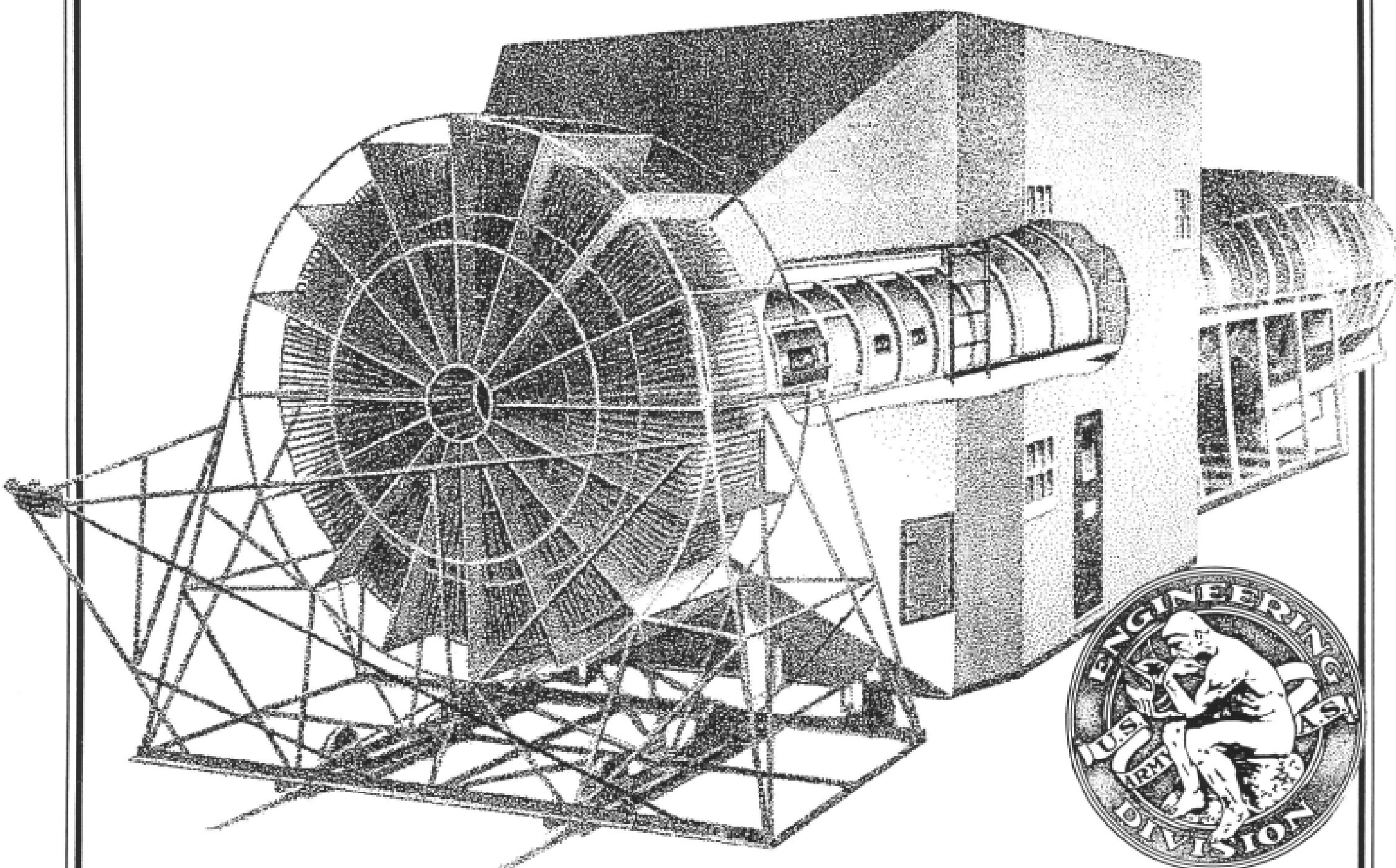
The American Society of
Mechanical Engineers

