressure GHe bottles being used at "B-1" for the Centaur tests was questioned. Therefore, a cryogenic hydrostatic pressure check was made in a test rig at "B-3" on April 16, 17, and 18. Since titanium alloy is more crack sensitive at low temperature, they were submersed in a LN<sub>2</sub> bath, filled with LN<sub>2</sub>, and then pressurized to 4700 psi using GHe. All six bottles passed this test. However, two were rejected from use on a subsequent X-ray examination at Lewis-Cleveland. The four remaining bottles are now usable from 0 to 3300 psi for the test program.</p> <p>The Centaur tank pressurant gas supply temperature conditioning system was tested on April 19. This test confirmed that the system could provide 180°R GHe at rated flow for the scheduled June tests.</p> <p>In addition to these tests the facility was modified for Centaur LOX tests. The Centaur LOX tank, outflow line, 16" dump line, LOX transfer line, valves, and miscellaneous equipment were cleaned. Filling the 13,000 gallon supply dewar with LOX was started on April 26.</p> <p>Centaur LOX tests are scheduled for May.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 MAY 1968

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY	<u>CENTAUR</u> YOV2273 (CPO - RF Lacovic; RSD - EF Gustke)		<p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellants (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test; LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>During May, three liquid oxygen test days were completed on the Centaur LOX tank.</p> <p>On May 2, two burp and three outflow pressurization tests were made, for a total of eleven data passes.</p> <p>On May 16, two burp and four outflow pressurization tests were made, for a total of thirteen data passes. These tests were originally scheduled for May 9, but were delayed to make repairs on the instrument bridges which are used with the platinum temperature sensors.</p> <p>On May 24, four burp and three outflow pressurization tests were made, for a total of sixteen data passes.</p> <p>These tests completed the original Block I test schedule. Presently, the test stand is being modified for the extended Block I tests to run LOX tank pressurization tests using cold (180°R) helium. Test runs are scheduled for the first two weeks in June.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 JUNE 1968

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY	<u>CENTAUR</u> YOY2273 (LVD - RF Lacovic; RSD - EF Gustke)	<p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellants (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test; LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>Two days of testing were performed during June on the Centaur LOX tank using 180°R helium for pressurization.</p> <p>On June 5, four burp tests and three outflow tests were made. The tank was pressurized thru the LOX vent standpipe for all tests.</p> <p>On June 19, four burp tests and four outflow tests were made. Of these tests, one burp and one outflow were made using the standpipe for pressurization. The remaining six tests were performed by pressurizing the tank thru a diffuser installed near the tank bottom. In this manner, the pressurizing gas was bubbled thru the LOX agitating the liquid.</p> <p>Two run days are scheduled for July using helium gas stored in the high pressure helium bottles at ambient and at LN<sub>2</sub> temperature. Tests will be made with and without the diffuser.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 JULY 1968

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY	<u>CENTAUR</u> YOQ2273 (LVD - RF Lacovic; RSD - EF Gustke)		<p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellants (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test; LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>During the first week of July the test facility was modified for the Centaur LOX tank pressurization tests.</p> <p>On July 9 one outflow test and one burp test were made using the diffuser and ambient helium. Two other outflow tests were made using 140°R helium, one thru the diffuser and one thru the standpipe.</p> <p>On July 12, four outflow tests and two burp tests were made. Two of the outflow tests were made using ambient helium thru the diffuser. The remaining tests used 140°R helium thru the diffuser except for one burp test thru the standpipe.</p> <p>These tests complete the Block I test schedule. Block II testing using flight weight propellant ducts will begin in October.</p>
B-1	SPECIAL TEST	<u>HELIUM SPHERE TESTS</u> YOQ2273 (LVD - RF Lacovic; RSD - JE Sholes)		<p>The "F" Site helium sphere tests were completed in late June. The test rig was moved to "B-1" during the first week of July for further testing with the Centaur tankage. "F" Site was put in a standby condition, and the personnel reassigned to other sites.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 AUGUST 1968

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-1	<p><b>HIGH ENERGY ROCKET ENGINE FACILITY</b></p> <p><u>CENTAUR</u>            YOQ2273            (LVD - RF Lacovic;            RSD - EF Gustke)</p> <p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellants (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test; LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>On August 27, a series of five helium blowdown tests were performed using one Centaur bottle at ambient temperature. Data were obtained on gas stratification in the bottle during blowdown, using four different control orifices.</p> <p>In addition to preparing for this test, considerable time was devoted to investigating methods for insulating the flight-weight Centaur ducts. There are two sets of ducts to be insulated for future tests at B-1 and B-2. A technique for insulating the ducts has been decided upon and insulation will be started the first part of September when the first set of ducts arrive.</p> <p>Modifications to the facility for Block II testing were initiated.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 SEPTEMBER 1968

