STATUS REPORT OF "J" SITE FROM JULY 1, 1961 - JULY 1, 1962

J-1

The gaseous hydrogen-liquid oxygen rocket test engine has been in operation for the entire 1 year period. At the same time construction has been proceeding to support the second phase of work to be done in the J-1 test rig.

MEMO to CS Moore, 5-5 Info for Yearly super fac mgmt rpt for PBS, 7-5-62

J. "J" Site - Rocket Test Area:

The operation of the various test stands making up the "J" site are listed below:

"J-1", The gaseous hydrogen - liquid oxygen rocket test engine has been in operation throughout the year. Work has now progressed to include the second phase of the test program.

8	Rocket Systems "J" Site	Hydrogen-Oxygen Rocket Engine 28K (Olver)	A hydrogen-oxygen rocket engine is operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber

STATUS: The rig has been in, more or less, continuous operation for the past year. The solid copper engines are fired for periods of approximately one to two seconds and heat transfer coefficients are calculated from temperature profiles measured in copper slugs. The solid engine program will continue for another four to six months. The solid engine program will probably continue until a suitable liquid hydrogen cooled engine is constructed. Such an engine has been designed and is under construction at Lewis Research Center for the [illegible] [illegible].

For the past six weeks, the [illegible] high capacity [illegible] hydrogen system has been utilized for burnoff tests. The burnoff tests are being conducted to [illegible] data in delivering the hot hydrogen facility. The tests have covered flow rates to 15 pounds per second.

PLUM BROOK ROCKET SYSTEMS FACILITIES STATUS REPORT CONTINUED

SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
J	ROCKET SYSTEMS "J-1"	Hydrogen-Oxygen Rocket Engine 28K (N.D.Sanders)	A hydrogen-oxygen rocket engine is operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.

STATUS: Two run days produced seven gaseous hydrogen burnoff data points. Based on this and pervious data the research engineers requested larger hydrogen weight flows and larger burner configurations. Modification of the facility is nearing completion to provide this capability. Numerous liquid nitrogen tests were made on two run days to check out the propellant controller for future rocket engine runs.

3/28/1963

PLUM BROOK STATION ROCKET SYSTEMS FACILITY STATUS REPORT CONTINUED

SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
J	ROCKET SYSTEMS J-1	Hydrogen-Oxygen <u>28K Rocket Engine</u> (N.D.Sanders)	A hydrogen-oxygen rocket engine is operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.
	STATUS:	Facility modifications to provide larger gaseous hydrogen weight flows has been completed. Two run days produced four research data points. This completed the 6 inch diameter stack study. A 20" diameter stack is being installed and more research data runs are scheduled. Preparation continues for the liquid hydrogen engine program. This operation is limited to two to three runs per day because the large gaseous hydrogen requirement depletes available trailers.	

PLUM BROOK ROCKET SYSTEMS DIVISION STATUS REPORT CONTINUED

SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 Hydrogen-Oxygen 28K Rocket Engine (N.D. Sanders)	A hydrogen-oxygen rocket engine is operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber
	STATUS:	The gaseous hydrogen burn off tests were completed during the month of April. Three run days produced a total of eight research data points. This 4 month series of tests was made to obtain data necessary for the design of a portion of the hot hydrogen Facility. Equipment used for the burn off tests is being removed and the cell build up is directed toward resumption of rocket engine firings. The next testing phase will utilize the solid copper heat sink engines. A hydrogen-air torch will be used instead of fluorine for engine ignition. This new ignition system is needed to check out the optical pyrometer for measuring combustion side wall temperatures of the rocket. A rocket engine test firing is planned during the week of May 20th.	
		J-2 Liquid Hydrogen Liquid Oxygen Throttling Tests (I.A. Johnsen)	Throttling and combustion instability tests of a liquid oxygen-liquid hydrogen pressure fed rocket system.

PLUM BROOK ROCKET SYSTEMS DIVISION STATUS REPORT CONTINUED

SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 Hydrogen-Oxygen 28K Rocket Engine (N. D. Sanders)	A hydrogen-oxygen rocket engine is operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.

STATUS: The solid copper heat sink engine has been reinstalled in the test cell. An identification heat check has been made on the revised thermocouple instrumentation. All pressure transducers have been recalibrated, cleaned, and reinstalled in the system. Facility controls have been moved to the new control panel and have checked out satisfactorily. The monitoring instrumentation changeover to the new control panel is nearing completion. The electrical hookup of the liquid hydrogen system, for hydrogen cooled engine test, has been completed. Items left for completion are final checkout of instrumentation and electrical systems and checkout of the engine igniter torch. Runs are scheduled for the first week of June.

SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 HYDROGEN-OXYGEN 28K Rocket Eng. (N. D. Sanders) OCO 425	A hydrogen-oxygen rocket engine operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.
			STATUS: Following complete installation and checkout of all necessary hardware and equipment, a hot firing of a copper engine was attempted on June 6, 1963. The purpose was to measure the combustion side wall temperature with a remote reading optical pyrometer and compare this with recorded thermocouple data. Gaseous fluorine previously used as an ignitor gave erroneous pyrometer results because of flame discoloration. A hydrogen-air torch was being tried this time as an ignition source and several "ignition attempts" were scheduled. Two aborted starts led to discovery of controller troubles. These were corrected and a third run was successfully accomplished. A fourth run attempt showed additional controller problems and further runs were cancelled. Investigation by the Plum Brook controls group is presently underway to determine the exact cause of the controller malfunctionings. Runs will be scheduled the first two weeks of July dependent on proper functioning of the controller.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K Rocket Eng. OC0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.

STATUS: A total of thirteen runs on 3 days were made this month. Successful engine ignition was obtained with both a GH_2-Air torch and a GH_2-GO_2 torch. The objective of these tests was to compare combustion wall temperatures as measured by thermocouples with those seen by an optical pyrometer. No direct correlation has been achieved to date. Further tests of this nature have been cancelled until some major change is made either to the pyrometer temperature measuring circuitry or to the problem of flame discoloration.

The next tests in the cell will include calibration of a new injector with LN_2 and flow controller checkouts. Hot firings will then be resumed to endurance test a copper injector.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K Rocket Eng. 0C0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.

STATUS: A total of five successful firings out of six attempts were made on two run days this month. The objective of the first two runs was to evaluate a copper injector face plate on the basis of endurance under hot firing conditions. The results from these tests indicate this injector to have definite promise of successful use for the extended runs with the future liquid hydrogen cooled engine.

The remaining runs were to checkout the O/F control circuitry of the fire valve controller. The engine was put on condition with fixed valve position, but immediately began to drift off condition upon being put on O/F control. The Plum Brook controls group is investigating this problem and future runs are anticipated to develop the necessary control stability.

Several "cold flow" runs with LN_2 were also made on a new injector to calibrate pressure drop versus weight flow. These tests also indicated further work was necessary in the Pc control portion of the fire valve controller.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K Rocket Eng. OC0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.

STATUS: A total of 19 runs on 4 days were made this month. The objective of these runs was to check out the Pc and O/F controlling circuitry of the fire valve controller. Accurate control of these parameters is of prime importance in the heat transfer work to be done at J-1. To date, system stability with fast accurate response has been obtained only at the 300 psia chamber pressure. A satisfactory arrangement between system pressures and controller response characteristics has yet to be determined for 600 psia chamber pressures. Future tests are planned to meet this objective. A modification to the J-1 test cell structure is scheduled to begin early in October. Cell operations will be curtailed approximately 3 weeks during the cell modification construction period.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K Rocket Eng. OC0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.

STATUS: A total of seven test runs were made this month. The purpose of these tests was to develop fire valve controller stability for a rocket engine operating between 300 and 500 PSIA chamber pressures. All objectives were met successfully. The fire valves retained their fast response characteristics, the desired chamber pressures were obtained with good accuracy, and oscillations in chamber pressure were small in amplitude.

The test cell operations were curtailed this month because on October 14th modifications to the test cell structure were started and presently the system piping is being altered. Checkout of the new LH_2 system with Liquid Nitrogen is scheduled to be started early in November.

Operations should resume by mid-November with a series of tests to evaluate a transpiration cooled injector.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K Rocket Eng. 0C0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective if to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.
		STATUS: Test cell operations were curtailed this month because of modifications to both the cell structure and to the system piping. All alterations have been completed and hydrostatic pressure checking has been finished on the altered piping system. Operational checkouts of the new LH_2 system were held up pending receipt of additional temperature measuring instrumentation. This equipment is now on hand and is presently being installed. Preliminary tests with liquid nitrogen are scheduled for December. Prior to the porous face injector tests, the gaseous hydrogen flow line will be cleaned. Equipment is on order to provide cleaning to the 5 micron range.	

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K Rocket Eng. OCO-425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range of from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.

STATUS: The J-1 test cell has been undergoing a build-up program for the past month. Although the main emphasis has been in preparing for the testing of a transpiration cooled injector, some work has also been done on the liquid hydrogen system.

The following work was done during the month of December:

(1) Work has been started on the setup for the cleaning of the GH_2 fuel line.

(2) All IRCs for the liquid hydrogen system were installed.

(3) Additions to the control panel for the liquid hydrogen system were completed.

The following work is planned for January:

(1) Complete the cleaning of the GH_2 fuel line.

(2) Checkout of the control system for the liquid hydrogen fire valve.

(3) Installation of a new Potter flowmeter in the liquid oxygen system.

The tentative date for a test firing with the transpiration cooled injector is late February. Manpower shortage could be a major problem if increased emphasis is placed on projects such as CENTAUR, B-1 Facility, or the operation of other cells at "J" Site. Therefore, the late February date is subject to further delay.

NOTE (A) : Due to a manpower shortage the operation start date had to be extended.

(Continued on Page 23)

J ROCKET SYSTEMS

J-1 HYDROGEN-OXYGEN 28K Rocket Eng. OC0425 (N.D.Sanders)

A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Presently, solid copper heat sink engines are being used. Ultimately, the program will progress to a highly instrumented liquid hydrogen cooled chamber.

STATUS: Preparations continued during this report period for the testing of the transpiration cooled injector.

The following work was accomplished during January:

1. Installation of the hydrogen gas flow and vent lines was completed.

2. Cleaning of the hydrogen gas flow line was started.

3. The new liquid oxygen flowmeter was installed and the liquid oxygen line was cleaned and pressure checked.

4. The liquid oxygen flowmeter was checked out with liquid nitrogen. A constant discrepancy was noted between it and the liquid oxygen Venturi. This is being investigated.

