HISTORIC AMERICAN ENGINEERING RECORD

DOCUMENTATION OF THE CONTROL HOUSE (BUILDING 3617) AND THE STATIC ROCKET TEST STAND (BUILDING 3618),

TEST AREA E HISTORIC DISTRICT
FORMER NAVAL AIR ROCKET TEST STATION (NARTS)

PICATINNY ARSENAL,
MORRIS COUNTY, NEW JERSEY

FINAL REPORT

June 2009

Prepared for
U.S. Army, Picatinny Arsenal, New Jersey

Through the U.S. Army Environmental Center,
Aberdeen Proving Ground, Maryland

Under a Cooperative Agreement with
U.S. Army Medical Research Acquisition Activity
Fort Detrick, Maryland

PANAMERICAN CONSULTANTS, INC.
Buffalo Branch Office
2390 Clinton Street
Buffalo, New York 14227-1735

Contract # DAMD17-00-2-006-0026

Panamerican Consultants
20 YEARS OF EXCELLENCE
1989-2009

HISTORIC AMERICAN ENGINEERING RECORD

DOCUMENTATION OF THE CONTROL HOUSE (BUILDING 3617)

AND THE STATIC ROCKET TEST STAND (BUILDING 3618),

TEST AREA E HISTORIC DISTRICT

FORMER NAVAL AIR ROCKET TEST STATION (NARTS)

PICATINNY ARSENAL,

MORRIS COUNTY, NEW JERSEY

FINAL REPORT

Prepared for:

U.S. Army, Picatinny Arsenal, New Jersey

Through the U.S. Army Environmental Center,
Aberdeen Proving Ground, Maryland

Under a Cooperative Agreement with
U.S. Army Medical Research Acquisition Activity
Fort Detrick, Maryland

Prepared by:

Kelly Nolte, M.A., Senior Architectural Historian

Mark A. Steinback, M.A., Senior Historian/Technical Editor

Mark Drumlevitch, B.A., Photographer

PANAMERICAN CONSULTANTS, INC.
Buffalo Branch
2390 Clinton Street
Buffalo, New York 14227-1735
(716) 821-1650

June 2009

Management Summary

Panamerican Consultants, Inc. (Panamerican) was contracted by the U.S. Army Environmental Center (AEC) under a cooperative agreement with the U.S. Army Medical Research Acquisition Activity for the U.S. Army, Picatinny Arsenal, New Jersey, to prepare Historic American Engineering Records (HAER) Level II documentation of two buildings, as well as to evaluate 52 buildings and structures and the Picatinny Golf Course, including its associated buildings and structures, for National Register of Historic Places (NRHP) eligibility. This document presents the HAER recordations for the Control House (Building 3617) and the Static Rocket Test Stand (Building 3618), two structures within the Test Area E Historic District of the former Naval Air Rocket Test Station (NARTS), now within the Picatinny Arsenal reservation. The evaluation of the 52 buildings and structures and the Picatinny Golf Course will be submitted as a separate report.

The U.S. Army, as a federal agency, has management responsibilities concerning the protection and preservation of cultural resources on land it controls or uses. Federal statutes require the Army to identify and evaluate significant cultural resources on these properties, and include: the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et. seq) through 2000 (which includes Section 106 compliance); the National Environmental Policy Act of 1969 (42 U.S.C. 4371 et. seq.); the Historic Preservation Act of 1974 (16 U.S.C. 469-469c); the Advisory Council on Historical Preservation (ACHP) Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800); as well as Army Regulation (AR) 200-1 Environmental Protection and Enhancement.

In accordance with HAER Documentation Level II, each resource was documented through large-format photography and written historic data and description. One copy of this data is submitted on archival materials as a two stand-alone packets (one for each building). In addition, for the sake of organization and future storage, digital and non-archival copies of the documentation for each of the structures have been submitted as a single report with two sections.

The Panamerican project team included Ms. Kelly Nolte, M.A., Senior Architectural Historian and Principal Investigator; Mr. Mark Drumlevitch, Photographer; and Mr. Mark A. Steinback, Senior Historian/Technical Editor. Ms. Nolte conducted the fieldwork and historic research and wrote the majority of the report, and Mr. Drumlevitch was responsible for all the large-format photography. Mr. Steinback prepared most of the historical background and edited the report. Dr. Michael A. Cinquino served as Panamerican's Project Director.

Table of Contents

CONTROL HOUSE
(Building 3617)
Northwest side E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

HAER NO. NJ-XXX

PHOTOGRAPHS

WRITTEN AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Mid-Atlantic Region
Custom House
2nd & Chestnut Street, Rm. 231
Philadelphia, PA 19106

June 2009

HISTORIC AMERICAN ENGINEERING RECORD

CONTROL HOUSE
(Building 3617)

Location: Control House (Building 3617) is located on the northwest side of E Road, which runs through the former Naval Air Rocket Test Station (NARTS), Test Area E at Picatinny, Rockaway Township, Morris County, New Jersey. E Road intersects with Snake Hill Road that leads up to Test Area E, which is off the installation proper.

UTM: 18.540140.4533700
Quad: Dover 1981 [1954]

Date of Construction: 1953

Engineer/Architect: Frank Grad & Sons Architects and Engineers, Newark, New Jersey

Present Owner/ Occupant: United States Army, Picatinny (formerly known as Picatinny Arsenal), New Jersey

Present Use: Abandoned, not in use

Significance: The Control House (Building 3617), its partner building, the Static Rocket Test Stand (Building 3618; Test Stand E-1), and their surrounding landscape have been determined eligible for the National Register of Historic Places under Criteria A and D as a historic district, the NARTS Area E Historic District. The Control House, which is a contributing element, is both nationally and regionally significant for the role it played in the Cold War (1946-1989) military-industrial complex and during the creation and testing of liquid and solid rocket fuels and engines, particularly the XLR-11 and XLR-99 rocket engines, the latter the workhorse engine of the early rocket era.

Kelly Nolte, Senior Architectural Historian/Director Architectural History Division
Mark A. Steinback, Senior Historian

Panamerican Consultants, Inc.
Buffalo Office
2390 Clinton Street
Buffalo, New York 14227-1735
June 2009

PART I. HISTORICAL INFORMATION

A. Physical History:

1. Date of erection: 1953.

2. Architect/Engineer: Frank Grad & Sons, Architects and Engineers, Newark, New Jersey. Frank Grad (1883-1968) established his architectural firm in Newark, New Jersey, in 1906, becoming Newark's first Jewish architect (Newarkology! 2008). Grad was born March 27, 1883 in Austria to Oslos, a painter and decorator, and Minnie (Keinstreich) Grad. (Publications differ regarding the year of his birth, listing either 1882 or 1883 [Newarkolgy! 2008; Urquhart 1913]. Panamerican has chosen 1883 since the Urquhart publication seems to have been based on an interview with him.)

Grad attended a preparatory school in Austria and then studied mechanical engineering at a Vienna technical school, taking additional courses in architecture. After completing his studies, he worked as a draftsman in England for less than two years before emigrating to the United States. On December 24, 1902, at the age of 19, he arrived in New York, and immediately began working for Gould & Eberhart in Newark. After a year, he took a draftsman position with the Domestic Sewing Machine Company. Grad next gained employment with the firm of Laurence F. Weir, Architect, New York. He remained there for three years, learning the practice of architecture in the United States. Deciding to start his own architecture office, Grad passed the New Jersey state architecture examinations, and opened his private practice in Newark in 1906 (Urquhart 1913:116).

In 1907, Grad married Kitty Furst, daughter of Bernard and Dora Furst of Newark, and they had two sons, Bernard (1908-2000) and Howard (1913-1992) (Urquhart 1913; *The New York Times* 1992, 2000). Grad's meteoric rise was chronicled in a 1913 history of the City of Newark, which highlighted the wide variety of buildings he had designed in northern New Jersey between 1906 and 1912. These structures included: John F. Schrink's jewelry factory (Newark); a Main Street office building (Orange); Salny Brothers department store (Morristown); the residence of A.M. Rosenberg (Newark); Job De Camp Warehouse (Newark); an apartment block for Joseph Green (Bloomfield); Alderman Lewis Semel's amusement hall (Newark), as well as several apartment buildings and offices through

Newark (Urquhart 1913:117). Grad was fully integrated into the social and professional life of Newark, having joined the Masons, the Odd Fellows, and the Newark A.O.B.A (could not locate acronym) as well as professional associations, which likely helped him to identify prospective commissions (Urquhart 1913:117). For a 30-year-old, Frank Grad was a roaring success.

Grad's sons would later join his practice; first, Bernard in the late 1930s, and then Howard in 1945 (BASF 2008; *The New York Times* 1992, 2000). The firm became Grad & Sons, Architect and Engineers. Bernard ("Bernie"), an architect, was a graduate of the Newark Academy (1927) and the University of Pennsylvania (1932) and studied at the *École de Beaux-Arts* in Fontainebleau, France. He was a Fellow of the American Institute of Architects, and served as a member of the Board of Overseers for the New Jersey Institute of Technology (*The New York Times* 2000). Howard was an engineer, who, like his brother, graduated from the University of Pennsylvania (1934). Howard supervised the company's projects for the North Atlantic Treaty Organization (NATO) in France and Britain during the 1950s. During the 1980s, he was a managing partner of Grad Partnership (*The New York Times* 1992).

The firm has gone by a number of names including: Frank Grad (1906-late 1930s to mid-1940s); Frank Grad & Sons (late 1930s to mid-1940s–1968); Grad Partnership (1968-1990); Grad Associates (1990-2007); Grad Architects (2007–2009); and GRAD (2009-present). The company celebrated its 100th anniversary in 2006, which was marked by the Newark Public Library in 2007 with an exhibition called "A Salute to GRAD Associates: One Hundred Plus One." The exhibition was accompanied by a selection of books on architectural history from the library's collection (Nelson 2006; Newark Public Library 2007).

The period comprising the years of Frank Grad & Sons and Grad Partnership, when the three Grads were working and then later when it was just the brothers, witnessed a shift in the source of company contracts, which mirrored trends emerging in American society and business. In the early years of his practice, Grad produced a number of structures that are now considered landmark Newark buildings, including the Young Men's and Young Women's Hebrew Association, Mosque Theater (now Symphony Hall), and Beth Israel Hospital (Newark Public Library 2007). The firm was already creating in a variety building types, but in the 1920s it had begun venturing into a new arena—government contracts (GRAD 2009). Grad worked on Newark municipal public buildings during the 1920s and 1930s, but it was federal contracts that helped catapult Grad into the upper ranks of architectural firms (GRAD 2009; Nelson 2006; *The New York Times* 1992).

After World War II, Frank Grad & Sons became involved with large-scale national defense projects, one of which was the classified NARTS project at the former Lake Denmark Naval Ammunition Depot in New Jersey. During the 1950s, the firm held a contract for the construction of U.S. military installations in seventeen countries worldwide in association with NATO. Howard Grad was in charge of the firm's NATO projects at that time (Nelson 2006; *The New York Times* 1992). In the late 1960s and early 1970s, Grad Partnership led the design of two of the largest projects then undertaken by the federal government: the Headquarters (HQ) of the Department of Defense (DoD), James V. Forrestal Building Complex, Washington, D.C. (1.7 million square feet [sq.ft.]), and the U.S. Social Security Administration HQ, Baltimore, Maryland (1.8 million sq.ft.) (GRAD 2009).

Also during this period, Grad designed three entirely new college campuses for the state of New Jersey--University of Medicine and Dentistry of New Jersey, Newark, Essex County College, Newark, and Bergen County College, Paramus—in addition to projects at Rutgers, Kean, William Paterson and Monmouth universities. Grad's Seton Hall School of Law building is one of the tallest buildings in New Jersey (Nelson 2006). Grad has designed more than half of all the high-rise office towers in New Jersey that are more than 25 stories and is credited with designing the first tallest building in New Jersey—the Raymond Commerce Building—in 1922 (Nelson 2006; GRAD 2009).

The firm Frank Grad exists today as GRAD at Two Gateway Center in Newark, New Jersey. The firm boasts 35 architects and works worldwide on architectural, engineering, planning, design, and interior design projects (GRAD 2009).

3. Original and subsequent owners: United States Navy, Third Naval District (Third), Bureau of Aeronautics (BuAer), Naval Air Rocket Test Station (NARTS), New Jersey; United States Army, Picatinny, New Jersey.

4. Original and subsequent occupants: The building was constructed by the U.S. Navy and was used by the Navy and Reaction Motors, Inc. (RMI), the first commercial rocket-engine company in the United States, as the Control House for the hot firing of rocket engines conducted at the Static Rocket Engine Test Stand (Building 3618). The Test Stand is located approximately 250' southeast of the Control House across the asphalt access road (E Road) through the NARTS area. The Control House has been used for no other purpose and has stood idle since at least 1970 (Walker 1970; Walter 1997a).

5. Builder, Contractor, Suppliers: Bethlehem Steel, Pennsylvania, all necessary steel; E.M. Waldron Company, Newark, New Jersey, site preparation and construction; RMI, project consultants; and BuAer, project consultants (NARTS 1951: Monthly Progress Reports for September, October, November and December).

6. Original plans and construction: A full set of blueprints for the Control House, the Static Rocket Engine Test Stand (usually referred to as Static Rocket Test Stand), and the general area are available at the Directorate of Public Works, Picatinny, New Jersey. Five blueprints from this collection are reproduced for this documentation. The title blocks on all the blueprints read: "Department of the Navy, Bureau of Yards and Docks/District Public Works Office 3rd N.D. New York, NY/FRANK GRAD & SONS, ARCH-ENGR/Newark 2, New Jersey." Some of the blueprints indicate that Frank Grad also had offices in Washington, D.C.

The Control House and the Static Rocket Test Stand, while two separate buildings, had an efficacious relationship; both structures were conceived as essential components of the same operation: to test rockets and motors. In many cases, the existing construction histories do not make any distinction between the two structures when discussing materials acquisition, site meetings, and other construction details. Because of this lack of distinction, the construction history that follows includes information about the Control House, the Static Rocket Test Stand, and the general area, known as Area E. The location of the original construction records is unknown; however, quarterly and monthly progress reports, still located in the Picatinny Technical Library, provided an excellent overview of the construction. These reports form the basis of the following construction history.