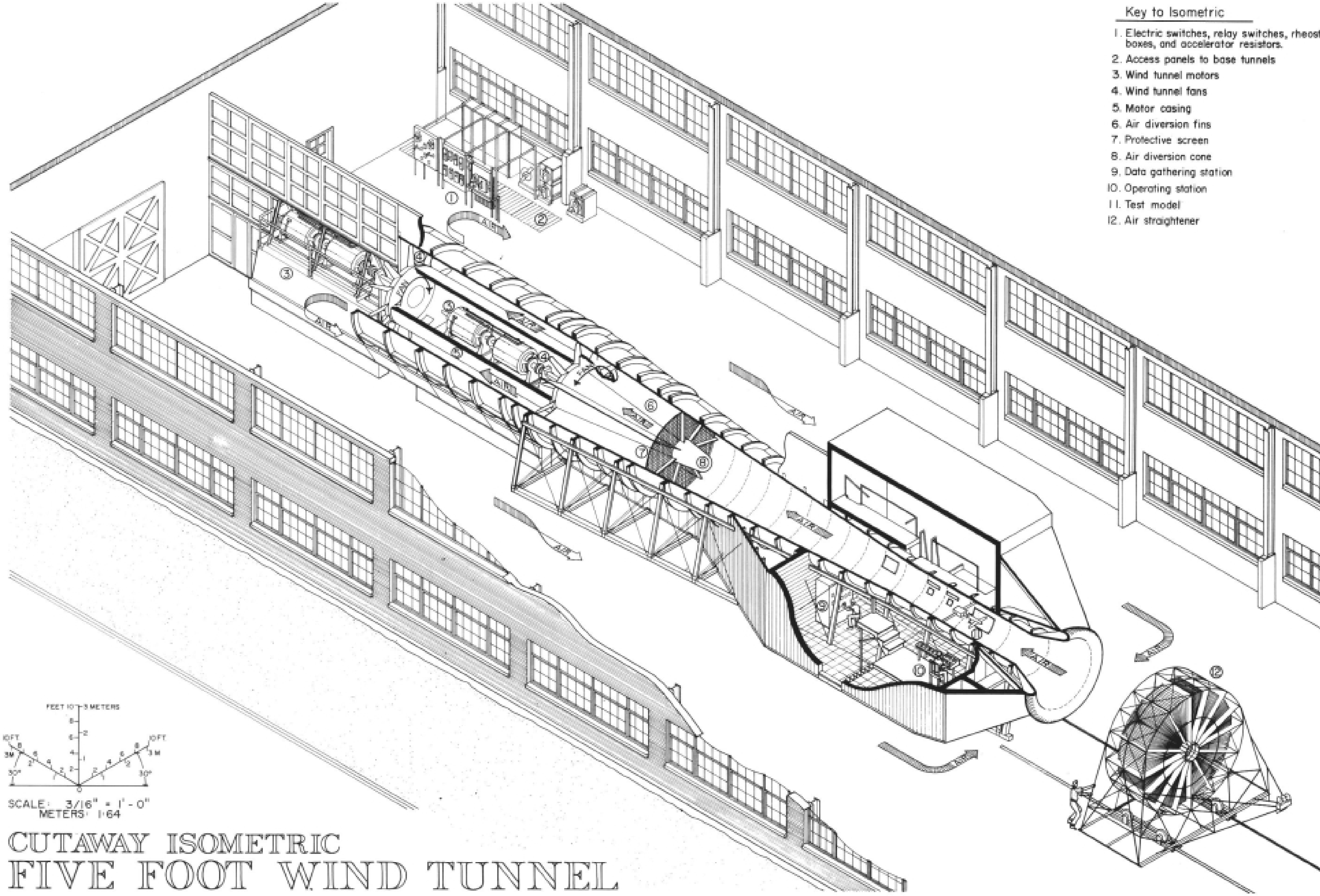
WRIGHT FIELD FIVE-FOOT WIND TUNNEL



A National Historic Mechanical Engineering Landmark

United States Air Force
Wright-Patterson Air Force Base
Dayton, Ohio

March 22, 1995



Key to Isometric

1. Electric switches, relay switches, rheostat boxes, and accelerator resistors.
2. Access panels to base tunnels
3. Wind tunnel motors
4. Wind tunnel fans
5. Motor casing
6. Air diversion fins
7. Protective screen
8. Air diversion cone
9. Data gathering station
10. Operating station
11. Test model
12. Air straightener

