LEWIS
RESEARCH
CENTER

Capabilities and Facilities of the Plum Brook Station

Sandusky, Ohio

NATIONAL
AERONAUTICS
AND
SPACE
ADMINISTRATION

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The boundaries of Plum Brook can be approximated by following the roads enclosing the wooded areas in this aerial view.

As a result of recent programmatic decisions, the Plum Brook Station of the NASA Lewis Research Center is being placed in a standby condition effective June 30, 1974.

NASA regards the 8000-acre Plum Brook Station as a rare and invaluable national resource and is interested in advancing its continued use by other agencies for nonaerospace purposes for the public good. The more than 450 professional and technical support personnel that comprise the Plum Brook complement have compiled an outstanding record over the years for designing, building, and operating the many varied and sizeable facilities located there. Among the Station's truly unique facilities, which are described in greater detail in this brochure, is the world's largest environmental simulator, which can duplicate and maintain air densities from sea level to the vacuum of space at temperatures from -300° F to 180° F. A 60-megawatt nuclear reactor located at Plum Brook is one of the most versatile and fully equipped of its kind in the nation. All the Station's test facilities have complete instrumentation systems and are fully supported by a broad range of appurtenances. Although each test facility was initially designed and constructed to meet a specific use, all share commonly the ability to be used for a wide variety of applications.

The large open land areas at Plum Brook, which originally were needed for hazard-exclusion distances, now offer attractive potential for other purposes such as noise abatement research, road and railroad test tracks, or perhaps for an unusual research use such as a site for ground-effects machine development. As you read through the brochure, I trust that some of the Station's broad potential will become apparent and that you will seek further information.

Bruce T. Lundin
Director
NASA-Lewis Research Center

ENGINEERING BUILDING

The modern Engineering Building has a total area of 57 625 square feet. At present, each of its 69 offices accommodates 3 or 4 persons. It has four large conference rooms and a library and it houses an IBM 1620 computer. It has a 550-seat auditorium and a 200-seat cafeteria. Three parking areas adjacent to the building provide space for 400 cars.

LOCATION

Lewis Research Center's Plum Brook Station is located in lightly populated farmlands 3 miles south of the Lake Erie port of Sandusky, Ohio. The Station is easily reached via the Ohio Turnpike's Sandusky Interchange. The Station is only 56 miles west of Cleveland, and is a short drive from Cleveland Hopkins International Airport.

PROPERTY

Plum Brook is situated on 8000 contiguous acres, 2600 of which are used as a buffer zone. An 8-foot security fence surrounds the Station, and several test sites have additional security fencing. There are 125 permanent structures on the grounds, 99 of which are large reinforced concrete bunkers that currently are used for materials, equipment, and records storage. An internal paved road system totaling 62.5 miles connects the buildings. In addition, a 15.7-mile rail system, with sidings to each major test site, provides maximum transportation flexibility. This system connects with the Chessie System main line.

UTILITIES

Electric power is provided by Ohio Edison Company by means of two widely separated 138 kilovolt transmission lines to the primary Plum Brook substation. Relaying protection and reclosing features provide what amounts to a dual source of power.

Potable water is supplied by the City of Sandusky and is stored for distribution in three vessels containing a total of 700 000 gallons. Raw water, used for cooling, testing, and fire protection, is provided by a Plum Brook owned intake in Lake Erie in addition to one owned by the City of Sandusky. The existing system can supply Plum Brook with 10 000 000 gallons of water per day.

The Station is served by Columbia Gas of Ohio, and natural gas is distributed throughout the Station by 9.24 miles of metered 6-foot steel gas lines. The present gas allotment is 195 million cubic feet per year.

Plum Brook has three sanitary waste-treatment systems, the largest of which is a 100 000 gallon per day high-rate trickling-filter secondary treatment plant. A new incinerator, now under construction, will be completed this year and will conform to all federal, state, and local environmental regulations. Although designed for natural gas firing, provisions have been made for its conversion to propane fuel.

PERSONNEL

During NASA's growth of the mid-1960's, a highly skilled and versatile staff of approximately 500 engineers, craftsmen, and administrators was created. This staff has the necessary capabilities to design, build, install, and operate test facilities serving a very broad range of experimental programs and disciplines. A substantial number of the professional staff hold graduate degrees.

In addition to the conventional disciplines, the professionals are well endowed with expertise in numerous special areas such as

- Vacuum technology
- Nuclear and "hot"-laboratory work
- Cryogenics
- Digital and analog instrumentation
- Closed-loop servocontrols
- Digital and analog computers

The technical support personnel are highly skilled and include

- Digital and analog electronics technicians capable of building, servicing, and operating equipment, including computers
- Technicians who build thermocouples and numerous other types of instrumentation
- Reactor operators
- Cryogenic and vacuum technicians
- Craftsmen such as electricians, welders, pipe fitters, and mechanics

In addition to its research and development capability, the Plum Brook staff is experienced in dealing with research experimentalists, converting their requirements to research hardware and obtaining the desired results.

REACTOR FACILITY

Plum Brook's 60-megawatt reactor facility is an extremely versatile experimental complex. It allows complete irradiation testing and analysis of materials, devices, and components over a wide range of conditions. Neutron fluxes up to 10^{15} neutrons per square centimeter per second (thermal energies) and $3x10^{14}$ neutrons per square centimeter per second (greater than 1 Mev) and gamma energies up to 25 watts per gram (water) are available. These fluxes are provided in six beam holes (6 in. diam), two through holes (12 in. diam), an in-core test facility, 41 reflector test holes, and various other in-tank experiment positions.

The reactor has these unique features

- A major cryogenic testing facility, which permits irradiation and subsequent testing of specimens in gaseous helium at temperatures from -400° F to ambient
- A lubrication testing facility, which permits friction and wear testing while the lubricant is being irradiated
- Remote experiment-positioning devices and ample instrumentation leadouts
- Twenty-five-foot deep water-filled canals for convenient transportation of radioactive materials from the reactor to a completely equipped hot laboratory

