Jean Temple
PBRF Files
(Jan Fay)

NASA
Plum Brook Station

Sandusky, Ohio
July 9, 1962

MEMORANDUM to Charles S. Moore

Subject: Information for yearly experimental facilities operation report for Plum Brook Station

1. The information contained herein is submitted as per your telephone request of 29 June 1962. The experimental facilities as Plum Brook Station do not lend themselves to the "running time" type of reporting usually associated with Wind Tunnels and similar rigs. This makes it necessary to present the information in a different format.

2. The Plum Brook Reactor went critical on a minimum size core June 14, 1961 and was first operated with the full size core on June 27, 1961. Since that time the Reactor has operated 318 hours at low power for calibration and training. Of this number 195 were spent approaching critical and 123 were spent at critical. A total integrated power for these very low power operations was 894 kilowatt hours. In addition to the Reactor operation at PBRF approximately 200 hours were spent in completing the hydraulic testing of the core. These are actually operating hours with the primary system pumps, etc being used. Test set up time of course has not been included.

3. Operations have continued in the Rocket Systems area for certain of the facilities and certain of the new facilities have gone operational during the last fiscal year. Many of the new facilities have been going through the shake-down runs and calibration tests associated with the initial operation. Some of the facilities have required rather extensive changes between scheduled test programs. Each of the facilities have been listed below with notes describing operations for the past year:

a. <u>"A" Site - Pump Research Laboratory:</u>

Between September of 1961 and May of 1962 ten Liquid Nitrogen and one Liquid Hydrogen run were made on the Liquid Hydrogen Pump installation. No operation of the LOX pump portion of the facility took place during the year.

b. <u>"B" Site - NERVA Test Stand:</u>

This facility is still in the construction phase, no operation was scheduled during the past year.

c. <u>"C" Site - Turbo Pump Facility:</u>

The Boiling Fluids rig was in operation throughout the year using Liquid Hydrogen. Several preliminary runs were made in order to check out the newly installed equipment and the data handling capabilities of the equipment associated with the experiment operations of the Hydrogen Pump rig have been limited to five or six check-out runs on the thrust balance system of the pump and to cold shock tests

of the pump suction and discharge lines.

d. "D" Site - Turbine Test Facility:

Operations have been limited to cold flow tests to investigate control problems and to a hot check of the gas generator. Results of these tests indicated that certain of the control valves and systems had to be modified and these changes are now being made.

e. "E" Site - Dynamics Laboratory:

Twenty-Nine research runs were completed between February and July of 1962 to support the MECA program, the SCOUT program and the Ranger payload systems as well as others.

f. "F" Site - Hydrogen Flow Facility:

This site was not operational during the Fiscal Year except for shake out testing that required several modifications to the existing equipment.

g. "G" Site - Pilot Plant:

Test operation of the Liquid Hydrogen Pump continued until the end of September 1961. After that time a new pump was installed and one run was made in June 1962. The turbine test facility at the same site had twelve runs between November 1961 and January 1962 using the NERVA three stage turbine. In addition one run was made in June of the Hy-Nut Turbine using Nitrogen gas.

h. Central Control:

This facility operates as a central control and data acquisition facility for most of the test stands. It has been in operation throughout the year as required to meet the various runs scheduled. In addition a considerable amount of time has been spent in de-bugging the data acquisition and read-out gear in order to eliminate deficiencies that showed up as part of various test operations as well as to improve the capabilities of the installed systems.

i. "I" Site - Liquid Fluorine Pump Laboratory:

During the past year this newly completed facility has been going through various check runs using gas helium and liquid nitrogen in order to "prove" the systems for use with liquid fluorine. Two liquid fluorine tests were conducted in March of 1962, one of which was considered successful. The second test resulted in partially destroying the test facility when a fluorine leak occurred in the equipment under test. The remainder of the fiscal year has been spent in rebuilding the facility for future fluorine tests.

PLUM BROOK STATUS REPORT (continued)

ITEM NO	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
5	Turbo Pump "C" Site	Boiling Fluids Rig F5C	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank. The research is intended to obtain basic information so that pumps can be designed for operation with small or zero net positive suction heads. The rig utilizes fairly sophisticated instrumentation including local density meters and pressure survey equipment. A variable power cylindrical electric heater is installed in the pump inlet for the purposes of simulating nuclear heating.

STATUS: A bearing failure occurred during the last run and considerable damage was done to the research hardware. The hardware is being reconstructed and some facility improvements are being installed. The research equipment is expected approximately February 1. Most of the month of February will be used to build up and checkout the rig. Approximately eight test days will be required to obtain data on the present configuration. Large quantities of data are gathered in a single day's operation.

The boiling fluids rig has been productive and generally runs quite well. There is a long and heavy work schedule ahead of it and covers such things as numerous configurations, the electric heat input and "cold" hydrogen. Presently, the rig is being reviewed to determine its suitability for pumping subcooled hydrogen ranging from its normal boiling point down to the slush point.

Liquid Hydrogen Turbo Pump F5A (Pinkel)	Liquid hydrogen turbo pump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM

STATUS: From the beginning this rig has been plagued with problems and several facility modifications have been required. The research turbo pump is a small scale high speed precision machine. The turbine is powered with high pressure cold hydrogen gas and is connected through an optical torquemeter directly to the pump. More than a year ago, during the first liquid nitrogen cooldown test, the oversized facility piping broke the inlet off the pump. Subsequently, it was found that the pneumatic pressure balance device was unstable and when

excited, caused the shaft of the pump and turbine to oscillate in the longitudinal mode at frequencies of several hundred cycles per second.

Flexible sections have been installed in the pump inlet and outlet lines and the facility lines have been anchored near the pump. The pneumatic thrust balance device has been replaced with a hydraulic unit using liquid nitrogen. Although oil is preferred for the thrust balance unit, the present research rig does not have provision for a scavenge and therefore, the nitrogen can be allowed to vent to the atmosphere. The modified propellant lines and the new thrust balance device have undergone considerable static testing and are both functioning satisfactorily. Rotating tests of the turbo pump unit will commence during the last week in February.

GENERAL The instrumentation requirements for these test rigs exceeds the available capability. Plum Brook is presently designing a patchboard system which will allow each rig to use all of the installed equipment. Revision of the instrument system will require four to six weeks and will commence in April. The work will be scheduled to coincide with major configuration changes in both the "C" and "C'" rigs so that a minimum interference can be expected.

6 Dynamics Laboratory "E" Site — PJO No. Unknown (Gabriel) — Vibration tests of the Atlas-Centaur vehicle

STATUS: Plum Brook personnel have attended several Centaur planning meetings, reviewed and criticized PERT schedule and made three trips - one each to General Dynamics and Astronautics, San Diego, Cape Canaveral, and Systems Engineering Laboratories, Fort Lauderdale, Florida. To date, most of the Plum Brook effort has been in the category of gathering information. Little productive effort can be exerted until some of the facility requirements and test objectives can be firmed up. Rocket Systems Division personnel plan to meet with Mr. Russ Dunbar and Ted Geris at their earliest convenience. The shaker equipment at "E" stand has been in rather continuous use during the past year. It has supported the SERT and MECA programs from Lewis Research Center and two outside contracts, both to Bell Aero Systems. The first contract was by J. P. L. for a digital accelerometer for the Ranger payload. The second was an Air Force contract covering the instrumentation package for the Sky Bolt missile.

PLUM BROOK ROCKET SYSTEMS FACILITIES STATUS REPORT CONTINUED

SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
C	TURBO PUMP	Boiling Fluids Rig F5C (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank. The research is intended to obtain basic information so that pumps can be designed for operation with small or zero net positive suction heads. The rig utilizes fairly sophisticated instrumentation including local density meters and pressure survey equipment. A variable power cylindrical electric heater is installed in the pump inlet for the purposes of simulating nuclear heating.
	STATUS:	The rig has been assembled minus the research gear and will be cold shocked with liquid nitrogen to checkout the instrumentation lines as they enter the tank. The research gear will then be installed, instrumentation hooked up, and cold-shocked again. This will enable proper turbine-pump alignment at both ambient and cryogenic conditions. It is anticipated that the first liquid hydrogen run will occur near the end of March, 1963.	
		Liquid Hydrogen Turbo Pump F5A (Pinkel)	Liquid Hydrogen turbo pump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.
	STATUS:	Note (A): Due to additional man hours required to install gas manifold the pump rotating tests were delayed. Research instrumentation and the gas manifolds have been completed. Presently the controls and operation instrumentation are being installed. Auxiliary systems checkout is scheduled to be started March 6. Rotating tests of the turbo pump will be started as soon as satisfactory systems checkouts have been completed. Liquid nitrogen pump tests are scheduled to start the last week of March. Note (B): The instrument systems revisions will be done by contract and the work will be scheduled to coincide with major research installation configuration changes so that required operation interferences will be held to a minimum.	

PLUM BROOK STATION ROCKET SYSTEMS FACILITY STATUS REPORT CONTINUED

3/28/1963

SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG F5C (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank. The research is intended to obtain basic information so that pumps can be designed for operation with small or zero net positive suction heads. The rig utilizes fairly sophisticated instrumentation including local density meters and pressure survey equipment. A variable power cylindrical electric heater is installed in the pump inlet for the purposes of simulating nuclear heating.

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STATUS: The research gear is being installed in the tank. Upon completion, all instrumentation will be attached and checked out and at that time the rig will be cold-shocked with liquid nitrogen. This will enable proper turbine-pump alignment at cryogenic temperature. It is anticipated that the first liquid hydrogen run will occur near the end of April. During March, progress on this rig has been retarded in order to speed up the progress on the turbo-pump.

Note (A)- The test cell contains both the Boiling Fluids rig and the Turbo-pump rig. Manipulation of manpower and test run times necessitated the delay from the end of March to the end of April for the first hydrogen run.

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Note (B)- The instrument systems revisions will be done by contract and work will be scheduled to coincide with major configuration changes so that required operation interferences will be held to a minimum.

Liquid Hydrogen Turbo Pump F5A (Pinkel)	Liquid Hydrogen turbo-pump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

STATUS: Rotating test with liquid nitrogen was attempted on March 22, 1963. The pump shaft would not rotate and presumably froze or seized due to the low temperature. No data was obtained. Research gear will be inspected and if no extensive damage is found; a rotating run will be scheduled for the first or second week of April.

	SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
April 1963	C	TURBO PUMP	BOILING FLUIDS RIG F5C (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank. The research is intended to obtain basic information so that pumps can be designed for operation with small or zero net positive suction heads. The rig utilizes fairly sophisticated instrumentation including local density meters and pressure survey equipment. A variable power cylindrical electric heater is installed in the pump inlet for the purposes of simulating nuclear heating.
			STATUS:	The research gear has been installed, all instrumentation checked out, and the rig cold shocked with liquid nitrogen. The turbine and pump have been aligned and all leaks repaired. As of April 30, 1963, instruments are being calibrated, the tank is being pressure checked, and the cryogenic fluids and gases are being supplied preparatory to the liquid hydrogen run scheduled for May 2, 1963.
			LIQUID HYDROGEN PUMP F5A (Pinkel)	Liquid Hydrogen turbo-pump tests to obtain impeller matching with centrifugal pump at speeds to 60,000 RPM.
			STATUS:	It was discovered that the reason for pump seizure on March 22, 1963 was due to a clearance problem in the thrust balance. Gaseous nitrogen was originally used in the thrust balance system but was found to be unstable. Liquid nitrogen was tried and the system stabilized. The clearance was enlarged and a run was tried on April 7, 1963. After pump data was recorded the test was stopped when the impeller shaft seized on the pump housing. Mis-alignment was caused by the warping of the bedplate which was sprayed with liquid nitrogen that was leaking past the thrust balance close clearance seals. A shield was made to protect the bedplate and on April 17, 1963, a successful liquid nitrogen run was made at speeds high enough to insure that the rig is ready to begin liquid hydrogen tests. These tests are scheduled for mid-May. Test schedules will depend on the availability of liquid hydrogen dewars.

PLUM BROOK ROCKET SYSTEMS DIVISION STATUS REPORT CONTINUED

SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG F5C (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.

STATUS: During the run of May 2 the lower pump bearing seized necessitating shutdown. Upon inspection of the rig, metal chips were found in the pump discharge line. The research gear gave no indication as to the source of these chips. The pump was disassembled, parts sent to Cleveland for repair, and is now being reinstalled preparatory to a liquid hydrogen run scheduled for the first week in June. The chips were analized and part of the rig was disassembled in an effort to locate the source of trouble. Indications are that drilling and tapping for actuator mounts or the installation and use of a new gaseous manifold could have provided the metal chips. As of May 27 the rig has been completely cleaned, a pump out line has been installed, the tank bottom lock foamed, and new instrumentation installed.

	LIQUID HYDROGEN PUMP F5A (Pinkel)	Liquid Hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

STATUS: The liquid hydrogen pump rig had been ready for operation since April 17, but tests were delayed because the two available dewars were in use at "A" Site. A liquid hydrogen run was attempted on May 28. The run resulted in a broken torque meter shaft and considerable damage to the turbine. Two problem areas are indicated. A facility control malfunction occurred and has been traced to an intermittent electron tube failure. Also the possibility that the turbopump components were inadequate for the new operating conditions. The electron tube failure caused the ten second scheduled ramp from 15,000 RPM to 36,000 RPM to occur in less than one second. The torque shaft failure occurred at about the time that maximum speed was reached. Two possible reasons (other than the rapid acceleration) may account for the failure. First, the liquid nitrogen thrust balance system chills the torque shaft and other components below their original design temperature. Second, the spring struts which support the turbine bearing are rapidly fatigued. However, completely accurate failure analysis is not likely.
Present plans include the installation of the axial inlet pump, converting the temporary LN_2 thrust balance system to a hydraulic system and redesign of the turbine bearing system. This work will be accomplished during the scheduled shutdown for the instrument changeover. Testing of the new pump is scheduled for August

NOTE (A): June runs have been cancelled.