CUTAWAY ISOMETRIC
FIVE FOOT WIND TUNNEL

DELINEATED BY: Hardlines: Design & Delineation, 1992

WRIGHT-PATTERSON AIR FORCE BASE RECORDING PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

WRIGHT-PATTERSON AIR FORCE BASE - FIVE FOOT WIND TUNNEL
BUILDING NUMBER 19
DAYTON VICINITY
GREENE COUNTY
OHIO

SHEET 4 OF 4

HISTORIC AMERICAN ENGINEERING RECORD
OH-79-B

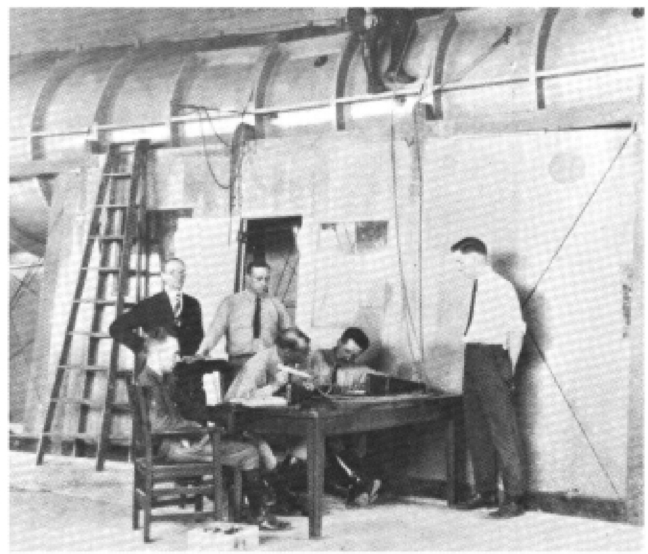
Introduction

The Wright Field Five-Foot Wind Tunnel is an outstanding example of an early aerodynamic testing facility that remains active today. The 5ft (1.52m) dimension refers to the diameter of the test section where the model to be tested is located. The tunnel was well known from the early 1920s to the late 1950s for its aerodynamic testing, contributions to aeronautical research and the development of nearly every major aircraft and associated hardware used by the U.S. Air Force and its predecessor the Army Air Service. It was conceived, designed, and built when very little aerodynamic theory or test data was available that could be used as a baseline for its design. The wind tunnel is a remarkable woodworking job and was considered an important money-saving device guiding the construction of early aircraft. It is a unique specimen of a highly sophisticated wind tunnel and is one that remains today. In a sense, it represents an extension of the Wright brothers' principle of applying wind tunnel testing as a technique to develop aerodynamic parameters and as a vital step in the airplane development cycle. Early wind tunnels showed the way for the first successful powered flights. They enabled the establishment of aeronautics as an exact science by allowing the measurement of lift and drag coefficients. Airplane development would have been more costly, dangerous, and slow if the five-foot wind tunnel had not been available for use prior to flight testing. The Air Force Institute of Technology today maintains and uses this facility as a teaching and research tool, and it remains a part of aviation history.

Facility History and Significance

The five-foot wind tunnel was constructed at McCook Field in Dayton Ohio during the 1921-1922 time period and was housed in a standard steel hanger. It was moved to its current site, Area B at Wright-Patterson Air Force Base during the 1928-1929 time period.

The five-foot wind tunnel was conceived by Air Service Engineering Division personnel at McCook Field based partially upon contacts they had with National Advisory Committee for Aeronautics (NACA) personnel in the early 1920s, their earlier constructed high speed 14 in (35.6 cm) tunnel, and their general knowledge of other facilities. The 14-in tunnel had been designed using the tunnel in the laboratory of Orville Wright as a basis for size and other characteristics. Prior to initiating the design of the five-foot tunnel, they had numerous contracts with the Massachusetts Institute of Technology (MIT) for testing models of early aircraft designs in the MIT 4-foot tunnel. Engineers at McCook Field originally designed an 8 ft (2.44 m) diameter tunnel but compromised to a 5 ft one due to air flow requirements and characteristics, speed range, cost, and portability requirements. It was projected during design that the tunnel would move to a permanent location at Wright Field in the near future.