5. Calibrations were made on the liquid hydrogen fire valve controller.

The following work will be accomplished in February:

1. Cleaning of the hydrogen gas flow line will be completed.

2. Clean the porous face injector.

3. Pressure check and install the injector-engine assembly.

4. Install pressure pickups.

5. Install and checkout the Shawmeter.

The tentative date for a test firing with the transpiration cooled injector is still late February.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K Rocket Eng. OC0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Preparations continued during this report period for the testing of the transpiration-cooled injector. For approximately three weeks, a great deal of effort has been devoted to cleaning the gaseous hydrogen fuel line, with repeated flushing of Dow Chlorothene Nu passed through a 2-micron filter.

Difficulty has been experienced in obtaining an accurate determination of the size of the particles in the fluid samples taken from the line. Cox Instrument Company has been requested to take a sample of the fluid discharging from the 2-micron filter. Results of this analysis will be compared with those made by Plum Brook personnel.

However, on February 29, Lewis and Plum Brook engineers agreed that further efforts to clean the line would be of minor value. Work is now being directed toward the back-flushing of the porous-face injector. A 5-micron filter has been installed in the gaseous hydrogen pressurizing line to the liquid hydrogen tank, as well as the installation of an orifice assembly to measure the flow of pressurizing gas. The vacuum jacket on the liquid hydrogen tank has been pumped down to 50 microns and the dip tube vacuum jacket to 20 microns. The entire liquid hydrogen system is now ready for pressure checking and cold flows. Liquid hydrogen temperature and liquid level measuring instrumentation have to be connected.

The contract to fill the voids in the cell walls with grout was started this month. Problems were encountered when the grout flowed under the floor and caused the floor to rise. This distorted the cell piping. Necessary alterations were made to realign the piping.

NOTE Ⓐ: As a result of the delay in determining the cleanliness of the gaseous hydrogen line, the tentative date for a test firing with the transpiration-cooled injector has now been extended to mid-March.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. 0C0425 (N.D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Early this month, cleaning of the porous-face injector was completed. This consisted of reverse flushing with Dow Chlorothene Nu passed through a 2-micron filter.

On March 11, two successful firings were made, using the porous-face injector with a Rockide-coated steel engine, at 300 PSIA chamber pressure. The results showed that the injector performed satisfactorily, with no evidence of hot spots. Face temperatures leveled off below 400° F. in less than one second.

No runs were scheduled during the week of March 16, as Lewis Research engineers requested a hold until the repaired Shawmeter was returned from the factory.

On March 26, two full duration firings were made, using the porous-face injector with the steel engine. Their purpose was to check out the Shawmeter, used to determine the combustion wall temperature. Although the engine throat was severely burned during the first run, results from these tests were conclusive enough to prove the Shawmeter unworthy of further testing. The flame discoloration had the same effect as during previous tests, that of driving the meter off scale, rendering the measurement valueless.

Pressure checking of the liquid hydrogen system began this month, but difficulty was encountered with facility hardware. This problem is being corrected and the system should be pressure checked and ready for cold flows with liquid nitrogen by mid-April.

Copper engine tests, using the porous-face injector are scheduled to start the week of April 13.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. OC0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

On April 14, three full duration runs were made at a chamber pressure of 500 psia. The porous-face injector was used with the No. 2 copper engine. The object of the test was to determine if the transpiration-cooled injector produced a temperature profile along the engine walls different from that obtained with the copper face plate injector. Preliminary investigation of the data indicates this injector will produce nearly identical results for heat transfer studies. No further runs of this type are being scheduled. During the above tests, the fire valve controller did not perform satisfactorily on Pc and O/F control. Desired conditions could be obtained only by fixed valve position control. Therefore, further "Controller" checkout runs were scheduled using a steel engine with the porous-face injector. The controller conditions chosen were the same as those scheduled for the first runs with the liquid hydrogen-cooled engine.

On April 28, five runs were made to check the controller operation. However, the fuel pressure regulator developed trouble during the last two runs and failed to pass the required flow. Thus, the controller setup still remains to be finalized for operating at 300 PSIA chamber pressure. Runs will also be scheduled in the near future at 600 PSIA chamber pressure.

The liquid hydrogen system has been pressure checked to 200 PSIG. Several leaks were encountered, including leaky valve bodies. The system is again being readied for checking at higher pressures.

Controller checkout runs are expected to continue til mid-May.

NOTE (A) : Further controller checkouts are necessary before setup of the liquid hydrogen engine can be installed.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. OC0425(N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

On May 8 and 13, eleven test runs were made. Their purpose was to complete the determination of fire valve controller gain settings which would produce stable performance over an operating range of 300, 450, and 600 PSIA chamber pressures. The porous face injector was found to be damaged following the tests on May 8, therefore, the high-flow copper face plate injector was used for the higher chamber pressure runs on May 13. The satisfactory results of these tests completed the research requirements of initial operating conditions for the liquid hydrogen cooled engine.

Effort for the balance of the month was directed toward the preparation of the liquid hydrogen system for operation with the liquid cooled engine. Minor modifications were made, both electrically and mechanically, and the entire system was successfully pressure checked to 1000 PSI. A vacuum of 50 microns has been maintained in the liquid hydrogen tank vacuum jacket.

On May 28, the liquid hydrogen system was filled with liquid nitrogen and several flow-tests were made. The tests showed that liquid hydrogen level and temperature instrumentation modifications are necessary and these modifications are presently being made. Three valves developed trouble and are now being repaired. Also, the controller has to be altered to improve its stability on weight flow control. Further tests of this nature are scheduled for the week of June 15th.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. 0C0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

On June 19, the liquid hydrogen system was filled with liquid nitrogen and several flow tests were made. Prior to these tests, three valves had been reworked, and additional instrumentation had been added for both liquid hydrogen temperature and level measurements. The purpose of these tests was to checkout this new instrumentation, and to adjust the fire valve controller gain for stable operation on weight flow control. Results of these tests are as follows:

(1) Satisfactory operation of the controller was obtained with a LH_2 tank pressure of 300 PSIA, but not at 600 PSIA.

(2) Liquid hydrogen level and temperature instrumentation in the LH_2 tank did not work completely satisfactorily.

(3) Liquid hydrogen temperature instrumentation in the flow line performed satisfactorily.

The above problems are being worked on and should be corrected prior to the next series of tests scheduled for the week of July 13.

Work has begun on replacing existing instrumentation cables into "J-1" Test Cell with new cables, terminal boxes, conduit, etc., in an effort to "clean-up" the instrumentation system for the cell.

The site modifications of the new 5000 psi GH_2 trailers are now complete and the electrical contract of the trailer hardware wiring was completed. The plumbing of the trailer hardware is nearing completion and a performance checkout is scheduled for July.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425(N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 PSI. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Efforts during the month of July were directed towards completion of plumbing and instrumentation of the 5000 PSI gaseous hydrogen trailers and in leak-checking the liquid hydrogen dewar vacuum jacket.

The 5000 PSI gaseous hydrogen trailers are now complete and checkout of the trailers will commence in August upon receipt of the modified flex hoses.

The leaks in the liquid hydrogen dewar vacuum jacket have been repaired and cold flow tests scheduled. The purpose of additional cold flow tests is to check out instrumentation and to adjust fire valve controller gain for stable operation above 300 PSIA tank pressure.

The liquid hydrogen-cooled rocket engine was received from Lewis Research Center on July 28. Since the engine was not pressure-checked at Lewis, the engine will have to be checked prior to its installation. It is anticipated that cold flow testing of the engine will commence early in September.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J-1	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425 (N.D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 PSI. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

The liquid hydrogen-cooled rocket engine was assembled to an injector and installed in the thrust stand. All "secondary" plumbing systems to the engine were made up and connected. This included a liquid nitrogen cooling system and a vacuum manifold setup for the engine instrumentation housings. In order to make the instrumentation hook-up easier, modifications were made to the connections to the engine cooling tubes pressure taps. Also, modification had to be made to the engine chamber pressure-checking gear because it was unusable as received from Lewis.

On August 18, the liquid hydrogen engine chamber was pressurized to 50 PSIG and the outside wrap was checked for leaks. Also, a vacuum was pulled on the instrumentation housings. Leaks were found between the cooling tubes, putting pressure under the wrap, around the tubes. Leaks were also found in the engine wrap and into one instrumentation housing. On August 19, the engine was removed from the stand and sent back to Lewis for repairs.

The 5000 PSI gaseous hydrogen trailers were sent to Gas Handling for pressurizing to 3000 PSI with gaseous nitrogen for regulator performance tests. The pressurizing was halted when excessive leakage through the main remote ball valves on both trailers was found to exist. Upon disassembly of these valves, dirt was found in the seats. Dirt was also found in the main discharge lines of the trailer. It was also found that moisture in one of the regulators had sufficiently affected the working parts to make it unusable. The other regulator was found to be in "like new" condition. Dirt was also found in the 5000 PSI trailer gas cylinder, indicating a need for thorough cleaning. Efforts have begun toward having these trailers cleaned by an outside contractor. Performance tests will be delayed until cleaning and repairs are made.

On August 24, an attempt to run liquid nitrogen through the liquid hydrogen system for controller checkout at higher tank pressures and flow reates was aborted due to controller malfunctioning. The main electronic timer which controls all events sequencing, developed trouble and failed to work. By August 31, the controls group isolated the problem and were taking corrective measures. Controller checkouts are tentatively scheduled for the second week of September. It is anticipated that cold flow checkouts of the engine will begin in late September.

The engine testing has been rescheduled from September to October.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425(N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 PSI. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Most of the effort this month was devoted to liquid nitrogen flows in the liquid hydrogen system for fire valve controller checkout. The trouble in the main electronic timer which developed in August was corrected and on Sept. 10 and 15, several cold flows were made. Severe instability was encountered on both days at all conditions of tank pressures and flow rates. Reduction of the data showed need for a smaller trim in the fire valve. The valve was removed, a new plug and seat were made in the Machine Shop, and the valve was reinstalled. On Sept. 23, with the valve C_v reduced to almost half, another series of cold flows was made. The result was stability over a wide range of tank pressures and flow rates. Insertion of a restriction in the flow lines on Sept. 24, to simulate engine cooling tube pressure drop, had no apparent effect on performance stability.