	SITE	LABORATORY	RESEARCH INSTALLATION (FOR)	DESCRIPTION
June 1963	C	TURBO PUMP	BOILING FLUIDS RIG (Pinkel) OF0538	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.

STATUS: Three liquid hydrogen pump runs were made during June with the following results: (1) June 11, 1963 - two recirculating cavitation runs and one locked-tank pump out run. The data was obtained on these runs in approximately twelve minutes at which time the bearings seized necessitating shutdown. (2) June 19, 1963 - after approximately ten minutes of recirculating pump runs the bearings seized. A small amount of data was obtained on this run date. (3) June 25, 1963 - three head-flow curve runs, five cavitation runs, and five pumpout runs were accomplished on this date. A large amount of data was obtained on these runs during approximately fifty minutes of pump run time. The bearings seized after the conclusion of these tests.

Sufficient data has been obtained on the research gear and it is now planned to install new research gear. During this time a patch board will be installed which will facilitate the running of both the boiling fluids rig and the turbopump rig. Rig and cell improvements will be made during this time. It is expected that all changes will be made in approximately six weeks.

		TURBO PUMP	LIQUID HYDROGEN PUMP OF0553 (Pinkel)	Liquid Hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM

STATUS: The plans for installation of the axial inlet configuration are in progress. Final machining of the pump parts is now in process at Cleveland. The majority of the turbine parts are at Plum Brook for an initial stack up. Limited amounts of machining has been necessary to obtain the correct clearances. After initial stack up, the parts will be sent to Cleveland for cleaning and balancing. Plans for updating the cell are in progress and this updating will be accomplished during July and August when the cell will be shutdown for patch board installation. The following are some of the modifications: (1) new turbine manifold, (2) a new type of hydraulic oil will be installed in the control valve system, (3) installation of hydraulic system for thrust balance and (4) modification of existing loop to accommodate new configuration.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		
		BOILING FLUIDS RIG OF0538 (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.
			STATUS: This rig was not scheduled to operate this month due to the installation of a new patch board system which will facilitate the operation of both the boiling fluids and the turbopump rigs. This installation work is expected to take six weeks. During this time, new research gear in conjunction with a nuclear heating simulator will be installed. Also, the air-operated drive turbine is being overhauled in Cleveland. Liquid hydrogen runs are scheduled to resume the middle of September.
		LIQUID HYDROGEN PUMP OF0553 (Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.
			STATUS: The stack-up of the turbine is proceeding and it is anticipated that the initial stack-up will be completed by 8-2-1963. The Lewis Machine Shop estimates that the axial inlet pump will be ready for initial stack-up by the second week of August. As soon as the pump and turbine assemblies are available for fitting, modifications of the present loop will begin. Work is still in progress on the cell updating modification. This work is for the purpose of updating the cell for more efficient operations.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		

BOILING FLUIDS RIG
0F0538 (Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.

STATUS: The installation of the patch board is proceeding and will be completed by the end of September. The research gear is being installed and it is anticipated that the turbine will be overhauled and on hand by Sept. 2nd. Minor rig changes are being made which will improve and increase the safety precautions of the operation. The nuclear heating simulator will be installed upon completing the stack-up of the pump. Liquid hydrogen runs are scheduled to resume about the middle of October.

NOTE (A) : The slow contractor progress made on the patch board installation necessitated moving the anticipated run date to mid-October.

LIQUID HYDROGEN PUMP
0F0553 (Pinkel)

Liquid hydrogen turbopump tests study impeller matching with centrifugal pump at speeds to 60,000 RPM.

STATUS: The axial inlet pump arrived at "C" site on 8-22-63. Loop modification has started and should be complete by 9-6-63. The work on the turbine stack-up was halted while replacement parts were machined. This work will proceed as soon as the loop is fitted and welded in place. The installation of the patch board and the updating modification work is still in progress.

NOTE (A) : The progress made on the patch board installation necessitated moving the anticipated run date to the first part of October.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		
		BOILING FLUIDS RIG 0F0-538 (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.

STATUS: The installation of the patch board is complete, the turbine has been installed, and, at present, the research gear is being installed. Instrumentation lines are being rearranged to smooth out cyclical run data. System valves and equipment are being overhauled and up-dated. An additional nuclear simulator heater has been instrumented and is being installed preparatory to a liquid hydrogen run scheduled for Mid-October.

LIQUID HYDROGEN PUMP 0F0-553 (Pinkel)	Liquid hydrogen turbopump tests study impeller matching with centrifugal pump at speeds to 60,000 RPM.

STATUS: The contracted portion of the patch board is complete and checked out. Instrumentation wiring is installed between the rig and the balance panels, terminations have to be completed.

The X-Rays of the six and eight inch diameter pipe welds on the loop showed that the welds were unsatisfactory. The welds were reworked and will be cold shocked on 10-1-63 and re-X-Rayed on 10-3-63.

Modification of the turbine inlet and turbine outlet for the new configuration is complete. The new hydraulic thrust balance system is complete.

The electrical revamping work is still in process. Valve and IRC wiring at the site is near completion and should be completed 10-7-63. The auxiliary panel equipment is yet to be wired. The wiring on the graphic panel is in process and should be complete the first of November. This includes moving the three controllers from the cell to "H" Building. This work is expected to be finished the first of November.

The stack up of the turbine is progressing and the necessary machining is being done to obtain the required clearances and tolerances. It is expected that it will be finished 10-8-63. Then the pump and turbine will be aligned and the complete package will be sent to Cleveland for balancing on 10-18-63.

NOTE Ⓐ: Due to the difficulty in welding and a re-evaluation of other work the scheduled run date was changed to Mid-November.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		
		BOILING FLUIDS RIG 0F0538 (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.

STATUS: The research gear has been installed and instrumentation Stathams and lines are being installed. Re-wiring of the graphic and auxiliary panels is continuing. A concrete pad is being installed for gaseous systems trailers. The camera electronic gear has to be checked out and, if necessary, repaired prior to an anticipated liquid hydrogen run on Nov. 15th.

NOTE Ⓐ : Rescheduling of the run date to Nov. 15th was necessary after a re-evaluation was made of the workload necessary to rewire and update the control panels.

LIQUID HYDROGEN PUMP 0F0553 (Pinkel)	Liquid hydrogen turbopump tests study impeller matching with centrifugal pump at speeds to 60,000 RPM.

STATUS: Loop modification work is complete for the axial inlet configuration. The six and eight-inch welds were cold shocked, x-rayed, and hydrostatically checked. A pin hole in the six-inch pipe was found during the hydrostatic test. The pipe was repaired and re-checked. The vacuum jacket has been welded in place and a satisfactory vacuum is being maintained.

Cold shock and thrust balance checkouts will be made before balancing rotating gear, thereby saving the time of re-balancing if machining is necessary. Machining work for instrumentation and correction at oil passages will be done while rotating parts are being balanced.

The electrical switches on the auxiliary panel are complete and checked out. The panel meters, annunciators, and graphic panel have to be wired. The controllers have to be moved and prints are being studied to determine a method that will use as much existing wiring as possible. To date, approximately 40% of the necessary transducers have been supplied and installed on the rig. The transducer tubing to test points has to be installed.

NOTE Ⓐ : The run date has been rescheduled to the first part of December for the following reasons: (1) Additional machining on research gear, (2) Additional time required for installation and checkout of research instrumentation, (3) Additional time required to relocate controllers.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		
		BOILING FLUIDS RIG 0F0553 (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.

STATUS: On November 22, sixteen liquid hydrogen runs were made. Digital data was recorded. Test results will not be known until the data has been reduced. Fifteen runs at 15,000 RPM were made and one run at 16,200 RPM. Flow control valve settings, vapor pressures, and NPSH pressures were varied during all runs. One vented tank and two locked tank pumpout tests were made. Due to a liquid hydrogen leak in an instrument connection, the facility was shut down after an hour and fifteen minutes of pump operation.

Upon inspection of the research rotating gear, it was revealed that the upper seal was worn completely flat, but the bearings appeared in good condition. The next liquid hydrogen run is scheduled to be made during the week of December 9th. Prior to the next liquid hydrogen run, the following items will be completed:

1. Angle actuators will be revamped.
2. A liquid hydrogen dewar backpressure valve will be installed.
3. The carbon seals will be replaced.
4. The nuclear simulator heater will be installed and checked out.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	(Continued)	LIQUID HYDROGEN PUMP 0F0553 (Pinkel)	Liquid hydrogen turbopump tests study impeller matching with centrifugal pump at speeds to 60,000 RPM.

STATUS: The following work was accomplished during the month of November:

1. A cold shock and thrust balance check was made.
2. The thrust balance parts were remachined so that proper pressure could be obtained.
3. The rotating components were sent to Lewis Research Center for balancing on November 14, and are scheduled to be completed by December 5, 1963.
4. The pump and turbine housings were machined for instrumentation pickups and oil passages were corrected.
5. The new controller base was installed at 'H' Bldg.

The following work is scheduled to be done in the month of December:

1. The controllers will be moved to 'H' Bldg. and rewired.
2. Meter panels above and below the graphic panel will be replaced.
3. All research gear and instrumentation will be installed.

NOTE (A) : The run date has been rescheduled to mid-January because of the time required for additional machining on thrust balance, and the fact that the controller installation work was delayed because emphasis was placed on 'F'Site CENTAUR installation. Controller installation work is now in the process of being contracted.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		
		BOILING FLUIDS RIG OFO-553 (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.
			STATUS: On December 12, 1963, seventeen data runs were made in one hour and five minutes of pump operation. Digital data was recorded and all runs were made at 15,000 RPM with NPSH varying from 5 PSI to 0 PSI. Actuator traverse and angle were in operation. On two of the above runs, the nuclear simulator heater applied 20 kw of heat to the liquid hydrogen. One locked tank and two vented tank pumpout runs were made. In order to obtain higher flows and to reduce the excessive pressure drop that was experienced in the December runs, the recirculating 3" control valve will be removed and a smooth flow diffuser will be installed in the pump discharge line. The above items to reduce the pressure drop and the following items will be completed prior to the next run which is scheduled for the second week of January: (1) Overhaul the tank pressurization valves. (2) Install and instrument density meter. (3) Install actuator angle submerged pickup. (4) Replace research gear seals and bearings. (5) Realign the turbine and research pump. (Continued on Page 15)

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C		LIQUID HYDROGEN PUMP OFO-553 (Pinkel)	Liquid hydrogen turbopump tests study impeller matching with centrifugal pump at speeds to 60,000 RPM.

STATUS: The following work was accomplished during the month of December:

(1) The balancing of the rotating pump parts was completed by the Lewis machine shop and returned on December 10, 1963. Additional machining was done on non-rotating parts and the pump was cleaned and assembled.

(2) The balancing of the rotating turbine parts was completed by the Lewis machine shop and returned on December 17, 1963. The turbine has been cleaned and assembled.

(3) The controller contract specifications and prints were completed and are ready to go out for bid.

(4) The turbine instrumentation installation continued.

(5) Wiring of research transducers and thermocouples was started.

The following work is scheduled to be done in January:

(1) Controller contract awarded and installation work completed by the end of January.

(2) Checkout of the controls system.

(3) Complete all instrumentation wiring.

(4) All turbine instrumentation work will be finished.

(5) Install torque meter.

(6) Pressure check all hydrogen lines.

(7) Checkout all ROV's, instrumentation, and mechanical systems.

(8) Install inlet photo-con if available and complete the water system.

NOTE (A) : The run date has been rescheduled to the first part of February. This run schedule delay is due to the necessity of contracting the controller wiring. Since this work could not be done by the Station's Control Unit due to an increase in workload.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG OF0553 (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum jacketed tank.

STATUS: On January 20, twenty-four data runs were made during one hour and fifteen minutes of pump rotation at 15,000 RPM. Digital data was recorded and NPSH varied from 10 psi to 0 psi. On seven of the above runs, the nuclear simulator heater applied up to 20 KW of heat to the liquid hydrogen. This was done in steps of 7 KW, 14 KW, and 20 KW respectively. On ten of the above runs, higher temperature liquid hydrogen was used at vapor pressures ranging from 18 psi to 20 psi. Approximately 5000 gallons of liquid hydrogen were used to make the twenty-four runs. Actuator angle and traverse did not function properly during these runs. The following changes must be incorporated in order to obtain better pictures of the inducer and to improve the data from both recirculating and pumpout runs:

1. Alter rotating research gear to lower the inducer approximately 1/2".

2. Install a 4" Hadley control valve in the pump discharge line.

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SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	(Continued)		

3. Remove vapor bulb No. 3 from system and repipe, using two vapor bulbs.

4. Alter instrumentation system to improve the reading of the liquid hydrogen temperature.

5. Replace plastic shroud.

6. Overhaul and install actuators.

7. Replace research gear seals and bearings.

8. Assemble research gear and realign with turbine.

During the time interval required to make the above changes, the roughing vacuum pump will be overhauled in the Cleveland shop.