Five-Foot Wind Tunnel Test (Early 1920's)
McCook Field

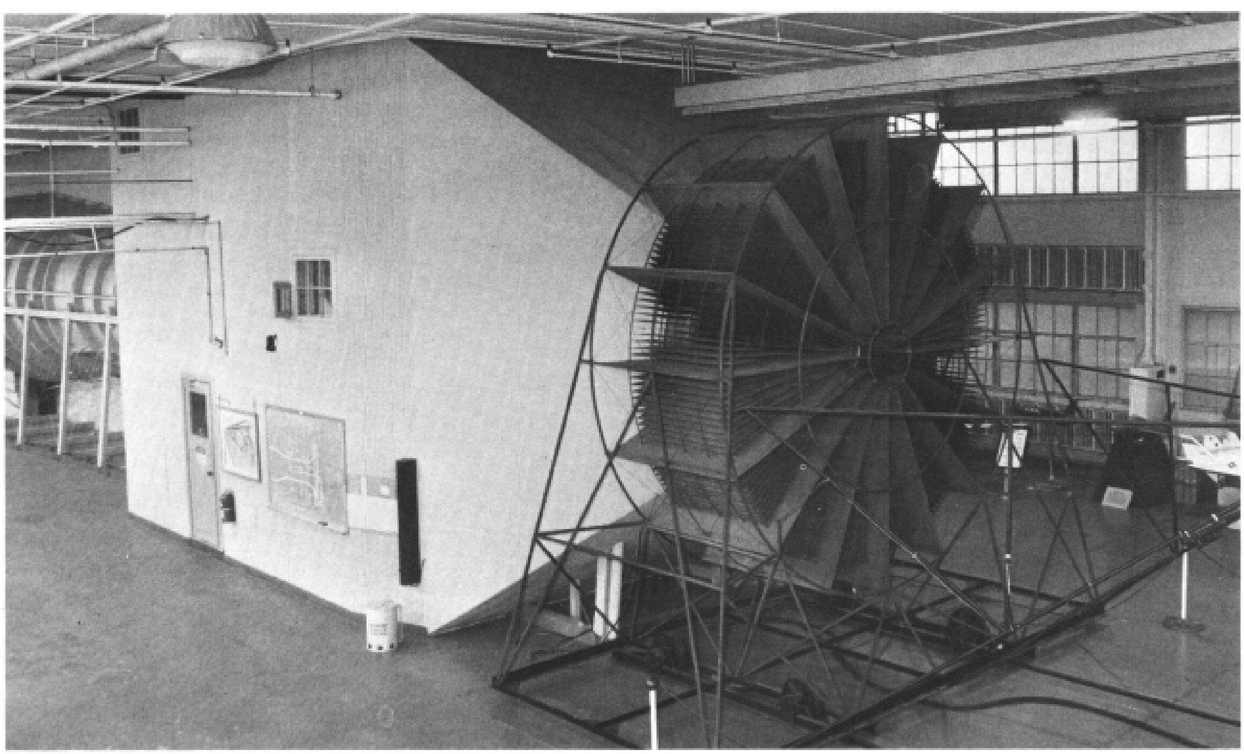
The design and technical specifications leading to the construction of the tunnel were prepared by personnel of the Engineering Division, Air Service. The tunnel components were planned and fabricated by McCook Field workmen. It was completed in 1922, and the final inspection team included Orville Wright.

The tunnel is the oldest operating wind tunnel in the country and represents a significant part of aviation history. It is an early example of a modern wind tunnel as well as a rare artifact that remains from McCook Field which was the predecessor of Wright Field. The tunnel is now located in Building 19, Area B, Wright Field which is a historically significant structure due to its age and that the building has not changed since it was built (Ref 8). The tunnel was planned as a research tool and also for engineering development. The tunnel was also used for various types of testing in the 1920s, 1930s, through World War II and beyond. In 1958, the management of the facility was turned over to the Air Force Institute of Technology (AFIT) where it is still used as a teaching and research tool.

The Wright Field Five-Foot Wind Tunnel is currently operational. It is supervised by the Air Force Institute of Technology. It is not generally open or available to the public. However, special arrangements can be made to tour the tunnel area by calling the AFIT Office of Public Affairs (513) 255-2216 or 9314.

Technical Background and Description

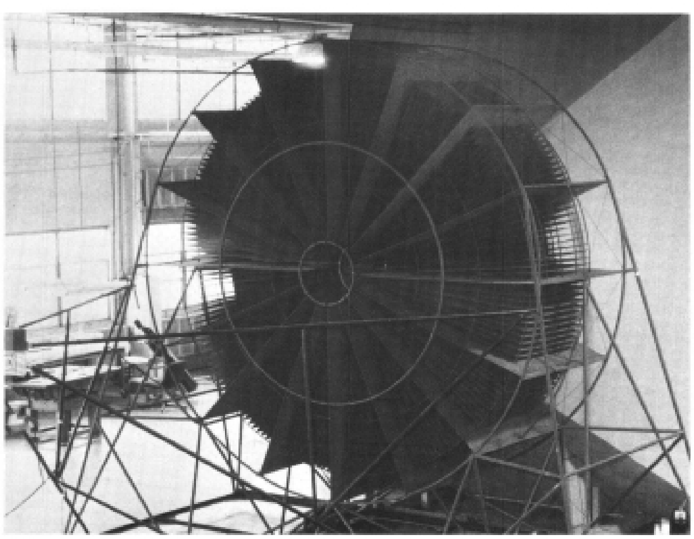
The five-foot wind tunnel can test models with wings spans up to 40 in (1.02m). It is a semi-open-circuit-type tunnel: room air is mixed with discharged air and drawn through the air straightener into the rounded 10 ft (3.05m) intake bell. The cutaway view of the tunnel (inside front cover) shows the air straightener pulled back from the tunnel air inlet, for illustration only, to show the tunnel inlet shape. The tunnel then tapers in diameter to the 5 ft test section. After the test section, the diffuser gradually increases in diameter to its maximum of 12 ft (3.66 m). At this point, the air enters the first



Five-Foot Wind Tunnel in Bldg 19, Wright Field

fan, then passes through the counter-rotating second fan before being discharged into the room. The two-fan design was developed for economic considerations. The tandem fan arrangement was a compromise between power, fan diameter and fan speed available (Ref 2). Four Sprague dynamometers, rewired as electric motors, were available as surplus from another program. Conserving electric power and low initial costs were considered important design goals.