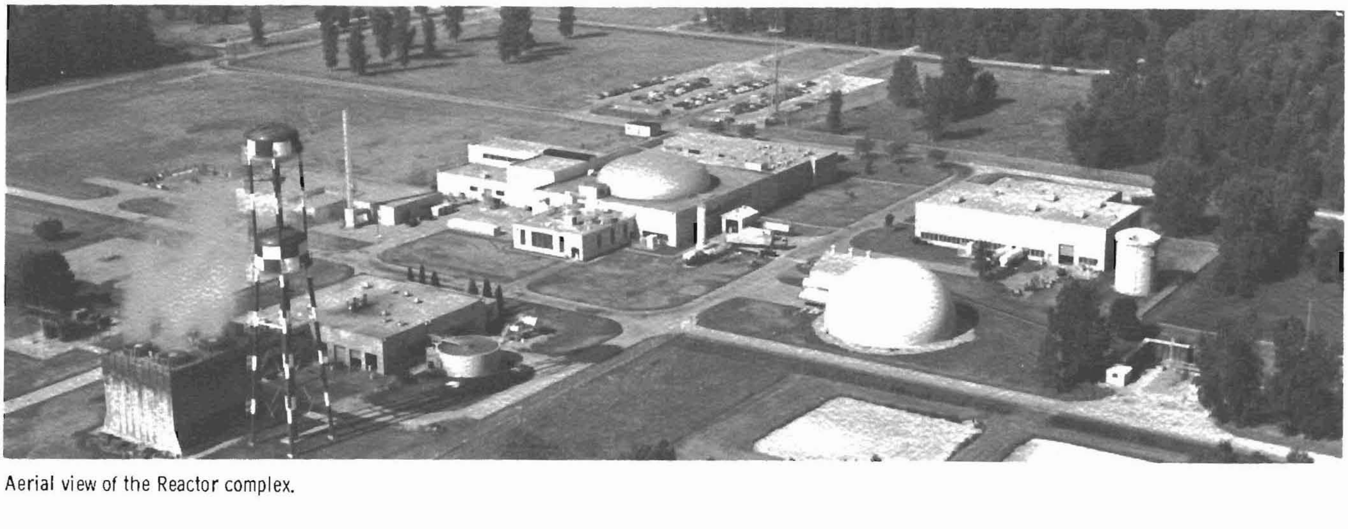
The hot laboratory has seven high-level cells completely equipped for post-irradiation testing and examination. In addition, radiochemistry, chemistry, and metallurgy laboratories are provided. A mockup reactor, nearly identical to the Plum Brook Reactor and used for reactivity and flux measurements, is located in one of the canals.

The reactor complex includes these additional features

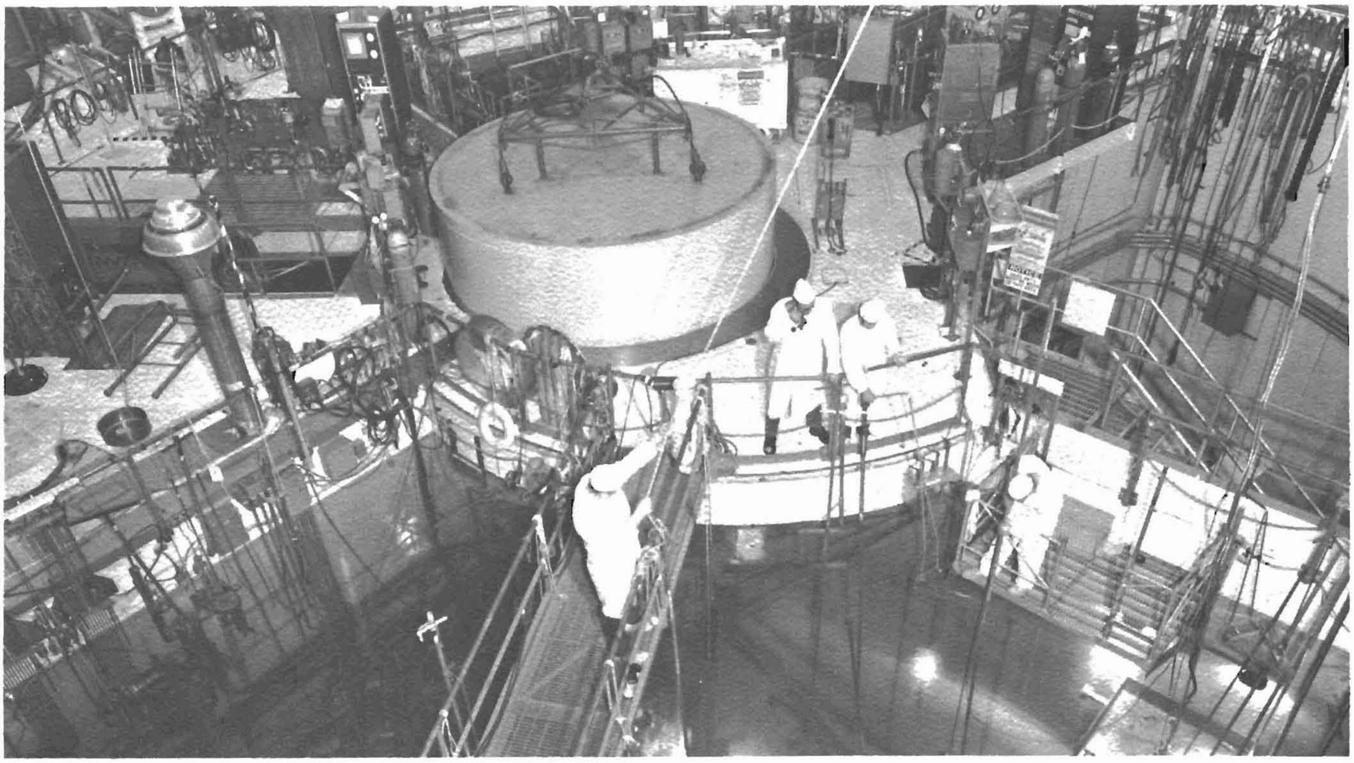
- Various auxiliaries such as deionized water, compressed air, helium and argon pure gas, and cooling water
- Office space for over 200 persons
- Machine and electrical shops
- Electronics laboratory
- Complete waste storage monitoring and cleanup facilities

Samples of the variety of testing that the reactor has been used for as well as exciting new possibilities are

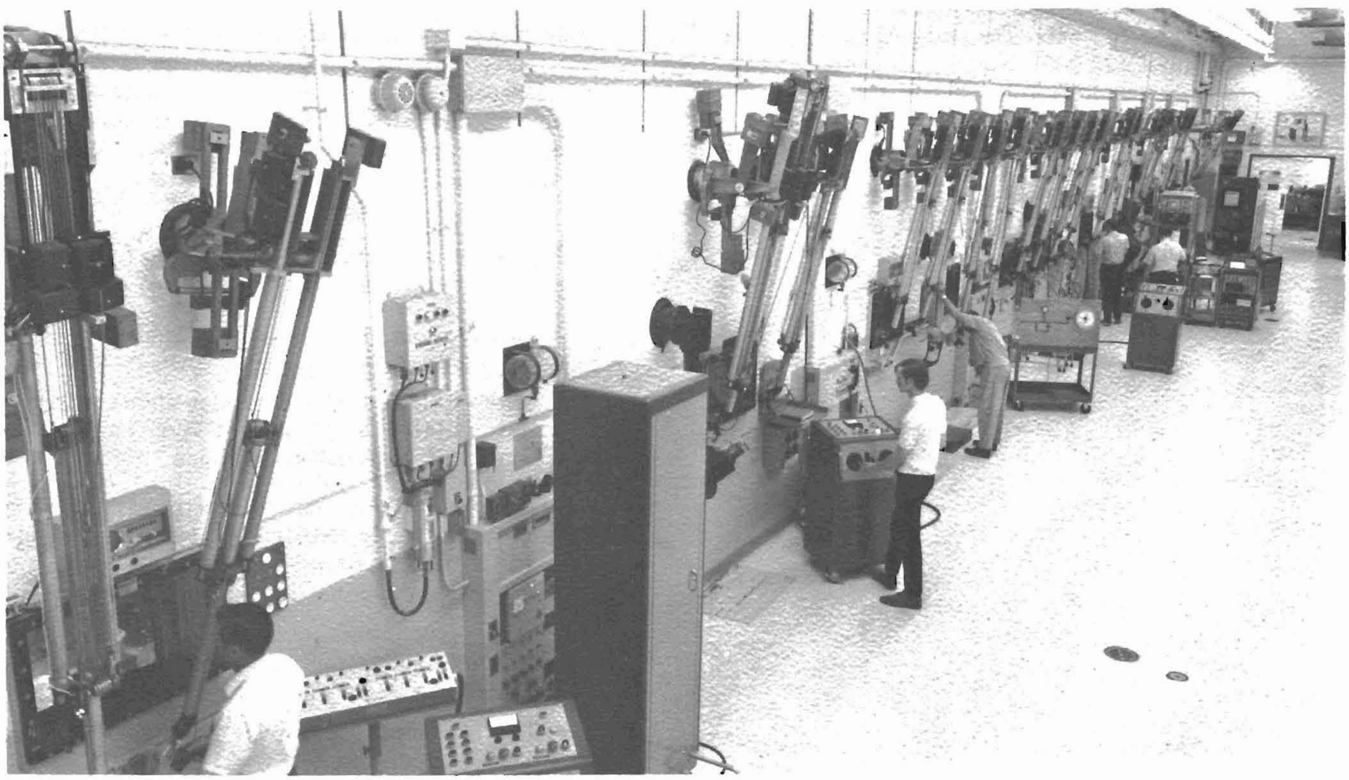
- Neutron activation analysis for trace elements (e.g., mercury, cadmium) in gas, liquid, or solid samples such as air, coal, and gasoline
- Neutron radiography of anything from a watch to a machine weld with dimensional analysis of the radiographs
- Irradiation of samples at temperatures ranging from -400° to 5000° F under pressures from vacuum to 1000 pounds per square inch in air, helium, and liquid metal
- Irradiation of lunar soil
- Irradiation of extraterrestrial rocks, including detection of uranium in meteorites
- Irradiation of biological specimens from single-cell organisms to laboratory animals
- Irradiation of agricultural products such as corn, wheat, etc.



