SEPTEMBER 1957

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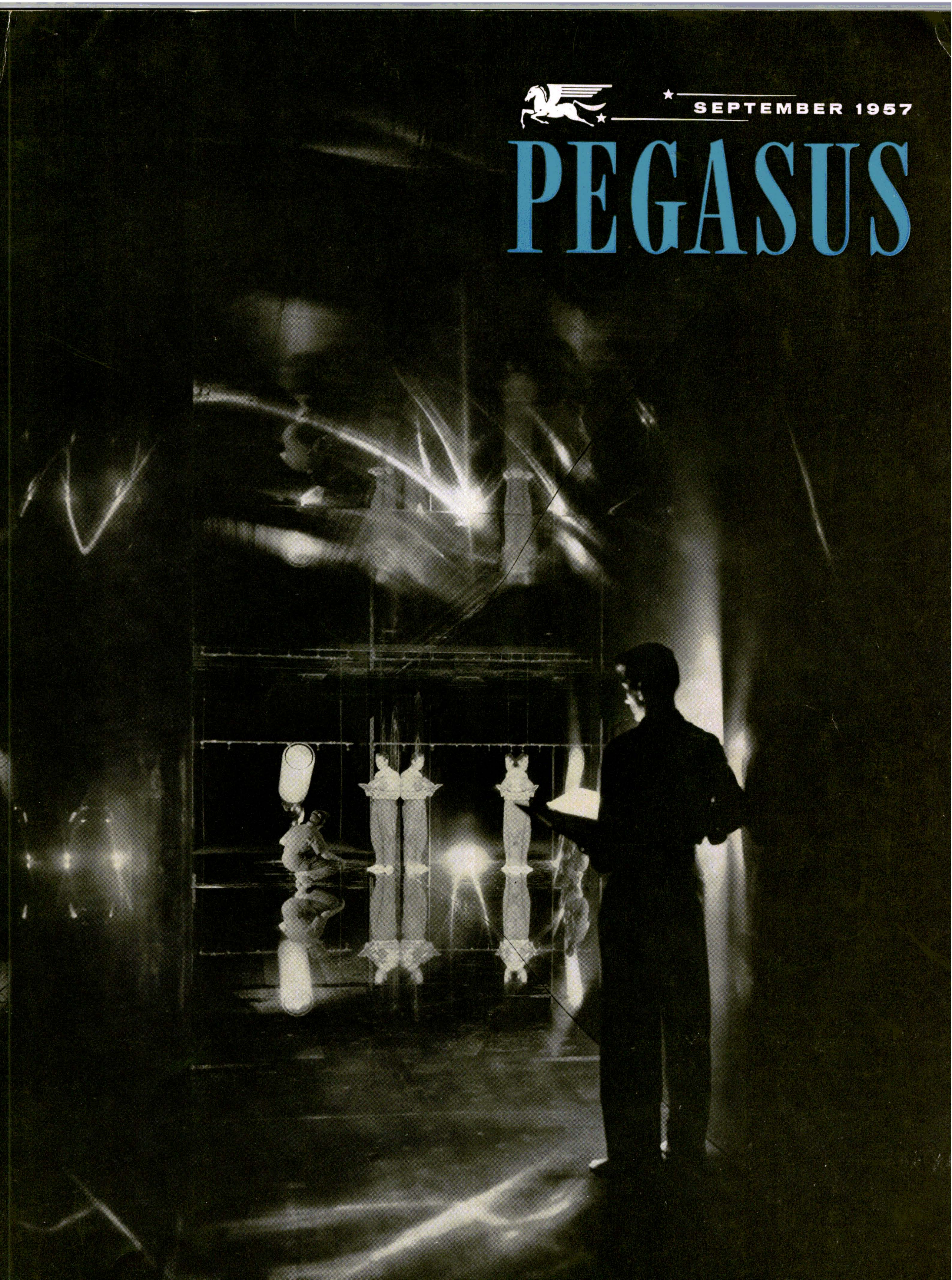

