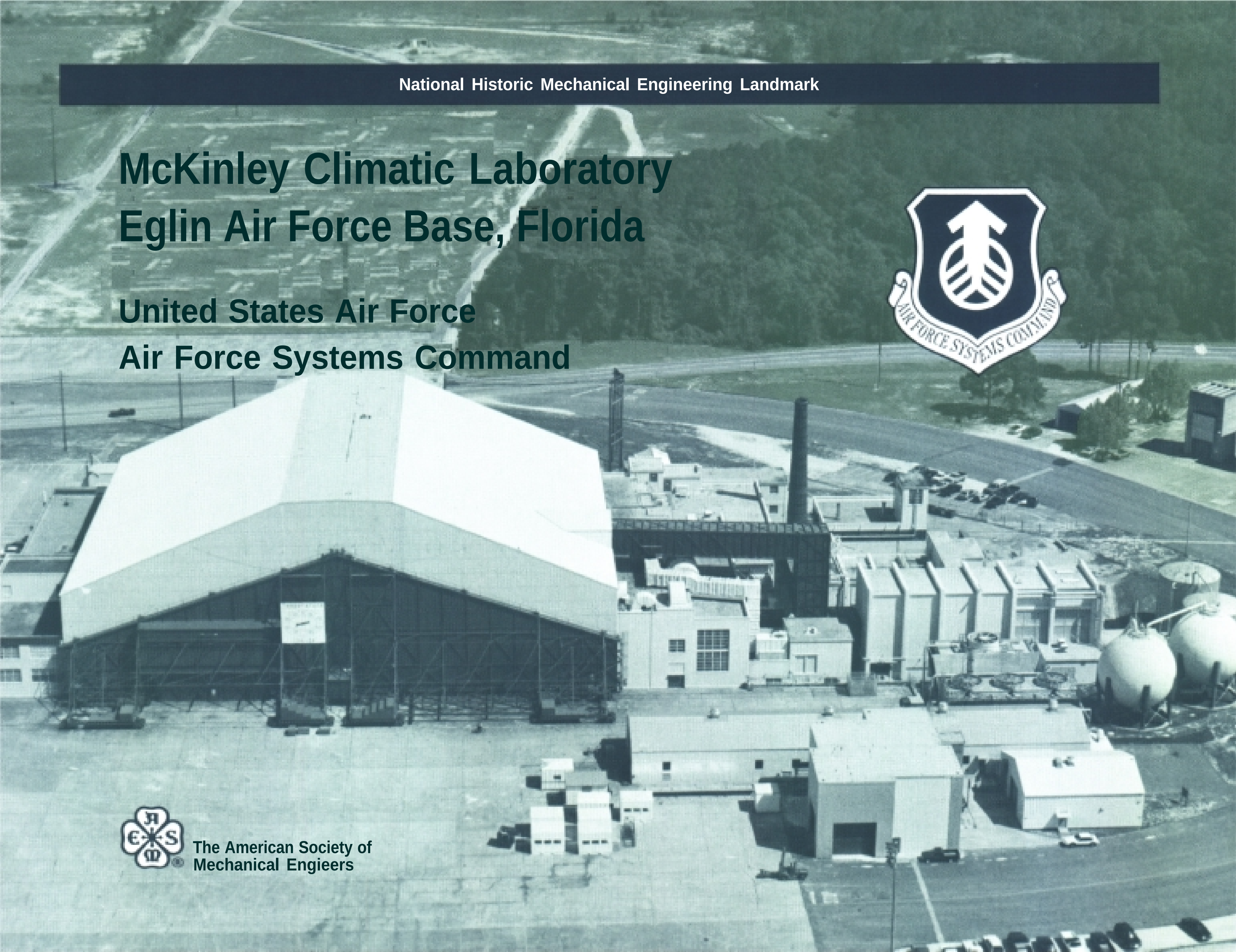
National Historic Mechanical Engineering Landmark

McKinley Climatic Laboratory
Eglin Air Force Base, Florida

United States Air Force
Air Force Systems Command



The American Society of
Mechanical Engieers

Historical Significance of the Landmark

Aviation advanced dramatically in design and manufacture during World War II. The Army had built Ladd Field at Fairbanks, Alaska, in 1940 as a child-weather testing station. Rigorous testing was difficult, however, due to the unpredictability and erratic duration of cold periods. The results of many tests were questionable. In the winter of 1942-43 U. S. Army learned that even the usually efficient German Air Force could not get its planes into the air during sub-zero weather. In September 1943 the cold testing program was assigned to the Air Proving Ground Command at Eglin Air Force Base in northwest Florida In May 1944 the Army Air Force approved plans for a refrigerated airplane hangar building.

