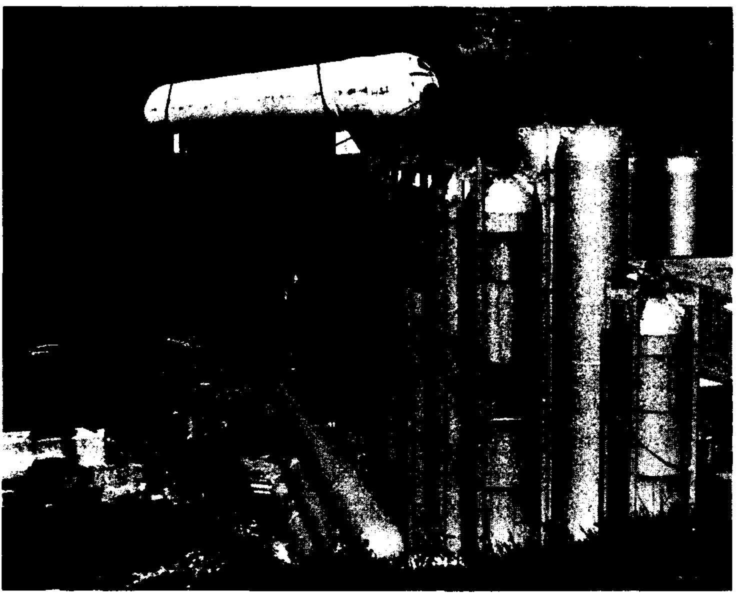
Saga of the Kennedy tank

Most people travel to Florida to take in the beautiful outdoor scenery, but Lewis staffers John M. Kazaroff and Lorenz C. Leopold flew to Kennedy Space Center to crawl inside a 36-foot long, 300-cubic-foot volume pressure tank.

The duo went there to inspect four surplus thrust chambers for leaks and to determine if the chambers could be installed in the Center's Rocket Engine Test Facility (RETF).

Leopold said, "It is the partial fulfillment of a long, hoped-for dream. As early as 1971 plans were made to conduct a comprehensive evaluation of the effects of materials fabrication techniques on thrust chamber low cycle fatigue life." The tanks are used to store propellants that are forced into the engine by high pressure gases. RETF needed larger tanks with higher psi ratings to replace the old liquid hydrogen and oxygen tanks. Thus, they made the trip to Kennedy, where just such surplus tanks existed.

"The Kennedy safety people took us to the "tank farm" and tied a lifeline to our coveralled midriffs. We then crawled into the cylinders carrying extension lights and dye



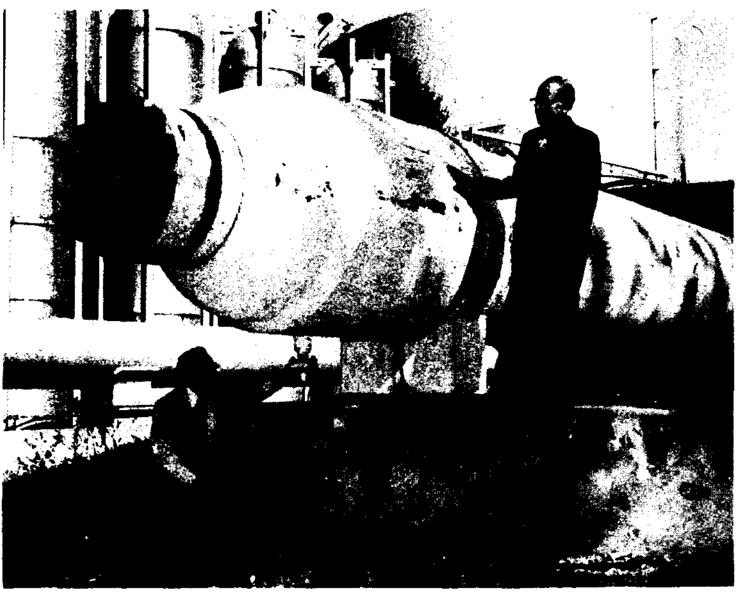
The high pressure tank is being lifted over existing tanks at the Rocket Engine Test Facility. (John Marton photo)

penetrant kits to identify cracks," explained Kazaroff. The work ended two hours later with metallurgist Kazaroff standing under the sunny Florida sky dictating his findings to recorder Leopold not yet out of the sizzling hot tank.

And when the smoke cleared, Lewis ended up with only one pressure chamber. The crawling duo had hoped to get four. Kennedy officials told them to repair one, and they (Kennedy) would utilize Lewis' repair method to get the other three in top condition.