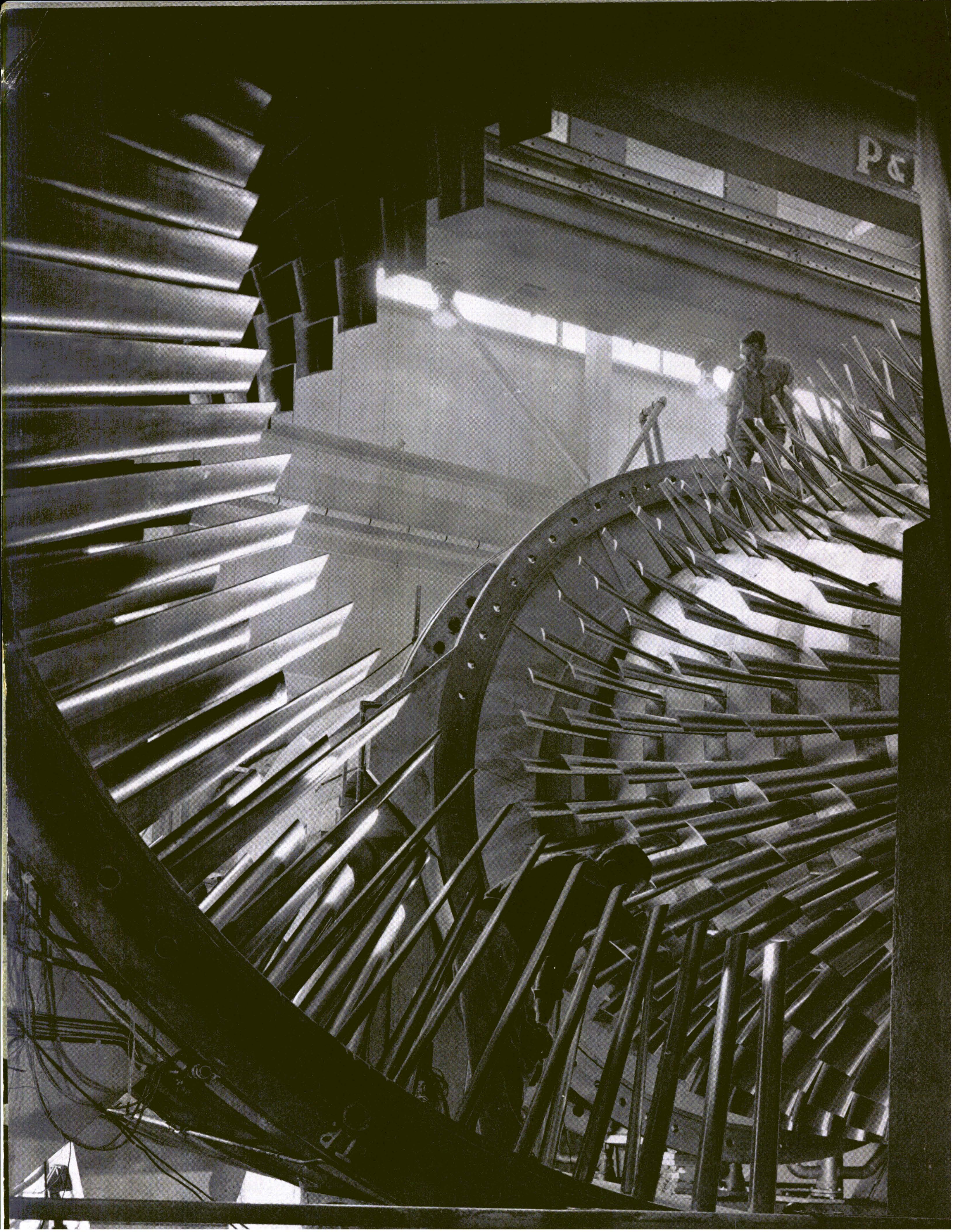
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The Pegasus is published by the Fairchild Engine and Airplane Corporation as a service toward greater understanding of the military, social and economic effects of aviation.

Blades of main drive compressor force air into 10x10-foot Wind Tunnel at Lewis Lab

THE FACE OF PROGRESS

By Matt Portz

ONE of the facts of life facing the United States is an urgency for us to do what must be done to maintain leadership in weapons technology.

In making this point to members of the Aviation Writers Association assembled at the National Press Club last spring, Dr. James H. Doolittle, Chairman of the National Advisory Committee for Aeronautics, used the ICBM as an example. He cited the tangle of problems which must be solved before the ICBM can become a practical weapons system. Questions demanding answer include those of propulsion, structure, configuration, guidance, aerodynamic heating, and a host of others.

Should we look at a few of the specific problems of ICBM propulsion, such as starting, combustion stability, cooling methods, and design of bearings, seals, injectors, and thrust chamber, we find there is no shortage of things to be done. Add the propulsion problems of weapon systems other than the ICBM—to say nothing of problems not dealing with propulsion—and we have a tangle indeed.

A key asset in helping to unsnarl the maze as it relates to aircraft and missile propulsion is NACA's Lewis Flight Propulsion Laboratory, adjacent to Hopkins Airport at Cleveland, Ohio. Here, efforts of most of Lewis' 2,700 scientific and supporting personnel and its more than $100-million research plant are devoted to solving mysteries of turbojet, ramjet, rocket, and nuclear propulsion systems. The goal of the Cleveland Laboratory is to provide the background of knowledge on which will be based the design of more efficient and more powerful engines to propel tomorrow's aircraft. In seeking the way toward superior-performing airplanes and missiles, Lewis research is teamed closely with the work of NACA's Langley and Ames Laboratories, as well as with the aircraft industry and military services.

Authorized by Congress in 1940, when the piston engine was of primary concern in aeronautical research, construction at Lewis was begun the following year. Although not the first, one of the earlier major facilities completed was the Altitude Wind Tunnel. It was designed with capabilities of testing a 4,000-horsepower piston power plant at conditions simulating 400 miles per hour and 50,000 feet altitude. The AWT's first project, the P-59, America's first turbojet-powered aircraft, was a preview of the impending propulsion revolution.