Considerable effort was expended in conducting model tests to achieve smooth, efficient air flow. The diffuser allows an interchange of potential and kinetic energy of the fluid flow. One goal was to develop a diffuser design where the total energy of air moving at the downstream end of the diffuser end was within ten per cent of its value at the inlet end. No thorough analysis of the aerodynamic characteristics of this interchange of energy had been previously perfected, and the design of the five-foot tunnel was based upon model tests. When built, it was considered the most efficient wind tunnel in the world (Ref 1). Other tunnel components such as the intake bell and air straightener were designed in a similar manner to produce smooth air flow. The tunnel centerline was elevated above the floor such that the volume above and below the tunnel centerline were in the optimum relationship to maximize return air.



Five-Foot Tunnel Air Flow Straightener

GENERAL SPECIFICATIONS
FIVE-FOOT WIND TUNNEL

Type Operation	Continuous
Stagnation Pressure	1 ATM (1.01 x 10^5N/m^2)
Power (4 Motors)	1600 HP (1193 KW)
Mach No. Range	0 - 0.3 (Approx)
Maximum Reynolds No.	1 X 10^6

A honeycomb type of structure was inserted into the throat of the intake bell for low speed tests. The air-flow straightener is on rails to facilitate the installation or removal of this honeycomb (Ref 7). It was also necessary to generate uniform air flow in the test section to add an aerodynamic fairing in front of the fan hub. A protective screen and air diversion cone were also placed before the first fan. Air diversion fins were located radially around a cylindrical core corresponding to the hub size and extending between the fans. The air passageway in the annular space has a constantly increasing area and air flow reaches its minimum velocity just before entering the first fan.

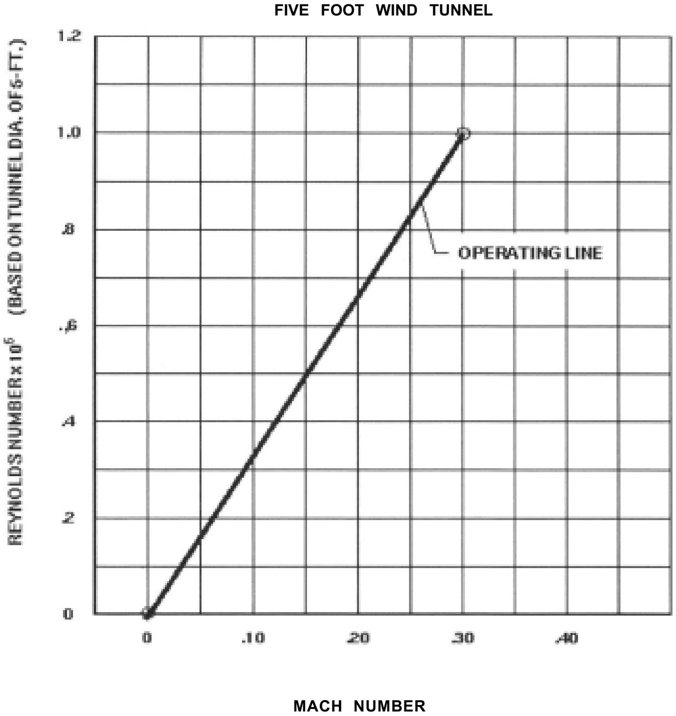
The intake bell, cylindrical tube, and diffuser sections of the tunnel were constructed from wood. Outer rings were built up by gluing together a number of segments to a thickness of about four inches and a depth of about six inches. To make the individually curved segments, large square boards were first glued together and the segments cut out to the proper curvature. Narrow staves of seasoned Port Arthur cedar were cut in a four-sided molder with tongue-and-grove joints. These were then

GENERAL DIMENSIONS
FIVE-FOOT WIND TUNNEL

	Length			Diameter	
Section	**Ft**	**M**		**Ft**	**M**
Tunnel Proper	96	29.26	Max at Fans	12	3.66
Intake Bell	5	1.52	Lip	10	3.05
			Throat	5	1.52
Test Section	18	5.49		5	1.52
Diffuser	48	14.63	Entrance	5	1.52
			Exit	12	3.66
Fan Section	25	7.62	Intake	12	3.66
Fan	12 Blades			11.92	3.63
Hub				8.67	2.64
Longitudinal Axis	9.92 ft (3.02m) above floor				