Aerial view of the Reactor complex.



Interior view of the reactor showing the water quadrants and reactor pressure tank.



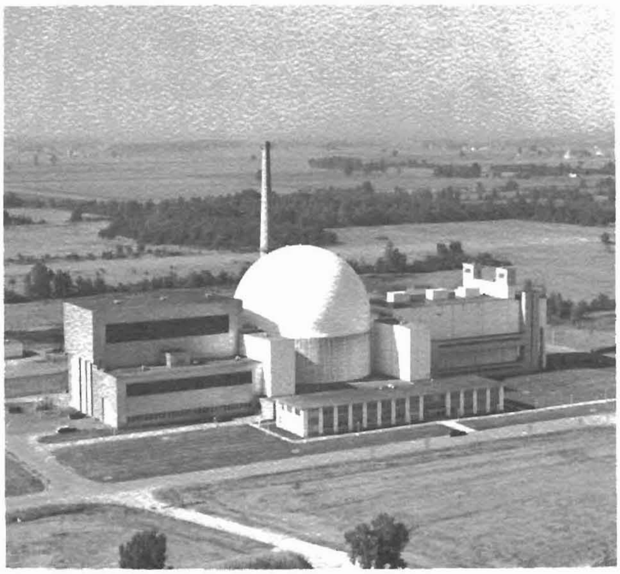
View of the operating side of the hot laboratory showing the remote manipulators for positioning post radiation test articles.

SPACE POWER FACILITY

The Space Power Facility is the largest controlled-environment test chamber in the world. Its 100-foot diameter and 121-foot height offers users 800 000 cubic feet of usable unobstructed volume. Nearly 8000 square feet are available as floor test area; the allowable floor loading is 200 tons. The chamber is shielded by 6- to 7-foot-thick concrete with a steel liner. The vacuum system consists of thirty-two 48-inch-diameter liquid nitrogen baffled diffusion pumps mounted in the chamber floor and two series of roughing pumps. Installation and removal of test articles is facilitated by two 50- by 50-foot doors and three railroad tracks, which run through the chamber and adjoining high bay areas. These high bay areas are themselves useful test facilities.

The outstanding facility and test support equipment capabilities include

- A 400-kilowatt arc lamp, which is 25 times more intense than presently used sources—This lamp provides high quality solar simulation with variable geometries up to 450 square feet vertical or horizontal beam. Beam intensities range from Earth orbit to terrestrial to Mars orbit.
- A vacuum facility with an altitude capability from sea level to 10^{-8} torr—The pumping system, which can remove 120 000 pounds of air per hour allows small engines to be operated in the chamber at typical altitudes.



The SPF test section dome dominates the landscape around Plum Brook.

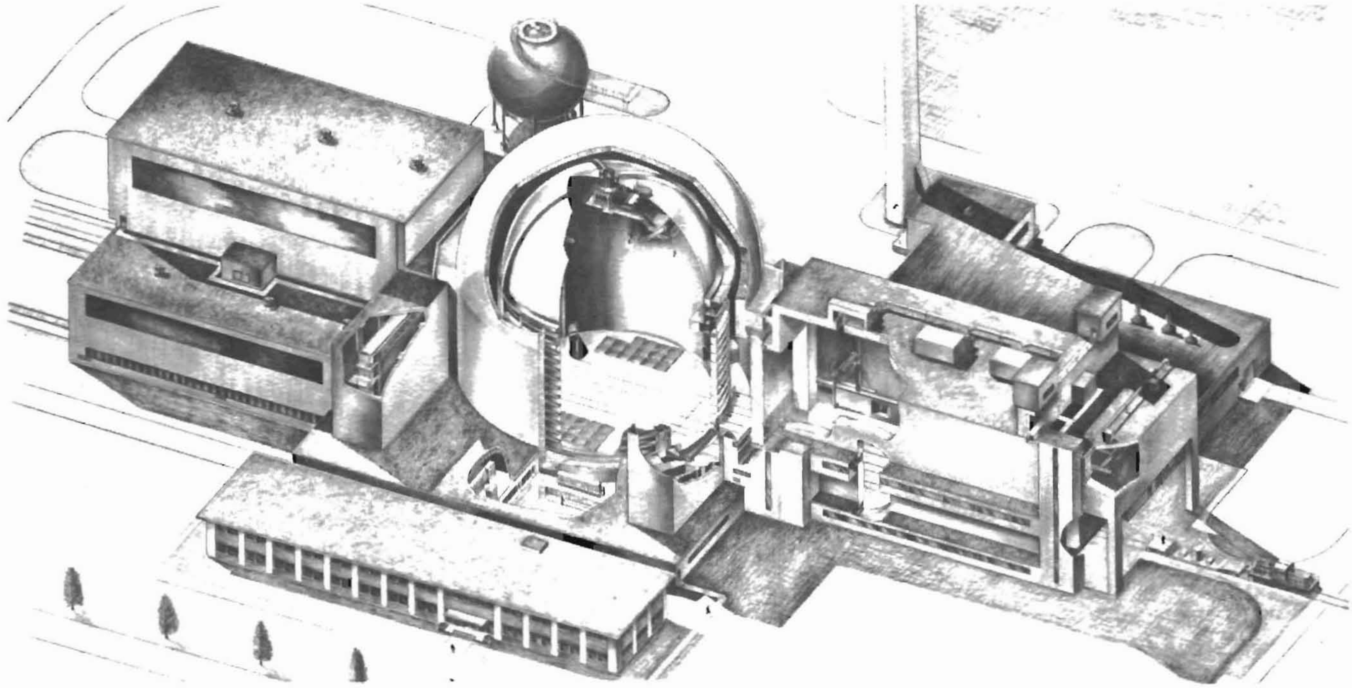
- A cryogenic system capable of removing up to 15 megawatts thermal power—This system provides sink temperatures from -300° F.
- A 7-megawatt dynamic radiant heater for higher temperature thermal simulation.
- Instrumentation, control, and data acquisition systems (e.g., an XDS 930 computer, FM high-speed recording systems, and a PDP8E minicomputer) with versatile capability for data recording and display and for automatic control or monitoring.
- A full complement of support shops and offices, a spacious test control center, cryogen storage areas, etc.