NOTE Ⓐ: A re-evaluation of the test schedule for this rig indicates that only $1\frac{1}{2}$ runs per month are possible for the following reasons: LH_2 dewars H-3 and H-4 are now being used by A, C, G, J, and F Sites. This situation may be relieved when H-7 dewar becomes available in April. However, conflicts with 'C' Site turbo pump rig also limits the running of this rig. Required lead time for reduction of digital data means that the digital data has to be supplemented by strip chart data in order that parameters can be determined in sufficient time for the next test run. This is a common problem and the number of strip charts often precludes concurrent research runs. The next liquid hydrogen run is scheduled for the week of February 17, 1964.

LIQUID HYDROGEN PUMP
OF0553 (Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

STATUS: The following work was accomplished during January:

1. The research gear was assembled and initial pressure checking completed. Necessary machining was accomplished and the pump reassembled, pressure checked and liquid nitrogen cold-shocked.

2. The torque shaft was returned from balancing and reinstalled.

3. The contract work for the relocation of the controller was completed. The NASA work proceeded on the panel wiring.

4. The turbine manifold was installed.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C			5. The turbine pressure and scavange oil pumps were installed. 6. Most of the instrumentation mounting work was completed for the first run, except for the following items; (a) four pressure transducers, (b) ten vibration pickups, and (c) the torquemeter alignment. 7. Work proceeded on the instrumentation and panel wiring which is scheduled to be completed the week of February 17. The following work is scheduled for completion in February: 1. Checkout of turbine manifold. 2. Checkout of oil system. 3. Final instrumentation work and checkout. 4. Complete panel wiring and checkout of controllers and valves. 5. Final pressure checking of hydrogen systems. 6. Final checkout of thrust balance system. NOTE (B): A re-evaluation of the test schedule indicates that $1\frac{1}{2}$ runs per month will be maximum possible since there will be conflicts with the Boiling Fluids Rig which is in the same building. The next run is scheduled for February 24.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG 0F0553 (Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed tank.

On February 26, nineteen data runs were made in one hour and eleven minutes of pump operation. Digital data was recorded with NPSH varying between 10 psi and 0 psi. Three of the above runs were made at 15,000 RPM and sixteen were made at 18,900 RPM. The traverse and angle of the rig's probe actuators operated successfully. The existing turbine drive is now in the process of being modified so that its speed can

lowing decisions were made:

(a) The Rocketdyne pump discharge valve which is not sealing properly will be replaced with a 4" Hadley butterfly valve.

(b) General Monitors Corporation hydrogen sensors will be installed downstream of the Hadley valve to indicate leakage and control facility shutdown before unsafe conditions occur.

(c) An Annin hydrogen "dump" valve will be installed upstream of the Hadley valve, so that chilldown hydrogen can be dumped prior to initiating the start-up test sequence. This system will allow a more realistic initial condition in the downstream piping, nozzle and reactor. Formerly, the chilldown fluid passed through these components prior to the starting of the test sequence.

Hydrogen data run will be made about a week and a half after the delivery of the Hadley valve which is scheduled to be delivered on March 16, 1964.

be increased from 18,900 RPM to 20,000 RPM,which is the pump speed needed for the next series of runs.

The following items will be completed before the next run:

(1) NPSH bulb No. 2 will be removed.

(2) Both probe actuators will be replaced.

(3) The turbine and research pump will be realigned.

The next run is scheduled for the week of March 2.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C		LIQUID HYDROGEN PUMP OF0553 (Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

The following work was accomplished during February:

(1) Oil leaks to pump rear bearing were discovered during cold shock. Correction, which necessitated machining on rotating parts and installation of an "O" Ring on inner diameter of labyrinth seal, was accomplished.

(2) Turbine was pressure checked and gas leaks were discovered. The correction similar to that made on the pump was accomplished.

(3) The pump was cold shocked and the turbine pressure checked. Both corrections were successful.

(4) The turbine manifold was checked out, except for a pressure check of the portion from the pressure regulator to speed control valve.

(5) The lubrication system for the turbine was checked out.

(6) The pressure control valve was added to the thrust balance system.

(7) The controller system was completedand checkout has been started.

(8) Two pressure transducers and five vibration pickups were mounted.

The following work is to be done in March:

(1) Checkout of NPSH system, thrust balance control valve and actuators.

(2) Mount remaining two pressure transducers and remaining five vibration pickups.

(3) Accomplish necessary instrumentation hookup:

  (a) Thermocouple patch and checkout.

  (b) Checkout actuator electronics.

  (c) High-frequency electronics installation.

(4) Wire in Auto-Man. controls for actuators.

(5) Check out and programming of controllers.

(6) Complete monitor meters wiring and check out.

(7) Complete the alignment of the torque meter.

NOTE (A): The schedule change is due to the extra time required to correct leak problems in pump and turbine, and additional time needed to complete the controllers. The next run is scheduled for late March or early April.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG OF0553(I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On March 5, seventeen data runs were made in 43 minutes of pump rotation. A speed of 19,375 RPM was reached. Digital data was recorded with NPSH varying between 10 psi and 0 psi. Included in the above runs was one locked-tank pumpout run, one constant NPSH pumpout run, and three varying NPSH pumpout runs. After completing these runs, the turbine air system was reworked in order to increase the speed to 20,000 RPM. Actuators were replaced and minor rig changes were made.

On March 13, forty-one runs were recorded at a speed of 20,000 RPM, in 1 hour and 49 minutes of pump rotation. The higher speed imparted more energy to the fluid, necessitating fewer data points per run before the vapor pressure increased beyond the range of temperature desired. Approximately 134 data points were digitized. The March 13 runs included two pumpout runs at 16 - 20 psi vapor pressure, two pumpout runs at 0 - 2 psi vapor pressure, and one locked tank pumpout run at 0 - 2 psi vapor pressure. All other runs were recirculating runs at both high and low vapor pressures. Approximately 12,000 gallons of liquid hydrogen were used.

On March 20, thirty-seven runs were recorded at 20,000 RPM, in 1 hour and 22 minutes of pump rotation. These runs included one pre-run calibration pass, 24 low vapor pressure runs, 12 high vapor pressure runs, one locked-tank, and one constant NPSH pumpout run. Two runs were made, applying 7 KW of heat; one run at 14 KW, and two runs at 20 KW of heat. Approximately 9000 gal. of liquid hydrogen were used.

After completing the March runs, the rig is being checked over and minor alterations and improvements are being made. Submerged Stathams will be added in parallel with existing ones on recirculating venturi differential pressure and NPSH pressure. These Stathams will give indications of smooth, rather than cyclical, flow before data is taken. The turbine is being subjected to investigation as to why misalignment occurs after completing a run. Angle and traverse actuators will be replaced. A flow stator is being installed to direct the flow through the scroll so that pressure drop is minimized. A 3" Annin vent valve is being installed so that Zero NPSH might be reached at high speed. The next anticipated run date will be during the week of April 13.

NOTE (A) : Run schedule has now been projected through Fiscal Year 65.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	LIQUID HYDROGEN PUMP OF0553(I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

The following work was accomplished during March:

(1) The controllers were checked out and programmed.

(2) The NPSH system was checked out for operation.

(3) Cold shocks and pressure checks were conducted to further check out the equipment.

(4) All monitor equipment was wired, calibrated and checked out.

(5) All instrumentation was wired and checked out.

(6) Digital recording data marker device was made and checked out.

A test run is scheduled for April 2. All necessary work will be accomplished for this hydrogen test run before April 2.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		

BOILING FLUIDS RIG
OF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On April 12, 40 data runs were made in one hour and forty-four minutes of pump rotation. The research gear consisted of a 78° helical inducer, a No. 1 booster rotor, and a directional flow stator ring. Twenty-two of the runs were made at a vapor pressure of 0-2 psi while the remaining eighteen were made at a vapor pressure of 16-20 psi. Included were seven locked tank pumpout runs and one vented tank pumpout run. All runs were made at 20,000 RPM with NPSH varying from 0-10 psi. Approximately 11,500 gallons of liquid hydrogen were used.

On April 29, 176 data runs were made in two hours and twenty-five minutes of pump rotation. The 84° helical inducer with the No. 1 booster and flow stator were used. Eighty-two runs were made at a vapor pressure of 0-2 psi, while ninety-four were made at a vapor pressure of 16-20 psi. All were recirculating data runs at a speed of 29,000 RPM with NPSH varying between 0-10 psi. 10,300 gallons of liquid hydrogen were used.

The 78° rotor with No. 3 booster rotor is now being installed along with a mass flow meter in preparing for data runs which will occur during the week May 18.

LIQUID HYDROGEN PUMP
OF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

On April 2, 5 tests at 10,000 RPM were made for control and operation checkout. The vapor pressure increased with each run, which was caused by a leak that developed in the vacuum jacketed loop piping, and subsequently resulted in the loss of vacuum. The run had to be cancelled.

The vacuum leaks were corrected, and on April 20, another run was started. One test was made at 10,000 RPM for checkout purposes. This test was shut down by the acceleration rate detector. A second start was attempted, but it was discovered that the pump shaft was bound by a clearance problem which may have been precipitated by an oil leakage into the pump rear bearing, which is hydrogen lubricated. Corrections are being made to increase the clearances and a heavier weight oil will be used as the thrust balance media. The next run is scheduled for May 4.

NOTE Ⓐ : Running time has been extended, since no data was taken in the last two runs.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	(NOTE Ⓐ : Schedules changed due to program reevaluation.)	
		BOILING FLUIDS RIG OF0553(I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.
			On May 18, 45 data runs were made in one hour and thirty minutes of pump rotation. The research gear consisted of a 78° helical inducer, a No. 3 booster, and a directional flow stator ring. Twenty-six of the runs were made at a vapor pressure of 0-2 PSI while the remaining nineteen were made at a vapor pressure of 16-20 PSI. All runs were made at 20,000 RPM using an NPSH range of 0-10 PSI. Approximately 9500 gallons of liquid hydrogen were used. In order to improve or smooth-out some of the cyclical data, the pump discharge line is being moved to the exterior of the rig. The next liquid hydrogen run is scheduled for the middle of June.
		LIQUID HYDROGEN PUMP OF0553(I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.
			On May 4, May 11, and May 25, test runs were conducted. Most of the data for head versus flow curves was obtained for the modified 78° inducer. Data taking for the head versus NPSH curves was started at the end of the May 25 run to check the auto-flow control and response time of the NPSH ramp program. No angle data has been successfully taken during the test runs. Four actuators have been mounted and three appear to be funtioning properly although the angles obtained were beyond the capability of the present readout potentiometers. It is planned to have eight actuators modified for proper measurements for the June 8th run. More data will be taken on June 1st for head versus NPSH curves. Four angle actuators have been adjusted for full travel and will be checked out. A new liquid hydrogen piping system (3 pieces) is scheduled for installation between the 17th and 26th of June. This work will not be attempted until adapters are made for connection of H-3 and H-4 dewars. Measurements and inspection of interfaces indicates the loop installation will be trouble-free and will not delay the turbo pump research program.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG OF0553 (I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. On June 15, 1964, twelve runs were made at 20,000 RPM. Recirculating and pump-out runs were made at 0 to 2 psi and 16 to 20 psi. The research gear consisted of the 78° helical inducer and No. 3 Booster with the stator directional ring omitted. NPSH was varied between 0 and 5 psi. Approximately 6000 gallons of liquid hydrogen were used. In order to improve the quality of the data, a recirculating line is being installed on the outside of the test tank. This change should help to smooth out cyclical data and increase the operation speed of the flow control valve. The next liquid hydrogen run is schedule for July 2, 1964.
		LIQUID HYDROGEN PUMP OF0553(I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM. On June 2 and on June 9, research runs were made, a total of eighteen curves were obtained holding pump flow constant and varying NPSH. Data was taken at speeds of 30,000 and 39,000 RPM. After the run of June 9, the cell was shut down for installation of the new loop and back transfer line. The pump and turbine were disassembled and sent back to Cleveland. The pump was balanced with the straight non-tapered 78° inducer and the turbine balance was checked. The loop and back transfer lines were installed and an LN_2 cold shock made on June 30. Pump and turbine parts were received from Cleveland on June 29 and reassembly started for a test run on July 8. All angle actuators were modified with a 180° readout potentiometer.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG PF0538(I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On July 2, twenty-one data runs were made representing 73 data points during thirty minutes of pump rotation. The 78° helical inducer with the No. 3 booster composed the research hardware. All runs were made at 20,000 RPM with NPSH varying between 0 and 10 psi. H-Q curves and cavitation data were recorded.

It was found that the liquid heated at a fast rate necessitating numerous cooling times. In order to thoroughly mix the fluid and thus dissipate the heat, it was decided to direct the re-circulating fluid in a manner that would tend to spread the flow. An elbow was welded to the line inside the tank to accomplish this.

On July 16, twenty-five data runs were made representing 91 data points during fifty-eight minutes of pump rotation. The 80.6° helical inducer with the No. 2 booster consitituted the research hardware. Three of the above runs were made at a vapor pressure of 16-20 psi while 22 were made at 0-2 psi.

On July 24, three-hundred and eight data runs were made representing 316 data points during three hours and fifty-two minutes of pump rotation. The 84° inducer and the No. 1 booster were used. In addition the directional flow stator and the nuclear similator heater were added. Speed, NPSH, and vapor pressure remained the same as for the previous run. The heat applied to the fluid was 7 KW, 14 KW, and 20 KW.

During the July runs all five actuators were in operation and functioning.

The research gear is being removed and a movable shroud will be installed ~~prior~~ to the next run scheduled for the second week of August.