REYNOLDS NUMBER VS MACH NUMBER

FIVE FOOT WIND TUNNEL

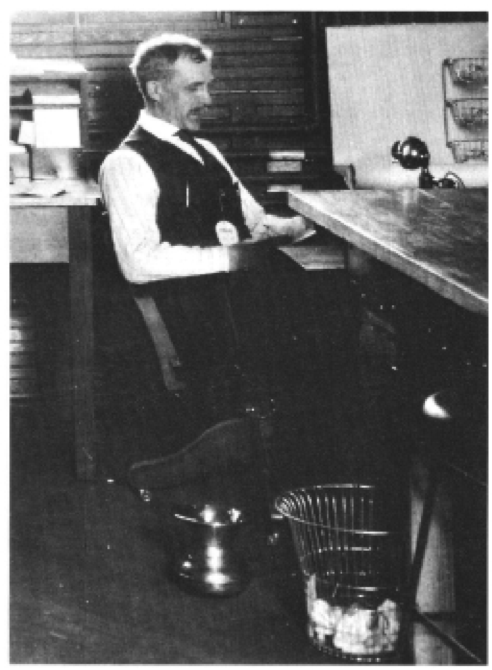


DESIGN

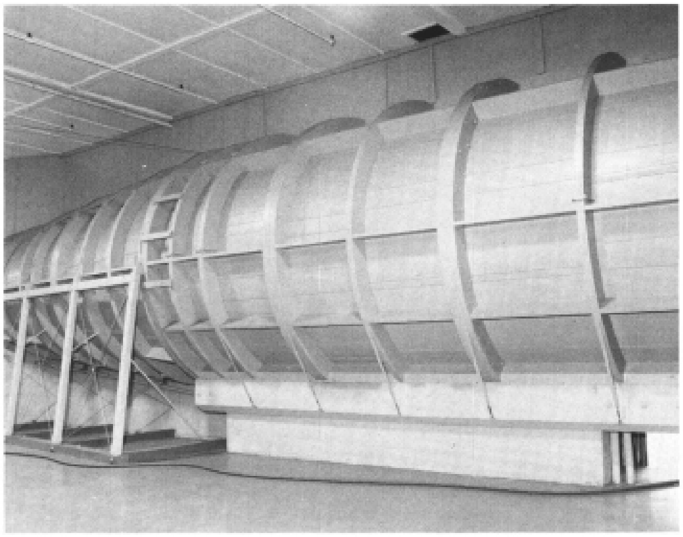
E. N. Fales was an aeronautical engineer, Air Corps, Materiel Division, Dayton, Ohio. He researched many of the existing aerodynamic testing facilities available after World War I both in the United States and Europe, and it is believed that this information was used to develop the characteristics and design of the five-foot tunnel. Many of the early technical reports and literature written describing the five-foot tunnel, its performance, design, and impact upon airplane development were authored by Fales.

CONSTRUCTION

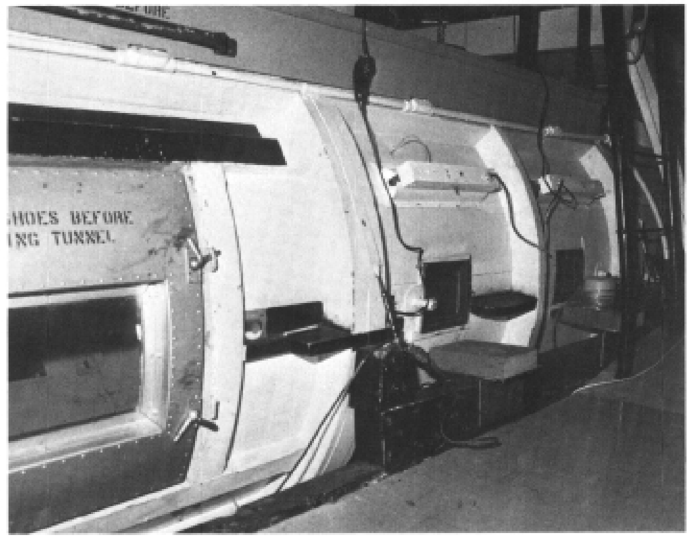
Construction of the tunnel was under the direct supervision of R. J. Myers, Foreman of the Wood Shops and a 40 year wood working veteran. He came to McCook Field during World War I and was one of the very early personnel of the Engineering Division. It was reported in 1923 that the wind tunnel was planned and constructed without special design drawings or specifications. This was evidence of the skill of McCook Field's wood workers.



