News
Pratt & Whitney Aircraft
Florida Research and Development Center
West Palm Beach, Florida
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DIVISION OF UNITED AIRCRAFT CORPORATION

1964

IX. 3

LAUNCH INFORMATION

Saturn S-IV

and

The RL10 Engine

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I. RL10 MILESTONES

October 1958	Design Begins
July 1959	First Engine Fired
November 1961	RL10A-1 Engine Passes Preliminary Flight Rating Test
March 1962	First Centaur Test Vehicle Static Fired
June 1962	Advanced Engine (RL10A-3) Passes Preliminary Flight Rating Test
August 1962	First Six-Engine Saturn S-IV Static Fired
September 1962	Full-Scale Engine Throttleability (to 10%) Demonstrated
May 1963	Hypergolic Ignition Demonstrated
June 1963	Instant Start Feasibility Demonstrated
October 1963	Low Idle Operation (pressurized mode) for Settling Propellant Demonstrated
November 1963	RL10's Power First Centaur Vehicle in Orbit
January 1964	RL10's Power First Saturn S-IV Vehicle in Orbit

RL10 STATISTICS

Rated Thrust	15, 000 Pounds
Height	69 Inches
Width	40 Inches
Weight	292 Pounds
Fuel	Liquid Hydrogen
Oxidizer	Liquid Oxygen
Specific Impulse	431 Seconds
Chamber Pressure	300 psia
Type Cooling	Regenerative
Total Firing Time	170 Hours through November 1963
Total Firings	4, 500 through November 1963

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The RL10, which powers the National Aeronautics and Space Administration's Saturn S-IV, is the newest propulsion system to be put to work in advancing our nation's space effort. On November 27, 1963, a pair of RL10's successfully powered a five-ton Centaur space vehicle in earth orbit in the first flight demonstration of the outer space powerplant which uses high-energy liquid hydrogen as fuel. A six-engine cluster of RL10's, generating a total of 90,000 pounds of thrust, powers the Saturn S-IV stage. The 15,000-pound-thrust engine was designed and developed for NASA's Marshall Space Flight Center at Pratt & Whitney Aircraft's Florida Research and Development Center, 20 miles northwest of West Palm Beach.

Less than seven months after the starting date of the contract in mid-October 1958, the first RL10 thrust chamber was tested. The official Preliminary Flight Rating Test was completed successfully in the record time of three years after beginning initial engine design. In the development program, the RL10 has completed more than 4,500 firings for an accumulated firing time of more than 170 hours. Many endurance tests have been conducted with the engine, with one firing lasting 28 minutes, approximately four times the mission requirements for engine burn in the Saturn S-IV program.

While the RL10 resembles other rocket engines outwardly, internally it contains many advances in state-of-the-art design, among them the method by which it obtains multiple utilization from its fuel. The liquid hydrogen at -423° F plays two roles before it is burned. In its first role, the hydrogen serves as a coolant by passing through the series of tubes which form the thrust chamber. In its second role, the hydrogen, which has picked up heat energy as a result of its cooling the chamber, is expanded through a turbine

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to provide power to pump both propellants into the system.

The engine was designed to provide a capability of multiple restarts in space, with long coasting periods between firings. The problems of maintaining a conventional lubrication system under conditions of coasting made it desirable to eliminate oil lubrication in the gearbox. The gears and bearings in the RL10 turbopump were developed to operate dry and to be cooled with hydrogen gas.

The RL10 has a nozzle expansion ratio of 40 to 1 and operates at a nominal chamber pressure of 300 pounds per square inch.

III. THE DEVELOPMENT OF LIQUID HYDROGEN

The successful development of Pratt & Whitney Aircraft's RL10 rocket engine was based upon the mastery of a powerful fuel -- hydrogen. At the advent of the space age, hydrogen held out the prospect of greatly-increased thrust per pound over hydrocarbon fuels such as kerosene. When burned with liquid oxygen (LOX), liquid hydrogen delivers 35 per cent more thrust per pound of propellant than conventional fuels. Engineers knew that if hydrogen could be leashed as a fuel for rocket engines it would make possible substantial payload increases.

An entire new technology had to be established before hydrogen could become a practical fuel. Techniques for handling hydrogen as a fuel were unknown. Because of its low boiling point (-423° F), it is difficult to keep in liquid form. It will vaporize immediately if exposed to heat. Liquid hydrogen is colorless, odorless, and of very light weight.

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Pratt & Whitney Aircraft's experience has proved that liquid hydrogen can be transported and stored practicably and that, in many ways if handled properly, the frosty liquid is safer than gasoline. Liquid hydrogen is chemically inert in the presence of all common materials around a test stand, including air, oil, and oxygen. It is non-toxic, non-irritating, and non-corrosive. It does not deteriorate or decompose from long-time storage. Today, it is possible to keep liquid hydrogen just as "ready" as liquid oxygen. The fuel is stored in dewar tanks, which are double-walled containers with a vacuum between the walls, similiar to a thermos bottle. Portable dewar tanks follow the same pattern of construction.