The operation schedule has been changed to allow time to install the new tank bottom. Site modifications are scheduled to be started the first of October and to be completed by the middle of December.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		
		LIQUID HYDROGEN PUMP QF0553 (I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

On July 10, a successful test was conducted and eighteen head versus flow curves were obtained at various constant NPSH's per curve. NPSH ranged from 2 to 20 PSI. Flow was ramped and pump speed was held constant for a series of curves at 30,000 RPM and a series of curves at 40,000 RPM. The research component had a total operating time of thirty-three minutes.

On July 13, the pump test was cancelled due to a test component failure. While the pump was rotating at 30,000 RPM a speed deviation was observed by the research engineer. The test was immediately stopped. Inspection of the research hardware revealed that the torque shaft coupling to the pump had failed, resulting in damage to the pump rear bearing and the turbine rotors. The turbo pump was subsequently repaired.

On July 30, a check run was made, varying NPSH and flow, during which no data was taken. On the first attempt to take data, the flow could not be controlled. Investigation indicated a faulty Delta P venturi pickup.

The faulty pickup was replaced and the system has been statically checked. The next test is scheduled for August 7.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		

BOILING FLUIDS RIG
PF0538(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Since more data was required with the existing test hardware, the movable shroud which was scheduled to be installed during August was not installed.

On August 7, during three hours and two minutes of pump rotation, 146 data points were obtained. The research gear consisted of the 840 inducer, the No. 1 booster, and the flow stator. Cavitation and H-Q data were recorded at 20,000 RPM.

On August 13, 137 data points were obtained. The research gear was the same as for the August 7 run.

On August 20, cavitation and H-Q data were obtained with 240 data points recorded. The research gear consists of another 840 inducer with larger clearances and the No. 1 booster with the flow stator. Following this run, the research gear was inspected and the pump bearings were changed. The research gear was reinstated for the next run scheduled for September 1.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

Two attempts to run were made during August.

On August 10, the pump was operating at a speed of 30,000 RPM and the programmed ramp had just started when the rear bearing failed. The bearing failure was caused by lack of cooling, since the bearing vents were closed and the hydrogen flow could not be maintained through the bearings. An interlock has now been installed to insure lubrication with rotation. The damage was confined to the pump and the torque shaft. The pump parts were repaired and a new torque shaft installed. Inspection of the new torque shaft revealed a flat spot near the seal portion, but it was determined that it would not affect the seal.

On August 28, with all systems ready, hydrogen leaks were spotted on the dewar. With the system in "standby", inspection of the pump showed large quantities of oil leaking past the torque shaft seal. It was decided that by the time the dewar connection leaks were fixed, oil would have time to seep into the rear bearing, past seals which were not run-in. This, compounded with leaks past the torque shaft, required cancellation of the test run.

During the short running time on August 10, the flow transducer signal looked normal. Also, data was obtained from the high frequency pickup located on the pump inlet. The torque shaft will be replaced and the rear bearing checked for oil. The next run is scheduled for September 4.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG PF0538(I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On September 1, 289 runs were made at 20,000 RPM during five hours and five minutes of pump rotation. Runs included head-flow, cavitation, and survey data at both low (0-2 psi) and high (16-20 psi) vapor pressure. NPSH varied between 0 and 5 psi. The research gear consisted of an 84° helical inducer with the No. 1 booster.

On September 11, an attempt was made to run using the same research gear but, due to shroud leakage, no data was obtained.

On September 17, after replacing shroud seals, it was found that the shroud continued to leak. Approximately 160 feet of movie film was taken but no digitized data was obtained. It was decided to replace the plastic shroud with one of stainless steel.

On September 24, a successful run was made. Ninety passes were made at 20,000 RPM. Approximately 9 head-flow curves were recorded. Tip clearance between the 84° inducer blade and steel shroud was .027". All runs were made at low (0-2 psi) vapor pressure. NPSH varied between 0 and 5 psi. Approximately 5,000 gallons of liquid hydrogen were used. A re-evaluation of the test requirements indicated that only 8 run days are needed to complete the last phase of the program. Upon the program completion the installation of a new tank bottom for the high speed turbine will begin. This installation should take approximately three months.

		LIQUID HYDROGEN PUMP QF0553(I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

On September 4, the pump was run at a speed of 30,000 RPM. 11 passes were made holding NPSH constant at 20, 15, and 2 and varying flow. 65 points were taken for completion of 3 curves. The shaft seals leaked thrust balance oil again. Since the designers of the optical torquemeter feel that it is imperative that the surfaces of the optical system be free of oil before readings can be obtained, the research gear was disassembled and the housings sent to the machine shop for modification. The modification will consist of a double seal arrangement with scavenge cavity between the two seals. While the rig is down for seal modification, four additional total pressure probes are being installed behind the centrifugal impeller to replace the single one presently used. The four readings will be averaged and used in place of the single reading.

The next run is scheduled for October 9, 1964.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG PF0538(I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On October 6, 197 data points, representing 22 curves, were recorded during 3 hours and 35 minutes at a pump speed of 20,000 RPM. The research gear consisted of an 84 degree helical inducer (10% blockage), a No. 1 booster, and the nuclear simulator heater. Included were seven cold (0-2 psi vapor pressure) head-flow curves, twelve cold (0-2 psi vapor pressure) heater curves at 0, 7, 14, and 20 KW, and three hot (16-20 psi vapor pressure) heater curves. Approximately 10,000 gallons of liquid hydrogen were used.

On October 7, 220 data points, representing 23 curves, were recorded during 3 hours and 58 minutes at a pump speed of 20,000 RPM. The research gear remained the same as for the October 6 run. Included were eleven hot (16-20 psi vapor pressure) cavitation and head-flow curves, two cold (0-2 psi vapor pressure) head-flow curves, and ten cold (0-2 psi vapor pressure) heater curves at 0, 7, 14, and 20 KW. Approximately 10,500 gallons of liquid hydrogen were used.

On October 21, 15 continuous data pumpout runs were recorded during 57 minutes at pump speeds of 15,000 and 20,000 RPM. The same research gear as for the preceding two runs was used. Included were 7 cold (0-2 psi vapor pressure) locked tank pumpout runs and 8 hot (16-20 psi vapor pressure) locked tank pumpout runs. Data was recorded on a startup and continued until the tank was empty for each run. Approximately 10,000 gallons of liquid hydrogen were used. The nuclear simulator heater was installed but not operated during this run.

NOTE: Another pumpout run is scheduled for the first week of November when data will be taken at speeds of 5,000, 10,000 and 15,000 RPM.

ALTERATIONS TO THE BOILING FLUIDS RIG

The vacuum system installation bids were opened on October 20. Only one bid was received. It was much higher than the estimate. The specifications are being revised and new bids are scheduled to be opened by December 7.

The service air heater order was placed October 26, with a 100-day delivery. The hot air system design and specifications are scheduled to be completed by November 19.

(Continued on Page 21)

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		

The design and specifications for the auxiliary dewar have been completed. The electrical drawings are in process and scheduled to be completed and sent to procurement in 25 days.

LIQUID HYDROGEN PUMP
QF0553(I. I. Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

On October 16, the pump and turbine were run for 43 minutes. Approximately 150 data points were obtained on the 78 degree straight inducer at pump speeds of 30,000 and 40,000 RPM. Approximately one-half of the data taken was for cavitation determinations and the other half for stall point determinations. Four of the eight probe angle actuators were installed (No.'s 5, 6, 7, and 8). To check the accuracy of a pre-set probe angle, Probe No. 5 was fixed in one position. This position was determined by a previous test in an air calibration stand. The other probe actuators were installed on the balancing system and functioned within the capability of the system, until the end of the test when No. 7 ceased to function because of a plugged static tube. It could not be determined if the oil leakage past the shaft seal was stopped by the double seal arrangement, since a high pressure oil leak developed during the run and covered the shaft area with oil.

On October 23, seven passes were made and approximately 70 data points were obtained during a running time of 17 minutes. The three probe actuators operated on "automatic" and functioned well. All the data was taken for cavitation determinations. Flow was held constant and the NPSH varied. The reason for the short running time was due to the insufficient supply of gaseous hydrogen trailers with non-leaking remote shutoff valves. Although there was minimal oil leakage past the seals, the torque shaft reflective surfaces were oil-free. Scavenge holes will be increased to accomodate more oil flow.

NOTE: The next scheduled run is November 6.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG PF0538(I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On November 2, ten pump-out runs were made at speeds of 5000, 7500 and 10,000 RPM during 45 minutes of pump rotation. Continuous data was recorded for each run. The research gear consisted of an 84° inducer, a No. 1 booster, and blade thickness representing 14% blockage. Included were four locked tank hot runs at a vapor pressure of 16-20 psi and six locked tank cold runs at a vapor pressure of 0-2 psi. Approximately 3500 gallons of liquid hydrogen were used.

On November 10, 350 data points, representing 13 curves, were recorded during three hours and eight minuts at a speed of 20,000 RPM. The blade thickness of the helical inducer represented a 23% blockage. Eleven H-Q curves, both hot and cold, and two cavitation curves were plotted. Approximately 8000 gallons of liquid hydrogen were used.

On November 18, 257 data points, representing 11 curves, were recorded during two hours and twenty-nine minutes of pump rotation at 20,000 RPM. The blade thickness of the inducer represented a 10% blockage. Included were two hot (16-20 psi V.P.) runs and nine cold (0-2 psi V.P.) runs. Approximately 6000 gallons of liquid hydrogen were used.

On November 23, 219 data points, representing 11 curves, were recorded during one hour and forty-one minutes of pump rotation at 20,000 RPM. The research gear remained the same as on the previous run. Three hot (16-20 psi V.P.) head-flow curves and five cold (0-2 psi V.P.) head flow curves along with three cavitation curves constituted the data. Approximately 5000 gallons of liquid hydrogen were used.

ALTERATIONS TO THE BOILING FLUIDS RIG

The opening of the vacuum system Invitation for Bids re-advertisement is scheduled for December 10.

The design and specifications for the Hot Air System are about 80% complete. Approximately 4 to 6 weeks of drafting is still required. Preliminary drawings on the compressed air heater have been submitted and reviewed and returned to the contractor. Unit delivery is scheduled for February 1965. Purchase requests have been issued for all other Government-furnished items.

(Continued on Page 22)

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP (Continued)		

The auxiliary dewar and associated piping mechanical specification has been completed and the electrical portion of the specification is 75% complete. Approximately two weeks of drafting is still required.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60,000 RPM.

Because a five to ten percent drop in pump performance was recorded in the October runs, the flow transducers and pump pressure rise transducers were recalibrated and the probes were checked. The results of these checks indicated no deviations that would account for the loss in performance.

On November 6, the pump was run to recheck its performance. No improvement in performance was recorded.

The pump was then completely disassembled and inspected, and it was found that the centrifugal front clearance was excessive by .005. An undersized replacement part and shortening due to wear accounted for the excess clearance. The proper clearance was set, which was the same as on previous runs before the loss in performance.

On November 25, the pump was checked again. No increase in performance was obtained.

Presently, the clearance of the front of the centrifugal is being further reduced to see if possibly this will correct the situation. If this does not improve the performance, the four additional probes that were added before the October runs should be removed, since it is possible that the probe blockage effect may have affected the pump performance.

The next scheduled run is December 4.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG PF0538(I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On December 3, 230 data points, representing eleven curves, were recorded during one hour and 35 minutes of pump rotation. The research gear consisted of the 84° inducer, the No. 1 booster, and the flow stator. The blade thickness represented a 14% blockage and tip clearance between inducer and shroud was .0015" at room temperature. Included in the above data were hot H-Q curves, cold H-Q curves, and cavitation curves. All runs were made at 20 000 RPM with NPSH varying from 0-10 PSI. Approximately 6000 gallons of liquid hydrogen were used.

On December 15, 50 data points, representing six curves, were recorded during 45 minutes of pump rotation. The research gear consisted of a movable shroud along with the standard 84° inducer and No. 1 booster. Both hot and cold H-Q curves were obtained with the shroud in the closed position. The shroud was then opened to 10%. No data was obtained in this position as the vapor bulb tubing broke necessitating shutdown. The next liquid hydrogen run using the movable shroud is scheduled for the second week of January 1965.

ALTERATIONS TO THE BOILING FLUIDS RIG

Bids for the vacuum system installation contract were opened on December 10. The low bid was for $53 959 with a 90 day completion time. The bid is being reviewed by Lewis Legal Counsel.

Drawings and specifications for the Hot Air Turbine Drive System are scheduled to be completed by January 8 and will then be reviewed by Rocket Systems Division.

Drawings and specifications for the Auxiliary Dewar and associated vacuum jacketed piping were completed. They are presently being reviewed by Rocket Systems Division. If no major changes are required, the Purchase Request should be in Procurement by January 15.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP (Continued)		
		LIQUID HYDROGEN PUMP QF0553(I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60 000 RPM.

On December 4, the pump was run with a reduced centrifugal rotor tip clearance of .008 in expectation of increasing the pump performance. Approximately twelve passes were made at 30 000 RPM. The performance was increased by approximately five percent.

On December 11, the pump was run at 30 000 RPM with a tip clearance of .004, to determine the effect of lower clearance. The over all pump performance shifted in a decreasing direction. The data was taken in the same manner as on the December 4 run. It was discovered on disassembly that one of the probes behind the centrifugal rotor had disconnected and been lost. The probe was not replaced for the next run.

On the December 17 run, the tip clearance was increased to .016 which was the same clearance used for configuration #1 and for the first block of data on the present configuration. A standard type neoprene shaft seal was installed to replace a carbon seal on both the turbine and the pump. The torque meter was mounted and set up as usual with the exception that the voltage to the light source was increased. The performance curve for this run duplicated the original data. There were no leaks of any type and the torque meter functioned perfectly for several runs and intermittently the rest of the test time. All angle actuators were functioning. During the thirty-five minutes of test time, the 30 000 RPM data was completed.