On Sept. 30, several runs with liquid hydrogen were made to check out the entire engine cooling system. Good, stable performance was obtained from this controller over a range of tank pressures from 600 to 900 PSIG. The burnoffs also performed satisfactorily.

Considerable work was expended on the liquid oxygen system. The flow line was completely reworked to provide proper inlet conditions to each of two flow measuring devices. It was felt that the poor comparison of measurements from these devices was partly attributable to poor inlet conditions. The entire LOX system was also extensively cleaned by the flushing of NA500, and most of the valves were rebuilt. Upon reassembly liquid nitrogen flows will be scheduled for re-comparison of the flow measuring devices.

The 5000 PSI gaseous hydrogen trailers were being cleaned by Dow Industrial Co. during the last week of September. Sufficient parts are on hand for the reassembly of one of these trailers. Following this, performance tests with gaseous nitrogen at 3000 PSIG will be made.

One other event to be scheduled prior to the installation and cold flows of the LH_2 engine will be a hot firing using a steel engine. The purpose will be a final performance check of all propellant systems, supporting equipment such as the controller, and operating procedure.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425 (N.D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

The liquid oxygen system was reassembled early this month and flow tests with liquid nitrogen were made on October 10 and 19 for cold shock and flow meter comparison purposes. These tests showed differences in weight flow measurements of approximately one per cent between a venturi and turbine type flow meter. These differences were considered satisfactory, since they were within the accuracies of the instruments.

In the September liquid hydrogen and nitrogen tests, the hydrogen tank liquid level optical type spot sensors were inoperative. When the liquid sensors were inspected, it was found that they had come apart in the tank. The entire liquid hydrogen flow system, upstream of the liquid hydrogen fire valve, was disassembled and inspected for the missing components. This was done to insure that the missing parts could not block the liquid hydrogen coolant passages in the engine. Different type sensors were installed but showed unsatisfactory operation during checkouts on October 21 and 29. These units are being re-checked at the present time.

The 5000 psi gaseous hydrogen trailer, No. 48, has been completely reassembled and pressure-checked to 3000 psi with gaseous nitrogen. On October 21 and 29, performance checks were made of the trailer and regulator assembly. The data indicates satisfactory pressure regulation with fairly good response characteristics.

A steel engine with a copper face injector assembly has been installed in the thrust stand for a hot firing scheduled for the first week of November.

NOTE: During November, the hydrogen gas trailers will be performance-checked to 5000 psi with nitrogen and hydrogen gas. Also, the liquid hydrogen-cooled engine will be installed in preparation for liquid nitrogen cold flow tests.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425(N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

The November 3 run was canceled because of instrumentation difficulties.

On the November 9 run, two hard starts were experienced during preliminary ignition tries and since other difficulties had extended the operation time beyond the allotted work hours, the run was cancelled after these two starts.

On November 13, three successful ignition tries were accomplished.

On November 18, a successful series of steel engine hot firings were made with good performance from all systems. During these firings, liquid hydrogen was flowed through an engine bypass line to simulate the operational conditions that would be encountered in the liquid hydrogen-cooled engine. Since the tests were successful, no further steel engine firings will be made.

During the early November performance tests on the 5000 psi gaseous hydrogen trailer, leaks developed at three flanges, causing a delay in the testing. The necessary repair parts were received on November 23, and the trailer was reassembled. The performance checks at 5000 psi with both gaseous nitrogen and gaseous hydrogen will be done in December.

The instrumentation groups are working on the liquid hydrogen cooled engine instrumentation system. The delivery of the gold-cobalt thermocouple amplifiers was extended to December 2 and this will cause a delay in the system completion. The engine is scheduled to be installed in late December.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425(N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 PSI. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Most of the effort this month was devoted to cell modification and performance checking of the Feedback System's 5000 PSI GH_2 trailer regulator.

All leaks in the 5000 PSI GH_2 system that had developed during November were repaired and another series of checks were made with 2500 PSIG GN_2 on December 3. For these tests, an Apco pressure regulator was installed in the flow line. Since this regulator is required for low chamber pressure rocket engine firing, a check was needed to determine if there would be any interacting effects between regulators. The seat of the Feedback regulator leaked at outlet pressures above 1000 PSIG but it was considered within acceptable limits. During sixteen tests the Feedback regulator performed satisfactorily at varying flow rates from 6#/second to 18#/second and the data showed no interaction between the regulators.

On December 12, the trailer was pressurized to 4900 PSIG with GN_2. When full trailer pressure was put into the Feedback regulator, the seat leakage was so excessive that the performance check had to be canceled. The regulator was disassembled and it was found that the main operating parts had been damaged. The damaged parts were repaired by the machine shop. A survey of other Company regulators is being made for possible replacement of the Feedback regulator.

On December 17, the continuous liquid level probe, with a new control unit, and the liquid level spot sensors were checked with LN_2 in the LH_2 tank. Both units performed satisfactorily.

The instrumentation group continued their work on the liquid hydrogen cooled engine instrumentation. The gold cobalt thermocouple amplifiers were delivered on December 28 and are now being acceptance checked.

NOTE: The research rocket engine is now scheduled to be installed by mid-January.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425(N.D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

During January various mechanical system modifications were made to the test cell.

Due to the fact that the GH_2 Apco regulator had a sluggish response and minor seal leaks, it was decided to install a new Apco regulator. On January 27, the new unit was checked at various weight flows. It had sluggish response characteristics that were worse than the original unit plus the fact that it had a considerable overshoot of pressure on shutdown. Therefore, it was decided to reinstall the original Apco regulator.

The Feedback Systems regulator has been modified, rebuilt and reinstalled on the 5000 psi GH_2 trailer. The regulator has been pressure-checked to 3000 psi with GN_2 and if time permits, it will be checked out before the cooled engine is installed on February 6.

The vacuum system for both the fuel system and the engine cooling system was extensively reworked so that better vacuums could be obtained.

The liquid hydrogen-cooled engine instrumentation work was continued through January. All of the procured equipment was delivered by mid-January. Based on the remaining workload and assuming no major instrument operational problems are encountered, the first engine cold flow tests are scheduled to begin by mid-March.

NOTE: As noted above, the scheduled start date has been changed from January 15 to March 15.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425 (N.D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

The regulator for the 5000 psi gaseous hydrogen trailer was reassembled and installed on the trailer; however, the regulator still has to be tested.

On February 1, the steel engine was removed from the stand and the liquid hydrogen-cooled engine was installed. The system for evacuating the liquid hydrogen engine instrumentation housings was completely reworked. Provision for remote isolation of each vacuum chamber and for the recording of the individual vacuums was added as requested by research engineers. All mechanical connections to the engine were made, including the liquid hydrogen coolant flow lines to the vacuum chambers, pressure transducers, and temperature probes. Considerable time was involved in locating and repairing leaks in the engine vacuum chambers. The liquid hydrogen system was pressure checked to 800 psig. Three valves required overhaul due to adverse weather effects. The liquid hydrogen engine manifold and tubes were pressure checked to 200 psig and a small leak was found in the wrap around the tubes.

The instrumentation system for recording the liquid hydrogen engine temperature data has been completely installed and checked out. The lines to "H" Building have been checked for noise, continuity, and patching.

On February 23, a tape recording of all channels of data on the 4 KC digitizer was reviewed by Lewis Research personnel. They expressed satisfaction with the noise level; therefore, the first liquid nitrogen cold flow through the liquid hydrogen engine was scheduled for March 3. One problem with the special platinum resistance balance panels has to be corrected prior to the March 3 run date. There is excessive voltage output when the sensor is at ambient temperature.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS		
		J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425 (N.D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		On March 3, liquid nitrogen was flowed through the cooling tubes of the liquid hydrogen-cooled engine. The test goals were to cold shock the engine with liquid nitrogen and to check the calibration of the temperature measuring instrumentation at liquid nitrogen temperatures. Tests were run at tank pressures of 400 psig and 600 psig and weight flow rates were 10.7 lb./sec. and 20 lb./sec.	

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOF)	DESCRIPTION
J	ROCKET SYSTEMS		This was the first time that the engine had been cold shocked and, structurally, the engine showed no harmful results from the liquid nitrogen tests. Both engine coolant temperature measurement systems were unsatisfactory and they provided no usable data. The temperature of the liquid nitrogen in the engine was higher than anticipated and platinum resistor output voltage exceeded full scale. The lead wires of the gold cobalt thermocouples were adding EMF to that produced by the junction, and thereby completely distorted the output data. On March 9, the liquid hydrogen engine was returned to Lewis Research Center for repairs. The entire gold-cobalt thermocouple system was replaced by a chromel-constantine thermopyle system. The platinum resistors will remain, but minor modifications are required. The liquid hydrogen engine was returned to Plum Brook on March 29. Reassembly and installation began immediately in preparation for a liquid hydrogen cold flow through the cooling tubes scheduled for April 2. Hot firing of the engine is scheduled for mid-April, if the liquid hydrogen cold flow data is satisfactory. The new APCO regulator, which had shown sluggish response characteristics during initial tests in January, has been disassembled and modified. The outlet pressure sensing circuit has been altered to increase sensitivity during low flow rates. On March 29, several flow checks were made, showing much faster response of the regulator. This regulator will be used for the first hot firing of the liquid hydrogen engine. The Feedback Systems regulator that had been previously rebuilt was used for the above flow checks. Excessive seat leakage was still a major problem. A survey of the field of large pressure regulators has resulted in the ordering of a unit from Sky Valve, Inc., of Syracuse, New York. Delivery is expected within two months. This unit will replace the existing Feedback Systems regulator for one of the 5000 psi gaseous hydrogen trailers. If this first regulator gives satisfactory performance, a second unit will be purchased for the remaining high-pressure trailer. The remainder of the month was devoted to cell maintenance and general preparation for the first hot firing of the liquid hydrogen cooled engine. A new porous-face injector was also backflushed with NA-500 solvent.