The assembly area is currently equipped with an expandable clean room. The disassembly area provides a volume of over 700 000 cubic feet, with extensive ventilation and contamination control areas. The control room can readily be made into a very large clean room. Access can be controlled through available change-room facilities.

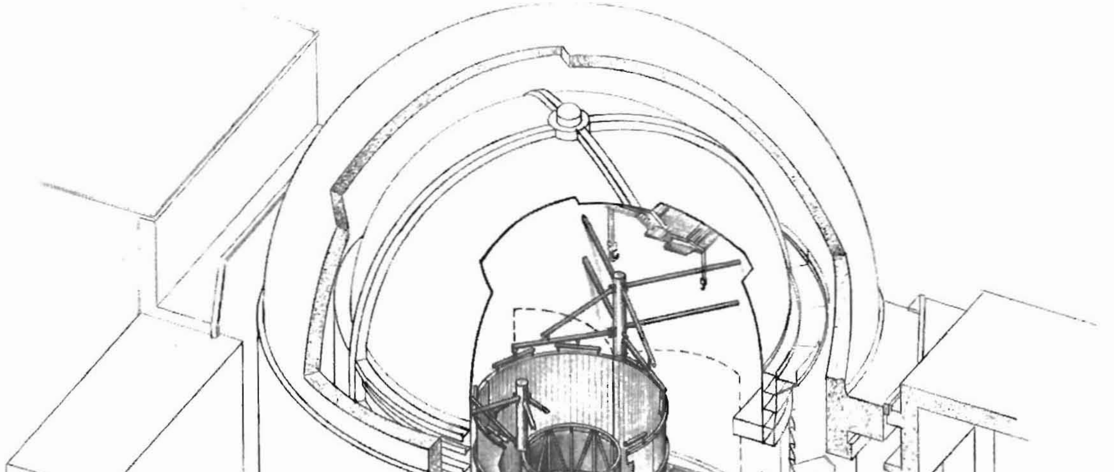
The Space Power Facility has been used for NASA tests requiring a simulated space environment. These include development testing of a 10 kilowatt (electric) space powerplant and flight qualification of the Skylab and Centaur aerodynamic shrouds. The facility offers prime capability for the combined systems testing of complete spacecraft up to the size of the Space Shuttle. Specialized environments such as solar wind simulation can be provided.

Extremely interesting new project areas for which the facility is well suited include

- Upper atmosphere ozone depletion experiments using full-scale jet engines
- Various kinds of environmental studies with both particulate and gaseous pollutants under controlled, measurable conditions
- Development of various energy systems and devices (e.g., terrestrial solar powerplant) under controlled climatic conditions prior to out-of-doors qualification
- Any experiments requiring an enclosed vessel where wall effects must be minimized, e.g., radiation scattering or reaction kinetics
- Thermonuclear fusion reactor research and development
- A variety of test programs ranging from automotive engine tests to holographic experiments in the high bay areas



A cut-away view of the test chamber, 70 ft. x 150 ft. x 70 ft. high shielded assembly/disassembly area and control center.



Artist's sketch showing the Brayton cycle radiator set inside a 40 ft. diameter by 40 ft. high cold wall. This configuration was used to successfully test the power generation system under environmental conditions.

ROCKET SYSTEMS FACILITIES

The rocket systems test facilities include 12 individual test sites, the four largest of which are

- Space Propulsion Research Facility
- Rocket Dynamics Control Facility
- High Energy Rocket Engine Research Facility
- Hypersonic Tunnel Facility

These facilities are large stands designed to accommodate full propulsion systems. The remaining eight facilities are component test facilities. All were designed to be highly flexible in application rather than to be used as special purpose facilities.

In addition to the usual utilities, these sites are serviced with most or all of the following:

- Remote-control rooms
- Central data acquisition
- Digital and analog computers
- High-pressure (2500 and 5000 psi) gases (helium, nitrogen, hydrogen, oxygen)
- Cryogenic fluids (hydrogen, oxygen, nitrogen)
- Railroad sidings
- Vacuum systems
- High-pressure (500 and 200 psi) steam

All sites are geographically separated from one another to allow concurrent hazardous operations, and each has a remote-control area.

The central data acquisition and computer systems are housed in the B-Control and H Buildings. The central data systems include two digital systems with variable sample rates from 2000 to 32 000 readings per second, which can be distributed over 100 to 600 channels, two 14-channel FM recorders, and numerous direct writing oscillographs and strip charts.

An SDS-910 digital computer is used to sequence and control several of the major facilities. A second digital computer (SDS-9300) is used for data manipulation and display. A TR-48 and several TR-20 analog computers are available for on-line control as well as for problem solving and analysis.

Four rocket sites use unusually high capacity steam-powered ejectors for vacuum purposes. Steam is generated in four boilers, and up to 2 000 000 pounds per hour is available for distribution to the sites at 200 pounds per square inch through 30-inch drain pipes.

Aerial view of SPRF. "B" Complex is shown at upper left.

SPACE PROPULSION RESEARCH FACILITY

The Space Propulsion Research Facility is designed for hot firing of full-size space vehicles in an environment simulating conditions at an orbital altitude of 100 miles.

Salient facility features include

- Thrust capability to 100 000 pounds and, with minor modifications, to 500 000 pounds
- A 38-foot-diameter by 55-foot high stainless-steel test chamber
- A 27-foot-diameter test chamber access door
- Liquid nitrogen cooled cold walls
- A 5×10^{-8}-torr ultimate static vacuum
- Quartz lamp thermal simulators
- Steam ejectors to pump rocket exhaust products
- Space soak (30 days is reasonable)
- Repetitive engine starts after simulated space coast period
- Storable and cryogenic propellant capability (fluorine not excluded)
- Propellant safety dump tanks