More than one head turned as the heavy chamber was brought across the airport from the tank plant railroad siding, closing airport traffic in the process. It had to go across the airport. Ohio law prohibits transporting so heavy a load over the state's highways and streets.

When the chamber arrived at RETF, it was lifted over the existing chambers at RETF and set in place. Installation work to connect it to the high pressure piping system is now underway.



Lorenz C. Leopold (left) and John M. Kazaroff inspect the high pressure chamber shipped to Lewis from Kennedy Space Center. (John Marton photo)

LEWIS NEWS

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Facility improvements 'back the attack' waged by researchers

The success of Lewis' front line researchers, like the success of any army, is dependent upon a well organized rear echelon support program. At Lewis, support for the research army comes in the form of the Construction of Facilities (CoF) budget, covering the construction, rehabilitation, modification and repair of research installations.

At the Center, responsibility for that support lies with the Facilities Engineering Division who are 'backing the attack' waged by researchers with a welcome infusion of CoF money for fiscal year 1983.

Their heavy artillery support are the Discrete projects — those costing over $500,000. The several million dollars in Discrete projects include a $1 million effort to broaden the Rocket Engine Test Facility's (RETF) ability to simulate a space environment during rocket engine tests and a $2 million modification to the Engine Research Building's (ERB) high pressure air system to provide a reliable air system for researchers using the current, antiquated system.

Other levels of support, also executed by the Facilities Engineering Division, include Rehabilitation and Modification and Repair — both of which cover programs costing less than $500,000 — and Minor Construction Programs which cost less than $250,000. Outside the CoF budget — but still a vital support function — is the in-house money for special job orders costing less than $75,000.

With the Discrete funds, the RETF will gain ground in achieving its major objective: the development of a low-thrust chemical rocket engine for a future space tugboat or Orbital Transfer Vehicle (OTV).

The $1 million project will provide the rocket engine test center on the "South 40" with improved support equipment for test engines, and more importantly, with special air ejectors and vacuum systems that will force air out of the engine firing chamber creating an improved vacuum to better simulate space, the work environment of future OTV's.

Facility Engineering staff expect to complete the modification work during the RETF's down time to minimize the interruption of ongoing research.

At the other end of the lab, the 450 psig high-pressure air system that feeds rigs in the ERB test cells will be improved.

The single, ancient air compressor

Continued on page 3

Funding provides center support

Continued from page 1

housed in the ERB basement was installed during World War II. It is the ERB's only source of 450 psig air.

About $2 million has been earmarked to provide an additional 450 psig air compressor. Included in the price will be new control equipment and piping. The modified system, will increase the reliability of the high pressure air system, thus preventing delays caused by a compressor failure.

The 12 month project is expected to begin late this year.

Less visible but just as important are the many rehabilitation and modification projects covered in the $1.5 million CoF program.

These include:

- The rehabilitation of the mechanical and electrical systems in building 125 of the Propulsion Service Laboratory (PSL). To be complete in 1984, the program will spend $390,000 for rehabilitation of water pumps in the PSL's cooling tower water system.

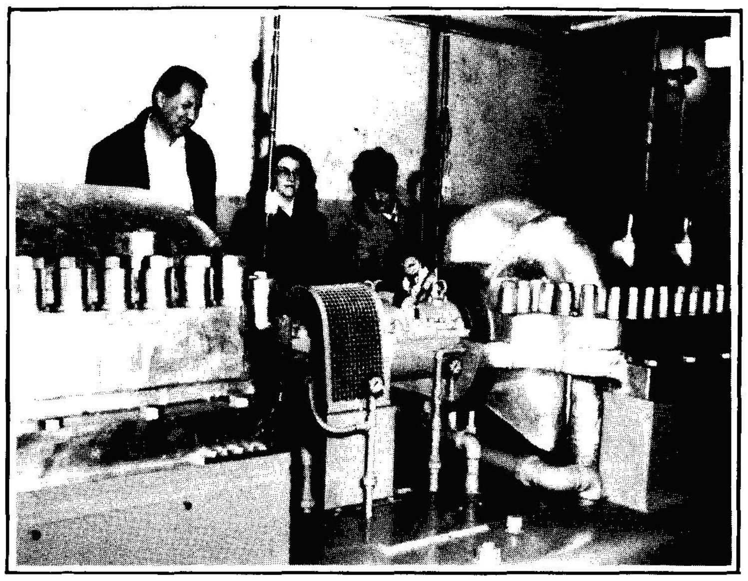
These and other PSL modifications will permit researchers to test similar smaller engines in the facility and — with the installation of two programmable computer controllers — eliminate hardwiring and reduce test installation time.

