

**HISTORIC AMERICAN ENGINEERING RECORD
ADDENDUM**

**8-FOOT TRANSONIC PRESSURE TUNNEL
BUILDING 640**

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA**

**Submitted to:
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER**

**Submitted by:
JAMES RIVER INSTITUTE FOR ARCHAEOLOGY, INC.**

Date: September 2006

**HISTORIC AMERICAN ENGINEERING RECORD
ADDENDUM**

**NASA LANGLEY RESEARCH CENTER
8-FOOT TRANSONIC PRESSURE TUNNEL**

HAER No. VA-118-D

Location: 640 Thornell Road
East Area of the National Aeronautics and Space Administration's
(NASA) Langley Research Center (LaRC), Hampton, Virginia

UTM Coordinates of facility center point: E380773, N4104688

The 8-Foot Transonic Pressure Tunnel (TPT), Facility No. 640, is adjacent to the southern branch of the Back River. The TPT is sited immediately east of Hunting Avenue and is adjacent to the 8-Foot High Speed Tunnel (Facility No. 641) to the east. The main entrance is at the southwest corner of the building and faces Hunting Avenue. To the northeast is the Full Scale Wind Tunnel (Facility No. 643) and to the south is a parking area. The large scale of these wind tunnels characterizes the setting of this area. The administrative core of Langley Air Force Base (LAFB) surrounds the LaRC east area and features buildings of the Renaissance Revival style. Many of these buildings have architectural and historical significance and contribute to a proposed historic district that is potentially eligible for listing in the National Register of Historic Places. The TPT is expected to fall within the boundaries of the proposed historic district.

Date(s) of Construction: Completed in 1953

Engineer: John Stack, Eugene C. Draley, Ray H. Wright, and Axel T. Mattson

Present Owner(s): United States Government

Present Use: Vacant

Significance: The 8-Foot TPT was the first of Langley's wind tunnels to be built incorporating the new slotted throat tunnel design from its inception. A significant improvement over its retrofitted predecessors, the new tunnel allowed transonic testing in a more stable environment. In the 1960s, Langley engineer Richard T. Whitcomb and his research team used the tunnel to develop the "supercritical airfoil," which would revolutionize military and civilian aircraft design. The 8-Foot TPT is significant at a national level because of its role in the early development of transonic tunnels and its later role in testing aircraft designs.

Project Information: This documentation was prepared in February 2006, for NASA Langley Research Center under contract with Science Applications International Corporation which assists NASA in addressing environmental compliance requirements.

The document was prepared as an addendum to Level III HAER documentation completed by the National Park Service. The purpose of the addendum is to provide Level I HAER documentation in partial fulfillment of the requirements of a Programmatic Agreement among the National Aeronautics and Space Administration, the National Conference of State Historic Preservation Officers, and the Advisory Council on Historic Preservation.

The documentation was prepared with the assistance of a number of individuals including:

Matthew R. Laird, Ph.D., Senior Researcher
James River Institute for Archaeology, Inc.
223 McLaws Circle, Suite I
Williamsburg, Virginia 23185

Richard K. Anderson, Jr.
Cultural Resource Documentation Services
741 Bultman Drive, Suite 21
Sumter, South Carolina 29150-2555

Chris Cunningham, Photographer
Chris Cunningham Photography
5104 Caledonia Road
Richmond, Virginia 23225

Michael Newbill
3755 Oyster Point Quay
Virginia Beach, Virginia 23452

David H. Dutton
DUTTON + ASSOCIATES LLC
506 Coalbrook Drive
Midlothian, Virginia 23114

Special thanks are also given to Kristen Poultney and Caroline Diehl of Science Applications International Corporation and Carol Herbert of NASA for their assistance and support in completion of this project.

CONTENTS

HISTORICAL BACKGROUND	4
Early Wind Tunnel Research	4
The Establishment of NACA and the Langley Memorial Laboratory	4
The Origins and Design of the 8-Foot Transonic Pressure Tunnel	5
Development of the “Supercritical Airfoil”	7
Testing in the Cold War Era and Beyond	8
Chronology	10
Sources Consulted	11
PHYSICAL DESCRIPTION	13

Historical Background:

Early Wind Tunnel Research

Early experimenters in the field of human flight, including Leonardo da Vinci and Sir Isaac Newton, recognized the necessity of testing the aerodynamic characteristics of aircraft models, whether by propelling them through the air or by placing them in a moving airstream. As early as the eighteenth century, Benjamin Robins had developed the first mechanical "whirling arm" device to spin a test model through the air, a concept that was elaborated on by Sir George Caley in the early nineteenth century. However, it was clear that these whirling arm devices created excessive turbulence that interfered with accurate testing. The result was the development of the wind tunnel, a device in which air could be moved past a stationary model under relatively controlled conditions.

A wind tunnel has five essential characteristics: it is comprised of an enclosed passage through which air is driven by a fan or other *drive system*. The heart of the wind tunnel is the *test section*, in which an aircraft *model* is supported in a carefully *controlled airstream*, which produces a flow of air around the model, duplicating that of a full-scale aircraft. The aerodynamic characteristics of the model and its flow field are then measured by appropriate balances and *test instrumentation*.

Francis H. Wenham, a Council Member of the Aeronautical Society of Great Britain, is widely credited with designing and operating the first wind tunnel in 1871, using a steam-powered fan to propel air through a tube. Most famously, Orville and Wilbur Wright used a wind tunnel of their own design to develop the glider prototype of the famous 1903 Wright Flyer, with which they performed the first powered aircraft flight at Kitty Hawk, North Carolina. Despite the success of the Wright brothers, however, it was European researchers who dominated the field of wind tunnel research in the years prior to World War I.¹

The Establishment of NACA and the Langley Memorial Aeronautical Laboratory

Recognizing that the U.S. was lagging considerably behind the Europeans in wind tunnel research, members of the American Aeronautical Society proposed at their inaugural meeting in 1911 that a national aeronautics laboratory be established. After several years of bureaucratic in-fighting, Congress finally created the National Advisory Committee for Aeronautics (NACA) in 1915, which was directed to "supervise and direct scientific study of problems of flight, with a view to their practical solution." In 1917, an aeronautical research facility and laboratory was established near Hampton, Virginia. Named for aviation pioneer Samuel P. Langley, the new Langley Memorial Aeronautical Laboratory (LMAL) began operation with relatively little experience in wind tunnel design or operation. In fact, its first operational tunnel, Wind Tunnel No. 1, was a direct copy of a British model which was already obsolete by the time it was completed in 1920.