The first tests began May 24, 1947, with a B-29, a C-82 cargo plane, P-80, P-51, P-47 fighters, and R5D helicopter in the hangar, as well as trucks, tanks, and clothing.

Modifications have kept the Climatic Laboratory able to test current aircraft including the C-5A, the largest transport. Today, its schedule is filled years in advance. The Climatic Laboratory is historically significance as the first and only facility of its kind. It has contributed significantly to the reliability of U.S. military equipment. The individual machines are not historic firsts but the complete plant and building are.

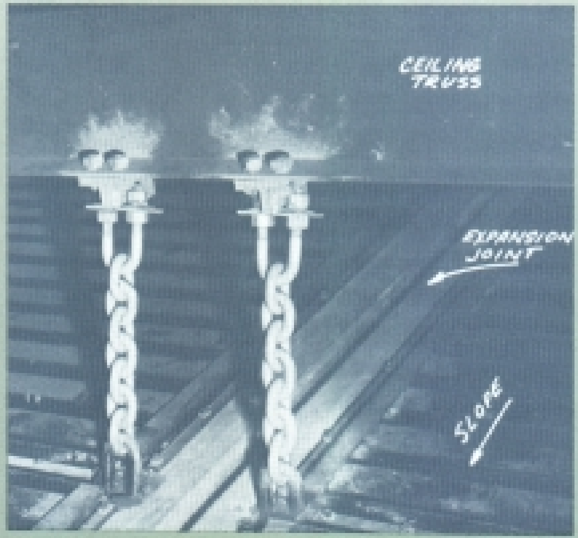
Technical Background

The purpose of the Climatic Laboratory is to measure the performance of parts of airplanes to armament when cold (or hot) and to find the cause when parts do not work. Measurement are made by instruments read by observers in a comfortable office. Aircraft are supported and tied so that wheels can be stowed and engines run. The ability to make detailed measurements during operations is the prime advantage of laboratory testing over outdoor testing Instrumentation has changed to keep pace with current technology. At present digital data transmission and a central computer are in use.

Description

The project, as proposed by Lieutenant Colonel Ashley C. McKinley, called for a refrigerated airplane hanger with several smaller rooms for armament and engine tests, workshops, and offices. The cover photograph of this brochure identifies the components of the facility.

To the left of the hanger is a two-story office and instrumentation building. The hanger doors are outside the building and roll on railroad tracks. Note the trusswork supports. Attached to the right front is the refrigeration-machinery building containing centrifugal compressors with heat exchangers, air-moving fans, and pumps. The two

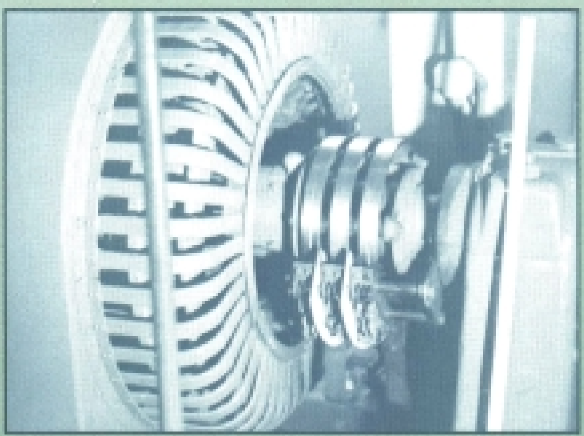


The ceiling deck supports 13 inches of insulation and is hung from the roof trusses. Only the chains go through the insulation. Shown during construction

spheres and two cylinders on the right are insulated tanks for cold liquids. To the left of the left sphere are cooling towers for evaporative cooling of the water that cools the compressed refrigerant gas. Behind the cooling towers is a cold-test cell for jet engines. Behind this engine cell is the smokestack of the steam-heating plant.