A 4,000-hp piston engine never was tested in the AWT. Before it could happen, Lewis research with piston engines ceased. The total effort of the Laboratory was directed to propulsion systems with greater performance potential. That was at the close of World War II. With the change in research emphasis, existing laboratory equipment was adapted and modernized. Then new equipment was built.

Extending knowledge is like going from known Point A to unknown Point B. Equipment at hand may get us to Point B, but once there, new research facilities are needed to get us to still-unknown Point C and beyond. Today's research facilities at Lewis, of necessity, extend far beyond capabilities of the still-useful AWT and other veteran research equipment.

Let's look at some results of turbojet research, view some of the newer research facilities which will make possible greater gains in both turbojets and ramjets and glance at other areas of Lewis research leading towards more productive flight and practical weapons systems.

In the early days of turbojet propulsion, certain engines were seriously limited by combustion failure at higher altitudes—sometimes as low as 10,000 feet. Detailed studies in the altitude facilities revealed the nature of the combustion problem and indicated new combustor design principles. These studies have since virtually removed turbojet altitude operating limits set by combustion, and have permitted high combustion efficiencies with low pressure losses.

Research in gas turbine engine components has paid off in improved compressors and turbines. Lewis demonstrated advantages of adjusting compressor stator blade angles, and pioneered transonic compressor design principles which permit high efficiency at both design and off-design conditions. Numerous techniques have been explored and presented to engine designers for cooling turbines, disks, and bearings. These have demonstrated that strategic materials can be saved and turbine engine performance increased beyond present practices.

The first practical afterburner was built and operated at Lewis 13 years ago. Subsequent research in this area established design principles incorporated in all afterburners manufactured in this country. Research on liquid injection, alone and in combination with afterburning, has enabled the achievement of increased power from existing engines.

The largest single body of systematic research data on the relation of fuels to engines has been provided by the laboratory for industry and military services, enabling them to establish optimum jet fuel specifications for emergency defense needs. Research on high-energy fuels of all types and on the appropriate engine modifications for use of these fuels will soon give more range and superior altitude performance to our aircraft.

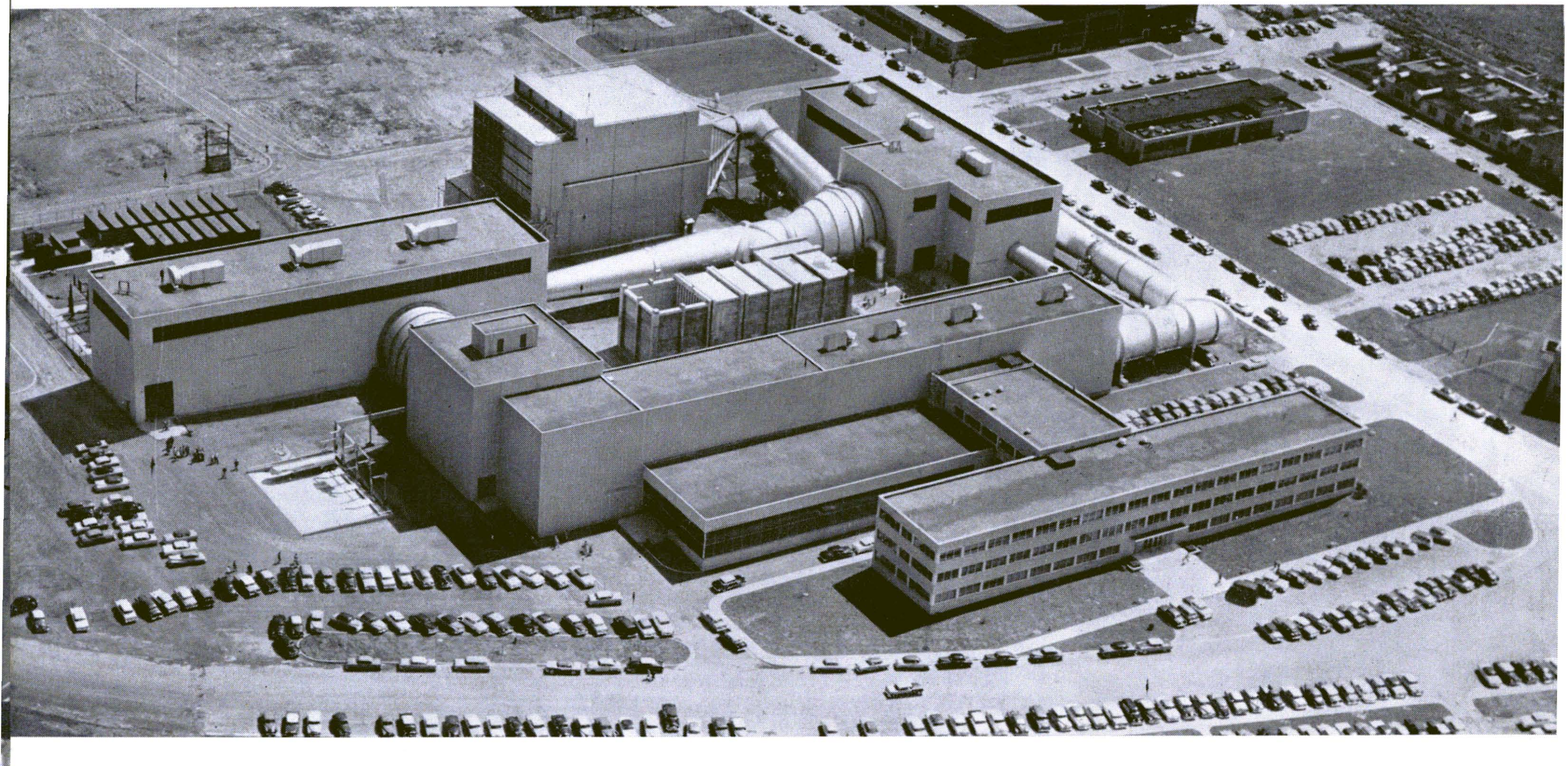
Each of the major Lewis research facilities, the Altitude Wind Tunnel, Icing Wind Tunnel, Engine Research Building, Propulsion Systems Laboratory, Materials and Stresses Laboratory, and High Energy Fuels Laboratory, contributed to these results.