NOTE: The next pump run is scheduled for the week of January 14.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG PF0538 (I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On January 15, 304 data points representing 32 curves were recorded during three hours and eighteen minutes of pump rotation. The research gear consisted of the 84° inducer and No. 1 booster. The moveable metal shroud was adjusted so that data was obtained at 10%, 50% and 100% of the maximum open position. Included in the above data were eight H-Q curves cold (0-2 psi V.P.), four H-Q curves hot (16-20 psi V.P.) and twenty cavitation curves at heat levels of 0, 7, 14 and 20 KW. All runs were made at 20 000 rpm with NPSH varying from 0-10 psi. Constant flow positions of 9 psi, 11 psi and 13 psi were held for the heater cavitation curves. Approximately 10 000 gallons of liquid hydrogen were used.

The next liquid hydrogen run will be made during the first week of February. The top propeller which is located above the inducer will be removed for these tests.

NOTE: The test program has been extended one month to obtain more visual study data and photographs.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Vacuum System:

A preconstruction conference has been scheduled for Friday, February 5. The installation should start shortly after this conference. It is estimated that the contract will be completed by May 10.

(2) Hot Air Turbine Drive System:

The drawings and specifications for this system are scheduled to be completed by February 17.

(3) Auxiliary Dewar System:

The drawings and specifications were completed in December but they are still being reviewed by the Rocket Systems Division and the Lewis Research Division to determine if the designed system will meet all of the research objectives.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP (Continued)		
		LIQUID HYDROGEN PUMP QF0553(I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60 000 rpm.

On January 11, the test data was completed for the 78° straight inducer program. Sixty-four data points were obtained at 30 000 and 40 000 rpm during a run time of twenty-seven minutes. Four Head vs Flow curves and three Head vs NPSH curves were completed. Following this run, the tapered 78° inducer was reinstalled in preparation for a test run to recheck the data taken before the test loop piping was changed from eight inches to the present three inch diameter. This data was needed to assure that the change did not affect the pump characteristics.

On January 22, the first run with the reinstalled tapered 78° inducer was made. Eight points were recorded at 30 000 rpm, during twenty-five minutes of test time. The test run had to be shutdown when the speed pickup wires became grounded.

On January 28, the second run was made with the reinstalled tapered 78° inducer. Approximately fifty data points were obtained at a speed of 40 000 rpm. All the data taken was for Head vs Flow curves.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG PF0538(I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On February 2, 240 data points, representing 23 curves, were recorded during 2 hours and 17 minutes of pump rotation. The research gear consisted of an 84° helical inducer and No. 1 booster. The movable metal shroud was adjusted so that data was obtained at 0%, 50%, and 100% of the maximum open position. Included in the above data were head-flow and cavitation curves with heat levels of 7, 14, and 20 KW applied. All runs were made at 20 000 rpm with NPSH varying between 0 and 10 psi. Approximately 6700 gallons of liquid hydrogen were used.

On February 19, 108 data points, representing 14 curves, were recorded during 1 hour and 30 minutes of pump rotation. The research gear was the same as for the previous run, with the exception of the plastic shroud which was used so that photographs could be taken. Head-flow and cavitation curves at various heat levels were recorded and photographed. All runs were made at 20 000 rpm with NPSH varying between 0 and 25 psi. Approximately 4500 gallons of liquid hydrogen were used.

The February 19th run completed the first portion of the research program. Presently, the vacuum pumps for liquid hydrogen cooldown are being installed. It is anticipated that this work will be completed by the middle of May and liquid hydrogen runs are scheduled to start as soon as the system has been checked out.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Vacuum System:

The vacuum system installation was started February 8 and is scheduled to be completed by May 10.

(2) Hot Air Turbine Drive System:

The design completion is being delayed until design data is received from the heat exchanger manufacturer.

(Continued on Page 22)

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP		

BOILING FLUIDS RIG (Continued)

(3) Auxiliary Dewar System:

The Design Review Committee submitted a proposal on February 17, and it is presently under administration review. It was also proposed that a 12 000 gallon liquid hydrogen dewar be used as an alternate configuration to the Auxiliary Dewar System.

LIQUID HYDROGEN PUMP
QF0553 (I.I. Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

After the data run of January 28, the inducer was removed and replaced by a spacer so that a pump performance map could be obtained without the inducer.

On February 2, the first run was made with this configuration and during a rotation time of 36.15 minutes, 210 data points were obtained. A complete 30 000 rpm and a partial 40 000 rpm map was obtained. High g loadings on the turbine rear bearing indicated a deteriorated bearing, so the pump was shut down. Disassembly and inspection of the turbine showed that the rear turbine bearing had failed, allowing the turbine wheels to scrape on their shrouding. The turbine was repaired, rebalanced and reassembled.

On February 19, both the turbopump and the boiling fluids rigs were set up for simultaneous runs. During the first attempt to take data at 40 000 rpm, an excessive g loading showed up on the front turbine bearing and necessitated shutdown. The pump and turbine have been disassembled. Damage was confined to both pump and turbine balance pistons and the torque shaft. Repair and balancing is now being accomplished.

NOTE: The next pump run is scheduled for March 5.

SITE	LABORATORY	RESEARCH INSTALLATIONS (FOF)	DESCRIPTION
C	TURBO PUMP	BOILING FLUIDS RIG PF0538 (I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Since the contractors were working on the cell alterations, no liquid hydrogen runs were made during March.

While the contracted work is being done, other cell systems are being updated and the vacuum systems and purge systems are also being revamped for improved operations. Research tests are scheduled to resume the first week of June.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Vacuum System:

The vacuum system is being installed and is scheduled to be completed by May 10.

(2) Hot Air Turbine Drive System:

The design is scheduled to be completed by April 30.

(3) Auxiliary Dewar System:

A decision still has to be made on the Design Review Committee proposal of February 17.

LIQUID HYDROGEN PUMP QF0553(I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

On the March 5 test run, the pump front bearing failed during the first two minutes of rotation. Disassembly of the pump showed that after the bearing failure, the pump shaft had severely rubbed on the front bearing housing and the shaft was bent. It was decided to install the next configuration which is now being assembled.

The next run is scheduled for the first of June.

SITE	LOCATION	RESEARCH INSTALLATIONS (FOR)	DESCRIPTION
C	TURBO PUMP SITE	BOILING FLUIDS RIG PF0538 (I.I.Pinkel)	The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

No Liquid Hydrogen runs were scheduled for April because installation contractors were working on cell alterations.

While this contracted work is being done, other cell systems are being updated and the vacuum systems and purge systems are being revamped for improved operations. Research tests are scheduled to resume in June.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Vacuum System Installation Contract:

Status as of April 30	% of Contract	% Complete
1.Engineering	2.2%	100%
2.Building Alterations	4.0%	40%
3.Equipment Removal	6.1%	99%
4.Piping	43.5%	94%
5.Cleaning & Testing	6.1%	0%
6.Electrical	29.2%	25%
7.Insulation	8.9%	0%

A contract change order dated April 16, will extend the contract completion date from May 8 to approximately June 20.

(2) Hot Air Turbine Drive System:

Completion of specifications and drawings is scheduled for the week of May 10. The purchase request will be forwarded for processing on May 10.

(3) New Boiling Fluids Rig (12 000 gallon dewar):

The research personnel have requested a change in rig concept which would eliminate the requirement for a new 12 000 gallon dewar (FY 65 program item). The proposal by research requires design, fabrication, and installation of a new pump loop which will have design features for phptpgraphing through a plastic shroud installed around the research pump. This proposal is subject to further discussion with research personnel and if approved it would add another rig to the site requiring the maintenance and operation of three separate rings at "C" site (Boiling Fluids, Turbopump Loop and new Pump Loop). All work for design of the 12 000 gallon LH_2 dewar has been deferred pending further discussion with research personnel.

LIQUID HYDROGEN PUMP QF0553 (I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

Modifications necessary for the next configuration are being carried out on the pump and cell systems. It is expected the next series of runs will begin the middle of June.

SITE	LOCATION	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO PUMP SITE	

BOILING FLUIDS RIG — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

PF0538(I.I.Pinkel)

No liquid hydrogen runs were scheduled for May because installation contractors were working on cell alterations.

While this contracted work is being done, other cell systems are being updated and the vacuum and purge systems are being revamped for improved operations. Research tests are scheduled to resume in August.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Vacuum System Installation Contract:

A change order to this contract and a stop order on the electrical portions will extend the contract completion date to June 25.

Present status of the contract:

		% Contract	%Complete
(a)	Engineering	2.2	100
(b)	Building alterations	4.0	40
(c)	Equipment removal	6.1	99
(d)	Piping	43.5	99
(e)	Cleaning and testing	6.1	99
(f)	Electrical	29.2	28
(g)	Insulation	8.9	0

Pro-rated % of completion = 67%

(2) Hot Air Turbine Drive System:

The purchase request for the installation of this system has been processed. The drawings and specifications are being reviewed by RSD personnel. Area 20 Safety Committee will review the plans and specifications, probably within 30 days.

(3) Auxiliary Dewar/New Boiling Fluids Rig Dewar System:

This concept has been deleted from the construction work. A modified pump loop (hereinafter referred to as the "high-speed loop"), using the existing

SITE	LOCATION	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO PUMP SITE	

Boiling Fluids Rig 2500-gallon dewar in series with this loop, is being substituted for the original concept of increasing the Boiling Fluids Rig dewar capacity. A controls system has been proposed for this high-speed loop. The mechanical design will proceed simultaneously with an analog computer simulation of the controls system.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

The pump lubrication system has been altered and a new housing piece has been made to accomodate a double seal arrangement with helium pressure and vent between seals. The volute section has been modified so that a proximity pickup can be installed to determine the centrifugal blade clearance. The pump inducer static taps have been modified to accomodate double 'O' rings. The new research gear stack-up has been checked for proper clearance and the torque-shaft couplings are being hand-lapped at the Lewis Machine Shop. New miniaturized total probes are presently being installed behind the centrifugal rotor.

All of the damaged turbine parts have been remade or remachined and the running gear stack-up has been completed. The second set of running gear, made of aluminum, has been completed and the stack-up is about 75% complete. The turbine lubrication system alterations have been completed. Oil will be scavenged from both sides of the front and rear bearings.

Installation is in progress on the new hydraulic actuator for ROV 278, a new hydraulic control for ROV 247, and the increase in size of ROV 248. The overhaul of the burnoff ignition system is about 30% complete and the relocation of the turbine oil pumps is 50% complete.

Research runs are scheduled to begin the first week of July.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

BOILING FLUIDS RIG — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

PF0538(I.I.Pinkel)

Installation contractors were working on cell alterations during June. While this contracted work is being done, other cell systems are being updated and the vacuum and purge systems are being revamped for improved operations. Research tests are scheduled to resume in September.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Vacuum System Installation Contract:

The vacuum system installation should be completed by the second week of July.

(2) Hot Air Turbine Drive System:

The purchase request has been processed, but the drawings still have to be approved.

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
C	TURBO PUMP SITE

(3) High-Speed Pump Loop:

The controls studies have been completed for this system, and the design should start the first week of July and is scheduled to be completed by the first of August.

(4) Rail Spur:

Bids for the rail spur were opened and construction should start by the second week of July.

LIQUID HYDROGEN PUMP QF0553(I.I.Pinkel)	Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

The pump and turbine are completely assembled and are installed on the bedplate. Instrumentation is being installed and is scheduled to be completed by July 7. Valve modifications are complete and the Q/N system has been installed. The wiring for valve control at "H" Building will be finished by July 9. A checkout cold shock to check alignment and proximity pickups will be made the week of July 19.

It is anticipated that the turbo-pump rig will be in operational status the week of July 26.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

BOILING FLUIDS RIG — PF0538 (I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

All systems are being updated prior to liquid hydrogen tests which are scheduled to begin in September.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Instrumentation and Motor Equipment Rooms - Design drawing and specifications were completed the last week in July.

(2) Hot Air Turbine Drive System - Design drawings and specifications were completed during the last week of July. The compressed air heater for this system is scheduled for delivery August 2.

(3) High Speed Loop - The system is being designed and the approval is being sought for the completed system flow schematic.

(4) Rail Spur - Acme Construction Company started work on the rail contract during July. The scheduled completion date is September 12.

(5) Vacuum System - The installation contract is completed and the necessary in-house modifications to the 2500 gallon LH_2 dewar are now in progress.

LIQUID HYDROGEN PUMP

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

Cold checkout was made on July 29. The centrifugal pump will be modified to provide a means of detecting the zero shift during run conditions. The pump will be rebalanced and then reassembled before the next run.

The next run is scheduled for August 20.

BOOST PUMP SYSTEM INSTALLATION

A tentative planning schedule calls for design to be completed by September 25, 1965; a contract awarded by December 31, 1965 and and construction and installation to be completed by March 31, 1966. A flow schematic drawing has been prepared, but approval for it will not be sought until research personnel complete an analog computer study of the proposed system and give the "go-ahead" on the basic system and configuration. No design work will be done until the flow schematic drawing has been approved.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

BOILING FLUIDS RIG — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

QF0533 (I.I.Pinkel)

No data runs were made during the month of August.

Next research run is scheduled for October.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Instrument and Motor Equipment Rooms-Specifications and drawings have been completed. Purchase Requests are awaiting approval of Special Job Orders for increased funds.