When the Navy began rocket development, contracts were loosely drawn because outcomes were uncertain, performance was conjectured, and the final design "was a balance between guesswork and the ability of the machine shop" (Durant 1951:74). During these early years, acceptance tests were conducted by a government representative at the contractor's plant using that contractor's instruments and formulas. The lack of instrumentation standardization and the inadequacy of testing procedures made the value of these tests doubtful. It was, therefore, desirable for the government to develop its own facilities at which trained personnel could test engines to specification using standardized methods of instrumentation.

Tests conducted at these government facilities would be unbiased and serve as a basis for comparison for various engines and the evaluation of hardware. With information gained from these testing facilities, the government could develop guidelines for new contracts that would ultimately lead to the development of superior rocket engines (Durant 1951). By 1950, the Navy had established three such testing facilities for air-related engines: the Naval Aeronautical Rocket Laboratory (NARL; at Lake Denmark, New Jersey) for the testing and evaluation of rocket engines; the Aeronautical Engine Laboratory (in Philadelphia, Pennsylvania) for the testing and evaluation of reciprocating engines; and the Aeronautical Laboratory (in Trenton, New Jersey) for the testing and evaluation of turbojet engines.

In addition to testing and evaluation activities, the Navy found it desirable to actually provide test facilities at NARL for rocket-engine contractors or other governmental agencies with inadequate or insufficient test facilities of their own. This was particularly true for engines with more than 10,000 pounds (lbs) of thrust. As the thrust capacity of engines grew, construction costs for the test stand, tankage and instrumentation, which were expensive initially, increased significantly, making the creation of large stands prohibitive for many companies. Some companies also were located so close to general habitation areas that the firing of very large engines was precluded because they were a public nuisance (Durant 1951).

When NARL and the adjacent ammunition depot became the Naval Air Rocket Test Station in 1950, the Navy undertook an extensive engineering study to create a master plan for the facility. The Navy requested $7,500,000 for the expansion and modernization of the existing test facilities; to purchase more land to better integrate their current holdings; to improve and standardize instrumentation; to provide for an underground propellant storage system; to create more housing; and to outfit specialized shops and laboratories (NARTS 1950: Progress Report for January; Durant 1951).

NARTS began a serious expansion program that included the construction of Test Area E, a site for the testing of rocket engines up to 350,000 lbs of thrust and which served as the location for a number of important research and design projects. The earliest projects (actually assigned to NARL), most of which were classified as restricted or confidential, included the development of methods and equipment for testing liquid propellant rocket engines (project no. ARL PP-201); various applications as related to the LARK guided-missile rocket engine (ARL PP-202 and ARL PP-202.1); and the acceptance tests and evaluation of the XLR-18-K-2 booster assembly rocket (ARL PP-203 and ARL PP-203.1) (Seiler 1949).

Prior to 1950, NARL had a number of temporary test stands that were made from Quonset Huts. At these temporary stands, the Navy with RMI had tested the rocket engines or components for the Douglas SKYROCKET, the Bell X-1 and the LARK. The Navy also had a large test stand for the development of the 20,000-lb thrust VIKING engine, for tests of the Consolidated-Vultee (Convair) MX-774 (a preliminary Intercontinental Ballistic Missile [ICBM]), and for certain tests on the SKYROCKET. The large stand, called the Viking Stand, was originally built in 1946 for engines with a capacity of 6,000 lbs thrust and was later converted for 20,000 lbs thrust (NARTS 1950: Progress Report for January). These facilities were in need of renovation and modernization and the demand for a large test stand was pressing.

In December 1949, BuAer asked NARL to recommend the most practical method of providing a testing facility for a 50,000-lb thrust rocket using ammonia and oxygen as propellants. The creation of such an engine was under consideration at the time and the problem of supplying an adequate test facility was an important factor influencing the decision. BuAer had three alternatives for NARL to consider: 1) modify the existing Viking Stand, which stood in RMI Area D and had only a 20,000-lb thrust capability; 2) modify an existing booster stand that had a 100,000-lb thrust capacity but its tank rooms only allowed motor testing; 3) construct a new stand. After consultation with the parties affected, NARTS believed that a new stand with an exceptionally high thrust capability must be constructed (NARTS 1952: Quarterly Progress Report for April).

A number of factors influenced the decision to build a new stand. BuAer also was considering the development of a rocket with a capability of 350,000 lbs of thrust and a larger stand was required to adequately test a booster assembly of this size. If the two existing stands were modified, the result would be a stand so specialized that it could be used for almost nothing else. The cost of any such modification would approach the cost of constructing a new multi-purpose stand (NARTS 1952: Quarterly Progress Report for April).

As a result, in September 1950, BuAer made the decision to proceed with the erection of a new attitude test stand with the capacity to test a 350,000-lb thrust missile assembly, and gave the go-ahead to prepare preliminary specifications and designs. The stand was to have propellant tank rooms integral with the structure so that motor testing alone also could be undertaken. The initial tank and piping installation was to accommodate liquid ammonia and liquid oxygen (LOX) as propellants in quantities sufficient to supply 100,000 lb-min of impulse (NARTS 1952: Quarterly Progress Report for April).

By May 1951, Frank Grad & Sons of Newark, New Jersey, had completed a preliminary design study for the construction of a 350,000-lb test stand and NARTS had assigned the project the number SI-211. Completion of the project, entitled "Assist in construction of 350,000 lb thrust test stand," and delivery of the test stand to RMI for engine development tests was slated for March 1952 (NARTS 1951: Monthly Progress Report for May). The project was marked as restricted. In July 1951, NARTS received a copy of the letter from the Chief, Bureau of Yards and Docks (BuDocks), to the Commandant, Third Naval District (Third), which approved the allocation of funds for the engineering, construction and instrumentation of a 350,000-lb thrust rocket test stand (designated as Test Stand E-1). Grad's design was approved by NARTS, BuAer and RMI after modifications had been made to the design of the trunnion mount, the mount that actually held the engine. RMI was then engaged in the testing of a 50,000-lb rocket and wanted a separate, special mount included in the test stand's design (NARTS 1951: Monthly Progress Report for July). NARTS and RMI agreed that the final completion date for Test Area E would be June 1, 1952.

During August, a series of conferences was held between NARTS and RMI to determine the instrumentation required. NARTS agreed that the amplifying, indicating, and recording equipment would be furnished by them and that the sensing instruments, because they were expendable equipment, would be furnished by RMI under their development contract (NARTS 1951: Monthly Progress Report for July). Throughout the summer RMI, NARTS, BuAer, BuDocks, and the Third hashed out the various equipment needs and obligations. The engineering contractor was scheduled to begin August 27 (NARTS 1951: Monthly Progress Reports for August and September).

By September 1951, Frank Grad & Sons was given the detailed engineering report of the test stand by NARTS as well as general layout of the instrument panels and conduits. In order to expedite the start of construction, District Public Works Office (DPWO) and the Third began discussing terms for a negotiated contract with E.M. Waldron Company, Newark, New Jersey, for the construction of the stand (NARTS 1951: Monthly Progress Report for September).

The negotiations between E.M. Waldron Company, the Third, and DPWO yielded a contract dated October 18, 1951. BuDocks began the purchasing process for the necessary steel from Bethlehem Steel. During the month of October, NARTS, DPWO, RMI, and Frank Grad & Sons met to discuss the structures in Area E. It seems that originally NARTS wanted a separate Field House, Control House and Test Stand in the area. In October, all parties agreed that the Field House and the Control House should be combined into a single two-story structure; RMI and NARTS had agreed on the purchase of equipment; and BuAer authorized NARTS to begin the purchasing of the instrumentation (NARTS 1951: Monthly Progress Report for October). The Field House was never constructed.

In November, E.M. Waldron Company began clearing the site and NARTS continued to work out last-minute details on the design of the test stand, including the schematic piping diagram and a valve and control parts list for the fuel, oxidizer and water systems. Actual construction started on November 19. With these additional details, Frank Grad & Sons hoped to have the final test-stand design completed by the beginning of December. NARTS also began the design of the recording racks in the Control House. After two conferences to establish specifications, Linde Air Products, then a division of Union Carbide, was selected for the installation of the oxygen storage tank and the nitrogen and oxygen cascade (NARTS 1951: Monthly Progress Report for November).

In December, the completion date for the project was pushed back to June 13, 1952 as a result of a number of design delays. With the test-stand design completed, E.M. Waldron's bid for construction was expected the first week of January. Waldron began excavations for the stand footings, clearing and grubbing the road and structure sites, and rough grading the road and parking areas. RMI continued to ask NARTS for more machinery and instrumentation concessions. NARTS, believing that these last-minute changes would greatly increase the total cost of the project, struck a deal for additional equipment with RMI. If NARTS did not have the requested equipment on hand, as either stock or surplus, RMI would be required to purchase the requested equipment out of their development contracts. Linde Air Products estimated that the installation of the required equipment would cost $13,000. NARTS requested that BuAer defray these costs to their new contract for LOX that went into effect on or about January 1, 1952 (NARTS 1951: Monthly Progress Report for December).

Construction continued though January 1952, and a number of delays pushed the project back ten days. BuAer apparently balked at including Linde Air Product's costs into their contract because NARTS began to investigate a new design for the cascade pressure sensing lines in the Control Room that would greatly reduce the cost of piping. NARTS continued to design the instrument racks, although the process slowed to accommodate higher priorities (NARTS 1952: Monthly Progress Report for January).

During February, as construction continued, subcontracts for clearing, grubbing, and blasting the site were nearly complete and contracts for structural and reinforced steel were let. The specific company or companies involved were not identified in the documentation. The new design for pressure sensing lines proved feasible in preliminary tests prompting NARTS to draw new specifications. Despite the slowdown in the design of the instrument racks, it was still proceeding ahead of schedule. Overall completion was estimated at 13 percent (NARTS 1952: Monthly Progress Report for February).

By March, the site of Test Area E was shaping up and NARTS recorded this progress in four photographs included in its March report. Copies of these photographs are included in this documentation. During this month, a NARTS engineer was sent to Muzillo Company, a local firm associated with RMI, to assist in the design and formulation of specifications for the high-pressure tankage and piping. NARTS continued to design the instrument racks, began fabrication of the pressure regulators, and placed orders for last-minute instruments (NARTS 1952: Monthly Progress Report for March).

By April 1952, the overall completion rate of the test stand was estimated at 22 percent. In that month, 68 tons of cast-iron pipe was received, presumably for the water and sewage system. As NARTS continued in its fabrication work related to instrumentation in April, the final completion date was moved to August 30, 1952 with three additional months required for the installation and testing of equipment (NARTS 1952: Monthly Progress Report for April, Quarterly Report dated April).

By May, the Control House and test stand were easily identifiable in site photographs (NARTS 1952: Monthly Progress Report for May). Copies of these photographs are included in this documentation. In June, construction of the test stand continued and overall project completion was estimated as 45 percent. In an effort to bolster spirits, the report noted that it was "encouraging to note that all heavy structural steel [had] been delivered to the site" (NARTS 1952: Monthly Progress Report for June, p. 7).

As July progressed, the two 25-bottle trailers for the oxygen cascade were received from the Charleston Navy Yard, South Carolina, and were installed. The Control Room of the Control House was completed and ready for instrument installation. NARTS had assembled a preliminary specification list for the engine mount in the test stand and was in the process of reviewing it so that a request for bids on design, fabrication, installation, and testing could be let (NARTS 1952: Monthly Progress Report for July). Photographs in the July report illustrated that all the structural steel was in place. Copies of these photographs are included in this documentation.

Despite a target date of August 30 for project completion and site turnover to RMI, the August progress report noted that the construction of the test stand was still continuing. The target date for completion would pass unmet. By then, the instrumentation in the Control Room was still being installed. By August, NARTS had completed the design specifications for the rocket-mount assembly and the specifications were let out for bid to seven firms. The seven firms were not noted in the documentation. The mount was designed to adapt the RMI engine to the E-1 trunnions (NARTS 1952: Monthly Progress Report for August).

As construction stretched into the autumn of 1952, the wiring of the Control Room continued through September and the test stand began to resemble its final configuration. Of the seven firms that had been asked to bid the motor assembly, three declined the request. NARTS had already received one bid and believed it would get three more. During September, the final completion date was set at February 1, 1953 as a result of problems encountered in the high-pressure fuel and water tanks (NARTS 1952: Monthly Progress Report for September, Quarterly Report dated September).

In October the rocket-motor mount job was awarded to Vimalert Company, Newark, New Jersey. Vimalert's bid was $26,000 and included the design, fabrication, installation, and testing of the mount. The bid was based on NARTS' preliminary mount design work. The scheduled completion date of the mount was estimated to be January 31, 1953. The October photographs show the test stand partially clad in its metal blow-off panels; grading equipment was still visible (NARTS 1952: Monthly Progress Report for October). Copies of these photographs are included in this documentation.

The November report noted that the construction of the stand was "virtually complete" (NARTS 1952: Monthly Progress Report for November), with only the electrical piping, tank and hardware installation remaining to be completed by the contractor. As Vimalert proceeded on the mount design, procurement of the steel for the mount had begun. Even as the stand neared completion, NARTS was still making design changes. It was decided that the water nozzle used to cool engine blasts should be an exhaust jet water cooling nozzle and NARTS began the process of designing it (NARTS 1952: Monthly Progress Report for November).

As December waned, Vimalert's mount design was approved for fabrication with an installation date set for January 5, 1953. Because of the nature of the mount, Vimalert believed that a special test floor should be installed directly beneath the thrust mount. The new floor, which was one foot lower than the old one, allowed for the clearance of the rocket nozzle. This new floor was actually a set of double doors that would be opened immediately before test firings. The doors were actuated by geared down electric motors hung below stationary parts of the floor. Safety latches were added to protect workers from accidentally opening the doors (NARTS 1953: Quarterly Report for January-March). By December, the Control House and test stand looked ready for action (NARTS 1952: Monthly Progress Report for December; Quarterly Report for October-December 1952).

As predicted, the actual completion of the test stand was delayed until February as a result of the lag in the delivery of the water and fuel tanks. In January, the Vimalert mount was installed, instrumented and tested with satisfactory results. Vimalert's proposal for the new mount test floor was accepted and the estimated delivery time was 60 days from contract. The floor was described as "being similar to a bomb bay with a 60" [inch] opening to permit vertical firing" (NARTS 1953: Monthly Progress Report for January). For more information on the rocket-test mount please see Supplemental Material.