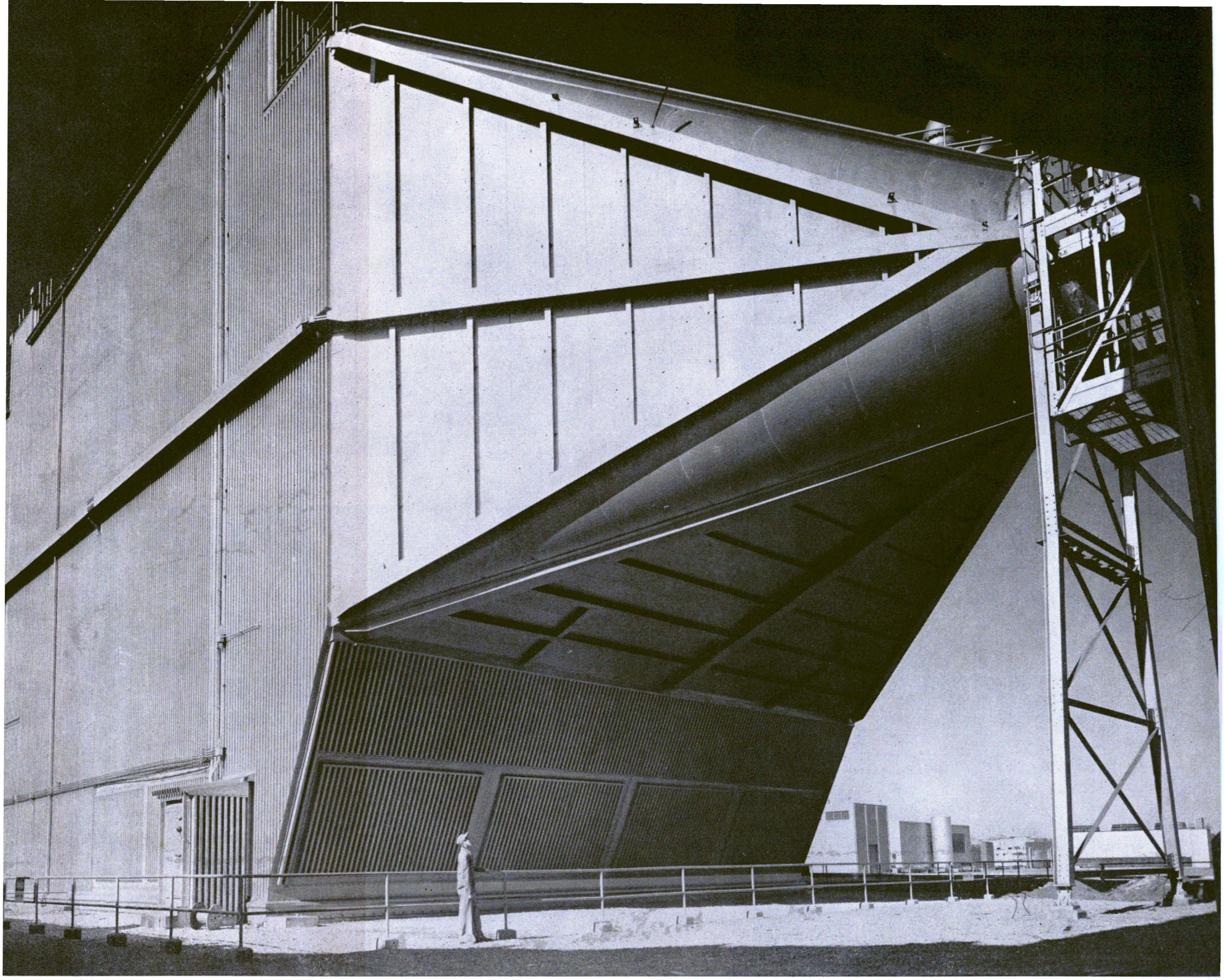
Two other key tools of research at Lewis are the 10x10-foot Supersonic Wind Tunnel, completed a year ago, and the 8x6-foot Supersonic Wind Tunnel, in operation since 1949 and now modernized to include transonic capabilities. Research at these two facilities on propulsion system installations in high performance fighters has left the fuselage nose available for radar devices without sacrificing performance of engines located in the fuselage. Boundary layer removal principles generally, and such specific contributions as half-spike inlets, vertical-wedge inlets, shock positioning control systems, and variable-geometry inlet systems have advanced the development of supersonic aircraft.