(2) Cabling from C-Site to H-Building - The contract is scheduled to be awarded in September but actual work may not begin until construction of Instrument and Motor Equipment Rooms (No. 1 above) has been started.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

(3) Hot Air Turbine Drive Systems - Bids for this contract are to be opened in late September. Compressed air heater was delivered the first week in August.

(4) High Speed Loop - Narrative specifications are complete; drawings are 80% complete and should be finished the second week of September. Tentative schedule calls for:

Design completion	- September 25, 1965
Contract award	- December 15, 1965
Construction & installation completed	- March 15, 1966

(5) Rail Spur Installation - The installation of two drain pipes (culverts) is all that remains to complete the Acme contract. Drainage ditch clean-out work may be added to the contract before these culverts are installed.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

On August 31, a research run was made during a rotation time of 30 minutes. Ten data runs were made to determine the stall curve. Five of the runs were considered good runs. Difficulty still exists in arriving at stall condition and, for this reason, only a limited amount of data was taken. A study of the test data will be made on September 7 to arrive at an alternate method of determining stall.

On disassembly of the pump, the rotating gear appeared in excellent condition. The next run schedule will depend on the results of the test data study mentioned above.

ALTERATIONS TO TURBO-PUMP RIG

Boost Pump Sytem - A flow schematic drawing for this boost pump system has been prepared, but approval for it will not be sought until research personnel complete an analog computer study of the proposed system and give the "go-ahead" on the basic system and configuration. No design work will be done until the flow schematic drawing has been approved. Tentative design-procurement-installation schedule cannot be determined until "go-ahead" on basic configuration is received from research personnel.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

BOILING FLUIDS RIG — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

QF0533 (I.I.Pinkel)

No data runs were made during the month of September. Liquid hydrogen runs are scheduled for the last two weeks of October.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Instrument and Motor Equipment Rooms:

Invitations for Bids for the construction work will be sent out the first week of October.

(2) Cabling from C-Site to H-Building (NAS3-8406):

This contract has been awarded. The completion date will have to be extended. The Instrument and Motor Equipment Rooms have to be constructed before this contract can be completed.

(3) Hot Air Turbine Drive Systems:

The bids for this contract were too high and efforts will be made to negotiate the contract.

(4) High Speed Loop:

The specifications are complete and the drawings are 95% complete and are scheduled to be completed October 15.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

(5) Rail Spur Installation:

Installation has been completed.

LIQUID HYDROGEN PUMP
QF0553 (I.I.Pinkel) — Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

Two tests were conducted during the month of September. Both tests were to obtain stall data on the present configuration which is inducer 1-A and centrifugal 3. Stall data is obtained at 20 000 rpm, 30 000 rpm and 40 000 rpm. At each speed, runs are made at two different ramp rates and at two NPSH levels.

On September 14, the pump was run for sixteen minutes and all the data was obtained for the 20 000 rpm series. One pass was made for the 30 000 rpm series. The run was terminated when a rear pump bearing failed due to lack of proper lubrication.

Steps were taken to insure a more satisfactory lubrication flow to the pump rear bearing.

On September 29 a run was made. The data for the 30 000 rpm and the 40 000 rpm stall runs was obtained along with several runs to check data repeatability. Seventeen passes were made during 35 minutes of rotation time. After shutdown the rotation gear appeared to be in good condition.

The next run will be scheduled after the present data has been reduced.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

BOILING FLUIDS RIG — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

QF0533 (I. I. Pinkel)

On October 21, the boiling fluids tank was checked out with liquid nitrogen. The vacuum pumps stalled after five minutes of operation and with a tank pressure of six psig.

On October 29, another liquid nitrogen test was made. Pressure and temperature senses were installed in the suction line near the pumps. The pumps stalled at 300 torr pressure and -60°F. In order to pass this critical pressure the vacuum control valves were partially closed and then reopened after the pressure was reduced. Once the stall pressure was lowered the pumps further reduced the pressure until the liquid nitrogen was cooled to its melting point. During this test the vacuum pumps oil reservoir overheated.

Additional cooling coils are being added to the vacuum pump reservoirs and the solenoid valves are being replaced to increase the oil flow.
Another liquid nitrogen run will be made the week of Nov. 10.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Instrument and Motor Equipment Rooms: The bids for this construction work will open November 30.

(2) Cabling from C-Site to H-Building (53-3406): The completion date for this contract cannot be determined until the bids on the Instrument and Motor Equipment Rooms are known. This contract cannot be completed until after the Instrument and Motor Equipment Rooms are completed.

(3) Hot Air Turbine Drive Systems: This work is being re-advertised. The new bid opening date is November 16.

(4) High Speed Loop: Since the Plum Brook drafting section has a large backlog of work, the remaining drawings for this High Speed Loop will be done by contract.

LIQUID HYDROGEN PUMP QF0553 (I. I. Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

Two data runs were made during October.

On October 12, five cavitation performance curves were obtained. Problems developed in the Q/N system and the manual ramp had to be used. This limited the amount of test data that would normally have been recorded. A series of passes were made with the Q/N mode to obtain data for trouble shooting the system. The total running time was 22 minutes.

On October 25, four data passes were completed at speeds of 20,000 and 30,000 rpm. This run was made to check the stall point that was recorded during September. On the second attempt to go to 40 000 rpm, the turbine drive gas entered the bearing cavity through a worn front seal and caused the bearing to over heat. The total running time was 14 minutes.

The next scheduled run depends on the completion of "H" Building modifications. If the modifications are completed on schedule, the run will be made November 17.

ALTERATIONS TO THE TURBO PUMP RIG

As reported in August, the schematics for the boost pump system have been prepared but further work cannot be done until it has been approved by the Lewis Research Division.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

BOILING FLUIDS RIG
QF0553(I.I. Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On November 10, a liquid nitrogen checkout run was made using the vacuum cooling system. The electrical loading on the vacuum pumps was excessive. Current transformers and meters are being installed along with remote re-sets so that loading can be controlled from the console.

Another liquid nitrogen run is scheduled for December 2.

NOTE: The test schedule change was required because alterations have to be made to the vacuum cooldown system.

ALTERATIONS TO THE BOILING FLUIDS RIG

1. Instrument and Motor Equipment Rooms:

   The bids for this construction work opened November 30. The contract should be awarded by December 20 and completed in 185 days (June 23).

2. Cabling from "C" Site to "H" Building (NAS3-8406):

   Should be completed by June 23. This work is dependent on the progress of the Room construction (Item 1).

3. Hot Air Turbine Drive System:

   Bids were opened November 16. Araco Company of Philadelphia was the low bidder, with 120 day completion date. Approval has not been received to award the contract. The bid was $13,500 over the job estimate of $65,000.

4. High Speed Loop:

   The remaining drawings for this contract are currently being done by Superior Design Company of Cleveland, and are scheduled to be completed by December 17.

SITE	SITE NAME RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE (Continued)

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel) — Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60 000 rpm.

No tests were conducted during November due to the shutdown of "H" Building for contract installation purposes. The next scheduled run is December 7.

ALTERATIONS TO THE TURBO-PUMP RIG

As reported in August, the schematics for the boost pump system have been prepared but further work cannot be done until it has been approved by Fluid System Components Division.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On December 9, a liquid hydrogen run was made at 20,000 r.p.m. during 7 minutes and 50 seconds of pump rotation. Two curves were plotted at a liquid temperature of 37°R. No data was recorded when the liquid temperature was 28°R, because of oscillation of the NPSH control valve.

On December 21, an attempt was made to cool the hydrogen to 26°R; however, the lowest temperature that could be obtained was 28°R. On the subsequent pass, the inducer pressure probe indicated almost full-scale oscillation, the carbon resistors gave incorrect readings and the pump pressure was low. Upon disassembly, the total rake position probe was found to be bent and a pump pressure probe fitting had vibrated loose.

A meeting is scheduled for the first week in January to review the proposed research program and to determine the amount of data that can be obtained.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Instrument and Motor Equipment Rooms (Contract No. NAS3-8786-PB):

R. G. Beer Corporation was awarded the contract on December 21, notice to proceed was given on December 29, and the work was started on December 29. The contract is scheduled to be completed in 136 days, or May 13.

(2) Hot Air Turbine Drive System:

Araco Company was the low bidder and the contract completion is 120 days after notice to proceed. This notice should be given to the contractor by January 7, making the completion date May 7.

(3) High-Speed Loop:

The Plum Brook Engineering Division personnel are currently reviewing the contract drawings.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE (Continued)	

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60 000 r.p.m.

Two tests were made during December. In the first week of December, during a run time of 19 minutes, four data runs were recorded. All the data needed to complete the cavitation portion of this configuration performance curve was obtained. The stall data could not be completed since the high frequency pickups were not functioning. One high flow rate pass was made for the NPSH curves.

In the third week of December, another test was made. During a run time of 13 minutes, five data passes were recorded. The remaining two stall curves were obtained for this configuration. The three NPSH curves were completed. On the last pass, a run of 45 000 r.p.m. was attempted and a critical speed was encountered, resulting in pump and turbine failure. All previous runs were at a maximum speed of 40 000 r.p.m. Due to the critical speed, all future running will be confined to speeds below 45 000 r.p.m.

The NPSH maps and the angle actuator data still have to be obtained for this Inducer I-A configuration. The next run is scheduled for the week of January 17.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE	

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On January 11, four cavitation curves were obtained. Two runs were made at 37°R. and two runs were made at 31°R., but the test had to be stopped when oscillations occurred below the 840 helical pump inducer and the over-pressurization caused a burst disc rupture.

On January 14 and 15, a boil-off test was made to determine the heat leak of the boiling fluids tank. It was found that over an eight-hour period, 1120 gallons of liquid hydrogen evaporated. This represents 2.33 gallons per minute or 134% per day.

On January 19, seven cavitation curves were obtained, which included three runs at 37°R., two runs at 34°R., and two runs at 31°R. Other passes were attempted, but oscillations below the inducer were experienced again.

On January 26, six cavitation curves were obtained. These included three runs at 37°R. and three runs at 34°R. An attempt was made to make a pass at 29.5°R. and again the oscillation stopped the run. Before the next run, a transducer will be submerged in the liquid to determine whether line perculation causes the oscillations that are encountered at the lower temperature.

The instrument tubing plug in the liquid hydrogen tank will be replaced, in order to update the rig, reduce the heat leak, and cut down on the hazard of hydrogen leakage.

The next liquid hydrogen run is scheduled for the second week in February.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Instrument and Motor Equipment Rooms (Contract No. NAS3-8786-PB):

The contract is in progress, is approximately 25% complete, and it is anticipated that the project will be completed by May 13.

(Continued on Page 24)

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP SITE (Continued)	BOILING FLUIDS RIG (Continued) (2) Hot Air Turbine Drive System (Contract NAS3-8789-PB, Araco Company): The parts are being fabricated by the contractor at the present time. There has been no on-site construction so far. The anticipated completion date is August 6. (3) High-Speed Loop: One of the drawings submitted by the A&E firm for this system requires extensive rework, which will cause an estimated 30-day delay. It is estimated that the construction contract will be completed by the middle of September. (4) Cabling from "C" Site to "H" Bldg. (Contract NAS3-8406-PB, Valley Electric Co.): Notice to proceed will be given the contractor on February 1.
		LIQUID HYDROGEN PUMP QF0553(I.I.Pinkel) — Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds to 60 000 r.p.m. On January 28, four data passes were recorded during a rotating time of seventeen minutes. The purpose of the run was to check the pump performance to insure that it had not changed due to the damage that was experienced on the December 14 run. It appeared from the monitoring data that the performance duplicated, although the digital data will have to be reduced before this is verified. While the data reduction section is reducing this data, the angle actuators will be readied for the next run which is scheduled for February 21.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP	

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On February 8, four cavitation curves were obtained. Two runs were made at 37°R, and two runs were made at 31°R. The NPSH was ramped on a continuous basis at 8 sec/psi from 5 psi to 0 psi. All passes were made at 20 000 rpm.

On February 16, fourteen cavitation curves were obtained. Five runs were made at 37°R, four at 34°R, four at 31°R, and one at 29.5°R. The NPSH was ramped on a continuous basis at 8 sec/psi from 5 psi to 0 psi. All passes were made at 20 000 rpm except the one at 29.5°R, which was made at 14 140 rpm.

All of the windows in the boiling fluids liquid hydrogen tank are being rebuilt along with the fabrication of window plugs which will be installed prior to the next run, scheduled for the second week of March.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Instrument and Motor Equipment Rooms (Contract NAS3-8786-PB, R. G. Beer Corp.):

The contract is in progress and is approximately 30% complete. It is anticipated that the project will be completed by May 13.

(2) Hot Air Turbine Drive System (Contract NAS3-8789-PB, Araco Company):

Some of the required shop drawings have been approved and parts are being fabricated at the present time. On-site construction has not been started. The anticipated contract completion date is August 6, 1966.

(3) High Speed Loop:

The high speed loop drawings which required reworking are in the process of being checked and approved. It is estimated that this contract will be completed by the middle of September.

(4) Cabling from "C" Site to "H" Building, (Contract NAS3-8406-PB, Valley Electric Co.):

Notice to proceed on this contract has been given, and work has been started. Coordination of this work with that of the instrument room construction is necessary since cable entrance at the site requires penetrations in the new addition. As soon as the concrete walls have been poured, this contractor can proceed to erect the cable.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBO-PUMP	

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

The data from the check run of January 28 was reduced during the week of February 14. There is a slight shift in both the head rise and stall point in the pump performance. The research engineer has decided to proceed to the next tests for angle and velocity data.