- Remodeling of the heating and air conditioning system that serves the ERB offices. Construction is underway and will provide an energy efficient replacement for the 45-year-old heating and cooling system.

The ERB cafeteria may be closed temporarily during construction. Medical Services will remain open, access however will be through the ERB's east parking lot doors.

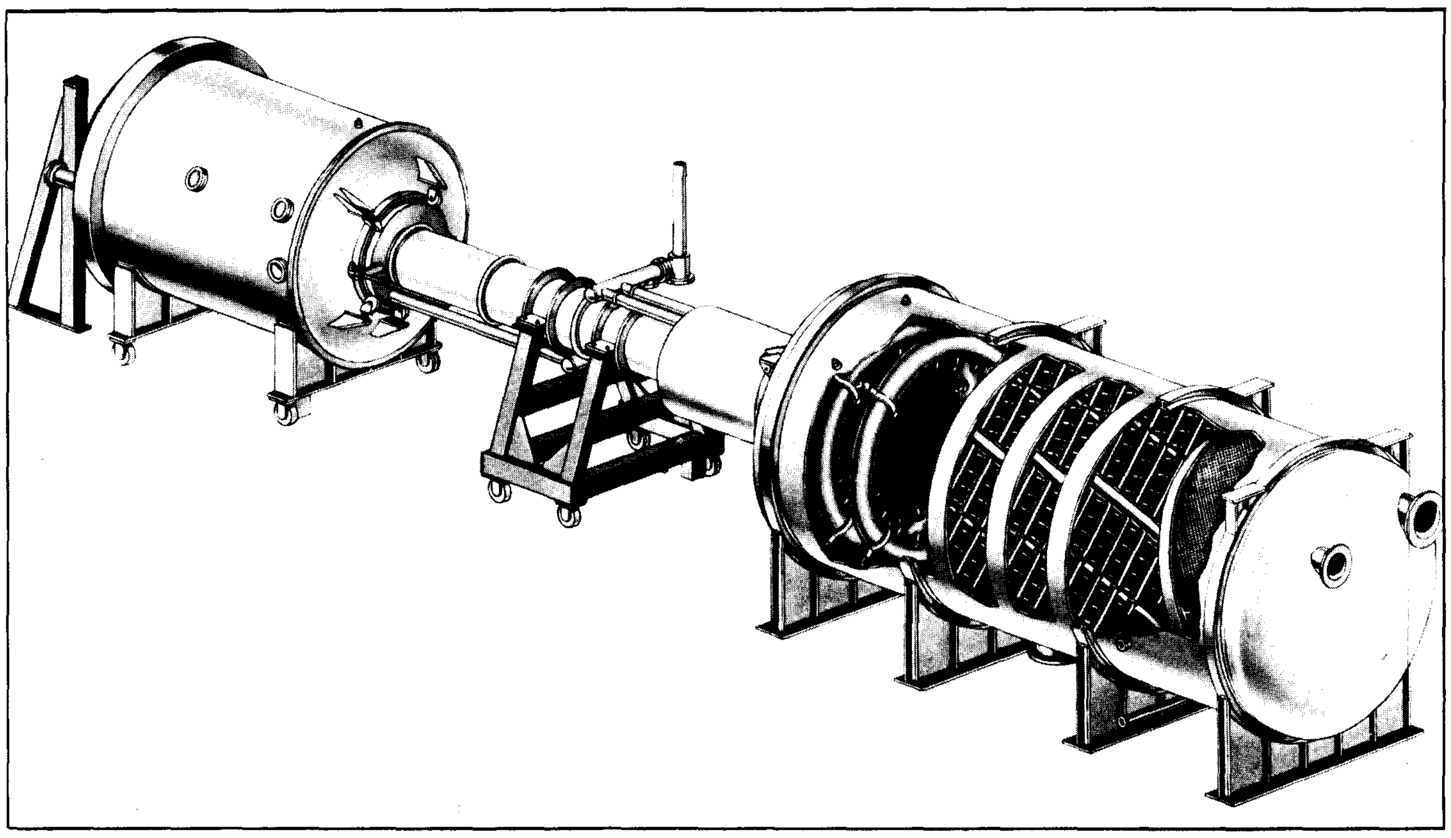
- $200,000 is to be spent improving the 35-year old electrical power transformers, associated motor control center and 18 motors for Cooling Tower 1, serving the ERB.
- Cables carrying information between Lewis' central and west areas will move underground to foil mother nature. Lightning causes interference with present overhead data communications between the two areas. The $460,000 budgeted for new, underground, lightning-proof data ducts will also provide enough extra room for future expansion in the West area.
- Support for Lewis' research facility includes improvements to the Industrial Waste Water Treatment System's electrical and mechanical water flow equipment. The system, next to the Lewis Library, treats 500,000 gallons of industrial waste each day in its twin 2.5 million gallon concrete basins.