During the 10x10's first year of operation it has paid handsome dividends by providing in-flight performance data on a number of ramjet configurations, high energy fuels, the B-58 "Hustler" engine pods, and the J-79 engine.

The 10x10 is a continuous-flow wind tunnel with a Mach number range from 2.0 to 3.5. It is operational to simulated altitudes of 160,000 feet in closed circuit for aerodynamic tests or to 87,000 feet on an open circuit for combustion propulsion research.

Aerial view of 10x10-foot Supersonic Wind Tunnel at Lewis, a key research tool where full-scale engines can be altitude-tested from Mach 2.0 to 3.5





Air enters this building from the left and after being dried goes through the converging duct at upper right into 10x10-foot Tunnel

Engineer and technicians check the installation of a Nose Inlet Model

Objectives of the tunnel include investigation of full-size and scale models of turbojet, ramjet, and other engine types, and their components. Areas of interest include thermodynamic and aerodynamic performance, operating temperatures and stresses, combustion efficiency, control systems, installation problems, and inlet and exit performance. Walls of the test section are of stainless steel plate 1 and 3/8 inches thick, 10 feet wide, and 78 feet long. Walls are flexible to permit nozzle throat size to be changed during operation by a system of large jack screws. For ease in handling models, the test section floor serves as an elevator which can be lowered to shop floor level. Air flow in the tunnel may be observed and photographed through a schlieren optical system, and closed circuit television permits observation of the model from the control room during testing operations.

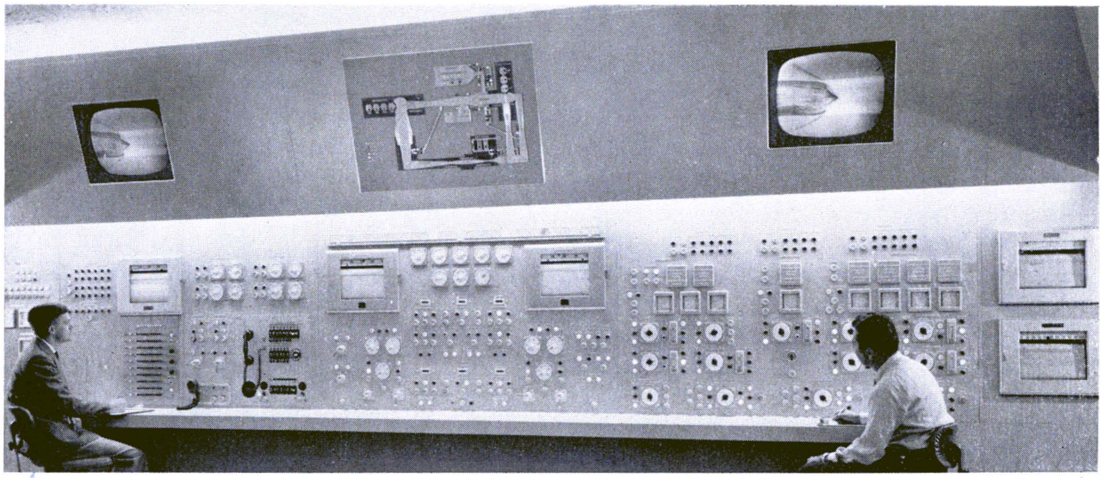
The tunnel's two axial flow compressors can move 80,000 cubic feet of air per second. Seven electric motors with a total capacity of 250,000 hp drive the compressors.

Supplementing the 10x10's Mach 2.0 to 3.5 range for Lewis full-scale engine studies is the 8x6-foot Supersonic Wind Tunnel with operating capabilities within the Mach 0.6 to 2.1 range. This summer, a $2-million modernization program was completed on this eight-year-old facility, physically not much smaller than the 10x10.

Formerly, the 8x6 operated only from Mach. 1.5 to 2.0. Its utility has been broadened into the important transonic speed range for investigations of full-scale power plant air inlet and outlet configurations, nacelle configurations and shapes, and interference between the engines and the remainder of the aircraft.