Refrigeration System

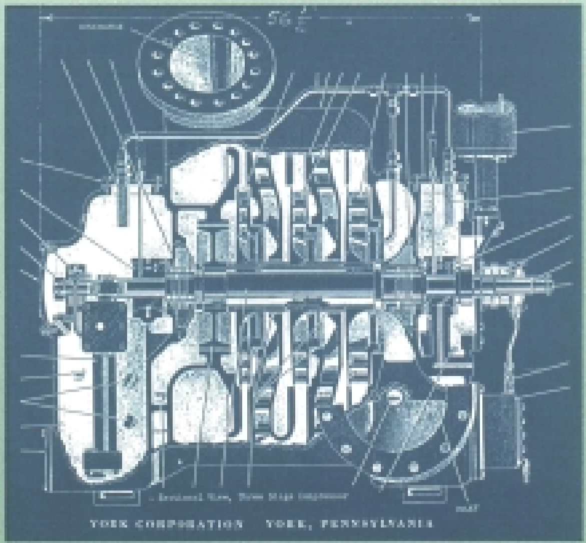
The refrigeration system is designed for flexibility, able to deliver cold air over a wide range of temperatures. Air is chilled by liquid refrigerant flowing through tubes because heat tranfer per unit area from metal to liquid is much faster than from metal to vapor. Liquid Freon 12 is pumped from the lowest pressure vessel, called the "surge tank," through air-cooling coils and back into the same tank. In the surge tank, pressure is maintained at the saturation pressure corresponding to the desired temperature for liquid going to the coils. The centrifugal circulating pumps maintain



The far end of the motor showing slip rings.

enough pressure on the cold refrigerant so that it does not vaporize in the coils. Part of the warmer liquid returning from the coils will evaporate when its pressure is reduced as it flows into the surge tank. Vapor flows from the top of the surge tank into the low-pressure-stage compressor.

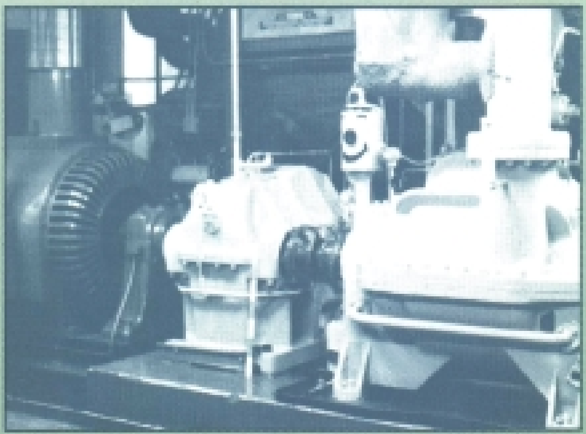
Vapor from the low-stage compressor (about 20 psig) flows into an intermediate pressure vessel called the "desuperheater," where the pressure is reduced. Here some vapor condenses to liquid, which flows back to the surge tank while vapor goes to the high-stage compressor. Discharge pressure from the high stage is about 150 psig. Here the vapor is hot enough to transfer heat to cooling water from the cooling towers. Liquid from the condenser can be sent to



Sectional view of the three-stage compressor, from an instruction book.

expand into the intermediate-pressure desuperheater or into the low-pressure surge tank or into the storage tank.

There are three refrigerating systems as described above. Each high-stage compressor is driven by a motor rated at 1,250 hp and each low-stage compressor has a 1,000 hp motor. Each of the six cooling plenums and two heating plenums contains two banks of coils. Each bank is 2 ft by 6 ft perpendicular to the air flow and 8 ft in the flow direction. Each plenum has a 100 hp fan capable of moving 78,500 cfm of air at -70°F. Centrifugal compressors are driven through step-up gears. The low-pressure compressor has four stages and is driven through 1.815 to 1 ratio gears.