Lewis will also build a giant "beehive" in the south 40 with funds contained in the Minor Construction Program budget. Lewis has no interest in bee keeping, the beehive is in reality a 61-foot diameter domed shelter that resembles a huge beehive. The structure is designed to protect salt and cinders while in storage for winter. It will be ready for use before the next blizzard season.



Facilities Engineering Division project team members James A. Dutka (left), Marlene S. Kleinherz and John Chorvan inspect the existing 450 psig air compressor in the basement of the ERB.

Altitude testing will pave way for new generation of space engines



An artist's rendering of the $1-million modification to the Rocket Engine Test Facility providing space-like vacuum for testing of future low-thrust engines. Denny Dubyk-artist

A $1-million modification to the Rocket Engine Test Facility, when completed next fall, will allow Lewis to test high area ratio rocket nozzles under simulated space conditions. The U.S. has no test facility currently with such capability.

"Demand for altitude testing arose because almost all future orbital vehicles will need rocket engines that have nozzle area ratios approaching 2000 to 1 to achieve necessary performance," explains Gregory Reck, Space Propulsion Branch Chief.

"These orbital vehicles will be launched only after they have been carried into orbit in the cargo bay of the Space Shuttle. The bell-shaped expansion nozzles on these vehicles' engines are necessary to obtain the last bit of impulse or 'miles per gallon' from the propellant onboard.

"Very little technology exists for these types of engines because no facilities are available where they can be tested in the same environment in which they will eventually operate," Reck continued.

When alterations are completed, the facility, located on 40 acres at the southern tip of the Center, will be capable of testing high area ratio engines in a genuine space environment. Data will be accumulated on rocket engine ignition, life and durability of the engine walls, heat transfer information, nozzle boundary layer conditions, and nozzle performance at various oxidant and fuel ratios.

Modifications to the facility will include a large vacuum tank to house the rocket engine, a long water-cooled diffuser section into which the engine exhaust will be funneled, an inter-cooler for cooling down the hot exhaust gases, and two gas ejectors to provide the pumping necessary to maintain the low vacuum environment during testing.

The present facility has been in operation for over 30 years and made important contributions to the nation's space program. During the early days of NASA, Lewis engineers pioneered and developed the technology of using hydrogen as a propellant, used for the Centaur vehicle, which has launched over 100 satellites in its illustrious history; the technology was also used in the Saturn vehicle upper stages to launch astronauts to the Moon during the Apollo program.

Averaging three rocket engine firings per week, the facility's other notable work includes solving the combustion instability problem that plagued rocket engines in the 1960's, pioneering efforts on using storable propellants and ablative engines, valuable heat transfer correlations with high pressure hydrogen/LOX and hydrocarbon/LOX engines, and important discoveries on how to extend the life of reusable engines like those presently used on the Space Shuttle.

Presently, the rocket facility comprises a test stand, an engine assembly area, propellant feed systems for both storable and cryogenic propellants, a very large scrubber for muffling and treating potentially toxic exhaust products, a half-million gallon water storage reservoir and numerous heavy wall tanks for storage of high pressure helium, hydrogen and nitrogen. Proposed modifications will add one more capability - altitude testing.

Work on the modifications will begin in June. Prime contractor is Shirmer Construction Company, Cleveland. □

Vega heads lab Hispanic programs

Jose M. Vega has recently been named Hispanic Employment Programs Manager for Lewis Research Center.

An electrical engineer, Cuban-born Vega's new duties include recruiting, establishing working relationships with other Hispanic federal employee groups in the Cleveland area and assisting the Center's 60 Hispanics in identifying and solving problems.

He began working at Lewis early last year, leaving a position as district engineer for the Puerto Rico Electric Power Authority. His Lewis assignment was to design electrical systems for research facilities.

Vega and his wife, Gladys, are the parents of two small children. □

Research associate is new chess champ

In the year that saw the long-held America's Cup go "down under," Lewis' traditional chess club champs experienced a similar shakeup from a new kid on the block.

Pappu Murthy, a Resident Research Associate in the Structures and Mechanical Technologies Division, sailed to victory in all club activities. Murthy scored 11-0-2 in tournament games and 10-0-0 in the club's speed chess competition.