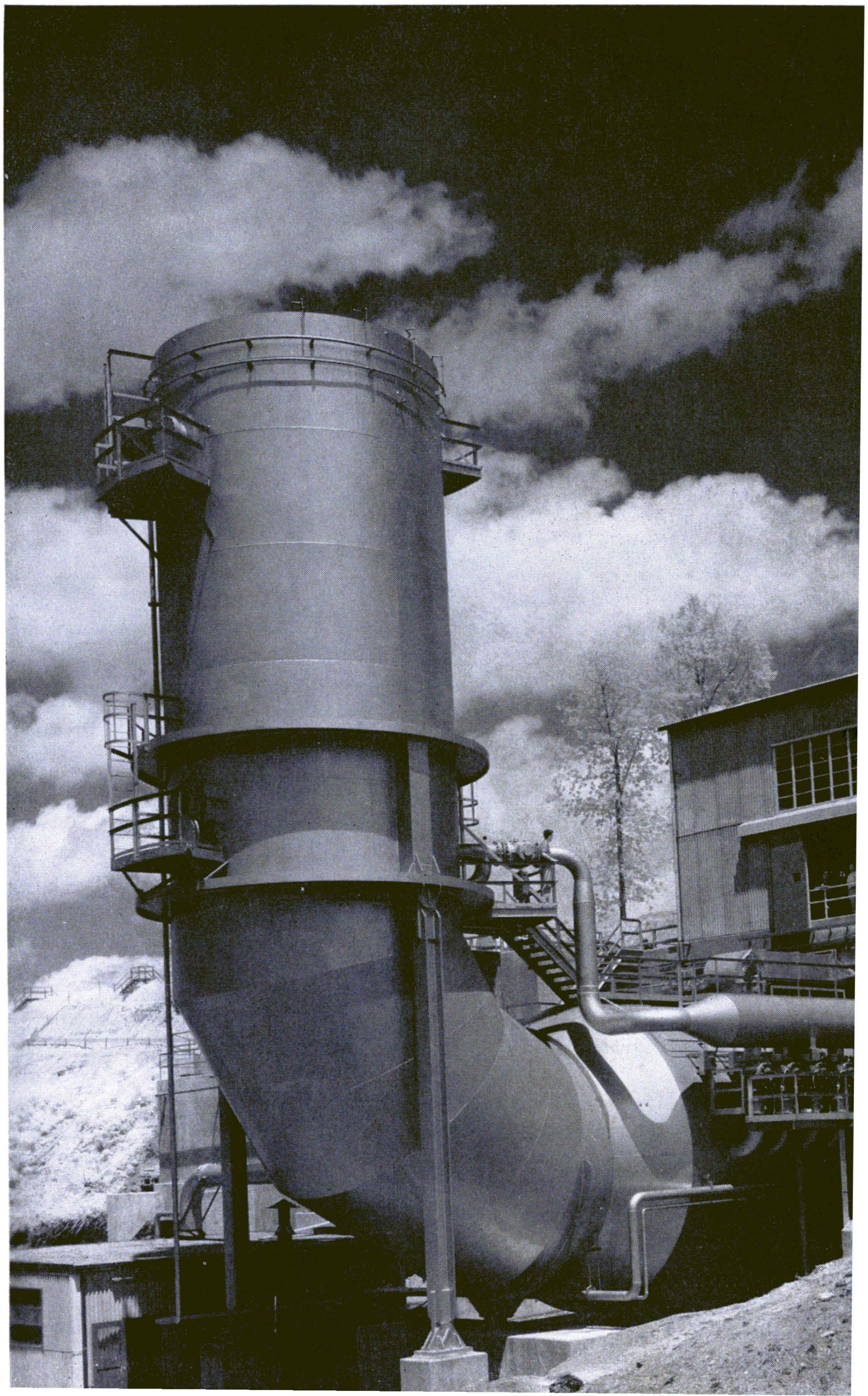
Modernization included modification of the throat and test section for transonic operation and construction of a return duct connecting air intake and discharge points.

Upstream connections in the throat were altered to permit flexing the walls through a greater range for transonic operations. The test section had 4,700 holes bored in its side and top surfaces to permit removal of boundary layers. A six-foot line connects the test section's external shell with large vacuum