SITE	LOCATION	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS TEST SITES		
J-1	ROCKET ENGINE SITE		
		28K ROCKET ENGINE PC0425(N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

On April 6, a liquid hydrogen cold flow test on Engine #1 was attempted. Flow conditions were approximately five pound/second for 15 seconds with a tank pressure of 700 psig. The test was aborted due to excessive hydrogen leakage from the engine cooling tubes during the pre-cool flow. Post run pressure checks revealed cracked solder joints in the vacuum chamber connections, an opening at one location in the engine wrap, and some small leaks in the joint between the cooling tubes and the exit manifold. No conclusive engine temperature data was obtained from either the new Chromel-Constantan thermocouples for the previously installed platinum resistors.

Five additional days of cold flows were made this month for the purpose of proving the temperature measuring instrumentation. Because the test engine was known to leak, liquid nitrogen was used, eliminating possible fire hazard.

On April 15, data was obtained which showed that the Chromel-Constantan thermocouples were operating properly.

Examination of the recorded temperatures showed that the results were strongly influenced by the methods used to install the thermocouples.

The remaining four run days were devoted to obtaining data from the platinum resistors. On April 26, the sensors performed satisfactorily.

On April 27, the liquid hydrogen Engine #1 was removed from the test stand and returned to Lewis Research Center. Tentative plans are to discard the present method of attaching the temperature measuring instrumentation to the outside of the engine cooling tubes. Work is presently

SITE	LOCATION	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION

underway to determine the best method of installing the Chromel-Constantan thermocouples directly into the liquid hydrogen flow in the cooling tubes. Engine #1 will be used as a test unit for this installation.

Liquid hydrogen-cooled Engines #2 and #3 were brought to Plum Brook this month for pressure checking. A small leak in the cooling tubes of Engine #2 could not be located during preliminary low pressure gas checks. A leak around one tube pressure tap on Engine #3 was repaired and the engine then proved to be pressure tight. Following a cold shock in a liquid nitrogen bath on April 27, both engines were hydrostatically pressure checked to 900 psig with helium. Small leaks at tube pressure taps in both engines showed up at approximately 600 psig. Leakage was also observed from the cooling tubes into the voids beneath the engine wrap on Engine #2. This engine was returned to Lewis Research Center on April 30. Engine #3 was satisfactorily repaired and is now leak-tight at 600 psig with helium gas.

Engine #3 is scheduled to be cold shocked with liquid hydrogen during the first week of May. Following satisfactory performance during this test and a post run high pressure gas check, it will be returned to Lewis. Liquid hydrogen temperature measuring instrumentation will then be installed. Engine #1 will then be cold flowed with liquid nitrogen to check the thermocouples installed directly in the liquid hydrogen flow in the cooling tubes. No tentative date has been set for the first hot firing of a liquid hydrogen-cooled engine.

SITE	LOCATION	RESEARCH INSTALLATION & DESCRIPTION	
J	ROCKET SYSTEMS TEST SITES		
	J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE PC0425 (N.D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

On May 7, liquid hydrogen was flowed through the cooling tubes of Liquid Hydrogen Engine #3. A total of five runs was made. Tank pressures ranged from 200 psig to 700 psig, and liquid hydrogen weight flows from 5 to 20 lb/sec. There was no evidence of any hydrogen leakage during these tests. A post-run gas pressure check showed a minor leak had developed at a cooling tube pressure tap joint. This is a silver solder joint and is repairable. The engine was then returned to Lewis for installation of temperature measuring instrumentation.

On May 20 and 21, liquid nitrogen was flowed through the cooling tubes of Liquid Hydrogen Engine #1. This engine had been returned from Lewis with chromel-constantan thermocouples installed in the liquid flow in the cooling tubes. No conclusive temperature data was obtained from these tests. The delta-temperature measuring setup gave answers of as high as 6° when a reading of zero should have been obtained.

On May 28, liquid nitrogen was flowed through a small section of a liquid hydrogen-cooled engine. Approximately 25 feet of copper tubing to the test piece inlet was immersed in liquid nitrogen in an attempt to recondense any gas in the liquid nitrogen flow stream. Three difference test setups were tried: first, the test section was completely immersed in a liquid nitrogen bath; second, the test section was left in the atmosphere with no liquid nitrogen around it; and third, the test section was left in the atmosphere, but liquid nitrogen was flowed into an insulated box around the thermocouple installation. A maximum of 0.25 degree ΔT was recorded during any of the above tests. These results indicate that previous test results may have been distorted by at least two factors: first, vapor may have been in the liquid stream to the test pieces; and second, the thermocouple junctions may not all have been at the same temperature. Further tests are being planned to eliminate these variables and their effects.

Based on the above-mentioned test results, emphasis has now been placed on performing some smaller-scale tests. Their purpose would be to evaluate various methods of thermocouple installation, insulation of the units from ambient conditions, and data readout methods. Full scale engine testing may be temporarily halted until satisfactory results are obtained from the small-scale tests.

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
J	ROCKET SYSTEMS TEST SITES

J-1 ROCKET ENGINE SITE

<u>28K ROCKET ENGINE</u>

PC0425 (N.D. Sanders)

A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Two newly-designed high-pressure Bendix optical level sensors were checked out in the facility liquid hydrogen tank. On June 2, the tank was filled with liquid nitrogen and on June 4, it was filled with liquid hydrogen. The tank was pressurized to 1000 psig on both days. The sensors proved to be reliable and will be used in the tank as high-level and low-level indicators.

On June 22, liquid hydrogen was flowed through a small section of a liquid hydrogen-cooled engine. Thermocouples immersed in the stream of liquid hydrogen were terminated on a copper tube in an insulated box. Liquid nitrogen flowing through the copper tube kept the terminations at a constant temperature. A temperature differential measuring system gave results of 0.17 degree . A Delta T of zero should have been obtained. On June 27 and 28, the simulated engine cold-flow test was repeated. The inlet piping to the test piece was changed in an attempt to eliminate any two-phase flow. No appreciable improvement in the data was obtained. Future tests will be performed to try to obtain the Delta T of less than 0.1 degree.

The Flowmatics 5000 psi regulator is being hydrostatically pressure checked and will be mounted on a 5000 psi gaseous hydrogen trailer early in July. Following the installation the regulator will be tested.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	ROCKET SYSTEMS TEST SITES	
	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> PC0425(N. D. Sanders) A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		Most of the testing this month was limited to flowing LN_2 through a small section of a liquid hydrogen cooled engine. The goal was to develop a satisfactory installation of thermocouples designed to measure the temperature difference between two stations one inch apart in the LH_2 flow stream. Various configurations were used in the physical layout of both the thermocouple reference junctions and the copper extension wires in an attempt to eliminate noise and external EMF effects. The results have not been satisfactory. Efforts are still being expended in this direction.
		The installation of the four-inch Flowmatics pressure regulator on a 5000 psi trailer has been completed and satisfactory pressure checked to 3000 psi. A performance check will be made August 4.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION

August 1965

J — ROCKET SYSTEMS TEST SITES

J-1 ROCKET ENGINE SITE

28K ROCKET ENGINE
PCO 425
(N. D. Sanders)

A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Three days this month were devoted to testing of research hardware. These tests again consisted of flowing LN_2 through a small section of a liquid hydrogen cooled engine. To date, all attempts at accurately measuring a very small temperature difference between two stations one inch apart in the LN_2 flow stream have proved to be unsuccessful. Typical troubles encountered have been excessive drift of thermocouple output, erratic output, false indications of a temperature difference, and inconsistency in the results. A variety of installations have been tried, but none have produced dependable, accurate data. New approaches to the problem are being considered but no definite decision has been made as to the next step in the program.

The four-inch Flowmatics pressure regulator installed on a 5000 psi gaseous hydrogen trailer has been performance-checked using gaseous nitrogen. Trailer pressure (regulator inlet pressure) ranged from 5000 psig down to 2000 psig. Flow rates were between 1 and 34 lb./sec. The test results were very encouraging. Leakage through the regulator seat was negligible. Response characteristics were satisfactory. The only difficulty encountered with the regulator was the excessive wear on the Teflon seat. According to the Flowmatics Company, this is not a typical trouble, and a slight change in operating procedure should eliminate this problem. Following the installation of a new seat, the next step will be a complete performance check with gaseous hydrogen.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION	
J	ROCKET SYSTEMS TEST SITES J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE PCO 425 (N. D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		The 5000 psi gaseous hydrogen trailer No. 48 was filled with gaseous hydrogen to 3000 psig early this month. Performance checks of the trailer four-inch Flowmatics regulator were then conducted on September 15. Due to pressure pick-up calibration problems the tests results were inconclusive. The performance trends, however, were encouraging, showing good response and stable regulation. Testing was resumed on September 29 with 2500 psig trailer pressure. Investigation of the data showed stable regulation over a wide range of flow rates. Response characteristics looked good, but were obviously affected by the lack of an "accumulator" volume in the dome pressure supply line. An accumulator will be installed before the next checkout runs. The four-inch pressure regulator that was received from the Sky Valve Company of Syracuse, New York on September 21, is now being installed on the remaining 5000 psi gaseous hydrogen trailer No. 47. All electrical hardware on this trailer is being modified to comply with the current safety committee standards. Performance testing of this regulator will start in November. No research hardware testing was done at Plum Brook this month. Small-scale tests were conducted at Lewis Research Center-Cleveland. These consisted of flowing liquid nitrogen through a small section of a liquid hydrogen cooled rocket engine. The problem of measuring a very small temperature differential between two points one inch apart in a liquid hydrogen stream has not yet been satisfactorily solved.	

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	ROCKET SYSTEMS TEST SITES	
	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> PCO 425 (N. D. Sanders) A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Gaseous hydrogen performance checks of the Flomatics regulator on hydrogen trailer No. 48 were conducted at 3 000 psig, on October 5. The test data showed that the slow response characteristics indicated in last month's tests have been satisfactorily corrected by the addition of an accumulator installed in the dome pressure supply line. The Sky Valve pressure regulator has been installed on gaseous hydrogen trailer No. 47. The installation of the mechanical and electrical hardware should be completed by mid-November. Three days this month were devoted to testing research hardware. These tests consisted of flowing liquid nitrogen and liquid hydrogen through a small section of a liquid hydrogen cooled engine. The tests were conducted to determine the temperature differential between two points one inch apart in the coolant stream. The results of the tests were satisfactory with both liquid nitrogen and liquid hydrogen flows. The thermocouples will now be installed on the liquid hydrogen cooled engine #3 in preparation for test firing during January.