His top performance (6-0-0) in the NASA Open Tournament qualified him to challenge and unseat the reigning club champ, Ray Holanda. The championship playoff consisted of two games, resulting in a draw and a win for Murthy.

The rankings of the six teams in the club's NASA Chess League are as follows: Enpassants with 3.5 match points; Gambiteers with 3; Knights with 2.5; Rookers with 1.5; Sicilians with 1 and the Pawns with .5 match points.

All Lab employees, including resident contractors and family members are eligible to participate in chess club activities, according to Club President Jerry Smetana, who adds that a women's chess tournament is being considered for the new season.

For more details, call Smetana at PAX 6229 or Jerry Winter at PAX 7131. □

CHESS CHAMPS - New chess club champ Pappu Murthy and fellow members of the Empessents (league champions): Leonard Cobb (left), Bernard Hamrock, Dave Brewe (team captain), Oral Mehmed and Rudy Duscha. Bill Richardson photo

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LewisNews

Center Teamwork Was Key To New Altitude Facility

By Jody Getz
Propulsion Research Branch

Lewis employees have been noted often for their team spirit and ability to conceptualize a venture that may not come to fruition for a long period of time. The interim, of course, requires dedication to the project and carrying out the efforts involved in realizing those goals.

Such was the case when members of the Space Propulsion Technology, the Test Installations and the Facilities Engineering Divisions witnessed the product of a five-year joint effort: the completion of the Altitude Facility located in the Rocket Engine Test Facility (RETF).

Joining in an "Altitude Facility Roll-out" ceremony held March 3 at the RETF were Center Director Andrew J. Stofan, who officiated the ribbon-cutting; Deputy Director John Klineberg; Warner Stewart, Director, Engineering and Technical Services Directorate; and Stuart Fordyce, Director, Aerospace Technology Directorate.

The opening of the new Altitude Facility is yet another demonstration of why Lewis is known as a "center of excellence"—in this case, by introducing the only altitude facility in the country with its unique and much-needed scope of capabilities.

Base To Build On

Testing facilities throughout the industry are available for tests involving the combustion chamber, injector, ignitor and cooling jackets of a rocket engine. Lewis' RETF also provides this source of data collection, for engines with small area ratio nozzles up to approximately 20:1, but to the exclusion of large or unconventional nozzles.

Although there are altitude facilities with capabilities of testing nozzles up to 400:1, future space engines could require nozzles with

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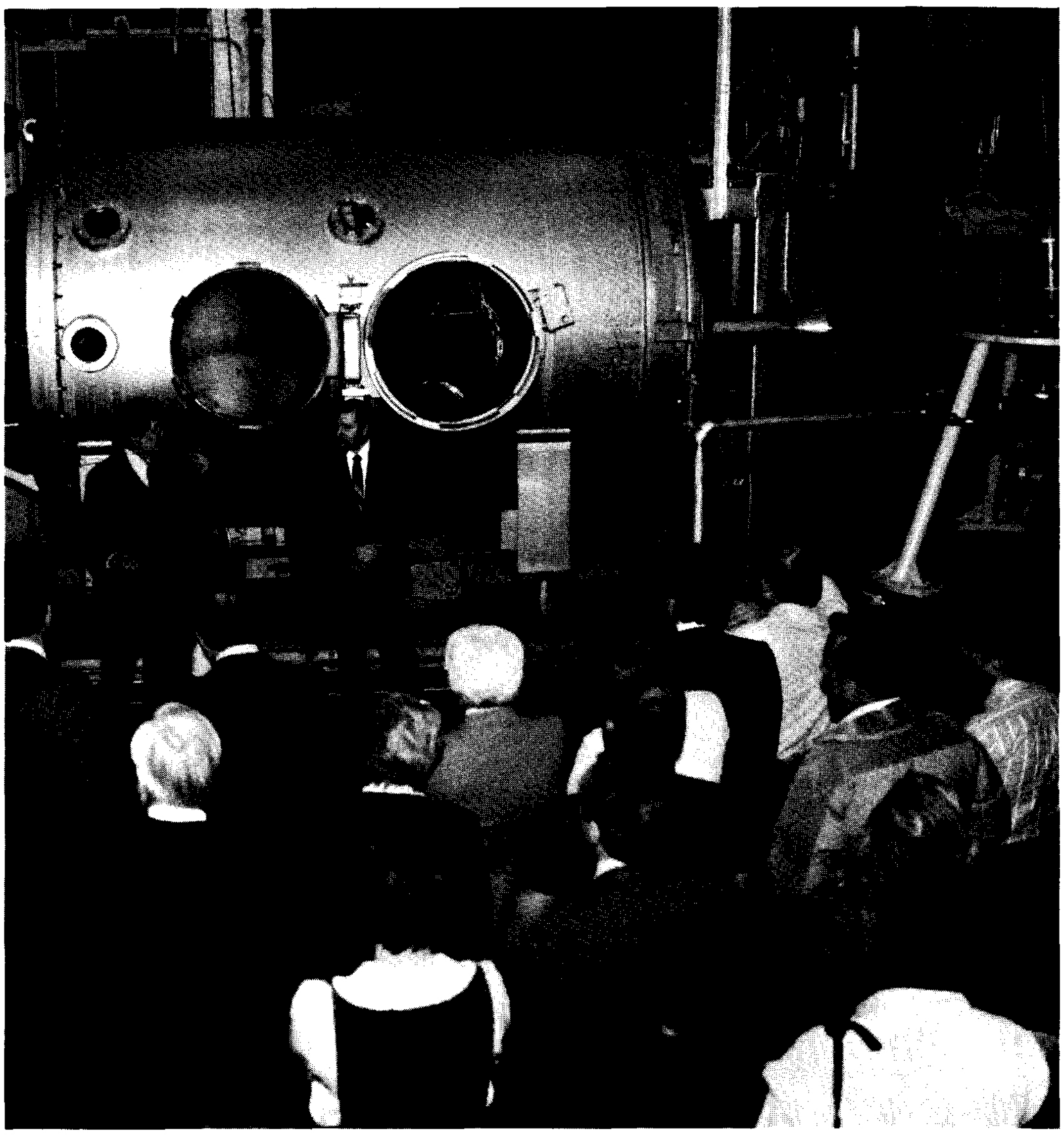