In February, as wiring and instrumentation continued, the fuel tank for the test stand was delivered and installation began. By March, the water tank still had yet to be delivered, although it was expected daily. Pressure testing for the piping in the fuel room was initiated and all control systems were in the process of being checked. The operating floor vendor reported delays in procuring the door actuators and this held up the job. NARTS called the subcontractors of these items in an effort to prod the process along. The delivery date for the floor was estimated for April 30, 1953 (NARTS 1953: Monthly Progress Reports for February and March).

The two remaining major items—the floor and the water tank—were delivered in April. The water tank was installed and piped in. During the latter part of April, the floor was installed and operated satisfactorily. By May 1, the test stand was considered complete enough to turn over to RMI for its instrumentation set-up. NARTS personnel would remain on the job for two to three weeks on a number of minor clean-up jobs (NARTS 1953: Monthly Progress Report for April). With the test stand turned over to RMI, the project was "considered complete" (NARTS 1953: Quarterly Report, dated July) and was no longer discussed in subsequent monthly or quarterly reports.

When completed, Test Stand E-1, the Static Rocket Engine Test Stand, was one of the largest static test stands on the East Coast, and the Control House recorded all information gained from the hot firing of engines in the stand.

7. Alterations and additions: At an unknown date a monopole antenna was placed on the roof of the Control House. It appears that a set of wooden steps was placed on the south side of the building so that the antenna could be reached. The stairs are now derelict. The use of the antenna is unknown.

Blueprints do not show any other additions or changes to the Control House. However, it is probable that instrumentation was changed during the life of the building.

B. Historical Context:

1. Introduction: Picatinny Arsenal (referred to as Picatinny) is a government-owned, government-operated facility in the Green Pond Brook valley in the Highlands of northwestern New Jersey. The U.S. Army established the Dover Powder Depot on more than 900 acres in 1880. Originally constructed for storage of powder and other munitions, the Dover Powder Depot became Picatinny Arsenal in 1907 with the construction of the first Army-owned smokeless powder factory. During the twentieth century, Picatinny Arsenal emerged as the leading facility for the research, development, engineering, and production of munitions. The installation was reenvisioned following a catastrophic explosion at the Navy's contiguous Lake Denmark Powder Depot that destroyed much of the Navy's facility. During World War II and the subsequent Cold War, Picatinny continued its leading role in the research, development, and engineering of munitions and weapons systems.

The Lake Denmark Powder Deport was established by the U.S. Navy on February 24, 1891 as its primary powder depot on the East Coast, and was at one time the Navy's largest storage facility. In 1926, as the Navy was building up the depot, lightning struck one of the storage magazines, causing a series of fires and sympathetic explosions that killed 19 people. The explosions sent shock waves through the Green Pond Brook valley, destroying everything within a 3,000' radius of the epicenter and causing great damage beyond the epicenter. The Navy depot, the adjacent Picatinny Arsenal, and many nearby non-military residences were impacted (Rogers 1931:Chapter IX; Fitch and Glover 1990:B/171-174).

The Navy and the Army both investigated the incident and a series of ammunition storage procedures and standards emerged from the findings. New magazine forms were developed—the most notable was the now ubiquitous, earth-covered igloo magazine that was designed to explode up and not out. Both investigations recommended that the Lake Denmark Ammunition Depot and Picatinny Arsenal undergo significant redesign. Between 1927 and 1937 both installations were completely rebuilt.

At the end of World War II, the Navy determined that the ammunition depot was excess to its needs and started to deactivate the facility. At about the same time, the Navy's Bureau of Aeronautics (BuAer) decided to establish a centralized, East Coast rocket-engine test center with applications for naval aviation. In 1948, the U.S. Naval Aeronautical

Rocket Laboratory (NARL) was established at Lake Denmark. Two years later, the facility was redesignated the Naval Air Rocket Test Station (NARTS), which operated alongside the Navy's commercial partner, Reaction Motors, Incorporated (RMI). The Navy disestablished NARTS in 1960, after less than ten years of service, and transferred all its property, test buildings and structures to Picatinny Arsenal. Although RMI continued to use some of the buildings until 1970, the Army never used the area for it intended purpose.

Picatinny and the Navy Ammunition Depot have long been of historic and architectural interest and since the 1980s numerous architectural surveys have been completed at Picatinny Arsenal (Thurber and Norman 1983; Ashby et al. 1984; Fitch and Glover 1990; Harrell 1993, 1994; Nolte et al. 1999a, 1999b). All of these documents concur that the Control House (Building 3617) and Static Rocket Test Stand (Building 3618), located in NARTS Area E, are eligible for listing in the National Register of Historic Places (NRHP), although the specific justifications for the inclusion vary among the investigator.

Historic American Buildings Survey (HABS)/Historic American Engineering Record (HAER) Level IV Inventory Cards reveal that buildings 3617 and 3618 were given a priority three rating (e.g., historic properties of *Value* [sic] which contribute to the cultural heritage or visual harmony and interest of the installation and its environs and which should be preserved if possible [U.S. Army Regulation (AR) 420-40 and Technical Manual (TM) 5-801-1]). The cards for both structures noted that the structures "possess significance as part of the post-World War II testing of the X-15 rocket engine" (Ashby et al. 1984).

A draft NRHP nomination form was completed for Picatinny Arsenal ca. 1983 but was never submitted (U.S. Department of the Army ca. 1983). This nomination form divides the installation into a number of historic areas but does not designate the NARTS area as one of them. Further, it states that three buildings within the facility are individually eligible for the National Register, but does not identify them. However, Harrell's 1994 report, which also cites three structures as individually eligible, lists two of them as Buildings 3617 and 3618. It was Harrell's belief that the two buildings needed:

> further research to evaluate the significance of these structures to the development of the X-15 Rocket Engine, and testing of liquid and solid rocket fuels. Buildings 3617 and 3618 may be

> individually eligible for listing on the National Register of Historic Places under Criterion A, as Cold War or Space Age research facilities, and under Criterion D for their ability to reveal information valuable to understanding development and testing of rocket engines [1994:E-459].

Panamerican Consultants, Inc.'s (Panamerican) reevaluation of more than 500 structures within Picatinny Arsenal in 1997, which included Buildings 3617 and 3618, concluded that the entire NARTS Test Area E formed a single district with Buildings 3617 and 3618, which were still surrounded by their original landscape design, as the two most important structures within it (Nolte et al. 1999b:99-119). Nolte et al. (1999b:131) reported that,

> [g]iven the historic importance of Test Area E, … both nationally and regionally, and the information it might potentially supply about the military-industrial complex's role in the early Cold War, the New Jersey HPO [Historic Preservation Office] ruled that this site is eligible for the NRHP and the New Jersey Register of Historic Places as a district under Criteria A and D. Clearly this is a site that illustrates the symbiotic relationship of private industry and government agencies in the creation of the vital military-industrial complex that sent the United States into space.

Despite the two structures' significance, Panamerican was concerned about their apparent poor condition; the structures exhibited much exposed and rusted rebar, significant areas of spalling concrete, and leaking roofs. Because of the buildings' perceived poor condition, Panamerican recommended that a full structural assessment be conducted to determine if they were sound. If buildings are not structurally sound, they have lost integrity and, therefore, are not eligible for listing in the NRHP. Nevertheless, Panamerican believed that the buildings were significant enough to warrant HABS/HAER recordation, even if they were not sound (Nolte and Steinback 1999a:131).

On July 2, 1999, the New Jersey HPO concurred that Test Area E was eligible for listing on the NRHP and the New Jersey Register of Historic Places as a district under Criteria A and D (Guzzo 1999).

2. History: Prior to the Army's and Navy's residency in the area, settlement of the Highlands, including the project area, was associated with the iron industry. Mining is reputed to have occurred at both Mount Hope mine (adjacent to Picatinny) and Dickerson mine (west of Picatinny) as early as 1710, making these sites the oldest iron-mining operations in both New Jersey and the thirteen colonies (Rutsch and van Voorst 1991:13; Rogers 1931:2-3; Fitch and Glover 1990:B/145-146). By 1737, the northern portion of Hunterdon County (which at that time consisted of the present counties of Morris, Warren and Sussex) had an approximate population of 1,750 whites and 70 African slaves (Pitney 1914:4). During the mid-eighteenth century, three forges were established either near or within what would become the Picatinny Arsenal reservation:

- Picatinny Forge, founded about 1749 and called Middle Forge after 1772;
- Mount Pleasant Forge, founded around 1750 and subsequently known as Lower Forge; and
- Burnt Meadow or Denmark Forge, founded in 1750 and known as Upper Forge.

Although there is little agreement about the structures that may have existed at these forges, Halsey inferred that these sites were "bloomary forges," where charcoal, ore, and limestone were shoveled into a furnace to create a "bloom" or semi-molten mass of metal and slag. While still hot, this mass was hammered to remove the slag and produce wrought iron (Halsey 1882:48-56; Rutsch 1999).

An important element to the successful operation of these establishments was that the necessary raw materials—iron ore, limestone, and charcoal—were found easily nearby. Mount Hope and Hibernia mines were located in the hills just east of these forges, while at least two limestone extraction pits were utilized within what is now Picatinny, and several charcoal kilns were adjacent to it (Rogers 1931:7; Fitch and Glover 1990:B-150; Sandy and Rutsch 1992:69; Rutsch et al. 1986:184-186).

The iron industry would expand into the Green Pond Brook valley when Jonathan Osborn (or Osbourne) erected a dam at the southern end of what is now Picatinny Lake and established one of the earliest forges in New Jersey in 1749. Within the boundaries of what is now Picatinny, Osborn's forge was called Picatinny Forge, but later became known as Middle Forge. The forge may have used ores from the nearby Mount Hope mine (Rogers 1931:7; Halsey 1882:41). Establishing his forge at the foot of Picatinny Peak near Green Pond Brook, Osborn created Picatinny Lake by damming the brook for his forge. Machinery and other implements from Middle Forge are on display at the installation museum (Rogers 1931:6; Myers 1984:7).

The following year (1750), Colonel Jacob Ford, Sr., who had purchased Mount Hope mine about the same time, established a forge at Mount Pleasant. Since this forge was south of Osborn's forge, it was sometimes referred to as the Lower Forge. In order to erect another forge. Ford, a leader in the colonial iron-working industry in New Jersey, constructed a dam on Burnt Meadow Brook in 1750, creating Lake Denmark in the process. Subsequently located near the southern end of Lake Denmark, this forge is referred to as the Upper Forge, or, later, as John Harriman's Iron Works or Burnt Meadow Forge. Jacob Ford, Jr., who would continue the family business of owning numerous iron operations in the Green Pond Brook valley, reacquired Middle Forge in 1772 (Fitch and Glover 1990:B-146; Rogers 1931:6-7; Halsey 1882:41).

Known as the Denmark Tract, Jacob Ford, Jr.'s tract contained approximately 6,231 acres and was located west of Mount Hope and east of Green Pond Mountain (or in the middle of the Green Pond Brook valley). Sources reported that the property was "returned to Courtland Skinner and John Johnson" on June 21, 1774 (Halsey 1882:334; Rogers 1931:5). Skinner and Johnson appeared to have purchased this tract for Ford, Jr. (Sandy and Rutsch 1992:43). The substantial tract included Mount Pleasant, Washington Forge, the Spicer properties, Middle Forge and Denmark lands, and portions of it remained in the Ford family until 1806, when it was purchased by Benjamin Holloway, who rebuilt the abandoned forge.

Ironmaster John Jacob Faesch, a Swiss, formerly employed by the American Iron Company (also known as the London Company), began to dominate the valley's iron industry. Southeast of the future arsenal near the village of Dover, he established the Mount Hope Furnace in 1772. Also in 1772, Faesch purchased a large tract of land in the Green Pond Brook valley. After demolishing two standing mills (a gristmill and a hemp mill) to construct the Mount Hope furnace on the best location for waterpower, Faesch increased his holdings by renting contiguous properties from Jacob Ford, Jr. He purchased Middle Forge from the Ford heirs in 1778 as well as over 1,900 acres of forested land adjacent to his forges. Faesch, like the Fords, acquired other forges in the Green Pond Brook valley as well as the Mount Hope mine. Moreover, he operated his forges, including Middle Forge, in conjunction with Mount Hope mine until his death in 1799 (Rutsch et al. 1986:46-49; Fitch and Glover 1990:B-146, B-150; Rogers 1931:7; Halsey 1882:41, 53). The historical records are unclear regarding the relationship between Ford's Denmark Tract and Faesch's tract, which, upon initial review, seems either to overlap or to be contiguous.

Faesch's various iron works played an important role in the Revolutionary War by providing the Continental Army with iron materiel, such as "cannon, shot, bar iron, shovels, axes and other iron implements" (Myers 1984:7). George Washington visited the ironworks at Mount Hope, and approved the transfer of a number of Hessian prisoners to Faesch in order to work at the facilities (Myers 1984:7; Fitch and Glover 1990:B-150; Rogers 1931:5; Rutsch et al. 1986:48). Within Picatinny's boundaries, the Walton Family Cemetery (known alternatively as the Walton Burial Ground or the Hessian Cemetery) lies near Picatinny's Mount Hope Gate and is reputed to contain graves of several of the Hessian prisoners. Since most of the graves in the cemetery are marked with fieldstones, following early custom, the Hessian connection is extrapolated from prisoner work at the local forge and those Hessians who remained in the area after the war. It is further alleged that three other Revolutionary War veterans, besides Peter Doland, are buried there, as well as a possible Civil War veteran, whose grave is unknown (U.S. Army Armament Research, Development, and Engineering Center [ARDEC] Historical Office nd:Item 19; Rutsch et al. 1986:55).

During the nineteenth century, the vicissitudes of the iron industry resulted in valley land changing hands often as the fires of forges burned less and less brightly (Sandy and Rutsch 1992:46-51; Halsey 1882:45, 334; Fitch and Glover 1990:B-150, B-154; Rogers 1931:5-6: Rutsch et al. 1986:59). Despite a depletion of forest timber (and subsequently charcoal), which began in the 1820s and contributed to the volatility of early nineteenth-century iron markets, Middle and Upper Forges continued to operate until the 1850s. Other factors reflecting the general volatility of the industry included frequent ownership changes and a continuous pattern of forge shutdowns and start-ups. On the other hand, providing new blood to the region's sclerotic economy, the Morris Canal was built between 1825 and 1831. Passing just south of Picatinny through Rockaway and Dover, the canal connected Jersey City on the Hudson River to Phillipsburg on the Delaware River by 1865. Constructed to carry cheap coal from Pennsylvania to the industrial centers developing along the New Jersey coast, the canal also provided coal to fuel the iron forges and furnaces in the Highlands, replacing the depleted timber supply. While anthracite coal traveled east, ore from the New Jersey Highlands was shipped westward in great quantities to newer furnaces constructed in Pennsylvania near the Delaware River (Rutsch et al. 1986:65-66; Halsey 1882:68-69; Fitch and Glover 1990:B/150-151).