Large-scale testing of liquid hydrogen fuel became possible in 1958, with the opening of the Pratt & Whitney Aircraft Florida Research and Development Center in West Palm Beach, Florida. Adjacent to the plant, the Air Force built the first tonnage production facility for liquid hydrogen. The facility takes natural gas, breaks it down into hydrogen gas, carbon dioxide, and other products, then refrigerates and purifies the hydrogen. The purity of the liquid hydrogen produced there is about 99.9999 per cent, among the purest materials produced in quantity by man.

By late 1963, Pratt & Whitney Aircraft at its Florida Center had handled nearly 40 million gallons of liquid hydrogen in the development program for its hydrogen fueled rocket engines.

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IV. THE FLORIDA RESEARCH AND DEVELOPMENT CENTER

United Aircraft Corporation's Pratt & Whitney Aircraft Division established the Florida Research and Development Center in 1956, primarily to test highly advanced jet engines. Work was started that year and the main buildings were completed in 1958. Soon afterward, the Research Center was expanded to include rocket engine research. The Research Center is located on an isolated 6,750-acre tract on the edge of Florida's Everglades in Palm Beach County.

The Research Center's rocket test area includes horizontal and vertical engine firing stands and complete component test facilities. All engine firing stands are equipped to simulate conditions the engines will encounter in space. The two horizontal stand complexes include single-engine structures that are adaptable to engines developing up to 250,000 pounds of thrust. The vertical test stand complexes are designed to accommodate rocket propulsion systems developing up to 500,000 pounds of thrust. One vertical test stand is used to check out dual-engine vehicle propulsion systems.

A multi-million-dollar addition to the Research Center's rocket engine test complex will soon be in operation. The addition will give Pratt & Whitney Aircraft the nation's most advanced liquid rocket propellant research capability. With the new facility, the Research Center will be able to handle safely all known combinations of liquid propellants, including high-energy types such as fluorine, hydrazine, diborane, and hydrogen.

Looking to the future, the Research Center has an extensive department of applied research. Areas of study for this department include mission analysis, engine and controls analysis, systems engineering, combustion,

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heat transfer, turbomachinery, and fluid flow.

Over the past four years, Pratt & Whitney Aircraft has conducted a comprehensive study to define the propulsion requirements for the next generation of launch vehicles. A major development in this study was achieved at the Research Center recently with the successful test firing of a cooled high-pressure hydrogen rocket chamber. About the size of a milk bottle, the chamber operated at about 3,000 psia and generated 11,000 pounds of thrust during the firing.

Pratt & Whitney Aircraft's Florida Research and Development Center employs 5,300 and has an annual payroll of about $43 million. In 1962, the company spent more than $18 million in purchasing from or subcontracting with 679 Florida businesses of which 539 were classified by Government standards as small Florida businesses.

V. THE PRATT & WHITNEY AIRCRAFT DIVISION

The Florida Research and Development Center is operated by Pratt & Whitney Aircraft, the major division of United Aircraft Corporation. Pratt & Whitney Aircraft was organized in Connecticut in 1925 to design and build aircraft engines. Its first engine, revolutionary for its time, was the radial, air-cooled wasp. It was followed by the Hornet, the Twin Wasp, and the Double Wasp. These famous engines ultimately provided half the aircraft power used by the Allied air forces during World War II. With the advent of the jet age, the skills and technology developed by Pratt & Whitney Aircraft during the piston-engine era helped the division to move to the forefront in manufacture of jet engines. Pratt & Whitney Aircraft engines today power

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many of the nation's most advanced military and commercial aircraft. In addition to the work being carried out at its Florida Research and Development Center, Pratt & Whitney Aircraft is developing other space-age power systems. Among them are fuel cells -- devices which convert chemical energy directly to electricity -- for space and industrial use. The Apollo command vehicle, which will carry man to the moon, will receive its on-board power and drinking water from a Pratt & Whitney Aircraft fuel cell. The division has also been selected to develop the fuel cell system for the lunar excursion module. At the Connecticut Advanced Nuclear Engineering Laboratory in Middletown, Pratt & Whitney Aircraft is developing SNAP 50/SPUR, a light-weight nuclear reactor which will be used to supply electrical power for deep space exploration.

Modified aircraft jet engines manufactured by the division are being used in ground installations to generate electricity and operate compressors which pump gas through long pipe lines. Other units are being developed to power ships and hydrofoils. The division employs about 41,000 persons and has its headquarters in East Hartford, Connecticut.

United Aircraft Corporation, Pratt & Whitney Aircraft's parent corporation, also has five other operating divisions. Hamilton Standard designs and manufacturers aircraft propellers and environmental controls for aircraft and space use. Sikorsky Aircraft is the world's leading designer and builder of helicopters. The Norden Division produces many electronic products for defense and aerospace. United Aircraft Corporate Systems Center carries out research, development, and study in a number of areas of space technology. United Technology Center is developing solid propellant rocket engines, principally the first-stage boosters of the Titan III-C space launch vehicle.

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In addition to these divisions, there are the United Aircraft Research Laboratories and two subsidiaries, United Aircraft International and United Aircraft of Canada Limited. The corporation employs about 66,000 persons. Sales in 1962 were $1,160,458,684.

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