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
J	ROCKET SYSTEMS TEST SITES		
	J-1 ROCKET ENGINE SITE		
		28K ROCKET ENGINE PC0425 (N.D. Sanders)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Early this month, the installation of all mechanical hardware on #47 gaseous hydrogen trailer (5000 ps) was completed, and the electrical equipment installation is now almost completed. Depending on the "J-1" test schedule, the initial pressure-checking and operational tests should begin by mid-December.

Liquid hydrogen Engine No. 3 was delivered to Plum Brook November 30. The thermocouple setup which proved satisfactory during October's small scale tests has been installed on this engine. The engine has a total of four instrumentation stations which will measure both the liquid hydrogen temperature and pressure. A "facility shakedown" test, consisting of the hot firing of a steel engine, is scheduled for early December. This steel engine has been installed in the test stand and final hookup of all systems is being completed. Following the "facility shakedown" tests, liquid hydrogen Engine No. 3 will be installed in the test stand, cold flowed and hot fired. The hot firing will occur in late December or early January.

A liquid hydrogen system check was made this month. The liquid hydrogen tank was pressure-checked and filled with liquid nitrogen. Some minor problems were encountered such as leaks through valve seats and body halves. The valves are being repaired.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	ROCKET SYSTEMS TEST SITES	
	J-1 ROCKET ENGINE SITE	
		<u>28-K ROCKET ENGINE</u> PC0425 (N.D. Sanders) — A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		On December 10, eight hot firings were made with a rockide-coated steel engine. The objective was a final "facility shakedown" test prior to installing Liquid Hydrogen Engine #3. Although, mechanically the facility functioned properly, the fire valve controller did not supply the desired chamber pressure or the required percent of fuel. Post-run investigation disclosed errors in several phases of the setup of the input signal to the controller. A thorough investigation of the controller gave no indication of malfunctioning of any circuit. Another series of runs, identical in purpose to this set, is scheduled for the first week in January. It is hoped that the Liquid Hydrogen Engine #3 can be installed in the test stand immediately following this next series of tests.
		No testing was done on #47 gaseous hydrogen trailer (5000 psi) this month. Initial pressure-checking and operational tests should begin by mid-January.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	ROCKET SYSTEMS TEST SITES	
	J-1 ROCKET ENGINE SITE	
		28-K ROCKET ENGINE PC0425 (N.D. Sanders) — A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		On January 5, four hot firings were made with a rockide-coated steel engine. The objective of the test was a final performance check of all propellant systems, supporting equipment, and operating procedure. The results of the test were satisfactory.
		The next three weeks were devoted to the installation and pressure checking of liquid hydrogen engine #3 and its supporting equipment. On January 25, three liquid hydrogen cold flows were made. The objectives of this test were to prove the temperature measuring instrumentation and to verify the structural integrity of the engine. An identical instrumentation setup had been checked out previously in a small test section under low pressure and low flow rates. Preliminary investigation of the temperature data showed the results to be satisfactory. The main problem now appears to be the structural integrity of the engine. Small leaks in the engine caused minor fire damage to some test cell instrument wires. Before another liquid hydrogen test run is made, all exposed wires in the area around the engine will be placed in metal conduit or wrapped with fire and heat-resistant tape.
		Liquid hydrogen engine #4 is scheduled to arrive at Plum Brook on February 4, for an initial cold shock and high pressure gas leak check. The results of these tests will determine whether engine #3 or #4 will be used for a hot firing.
		NOTE: Because of the above reasons the hot firing has been rescheduled to March. No testing was done on #47 gaseous hydrogen trailer (5,000 psi) this month. Initial pressure checking and operational tests should start the first part of February, and will take about four weeks.

February 1966

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION	
J	ROCKET SYSTEMS TEST SITES		
	J-1 ROCKET ENGINE SITE		
		28K ROCKET ENGINE PC0425 (N.D. Sanders)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		The final series of performance checks on the high pressure gaseous hydrogen trailer No. 48 were completed this month. The evaluation report of the 4-inch Flowmatics regulator on this trailer is now being finalized. This trailer has been in use for several months and has been giving satisfactory performance. Liquid hydrogen cooled engine No. 4 arrived at Plum Brook February 24. On February 28, the engine was pressurized to 600 psig while immersed in liquid nitrogen. No indication of leakage was observed. Following warm-up to ambient temperature, the engine was repressure-checked to 600 psig and again no leakage could be found. The engine was then sent back to Lewis-Cleveland for the installation of the temperature and pressure instrumentation. The engine is scheduled to be returned to Plum Brook during the week of March 21. Approximately 1½ weeks will be required to install the engine prior to cold flow tests with liquid hydrogen. Considerable effort has been expended this month toward the goal of minimizing the exposure of instrumentation and control cabling to any fire which might occur in the test cell. Conduit runs are being extended as close as is practical to flow control valves and to temperature and pressure transducers. This work should be completed by mid-March.	

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
J	ROCKET SYSTEMS TEST SITES		
	J-1 ROCKET ENGINE SITE		
		28K ROCKET ENGINE PC0425 (N.D. Sanders)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Engine No. 4 was delivered to Plum Brook on March 16. This engine has six instrumentation stations for measuring liquid hydrogen temperature. Leakage from the chamber to the outside was discovered during a final pressure check of the engine-injector assembly. Provisions had been made between the cooling tubes for the installation of hot gas side thermocouples. Sealant failure in these unused holes allowed the leakage. The situation was corrected at Plum Brook by Lewis-Cleveland personnel. Another cold shock pressure-check procedure showed that the repairs were satisfactory. Engine No. 4 has been installed in the test stand and is being prepared for a liquid hydrogen cold flow early in April.

Liquid Hydrogen Engine No. 5 was cold shocked in a liquid nitrogen bath and pressure checked to 600 psig this month. No evidence of any leakage could be found. The engine was then returned to Lewis-Cleveland for installation of the instrumentation.

The conduit extensions mentioned in the status report for February are completed. Instrumentation wires are reconnected and all circuits are being checked out.

The first performance checks of the Sky Valve regulator installed on high pressure Gaseous Hydrogen Trailer #47 showed severe oscillations in regulated outlet pressure. The use of a built-in adjustment feature gave no appreciable improvement in the regulator's performance. No recommendations have been received from the Sky Valve Company concerning this problem.

May 1966

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	

28K ROCKET ENGINE
PC0425(N.D.Sanders)

A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

On May 3 and 11, several liquid nitrogen cold flows were made with liquid hydrogen engine #3. The purpose of these tests was to determine the pressure drops across the engine and downstream control valve versus weight flow. On the basis of these tests, the control valve is being replaced with another valve that has a 60% greater flow capacity (C_V = 320).

On May 18, seven hot firings were made with a rockide-coated steel engine. The purpose of these tests was to develop a procedure for slowly bringing chamber pressure up to its full value. The copper injector was damaged during these firings. The suspected cause of damage was the programming of the LOX purge valve. Because of the electrical circuitry, the LOX purge valve closed when the LOX control valve opened. A change in the circuitry has been made to keep the purge on until the LOX flow builds-up pressure in the injector dome.

Another steel engine hot firing will be made during the first week of June to verify that the cause of injector damage has been eliminated and to improve the slow start-up procedure developed during the last hot firing.

During the hot firing of liquid hydrogen engine #4, the coolant valve was choked because of the high rate of heat flux into the coolant during engine start-up. This problem is being investigated by the controls group at Lewis-Cleveland and at Plum Brook. It has been proposed that a control valve upstream of the engine, as well as the one downstream, may be needed.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-I ROCKET ENGINE SITE	28K ROCKET ENGINE PC0425 (N.D.Sanders) — A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. On June 1 and June 11, a total of 16 hot firings were made with a rockide coated steel engine. The purpose of these tests was to develop engine start-up procedures that would give a slow rise in chamber pressure. Engine start-ups were successfully made with both a high and a low Pc injector at 300 and 150 psia chamber pressures. Two new hydraulic control valves have been installed in the LH_2 flow lines. This valve upstream of the engine will control inlet manifold pressure. This is an entirely new system including the controller, and must be checked out completely. A large valve has been installed downstream, and will control LH_2 weight flow through the engine. LH_2 cold flow tests with Engine #4 are scheduled for mid-July. Hot firing tests are scheduled for late July or early August. The hot firing tests will not be run until satisfactory performance has been achieved with the entire LH_2 system. Analog studies of the LH_2 system are being conducted by the Plum Brook Controls group. Various methods of controlling the coolant during engine combustion are being investigated.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION	
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> PC0425 (N.D.Sanders)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		The study of various methods of controlling the liquid hydrogen coolant flow through the engine was completed in early July. The decision was made to control the engine inlet pressure during both the transient and steady state portions of the hot firing and to control weight flow only during the steady state portion. On July 21, Liquid Hydrogen Engine #4 was cold flowed with liquid hydrogen. The purpose of this test was to check out the two new hydraulic control valves and the new pressure controller. With the modifications as determined from the July 21 run, another liquid hydrogen cold flow was made on July 28. After one run, the seat in the liquid hydrogen tank pressurization regulator had to be replaced. The cold flow was completed on July 29. All test objectives were successfully accomplished. A hot firing of Liquid Hydrogen Engine #4 is scheduled during the first week of August. On July 7, Liquid Hydrogen Engine #7 was pressure checked to 700 psig with gaseous nitrogen. No leaks were found. The engine was then returned to Cleveland.	