Bob Walkup, Photo Lab

At the recent Altitude Facility Rollout, attendees gather in front of the new rocket engine test capsule housing the 1000:1 ratio nozzle. Opening remarks were made by Carl Aukerman (at podium on left) of the Space Propulsion Technology Division and Center Director Andrew J. Stofan (on right).

...Altitude Facility

(Continued From Page 1)

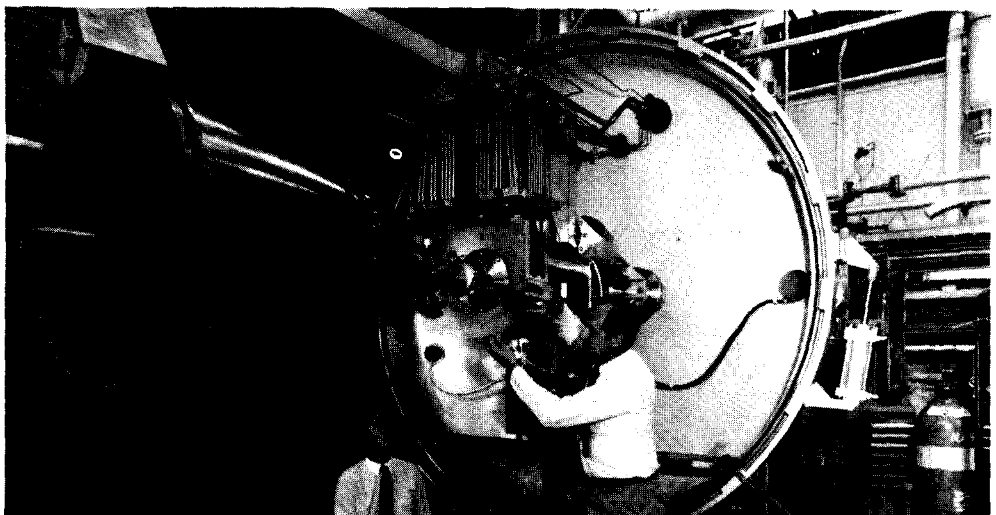
an area ratio of 1000:1 or larger. Recent attempts to design nozzles for these new applications have revealed uncertainties in the computerized models.

While, initially, evidence pointed out a generic, basic need, it soon unfolded into a critical issue with the advent of the Orbital Transfer Vehicle (OTV) Program. The OTV will be carried into space on the Space Shuttle, be used to transfer payloads from one orbit to another, and become based at the Space Station.

A need had been identified for high area ratio nozzle rocket engines and, thus, the simulated environment in which to test them. And, with the OTV Program, concerns emerged in industry over the capabilities and projected performance of these engines.

Because critical information could be obtained only through actual testing, an altitude simulation facility which could provide some very specific and unique capabilities was needed. Such a facility would be able to provide an experimental data base that would allow industry to perform successful studies of size, cost and performance, as well as the subsequent design specifications to build large area ratio nozzles.