¹ Donald D. Baals and William R. Corliss, *Wind Tunnels of NASA* (Washington, D.C.: National Aeronautics and Space Administration, 1981), 1-12.

By 1922, however, NACA made a tremendous leap forward in the field of aeronautical research with the completion of the Variable Density Tunnel (VDT), the first tunnel in the world to use the principle of variable density in pressure to accurately predict flow characteristics of scale model aircraft. When using small-scale models, engineers had to contend with “scale effects,” as the flight characteristics of scaled-down versions could not be applied to full-sized aircraft without applying a correction factor. Scale effects could be addressed by proportionally varying air pressure in the tunnel, however, and the VDT was successfully used to test aircraft components. For example, research on airfoil sections conducted in the tunnel was used in the design of a number of famous aircraft, including the DC-3, B-17, and P-38.²

Despite its research value, the VDT could not evaluate the aerodynamic characteristics of a complete airplane, such as how rotating propellers affected aircraft control, nor could it adequately quantify the interference effects—or “drag penalties”—of various aircraft components such as external struts, wheels, and engine-cooling installations. In addition, aircraft test models had to withstand large forces and the strength of available materials limited their size. It was always possible to test actual aircraft in flight, but variations in atmospheric conditions required numerous flight checks to average the results. Given the current state of testing technology, the only alternative was to build a wind tunnel large enough to accommodate full-sized aircraft.

The first tunnel at Langley to accommodate full-scale aircraft components was the Propeller Research Tunnel (PRT), which became operational in 1927. Measuring 20 feet in diameter, the tunnel was large enough to test actual fuselages, engines, and propellers. Based on research conducted with the PRT, NACA engineers redesigned engine cowlings that dramatically reduced drag. Bolstered by the success of the PRT, NACA authorized the construction of the Full Scale Tunnel (FST) at Langley in February 1929. With the benefit of relatively low labor and material costs and a large pool of unemployed engineers, this Depression era project was completed in May 1931 at a cost of \$900,000. The largest wind tunnel in the world at that time, the enormous exterior structure measured 434 feet long, 222 feet wide, and 90 feet high. The test section measured 30 feet high by 60 feet wide and allowed the installation of aircraft with wingspans up to 40 feet. Early testing in the FST indicated unexpectedly high wind resistance caused by external aircraft components, prompting the government to send a steady stream of military aircraft to Langley for “drag cleanup tests.”³

The Origins and Design of the 8-Foot Transonic Pressure Tunnel

In the late 1930s, the Special Committee on Future Research Facilities proposed the construction at Langley of a wind tunnel with a 16-foot diameter test section that could evaluate the cowling and cooling of full-sized aircraft engines and propellers. Approval

² Baals and Corliss, 12-19.

³ HAER, *NASA Langley Research Center, Full-Scale Wind Tunnel, VA-118-A* (Washington, D.C., U.S. Department of the Interior, 1995), 9-15.

for construction was granted in 1939, and the new 16-Foot High Speed Tunnel (HST) became operational on December 5, 1941, just two days before the Japanese attack on Pearl Harbor. During World War II, the new tunnel was used to evaluate the cooling problems plaguing the air-cooled engines that powered virtually every U.S. fighter and bomber aircraft. Later in the war, testing focused on evaluating full-sized propellers and the shapes of the first atomic bombs.

While the 16-Foot HST was never Langley's largest or fastest wind tunnel, it did play an important role in the postwar evolution of tunnel design, and led directly to the design of the 8-Foot Transonic Pressure Tunnel. Aeronautical engineers had long recognized a significant flaw inherent in solid-walled test chambers, observing that the walls tended to suppress flow streamlines and produced deceptive aerodynamic effects. Reducing the size of aircraft models allowed for greater distance from the walls and raised the choking speed. However, this exacerbated the problem of "scale effects," as the flight characteristics of a model could not be applied to a full-sized aircraft without applying a correction factor. The use of smaller models hampered the engineers' ability to evaluate the aerodynamic characteristics of a complete airplane, such as the interference effects—or "drag penalties"—of various components such as external struts, wheels, and engine-cooling installations. Aircraft test models had to withstand large forces, and the strength of available materials also limited the extent to which they could be reduced in size.

Researchers already had theorized that this interference problem might be counteracted by placing slots in the test section throat which would reduce the blockage effect caused by the tunnel walls, and some experimental configurations had been tested. However, Wright was the first to engineer a practical application for this concept, which came to be known as "slotted throat" or "slotted wall tunnel" design. John Stack, Wright's division chief, took up the cause of slotted-throat testing, and—despite considerable skepticism—succeeded in persuading NACA to allocate funding and personnel to the problem. The first team of researchers investigating the slotted-throat tunnel configuration conducted preliminary testing in Langley's 16-Foot High Speed Tunnel early in 1947. These experiments confirmed the potential of the new design, which allowed for a consistent testing environment at transonic speeds (up to and beyond the speed of sound, or Mach 1, approximately 761 mph at sea level). While funding for a new slotted wall tunnel was forthcoming, Langley engineers decided in the interim to convert both the 8-Foot High Speed and 16-Foot High Speed Tunnel, and both were allowing transonic testing by the end of 1950.