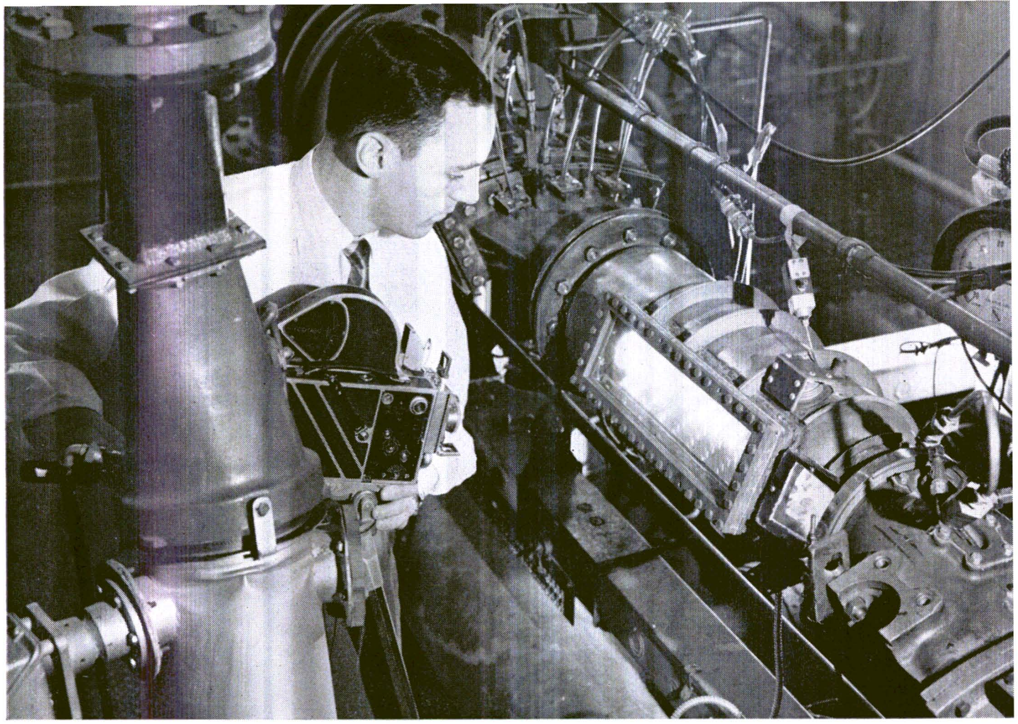


Control panel, one of three for the 10x10, features tunnel model at top center and closed circuit TV monitor screens on each side

Technicians at work in test section of recently-modernized 8x6 facility



"Scrubber" silences rocket engine operations and removes exhaust gas



Engineer uses motion picture camera to record combustion test rig

pumps for the removal of air. And now that closed circuit operation is possible, 8x6 economy is increased considerably through less demand on the expensive air dryer bed. Tunnel utility is also extended because air dryer limitations on operations are reduced. An added dividend is that a large scale transonic-supersonic tunnel has been provided at a fraction of the cost of building a new one to accomplish the same purpose.

Realization of the full potential of ramjet engines for guided missiles requires solution of combustion, internal flow, cooling and control problems. Many of these have been attacked and solved in full scale investigations in the 8x6 and 10x10 tunnels. In addition to basic and general research programs on ramjets, considerable effort is being devoted to ramjet power plants for specific missiles. This is a cooperative effort by Lewis, the manufacturers, and the Air Force in working out designs and methods to meet the high performance requirements demanded by missiles.

Basic principles of ramjet automatic shock-positioning control systems were outlined by Lewis several years ago. Later investigations evaluated general stability and response characteristics of various control loops and arrangements. Design requirements of satisfactory control systems were further established by determination of engine and inlet-duct dynamic characteristics. This information was used to build complete control systems which were operated on full scale ramjet engines in the laboratory.

Rockets, along with ramjets, have been receiving greater attention in recent years. Since the thrust of rocket power is essentially independent of flight speed, it is useful in assisting takeoff of heavily-loaded turbojet-powered aircraft, and in boosting ramjet-powered missiles to flight speed. These are, of course, only secondary uses of rocket power. The rocket is an ideal aircraft and missile power plant at extreme altitudes because its thrust increases in this realm where the air-breathing engines are no longer effective.

Lewis research has made a number of contributions to total knowledge of rockets. Fundamental studies have established widely-used pools of performance data for rocket propulsion systems. These studies have also provided useful information on high-altitude rocket ignition, high-energy propellants, cooling, and means for eliminating combustion oscillations. A major addition to the tools available to Lewis rocket researchers is the $2.5-million Rocket Engine Research Facility now being completed. Activity here will undertake to determine, with practical-sized rocket engines, means to utilize effectively new high-energy fuels. The facility is versatile enough to permit research and design ideas to be carried through initial investigations with low-cost fuels before using more expensive fuels of scarcer varieties.

Equipment here consists of a thrust stand, propellant supply and storage systems, silencing and exhaust gas disposal system, and an operations building which includes an instrument and control room.

As with other means of applying power to an aircraft, nuclear power offers its own unique reward—that of increased ranges unobtainable with conventional or chemical fuels. Much basic knowledge in many areas, including heat transfer, corrosion of materials, and shielding, must be obtained before nuclear-powered flight becomes a reality.

Schedueld for completion in 1959 near Sandusky, Ohio, is the NACA Research Reactor where Lewis scientists will study problems of aircraft nuclear propulsion. When in operation, the reactor will enable study of temperatures, stresses, corrosion, and radiation conditions which would be experienced in an aircraft nuclear power plant.

Aeronautical progress has been bounding ahead in recent years. Considering speed alone, during the 36 years from the Wright's flight in 1903 to World War II, top speed of airplanes was increased from 30 mph to 469 mph. With the advent of the research airplanes, speed jumped to 1,100 mph in 1947; then to 1,650 mph in 1953; and by last year it had pushed to more than 2,100 mph by the X-2. We may reasonably expect even greater performances from the X-15.

Progress in increasing speed of manned aircraft has been fast. It has also been fast with unmanned missiles. The missiles of World War II were in the 3,500-mph class. By 1949, rocketeers had brought missile speed up to 5,150 mph. Last year, an NACA research vehicle went to 6,864 mph. Since then, missiles have surpassed this mark.