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION	
J	J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE PC0425 (N.D.Sanders)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		On August 4, an attempt was made to hot-fire liquid hydrogen cooled engine #4. Several problems which developed during the day prevented more than a low Pc ignition checkout run. Both liquid level measuring units in the liquid hydrogen tank failed to operate properly. Leakage through the seat of the liquid hydrogen weight flow control valve during tank pressurization decreased the available liquid hydrogen for a test run. A broken stem in the Flomatics pressure regulator on the gaseous hydrogen trailer #48 required the trailer pressure to be bled down to the 2400 psi manifold pressure.	
		On August 11, a successful hot firing of liquid hydrogen engine #4 was made. During the run, the liquid hydrogen weight flow and engine inlet pressure controls performed properly. The engine appeared to be cooled satisfactorily, although several of the leaks	

(Continued on Page 28)

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE (Continued)	28K ROCKET ENGINE (Continued) which had previously been repaired, reappeared. Several cracks were also discovered in the mesh surface of the porous face injector. Investigation of the data showed that the gaseous hydrogen fuel flow was only 9% of the total weight flow, instead of the desired 15%. As a result, a series of steel engine hot firings were made on August 18 to check out the entire fuel weight flow control. During these tests, the desired fuel flow again was not obtained. Severe oscillations also occurred in gaseous hydrogen regulator outlet pressure. On August 22, gaseous nitrogen flows through the fuel system indicated that a modification to the fuel pressure regulator had eliminated the pressure oscillations. During the week of August 22, the controls group made several modifications to the fire valve controller. On August 31, another series of hot firings of a steel engine was made. The results of these tests were completely satisfactory. The gaseous hydrogen fuel flow showed no evidence of the oscillations which had occurred during the previous tests on August 18. The desired gaseous hydrogen weight flow was obtained with the fire valve controller performing properly. Liquid hydrogen cooled engine #5 will be brought to Plum Brook and installed in the test stand immediately. A hot firing of this engine is tentatively scheduled for the week of September 12.
	J-3 VACUUM ENVIRONMENT TANK	TANK INSULATION TESTS OR1327(I.A.Johnsen) Various liquid hydrogen tanks will be tested under a vacuum environment. The effectiveness of various types of insulation will be studied. Since completion of the double-guarded calorimeter test program on July 29, the main effort in the facility has been directed in upgrading the electrical systems to meet Class I, Group B, Division II requirements. This effort will be maintained until mid-September, whereupon testing of the Centaur arc tank will begin. The arc tank has been insulated at Linde with six panels of carbon dioxide backfilled insulation. The objective of this program will be to measure the carbon dioxide cryo-pumping ability of each panel.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	

28K ROCKET ENGINE
PC0425 (N.D.Sanders)

A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Liquid hydrogen cooled engine No. 5 was received September 1, and was installed in the test stand on September 6. The hot firing, scheduled for the week of September 12, was delayed one week because of excessive noise on the cables to "H" Building.

On September 22, a successful hot firing was made. The desired run duration of 8 seconds at 300 psia chamber pressure was obtained. Post-run pressure checks showed the engine to be pressure-tight. The temperature data from the hot gas side thermocouples corresponded with the expected values. The absolute and differential temperature measurements from the thermocouples immersed in the liquid hydrogen coolant stream were questionable. A temperature gradient with depth in the coolant tube was indicated.

Based on the results of the September 22 test, the immersion depth of the liquid hydrogen coolant thermocouples is being changed. This work is being done at Plum Brook by Lewis-Cleveland personnel, while the engine remains in the thrust stand. Two defective thermocouples will be replaced. The next hot firing is scheduled for the first week of October.

On September 26, liquid hydrogen cooled engine No. 8 was cold shocked and pressure checked to 900 psi. It was found to be pressure tight and was returned to Cleveland for installation of instrumentation.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> PC0425 (N.D.Sanders) — A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Nine hot firings of LH_2 Engine No. 5 were made during three days this month. Five of these firings were good data producing runs. Run duration averaged approximately ten seconds. The engine was pressure checked following each series of runs and found to be pressure tight. Data from the liquid hydrogen coolant thermocouples showed a definite temperature gradient with depth in the coolant stream. This phenomenon is being explored by repeating run conditions and varying the thermocouple immersion depth. The absolute liquid hydrogen temperature measurements compare favorably with the expected results. Data from the hot gas side thermocouples has been satisfactory. Run conditions to date have been as follows: Chamber pressure - 300 psig LH_2 engine inlet manifold pressure - 600 psig minimum; 900 psig maximum LH_2 coolant weight flow - 11.0#/sec. minimum; 16.0#sec. maximum The next series of runs is scheduled for the first week of November. The immersion depth of several liquid hydrogen thermocouples has been readjusted. For these runs previous conditions will be repeated. The next step in the program will be to increase chamber pressure while duplicating other previous run conditions. (Continued on Page 26)

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> PC0425 (N.D. Sanders) A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. On November 1, three hot firings were made with LH_2 - cooled engine No. 5. The series of tests at a chamber pressure of 300 psia is completed. The lower range of coolant system parameters was extended to a weight flow of 9.7 lb/sec at an inlet manifold pressure of 600 psig. During post run pressure checks, three small leaks were discovered in the engine cooling tubes. The engine was removed from the stand and sent to Lewis-Cleveland for repairs. Engine No. 6 was received on November 10, following re-adjustments on the LH_2 thermocouples' depths. Initial pressure checks showed a leak at Station No. 6 so the engine was returned to Lewis-Cleveland for repairs. On November 21, Engine No. 6 was returned. Pressure checks were satisfactory, and the engine was installed in the stand. The next series of tests are scheduled for the first week of December. These tests will be at 450 psi chamber pressure. (Continued on Page 26)

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE (Continued)	<u>28K ROCKET ENGINE</u> Several performance tests were made this month with the Skyvalve pressure regulator for the high pressure GH_2 trailers. Results were unsatisfactory. Further tests of the Skyvalve will not be made. In spite of contractor and NASA efforts, the regulator performance was unstable at high flow rates.
	J-3 VACUUM ENVIRONMENT TANK	<u>TANK INSULATION TESTS</u> OR1327 (I.A. Johnsen) Various liquid hydrogen tanks will be tested under a vacuum environment. The effectiveness of various types of insulation will be studied. On November 18 the cryopumping performance of six Linde self-evacuating multi-layer insulation panels was tested. Three test panels were backfilled with instrument grade CO_2, and the remaining three panels with water pumped GN_2. All six panels were attached to a Centaur Arc Tank. Under atmospheric ground hold conditions, with the tank filled with LH_2, the CO_2 panels cryopumped into the low 10^{-5} torr range. They remained at this pressure during the duration of the test. The GN_2 backfilled panels were capable of cryopumping to the low micron range during the ground hold portion of the test. As would be expected the cryopumping action of the GN_2 panels was considerably more sluggish than the CO_2 panels. Under space vacuum conditions, all panel pressures increased to the 20 to 100 micron range. Subsequent investigation of the panels showed they were leaking on the surface next to the tank wall, which explained the high test pressures. The leaks occurred when a vacuum was drawn in the vacuum chamber. This has been a continuing problem with the self-evacuating insulation system. Since these panels are not repairable, this test completed the testing of panel insulation systems. The Arthur D. Little Gold-Mylar insulated calorimeter is scheduled for testing in February. A fifty-gallon vacuum insulated flash dewar is under fabrication to minimize cold guard liquid hydrogen consumption. The double-guarded calorimeter, with a purged multilayer insulation, is scheduled for testing in April. Both ground hold and space environment thermal effectiveness will be evaluated. Rapid evacuation tests to simulate a typical missile ascent will be performed to evaluate transient heat fluxes.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE PC0425 (N.D. Sanders) A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

During December, six test firings with Engine No. 6 were attempted and four were successfuly completed, on two run days. Three of these tests were at a chamber pressure of 300 psia. The test conditions duplicated previous runs with Engine No. 5, to allow comparison of data between the two engines. The final test was made at 450 psia Pc. This was the first time one of the LH_2 cooled engines was tested at a chamber pressure above 300 psia. The engine performed satisfactorily during all runs. However, several hot-gas-side thermocouples at critical locations became defective. The loss of these thermocouples reduced the amount of data obtainable and, therefore, Engine No. 6 was removed from the test stand. Since the engine is still pressure-tight, Lewis-Cleveland personnel are attempting to repair the defective thermocouples.

Before each series of runs, metals of various melting temperatures were plated onto the engine combustion wall. We wanted to confirm the engine wall temperature data of the hot-gas-side thermocouples by observing which metals did not melt during the tests. Photographs of the platings were taken before and after each firing for comparisons. The results compared favorably with the thermocouple data.

Engine No. 9 was cold-shocked and pressure-checked to 1200 psig this month. The engine is pressure-tight and was returned to Lewis-Cleveland for installation of all instrumentation.

Engine No. 7 is being completed in Lewis-Cleveland, and should arrive at Plum Brook during the first week of January. Engine testing is scheduled for the week of January 16.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE YPC0425 (N.D.Sanders) — A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. LH_2 cooled engine No. 7 was received at Plum Brook on January 5 and was installed in the test stand on January 12. A two-day installation delay was caused because of the added requirement to purge the area between the engine and the instrument boxes. On January 20, four test firings were made, two tests at 300 psia chamber pressure and two at 450 psia. Holes were found in two cooling tubes after the final run, and the engine was sent to Lewis-Cleveland for repair on January 23. We have spent considerable time on cell maintenance this month. New operator lines were installed to all the LF_2 ignition system valves. The K bottle supply for loading the GH_2 systems' regulators was replaced by two of the area's permanent storage bottles. Engine No. 6 is scheduled to be returned early in February for a short series of tests at chamber

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE YPC0425 (N.D.Sanders) — A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. LH_2 cooled Engine No. 6 was installed, pressure checked, and cold shocked by February 6. One unsuccessful attempt was made on February 9 to hot fire this engine at a chamber pressure of 600 psia. The coolant inlet manifold cracked approximately one second after ignition and the run was terminated by the safety circuit. Temperature and pressure cycles during previous runs had apparently weakened the engine in this area. Design changes have been incorporated in later engines to reduce the possibility of this failure recurring. Engine No. 8 was installed and cold shocked on February 21. The installation of the hot-gas-side thermocouples at four stations on this engine has been changed in an attempt to better the quality of the combustion-wall temperature data. Hot firing of this engine is scheduled for early March.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE YPC0425 (N.D.Sanders) — A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. On March 8, two successful hot firings were made with LH_2 cooled engine No. 8. Chamber pressure of 300 psia, and coolant inlet manifold pressure of 700 psig, were held constant for each run. Coolant weight flow was changed from 12.5 lb/sec for the first run, to 11.2 lb/sec for the second run. After the second firing, two small holes in the engine cooling tubes were discovered during pressure checks. The engine was returned to Cleveland on March 10. The next series of research data runs in J-1 will be with a copper engine (wire wrap profile). The installation of all temperature instrumentation on LH_2 engine No. 9 was held up pending the results of tests on engine No. 8. It will take approximately three months to complete this engine. During this time, copper engine tests will be made. The goal of these tests is to extend the range of the hot-gas-side heat transfer data obtained in previous copper engine tests. A rockide coated steel engine was installed in the test stand on March 29. A short series of tests will be made with this engine to verify proper start-up procedures. A very short Pc rise-time is required for the copper engine tests.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> YPC0425 (N.D. Sanders) A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. Nineteen (19) test runs were made on four run days this month. These tests, using a rockide-coated steel engine with a copper-face injector, were made to verify proper start-up procedures. A very short Pc rise-time is required for the copper engine tests which are next on the schedule. The series of tests on April 4 were terminated after only four starts because of troubles with the fire valve controller. On April 11, only one run was made. Controller problems again caused an early termination. A burned-out check valve in the liquid fluorine ignition system allowed only three runs on April 21. The troubles with the controller had been cleared-up before this series, and it performed properly during each run. On April 26, eleven runs were made. Chamber pressure was 300 psia for all runs. Satisfactory fast-starts were verified for 15 and 20 percent fuel. The third attempt to start with 28 percent fuel ended with a detonation in the LOX dome of the injector. Damage to the injector was extensive. A new porous-face injector has been installed for the completion of these start-up tests. It is hoped that one more series of tests, scheduled for the first week of May, will conclude the rapid-start tests at 28 percent fuel. The No. 3 copper engine can then be installed for the heat transfer tests.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	

<u>28K ROCKET ENGINE</u>
YPC0425 (N.D.Sanders)

A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

On May 10, five successful test firings were made. A new porous-face injector was used with a rockide-coated steel engine. These tests were made primarily to develop a very short chamber pressure rise-time with a 28 percent fuel mixture. Two runs were made with this porous-face injector to compare the start-ups at 15 and 20 percent fuel with those obtained previously with the copper-face injector. All goals were successfully accomplished.