Despite the success of these early tunnel conversions, it was apparent that a completely new slotted-throat tunnel was necessary. The older retrofitted tunnels exhibited a number of problems, including excessive turbulence, and high humidity and fog caused by the need to draw outside air into the main airstream for cooling purposes. The design team for the new slotted throat tunnel, including John Stack, Eugene C. Draley, Ray H. Wright, and Axel T. Mattson, sought to address these problems while providing a consistent test environment to investigate the problems of flutter and buffeting at transonic speeds. The

facility was built near Back River on the site of the former 1927 Propeller Research Tunnel, which had been demolished in 1950. Completed in 1953 and designated the 8-Foot Transonic Pressure Tunnel (TPT), the tunnel had a single-return, closed circuit pressure design that was capable of operating at pressures between 0.1 and 2.0 atmospheres. The tunnel's fan section was composed of a single rotor followed immediately downstream by two sets of 32 aluminum straightening vanes. The rotor measured approximately 17 feet in diameter and had 32 wooden blades. The fan was powered by a 25,000 hp wound-rotor induction motor with speed control from 0 to 840 rpm, with an optimum operating speed in the range of 500-700 rpm. The air temperature in the tunnel was controlled by finned cooling coils across one corner of the tunnel. Water circulated through the cooling coils and was pumped from the tunnel to a three-cell redwood cooling tower where it was cooled by the atmosphere. The tunnel air could also be dried to a low dewpoint by circulating it through a dryer using silica gel as a desiccant.

The test section of the 8-Foot TPT was rectangular in cross-section, with a cross-sectional area of about 50 square feet. The upper and lower walls were slotted to permit continuous operation through the transonic speed range, with the slots comprising approximately five percent of the total periphery of the test section. Each vertical side wall had 15 rectangular optical plate glass observation windows, while the entire test section was enclosed in a large plenum about 36 feet in diameter.

The air speed in the test section could be continuously varied up to Mach 1.2 (over 900 mph at sea level), depending on the size of the testing model used. In 1958, a suction system was installed which removed the boundary layer air from the plenum and returned it through to the slots to the circuit so that stagnation pressure remained unchanged. This improvement increased the speed potential of the tunnel to Mach 1.3. Models were supported by a sting-type support system in which the horizontal sting was attached to a tapered support strut, which in turn connected downstream to a motor-driven metal arc. Instrumentation included strain-gauge balances, three manometers, data recording and reduction equipment used for handling steady-force and pressure information, and a schlieren apparatus for visual flow studies.⁴

Development of the "Supercritical Airfoil"

In the 1960s, the 8-Foot TPT would prove indispensable to Langley engineers in developing the revolutionary supercritical airfoil. Once the first U.S. swept-wing jet transports were operational by the late 1950s, most U.S. aeronautical engineers assumed that the design of subsonic transport aircraft was a "mature" technology and concentrated

⁴ Baals and Corliss, 36-37, 60-64; Hansen, 322; 329, 444, 474; NACA, *Characteristics of Nine Research Wind Tunnels of the Langley Aeronautical Laboratory* (Washington, D.C., NACA), 27-35; Cuyler W. Brooks, Charles D. Harris, and Patricia Reagon, *The NASA Langley 8-Foot Transonic Pressure Tunnel Calibration* (Washington, D.C.: NASA TP-3437, 1994), 4.

almost exclusively on developing supersonic civil transport. In contrast, European engineers continued to work on developing advanced airfoil (wing cross-section) designs to increase high-speed subsonic cruise efficiency. After his groundbreaking discovery of the “area rule” concept that influenced supersonic aircraft design, Langley engineer Richard T. Whitcomb turned his attention to exploring potential design improvements to conventional subsonic transport. In the course of this work he achieved another major breakthrough.

At this time, the optimum cruise speed of commercial passenger jets such as the Boeing 707 was between Mach 0.7 and Mach 0.8. Aircraft designers and manufacturers were interested in increasing the optimum speed to Mach 0.9 to Mach 0.95 without compromising fuel efficiency. But as an aircraft reaches the speed of sound, there is a point at which the air flowing over the wings reaches supersonic speeds while the plane itself is moving slower, causing a significant drag effect. This phenomenon occurs roughly halfway between the leading edge and the trailing edge of the wing. Aircraft designers addressed this problem by angling the wings back from the fuselage and making them thinner. However, these approaches tended to increase aircraft weight and decrease range and fuel economy, since thinner wings could not be used to store as much fuel.

In the early 1960s, Whitcomb began developing a new airfoil shape that would allow the wing to reach a higher speed before the airflow over it reached the speed of sound. What he came up with was an airfoil characterized by a well-rounded leading edge, a flatter upper surface that pushed the critical Mach point further back on the wings, and a sharply down-curving trailing edge that increased lift. By 1964, Whitcomb and his research team were testing this new design—what he termed the “supercritical airfoil”—in the 8-Foot TPT. A combination of wind tunnel and flight testing indicated that supercritical airfoils could allow passenger jets to fly up to 10 percent faster. After the National Aeronautics and Space Administration (NASA) presented this data in 1972, aircraft designers evaluating Whitcomb’s breakthrough recognized that by maintaining slightly lower speeds, jets equipped with supercritical airfoils had significantly greater range and better fuel efficiency, characteristics that were appealing to commercial airlines.

By the mid-1970s, supercritical wings were being used in the design of a wide variety of commercial and military aircraft. In recognition for his outstanding research in supercritical airfoil technology, NASA awarded Whitcomb a \$25,000 prize in 1974; that year he also won the Wright Brothers Memorial Trophy of the National Aeronautic Association for his “enduring contributions to aeronautics.”⁵

Testing in the Cold War Era and Beyond

During this period other Langley engineers were using the 8-Foot TPT for important research in other areas. Stuart G. Flechner, James C. Patterson, Jr., and Paul G. Fournier

⁵ Chambers, Joseph R., *Concept to Reality: Contributions of the NASA Langley Research Center to U.S. Civil Aircraft of the 1990s* (Washington, D.C., NASA, 2003); Baals and Corliss, 62-63.

conducted extensive tests on advanced energy-efficient subsonic transport models. Their research contributed to the growing national database on the effects of engine nacelle and pylon cant angle and engine longitudinal and vertical position on cruise performance, including the effects of powered nacelles. As a result, the 8-Foot TPT played a significant part in advancements in the airframe and engine industries.

In 1981, modifications were made to the 8-Foot TPT in support of the Laminar Flow Control (LFC) Experiment on a 7.07-foot, 23-degree swept supercritical airfoil. A honeycomb and five screens were installed in the settling chamber upstream of the test section, as well as a 54-foot-long contoured test section liner that extended from the upstream end of the test section contraction region, through the test section and into the diffuser. The honeycomb and screens were installed as permanent additions to the facility, while the liner was to be removed at the conclusion of the LFC Experiment.