1,500 hp centrifugal compressor driven by original wound-rotor induction motor through step-up gears. A one-meter stick appears in this photograph.

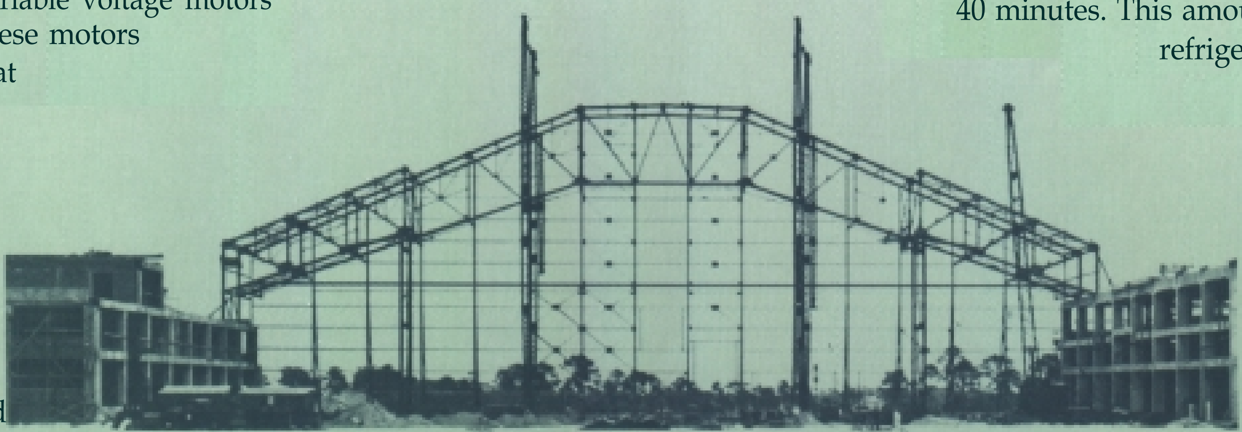
The original motors were wound-rotor induction motors rated 1,770 rpm at full load. The high stage has 4.083 to 1 gear ratio and its compressor has three stages. The wound-rotor motors were operated between 1,000 rpm and 1,770 rpm. The rotor windings are connected through three slip rings to external resistors having thirteen resistance steps. This arrangement allows compressor-pressure ratio to be reduced to fit temperature requirements. Power savings through operating the refrigeration at the best pressure ratio exceeds losses in the induction motors even though the motor efficiency goes down in proportion to the speed reduction. For example, when operating at half speed, the pressure ratio would be 1/4 normal and power needed 1/8 normal. Then with motor efficiency reduced to 1/2 normal, the motor shaft power would be 1/8 normal, but the electric load would be 1/4 of full load.

The York Corporation built the refrigeration equipment and Allis-Chalmers built the motors. Recently the induction motors were replaced by brushless synchronous variable frequency variable voltage motors made by EMICC. These motors keep their efficiency at reduced speed. They are operated between 350 and 1,800 rpm.

Air-makeup System

When engines under test are run, the air used is exhausted from the building and is replaced by cold air from the air-makeup system. The original system, called the jet wing system, has maximum capability of 200 pps of outside air. It has one 1,500 hp centrifugal compressor, driven by the only original wound-rotor induction motors remaining.

After leaving the jet wing, the air is further cooled in the six main cooling plenums and mixed with return air. The original plant could test the largest reciprocating engines, but only small jet engines at take-off power. The air-makeup system was added in 1966 to provide air for large jet engines. Total capacity was raised to 450 pps. The full power of the refrigeration is needed for only about two hours a day when engines are run. Only a small part of the capacity was needed to keep the chamber cold.



This 1945 photograph shows the concrete side buildings supporting the first roof truss, which is 24-feet thick. The span is 254 feet.

The remaining capacity can be stored about 20 hours to be withdrawn in 1/2 to 2 hours to provide replacement air when large jet engines are run.