The angle actuators have been calibrated and installed on the pump. The test schedule may be affected because there has been a delay in getting the data reduction program written for the angle data. The tape for data recording has been supplied, and a run is scheduled for March 4.

An additional run in liquid nitrogen has been requested, to check out the pump in a fluid which exhibits close to zero fluid property effect.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On March 22, four cavitation curves were obtained at three flow coefficients. Two passes were made at a liquid temperature of 36.5°R. while the remaining two were made at 42°R. All passes were made at 20 000 rpm with NPSH ramped from 5 psi to 0 psi.

On March 31, ten cavitation curves were obtained at two flow coefficients. Included were three passes at a liquid temperature of 36.5°R, two at 34°R, and two at 26.9°R. All passes were made at 20 000 rpm with NPSH ramped from 5 psi to 0 psi.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Instrument and Motor Equipment Rooms (Contract NAS3-8786-PB, R. G. Beer Corp.):

The contract is in progress and is approximately 60% complete. It is anticipated that the project will be completed by May 13.

(2) Hot Air Turbine Drive System (Contract NAS3-8789-PB, Araco Company):

Some of the required shop drawings have been approved and parts are being fabricated at the present time. On-site construction has not been started. The anticipated contract completion date is August 6, 1966.

(3) High Speed Loop:

The high speed loop drawings are in the process of being checked and approved. It is estimated that this contract will be completed by the middle of September.

(4) Cabling from "C" Site to "H" Building, (Contract NAS3-8406-PB, Valley Electric Co.):

Work has been started and is approximately 15% complete. The anticipated completion date for this contract is May 1, 1966.

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
C	TURBOPUMP			

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

Two cavitation data test runs were made during March. On March 14, during a rotation time of 21 minutes, six data passes were completed. Passes were made at 110%, 120%, and 140% of design flow. The test had to be terminated because the rear turbine bearing overheated and because of low hydrogen gas pressure to the turbine. The turbine bearings and seals were replaced following the test.

On March 16, another cavitation data run was made. During a rotation time of 20 minutes, five data passes were made. Two passes were considered good. The passes were made at 150% of design flow, which made flow controlling very difficult, since the flow was very close to the maximum capacity of the pump. Again, the turbine rear bearing overheated and it was necessary to terminate the testing.

Subsequent to the March 16 test, it was decided to redesign and build a new bearing support housing which will increase heat transfer away from the bearing.

The angle actuator data appeared good from the "on line" monitoring. A discrepancy of angle reading occurred and is being investigated. It is not clear at the present whether there is a system malfunction or whether the data represented what is actually occurring.

It is anticipated that redesign of the turbine rear bearing housing will result in a one-month delay in the research program.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	BOILING FLUIDS RIG QF0553 (I.I.Pinkel) The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. On April 7, ten cavitation curves were obtained. Included were three at 36.5°R, two at 34°R, two at 31°R, two at 27°R and one at 26.7°R. All runs were made at 20 000 rpm with NPSH ramped from 5 psi to 0 psi. On April 14, eight cavitation curves were obtained. Included were three at 36.5°R, one at 34°R, one at 31°R, one at 28°R, and two at 27°R. All runs were made at 20 000 rpm with NPSH ramped from 5 psi to 0 psi.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	BOILING FLUIDS RIG (Continued) ALTERATIONS TO THE BOILING FLUIDS RIG (1) Instrument and motor equipment rooms (Contract NAS3-8786-PB, R. G. Beer Corporation): The contract is in progress and is approximately 90% complete. It is anticipated that the project will be completed by May 13. (2) Hot Air Turbine Drive System (Contract NAS3-8789-PB, Araco Company): There have been some delays in obtaining acceptable design for Hot Air Line from Araco; however, some of the required shop drawings have been approved and parts are being fabricated at the present time. "On-Site" construction has not been started. The anticipated contract completion date is August 30. (3) High Speed Loop: The high speed loop specifications and drawings are complete and are being checked. It is estimated that this contract will be completed by the middle of September. (4) Cabling from "C" Site to "H" Building, (Contract NAS3-8406-PB, Valley Electric): Work has been started and is approximately 40% complete. The anticipated contract completion date is June 15.
		LIQUID HYDROGEN PUMP QF0553 (I.I.Pinkel) Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm. The material for the new turbine rear bearing support housing was supplied to the contractor and machining began on April 29. It is scheduled to be completed by May 16. Data taken for the secondary objectives of the test program is being analyzed. Discrepancies have been found and are being considered for determining the future testing sequence and priority. Work on the turbine assembly will proceed when the new housing is completed. The pump will be modified if required by test sequence decisions.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On May 17, seven cavitation curves were obtained. Included were two at 36.5°R., one at 34°R., one at 31°R., two at 30°R., and one at 28°R. All runs were made at 20,000 rpm with NPSH ramped from 5 psi to 0 psi.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Hot Air Turbine Drive System (Contract NAS3-8789-P8, Araco Company):

An acceptable design for Hot Air Line has not been received from Araco; however, some of the required shop drawings have been approved and parts are being fabricated at the present time. "On-site" construction has not been started. The anticipated contract completion date is August 30.

(2) High-Speed Loop:

The high-speed loop specifications and drawings are complete and are being checked. It is estimated that this contract will be completed by the first of November.

(3) Cabling from "C" Site to "H" Building, (Contract NAS3-8406-PB, Valley Electric):

Work has been started and is approximately 80% complete. The anticipated contract completion date is June 15.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

It has been determined by the research personnel to proceed with the main program objectives. The main study objective of the program is the study of change in performance due to an inducer to centrifugal match. Data will not be taken for the secondary objectives at the present time. With the data required for the main objective completed for 3-A; the pump was disassembled and inducer 3-B was installed.

The new turbine rear bearing support piece housing is complete. The bearing has been assembled for clearance check and the rotating components have been sent to Lewis-Cleveland for balancing.

The next scheduled run is June 14.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
QF0553 (I.I. Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On June 22 an attempt was made to operate the Boiling Fluids Rig to obtain normal head-flow curves. On the second pass the jack shaft connecting the research pump with the CH-5 turbine was bent necessitating shutdown. This over loading of the shaft was caused from the dead heading of the pump discharge against a closed dewar valve The control valve switch was in the open position but the valve was closed. The dewar valve actuator regulator is being checked out to determine the cause of the valve malfunction.

It is anticipated that the next run will be made during the third week of July.

ALTERATIONS TO THE BOILING FLUIDS RIG

1. Instrument and motor equipment rooms (Contract NAS3-8786-PB, R. G. Beer Corporation):

   The contract is completed.

2. Hot Air Turbine Drive System (Contract NAS3-8789-PB, Araco Company):

   There have been numerous delays in obtaining acceptable designs for Hot Air line from Araco; however, some of the required shop drawings have been approved and parts are being fabricated at the present time.

   "On-Site" construction has not been started. The anticipated contract completion date is October 30.

3. High Speed Loop:

   Bids for this contract were opened June 27. There is a good possibility that an award can be made by July 6. The contract completion time is 120 days.

4. Cabling from "C" Site to "H" Building, (Contract NAS3-8406-PB, Valley Electric):

   This contract was completed June 24.

LIQUID HYDROGEN PUMP
QF0553 (I.I. Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm

On June 16 a test was conducted to obtain the stall data for configuration 3-B. Two passes were made at 20 000 rpm. The turbine rear bearing failed on the third pass, a 10 000 rpm test. It was felt that the turbine clearances were to close. The turbine has been repaired and the clearances have been increased.

The next test run is scheduled for July 7

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

A new jack shaft and splined ends have been fabricated and are being balanced. It is anticipated that the next liquid hydrogen run will be made during the last week of August.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Hot Air Turbine Drive Systems (Contract NAS3-8789-PB, Araco Company):

There have been numerous delays in obtaining acceptable designs for the hot air line from Araco; however, some of the required shop drawings have been approved and parts are being fabricated at the present time. "On-site" construction has not started. The anticipated contract completion date has now slipped from October 30 to November 30.

The next two bootstrap tests are scheduled for August 24.

(2) High Speed Loop (Contract NAS3-9450-PB, Valley Electric Company):

This contract was awarded early in July. The contract completion time will be 150 days after notice to proceed has been issued.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

Two July test runs completed the data for inducer configuration 3-B. A total of 17 passes was made during the two tests.

The 3-C inducer configuration is being installed. The next scheduled test is August 5.

SITE

C

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On August 30, five data curves at 36.5°R were obtained. Included were three head-flow curves at 10, 5, and 0 psi NPSH; one locked tank pump-out curve; and one cavitation curve. All runs were made at 20,000 r.p.m. using the boost rotor.

The next liquid hydrogen run is scheduled for September 8.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Hot Air Turbine Drive Systems (Contract NAS3-8789-PB, Araco Company):

There have been numerous delays in obtaining shop drawings from Araco; however, most of the drawings are nearly completed. On the last submittal, only minor changes were required. It is estimated that the notice to proceed on the field installation work will be issued by the end of September or first of October.

(2) High Speed Loop (Contract NAS3-9450-PB, Valley Electric Company):

Shop fabrication of the vacuum-jacketed piping has been started by the contractor's sub. Notice to proceed on site construction and installation of certain portions of the contract (which do not cause an extended shutdown of the site) was given on August 25.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 r.p.m.

Two test runs were conducted during August to obtain stall data for Inducer 3-C.

On August 4, four data passes were made at 20 000 and 30 000 r.p.m. While operating in the stall region during a 30 000 r.p.m. pass, rubbing occurred. The pump was disassembled and the necessary modifications were made to eliminate the problem.

On August 23, seven data passes were made at all speeds to complete the stall data for Inducer 3-C. Also, a data pass was made to check the pump pressure drop during cavitation.

The next run is scheduled for September 1.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On September 8, an attempt was made to operate the boiling fluids rig; however, on the second pass excessive vibrations necessitated shutdown. It was found that the bearings and seals had disintegrated, causing minor damage to the research pump parts.

The next liquid hydrogen run is scheduled for October 25.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Hot Air Turbine Drive Systems (Contract NAS3-8789-PB, Araco Company):

It is estimated that notice to proceed on all work exterior to the test cell and approved by the Engineering Department will be given the second week of October.

(2) High Speed Loop (Contract NAS3-9450-PB, Valley Electric Company):

Materials and equipment are being fabricated by the contractor, although there has been no "on site" work started. It is anticipated that portions of this contract will be installed within the next month without affecting the research testing schedule.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

On September 1, inducer configuration 3-C was tested. During the second cavitation data pass, severe vibration occurred. The test unit was disassembled and inspected. Rubbing had occurred, but there was no damage to the bearings.

After reviewing the data, the research personnel have decided to make the next test without the inducer. Modifications are being made and the next run is scheduled for the last week of October.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	**BOILING FLUIDS RIG** QF0553 (I.I.Pinkel) The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. During October preparations were made for a November 2 liquid hydrogen run. **ALTERATIONS TO THE BOILING FLUIDS RIG** (1) Hot Air Turbine Drive System (Contract NAS3-8789-PB, Araco Company): The contractor was given a notice to proceed on all work exterior to the cell. The hot air line from the underground to the turbine has been deleted from the contract. The design and installation work will be done "in-house". (2) High Speed Loop (Contract NAS3-9450-PB, Valley Electric Company): Portions of this contract are being fabricated and the installation work is scheduled to begin November 15. **LIQUID HYDROGEN PUMP** QF0553(I.I. Pinkel) Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm. During October one test run was made. On October 31 two passes were completed when severe vibrations occurred. The pump was disassembled and repaired. The next run is scheduled for November 4. Eight more cavitation runs are needed to complete the data for the centrifugal.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
QF0553(I. I. Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On November 4, nine cavitation curves were obtained. Included were four at 42°R, one at 39°R, and four at 36.5 R. Speed was held constant at 20 000 rpm, flow coefficients were .090 and .060, and NPSH was controlled from 2 psi to a locked-tank condition.

On November 10, eight cavitation curves were obtained. Included were two at 42° and six at 36.5°R. All runs were made at 20 000 rpm with NPSH controlled between 5 psi and 0 psi.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Hot Air Turbine Drive System (Contract NAS3-8789-PB, Araco Company):

At the present time the natural gas line is being installed underground from the boiler house to the hot air heater. It is estimated that 15% of the contract has been completed.

(2) High Speed Loop (Contract NAS3-9450-PB, Valley Electric Company):

Contractor work at the test cell began on November 15 and it is estimated that 20% of this contract has been completed.

LIQUID HYDROGEN PUMP
QF0553(I.I.Pinkel)

Liquid hydrogen turbopump tests to study impeller matching with centrifugal pump at speeds of 60 000 rpm.

A test run was attempted on November 4. During the first data pass at 35 000 rpm, severe vibrations occurred. Inspection of the pump parts indicated that 35 000 rpm was a critical pump speed. The program was adjusted using 27 500 rpm instead of 35 000 rpm. On November 10, a total of eight data passes were obtained at 25 000, 27 500, 30 000, and 40 000 rpm. The tests were made at various flow coefficients while the NPSH was ramped from 20 psi to 0. This test completes the pump test program.

This is the last test operations report for this research installation. No new pump programs are planned.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
QF0553(I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

The site modifications continued during December. Contracts NAS3-8789-PB and NAS3-9450-PB have to be completed before testing can continue. A checkout run is scheduled for mid-March.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Hot Air Turbine Drive System (Contract NAS3-8789-PB, Araco Company):

The work is progressing and the contract is 45% complete. The contract is scheduled to be completed by March 1.