These figures are cited merely to point out that some of the aeronautical mysteries are being solved. Lessons learned in making past improvements will engender greater future progress.

Individual blows of workmen chiseled the face of a mountain to produce sculpture of unique size and strength on South Dakota's Mt. Rushmore. Like these workmen, many agencies of research are contributing to the total effort which will untangle the aeronautical problems facing us. But, unlike the sculptors, the researchers who are chipping the face of progress will never complete their work. Each triumph will uncover additional problems demanding solution.

Scientists at NACA's Lewis Flight Propulsion Laboratory, teamed with other research men, will continue to find answers to problems as they arise. The facts of life are being faced.

The
PEGASUS

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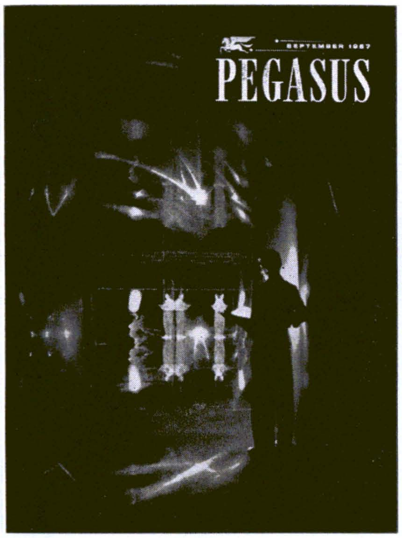
Published monthly by **FAIRCHILD** ENGINE AND AIRPLANE CORPORATION
Vol. 26 September 1957 No. 9
Hagerstown, Md.

THE FRONT COVER

Reflections from stainless steel sides of the 10x10-foot Supersonic Wind Tunnel at the Lewis Flight Propulsion Laboratory produce the eerie quality of this unusual photo



Ten Supersonic Years

Except for a handful of dedicated men who had been working toward a specific climax for a long time, October 14, 1947 was just another day. It was no more or less significant or eventful than any other.

It was not until June 10, 1948—nearly eight months later—that the public was informed that on that fateful fall day nearly eight months earlier Capt. Charles E. "Chuck" Yeager had become the first man to fly faster than sound. He had jockeyed the rocket-powered, stubby-winged Bell X-1 at better than 760 miles an hour after being dropped at 30,000 feet from the belly of a B-29 "mother plane."

Thus, as this is written, we are approaching the end of the first decade of supersonic flight. The next decade, and the ones to follow after it, will no doubt see even greater accomplishments in man's conquest of speed and space, but it is doubtful whether they will eclipse in importance this first pioneering 10 years.

Looking back, it is positively amazing the progress that has been achieved in the field of supersonics. Following that first eventful flight during which Yeager pierced the then mysterious "sound barrier", there were many other such sorties, and much valuable data recorded. Faster-than-sound flight became almost routine, and on December 12, 1953 Yeager, then a major, flew the X-1A at more than 1,600 miles an hour, and the top speed of this rocket craft now stands at something in the neighborhood of 2,160 miles an hour.

The real significance of the situation is the fact that for seven years after Yeager first cracked the sound barrier all supersonic flights were made in research aircraft. It was not until 1955 that the data collected by Yeager and others had resulted in the production of our first supersonic operational fighter—the North American F-100 Super Sabre.

In the two years since then there has been a succession of supersonic fighters in the USAF's so-called "Century Series." These include the McDonnell F-101, Convair F-102 and the Mach 3 (three times the speed of sound) Lockheed F-104, not to mention a number of Navy fighters of comparable capabilities. (A Navy F8U-1 fighter won the 1956 Thompson Trophy with a speed of 1,015.4 mph.) Now too, we have a Mach 2 bomber, the Douglas B-58 Hustler, which can show its tail to all but the fastest fighter craft. Meanwhile, missiles have achieved speeds of Mach 10 and up.

During the next decade the big battle will be against the "heat barrier"—to develop metals and other materials capable of standing up under the tremendous friction heat generated in supersonic flight. Just recently it was announced that a new stainless steel capable of withstanding heat and stresses up to Mach 4 has been developed, and new break-throughs in this field are sure to follow.

It will take someone with more technical knowledge and imagination than we to even hazard a guess as to what flight speeds will be 10 years hence. The genesis of whatever comes to pass in the realm of supersonic flight, however, can be traced directly to these past 10 years.—RGP

PEGASUS PICTURES

BACK COVER: Propellers awaiting installation frame C-123 assault-logistic transports in this view from prop shop at Fairchild Aircraft Division. Photo by Floyd B. Hall.

CREDITS: Pages 1 through 5, National Advisory Committee for Aeronautics. Page 6, top, US Air Force; lower right, Fairchild Engine Division; balance, General Dynamics Corporation. Pages 8 through 12, Southwest Airmotive Company. Page 15, Air National Guard.

PRINTED IN U.S.A.
JUDD & DETWEILER, INC.
WASHINGTON, D. C.