By 1882, Denmark Forge was no longer in operation and was followed into inactivity five years later by the Denmark mine (Sandy and Rutsch 1992:53). As the profitability of the iron industry declined after 1880, the population of the region declined in tandem, to a low of 2,423 in 1940 (Rutsch et al. 1986:27-29, 35). By the beginning of the twentieth century, only 20 iron mines in the Highlands were in operation, including the Mount Hope mine, which had passed to the control of the Empire Steel & Iron Company. The decline of the iron industry continued through the twentieth century, and resulted in a continual ebbing of the region's population over the next forty years (Fitch and Glover 1990:B-155; Sandy and Rutsch 1992:37). While the Highlands' lakes continued to be popular as resorts and vacation spots, the area around Picatinny Arsenal became attractive to suburban development with improvements in the automobile and the region's transportation infrastructure. Population surged following World War II with the construction of Interstate routes 80 and 287, the development of suburban residential communities and ancillary commercial construction (Fitch and Glover 1990:B-155; Rutsch 1999).

***Picatinny Arsenal/Lake Denmark Powder Depot*.** Picatinny Arsenal was established on September 6, 1880 as the Dover Powder Depot under the command of Major Francis H. Parker of the Ordnance Department. Picatinny's initial purpose was the storage of "powder, projectiles, and explosives, both for reserve supply and for issue; also for the preparation and issue of these stores" (Rogers 1931:53). A board of Ordnance Department officers chose the Green Pond Brook valley near Dover as the site of the depot based on several criteria: the site had to be a sparsely populated region near New York City, capable of storing a large amount of powder, and accessible by train. Between 1880 and 1881, the government acquired 1,866.12 acres from various owners for a total of $62,750, or about $34 per acre. After Major Parker requested that the installation's name be changed, the new depot became Picatinny Powder Depot on September 10, 1880, with construction beginning six days later (Fitch and Glover 1990:B-160; Rogers 1931:10-11).

Between 1880 and 1890, construction activities focused on the erection of storage magazines, officer's quarters, and service facilities. The first powder-storage magazine was completed in 1881 with the storage capacity of 10,000 pounds of black powder. With four powder magazines completed by November 1886, the depot received its first shipment of powder (300,000 pounds) for storage later that month. To facilitate access to the installation and the general shipment of freight, the Morris County Railroad began building a rail line through the depot in 1886. In 1887, 23½ miles of track traversed the powder depot and connected it to the Delaware, Lackawanna & Western Railroad and the Dover Central Railroad of New Jersey at Wharton. A privately owned line called the Northern & Wharton Railroad also ran through the depot and maintained five associated stations. Seventy men were employed at the depot and 900,000 pounds of powder were stored at the facility by that time. From 1893 until 1907, the facility was known as the United States Powder Depot (Fitch and Glover 1990:B/164-166; Rogers 1931:53-54, 71; Rutsch 1999:19-21).

In June 1891, 315 acres of Picatinny Powder Depot land near Lake Denmark were ceded to the United States Navy for the establishment of a Navy powder depot. (This area is now part of Picatinny.) After vacating its powder magazine on Ellis Island in New York harbor, the Navy utilized the Lake Denmark facility as its primary depot on the East Coast. Storing powder, ammunition, high explosives, and artillery shells, the Lake Denmark Powder Depot was enlarged when the Navy acquired more than 146 additional acres in two purchases in 1902. By 1892, a shell house, a storage magazine and three residential structures were completed (Rogers 1931:29-31; Fitch and Glover 1990:B/166-168; Harrell 1994:6).

Historical development within Picatinny has been concentrated in the areas south and east of Picatinny Lake, which included most of the areas initially purchased by the federal government in 1880-1881 (Rogers 1931: 58-61, 77; Harrell 1994). Construction phases at the post dovetailed with the installation's manufacturing activities and changes in its mission over time. The initial phase of development covered the depot/storage period from 1880 until 1907. The depot’s first phase of operation involved powder storage and increasing involvement in the assembly of cannon charges. In 1897, workers at the depot assembled powder charges that included manufacturing and filling the storage bags. Between 1902 and 1906 armor-piercing shells were assembled at the depot, where projectiles were filled with explosives, such as Maximite and Explosive "D" (Rogers 1931:54; Fitch and Glover 1990:B-168; Harrell 1994:6).

A major change in the installation's mission occurred in 1907 with the construction of the first Army-owned smokeless powder factory. This activity resulted in the redesignation of the depot as Picatinny Arsenal, and marked the beginning of the Picatinny's important manufacturing phase, which continued until the early years of World War II. Manufacturing increased gradually in the years before World War I as Congress approved continual expansion of the arsenal's production facilities. Picatinny maintained sole responsibility for the assembly of fixed ammunition over .50-caliber by 1909. By 1913, the arsenal was operating a plant for the manufacture of Explosive "D," which was used in armor-piercing projectiles. An Officer's Training School was established in late 1911 to provide training in chemistry, explosives and ballistics, as well as ammunition manufacturing processes. When the United States entered World War I, Picatinny Arsenal saw a rapid development of its physical plant both around Picatinny Lake and Lake Denmark to meet the exigencies of preparing for war and to accentuate its storage capabilities. During this time, the development of the arsenal as a research and administrative installation also began as the Picatinny personnel provided technical assistance to the private sector producing explosives for the war effort. During the 1920s, munitions experimentation and training had replaced powder production as the arsenal's mission, foreshadowing the later expansion of the facility into a complete ammunition arsenal (Rogers 1931:54-56; Kaye 1978; Fitch and Glover 1990:B/168-170; Harrell 1994:7).

While the Ordnance Department was transforming Picatinny Arsenal into a center for explosives research and development through an extensive renovation and construction program, the Navy was constructing additional powder-storage magazines at its Lake Denmark installation. On Saturday afternoon, July 10, 1926, lightning struck the 461-acre Lake Denmark Powder Depot, causing a series of fires and sympathetic explosions throughout the southwest end of the depot. These explosions killed 19 people, including eleven Marines fighting the fires, and sent shock waves throughout the Green Pond Brook valley, destroying everything within a 3,000’ radius of the epicenter. Beyond this radius many structures were severely damaged, both within the Navy depot and the adjacent arsenal as well as among the nearby non-military residences (Rogers 1931:Chapter IX; Fitch and Glover 1990:B/171-174).

Once the fires were extinguished, the Navy appointed a Court of Inquiry to investigate the incident. The results of the investigation led to changes in safety and ammunition-storage procedures and standards. Since Picatinny stored material similar to that stored by the Navy at Lake Denmark and had been damaged by the explosions, a board of Army officers also investigated the incident. This commission recommended that Picatinny Arsenal not only be reconstructed but also enlarged for the purpose of consolidating the Army's ordnance activities in northern New Jersey. Devised with the safe handling of explosives as a top priority, plans for rebuilding the arsenal called for the division of the arsenal into zones based on the function or activity occurring in that zone (Rogers 1931:94-96; Fitch and Glover 1990:B/174-176). These functional zones were:

- powder and explosives production and handling;
- powder and explosives storage;
- powder and explosives testing; and,
- non-hazardous manufacturing and offices for administration and research (Rogers 1931:94).

Between 1927 and 1937 both the Navy Ammunition Depot and Picatinny Arsenal were completely rebuilt. With rehabilitation nearly complete in 1931, Picatinny became not only the major ammunition arsenal of the U.S. Army, but was an important center of ammunition research, development, and manufacturing, which included operation of experimental and production plants for the development of a range of propellants and explosives. By the time of the entry of the United States into World War II, the arsenal contained 567 buildings and was producing smokeless powder, high explosives, fuzes and primers, assembled rounds of artillery ammunition, bombs and grenades, and pyrotechnics (e.g., airplane flares and signal smokes), all at experimental or peace-time levels (Thurber and Norman 1983:28-29; Fitch and Glover 1990:B/177-180; Harrell 1994). In addition, the arsenal was responsible for the standardization of new designs for artillery fuzes and for the development of nose and tail-bomb fuzes. Arsenal personnel also improved the design of artillery primers, trench mortars and rounds of chemical and tracer ammunition. The Research and Chemical Branch developed fuze powders, primer mixtures, pyrotechnic compositions, propellant compositions, and new high explosives. Picatinny's mission also called for the development of new munitions designs utilizing the latest technology and, in the event of a national emergency, to provide private industry with production plans and testing. For example, during the 1930s, researchers at DuPont and

Picatinny developed flashless, non-hygroscopic (i.e., non-water absorbent) powders or FNH. DuPont developed M1 powder, and Picatinny developed M3 powder, both of which were tested for composition and specific weapons at the arsenal (Thurber and Norman 1983:29; Green et al. 1990; Kaye 1978).

During World War II, many important advances, new products or simplified methods of production were made at the arsenal in its newly constructed laboratories and testing facilities. As the importance of Picatinny's research and development (R&D) activities grew, more emphasis was placed on this R&D function, which it would retain after the war. In one year the job-training methods, research projects, and improved work developments originating at Picatinny and passed along to other plants saved the United States more than $30 million (Kaye 1978). While expanding production capabilities to meet the munitions requirements of fighting a two-front war, the arsenal continued to conduct research on tetryl manufacturing and nitrocellulose powder. It also provided explosives and powder production training to both civilian and military personnel.

The responsibility of the Mechanical Branch of the Technical Division was the development and design of ammunition and special bombs for specific jobs. During the war, a number of special components were designed and tested at Picatinny, including both aboveground and long-delay bomb fuzes. In addition, the Mechanical Branch created pyrotechnic devices, such as flares and signals (Thurber and Norman 1983:32-33; Kaye 1978; Fitch and Glover 1990:B/179-183). One of the most important bombs developed for a particular need was created to blow up the Ploesti oil fields in Romania, a vital source of oil for Nazi forces. The bombs created by Picatinny for this mission obliterated the Ploesti installations (Kaye 1978).

In addition to the development and evaluation of new explosives, the Chemical Engineering Section, part of the Technical Division, was responsible for improvements in the performance of regularly used, standard military explosives. The invention of Haleite, named for Dr. George C. Hale, chief chemist at Picatinny, is regarded as its most significant accomplishment. Although just entering production at the end of the war, Haleite (ethylenedinitramine or EDNA) could be press-loaded into small shells without a desensitizing agent and its derivative, ednatol, could be melt-loaded into large shells. Manufacturing problems, however, prevented Haleite from being used in combat (Green et al. 1990; Thurber and Norman 1983:33). During research subsequent to the development of

Haleite, Picatinny's chemists created another explosive, PTX-2 (Picatinny Ternary Explosive), a combination of PETN (pentaerythritol tetranitrate), RDX ("Research Department Explosive"), and TNT (trinitrotoluene). Preliminary firings at the arsenal revealed that it was adaptable to shaped-charged ammunition, although by the end of the war PTX-2 was still in the testing stage (Green et al. 1990).

During the war, Lake Denmark Ammunition Depot continued to operate as the Navy's propellant and projectile storage area (Fitch and Glover 1990: B/179-183). Several sources suggested that the 3400 Area of the Lake Denmark Depot was built to house prisoners-of-war, but no evidence has been located to document whether POWs were ever held there (Thurber and Norman 1983; Fitch and Glover 1990:B-183) and it appears likely that no POWs were ever held there.

The post-war years were marked by both the Cold War with the Soviet Union and hot wars in Asia and the Middle East. During this period, Picatinny continued as a center for R&D for new weapons systems and advances in production processes. Innovations in these areas and the development of new materials had occurred consistently at the arsenal over its history. These types of innovations increased after the war and included the development of photoflash cartridges and bombs, the study of plastics and adhesives in the packaging of ammunition, the research on warheads for the NIKE, HONEST JOHN, SERGEANT, and other nuclear and conventional missile programs, and the production of a tank-piercing rocket for the 3.5-inch bazooka, and an atomic shell for the 250-millimeter (mm) gun (Fitch and Glover 1990:B/182-184; Gaither 1997:94, 102).

After World War II, the Navy's BuAer decided to establish a rocket-engine test center on the East Coast, and initiated modifications to the existing facilities at Lake Denmark. On July 1, 1948, the U.S. Naval Aeronautical Rocket Laboratory (NARL) was established there. Less than two years later, the Naval Ammunition Depot was officially disestablished, and the NARL was redesignated the Naval Air Rocket Test Station (NARTS) on April 1, 1950. All physical facilities of the former Lake Denmark depot were made a part of NARTS. As it evolved, NARTS had three major work categories: qualification tests, preliminary investigations, and technical services; all of which were included in its mission "to test, evaluate and conduct studies pertaining to rocket engines, their components and propellants" as assigned by the Chief of Naval Operations (U.S. Department of the Navy 1997a, 1997b; Nolte et al. 1999c).

The history of NARTS is intimately associated with the history of Reaction Motors, Inc. (RMI). RMI was formed in 1941 and was the first enterprise devoted to the commercialization of the rocket engine (Shesta 1978; Nolte et al. 1999c). By the middle of 1946, all of RMI's activities had been transferred to Lake Denmark, where a construction program for rocket test stands was underway. By 1958, RMI and Thiokol Chemical Corporation merged and RMI became a division within the company (RMD). In 1956, RMI was awarded the contract to develop the XLR-99 liquid rocket engine for eventual use in the X-15. The initial testing, including test firings, of that engine was conducted at Lake Denmark, much to the displeasure of the local residents. In 1960, the Navy decommissioned NARTS and the facilities became part of Picatinny Arsenal under the Ammunition Development Division of the Ammunition group at Picatinny. Renamed the Liquid Rocket Propulsion Laboratory, the entire facility was leased almost immediately to the Thiokol Chemical Corporation, RMD. As a result of changes in the rocket industry during the 1960s, RMD at Lake Denmark was shutdown by 1972. The rocket test areas of the Lake Denmark site were abandoned to the Army and have been largely unused since, except as backdrops for training exercises or as spaces for other types of activities (Shesta 1978; Nolte et al. 1999c; U.S. Department of the Navy 1997c).