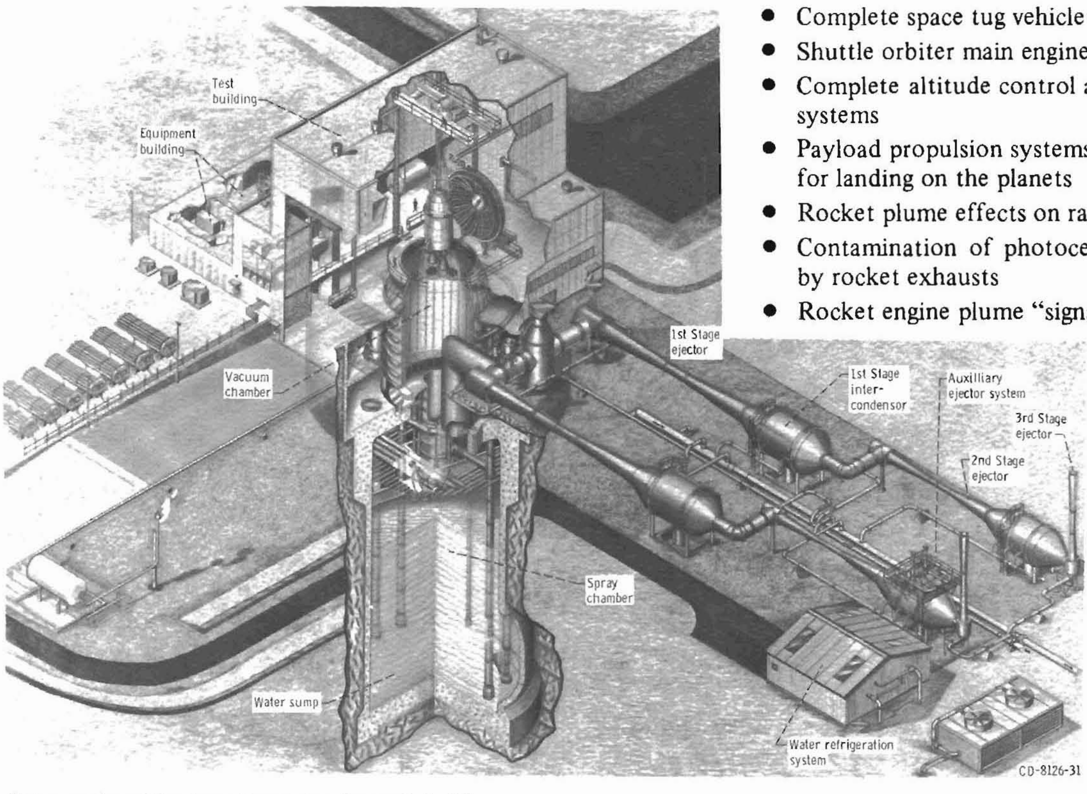
In operation, an entire vehicle can be vacuum "soaked" to the proper environmental space conditions in preparation for engine test firing. With the -320° F cold walls and 5×10^{-8}-torr vacuum, rocket engines can be ignited in the chamber under space conditions. As chamber pressure builds up because of the exhaust gas, an 11-foot-diameter valve opens in 0.4 second to connect the chamber to a steam ejector system. Two parallel steam ejectors remove the engine exhaust products from the chamber while maintaining a moderate vacuum level. Three large dump tanks are located in the exhaust spray chamber to receive propellants in an emergency situation.

The exhaust system includes a 250 000 gallon-per-minute water spray system for cooling the rocket exhaust. The spray system water is recirculated through the 1.75-million-gallon catch basin under the chamber.

The facility has been used to date for Centaur research and development; the longest engine firing was 8 minutes.

Possible future uses for the Space Propulsion Research Facility include testing or investigation of

- Complete space tug vehicle
- Shuttle orbiter main engine
- Complete altitude control and orbital maneuvering systems
- Payload propulsion systems, such as those required for landing on the planets
- Rocket plume effects on radio signals
- Contamination of photocells and optical systems by rocket exhausts
- Rocket engine plume "signatures"



Cut-away view of the Space Propulsion Research Facility.

ROCKET DYNAMICS AND CONTROL FACILITY

The Rocket Dynamics and Control Facility was designed primarily for altitude testing large rocket propellant and turbopump systems. It has a complete gas and cryogen supply system. The test stand base is 50 feet square and 210 feet high. It is totally enclosed above the 74-foot level and has electrically operated roll doors on three sides to allow access by the 65-ton crane for model installation and free ventilation during fueled tests. Test articles are generally mounted at the 73½-foot level. At this elevation the test area is 32 by 27½ feet and can extend to the roof. Movable floors and work platforms provide access to the test article.

Recently, Lewis has used this facility for cryogenic shroud unlatch tests and structural loading tests on the Titan/Centaur shroud.

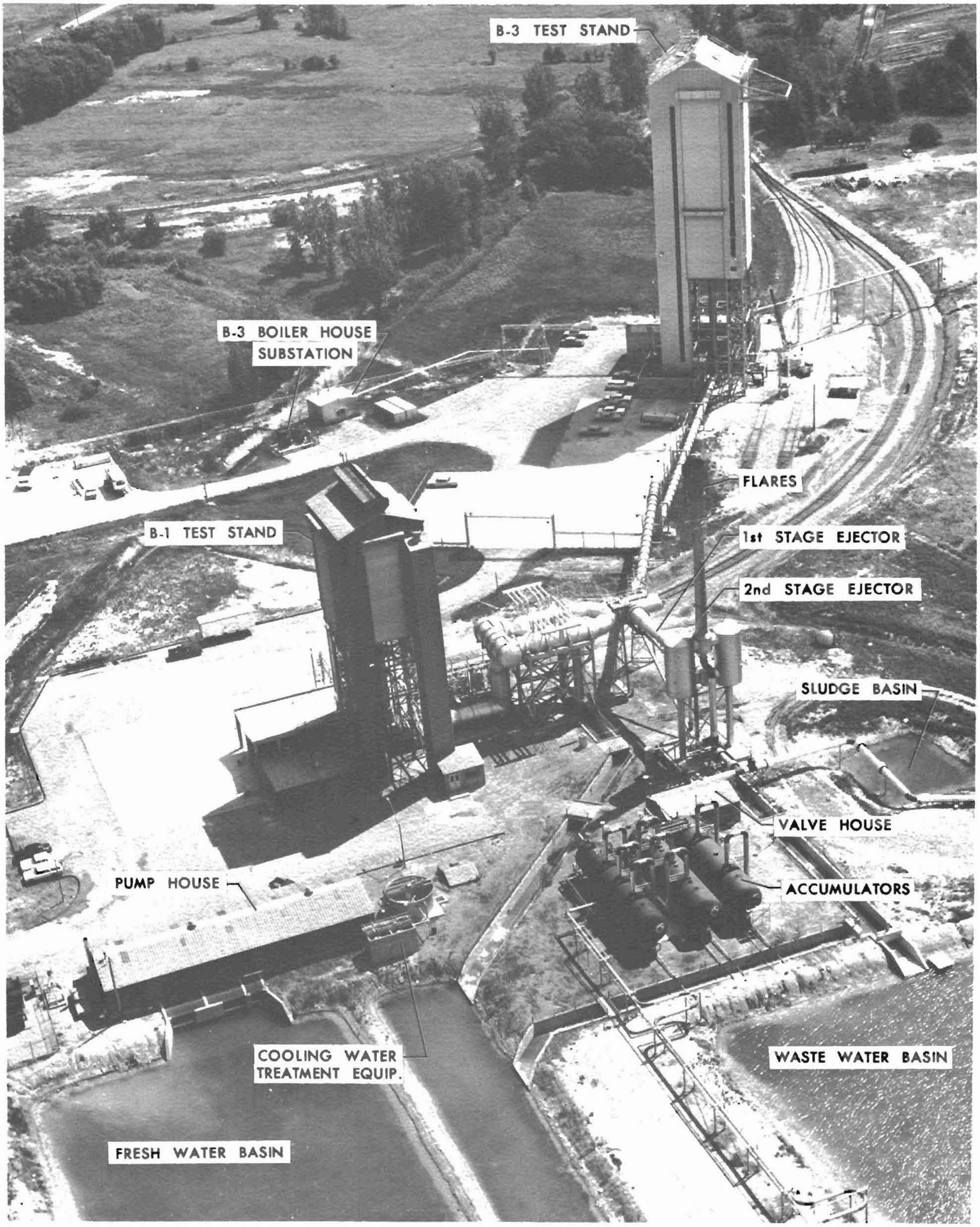
The facility is ideally suited for testing large turbopump systems such as those used in the electric power industry and other fields where large capacity rotating machinery is used.