R. J. Myers



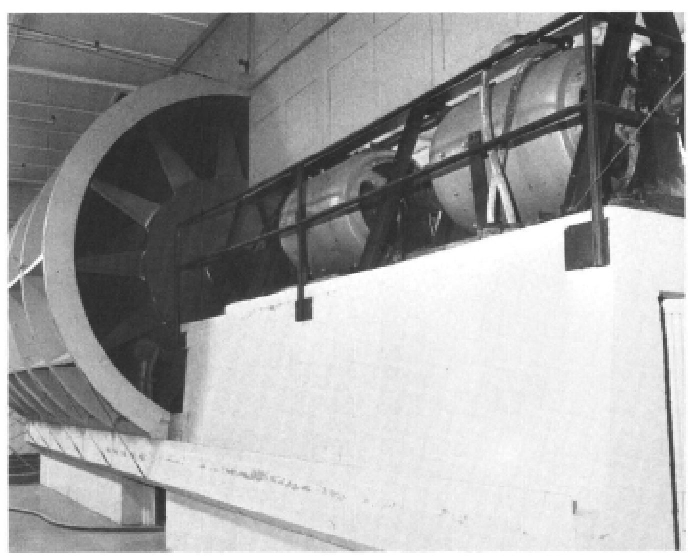
Five-Foot Tunnel Wooden Construction



Five-Foot Tunnel Test Section and Observation Windows

placed inside the circumferential rings and glued and screwed together. Each section of the tunnel was therefore a rigid unit. These units were then bolted together at the flanges to form the tunnel walls. Sections were supported from the floor by cradles under alternate rings.

Models were supported in the test section by wires connected to the measuring balances. Two force balances were provided for the tunnel. For low speed work, a standard National Physics Laboratory (NPL) type balance was used to compare data with earlier tests. For high speed work, a balance of the Wright type, which still exists today, was used. This balance was a new feature, that eliminated velocity fluctuations and allowed the operator to directly read the lift to drag ratio. Today, a full six-component strain gage balance measures aerodynamic forces, and the model is mounted at the front of a beam (sting) which is supported downstream from the tunnel walls or floor to reduce or eliminate air turbulence on the model. Models were installed or removed from the tunnel through two small doors located in the top of the tunnel test section.



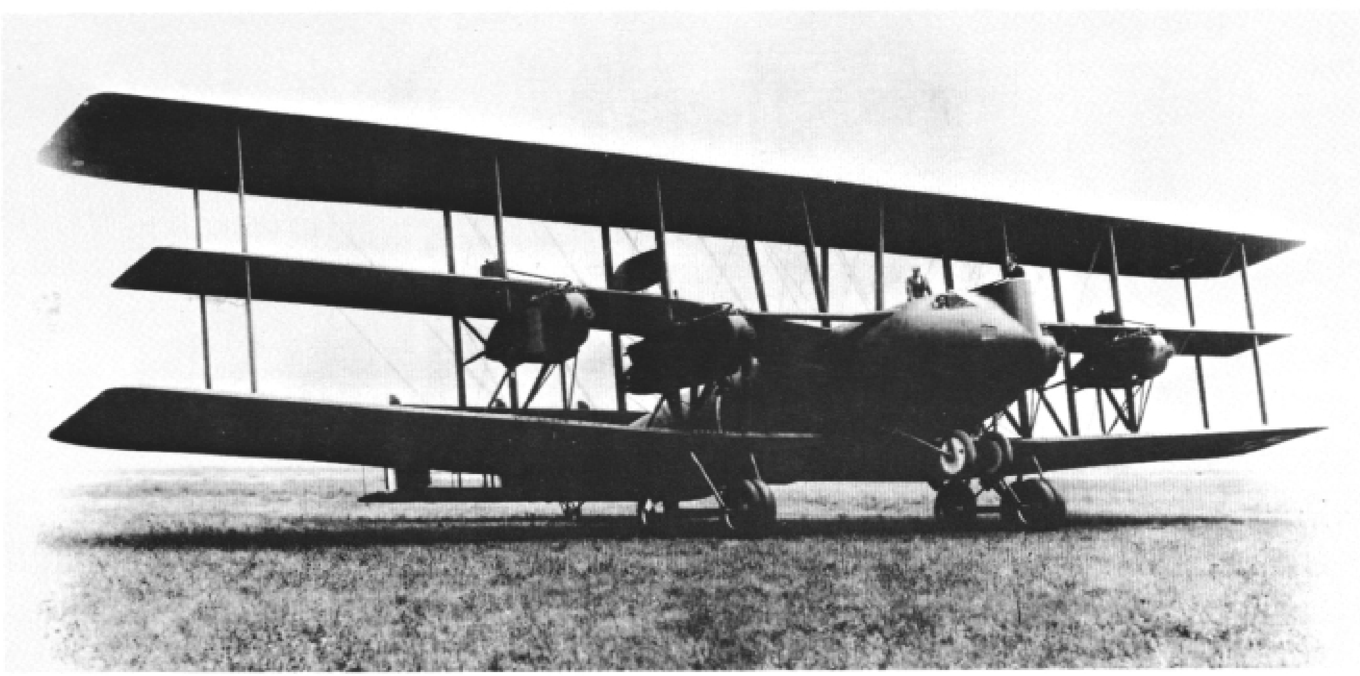
Five-Foot Tunnel Drive Motors and Fan Section

Facility Contribution

The Wright Field Five-Foot Wind Tunnel made significant contributions to the development of early aviation in the 1920s and continues today to provide students with a basic understanding of wind-tunnel testing procedures. It retains its ability to test complete scale models of an actual airplane and to conduct tests in support of research on the general principals of aeronautics.