By 1977, most production of weapons and ammunition had ceased at the arsenal and its activities focused on R&D. At that time the Army established the U.S. Army Armament Research and Development Command (ARRADCOM), headquartered at Picatinny, to be responsible for developing new and improving old weapons and munitions. In 1983, ARRADCOM was disestablished and its mission was transferred to the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island Arsenal, Illinois. The munitions and weapons R&D activities remaining at Picatinny were renamed the U.S. Army Armament Research and Development Center (ARDC). In 1986, ARDC was renamed the U.S. Army Armament Research, Development, and Engineering Center (ARDEC) with its headquarters at Picatinny. ARDEC was transferred from AMCCOM to the U.S. Army Tank-Automotive and Armaments Command (TACOM) in 1994. Representing the technical expertise of the U.S. government in guns and ammunition of all sizes, from pistols to howitzers, ARDEC played an essential role in developing items and technologies as diverse as warheads, gun fire control, mines, and smart ammunition, among other responsibilities (ARDEC 1995). In the mid-1990s, over 1,000 buildings were spread out over Picatinny's nearly 6,500 acres, making Picatinny "the largest Army installation devoted solely to research and development" (STV/Lyon Associates, Inc. 1994). In

2003, ARDEC was transferred from TACOM to the U.S. Army Research, Development and Engineering Command (RDECOM). As the Army's "Center of Lethality," ARDEC at Picatinny is "the Army's principal researcher, developer and sustainer of current and future armament and munitions systems" (ARDEC 2008).

In October 2006, Picatinny was recognized by the American Institute of Aeronautics and Astronautics (AIAA) for its "vast work done with rockets and propulsion during the arsenal's history" and designated as an historic aerospace site (Picatinny 2006; AIAA 2006). A small park area in front of Buildings 1 and 94 recognizes this designation with a plaque that reads:

A GATEWAY TO SPACE
At Picatinny Arsenal's Lake Denmark Area, Reaction Motors Inc.
Produced and Tested the XLR-11 Rocket Engine that Powered
Capt. Chuck Yeager's Supersonic Flight In The Bell X-1 Airplane
on 14 Oct. 1947.
XLR-11's Powered The First 24 Flights of the Record Setting X-15
Rocket Plane and a Family of Lifting Bodies Whose Flight Data
Influenced The Design of The Space Shuttle and Provided a
"Gateway To Space."

Picatinny joined other prestigious sites such as Auburn, Massachusetts (the site of Robert Goddard's first liquid rocket launch), the Boeing Red Barn in Seattle, and Farnborough, England (the site of the Royal Aircraft Research Establishment). These early rocketry sites are quickly disappearing thereby making their identification and designation more difficult. On the occasion of the designation, AIAA Region I Director Thomas Milnes commented,

> Our recent technological heritage is more difficult to acknowledge, mainly because so many advancements have happened so quickly that it is hard to gain the perspective needed to judge a site's historic impact. Because of this difficulty, many sites that have helped define aerospace in the 20th century have been lost. Luckily, Picatinny Arsenal still exists [Picatinny 2006].

3. Naval Air Rocket Test Station (NARTS): Although Picatinny Arsenal had a long history of conducting cutting-edge military R&D projects, its sister installation, Lake Denmark Naval Ammunition Depot (NAD), had served the Navy simply as a storage facility since its inception on February

24, 1891. While the pace of its activities ebbed and flowed with peace and war, NAD was never involved in any special research until after World War II, when the Department of the Navy decided to locate a rocket-testing facility at its extreme northeastern corner not far from Lake Denmark. The research and testing carried out in this small area would in many ways rival the best work ever done at Picatinny (Durant 1951:76; Baranowski 1959). Every architectural study completed at Picatinny has highlighted this area as significant (Thurber and Norman 1983; Ashby et al. 1984; Fitch and Glover 1990; and Harrell 1993, 1994; Nolte et al. 1999b).

At the end of World War II, the Department of the Navy Bureau of Ordnance (BuOrd) determined that Lake Denmark NAD, at one time the Navy's largest storage depot, was excess for then-current needs, and started to deactivate the facility. However, the BuAer recognized the opportunity to establish a centralized, East Coast rocket-engine test center with applications for naval aviation, and initiated steps to receive management control of NAD. After modifications to existing facilities, the U.S. NARL was established at Lake Denmark on July 1, 1948 with functions similar to those at the Air Force Rocket Test Facility at Muroc, California (later, Edwards Air Force Base). The Officer-in-Charge (OIC) of NARL reported to the Commanding Officer of NAD for command and BuAer for management. Its mission was the "evaluation and development of rocket engines and their components" (NARTS 1950: Progress Report for January; Baranowski 1959). The first (and only) OIC of NARL was Commander Dayton A. Seiler, who served from July 12, 1948 to April 1, 1950.

Lake Denmark was selected as the site for the laboratory because the depot met the necessary criteria for a successful testing facility. The Navy had occupied the site since the 1890s (as an ordnance depot) and had already invested in the facility's infrastructure for such items as roads, utilities, barracks, and potentially convertible warehouses. Lake Denmark was located in a fairly isolated area, but had excellent transportation connections up and down the East Coast. The depot was situated in a highly industrialized portion of the country that made the hiring of specialized personnel and the procurement of materials easier. Empty buildings could be easily adapted to rocket-testing functions, and the Navy had already leased a number of them to Reaction Motors, Inc., the pioneer firm for the commercialization of rockets. Moreover, propellant storage facilities, high pressure inert gas storage, and test stands had been constructed by the Navy for RMI. The site was close enough to Washington, D.C., for liaison with the Bureau of Naval Weapons

(BuWeps) and the newly organized Department of Defense (DoD), as well as other East Coast rocket manufacturers (Seiler 1949; NARTS 1950: Project Report for January; Durant 1951:76).

RMI, initially incorporated at Pompton Plains, New Jersey, in December 1941, worked closely with the Navy during the war, but required additional facilities to meet the accelerated demands of post-war jet-engine development. The Navy offered the use of buildings and land formerly associated with the NAD ordnance battalion area for manufacturing shops and offices.

> The RMI administration area at the Naval Ammunition Depot's main gateway features two large buildings where research and development engineers and manufacturers produce rocket engines; in one building the engines are designed and models made; in the other, the approved designs are put in production. Nearby are separate buildings for the administration offices, cafeteria, security section and other facilities. The testing area, gleaming with the huge new power and supply plants, illustrates the rapid growth of [the] organization ... [RMI 1948:2-3].

By the middle of 1946, all of RMI's activities had been transferred to Lake Denmark, where a construction program for rocket test stands was underway (*The RMI Rocket* December 1951).

Scheduled for completion in December 1949, the construction of additional test facilities included one booster test stand of 100,000-lb thrust capacity, and two test stands of 20,000-lb. thrust capacity. Plans for the renovation and expansion of the facility were included in the budget for the following year (Seiler 1949). NARL personnel comprised seven officers, 36 enlisted men, and 123 civilian employees. The earliest projects assigned to NARL, most of which were restricted or confidential, included the development of methods and equipment for testing liquid propellant rocket engines (project no. ARL PP-201); various applications as related to the LARK guided-missile rocket engine (ARL PP-202 and ARL PP-202.1); and the acceptance tests and evaluation of the XLR-18-K-2 booster assembly rocket (ARL PP-203 and ARL PP-203.1) (Seiler 1949; NARTS 1950: Progress Report for January).

In addition to testing and evaluation activities, the Navy found it desirable to actually provide test facilities at NARL for rocket-engine contractors or other governmental agencies with inadequate or insufficient test facilities of their own. This was particularly true for engines with more than 10,000 lbs of thrust. As the thrust capacity of engines grew, the costs of construction for the test stand, tankage, and instrumentation, which were costly to begin with, increased significantly making the creation of large stands cost prohibitive for many companies. In addition, some companies were located so close to general habitation that the firing of very large engines was precluded because they were a public nuisance (Durant 1951).

On April 1, 1950, NAD was officially disestablished and NARL was redesignated the Naval Air Rocket Test Station (NARTS) under the command and coordination control of the Commandant, Third Naval District, and management control under BuAer. Its purpose was to test and evaluate rocket engines, components and propellants as well as train service personnel in the handling, servicing and operation of rocket engines. All physical facilities of the former Lake Denmark depot were made a part of NARTS, but as a result of the large amount of ordnance still stored on site, a number of buildings were retained by BuOrd and the facility received the additional task of acting as an ordnance reserve stock point (Baranowski 1959).

In the early 1950s, the Navy undertook an extensive engineering study to create a master plan for the facility. The Navy requested $7,500,000 for the expansion and modernization of the existing test facilities; to purchase more land to better integrate their current holdings; to improve and standardize instrumentation; to provide for an underground propellant storage system; to create more housing; and to outfit specialized shops and laboratories (NARTS 1950: Progress Report for January; Durant 1951). NARTS began an expansion program that included the construction of Test Area E, a site for the testing of rocket engines up to 350,000 lbs thrust, and which undertook a number of important research and design projects (NARTS 1951, 1952: various Monthly Progress Reports).

By 1952, RMI had constructed its main rocket-engine test area at NARTS, operated by permit. The area contained an administration building, and storage buildings, as well as 17 test cells, which had maximum thrust operation ranging from 10,000 to 50,000 lbs. Adjacent to RMI's test area, NARTS maintained four test cells and was planning what would become Test Area E. RMI also owned 237 acres adjacent to NARTS (RMI ca. 1953:15-16). At this time, the Naval installation consisted of 760 acres and represented a multimillion-dollar investment. It was anticipated that the staff would double in the next decade. The facility's earliest work had been devoted primarily to liquid propulsion, but was beginning to include evaluation of rocket engines and rocket systems, development of methods for analyzing rocket propellants, and the collaboration with private industry on a wide range of experiments and safety manuals. All these functions were a part of NARTS' mission as assigned by the Chief of Naval Operations: "to test, evaluate and conduct studies pertaining to rocket engines, their components and propellants" (NARTS ca. 1959a).

As it evolved, NARTS developed three major work categories: qualification tests, preliminary investigations, and technical services, all of which were included in its assigned mission (Durant 1951:76-77; Naval Historical Center 1998; NARTS ca. 1959a). Qualification tests included the actual qualification tests themselves; safety and reliability determinations; evaluations of contractor products, age-test programs; and investigations of performance deficiencies in production items in operational use. In the early 1950s, NARTS completed qualification programs on the engines, and arresting landing and simulated catapulting systems for BULLPUP (engine XLR 58-RM-2) and SPARROW (engine XLR 44-RM-2) as well as the engines on the Air Force SIDEWINDER. NARTS worked on a number of major preliminary investigations including: damage control of propellant oxidizers; a variable thrust engine for spacecraft application; ultra high-density propellant systems; and the investigation of monopropellants as gas generates (NARTS ca. 1959b, ca. 1960).

Technical services were provided by the Rocket Propulsion Laboratory for the BuWeps, other government agencies and private contractors. These services included the development of specifications and procedures for mixed amine fuel (a group of organic compounds of nitrogen that may be considered ammonia derivatives in which one or more of the hydrogen atoms has been replaced by a hydrocarbon radical). In the 1950s, technical services were provided to the Standard Oil Company, Fulton Irgon Corporation, Camin Labs, Aerojet-General, Olin Industries, Phillips Petroleum, Grand Central Rocket Co., Sperry Gyroscope, and RMI, to name a few (NARTS ca. 1959b, ca. 1960).

The heart of the NARTS organization was the Rocket Propulsion Laboratory. All other departments—Administration, Supply and Fiscal, Public Works, Security, Medical and Industrial Relations—served the needs of the Rocket Propulsion Laboratory. The Laboratory itself was grouped into four divisions: Propellant, Rocket Engine, Engineering Services, and a more loosely organized Project Group. The Propellant

Division was responsible for analytical chemistry and propellant evaluation as well as physical chemistry and propellant synthesis. The Rocket Engine Division was responsible for design, creation, instrumentation and testing of rocket engines. The Engineering Services Division was responsible for material control, photography, as well as technical publications and a large library. The Project Group was responsible for following through on new ideas and testing hypotheses (NARTS ca. 1959b).

The military and civilian personnel that staffed NARTS in the mid-1950s held impressive credentials. Dr. John D. Clark, NARTS chief chemist from 1949 to mid-1950s, headed the Propellants Division. Clark, a Stanford Ph.D., was best known for the creation of a new family of monopropellants and for developing a simplified technique for determining theoretical rocket-engine performance as well as the invention of a device for in-field use in the analysis of white fuming nitric acid. The Rocket Engine Division, which encompassed the Design, Shops, Test and Instrumentation branches, was directed by John J. Canavan. The Project Group included Frederick R. Hickerson, the inventor of a unique variable thrust rocket engine. The director of the Station itself was Commander Donald T. Jensen, USN. Jensen, a Naval Academy graduate, had worked on the LARK project. The Station's technical director was Irving Forsten, who had worked with Ranger and Grumman and had served as a research scientist with the National Advisory Committee on Aeronautics (NACA, the predecessor of the National Aeronautics and Space Administration [NASA]) (NARTS ca. 1959a).

The NARTS facilities began as a small liquid propellant test stand, but by the late 1950s the facilities were spread out over more than 700 acres in many buildings, firing bays and other structures. Growth was expected to continue and about 1957 NARTS published a recruitment brochure aimed at luring new college engineering graduates to work at Lake Denmark (NARTS ca. 1957). The amount and types of projects had greatly increased. Liquid and solid rocket engines could now be test fired and analyzed at the facility.

The test facilities were generally grouped into six test areas, two used especially by and for NARTS projects and the others leased to RMI. Test Areas A, B, and C—completed in 1947—and G were leased by RMI. NARTS used Test Areas D and E and sometimes G. Test Area E, completed in 1953, was considered the "elite" among the many facilities at NARTS (NARTS ca. 1959b). It was here that the Navy fired liquid propellant rocket engines with a thrust up to 350,000 lbs. from one of the largest static test stands on the East Coast (NARTS ca. 1959b). Areas R and S, which occupied 263 acres immediately north of the Navy test areas, were owned by RMI but were connected to A, B, C, and E areas by Lake Denmark Road (Redmond 1957).