HIGH ENERGY ROCKET ENGINE RESEARCH FACILITY

The High Energy Rocket Engine Research Facility was designed for hot firing tests on a variety of engine systems at altitude conditions. The stand has a 34- by 42-foot base, is 135 feet high, and is equipped with three large, electrically activated rollup doors. It is enclosed above the 68-foot level. Two test-mounting methods are available; a 13½-foot-diameter by 30-foot-long vacuum capsule is used for testing entire engines in a space environment, and a steel test carriage is used for cold flow tests. Engines with thrust up to 6000 pounds can be run for approximately 6 minutes by using the existing format; the thrust capacity can be increased to 30 000 pounds with minor modifications.

Lewis has tested both the Centaur vehicle and NERVA rocket propellant feed systems in this facility. Possible future applications include ones similar to those listed for the Space Propulsion Research Facility, but on a somewhat smaller scale.

An evening test of the Centaur rocket engine in "B-1."



An aerial view of "B" Complex.

HYPERSONIC TUNNEL FACILITY

The Hypersonic Tunnel Facility is a free-jet wind tunnel designed for aerodynamic testing at Mach 5, 6, and 7. The airstream is uncontaminated (nonvitiated) and can be heated to stagnation temperatures from 1800° to 3500° F. The supersonic jet is 42 inches in diameter and will accommodate models up to about 20 inches in diameter.

The tunnel test section is housed in a cylindrical test chamber 25 feet in diameter and 20 feet high. The mounting system for the test article is designed to accommodate model injection as well as fixed-position mounting. The mounting system can measure the angle of attack and thrust.

The facility has the following outstanding capabilities:

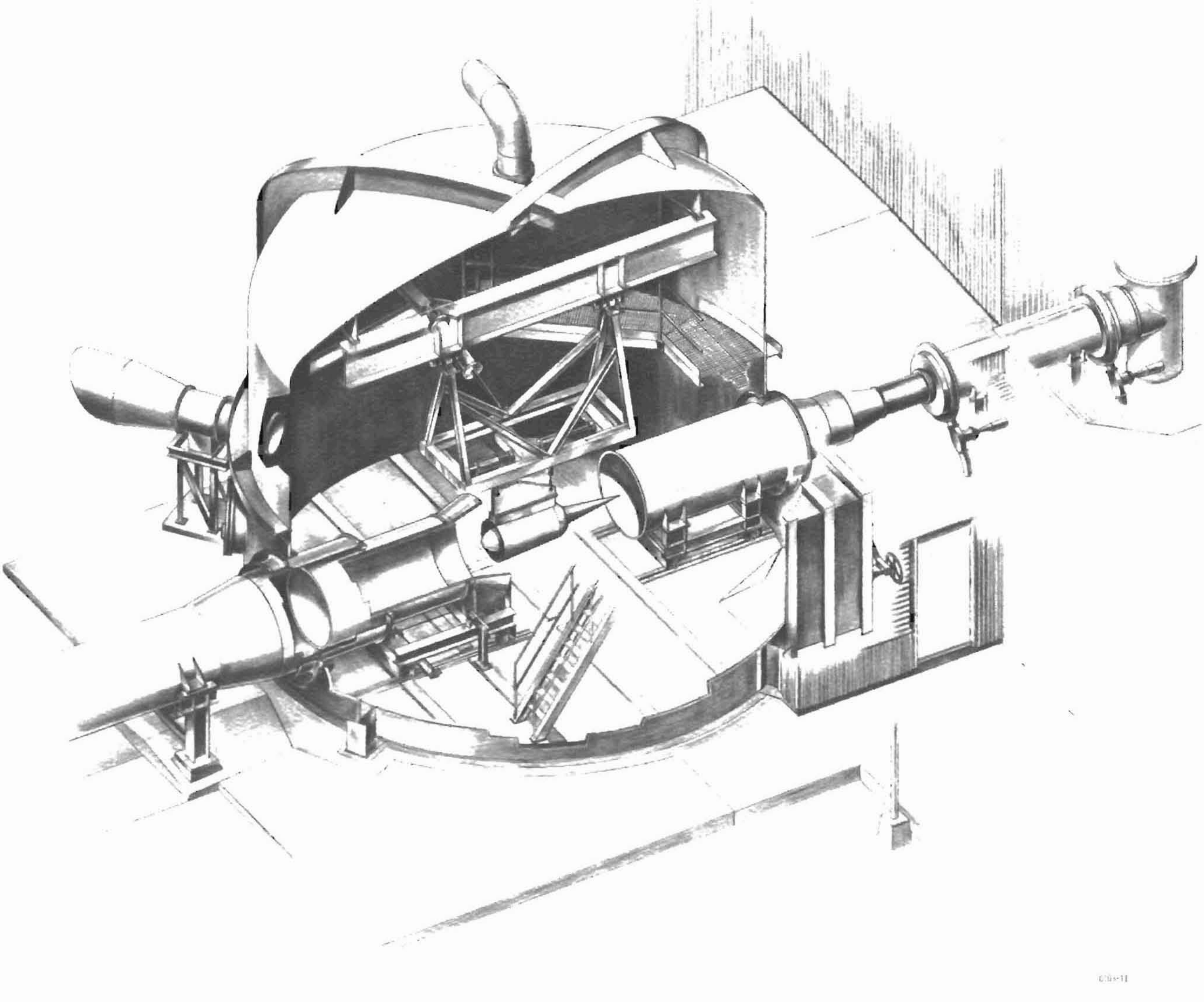
- Operation with a noncontaminated airstream
- Operation at Mach 5, 6, and 7
- Test-altitude simulation from 60 000 to 120 000 feet
- Heater operation to 1200 pounds per square inch and 4500° F
- Hot nitrogen flow rates from 35 to 100 pounds per second
- Electrical induction system rating of 1.5 megawatts
- Hydrogen pebble-bed heater operation to 1500° F and 1200 pounds per square inch

The clean tunnel airstream is synthesized by blending hot and cold gaseous nitrogen with cold gaseous oxygen to produce the desired temperature and gas composition. The nitrogen is heated in a large storage-type graphite bed which, in turn, is heated inductively. The graphite bed is approximately 5 feet in diameter and 35 feet long and is thoroughly insulated from its pressure storage vessels (5000 and 2500 psi, respectively). The nitrogen vessel is a railroad car with a capacity of about 750 000 standard cubic feet at a working pressure of 5000 pounds per square inch.