The tunnel was considered advanced for its time because of its power, speed range, and combined features which were not available in any other single facility. These features were the air straightening vanes, intake bell, and decelerating cone. At McCook Field, two interchangeable test sections were also available.

The five-foot tunnel contributed to the development of methods to measure aerodynamic performance factors including lift, drag, and stability on a model and convert these data to the full-scale airplane. In its early existence, over a five-year period, approximately 50 tests were conducted on projects valued at several million dollars. A 1/70 scale model of the XNBL-1 Barling Bomber was one of the airplanes tested in this facility during the early 1920s. The tunnel provided critical data on the performance and stability of this 20-ton airplane which had six engines and was the largest built at the time. It contained many novel and untried features. The stabilizer setting needed for stability was predicted by wind tunnel tests and was found to be correct during its initial flight (Ref 3). Other five-foot tunnel tests conducted on scaled models during this same time period were on the Curtis P-1 Pursuit airplane and the Army Night Observation airplane. Testing was also conducted to determine the general effectiveness of ailerons on airplane control. In the 1930's and 1940's, the five-foot tunnel contributed data important to the solution of flutter problems that could lead to catastrophic failures. After World War II, aircraft that have benefited from tests in the five-foot tunnel include the F-15, F-4C, C-130, EC-135 and many missile systems. Recently, research flutter testing was conducted in the tunnel.



Barling Bomber

Text of the Wright Field
Five-Foot Wind Tunnel Plaque

NATIONAL HISTORIC
MECHANICAL ENGINEERING LANDMARK

WRIGHT FIELD FIVE-FOOT WIND TUNNEL
1922

WIND TUNNEL TESTING OF AIRCRAFT MODELS IS ESSENTIAL TO DETERMINE AERODYNAMIC PARAMETERS SUCH AS LIFT AND DRAG. THIS EARLY EXAMPLE OF THE MODERN WIND TUNNEL WAS CONCEIVED AND BUILT BY THE AIR SERVICE ENGINEERING DIVISION WHEN LITTLE AERODYNAMIC THEORY OR DATA EXISTED AS A BASIS FOR ITS DESIGN. YET, WHEN COMPLETED, THIS WOODEN TUNNEL WAS CONSIDERED THE MOST EFFICIENT IN THE WORLD AND PROCUDED VERY SMOOTH AIR FLOW. THE FINAL INSPECTION TEAM INCLUDED ORVILLE WRIGHT.

THE MODEL IS MOUNTED IN A TEST SECTION FIVE-FEET IN DIAMETER. AIR FLOW IS PROVIDED BY TWO FANS DRIVEN BY ELECTRIC MOTORS TOTALING 1600 HP. THE TUNNEL STILL IS USED FOR TEACHING AND RESEARCH.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

1995

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The ASME

The American Society of Mechanical Engineers, founded in 1880, is a worldwide engineering society focused on technical, educational, and research issues. It conducts one of the world's largest technical publishing operations, holds technical conferences, and sets many industrial and manufacturing standards.

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Air Force Institute of Technology (AFIT)

The Air Force Institute of Technology contains the graduate engineering school for the U.S. Air Force located at Wright-Patterson Air Force Base, Ohio. They maintain and operate the five-foot wind tunnel which is located in the Area B part of the base and is the home of Aeronautical Systems Center.

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Acknowledgment

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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, noting, recording, and acknowledging mechanical engineering achievements of particular significance. The History and Heritage Committee is part of the ASME Council of Public Affairs and Board of Public Information. For further information please contact Public Information, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017-2392, (212) 705-7740.

Designation

The Wright Field Five-Foot Wind Tunnel is the 114th National Historic Mechanical Engineering Landmark to be designated. Since the ASME Historic Mechanical Engineering Recognition Program began in 1971, 170 Historic Mechanical Engineering Landmarks, 6 Mechanical Engineering Heritage Sites, and 6 Mechanical Engineering Heritage Collections 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 Historical 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.

The Nominator and Author

Nelson D. Wolf, P.E. is a section chief in the Wright Laboratory at Wright-Patterson Air Force Base, Ohio. He is an ASME member and currently Chairman of the Dayton Section History and Heritage Committee. In the late 1950's, he worked as an engineer in a mechanical instrumentation group that serviced the five-foot wind tunnel. This Landmark brochure is the result of his research of documents found in the Wright Field technical library.