Through the 1980s and early 1990s, the 8-Foot TPT continued to be used by Langley engineers for a variety of tests, including evaluations of the space shuttle design, and experiments requiring subsonic and transonic capabilities. In 1996, however, the tunnel was deactivated after a NASA study determined that the facility was underutilized and its technology was outdated.⁶

⁶ Gary E. Erickson, *Wind Tunnel Application of a Pressure-Sensitive Paint Technique to a Faceted Missile Model at Subsonic and Transonic Speeds* (Washington, D.C., NASA, 2004); Charles D. Harris and Cuyler W. Brooks, Jr., *Modifications to the Langley 8-Foot Transonic Pressure Tunnel For the Laminar Flow Control Experiment* (Washington, D.C., NASA, 1988); Charles D. Harris et al., *The NASA Langley Laminar-Flow-Control Experiment on a Swept, Supercritical Airfoil Evaluation of Initial Perforated Configuration* (Washington, D.C., NASA, 1992).

Chronology:

- 1950 Langley engineers retrofit the existing 8-Foot High Speed and 16-Foot High Speed Tunnels to the new slotted throat design, proving the effectiveness of the new design technology.
- 1953 Construction is completed for the 8-Foot Transonic Tunnel, the first at Langley to incorporate the new slotted throat design from its inception.
- 1958 A new plenum section is added, increasing airspeeds to Mach 1.3.
- 1964 Langley engineer Richard T. Whitcomb and his team test their new "supercritical airfoil" design in the tunnel.
- 1981 The tunnel is significantly modified in support of the Laminar Flow Control (LFC) experiment with the installation of a honeycomb and five screens in the settling chamber upstream of the test section, as well as a 54-foot-long contoured test section liner.
- 1996 NASA closes the facility.

Sources Consulted:

- Baals, Donald D. and William R. Corliss. *Wind Tunnels of NASA*. Washington, D.C.: National Aeronautics and Space Administration, 1981.
- Brooks, Cuyler W., Charles D. Harris, and Patricia Reagon. *The NASA Langley 8-Foot Transonic Pressure Tunnel Calibration*. Washington, D.C.: National Aeronautics and Space Administration, TP-3437, 1994.
- Butowsky, Harry A. *Man in Space: National Historic Landmark Theme Study*. Washington, D.C.: National Park Service, Department of the Interior, 1984.
- Butowsky, Harry A. National Register of Historic Places Inventory-Nomination Form, Eight-Foot High Speed Tunnel. Washington, D.C.: National Park Service, Department of the Interior, 1984.
- Chambers, Joseph R. *Concept to Reality: Contributions of the NASA Langley Research Center to U.S. Civil Aircraft of the 1990s*. Washington, D.C.: National Aeronautics and Space Administration, SP-2003-4529, 2003.
- Erickson, Gary E. *Wind Tunnel Application of a Pressure-Sensitive Paint Technique to a Faceted Missile Model at Subsonic and Transonic Speeds*. Washington, D.C.: National Aeronautics and Space Administration, TM-2004-212991, 2004.
- Hansen, James R. *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958*. Washington, D.C.: National Aeronautics and Space Administration, 1987.
- Harris, Charles D., and Cuyler W. Brooks, Jr. *Modifications to the Langley 8-Foot Transonic Pressure Tunnel For the Laminar Flow Control Experiment*. Washington, D.C.: National Aeronautics and Space Administration, TM-4032, 1988.
- Harris, Charles D., Cuyler W. Brooks, Jr., Patricia G. Clukey and John P. Stack. *The NASA Langley Laminar-Flow-Control Experiment on a Swept, Supercritical Airfoil Evaluation of Initial Perforated Configuration*. Washington, D.C.: National Aeronautics and Space Administration, TM-4309, 1992.
- Historic American Engineering Record (HAER). NASA Langley Research Center, 8-Foot Transonic Pressure Tunnel, VA-118-D. Washington, D.C.: National Park Service, U.S. Department of the Interior, 1995.

National Advisory Committee for Aeronautics (NACA). *Characteristics of Nine
Research Wind Tunnels of the Langley Aeronautical Laboratory.* Washington,
D.C.: NACA, 1957.

Physical Description:

The TPT was built on the site of the former Propeller Research Tunnel that was demolished in 1950. Construction commenced in 1950 and the TPT was complete and operational in 1953. Langley engineers designed this tunnel from the outset using the new concept of the slotted wall test section. The purpose of this wind tunnel was to further study transonic aerodynamics at high Reynolds numbers and to investigate flutter and buffeting in the transonic environment.

The TPT is currently described as: "... a continuous-flow, variable-pressure tunnel with control capability to independently vary Mach number, stagnation pressure, stagnation temperature and humidity. The top and bottom walls of the test section are axially slotted to permit continuous variation of the test section mach number from 0.2 to 1.2; the slot contour provides a gradient free test section 50 inches long for Mach numbers equal to or greater than 1.0 and 100 inches long for Mach numbers less than 1.0."⁷

Three principal structures compose the TPT; the tunnel circuit, the motor house, and the office/control room/shop building. While occupying a rectangular site, the facility has an irregular plan. Its dimensions, excluding the motor house at the southeast corner, are approximately 230 feet (north-south) by 100 feet (east-west).

The tunnel circuit is a tubular form fabricated from 13/16" to 1" inch welded steel plates, reinforced to 1-1/4 inches at various hatches and openings. The steel shell is heavily insulated and the exterior surface is encapsulated in a cementitious coating. The tunnel is elevated above the ground and supported on a combination of steel and concrete bents. The bottom of the tunnel is approximately twenty feet above grade at the test cell. The plenum surrounding the test cell has a diameter of approximately 36 feet. Rectangular in plan, the diameter of the circuit is consistent from the area of the test cell located on the east side to the northeast corner. At the northeast corner the tunnel circuit starts to enlarge as it returns to the slotted test cell. The airflow moves in a clockwise direction driven by a 17-foot diameter, 32-blade fan located in the southern leg of the tunnel, on axis with the adjacent motor and motor house. Two sets of 23 aluminum straightening vanes are downstream of the fan. Turning vanes are positioned at corners within the tunnel. On the upstream side of the turning vanes in the northeast corner is a fine-grid water-cooled coil that removed excess heat without adding moisture to the circulating air. The model mount is a "sting" that is adjustable for angle of attack. The test cell is equipped with observation windows and a remote-controlled schlieren camera system for imaging and photographing shock waves. An observation room for the test cell is in a structure located between the tunnel and the office building. Exposed on the exterior at the east side of the tunnel are numerous large pipes that are part of the boundary layer control system. The pipes are connected to an air compressor in the adjacent office and control room building. The function of the boundary layer control system was to remove

⁷ Technical report: rdp3437.tex, published by Langley Technical Report Server, 2003.

air near the walls (the boundary layer) of the tunnel and test cell and thereby drop the pressure and reduce turbulence so that the remaining air could accelerate to supersonic speeds.