This is accomplished by storing a 20 percent solution of calcium brine at 24°F and methylene chloride at -97°F. When a test begins, one cylindrical tank holds 110,000 gallons of calcium chloride while the other is empty. This Stage I system can cool 450 pps of high-humidity air from 100°F to 40°F for 40 minutes. This equals 4,485 tons of refrigeration. The low-temperature Stage II liquid is methylene chloride stored in 36-ft spherical tanks holding 137,500 gallons. It can cool 450 pps of saturated air from +40°F to -65°F for 40 minutes. This amounts to 4,285 tons of refrigeration. The air-makeup system added 800 hp to the previous load while adding 8,700 tons of refrigeration. The cross section of the tube banks is 31 ft by 40 ft.

When an engine is run, a 700-hp variable-speed fan blows outside air over coils in the air-makeup plenum while pumps circulate brine through the coils. Air goes first across the tubes containing calcium chloride and then across the tubes containing methylene chloride and then can go either into the main chamber or the engine test chamber. Larger engines take more air so the brine must be expended more quickly and test time is shorter. An engine using 450 pps can be run 40 minutes. A test begins with one brine tank full of chilled liquid and the other empty.

Main Chamber Dimensions

The main chamber dimensions are 252 ft wide, 201 ft deep, and 70 ft high in the center. Usable floor area is 55,000 square ft. The upper temperature is 165°F when the steam heating is run. Following are features of other chambers:

All-Weather Room: 42 by 22 ft. Temperature: +170°F to -80°F. Rainfall to 15 in. per hour. Wind machine: 60 knots. Snow can be produced. Weather can be changed in a few hours. This room is regularly used.

Temperature Altitude Chamber: Altitude pressure to 80,000 ft. Temperature controlled to +140°F to -80°F. Chamber size: 13.5 ft long, 9.5 ft wide, 6.9 ft high. This room is frequently used.

Engine Test Cell: This room has not been used for engines in recent years because engine builders have their own facilities. It is used for battle tanks, trucks, radar, etc. It has air makeup equal to the main chamber.

Small Test Rooms: Originally the Climatic Laboratory had several small test rooms: Desert Room, Hot Test Room, Marine Room, and Jungle Test Room. These rooms have been removed.

While the machinery was state of the art in 1945, the building was a step into the future. The original floor was formed of reinforced-concrete slabs 12 in. thick and 12.5 ft square. The slabs had expansion joints made of sheet copper and rested on insulation consisting of 15 in. of cellular glass block, vapor sealed with roofing felt top and bottom. The glass block insulation rested on a subfloor of 8-in.-thick reinforced concrete. The floor had been failing, however, because water had penetrated the insulation. The central part of the floor was replaced in 1990, using 25-ft square top slabs with silicone joint sealing and rubberized-asphalt vapor seal around the foam-glass insulation blocks. The contraction of the slabs, calculated at 0.28 in., requires the joints to be 9/16 in., to stay within the stretch limit of the seal.

The walls and doors of the main chamber are insulated with 13 in. of glass-wool board enclosed on both sides by galvanized steel. Each of the main doors weighs 200 tons and is supported on rails 25 ft apart. When the doors close, hooks engage catches about the perimeter. A power drive draws on the hooks and pulls the door about 6 in. against sponge-rubber seals. The ceiling insulation is supported by a corrugated steel deck. Deck beams are hung from the trusses by chains. Only the chains and light wires penetrate the insulation. The air ducts are in the room. The vapor barrier on the warm side of the insulation began failing after 30 years. At times there have been 200-Pound icicles hanging from the ceiling.

Abbreviations:

amp	amperes
cfm	cubic feet per minute
hp	horsepower
pps	pounds per second
psi	pounds per square inch
psig	gage pressure above atmospheric
rpm	revolutions per minute
v	volts

Biography

On June 12, 1971, the great refrigerated hanger at Eglin AFB was formally dedicated as the McKinley Climatic Hanger to honor Col. Ashley C. McKinley (1896-1970). Col. McKinley's career began when he enlisted in the Missouri National Guard in 1916 and later in the Army Signal Service. There, he won his wings as a dirigible pilot and later commanded a balloon observation company on the front lines. He later instructed in aerial photography and surveying. His book on aerial surveying was considered a standard of its time.