Since Lewis' RETF already could provide much of the necessary framework, it was proposed that the Center build this unique Altitude Facility. That proposal led to Construction of Facility (C of F) funds being committed in FY 1984 —the only rocket propulsion related C of F project approved within NASA on an Agency-wide basis for several years.



Monitoring testing of the new Altitude Facility's large area 1000:1 ratio nozzle are Ken Kacynski (kneeling on left) and Al Pavli of the Propulsion Research Branch.

Timely Operation

Members of the Space Propulsion Technology Division and the Facilities Engineering Division began the first stages of planning by providing conceptual designs of the facility. With those guidelines, a construction contract was awarded in the fall of 1983, and a "Groundbreaking Ceremony" was held here on October 14, 1983.

The construction produced a multi-faceted facility that provided the much-needed rocket engine research capability:

- Large test chamber housing the rocket engines (with the large area ratio nozzle test capability)
- Long, water-cooled diffuser section into which the hot engine exhaust is funneled
- Water spray tank for cooling the exhaust gases
- Two gas-driven ejectors to provide the pumping necessary to

(Continued On Page 4)

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Editor James Francescangeli

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TEAM RECOGNITION—The **Lewis Awareness Program** recognized recently the contributions of the **Rocket Engine Test Facility** (RETF) **Altitude Simulation Project Team.** The team, composed of people from the Space Propulsion Technology Division and all five divisions of the Engineering and Technical Services Directorate, were honored for their contributions, since the early 1980s, in all phases of construction of a unique, high-performance altitude simulation facility for the development of technology for advanced liquid rocket engine components; in particular, extremely high area ratio nozzles. This was an especially noteworthy achievement because no other facility existed that was capable of reaching the conditions needed to obtain the required nozzle data—a project accomplished at a cost far below that estimated using conventional approaches. Present to congratulate team members with an Awareness recognition folder were Center Director **Andrew J. Stofan** and Deputy Director **John Klineberg.**

ly better than those of current state-of-the-art structural ceramic materials. This composite shows the high as-fabricated strength necessary for an application in advanced propulsion systems, where high-temperature stability and structural reliability are prime issues. Its strength is effectively maintained during severe thermal shock and during air exposure at temperatures above 2500°F. Supporting mechanistic studies indicate that future development of improved fibers, optimized fiber-matrix interactions, and innovative matrix processing approaches may significantly improve its already high thermal-mechanical properties.

In summary, it is fair to say that our materials research has helped make available new national options for high performance aerospace propulsion and power systems.

Space Propulsion Technology Division

During the past year, Division programs in primary and auxiliary propulsion for Earth-to-orbit and in-orbit vehicles experienced continued growth. Increased emphasis was placed on technology efforts for LOX/hydrocarbon engines and for work in cryogenic systems for application to hypersonic vehicles. In addition, the Division continues to provide critical operations support across the Directorate.

Data on the performance of a 1000:1 area ratio nozzle operating at simulated altitude conditions were obtained in the Lewis Rocket Engine Test Facility. The data obtained during the program were for the highest area-ratio nozzle ever tested, and provided valuable insight into the boundary layer and heat transfer characteristics of such nozzles.

During 1986, gaseous hydrogen-oxygen and multipropellant resistojets (a low-thrust, resistance-heated rocket) were baselined as the propulsion system for the Space Station. An intracenter effort demonstrated that the life and performance of 25 and 50 lbs. thrust gaseous hydrogen-oxygen thrusters are consistent with Space Station requirements. Multi-propellant resistojets using grain-stabilized platinum components will provide a low-thrust propulsion system capable of using a variety of Space Station waste gases, such as water vapor, carbon monoxide and carbon dioxide, as propellants.

Industry has shown strong interest in the technologies that enabled non-damaging starting and erosion-free operation of arcjets. The starting and operation problems with arcjets were solved by a proper combination of strong swirl-stabilized flow, optimized throat diameter and length, along with cathode/anode spacing, and a pulse-width-modulated power processor.

Fundamental studies have begun on low Reynolds Number nozzles used on low-thrust resistojets and arcjets. Adaptation of existing computer codes has provided a preliminary description of the complex flow field inherent with the use of low Reynolds Number nozzles.

The first phase construction of a new turbopump facility at the Rocket Engine Test Facility (RETF) has been completed. This new facility will use the cryogenic fluid supply of the RETF to enable full-scale space engine and booster type turbopump simulations. When completed, the facility will provide an important new Lewis capability to test cryogenic turbomachinery at pressures up to 5000 psi.