To maintain its functionality, a facility of this type requires regular and frequent modifications and improvements. Real property records for 1967 through 1985 list 27 projects of this type. Most were relatively minor such as modifications to the schlieren system (1967, \$37,823.25), installation of a yaw coupling (1977, \$44,541.22), and modifying stairwells for life safety codes (1985, \$14,781.49). Major improvements that contributed to ongoing mission execution included installation of a new plenum section in 1958. The plenum surrounds the test cell in a slotted-throat transonic tunnel and allows air removal to obtain the desired static pressure in the test cell. To assist in smoothing out airflow a honeycomb and five screens were permanently installed in 1981 immediately upstream from the test cell. In 1981 a contoured test section liner was also installed temporarily in support of a Laminar Flow Control experiment, but removed upon its completion.

A large motor house contains a 25,000-horsepower induction motor. This structure is located at the southeast corner of the wind tunnel. Its nominal dimensions are 50 feet long (east-west) by 30 feet wide (north-south). The base of the motor house is reinforced concrete and the floor in the motor room is elevated approximately 30 feet above grade so that the motor's drive shaft aligns with the fan. The room below houses switch gear and motor controllers. A semicircular roof of welded steel plate tops the motor house.

The office/control room/shop building is a one and three story structure. The three main levels are high bay spaces; mezzanines occur on the upper two floors. The three-story portion of the building is surrounded by the tunnel and extends above its top. One-story elements project to the east and west below the tunnel. A shop extends to the north under and beyond the tunnel. The north end of the shop has two stories and abuts the electrical equipment room of the 8-Foot High Speed Tunnel (Facility No. 641). The nominal dimensions of the three-story segment are 130 feet long (north-south) by 30 feet wide (east-west) by 75 feet tall. The exterior walls are clad in smooth aluminum panels capped by an aluminum coping. Aluminum windows with a combination of fixed and projecting sash are arranged in horizontal bands. Aluminum louvers and flush panels fill many of the sashes in the top sections of the windows. The windows of the shop at the north end are ornamented with flat aluminum surrounds. All aluminum components on the exterior have a natural aluminum color. Several rolling steel overhead doors provide access to shop and lab spaces. The front entrance, at the southwest corner of the building, is a pair of aluminum and glass doors. Projecting curved pilasters clad in aluminum flank these doors. Above the doors is a narrow curved aluminum cornice. Mounted on the wall above the cornice is a three-part cast aluminum emblem in the form of a winged shield. It bears the letters NACA designating National Advisory Committee for Aeronautics. The streamline moderne style of the late 1930s and 40s influences the detailing of the entrance features. The building has a concrete foundation supported on piling. The

ground floor is a concrete slab; upper floors are concrete over steel decking supported by steel framing. The observation enclosure between the office/lab/shop building and the tunnel circuit is covered with "shotcrete". A catwalk with metal rails serves access panels in the bottom of the tunnel circuit. The catwalk, accessed from a caged steel ladder adjacent to the front entrance, runs immediately below the tunnel circuit along its south side.

The TPT operated for 43 years, from 1953 to 1996. Despite modifications and improvements made during this period and closure for 10 years, it generally retains integrity of association, location, setting, design, feeling, material and workmanship.

**HISTORIC AMERICAN ENGINEERING RECORD
ADDENDUM**

INDEX TO PHOTOGRAPHS

NASA LANGLEY RESEARCH CENTER
8-FOOT TRANSONIC PRESSURE TUNNEL
Hampton
Virginia

HAER No. VA-118-D

Chris Cunningham, photographer, March 2006

- | | |
|-------------|---|
| VA-118-D-10 | VIEW OF 8-FOOT TRANSONIC WIND TUNNEL
LOOKING NORTH. |
| VA-118-D-11 | Photocopy of photograph (original in Langley Research
Center Archives, Hampton, Virginia [LaRC] (EL-2002-
00282)
8-FOOT TRANSONIC WIND TUNNEL CONTROL
ROOM. |
| VA-118-D-12 | VIEW LOOKING SOUTHEAST ALONG WEST SIDE
OF TUNNEL FACILITY FACING HUNTING AVENUE.
TUNNEL CIRCUIT IS OVERHEAD, SHOP FACILITY
DOOR IN FOREGROUND. |
| VA-118-D-13 | Photocopy of photograph (original in Langley Research
Center Archives, Hampton, Virginia [LaRC] (EL-1996-
00021)
TEST CELL INTERIOR WITH EXAMPLE OF TEST
MODEL AND MOUNTING DEVICE ("STING") CA.
1956. |