In 1926 Capt. McKinley resigned from the Army and operated an aerial surveying and photography business. In 1928-29 he photographed the Byrd Antarctic Expedition. He describes his photography of the flight to the South Pole in the October 1932 *National Geographic.*

In 1941 McKinley reentered the Army Air Corps and immediately was placed in charge of the Army Air Force cold-weather operations at Ladd Field, Alaska. Here he found the testing for airplane cold performance to be unreliable and excessively expensive. Through experience with delivery of airplanes to Russia over the northern route and contacts with Soviet pilos, he concluded that all U.S. military planes should be capable of operating at -65°F. He served at Eglin AFB during the planning and building of the Climatic Laboratory and retired with a disability in 1947 soon after completion of the Climatic Laboratory project.

He then joined Admiral Byrd as a civilian consultant. During the final five years of his career he was in charge of a Navy staff section. He died in Florida on February 11, 1970, and is buried at Arlington National Cemetery.

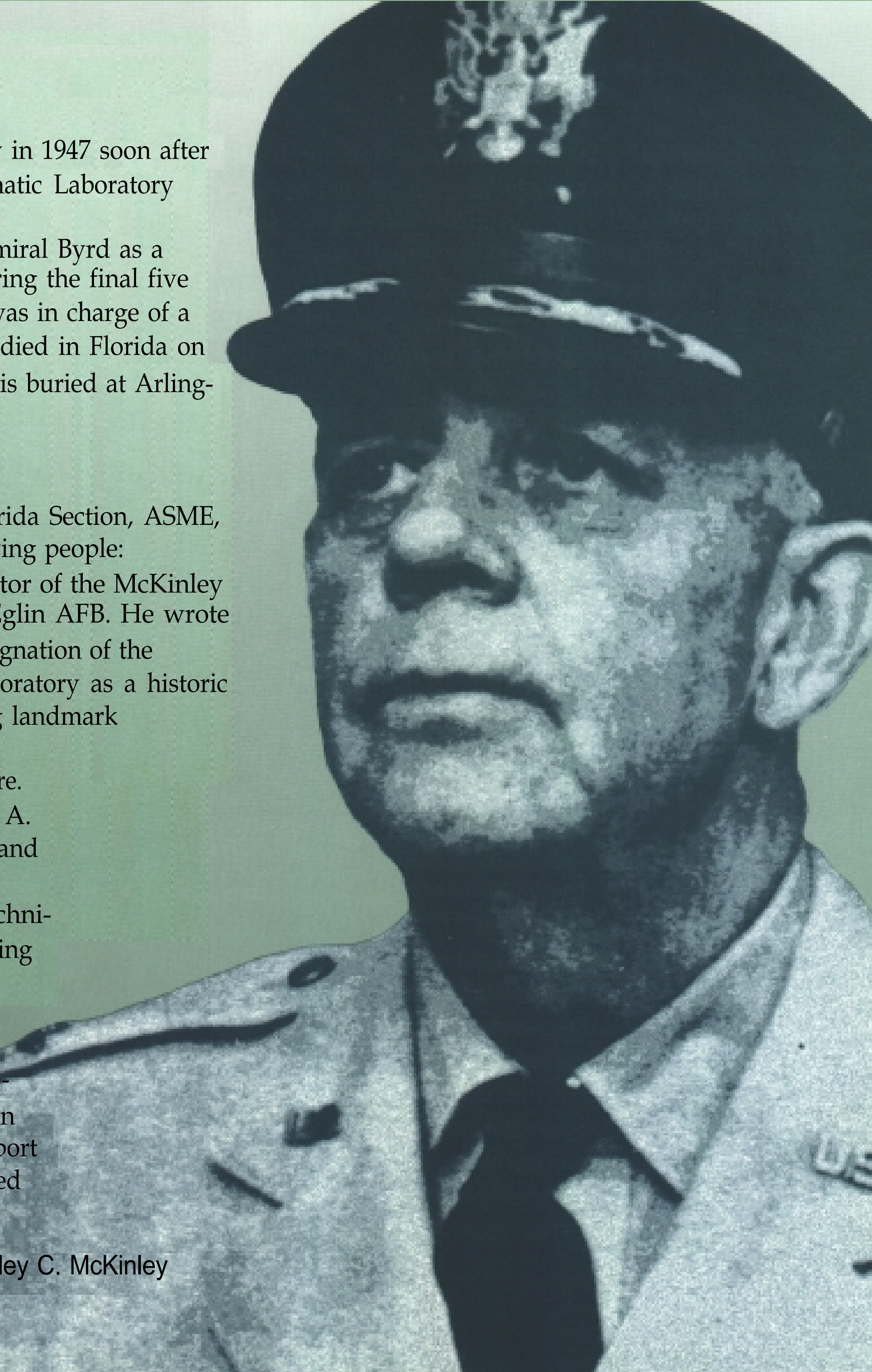
Acknowledgments

The Northwest Florida Section, ASME, is grateful to the following people:

Kirk Velasco, Director of the McKinley Climatic Laboratory, Eglin AFB. He wrote the nomination for designation of the McKinley Climatic Laboratory as a historic mechanical engineering landmark in 1987 and helped the author with this brochure.

Joe Shearer, Robert A. Gary, Stan Loenntzen, and Richard L. Coker—all employees of Vitro Technical Services, the operating contractor—provided explanation of the machinery.

Julie Massoni, historian, MSD, AFSC, Eglin AFB, arranged for support of this writing and edited the brochure.



Col. Ashley C. McKinley

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The History and Heritage Program of the ASME