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-1	<p>HIGH ENERGY ROCKET ENGINE FACILITY</p> <p><u>CENTAUR</u>            YOQ2273            (LVD - RF Lacovic;            RSD - EF Gustke)</p> <p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellants (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test; LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>Modifications for Block II Centaur tests continued as follows:</p> <ol style="list-style-type: none"> <li>1. The outflow line was cut and is being altered to accept either LOX or LH<sub>2</sub> flight-weight ducts.</li> <li>2. Two Centaur Engine LOX valves and two Centaur Engine LH<sub>2</sub> valves were checked out for operation as duct shutoff valves.</li> <li>3. A new helium diffuser for the LOX tank was fabricated, cleaned, and is now being installed.</li> <li>4. A new quartz view port was installed in the LH<sub>2</sub> tank.</li> </ol> <p>Neither LOX or LH<sub>2</sub> ducts have been received from the contractor. The LOX ducts are expected the second week of October. They must be instrumented and insulated prior to installation.</p> <p>Block II Centaur testing will start early in November.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 OCTOBER 1968

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-1	<p>HIGH ENERGY ROCKET ENGINE FACILITY</p> <p><u>CENTAUR</u>            YOQ2273            (LVD - RF Lacovic;            RSD - EF Gustke)</p> <p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellants (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test; LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>The following items were accomplished in preparation for Block II Centaur LOX tests:</p> <ol style="list-style-type: none"> <li>1. The LOX diffuser ring fabrication and installation was completed.</li> <li>2. The high-pressure helium bottle instrumentation and installation was completed.</li> <li>3. The Centaur LOX ducts were received October 15. The ducts have been instrumented and one set has been insulated.</li> <li>4. Using the LOX ducts, the final field fit and fabrication of the outflow line was completed.</li> </ol> <p>All components of the LOX outflow line should be cleaned and installed the first week of November. Two LOX outflow tests are scheduled for mid-November.</p>

SECTION II  
 PLUM BROOK ROCKET SYSTEMS DIVISION  
 TEST OPERATIONS REPORT  
 FOR THE MONTH OF  
 NOVEMBER 1968

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
B-1	<p><b>HIGH ENERGY ROCKET ENGINE FACILITY</b></p> <p><u>CENTAUR</u> Y0Q2273 (LVD - RF Lacovic; RSD - EF Gustke)</p> <p>Advanced Centaur tests. Data will be obtained on pressurization and outflow of propellants (LH<sub>2</sub>/LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test; LN<sub>2</sub> being substituted for non-flowing propellant.</p> <p>The LOX outflow line components were fabricated, cleaned, and installed the first two weeks of November.</p> <p>The first test of the Block II series of tests-- which are to investigate the redesigned Centaur propellant ducts and tank pressurization hardware-- was made on November 20. It was a two-burn outflow test using the LOX standpipe for pressurization.</p> <p>Outflow Test #2 was made on November 22 using the LOX bubbler for pressurization. This test was aborted during the first burn due to human error in the operation of the paper tape programmer, causing LOX tank pressure to decrease rapidly.</p> <p>The LOX duct chilldown time on both test days was about 40 seconds from the start of LOX transfer until LOX temperature was reached. The pressure drop across the LOX duct was considerably higher on November 22 than on November 20. This difference will be checked when Outflow #2 is repeated the first week of December.</p> <p>Insulation of the second set of LOX ducts (to be used at B-2) was completed. One set of LH<sub>2</sub> ducts was received on November 21. This duct set has been instrumented and insulation has been started. The second duct set was received on November 27.</p>

## SECTION II

## PLUM BROOK ROCKET SYSTEMS DIVISION

## TEST OPERATIONS REPORT

FOR THE MONTH OF

DECEMBER 1968

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
B-1	HIGH ENERGY ROCKET ENGINE FACILITY	<u>CENTAUR</u> <u>Y0Q2273</u> (LVD - RF Lacovic; RSD - EF Gustke)		Advanced Centaur Tests. Data will be obtained on pressurization and outflow of propellants (LH <sub>2</sub> /LOX) from a battleship type Centaur tank. Only one propellant will be outflowed in any one test; LN <sub>2</sub> being substituted for non-flowing propellant.
		<p>On December 3, the third and final LOX outflow test of the Block II series was made to check out the redesigned Centaur vehicle propellant ducts. This was a two-burn outflow test using the LOX standpipe for pressurization.</p>		
		<p>The LOX duct chilldown time was about 40 seconds from the start of LOX transfer until LOX temperature was reached. The pressure drop across the duct compared favorably with that obtained on the test of November 20. It is suspected that the higher pressure drop in one duct, observed on the test of November 22, was caused by blockage of the opposite duct. This blockage was evidently a piece of plexiglass which was part of a window in the thrust barrel. This window was installed to allow viewing of pull through in the LOX sump while still simulating the flow disturbance of the thrust barrel. When the LOX system was disassembled we discovered this window had broken up.</p>		
		<p>The following items were completed in preparation for Block II LH<sub>2</sub> tests:</p>		
		<ol style="list-style-type: none"> <li>1. The battleship captive firing adapter was modified to accept the new larger LH<sub>2</sub> engine duct.</li> <li>2. The second set of LH<sub>2</sub> ducts were instrumented.</li> <li>3. The insulation on both sets of LH<sub>2</sub> ducts was completed.</li> <li>4. The two total probe rakes for checking flow distribution in the LH<sub>2</sub> duct legs were completed.</li> </ol>		
		<p>The Block II LH<sub>2</sub> outflow tests will begin the week of January 13 as scheduled.</p>		