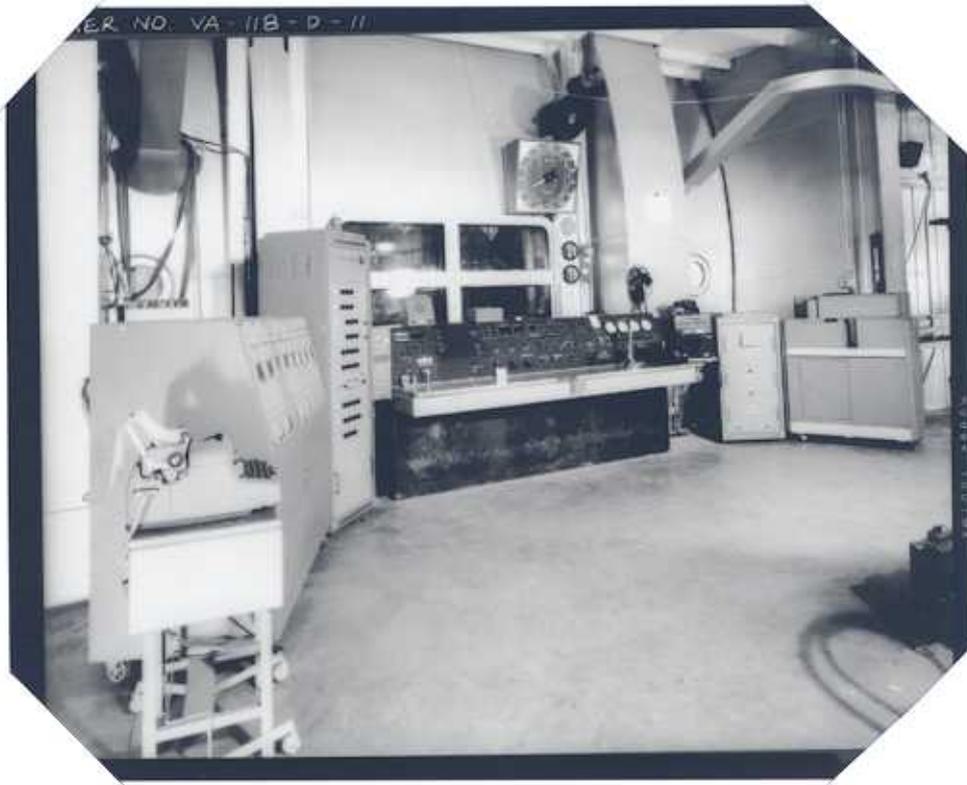
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER NO. VA-118-D-10



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER NO. VA-118-D-11



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER NO. VA-118-D-12



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER NO. VA-118-D-13



8-FOOT TRANSONIC PRESSURE TUNNEL

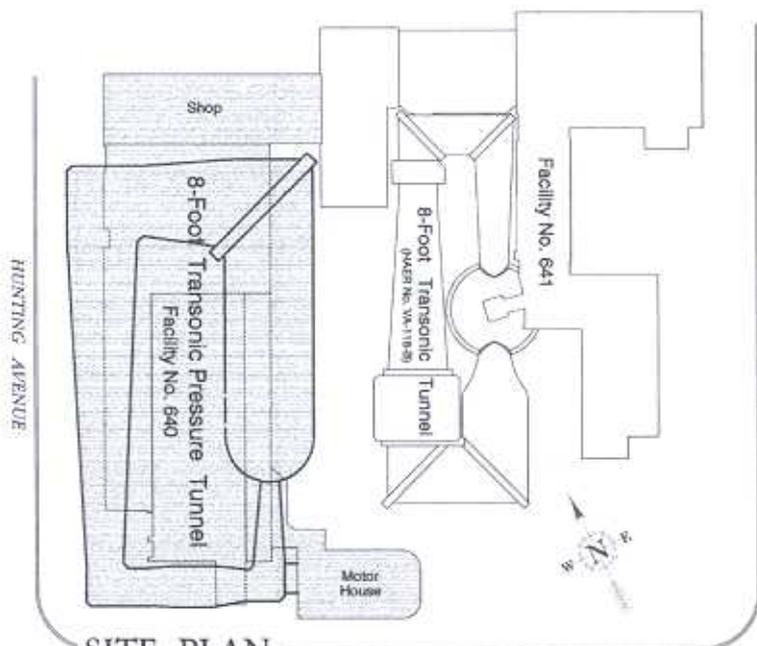
Building 640

National Aeronautics and Space Administration - Langley Research Center
Hampton, Virginia

The 8-foot Transonic Pressure Tunnel was built in 1953 and incorporated a new slotted-throat test cell design prepared by John Stack, Eugene C. Draley, Ray H. Wright, and Axel T. Mattson. The design team relied on data and experience gathered from years of tests at the 8-foot High Speed Tunnel (Building 641, HAER No. VA-118-B built in 1933) and the 16-foot High Speed Tunnel (Building 1146, HAER No. VA-118-E built in 1947), both of which had been converted in the late 1940s for supersonic operation. The new tunnel was a single-return, closed circuit design which could run at pressures from 0.1 to 2.0 atmospheres. Other advances included water-filled cooling coils for controlling air stagnation temperatures from -40° to +180° F and desiccants for controlling humidity. A 25,000-horsepower induction motor powered a 17 ft. diameter single rotor tunnel fan with 32 wooden blades at speeds up to 840rpm. The test cell had a rectangular cross section of about 50 sq ft, and was equipped with 15 optical glass observation ports on its vertical sides. A remote-controlled, single-pass schlieren system imaged air flow for models mounted on a sting-type model-support which kept a model's center of gravity on the tunnel's centerline for angles of attack ranging from -10° to +15°. The sting could support a normal force up to 4,000 lbs., and axial and side forces of 400 lbs. each. The upper and lower walls of the test section featured slots whose area made up 5% of the test cell periphery. The original test cell instrumentation consisted of strain balances and three 100-tube tetrabromomethane manometers with 10-foot working heights. Recordation was by means of photography, there being no dynamic recording available as late as 1957. A new plenum section was installed in 1958. In the early 1960s Langley engineer Richard T. Whitcomb (discoverer of the "area rule" in supersonic design) began working on a supercritical wing design for subsonic aircraft, and the 8-foot TPT was the site of groundbreaking tests for wing designs which improved the speed, range and efficiency of passenger jets.

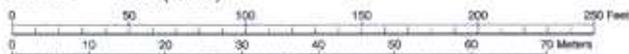
NASA presented Whitcomb's data in 1972, and soon supercritical wing designs appeared in numerous commercial and military aircraft. During the 1960s and 70s the 8-foot TPT also participated in the development of improved engine nacelles and pylons which made significant contributions to development of airframes and engines. In 1981 a 54-foot long contoured test section liner was installed along with a permanently mounted honeycomb and five screens as part of a Laminar Flow Control experiment on a swept supercritical airfoil. In the 1980s and 90s, the 8-foot TPT continued to contribute to various subsonic and transonic tests as well as evaluations of space shuttle designs. It was closed in 1996.