The ASME History and Heritage Recognition Program began in September 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee, initially composed of mechanical engineers, historians of technology, and curator (emeritus) of mechanical engineering at the Smithsonian Institution. The Committee provides a public service by examining, nothing, recording, and acknowledging mechanical engineering achievements of particular significance. The History and Heritage Committee is part of the ASME Council on Public Affairs and Board on Public Information. For further information please contact Public Information, American Society of Mechanical Engineers, 345 East 47 Street, New York, NY 10017-2392, 212-705-7740.

Designation

The McKinley Climatic laboratory is the 85th National Historic Mechanical Engineering Landmark to be designated. Since the ASME Historic Mechanical Engineering Recognition Program began in 1971, 20 international, 85 national, and 9 regional Historic Mechanical Engineering Landmarks have been recognized. Each reflects its influence on society, either in its immediate locale, nationwide, or throughout the world.

An ASME landmark represents a progressive step in the evolution of mechanical engineering. Site designations note an event or development of clear historical importance to mechanical engineers. Collections mark the contributions of a number of objects with special significance to the historical development of mechanical engineering.

The ASME Historic Mechanical Engineering Recognition Program illuminates our technological heritage and serves to encourage the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians, and travelers. It helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

NATIONAL HISTORIC
MECHANICAL ENGINEERING LANDMARK

McKINLEY CLIMATIC LABORATORY
EGLIN AIR FORCE BASE, FLORIDA
1944

DESIGNED AND CONSTRUCTED IN THE EARLY 1940s, THIS LABORATORY HAS AN UNEQALLED CAPACITY TO SIMULATE A WIDE RANGE OF CLIMATIC CONDITIONS FROM ARCTIC COLD TO DESERT HEAT TO JUNGLE MOISTURE. DATA FROM TESTS OF SOME 300 DIFFERENT AIRCRAFT AND OVER2,OOO ITEMS OF EQUIPMENT PROVIDED INFORMATION VITAL TO THE PERFORMANCE, SAFETY, AND RELIABILITY OF AIRCRAFT OPERATING IN EXTREMES OF WEATHER.

ORIGINALLY KNOWN AS THE CLIMATIC HANGAR, THE LABORATORY WAS RENAMED IN 1971 IN HONOR OF COLONEL ASHLEY C. McKINLEY, USAF, WHO FIRST RECOGNIZED THE NEED FOR AN ALL-WEATHER TESTING FACILITY AND MADE MAJOR CONTRIBUTIONS TO ITS DESIGN.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS – 1987

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