NARTS and Reaction Motors, Inc. Reaction Motors, Inc. was formed by James H. Wyld, Lovell Lawrence, Jr., John Shesta, and Franklin Pierce, all early members of the American Rocket Society who spent their Sunday afternoons experimenting with rocket engines in the garages of their New Jersey homes. Wyld overcame a major problem of rocket design by developing the first American regeneratively cooled engine, one that cooled its combustion chamber by circulation of its propellants. Wyld's principle, formulated in 1938, was close to the solution discovered about the same time by German scientists working on the development of the V-2 missile (Ordway and Winter 1983: 542-544; Shesta 1978).

Awareness of German rocket advances led the United States to start a formal rocket research program. Wyld's new engine was of particular interest to the Navy's BuAer. After several successful test runs of the Wyld engine—and the bombing of Pearl Harbor—a contract was awarded to a newly formed company named Reaction Motors, Inc. after the motors it was to build (Shesta 1978; Ordway and Winter 1983:542-544).

One week before Christmas 1941, the four founders of RMI pooled their resources and with $5,000 formed the company making it the first enterprise devoted to the commercialization of the rocket engine (Thiokol 1997). The company began working in the basement of Shesta's house. From there they moved into a small shop in Pompton Plains, New Jersey, where in nine months the company designed and produced ten different types of rocket engines ranging in size from 50 lbs. to 1,000 lbs. of thrust (Shesta 1978; RMI 1957; Winter and Ordway 1982:np).

> By 1946 the local population of Pompton Plains, N.J. had become resentful of the noise made by our rockets, as well as the noxious fumes from our nitric acid motors[,] which we also tested from time to time. We thus moved once more, this time to Lake Denmark, N.J., to the Naval Ammunition Depot. The Navy had some unoccupied buildings there[,] which were made available to us. This move might be looked upon as a milestone in RMI's progress. Almost overnight we had become a large concern—at least in our estimation [Shesta 1978:np].

RMI located their new engine design, model construction and production facilities to the former ordnance battalion area at NAD. Engine testing occurred at a secluded location on a narrow dirt road between Hibernia and NAD. The new RMI site was located “in a natural ‘bowl’ of surrounding hills insulated by thousands of acres of Government property acquired specifically for ammunition storage and testing [and] provides one of the best areas on the Eastern seaboard for rocket engine testing” (Winter and Ordway 1982). Shortly after the company’s relocation, it purchased 237 acres adjacent to the Navy-owned test area. By 1951, the Navy was in the process of planning and designing a new area at the renamed NARTS to test engines with a larger thrust capacity—Test Area E (Winter and Ordway 1982).

In November 1953, Mathieson Chemical Corp purchased a controlling interest in RMI, and merged with Olin Industries, Inc. in May 1954, forming the Olin Mathieson Chemical Corp. By the end of 1954, RMI had sales of $4.7 million and a work backlog of more than $7.5 million (Ordway and Winter 1983:549; Winter and Ordway 1985). By 1957, one year before it merged with Thiokol Chemical Corporation, RMI organized into six divisions—Applications Engineering and Contracts, Project Engineering, Component Development, Production, Finance, and Administration—had sales of about $24.5 million dollars and had 1,639 employees. Quality Control was conducted by a military inspector, while an in-plant BuAer representative served as RMI-DoD liaison (Thiokol 1997; Ordway and Winter 1983:549; RMI 1957). With an interest in Flight Refueling, Inc., RMI had offices in Denville, New Jersey, Washington, D.C., Dayton, Ohio, and Los Angeles, California.

The principal work of RMI was the development and production of solid and liquid propellant rocket powerplant (engine) systems and related components. In addition to the development of specific products, RMI was involved in basic research and state-of-the-art technology work. By 1957, Reaction Motors occupied 350,000 sq.ft. of enclosed space and owned 60 acres for the future expansion of the company. The company had a $4,000,000 plant in Denville, New Jersey, that was one of the most modern and complete rocket facilities in the United States. The 200,000 sq.ft. plant featured administrative offices, research activities and pilot production facilities. It maintained 150,000 sq.ft. of engineering, manufacturing and test facilities at NARTS at Lake Denmark (RMI 1957).

In 1957, RMI’s main test area consisted of almost 300 acres (50,000 sq.ft. enclosed) at Lake Denmark just seven miles from its Denville plant. This included 21 test stands for the static hot firing of rocket engines and components; 18 stands with thrust capacities from zero to 20,000 lbs; and three large stands with capacities from 50,000 to 1,000,000 lbs. thrust. Environmental test facilities, instrumentation areas, offices and propellant-handling and storage facilities were also located at Lake Denmark (RMI 1957; Redmond 1957).

The engine test stands could hold complete rocket-engine systems for simulated flight trials. Engine, propellant lines, tanks and any related equipment could be mounted in the precise locations they occupied on a plane or a missile. Following successful trial runs at Lake Denmark, the engines were released for field testing (RMI 1957). State-of-the-art testing facilities included tank rooms, firing rooms, and control rooms, all constructed to permit the visual observation of items under test. The instrumentation areas used the highest standards for quality and accuracy in the industry. Equipment could measure for pressure, flow, force, temperature, linear and angular displacement, and acceleration in the form of vibration. A rapid tape-recording and playback system facilitated the analysis and evaluation of data (RMI 1957). The activities of RMI dovetailed with the mission of NARTS, which as stated in December 1956 was to "conduct tests and evaluation of rocket engines, their components and propellants," performed in support of technical research and development for BuAer (NARTS 1956). NARTS still served as a technical ordnance reserve stock point, an assignment, the document noted, not devoted to its R&D mission (NARTS 1956).

On April 30, 1958, RMI and Thiokol Chemical Corporation merged and RMI became a division within the company (Reaction Motors Division [RMD]). Thiokol had its beginning in 1926, when a serendipitous laboratory experiment formulated the world's first synthetic rubber. Three years later, in 1929, the Thiokol Chemical Corporation was formally created, taking its name from the Greek words for sulfur and glue, the products used to create synthetic rubber. The liquid polymer rubber was used extensively as an indestructible sealant for gun turrets, fuel tanks, and seams of all kinds. Scientists at Cal Tech's Jet Propulsion Laboratory discovered that Thiokol's polymer sealant made the best solid propellant fuel binder available at the time. Thiokol was suddenly in the rocket business (Thiokol 1997; Winter and Ordway 1982).

Thiokol opened its first small-scale rocket operations in Elkton, Maryland, and, by 1950, had facilities at the U.S. Army's Redstone Arsenal, Huntsville, Alabama, in the old Redstone Ordnance Plant's production lines. In 1952, it won a contract to refurbish and operate the Longhorn Army Ammunition Plant in Marshall, Texas. By 1958, Thiokol had a contract with the U.S. Air Force to build the first stage rocket motor for the revolutionary Minuteman intercontinental ballistic missile (ICBM) at their Brigham City, Utah, rocket motor plant (Thiokol 1997).

On October 14, 1947, Chuck Yeager became the first human to break the sound barrier, flying the Bell X-1, powered by RMI's 6000C-4 engine (also known as the XLR-11 [its U.S. Air Force designation] and "Black Betsy") (Winter 1988:83-84, 1994a). In 1956, RMI was awarded the contract to develop the XLR-99 liquid rocket engine for eventual use in the X-15. Much to the displeasure of local residents, the initial testing, including test firings, of the XLR-99 was conducted at Lake Denmark at NARTS Test Area E, which RMI leased from the Navy (*The Citizen* 1958-1960; NARTS ca. 1959a; Winter 1987:410). Building on the knowledge gained from the development of the XLR-11, the XLR-99 (also known as "the Pioneer") was the most powerful, most complex, and safest man-rated (safe to carry a human), throttle-able rocket propulsion system in the world. The engine would prove exceptionally reliable and extraordinarily safe despite its long development period (Thiokol 1997; Jenkins 1996:9-11, 40-41). The X-15, the experimental hypersonic aircraft, was a joint NACA, Navy, and Air Force project. "The X-15 program contributed significantly to the U.S. manned space program in general, and was the only existing database on winged manned reentry vehicles available when the development of the Space Shuttle was begun in the 1970s" (Jenkins 1996:11).

NARTS and Test Area E. Conceptualized and constructed between 1951 and 1953, Test Area E was considered by the Navy to be its premier rocket-engine testing area. NARTS engineers completely designed the original plan for the test area in consultation with RMI. They drew up the preliminary specifications and maintained an active role during the final architectural detailing and construction. The architectural and engineering firm chosen was Frank Grad & Sons, an old firm with an outstanding reputation from Newark, New Jersey, which also had offices in Washington, D.C. The development of the Test Area E project was considered one of the major accomplishments of the NARTS engineering staff. When the Test Stand was first put into use it was one of the largest static test stands on the East Coast (NARTS ca. 1959b).

In a public relations brochure on NARTS and its facilities, the Navy described Test Area E:

> Static firings can be made at any attitude on Test Stand E-1 with the test engine ‘tied’ to a mount fastened to trunnions 15 ft apart and located on a cantilevered balcony 60 ft above grade. The engine mount is basically a hollow beam of rectangular cross-section bridging the space between the trunnions. A sliding roof permits vertical erection of missiles up to 90 ft in length.
>
> Two sets of double doors (like a bomb bay) are affixed in the operating floor under the mount. Located under the floor are separate tank rooms for fuel and oxidizer and separate cascade rooms for individual pressurizing of propellants. The liquid oxygen tank capacity is 2500 gal and is rated at 50 psi while the working pressure of the 3000 gal ammonia tank is 225 psi. Also located in the propellant tank room is a 2400 gal water tank, rated at 1500 psi, which is used to cool the engine jacket. Propellants are pressurized by gas stored at 2000-2200 psi. Nitrogen gas is used for pressurizing fuel and cooling water and gaseous oxygen is used for pressurizing the liquid oxygen.
>
> The control room for Test Stand E-1 is located below grade in a concrete building 250 ft away. Instrumentation provides measurement of all the usual rocket engine parameters—pressure, force, flow rate and temperature. The total number of installed recording channels includes 35 potentiometer recorders, eight direct writing Sanborn recorders, and a 2-channel cathode ray oscilloscope. Terminations are also installed in the recording racks for two 18-channel magnetic oscillographic recorders. Thus there are 79 allocated recording channels with 17 spare channels available [NARTS ca. 1959a].

In addition to testing the XLR-99 motor, NARTS compiled an impressive record of notable contributions to rocket engine and propellant R&D. These accomplishments included:

1951-1954	Development of analytical methods for hydrazine, methyl hydrazine, butyl mercaptan and mixed acid
1952	Development of methods for inhibiting corrosion of nitric acid
1953	Design and construction of largest rocket test stand in the East
1954	Discovery of the mechanism of corrosion of stainless steel by nitric acid

1954	First complete qualification test of rocket engine by a government laboratory
1955	Origination of Mollier charts for decomposition of hydrogen peroxide
1955	Developing a shorthand method for rocket propellant performance calculation [NARTS ca. 1957].

The brochure advertising these accomplishments quickly added that these were just the achievements “that can be named” publicly (NARTS ca. 1957). Further research might uncover a host of then-classified NARTS achievements.

Despite the success of RMI/RMD and the accomplishments of NARTS, the Naval Air Rocket Test Station, Lake Denmark was disestablished on August 1, 1960, and the facilities reverted to the U.S. Army for incorporation into Picatinny Arsenal. With this new acquisition, Picatinny Arsenal obtained major capabilities in liquid fuel programs and renamed the entire area the Liquid Rocket Propulsion Laboratory (LRPL) (Picatinny Arsenal ca. 1960). Navy liquid propellant development projects were transferred to the Naval Ordnance Test Station, China Lake, California, the Naval Propellant Plant, Indian Head, Maryland, and the Naval Weapons Laboratory, Dahlgren, Virginia (Naval Historical Center 1998). Although the Army had expressed great hopes for the area, the Lake Denmark Test Area was almost immediately leased by Thiokol (Picatinny Arsenal ca. 1960). A *Test Facilities Data Book* prepared by Thiokol (Edson 1962) provides an excellent overview of the facilities at that time. This volume was intended for use by test area operating personnel, engineering and management personnel of RMI, other divisions of Thiokol, and industrial companies interested in using the facilities, and presented an illustration of Test Area E’s layout during the first years of the Army’s command over the facility, although the configuration of the structures probably had not changed since the mid-1950s (Edson 1962).

During the mid-to-late 1960s, changes in rocket development, notably switching from liquid to solid propellants, resulted in a decline in business at the Denville plant. Efforts were made to retool and to undertake new, more profitable projects (Walker 1970; Thiokol 1997). RMD’s location undermined its ability to attract clients, such as NASA, which sought to build larger and more powerful rocket engines. Although the Lake Denmark area was secluded in 1949, population trends of the period (i.e., suburban sprawl) less than ten years later produced the same problems for RMD that afflicted RMI at Pompton Plains during World War II:

complaints from area residents about noise and damage from shock waves. Moreover, the New Jersey State Supreme Court ruled that Thiokol Chemical Corporation, as RMD's parent, was liable for property damage caused by testing the X-15 engine (Winter 1987:415). The company that began by developing Jet-Assisted Take-Off (JATO) engines; motors for America's first missiles (the LARK and GORGON); and engines or propulsion systems for the VIKING rocket, the Bell X-1, the MX-774, the Republic XF-91, the Rocket-on-Rotor (ROR) for the HRS-2 helicopter, the North American X-15, the BULLPUP, CORVUS and CONDOR missiles, and the Surveyor spacecraft control system, discontinued work in the liquid propulsion field by 1970 and ceased operations less than two years later (Shesta 1978; Ordway 1985, 1987). The rocket test areas of the Lake Denmark site were abandoned to the Army and have only recently been used for various Army activities not related to rockets or rocket-engine testing.

4. NARTS Area E Historic District: The NARTS Area E Historic District was determined eligible for the NRHP in 1999 under Criteria A, contributing to the broad patterns of history, and Criteria D, providing information about a little known or understood period of history (Guzzo 1999). This site illustrates the symbiotic relationship between private industry and government agencies in the creation of the vital military-industrial complex that propelled the United States into space. The NARTS Area E Historic District's period of significance is the Cold War (1946-1989), in this case, the height of the Cold War, 1950-1969.

The buildings that contribute to the district are listed below.