These drawings were completed by Richard K. Anderson, Jr. of Cultural Resource Documentation Services, Sumter, SC for inclusion in the Historic American Engineering Record (HAER) of the National Park Service, U.S. Department of the Interior. The HAER program documents significant engineering and industrial sites throughout the United States. Project records are maintained in the Prints and Photographs Division of the Library of Congress. Mr. Anderson prepared these drawings under contract to the James River Institute of Archaeology (JRIA) of Williamsburg, VA (Matthew Laird, Senior Historian) with the assistance of Carol Tyrer. JRIA conducted the HAER documentation project for NASA Langley Research Center under contract to Science Applications International Corporation (SAIC), Hampton VA, which assists NASA in addressing environmental compliance requirements. Caroline Diehl of SAIC and Carol Herbert of Tessada & Associates assisted in identifying and copying numerous references and engineering drawings in support of this project. Matthew Laird composed the HAER data pages with input from David Dutton and Michael Newbill; Chris Cunningham of Richmond, VA prepared additional large format photographs as addenda to earlier HAER coverage.

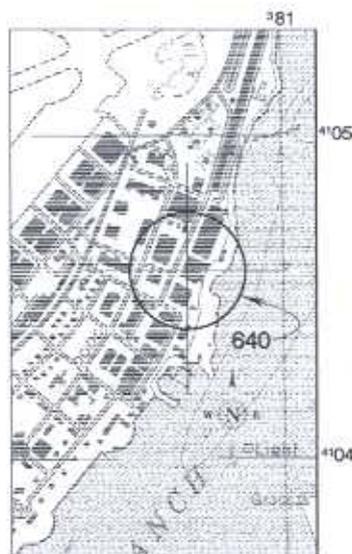


SITE PLAN

Scale: 1" = 25'-0" (1:300)

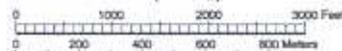


Based on NASA Langley Research Center "Real Estate Management Office, June 1980 Facility Brochure."



LOCATION MAP

Scale: 1" = 600' (1:7200)



Based on USGS 7.5 min. Hampton, VA quadrangle; 1965, revised 1980.

UTM Coordinates: 18-380770,4104890

Richard K. Anderson, Jr., 2006.

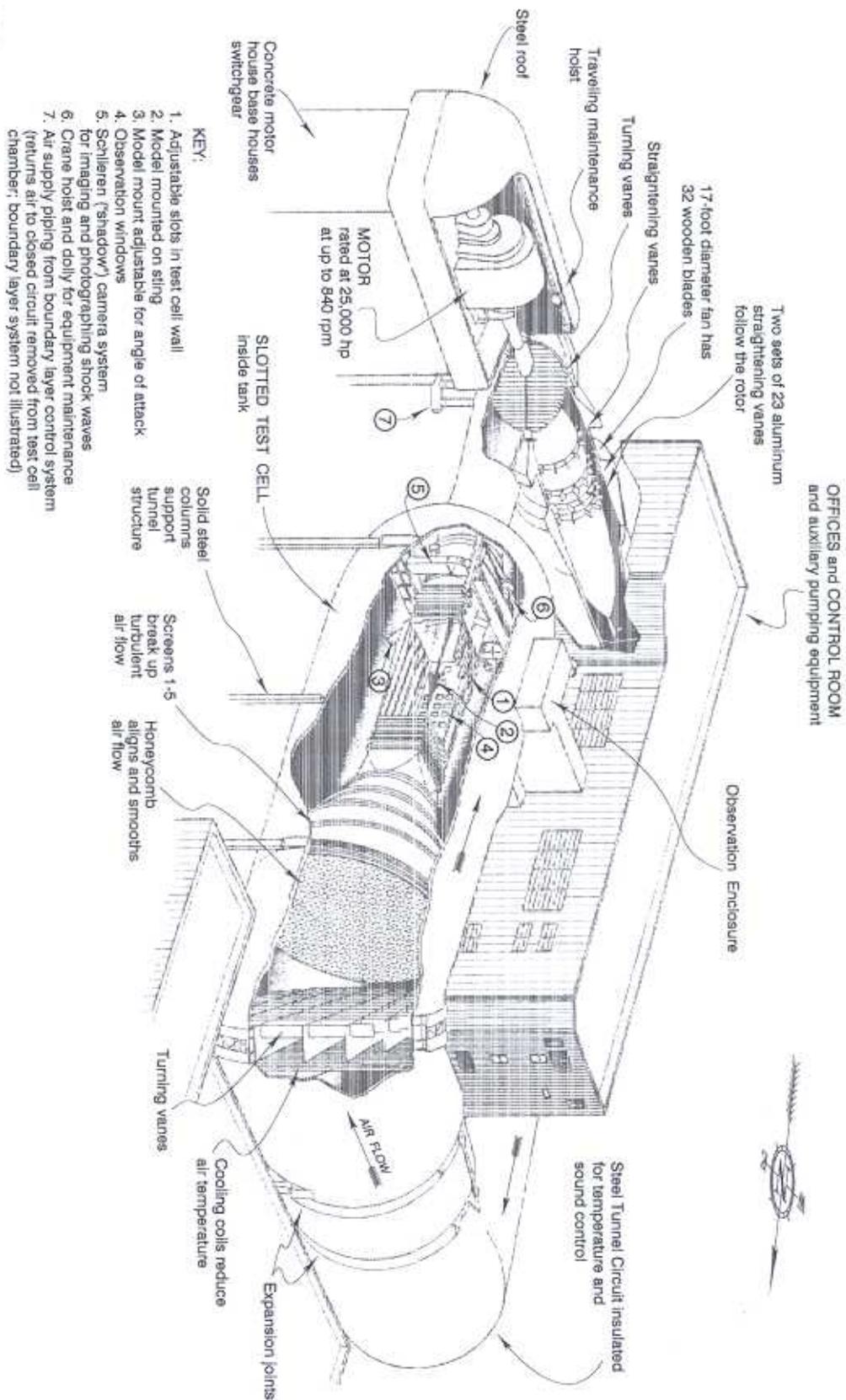
NASA LANGLEY RESEARCH CENTER RECORDING PROJECT
DRAWING TITLE: 8-FOOT TRANSONIC PRESSURE TUNNEL
DRAWING NUMBER: 8-FOOT TRANSONIC PRESSURE TUNNEL (1953)