The facility has a gaseous hydrogen fuel system that is used to supply hot hydrogen fuel to the ramjet engine being tested, and the fuel lines are electrically trace heated.

One potential use of the 1.5 megawatt induction heater is its operation as a multiple purpose process oven. The oven would be about 5 feet in diameter and 35 feet high. Temperatures to 4500° F could be realized in any atmosphere compatible with graphite.

Aerial view of the Hypersonic Tunnel Facility.



The HTF test section with an experiment positioned in the chamber is illustrated in this artist's sketch.

ADDITIONAL ROCKET SYSTEMS TEST FACILITIES

In addition to the four major test sites described in the preceding pages, the Rocket Systems Test Facilities Complex contains eight other test sites that have been used in a wide variety of research projects on space propulsion system components. A few highlights of these facilities follow.

The Liquid Hydrogen Pump Facility was designed for hydrogen and oxygen pump research and has both hydrogen- and oxygen-pump flow loops. The hydrogen loop is designed for flows of about 20 000 gallons per minute and discharge pressures to 1000 pounds per square inch gage. The pump drive train consists of a hot-air turbine and a gearbox and is capable of generating 20 000 horsepower at speeds to 60 000 rpm.

The oxygen-pump loop is designed for 1500 gallons per minute at a discharge pressure of 1000 pounds per square inch gage. Its pump drive is a hot-air-turbine, gearbox combination of much smaller size. The rating is 1200 horsepower at 60 000 rpm.

The Turbopump Facility was designed for research on pump inlets and inducers. The research pump casing is constructed of transparent material and is submerged in a Dewar that has viewing ports and a strobe lighting system. This arrangement permits photographic studies of the fluid flow through the pump inducers. The facility is suitable for use with normal liquids as well as cryogens, including liquid hydrogen.

Both the Liquid Hydrogen Pump and the Turbopump Facilities are well suited for general pump research and could be readily adapted to small or moderate size compressor research. Particularly interesting is the possible use of these facilities in the newly emerging component research areas associated with "the hydrogen economy."

The Controls and Turbine Test Site was designed as a hot-turbine research facility. It has gas generators, gearboxes, and bedplates for the operation of two turbine rigs. Currently the facility is being used as a hydraulics laboratory for evaluation of valve actuators and structural loading systems.

Potential applications include

- Turbine research on automotive and heavy equipment turbines
- Testing of complete automotive powerplants
- Testing of gas-turbine electric generating systems

The Dynamics Stand is a seven-level, 144-foot-high structure that was originally used for dynamics tests of the Atlas/Centaur launch vehicle and payload. The main test areas surround a 14-foot-diameter well, which extends the full height of the building. The largest door opens to a height of 125 feet.

The stand has shaker equipment for vibration testing. The largest unit is rated at 20 000 pounds of force and operates at frequencies from about 20 to 2000 hertz.

"H" Control Building is shown with ground lines radiating to a variety of test facilities. The Dynamics Stand is in the right background.

This facility is well suited for static and dynamic structural testing of large equipment or structures subject to vibration loads of varying frequency and intensity. It has numerous fluid systems so installed that problems associated with the coupling of fluid systems with structures can be investigated.

The Hydraulic Laboratory was designed for investigating fluid mechanics problems encountered in cryogenic and noncryogenic vehicle systems. For example, the dynamic and steady-state performance of a water-to-liquid-hydrogen heat exchanger was recently investigated. Basically, the facility consists of a system of high-pressure supply vessels, test hardware installation areas, and catch vessels. Systems and components such as valves, flowmeters, and heat exchangers can be installed between the supply and catch vessels and tested under a wide range of pressure and flow conditions.

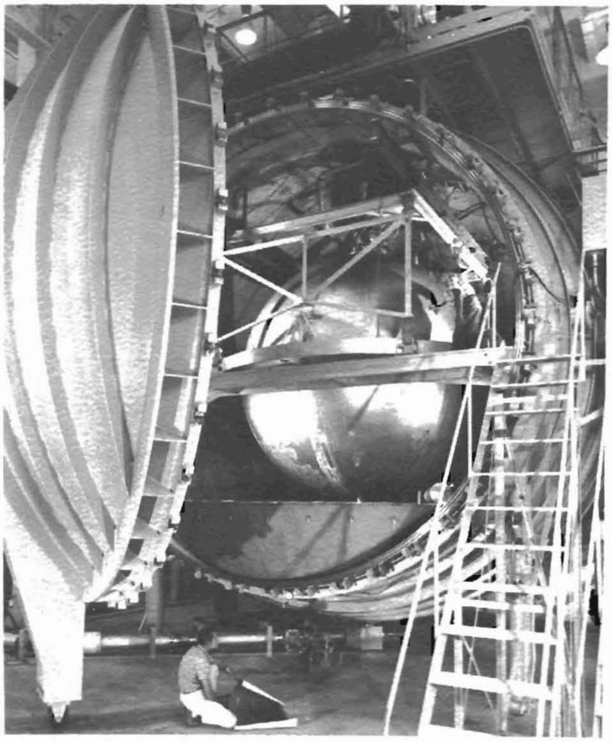
The Materials Compatibility Laboratory consists of a 38-foot-diameter steel containment vessel enclosing a dynamic materials compatibility test rig. High-pressure liquid fluorine may be flowed through a compatibility test specimen and caught in a receiver vessel. The entire test loop can be operated while immersed in liquid nitrogen. Unique features include the total containment provided by the 38-foot sphere and the ability to handle highly chemically reactive substances such as fluorine.

At the Fluorine Pump Facility, fluorine and mixtures of fluorine and oxygen (FLOX) have been evaluated as rocket engine oxidizers. Liquid fluorine pumps with speeds up to 20 000 rpm and flow rates of 50 pounds per second may be tested at this site.

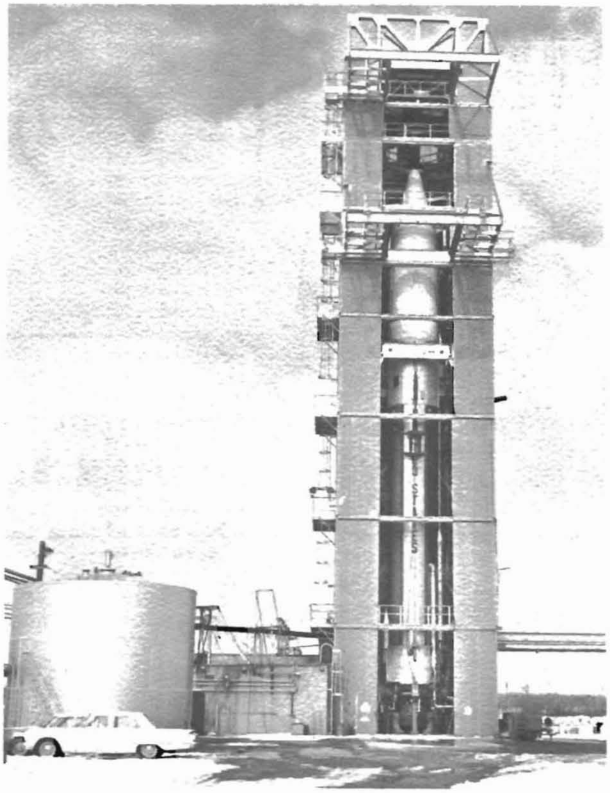
The main feature of the Cryogenic Propellant Tank Facility is a 25-foot-diameter spherical test chamber with a 20-foot access door. The facility was originally built to test rocket liquid-hydrogen fuel tanks up to 18 feet in diameter. Shakers have also been installed to allow the effects of vibration on tanks and insulation at cryogenic temperatures to be tested. This chamber is equipped with cold walls that can be cooled with either liquid nitrogen (-320° F) or liquid hydrogen (-425° F). Vacuum levels of the order of 10^{-8} torr are attainable.