3617 (1953)	Control House
3618 (1953)	Static Rocket Test Stand, Test Stand E-1 including firing pit
3619 (1953)	Liquid Oxygen (LOX) pad; erroneously assigned a separate number, it is part of 3618

Other elements include:

Road network
Retaining walls
Visual aspects of drainage, ventilation and access structures within the landscape

Buildings that are noncontributing to the district are:

3622 (ca. 1960)	Water Tower
3623 (ca. 1960)	Water Tower Support Building
3625 (ca. 1960)	Maintenance Building, Test Stand E-1A
3627 (ca. 1960)	Control Room
E-1D (ca. 1960)	Control Room, gun turret.

NARTS Area E is located off Picatinny proper in the Snake Hill Road area of the former Naval Ammunition Depot. A map of NARTS Area E Historic District is included as part of this documentation. Test Area E occupies 14 acres on a precipitous slope that was used to advantage in the construction of Buildings 3617 and 3618. In addition to its two major buildings—3617 (Control House), and 3618 (Static Rocket Test Stand)—the area also includes the remnants of Building 3619, the LOX tank pad and remaining tank supports at the foot of the bridge portion of Building 3618; Buildings 3622 and 3623, a 400,000-gal Water Tower and attached Support Building; Building 3625, Maintenance Building; Building 3627, Support Building; and Building E-1D (Control Room), made from an old Navy gun turret. The area is accessed by E Road, an asphalt road off of Snake Hill Road that climbs the slope and circles around the rear, south, of the Rocket Test Stand, passing under the bridge that extends from the LOX pad to the rear entry of the Test Stand. In addition to the road, other landscape features that comprise the district include: the Test Stand firing pit; Buildings 3619 and 3625; rock and concrete retaining walls; and a number of concrete drains and earth-fast ventilation shafts. The entire area is enclosed in a chain-link fence that is now secured with a padlock. The chain-link fence forms the boundary of the district.

Original blueprints of the NARTS Area E show that a spot was initially set aside for a water tank, which was later built and is still extant (Buildings 3622/3623). The water tank was an important addition since large amounts of water were needed to cool the blasts from the engines tested. The three other structures—Building 3625 (Maintenance Building), Building 3627 (Support Building) and Building E-1D (Control Room), a former gun turret—were probably constructed in the early 1960s. The reuse of gun turrets was a common practice and several are still in use throughout the installation. The LOX pad was constructed by NARTS at the same time as the Static Rocket Test Stand and served as an auxiliary part of the stand. When the Army absorbed the NARTS facility in 1960, the exact purposes of the specific structures were not known and the connection between the structures was lost to Army administrators. As a result, the LOX area was treated as a separate building and assigned its own number. A similar confusion seems to have applied to Building 3625. The Army identified it as a maintenance facility (Walter 1997b), while RMD of the Thiokol Company referred to the structure as Test Stand E-1A (Edson 1962).

NARTS Area E Historic District is associated with a much larger NARTS complex, frequently called the Lake Denmark Test Area, which is located off Snake Hill Road in the extreme southeastern end of Picatinny. The Lake Denmark Test Area was broken into smaller test area segments called Areas A, B, C, D, E, G and later S and R, all of which were operated by RMI/RMD with the exception of Area D.

NARTS Area D was the exclusive purview of the U.S. Navy's East Coast rocket center. It is here, presumably, that the Navy tested its contractors' work, conducted independent tests, wrote guidelines, and experimented with any number of rocket-related activities such as the decay time for hydrogen peroxide. It was the area where the majority of the NARTS projects were conducted (NARTS 1959a). In connection with Test Area E, the largest static rocket test stand on the East Coast, Area D served as the nerve center for various Navy rocket projects, the most important of which was the testing of the XLR-99 rocket engine, which was conducted with RMD. In 2004, the New Jersey HPO concurred that NARTS Test Area D was eligible for listing to the NRHP as a district under Criteria A, contributing to the broad patterns of history, C, architecture/industrial significance, and D, providing information about a little known or understood period of history through Criteria Consideration G, exceptional importance for a property less than 50 years of age (Nolte and Steinback 2004; Guzzo 2004). NARTS Test Area D is immediately adjacent to, and southeast of NARTS Area E Historic District.

Picatinny's 1500 Area off Lake Denmark Road is northwest of and almost immediately adjacent to (less than 2,000' from) NARTS Area E. The 1500 Area was the U.S. Army's Rocket Test Area. This 20-acre site played a key role in the Army's initial forays into space including the development of some of the most important rocket and missile programs ever devised—HONEST JOHN (the first tactical nuclear missile), REDSTONE, LITTLE JOHN, and NIKE AJAX, to name a few. In 2008, the New Jersey HPO concurred that the Rocket Test Area Historic District was eligible for the

NRHP under Criteria A and C, through Criteria Consideration G (Nolte et al. 2007; Nolte and Steinback 2008; Stack 2008). Although the Army's rocket area lies adjacent to the Navy's rocket area, it is not known if the two services collaborated. However, in the early, heady days of rocket work, there were few scientists and engineers with any expertise and it can be assumed that rocket information was shared in some way.

NARTS Area E Historic District is surrounded by other NRHP eligible districts and by work areas that once serviced and tested rockets, missiles and engines. At present, NARTS Area E Historic District, NARTS Area D Historic District, and the Rocket Test Area Historic District all attest to the Lake Denmark area's past as an important rocket center.

5. Control House (Building 3617): Building 3617, Control House, was built in 1953 as part of a special NARTS facility for the testing of rocket engines with 350,000 lbs thrust and could be modified to test engines up to 1,000,000 lbs thrust. The structure itself has no discernable style or ornamentation. It is a rectangular, steel-framed, reinforced concrete two-story structure with a corrugated metal roof. The building is built into a precipitous slope and uses that slope to shield a portion of the first story from the engine blast from the Test Stand. The Control House is built on a concrete foundation and has industrial steel sash windows. The interior includes mirrors in a periscope arrangement to allow rocket engine firings to be observed safely.

The Control House had two functions: to serve as the Area E control room and instrumentation center and to serve as a mechanical laboratory (Edson 1962). As documented in Section B.3, the construction of the Control House was less about the physical building and more about the contents and actual operation activities of the building. Before the age of computers and digital photography, the construction of the Control House was guided by the need to collect particular types of data by the safest means possible. The construction of the building was guided by a set of criteria that had little to do with the physical appearance of the building. The Control House had to be close to the Rocket Test Stand; the equipment within the building had to photograph and record a significant number of variables on racks of machines that were operated by scientists, engineers, and handlers of all types; the blast from the stand had to be observed, as well as photographed, in safety; the entire process had to be tightly controlled from initiation to completion or abort; and the building had to withstand an explosion or blast from approximately 250' away. No one cared what the Control House looked like, only that all of these functions could be contained under one roof safely.

Building 3617 was simply a cover for the numerous support and control activities related to the Static Rocket Test Stand, Building 3618. It was never painted, landscaped in any formal way, or given a special (memorial) name.

PART II. ARCHITECTURAL INFORMATION

A. General Statement:

1. Architectural character: The building has no particular architectural style. It is significant for the activities it sheltered and the work that it supported in the early days of rocketry, not its look or style.

2. Condition of fabric: Poor. The building has been empty since the early 1970s and has had no real caretaker. The concrete is spalling and crumbling, plant life has metastasized in every crevice and crack, and the doors and windows stand open or are broken. It is interesting to note, however, that the interior still stays dry. The building was in poor condition in 1997, when it was formally evaluated (Walter 1997a), and is in worse condition in 2009.

B. Description of Exterior:

1. Overall dimensions: The 1962 Thiokol test area data book describes the Control House, then designated as building #801-3617, as “basically a two story, 42' x 50', 4161 sq. ft. reinforced concrete building. The ground floor control room [basement] and instrumentation center is housed in 2' thick reinforced concrete ceilings and walls. All exposed [to the Test Stand] walls are earth-fast” (Edson 1962).

2. Foundations: The foundations are poured, reinforced concrete. On the southeast and southwest sides of the building, the foundation and the entire first floor, basement, are made earth-fast by the slope of the hillside. The northeast foundation is partially earth-fast.

3. Walls: The walls are 2’ thick and made from reinforced concrete. The basement, first floor, of southeast and southwest sides of the building are shielded and made earth-fast by the slope of the hillside. The northeast side is partially earth-fast. The only fully exposed two-story portion of the building is the northwest side. The walls are completely devoid of any decoration but the interior walls were painted.

4. Structural systems, framing: The structural system is poured reinforced concrete 2’ thick.

5. Openings:

a. Doorways and doors: The Control House has four doorways with five doors. Two doorways are on the southwest side of the building: one doorway has a rolling steel vehicular door, now rusted halfway open, and the other doorway is a pedestrian metal door with 1/1 metal-enmeshed upper light. Both doors lead into a large, open work area on the second floor. These doors appear to be original. Two doors are also found on the northwest side of the building, both of which are pedestrian and open onto the first, ground floor. The door on the south end of the west side is metal with a 1/1 enmeshed upper light like the door on the north side of the building. The doorway on the north end of the west side features double doors that open into the boiler room. The double doors are metal and the lower panel is louvered and the upper panel is six true divided lights, arranged in three rows of two. There are metal louvers built into the wall above each door. Elevation drawings of the building clearly show these metal louvers and doors. There are no doors on the southeast and northeast sides.

b. Windows: There are traditional windows on only two sides of the building: the northwest and the northeast sides. The windows are either tri-part or single steel frames. The lights in both the single and triple windows are four-part, awning-style with only the center portion of the window opening. There are metal, fixed louvers for ventilation of the boiler room over the double doors on the northwest elevation and a single, small louvered opening on the northeast side.

On the southeast side of the building are a series of four “periscope” openings that are surrounded by a 1’-thick, reinforced concrete window well. The window well, which is quite deep, is accessed between the first and second and third and fourth mirrors by a set of 15 steel rungs embedded into the wall. The window well extends down to the ground level, basement, to observation windows in the control room. Four mirrors are extended at an angle from the surface of the southeast wall of Control House. These mirrors were set at a 45-degree angle so that they could capture the blast and firing of a rocket engine in the Static Test Stand approximately 250’ directly southeast, across the road from the Control House. In periscope fashion, the image was then bounced down to a second mirror, also angled at 45 degrees, at the bottom of the window well and then into the Control Room where the blast and firing was then viewed and recorded safely by observers. The blast and firing also could be photographed and filmed from this position.

6. Roof: The roof, which has an overhang of about 8 inches around the entire building, is flat, built-up and has two ventilation turbines. The roof is pitched slightly higher at the ridge and at the southeast end so that it could drain to the corner of the northwest end. At an unknown date, an antenna was added to the roof and a set of wooden access stairs, presumably to tend the antenna, were added on the southwest side of the building. The stairs are now totally derelict.

7. Gutters and drains: The Control House, which has a roof pitched slightly higher on the southeast end and in the middle drained out through holes in the roof and out traditional metal down spouts strapped on the north corner of the northwest elevation and the north corner of the southeast elevation. The water exited onto traditional splash bocks.

The window well for the periscope arrangement for viewing the Static Rocket Test Stand, Building 3618, has a scupper drain in the bottom so the well did not fill with water.

8. Exterior stairs: A set of exterior concrete stairs begins on the second level at the southern corner of the southwestern end of the Control House and extends down the slope of the hill to the northwest side of the building. The stairs, which are located almost immediately outside the pedestrian door on the southwest façade, are also almost immediately outside the pedestrian door on the northwestern façade. A simple, metal pipe balustrade, which could withstand the weather, was used.

It is unclear why an exterior stair was constructed since an internal stair is in place in this corner of the building. No explanation was given in any of the documentation, and it can only be presumed that the exterior stair was related to a safety issue.

9. Lighting: The Control House has only three exterior lights and they are associated with the pedestrian doors. All of the lights are the same; a single metal fixture for a single exposed bulb in an explosion cage. One light is located between the pedestrian door and the rolling door on the southwest end of the building; one is over the single doorway on the northwest side; and the other is over the double doors, above the louvers, also on the northwest side.

C. Description of the Interior:

1. Floor Plans: The original floor plans are included in the attached photographs. Blueprints indicated that the second story was originally a large open, "L"-shaped workroom accessible through a pedestrian or vehicular door on the southwest end of the building. The southwest corner of the building also contains an enclosed stairwell with concrete winding stairs that have simple, metal pole balustrades. Immediately north of the stairs and sharing a wall is a large bathroom. The bathroom contained lockers, a lounge area, two toilet stalls, two urinals, and a large "service closet." The floors, walls and ceilings on the second floor are concrete.

At some unknown date, the workroom was divided into three spaces. The northeast leg of the "L" was divided from the workroom by two wood-frame, wallboard-covered walls, and turned into a separate work space that utilized the large windows on two sides. This room has asphalt tile laid on the floor. The north end of the workroom was divided from the larger workroom and a long narrow room was created using wood-frame, wallboard walls. This room, too, takes advantage of a set of large windows. The use of the two created rooms is not known, but it can be presumed that they were used as part of the building's mechanical laboratory function.

The Mechanical Laboratory was located on the second floor of the building and occupied a total floor space of about 1,800 sq.ft. The area was divided into a "white" room for LOX clean assembly, a valve and component repair laboratory, and a general assembly area. The valve laboratory included two pneumatic benches with four stages of nitrogen gas regulation from 0-1,500 psi, complete sets of tools, some spare parts for the service of most commercial valves used in the test area, and a polyethylene bag-sealing machine for protecting delivered components (Edson 1962). RMI boasted that the instrumentation available in all its test areas had "the highest standards for quality and accuracy in the industry" (RMI 1957).

The first floor, or basement as it was called in the blueprints, has not changed from its original configuration. It was here that the real work of the Control House was conducted. The basement was divided into three rooms: the Office, the Boiler Room, and the Control Room.

The heart of the Control House was the Control Room. It was here that the activities at Static Rocket Test Stand were observed, monitored, and assessed. Located within the air-conditioned Control Room was the central control panel with 54 control circuits for directing and monitoring the testing on the stand. Data-acquisition equipment in the Control Room included: 48 Brown recorders with direct readout at 4 cps (cycles per second) response; 54 CEC (Consolidated Electrodynamics Corporation) oscillograph channels, 600 cps response; 8 Sanborn recorder direct readout channels; 14 channels of tape. RMI boasted that this maze of instruments was capable of continuously recording separate events occurring within the engine at intervals ranging from one-tenth of a second to less than one millisecond (RMI 1957). Before the age of computers, this array was top-of-the-line and state-of-the-art, and there was nothing that the happened at the Rocket Test Stand that the observers in the Control Room did not know, given the equipment that they had.