8-FOOT TRANSONIC PRESSURE TUNNEL (1953)
BUILDING 640, 84 THORNELL ROAD
HAMPTON
VIRGINIA

SHEET
1 - 3

HISTORIC AMERICAN
ENGINEERING RECORD
VA-118-D

CUTAWAY VIEW of 8-FOOT TRANSONIC PRESSURE TUNNEL



1/8 Scale
 Cutaway drawing based on sketch by an unknown artist, NACA Langley Research Center negative number L-481-1288.
 Annotations based on material in NACA engineering drawings and in "Characteristics of Nine Pressure Wind Tunnels of the Langley Aeronautical Laboratory" by the National Advisory Committee on Aeronautics (NACA), 1957, pp. 273-8.

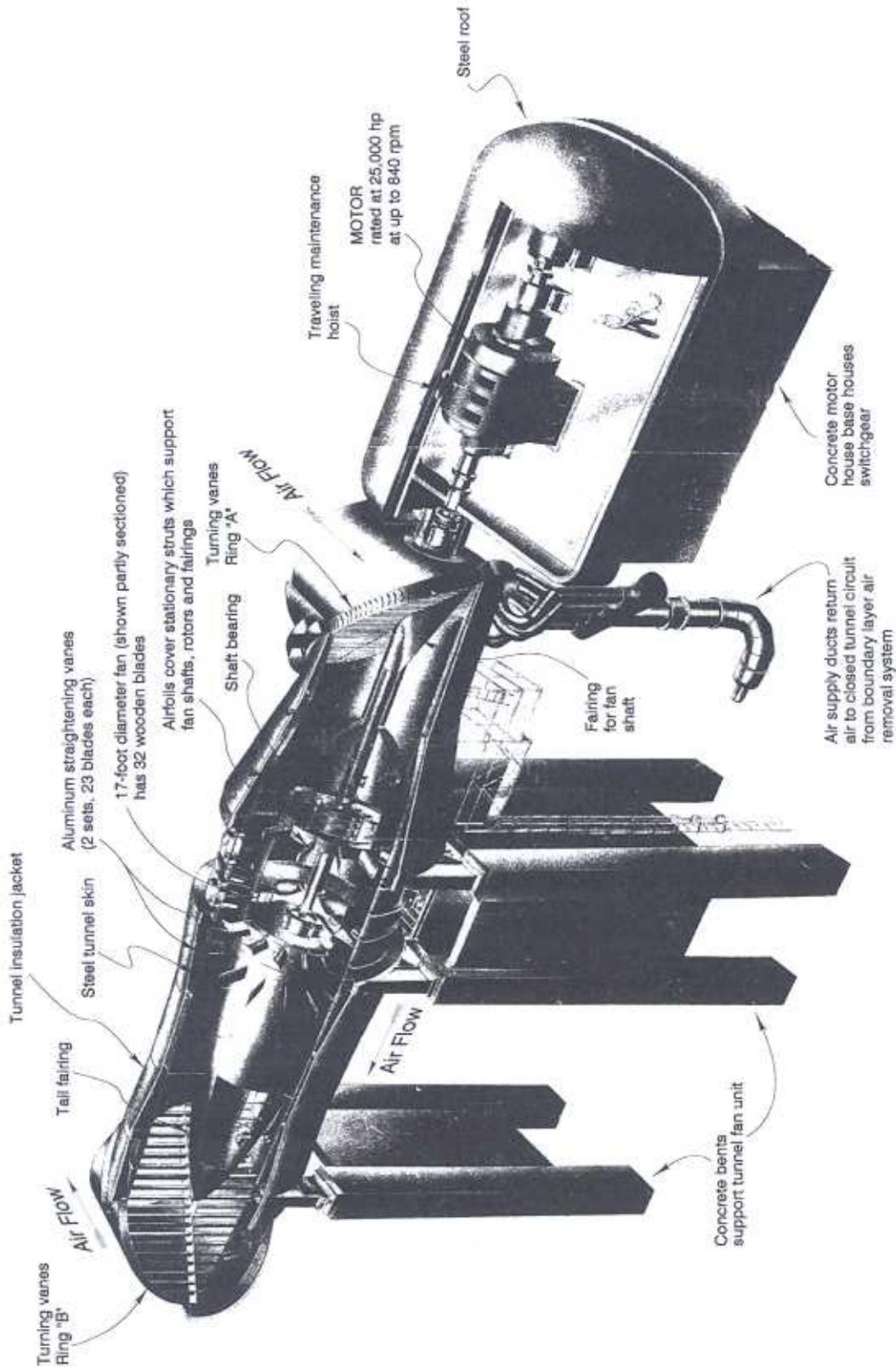
Richard K. Anderson, Jr., 2006.

NASA LANGLEY RESEARCH CENTER RECORDING PROJECT
 DIGITAL SCAN AND REPAIR
 NASA-88-358-REV-01

8-FOOT TRANSONIC PRESSURE TUNNEL (1956-53)
 BUILDING 601, W. W. THORNTON ROAD
 HAMPSTON

WINDRA
 SHEET
 4 - 1

HISTORIC AMERICAN
 ENGINEERING RECORD
 VA-118-C



CUTAWAY VIEW OF FAN UNIT

No Scale.
 Cutaway drawing based on sketch by an unknown artist, NASA Langley Research Center drawing number 13-14096-7.
 Annotations based on material in NASA engineering drawings and "Characteristics of High Speed Wind Tunnels of the Langley Aeronautical Laboratory," by the National Advisory Committee on Aeronautics (NACA), 1957, pp. 27-34.

Richard K. Anderson, Jr., 2006.

8-FOOT TRANSONIC PRESSURE TUNNEL (1950-53)

REPRODUCED FROM THE NATIONAL ARCHIVES

NAVIGATION

HEAD LIGHT RESEARCH CENTER ENGINEERING PROJECT

SCALE

1 - 1
 ENGINEERING ROOM
 14-1124-C