The Rocket Systems test facilities, in addition to the uses previously mentioned, could also serve as sites for

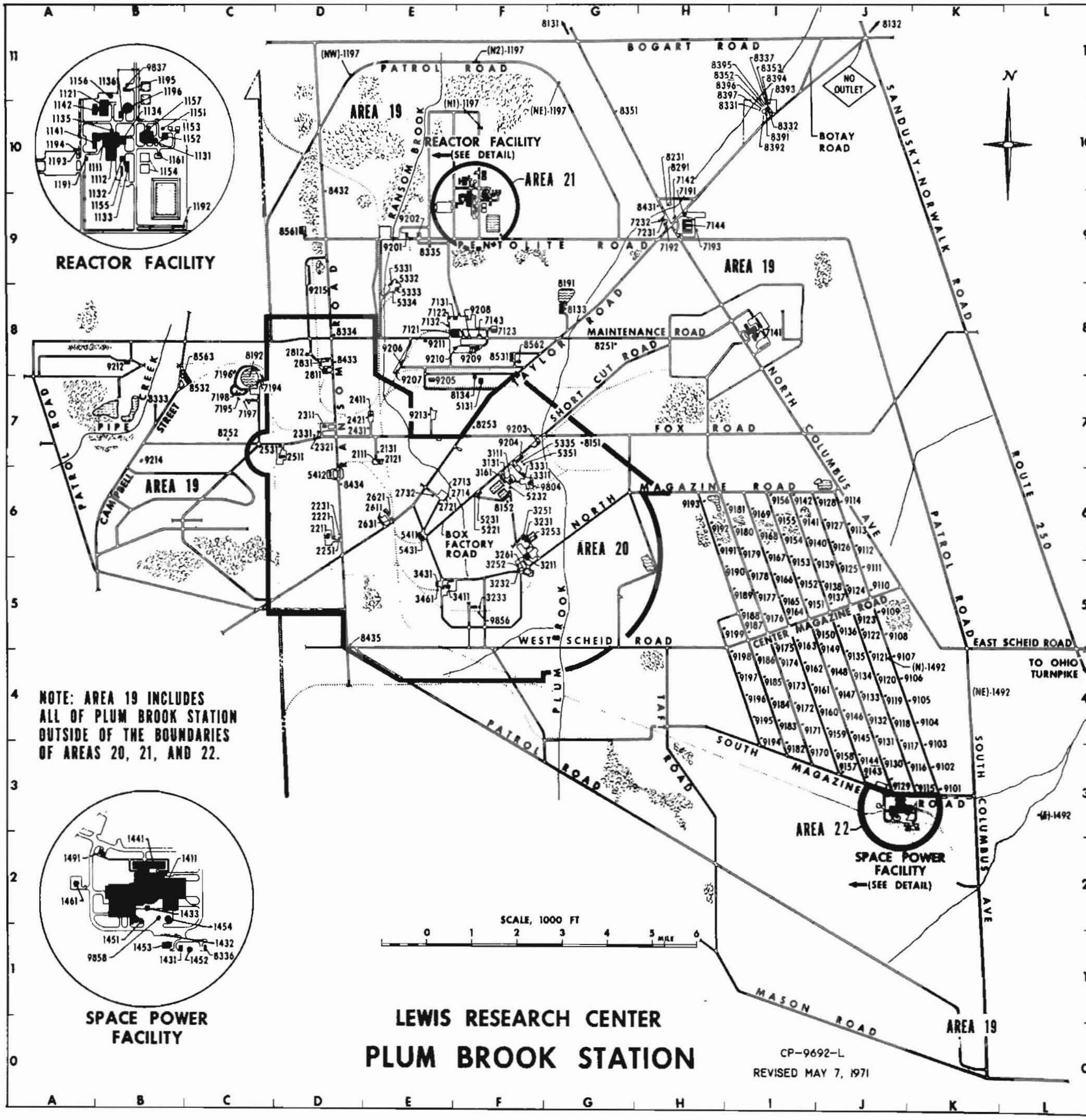
- Cryogenic research and development, including liquefied-natural-gas work
- Turbine, compressor, and pump research
- Automotive and heavy equipment power sources research
- Testing a multitude of high energy flow processes



Interior view of the cryogenic propellent tank test area.



The Dynamics Stand with an Atlas/Centaur rocket in place.


LEWIS RESEARCH CENTER
PLUM BROOK STATION
CP-9692-L
REVISED MAY 7, 1971
REACTOR FACILITY
SPACE POWER FACILITY
NOTE: AREA 19 INCLUDES ALL OF PLUM BROOK STATION OUTSIDE OF THE BOUNDARIES OF AREAS 20, 21, AND 22.
SCALE, 1000 FT
AREA 19
AREA 20
AREA 21
AREA 22
REACTOR FACILITY (SEE DETAIL)
SPACE POWER FACILITY (SEE DETAIL)
BOGART ROAD
PATROL ROAD
PENTOLITE ROAD
MAINTENANCE ROAD
FOX ROAD
MAGAZINE ROAD
CENTER MAGAZINE ROAD
SOUTH MAGAZINE ROAD
WEST SCHEID ROAD
EAST SCHEID ROAD
MASON ROAD
TAFT ROAD
TAYLOR ROAD
SHORT CUT ROAD
NORTH COLUMBUS AVE
SOUTH COLUMBUS AVE
SANDUSKY-NORWALK ROAD
ROUTE 250
BOTAY ROAD
RANSOM BROOK
PLUM BROOK
RANSOM ROAD
PIPE STREET
PIPE CREEK
CAMPBELL
BOX FACTORY ROAD
NO OUTLET
TO OHIO TURNPIKE
N

PLUM BROOK

REAL PROPERTY INVENTORY

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1112 REACTOR HOT LABORATORY. F-9
1121 REACTOR ATS BUILDING. F-10
1131 REACTOR SERV. EQUIP. BLDG. F-9
1132 REACTOR FAN HOUSE. F-9
1133 REACTOR WASTE HANDLING BLDG. F-9
1134 REACTOR PRIMARY PUMP HOUSE. F-9
1135 REACTOR GAS SERVICES BLDG. F-10
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1141 REACTOR OFFICE & LABORATORY. F-9
1142 REACTOR OFFICE BUILDING. F-10
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1152 REACTOR COOLING TOWER. F-9
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1156 REACTOR ATS WATER STORAGE TANK (200K GAL). F-10
1157 REACTOR PRECIPITATOR. F-10
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