Copper engine No. 3 has been installed in the test stand. Final connections of all pressure pickups and engine thermocouples are nearly completed. Hot firings of this engine are scheduled for the first week of June.

LH2 engine No. 10 was cold shocked and pressure checked on May 11. The engine was pressure-tight and was returned to Lewis-Cleveland for installation of all thermocouple instrumentation.

A considerable amount of work was accomplished this month on the instrumentation system between "J-1" Test Cell and the Auxiliary Instrument Trailer. New conduit runs were installed, new cable was pulled, and new termination boxes have been installed in the test cell. Signal conditioning equipment has been relocated and a new scanner system has been installed in the Auxiliary Trailer. Improvements in the data quality and instrumentation capacity are expected; also, the general area appearance will be improved.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE YPC0425 (N.D. Sanders) A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustiongases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. A total of ten test firings were made on four run days this month using two different copper engines. These tests were made to extend the hot-gas-side heat-transfer data obtained in earlier tests with copper engines No.'s 1 and 2. On June 9, 13 and 14, nine test firings were made on copper engine No. 3. Run conditions were 300 psia chamber pressure with fuel weight flows of 15, 20, and 28 percent. Thermocouple rods had been installed at several additional axial locations along the engine. Static and differential pressures along the engine axis were also obtained during the firings. Following the above tests, copper engine No. 2 was installed in the test stand. This engine had thermocouple installations at locations 60 degrees apart in the chamber. The purpose of testing with this engine was to determine if a circumferential temperature profile was produced in the combustion chamber by the injector. One test firing was made on June 29, at a chamber pressure of 300 psia, and a fuel weight flow of 15 percent. Investigation of the low Pc, porous-face injector immediately after the run showed the face platewas beginning to warp. Therefore, it was decided to eliminate any further copper engine testing with this injector and to save it for the future liquid hydrogen engine tests. Copper engine No. 2 will be reinstalled in the test stand with the old high Pc porous-face injector used for previous liquid hydrogen engine tests. This injector has severe face-plate warpage. The effect of this warpage on the combustion chamber temperature profile will be investigated. Liquid hydrogen-cooled engine No. 9 arrived at Plum Brook this month. Installation of this engine in the test stand will begin immediately after the completion of the copper engine tests.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	

<u>28K ROCKET ENGINE</u>
YPC0425 (N.D.Sanders)

A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

A total of six test firings were made on three run days this month. Copper engine No. 2 was used for all tests, with two different injectors. The purpose of these tests was to determine if a circumferential temperature profile was produced in the combustion chamber by the injectors.

On July 7, one run was made with the old high Pc porous-face injector which had been used for the previous liquid hydrogen cooled engine tests. This injector had severe warpage on the face plate. Run conditions were 300 psia chamber pressure and 15% fuel.

On July 14, a second run was made with this same engine-injector combination. For this run, the engine had been rotated 30 degrees C.C.W., with respect to the injector, from its previous position. Run conditions again were 300 psia chamber pressure and 15% fuel. Since thermocouples had been installed in the engine chamber at locations 60 degrees apart, this rotation allowed a temperature comparison at 30 degree intervals.

On July 21, three successful firings were made in four attempts. A low Pc copper-face injector was used with copper engine No. 2. Chamber pressure again was 300 psia, but with two fuel weight flows, 15 and 20 percent fuel, for the first two runs. The third run programmed a slow rise in chamber pressure (approx. 1.5 seconds to full value), to simulate the liquid hydrogen cooled engine start-ups.

This month's tests completed the current program of copper engine firings. Liquid hydrogen cooled engine No. 9 is now being installed in the test stand. The hot firings of this engine will be delayed slightly, pending the completion of the modifications to the instrumentation system into the test cell. The major delay will be due to the installation of a new patch board, scheduled to be delivered August 4. Testing of liquid hydrogen engine No. 9 should begin by mid-September.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION	
J	J-1 ROCKET ENGINE SITE	28K ROCKET ENGINE YPC0425(N.D.Sanders)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Most of this month's activity was in preparation for the hot firing of liquid hydrogen cooled Engine No. 9. This engine had been installed in the test stand on July 28. The temperature and pressure instrumentation has been connected, and at present the complete instrumentation system is being checked out. Since the last firing of a liquid hydrogen cooled engine, all instrument cables between the test cell and the auxiliary instrument trailer have been replaced and a new patchboard installed. A liquid nitrogen cold flow for a system checkout is scheduled for September 1. The hot firing of Engine No. 9 is scheduled for Sept. 8.

Two other liquid hydrogen cooled engines were cold-shocked in liquid nitrogen, pressure-checked, and returned to LeRC-Cleveland this month. Engine No. 8 had a nickel plating over some holes which had occurred during the last hot firing. Engine No. 12 is a new engine and the cold-shock/pressure-check is a standard procedure for all new engines before installation of temperature instrumentation. Both engines checked satisfactory.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS	J-1 HYDROGEN-OXYGEN 28K ROCKET ENG. PC0425 (N.D.Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 PSI. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

Most of the effort this month was devoted to liquid nitrogen flows in the liquid hydrogen system for fire valve controller checkout. The trouble in the main electronic timer which developed in August was corrected and on Sept. 10 and 15, several cold flows were made. Severe instability was encountered on both days at all conditions of tank pressures and flow rates. Reduction of the data showed need for a smaller trim in the fire valve. The valve was removed, a new plug and seat were made in the Machine Shop, and the valve was reinstalled. On Sept. 23, with the valve C_v reduced to almost half, another series of cold flows was made. The result was stability over a wide range of tank pressures and flow rates. Insertion of a restriction in the flow lines on Sept. 24, to simulate engine cooling tube pressure drop, had no apparent effect on performance stability.

On Sept. 30, several runs with liquid hydrogen were made to check out the entire engine cooling system. Good, stable performance was obtained from this controller over a range of tank pressures from 600 to 900 PSIG. The burnoffs also performed satisfactorily.

Considerable work was expended on the liquid oxygen system. The flow line was completely reworked to provide proper inlet conditions to each of two flow measuring devices. It was felt that the poor comparison of measurements from these devices was partly attributable to poor inlet conditions. The entire LOX system was also extensively cleaned by the flushing of NA500, and most of the valves were rebuilt. Upon reassembly liquid nitrogen flows will be scheduled for re-comparison of the flow measuring devices.

The 5000 PSI gaseous hydrogen trailers were being cleaned by Dow Industrial Co. during the last week of September. Sufficient parts are on hand for the reassembly of one of these trailers. Following this, performance tests with gaseous nitrogen at 3000 PSIG will be made.

One other event to be scheduled prior to the installation and cold flows of the LH_2 engine will be a hot firing using a steel engine. The purpose will be a final performance check of all propellant systems, supporting equipment such as the controller, and operating procedure.

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> YPC0425(N.D.Sanders)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.
		Liquid Hydrogen Cooled Engine No. 10 was received, cold shocked, and pressure checked to 1000 PSIG this month. The copper face injector to be used with this engine arrived at Plum Brook on October 30. These items are now being assembled for immediate installation in the test stand. The hot firing of this engine is tentatively scheduled for mid-November.	
		been initiated.	

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	

<u>28K ROCKET ENGINE</u>
YPC0425(N.D. Sanders)
(C&ECD - L.Bryant;
RSD - G.D.Mackay)

A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

The hot firing of LH_2 cooled Engine No. 10, scheduled for November, was cancelled. Twenty hot-gas-side thermocouples, out of a possible total of thirty-two, were found to be inoperative during pre-run checks. Ten had been deleted because of difficulties during original installation, and ten more failed during pre-run LN_2 cold shocks.

The GH_2 fuel line is presently being modified in the test cell. This change will allow installation of either the new U-tube design or the old wire-wrap design engines in the test stand. A series of hot firings of a rockide coated U-tube design steel engine is tentatively scheduled to begin in December. These tests will be run to determine injector performance and ignition start-up procedures.

<u>TANK INSULATION TESTS</u>
YOR2023(I.A.Johnsen)
(CRD - J.R.Faddoul,
I.E.Sumner, and
J.R.Barber; RSD -
T.C.Cintula)

Various liquid hydrogen tanks will be tested under a vacuum environment. The effectiveness of various types of insulation will be studied.

A test run was started November 27 on the Linde semi-panel insulation applied to the aluminum stackable double-guarded calorimeter. The test sequence consisted of ground hold performance followed by a rapid evacuation to space hold conditions. The net heat flux under each condition of testing was slightly higher than desired; however, it was still low enough to represent an excellent insulation system. The same test sequence will be repeated after a 30-day air environment soak to determine the degradation to the insulation. The final test will be at space vacuum conditions with the insulation panel valves open to the vacuum chamber.