RETF Instrumentation And Control Rooms Being Expanded

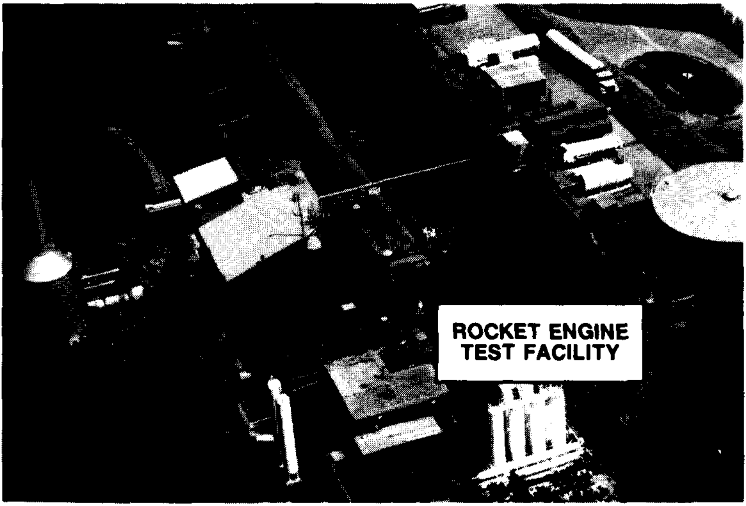
The Rocket Engine Test Facility (RETF) instrument and control areas are being modified to support expanded facility operations.

The instrument room will be enlarged to accommodate independent instrumentation for each of the three test stands located at the RETF: the sea-level test stand; the altitude exhaust test stand; and a new turbopump test stand that will become operational later this year.

According to Project Manager Pisal Satayathum of the Facilities Engineering Division, improvements also include upgrading the electrical power distribution system and building a new office, a conference room, and toilet facilities.

A $623,000 fixed price contract for the work has been awarded to Hausmann and Johnson, Inc. of Cleveland. The modifications are expected to be completed by January 1989.

—Mickey Seaver



Modifications to the Rocket Engine Test Facility will accommodate independent instrumentation for each of its three test stands, upgrade the electrical power distribution system, and provide a new office and conference room.

Enhanced Research Capability Provided By Modification To Rocket Engine Test Facility

Modification to the Rocket Engine Test Facility (RETF) instrument and control rooms has been completed by the Facilities Engineering Division. These modifications will give RETF the capability to rapidly switch instrumentation and control from one test stand to another, allowing for better utilization of the facility and for more research objectives to be reached.

The RETF has been modified extensively over the past several years, with the addition of high-combustion pressure capability, altitude rocket test capability, and turbomachinery test capability. The facility now consists of three test stands; originally there was one. The increase in capability has resulted in an increase in research activity and a requirement to improve facility productivity.

Research in many facets of future rocket engines is conducted at the RETF. Rocket combustion chambers are tested for cooling and life improvements necessary for future boosters. Large rocket nozzles will be tested for use in future space transfer vehicles, such as those required for future Mars missions. Turbomachinery for future rocket engine pumps will be tested for use in both booster and space transfer vehicles.

—Mickey Seaver

The new Instrument and Control Room at the Rocket Engine Test Facility allows for better facility utilization.

Combustion Air System Connected To Rocket Engine Test Facility

The Rocket Engine Test Facility (RETF) is scheduled to be completely connected to the combustion air system sometime this month. This will permit continuous altitude testing which will greatly increase the productivity of the facility. The facility is designed for both sea level and altitude testing of rocket engines.

The RETF, located in the south area of the lab, is a stand-alone facility dedicated to rocket combustion research. The complex includes two major buildings along with extensive support services, and is the only complex at Lewis capable of operational rocket testing.

Before being connected to the combustion air system, the RETF's altitude test stand used a blow-down ejector system powered by gaseous nitrogen as the motive (moving) fluid to create a vacuum. The gaseous nitrogen motive fluid system limited the total run duration at maximum thrust to approximately five minutes and required overnight repumping before the next altitude test could be run.

The $695,000 modification to the combustion air system project extends 150 psig. combustion air piping from an existing line near building 51 to the RETF area. The new pipe line is approximately 2,200 feet long and 24 inches in diameter. It runs primarily underground from building 51 under Cedar Point Rd. and along Lower South Rd. to just north of the RETF. Once at the RETF, the piping runs above ground to the ejector platform. The existing ejector system will be replaced with new ejectors specifically sized to run with 150 psig. combustion air as the motive fluid.

The project, under contract to the Soehnlen Piping Co., Inc., Louisville, Ohio, is being managed by Gene Pinali, Facilities Engineering Division.

—Gene Pinali