(2) High Speed Loop (Contract NAS3-9450-PB, Valley Electric Company):

It is estimated that this contract is 60% complete. The contract scheduled completion date is January 22.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	BOILING FLUIDS RIG YQF0553(I.I.Pinkel) — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

The site modifications continued during January. Contracts NAS3-8789-PB and NAS3-9450-PB have to be completed before testing can continue. The contract work checkout will begin in March.

ALTERATIONS TO THE BOILING FLUIDS RIG

(1) Hot Air Turbine Drive System -
(Contract NAS3-8789-PB, Araco Company)

The work is progressing and the contract is 65% complete. The contract is scheduled to be completed by March 1.

(2) High Speed Loop -
(Contract NAS3-9450-PB, Valley Electric Company)

The contract is 75% complete. The completion date will be based on the contractor's ability to obtain cryogenic vacuum jacketed piping.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YQF0553 (I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

The site modifications continued during February. Contracts NAS3-8789-PB and NAS3-9450-PB have to be completed before testing can continue. The contract work checkout will begin in March.

(1) Hot Air Turbine Drive System -
(Contract NAS3-8789-PB, Araco Company)

The work is progressing and the contract is approximately 80% complete. Completion date is March 15.

(2) High Speed Loop -
(Contract NAS3-9450-PB, Valley Electric Company)

The contract is 85% complete. The completion date will be based on the contractor's ability to obtain vacuum jacketed piping.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YQF0553 (I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

The site modifications continued during March. Both contracts are expected to be completed in April and a systems checkout is scheduled.

(1) Hot Air Turbine Drive System -
(Contract NAS3-8789-PB, Araco Company)

This contract is completed except for the drying out of some pipe insulation and minor piping connections. Completion date in April 15.

(2) High Speed Loop -
(Contract NAS3-9450-PB, Valley Electric Company)

This contract is essentially completed. The hydrostatic pressure check is complete and the contractor is cleaning up the site area.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YQF0553(I.I.Pinkel) — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

The site modifications continued during April. Both contracts are expected to be completed in May and a systems checkout is scheduled.

(1) Hot Air Turbine Drive System - (Contract NAS3-8789-PB, Araco Company):

The contract is complete except for the drying-out of some pipe insulation and the repair of a window flange.

(2) High-Speed Loop - (Contract NAS3-9450-PB, Valley Electric Co.):

The contractor is essentially finished with his work and should be out of the area sometime during the first week of May.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	
		BOILING FLUIDS RIG YQF0553(I.I.Pinkel) — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.
		Site modifications continued during May. Both contracts have been completed except for systems checkout. "In-house" miscellaneous piping and valving work is underway to update the test cell. Testing is scheduled to start in July.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	BOILING FLUIDS RIG YQF0553(I.I.Pinkel) — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. Site modifications continued during June. The "On-Mark" instrumentation plug is scheduled to be completed during the second week of July and will be installed on the top of the rig. The rig will then be liquid nitrogen cold-shocked. Liquid hydrogen runs are scheduled for the latter part of July.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	BOILING FLUIDS RIG YQF0553(I.I.Pinkel) — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. Site modifications continued during July. All piping and rig alterations have been completed. The hot air turbine and research gear are presently being installed. Upon completion of this installation, the rig will be cold-shocked with liquid nitrogen and prepared for a liquid hydrogen run. It is anticipated that testing will begin the middle of August.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	BOILING FLUIDS RIG YQF0553 (I.I.Pinkel) — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. The research gear and hot air turbine were installed during August and a series of checkout tests were made. The pump was checked out in liquid nitrogen to 6,000 RPM on August 30. The research gear was disassembled and inspected. A liquid hydrogen cold shock is scheduled for September 7. A data test is scheduled for September 14.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YQF0553 (I.I.Pinkel)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On September 9 the research pump was checked out in liquid hydrogen. After a rotation time of seventeen minutes at 20,000 RPM, the top turbine bearing began to freeze when the turbine was not operating. Several data passes were made during the testing. The flow control system was unstable in automatic control. The rig was shutdown to enable modification to the flow controller and to modify the turbine oil supply system.

On September 14 tests were conducted to speeds of 25,000 RPM. Difficulty still existed with the automatic flow control and with the top turbine bearing running below normal temperature. After a run time of 15 minutes, the top turbine bearing failed. Useful data was obtained on one pass.

The turbine is being modified to incorporate a better scavange system. A heater is being installed near the top turbine bearing. The flow venturi was removed and inspected. The sensor lines from the venturi are being shortened.

The next scheduled run is October 6.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	
		BOILING FLUIDS RIG YQF0553(I.I.Pinkel) — The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. A test run was made on October 19. Two useful data curves were obtained before the top turbine bearing failed. The turbine was disassembled and inspected. Modifications are being made to improve bearing lubrication and to bring all components within design tolerances. The next run is scheduled for November 19.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	BOILING FLUIDS RIG YQF0553(I.I.Pinkel) (FSCD - P.R.Meng; RSD - W.D.Pack,Jr.) The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. A test run was made on November 28. Three speed survey runs were made from 0 to 27,000 r.p.m. These tests were made to check for critical speeds and to check the modifications made to the turbine. Because of progressively higher vibration readings during the three runs, the testing was terminated. The pump and the turbine were disassembled and inspected. The turbine bearings showed only a slight amount of wear; however, the pump booster had some unidentified metallic material plated to its casing. The turbine has been reassembled and is being installed. The pump has been repaired, rebalanced, and is being reassembled. The next scheduled run is December 7.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YQF0553 (FSCD - P.R.Meng; RSD - W.D.Pack,Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Two test run days were made during December.

On December 7, three 0 to 27,000 rpm checkout runs were made to check the performance of the pump and turbine. The monitor equipment indicated that the pump and turbine were running smoothly, but during the data run the pump lower bearing failed while the speed was being increased to 25,000 rpm. Improper radial bearing clearance appeared to be the cause of the failure. The differential contraction of the shaft, housing, and bearing assembly caused the problem . The bearing housing was remachined, increasing the clearance between the bearing and the housing.

On December 21, sixteen data passes at 25,000 rpm were made during a rotation time of fifteen min. Data was taken for head vs. flow, for cavitation curves, and at temperatures of 37.5°R and 40°R.

The next run is scheduled for January 9. "C" Site ("H" Building) modifications under the RCA "H" Building contract are scheduled to be started January 10.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	
		BOILING FLUIDS RIG YQF0553 (FSCD - P.R.Meng; RSD - W.D.Pack,Jr.) The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. The test run scheduled for January 9 was cancelled. Additional time was needed to rebalance and reinstall research hardware that had been damaged on December 21. The run could not be rescheduled during January because the "H" Building control panel was being reworked by RCA (Control Data Switching System contract). The RCA contract was completed January 26 and is being checked out for a test run scheduled for February 6.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YQF0553
(FSCD - PR Meng;
RSD - WD Pack,Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Research test runs were made on February 6, February 16, and February 21. The research hardware for the tests was the 80.6 degree inducer with the #2 booster. A total of thirty-three (33) data passes was made during a total rotation time of twenty minutes.

The 80.6 degree inducer with booster #3 has been installed and the next test run is scheduled for March 1.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YQF0553
(FSCD - PR Meng;
RSD - WD Pack, Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Three test runs were made during March.

On March 1, data was obtained on the 80.6 degree inducer with booster #3. A complete set of data was obtained for the fluid property effect studies.

On March 8 the lucite shroud was installed, and the shroud design was successfully checked out during two runs from 0 to 30,000 RPM.

On March 22 data was obtained on the 84 degree inducer with booster #1. A review of the data showed that the venturi temperature probe had failed and that the flow coefficient (Q/N) had deviated. Some usable data was obtained but it will be necessary to rerun the configuration.

The next run is scheduled for April 8. The 84 degree inducer with booster #1 will be tested.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	
		BOILING FLUIDS RIG YQF0553 (FSCD - PR Meng; RSD - WD Pack, Jr.) The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank. Two test runs were made during the month of April. On April 8, sixteen data passes were made with the 84° inducer and Booster #1. Thirteen of the passes were at 37°R and four of the passes were at 42°R. All the requested data was obtained. On April 24, thirteen data passes were made with the 80.6° inducer and Booster #2. One cold run (34°R) was completed. Because the liquid shutoff valve was leaking hydrogen from the dewar into the run tank, six of the scheduled cold runs had to be cancelled. The next run is scheduled for May 9. The 80.6 degree inducer will be tested with Booster #1. Movies will be taken with the lucite shroud installed.

SITE	SITE NAME	RESEARCH INSTALLATION	&	DESCRIPTION
C	TURBOPUMP			
		BOILING FLUIDS RIG YQF0553 (FSCD - PR Meng; RSD - WD Pack, Jr.)		The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.
		Two tests were conducted during May. Both tests were made with a lucite shroud installed over the inducer for photographic data. The shrouds cracked both times during the third pass. The May 20 shroud failure was due to thermal stresses. The failure on May 29 probably resulted from some object hitting the inducer and the shroud. The next scheduled run is for the week of June 10.		

SITE	SITE [redacted]	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YQF0553
(FSCD - PR Meng;
RSD - WD Pack, Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Two tests were conducted during the month of June. On June 14, photographic research movies were taken of the 86° inducer. The movies were taken at two flow conditions selected as being high and low flows. On June 21, a test was conducted to obtain additional data on the 86° inducer. 34°R and 30°R fluid temperature data had been requested. After several runs at 34°R the vacuum pumps overloaded due to the cold condition of the pumps. Hot water will be piped to the pump cooling jackets to keep pump oil at operating temperature.

The next run is scheduled for mid-July.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YON0553
(FSCD - PR Meng;
RSD - WD Pack, Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

On July 12, eleven data passes were made at high flow rates. Three of the passes were at 34°R and eight made at 37°R.

On July 25, a test run for photographs was cancelled due to cracking of the shroud. A new lucite shroud was installed and a test was conducted on July 30. The shroud again failed.

The next run is scheduled for August 13.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YONO553
(FSCD - PR Meng;
RSD - WD Pack, Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

One test was made during August. On August 16, tests were conducted on an 80.6 degree inducer with a blunt leading edge. Nine cavitation data curves were obtained.

The pump and turbine were disassembled for inspection,and repairs are being made to the bearing thermocouples.

The next scheduled run is September 10. Two additional data curves are needed to complete the data requested for the 80.6 degree inducer with the blunt leading edge.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YON0553
(FSCD - PR Meng;
RSD - WD Pack, Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Three tests were conducted during September. On September 10, fourteen data passes were made on the 80.6 degree inducer with the blunt leading edge.

On September 19, ten data passes were obtained for the 80.6 degree inducer with the faired leading edge. Four of the passes were at a temperature of 34°R and one at 30°R.

On September 25, eleven data passes were obtained for the 80.6 degree inducer with the faired leading edge. Three of the passes were at a temperature of 34°R and four at 30°R.

The next scheduled test is October 4. The test is scheduled to obtain any data needed to finish the 80.6 degree faired inducer. The next series of tests will be made with an extended inlet section.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YON0553
(FSCD - PR Meng;
RSD - WD Pack, Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Test runs were conducted October 4 and October 25. The tests were made to complete the data needed on the 80.6 degree inducer with the faired leading edge.

On October 4, fifteen tests were made at various flows at 30°R, 34°R and 36.5°R. On October 25, fifteen tests were made at 36.5°R, 38°R, 39°R, 40°R and 41°R.

The 84 degree inducer has been installed with the extended inlet section. A lucite shroud has been installed for photographs. The configuration will be tested on November 1.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YON0553
(FSCD - PR Meng;
RSD - WD Pack, Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

Eight test runs were conducted during the month of November.

Date		No. of Tests
Nov 1	84° inducer - extended lucite shroud with centerbody	23
Nov 7	80.6 faired inducer - extended metal inlet with centerbody	11
Nov 8	80.6 faired inducer - extended metal inlet with centerbody	32
Nov 12	80.6 faired inducer - extended metal inlet with centerbody	29
Nov 14	80.6 faired inducer - extended metal inlet without centerbody	38
Nov 19	80.6 faired inducer - extended metal inlet without centerbody	20
Nov 21	80.6 blunt inducer with short metal shroud	23
Nov 27	3-bladed inducer - short metal shroud	26

Testing has proceeded exactly according to the plan for completion of the program by January 1, 1969. Remaining tests will require all available test days in December. Therefore, any equipment failure or other significant trouble will result in either an uncompleted program or an extension beyond January 1.

SITE	SITE NAME	RESEARCH INSTALLATION & DESCRIPTION
C	TURBOPUMP	

BOILING FLUIDS RIG
YON0553
(FSCD - PR Meng;
RSD - WD Pack, Jr.)

The rig consists of a liquid hydrogen pump submerged in the bottom of a vacuum-jacketed liquid hydrogen tank.

During the month of December, seven run days were completed.

Date	Configuration	No. of Tests
Dec 4	78° inducer - extended inlet with centerbody	43
Dec 5	78° inducer - extended inlet with centerbody	34
Dec 11	80.6° faired inducer - extended inlet with centerbody	5
Dec 12	80.6° faired inducer - extended inlet with centerbody	27
Dec 16	80.6° faired inducer - extended inlet without centerbody	35
Dec 19	80.6° full blunted inducer - extended inlet with centerbody	45
Dec 30	80.6° medium blunted inducer - extended inlet with centerbody	42

The one- and two-bladed inducers originally scheduled for testing were not tested, in order that additional data could be obtained on leading edge blunting effects. The present program is complete and all manpower has been dispersed to other areas.