The next test program will be the "Transient Venting of a Multilayer Insulation" which will probably begin in early March.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> YPC0425 (C&ECD - L.Bryant; RSD - G. D. Mackay) — A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles. On December 21, the Rockide-coated steel U-tube engine, fitted with a 300 Pc injector, was test fired. The injector performance and ignition start-up procedures were tested. The test data is applicable to liquid hydrogen cooled U-tube engines which are scheduled to be tested at J-1 site. A total of five successful test firings were made, two for ignition tests and three for injector performance. The 500 Pc U-tube injector will now be installed for a similar performance evaluation. This injector will subsequently be used for both liquid cooled U-tube and copper engines. A series of cold flow tests to determine injector pressure drop characteristics is scheduled for January.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION	
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> YPC0425 (C&ECD - L. Bryant; RSD - T.C. Cintula)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles.
		A total of 12 test firings was made this month on 2 U-tube contour rockide-coated steel engines with a 500 Pc porous face injector. Desired chamber pressure for these runs was 400 psia. The test firings were made to develop start-up techniques, such as valve sequencing and position settings, applicable to research engines.	

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	

<u>28K ROCKET ENGINE</u>
YPC0425
(C&ECD - L Bryant;
RSD - TC Cintula)

A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles.

A total of 12 test firings were made this month on the U-tube contour steel nozzle with a 500 Pc porous face injector.

Optimum valve settings and position sequences now have been established for 400 and 600 Pc slow and fast rise start-ups for this test configuration. During the last reporting period, the 300 Pc slow rise start-up was evaluated.

On February 21, an 800 Pc test firing was attempted with this nozzle-injector combination. The firing resulted in destruction of the solid steel nozzle. There was only minor damage to the injector and to the test facility.

Delivery of three new solid steel U-tube contour nozzles is expected shortly, and the next test is scheduled for the week of March 25.

<u>TANK INSULATION TESTS</u>
YOR2023
(CRD - JR Faddoul,
IE Sumner, & JR Barber;
RSD - DG Perdue)

Various liquid hydrogen tanks will be tested under a vacuum environment. The effectiveness of various types of insulation will be studied.

No test operations were scheduled during February. The month was spent preparing the test cell for the next configuration. The equipment is being modified to accept the copper heat transfer tank. The KD-850 vacuum pump was installed, and check-out runs are scheduled for March. The major portion of the instrumentation changes for the copper heat transfer tank are scheduled to be completed in March, and tests are scheduled to start in April.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> YPC0425 (C&ECD - E. Bryant; RSD - TC Cintula) A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles. This reporting period was spent in rebuilding the test cell. All major systems have been checked and the cell is expected to resume research operations in the first week of April. The initial test firings will be with the H-Tube Contour Steel Engine with a 500 Pc injector. Firings at chamber pressures of 400 and 600 PSIA will be made to determine if previously established valve settings and position sequences are still optimum. Wire wrap contour LH_2 cooled engine #12 will be installed immediately following the steel engine checkout. The purpose will be to determine if a new thermocouple configuration is suitable for research data. If successful, this engine will be returned to Lewis-Cleveland for complete instrumentation.

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> YPC0425 (C&ECD - RJ Quentmeyer; RSD - T Cintula)	A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles.
		A total of 19 test firings were made during April. The test configuration was the steel U-tube contour nozzle with the 500 Pc injector. These test firings were to evaluate start-up characteristics, and to substantiate optimum performance from previously established valve settings after rebuilding. The facility is now being prepared to accept the LH_2 cooled wire wrap engine #12. Test firings will be made at chamber pressures of 300 and 450 psia. This test configuration will be used to evaluate two different methods of thermocouple installation for measurement of LH_2 cooling properties. This program will start in May.	

SITE	LOCATION	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
J	ROCKET SYSTEMS TEST SITES		
J-1	ROCKET ENGINE SITE		
		28K ROCKET ENGINE PC0425 (N.D. Sanders)	A hydrogen-oxygen rocket engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to chamber wall. The objective is to extend heat transfer theory into the region required for the design of nuclear rocket nozzles.

On April 6, a liquid hydrogen cold flow test on Engine #1 was attempted. Flow conditions were approximately five pound/second for 15 seconds with a tank pressure of 700 psig. The test was aborted due to excessive hydrogen leakage from the engine cooling tubes during the pre-cool flow. Post run pressure checks revealed cracked solder joints in the vacuum chamber connections, an opening at one location in the engine wrap, and some small leaks in the joint between the cooling tubes and the exit manifold. No conclusive engine temperature data was obtained from either the new Chromel-Constantan thermocouples for the previously installed platinum resistors.

Five additional days of cold flows were made this month for the purpose of proving the temperature measuring instrumentation. Because the test engine was known to leak, liquid nitrogen was used, eliminating possible fire hazard.

On April 15, data was obtained which showed that the Chromel-Constantan thermocouples were operating properly.

Examination of the recorded temperatures showed that the results were strongly influenced by the methods used to install the thermocouples.

The remaining four run days were devoted to obtaining data from the platinum resistors. On April 26, the sensors performed satisfactorily.

On April 27, the liquid hydrogen Engine #1 was removed from the test stand and returned to Lewis Research Center. Tentative plans are to discard the present method of attaching the temperature measuring instrumentation to the outside of the engine cooling tubes. Work is presently

SITE	LOCATION	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
			underway to determine the best method of installing the Chromel-Constantan thermocouples directly into the liquid hydrogen flow in the cooling tubes. Engine #1 will be used as a test unit for this installation. Liquid hydrogen-cooled Engines #2 and #3 were brought to Plum Brook this month for pressure checking. A small leak in the cooling tubes of Engine #2 could not be located during preliminary low pressure gas checks. A leak around one tube pressure tap on Engine #3 was repaired and the engine then proved to be pressure tight. Following a cold shock in a liquid nitrogen bath on April 27, both engines were hydrostatically pressure checked to 900 psig with helium. Small leaks at tube pressure taps in both engines showed up at approximately 600 psig. Leakage was also observed from the cooling tubes into the voids beneath the engine wrap on Engine #2. This engine was returned to Lewis Research Center on April 30. Engine #3 was satisfactorily repaired and is now leak-tight at 600 psig with helium gas. Engine #3 is scheduled to be cold shocked with liquid hydrogen during the first week of May. Following satisfactory performance during this test and a post run high pressure gas check, it will be returned to Lewis. Liquid hydrogen temperature measuring instrumentation will then be installed. Engine #1 will then be cold flowed with liquid nitrogen to check the thermocouples installed directly in the liquid hydrogen flow in the cooling tubes. No tentative date has been set for the first hot firing of a liquid hydrogen-cooled engine.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> YOR0425 (CRD - RJ Quentmeyer; RSD - TC Cintula) A hydrogen-oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles. This month has been spent in preparing the liquid hydrogen cooled U-tube contour engine for test firings. A test run date of August 1 has been established. This will be the first firing of a liquid cooled engine of this configuration in "J-1" Test Cell. Considerable effort has been spent in the fabrication of the manifold piping for this engine. All manifold piping has now been cold-shocked, X-rayed and pressure-checked. Following the test of the liquid hydrogen U-tube contour engine, the facility will be modified for the installation of either the copper wire wrap engine or the copper U-tube engine for heat transfer studies. Nearly one month of build-up time will be required for either engine.

August
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SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
J	J-1 ROCKET ENGINE SITE	<u>28K ROCKET ENGINE</u> YOR0425 (CRD - RJ Quentmeyer; RSD - TC Cintula)	A hydrogen/oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles.

The LH_2 cooled U-tube contour engine was fired on August 8, at a chamber pressure of 300 psi. Although the firing was successful, several engine coolant tubes burned out at a location 2 inches from the injector. At this area, localized heating of the entire circumference of the engine was evident.

To investigate the circumstances of the localized heating, an instrumented, forged steel, U-tube contour engine is being installed. The low Pc porous face injector is having additional hydrogen holes drilled over half of the injector circumference to provide a cooling profile. This configuration is scheduled for testing on September 5.

The next test program will be the copper U-tube contour engine. This program is expected to be completed by October 15 and be followed by testing of a fully instrumented LH_2 cooled U-tube engine.

SITE	SITE NAME	RESEARCH INSTALLATION	& DESCRIPTION
J	J-1 ROCKET ENGINE SITE		
		<u>28K ROCKET ENGINE</u> YOR0425 (CRD - RJ Quentmeyer; RSD - TC Cintula)	A hydrogen/oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles.
		Test firings were made on September 5 and 7 on the U-tube contour steel engine and low Pc porous face injector configuration. Both runs were at a chamber pressure of 300 psia. The injector was modified for these firings by adding additional fuel coolant holes at the injector circumference. These holes provided 15%, 7-1/2%, and 3-3/4% additional fuel coolant capabilities to the injector, based on complete circumferential coverage. A Kistler crystal high-frequency transducer indicated stable combustion throughout each test run. The next test date or engine configuration has not been established.	

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
J	J-1 ROCKET ENGINE SITE	

<u>28K ROCKET ENGINE</u>
YOR0425
(CRD - RJ Quentmeyer; RSD - TC Cintula)

A hydrogen/oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles.

A total of eleven test firings were made in the month of November with the instrumented copper nozzle of U-tube contour and modified porous face injector. Heat transfer data were obtained for the following listed test parameters:

Pc	% Fuel
150	15 1/4
500	15 1/4
600	20
600	24
800	15 1/4

An additional test was added to the program and is scheduled for December 10. This test will investigate the effect of various hydrogen flowrates thru the peripheral coolant holes in the injector. Heat transfer data will be compared for the following conditions:

Pc	% Fuel
600	15 1/4
600	24
800	15 1/4

This information will complete the copper nozzle test program. No future test programs are anticipated for J-1 Test Cell.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION	
J	J-1 ROCKET ENGINE SITE		
		<u>28K ROCKET ENGINE</u> YOR0425 (CRD - RJ Quentmeyer; RSD - TC Cintula)	A hydrogen/oxygen engine operated over chamber pressure range from 200 to 900 psi. Heat transfer is measured from the combustion gases to the chamber wall. The object is to extend heat transfer theory into the region required for design of nuclear rocket nozzles.
		On December 10, four test firings were made with the U-tube contour copper nozzle and a modified porous face injector. These runs were made at identical conditions to previous runs, to compare heat transfer effects of different injector designs. This series of runs was in addition to the original "finish up" program. No further rocket engine tests are scheduled for the facility.	