The Control Room is a long, narrow room that occupied half of the basement floor on the southeast side of the building. The room was fully earth-fast on its northeast, southeast and southwest sides. While other parts of the building were not air conditioned, the Control Room was. Given the excessive amount of equipment contained in this room, this is not surprising. Blueprints indicate that the floor was covered by asphalt tile and that the walls were "wainscoted" about 36 inches up, meeting acoustical tile that was also on the ceiling. The wainscoting is just preformed, sheet paneling. The room can be closed-off from the rest of the building by a metal door.

The Control Room is accessed through a small Office. The Office can be accessed from the first floor by the stairway that opens in its southwest corner or through an exterior door. A portion of the southwest wall is covered with a wire equipment cage. This small room has a concrete floor and a ceiling and walls of concrete and concrete block. The concrete floor is overlain with asphalt tile.

The Boiler Room in the Control House is completely isolated from all other parts of the building and can only be accessed from the outside through a pair of doors on the northwest side of the building. The Boiler Room was used to heat the entire Area E complex. Steam was delivered to the Test Stand through a three-inch fiberglass insulated main. The Control House was heated by forced-air, steam-coil heat in the Control Room and radiators in the upstairs laboratory (Edson 1962). At a later, unknown date, a full heating, ventilating, and air-conditioning (HVAC) system was added to the building and was put in the boiler room. The room itself has concrete floors, walls and ceiling.

2. Flooring: Throughout the building, all of the floors are poured concrete. Asphalt tiles have been glued over the concrete, except in the Boiler Room.

3. Wall and ceiling finish: All of the original walls are poured, reinforced concrete with the exception of the wall between the Office and the Boiler Room in the basement; that wall is concrete block. At an unknown date, walls were added on the second floor to divide the Work Room into three spaces. These walls are of traditional, wood-frame with wallboard construction. In the Control Room, preformed paneling has been added to the wall as a wainscoting with acoustical tiles above it.

The ceilings in all spaces are poured, reinforced concrete. The ceiling in the Control Room was overlain with acoustical tiles. The tiles are now coming unglued.

4. Stairways: The Control House has one internal stairwell located in the southwest corner of the building. The well has one steel window with four lights located above the only landing. The winding stairs have one landing located at the junction of the first and second floors. The stairwell has concrete walls and ceiling and contains a concrete staircase with a simple metal pole balustrade. At the foot of the staircase on the first floor/basement level is a closet, and at the rear of the stairs on the first floor/basement level is a shelved storage cubby.

5. Mechanical equipment: Original utilities to the Control House included: 110/220-volt, three-phase, 60-cycle electricity, 28-volt DC, steam heat (radiators on the second floor and radiant heat in the basement), potable water, and 10,500 psi nitrogen gas (Edson 1962). The Control House had its own electrical transformer/substation, TR 3617, located about 40’ from the Boiler Room on the northwest side of the building. The original boiler is still in the Boiler Room. A newer HVAC system was put in the building at an unknown date and still remains.

As is typical of many research and military buildings, all of the plumbing and wiring is exposed along the interior walls of the building. Wiring is placed in conduits and attached by straps to the wall or hung by straps from the ceiling. Radiators on the second floor are attached to the wall and not the floor, as is typical of these types of buildings.

The instrumentation cables from the Control Room to the Test Stand are buried underground and carried in clay pipes. These pipes can be opened at a number of places through concrete access points on the ground between the Control House and the Test Stand.

6. Lighting: The Control House was illuminated throughout with ceiling-mounted electrical lights. On the second floor, the lights were a combination of hanging fluorescent lights and large, single bulb, flared, metal shade lamps. The hanging fluorescent lights were in the two rooms that were created from the original large Work Room. These rooms still contain the metal shade lamps. The rest of the second floor was lighted with the metal shade lamps.

The basement was also lighted by ceiling-mounted, large, single bulb, flared, metal shade lamps. Twelve of them were situated in the small confines of the Control Room. The amount of light produced by these lamps was so great that rings were burned into the asphalt tiles below each lamp in the Control Room.

7. Plumbing: Water for the Control House was supplied through a system that was shared by the entire Area E. The water system for Test Area E was renovated in mid-1961. At that time, water was purchased from Picatinny Arsenal on a general, flat rate utility basis. The supply was plentiful—and potable—and it was believed that Picatinny's water supply could accommodate all future requirements of the test area. Because of the altitude of Area E, a boost pump was required to send the water through the eight-inch service piping (Edson 1962).

The 400,000-gallon Water Tower (Building 3622) in Area E, southwest of the Control House, supplied raw water to the area, but functioned only when the pump was turned on (Abramson et al. 1953). It is not a contributing element to the historic district.

The bathroom still contains two original sinks, two original toilets, and two original urinals. It is interesting to note that there is only one bathroom. The need for separate men's and women's facilities was not anticipated. It appears that women were not going to be working in the Control House, or at least in mixed company.

D. Site:

The Control House, Building 3617, is located off Picatinny proper, along E Road from Snake Hill Road in the NARTS Area E Historic District. A copy of the NARTS Area E Historic District map is included in this documentation. The district, which is enclosed by a fence, is generally inaccessible without a key. It is adjacent to the NARTS Test Area D Historic District and less than 2,000' from the 1500 Rocket Test Area Historic District. The structures in the district are purposely perched on a precipitous slope that they used to maximum effect. The slope is the defining natural landscape element of the district.

A single asphalt road (E Road) leads up to Area E. Although the road has been paved, the slope is significant and a four-wheel drive vehicle is required in bad weather. The road passes between the two largest buildings in the test area, the Control House (Building 3617) and the Static Rocket Engine Test Stand (Building 3618). The road then loops to the southeast and passes the ramp/bridge to the Test Stand and returns under the ramp/bridge to the Control House. The path of the road passed all of the primary structures within Area E when it was active and is the defining manmade landscape element.

The Control House, which is approximately 250' northwest of the Test Stand, sits lower on the slope than the Test Stand. The Control House, which controlled and monitored activities at the Test Stand, used the slope to shield its first floor from blast/engine emissions (e.g., heat, exhaust, smoke, fire) stemming from testing at the stand. The Test Stand also used the slope of the area to advantage. A rocket engine was actually cantilevered from the Test Stand and fired down the side of the slope into a pit area dug deeply into the slope. The slope itself provides insulation and protection from the blast.

In order for the Test Stand to fully utilize the slope, the building was poised right at the edge of the slope. Some excavation occurred at the base of the slope, to deepen the exhaust pit. In order for the plan to work, the slope at the firing end of the stand (northeast side) had to be shored up with a concrete retaining wall and a rubble wall. The pit itself was lined with rubble and naturally held water at various times of the year.

When completed and in use, the areas around the Test Stand and the Control House were completely devoid of trees and shrubs; anything that could burn or get in the way of observing an engine test was removed. The bare ground was probably seeded to prevent erosion, but everything else was cut down. The Control House had a bituminous paved area on the southwest side of building and a concrete paved area on its northwest side.

Test Area E contains a number of other structures in addition to the Control House and the Static Rocket Test Stand. These structures are: Buildings 3622 (ca. 1960) Water Tower; 3623 (ca. 1960) Water Tower Support Building; 3625 (ca. 1960) Maintenance Building, Test Stand E-1A; 3627 (ca. 1960) Control Room; and E-1D (ca. 1960) Control Room, a gun turret. However, they are not original (i.e., 1953) to the site and are noncontributing elements to the district. When in use, they too would have been in cleared areas with unobstructed sight lines to the Static Rocket Test Stand.

The area at present is completely overgrown and it is difficult to comprehend how the buildings worked with each other. Large trash-trees, shrubbery, and a deteriorating site conspire to further undermine understanding of the site as a whole.

PART III. SOURCES OF INFORMATION

A. Architectural Drawings: The Directorate of Public Works (DPW), Picatinny has a collection of blueprints related to the Control House (Building 3617), a number of which were photographed and used in this document or were cited as bibliographic references. These blueprints are easily accessed through the Picatinny Cultural Resources Coordinator and DPW. One of the drawings has been photographed and accompanies this documentation.

B. Bibliography:

1. Primary and unpublished sources:

Abramson, B.N., D.S. Brandwein, and H.C. Menes
1953 *Description of Test Facilities at the Naval Air Rocket Test Station.* U.S. Naval Air Rocket Test Station, Technical Note No. 36. U.S. NARTS, Lake Denmark, Dover, NJ. December. On file in the Technical Library, Picatinny Arsenal, NJ.

American Institute of Aeronautics and Astronautics (AIAA)
2006 *Picatinny Arsenal and Marine Park Designated Historic Aerospace Sites* [press release]. American Institute of Aeronautics and Astronautics Communications Office, Reston, VA [online document]. Available URL:
"http://intranet.aiaa.org/industryresources/PDF/HistoricSitePicatinnyMarinePark.pdf" [accessed March 17, 2009].

Army Armament Research, Development and Engineering Center (ARDEC)
1995 *ARDEC 95*. U.S. Army Armament Research, Development and Engineering Center, Picatinny Arsenal, NJ. U.S. Government Printing Office, Washington, D.C.

2008 Armament Research, Development & Engineering Center: The Army's Center of Lethality. U.S. Army Research, Development and Engineering Command, Picatinny Arsenal, NJ [online document). Available URL:
"http://w4.pica.army.mil/PicatinnyPublic/organizations/ardec/index.asp" [accessed March 19, 2009].

ARDEC Historical Office
nd *Points about Picatinny.* ARDEC Historical Office, Picatinny, NJ.

Ashby, David E., David Buchanan, Robie Lange, John D. Mocum, Pamela J. Thurber, and Debra Wolf
1984 HABS/HAER Inventory Cards for Picatinny Arsenal, NJ. HABS/HAER Pilot DARCOM Project, Picatinny Arsenal, NJ.

Baranowski, John J., Capt. (Commanding Officer, NARTS)
1959 *Command Histories.* U.S. NARTS, Lake Denmark, Dover, NJ. July 31. On file at the Naval History Center, Annapolis, MD.

The Citizen
1958-1960 *The Citizen of Morris County* (newspaper). Denville, NJ.

Directorate of Public Works (DPW)

nda Military Real Property Card Files, 405-90f. On file at Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

ndb Vertical building drawing files and blueprints, by building number. On file at Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

ndc Maps. Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

Durant, Frederick Clark, Lieut. Comdr.

1951 The Naval Air Rocket Test Station—Purpose and Progress. *American Rocket Society Journal* (June):74-79.

Edson, D.

1962 *Test Facilities Data Book.* Thiokol Chemical Corporation, Reaction Motors Division, np.

Frank Grad & Sons

1952 *U.S. Naval Air Rocket Test Sta., Lake Denmark-Dover, N.J., Control House [3617] Plans, Elevations, Sections, U.S. Naval Air Rocket Test Station, Lake Denmark, Dover, N.J. [Blueprint, as built]*. Dated February 5. Frank Grad & Sons, Newark, NJ. On file at Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

Fortune

1950 "Rockets." Reprint of article that appeared in *Fortune,* November, volume and pages unknown. Ms. on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

GRAD

2009 Grad. Grad Associates, P.A., Newark, NJ [online www]. Available URL: "http://www.gradarchitects.com" [accessed March 17, 2009].

Guzzo, Dorothy P., Deputy State Historic Preservation Officer

1999 Letter to Ronald J. Kraus, Director, Public Works, Picatinny Arsenal. Re: HPO-G00-10, Identification of Historic Properties, including Test Area E, Naval Air Rocket Test Station District NRHP eligiblity. Dated July 12. Department of Environmental Protection, Historic Preservation Office, State of New Jersey, Trenton.

2004 Letter to Paul T. Seitz, LT. COL., U.S. Army Garrison Commander, Picatinny Arsenal, NJ. Re: Identification of Historic Properties. Dated April 12. Department of Environmental Protection, Historic Preservation Office, State of New Jersey, Trenton.

Jenkins, E.

1953 *Mount Test For E-1 Test Stand.* U.S. Naval Air Rocket Test Station, Technical Note No. 23. U.S. NARTS, Lake Denmark, Dover, NJ. March. On file in Technical Library, Picatinny Arsenal, NJ.

Naval Air Rocket Test Station (NARTS)

1949 (September)-1953 (April) Monthly Progress Reports. U.S. NARTS, Lake Denmark, Dover, NJ. On file in the Technical Library, Picatinny Arsenal, NJ.

1956 *Long Range Plan for Fiscal Years 1957-1960.* December. U.S. NARTS, Lake Denmark, Dover, NJ. On file at the Technical Library, Picatinny Arsenal, NJ.

ca. 1957 *Prospect Careerwise; Engineering Opportunities at U.S. Naval Air Rocket Test Station, Lake Denmark, Dover, New Jersey.* Technical Information Branch, U.S. NARTS, Lake Denmark, Dover, NJ. On file in the Naval Historical Center, Annapolis, MD.

ca. 1959a *All About NARTS Engineering Facilities; U.S. Naval Air Rocket Test Station, Lake Denmark, Dover, N.J.* Technical Publications Branch, U.S. NARTS, Lake Denmark, Dover, NJ. On file at the Command Historian's Office, Picatinny Arsenal, NJ.

ca. 1959b *Test Evaluation.* Np. On file at the Naval Historical Center, Annapolis, MD.

1959a *Foundational Research Program.* Quarterly Progress Report 1-60. June. U.S. NARTS, Lake Denmark, Dover, NJ. On file at the Technical Library, Picatinny Arsenal, NJ.

1959b *Variable Thrust Rocket Engine for Spacecraft Application, Proposal.* U.S. NARTS, Lake Denmark, Dover, NJ. On file at the Technical Library, Picatinny Arsenal, NJ.

ca. 1960 *Test Evaluation.* Np. On file at the Naval Historical Center, Washington, DC.

Picatinny Arsenal

1956a *Picatinny Arsenal, Dover, NJ.* Np. January. On file in Technology Library, Picatinny Arsenal, NJ.

1956b *Functions and Facilities of Picatinny Arsenal, Dover, NJ.* Np. On file in Technology Library, Picatinny Arsenal, NJ.

ca. 1960 *Picatinny Arsenal, Armament Technology Ordnance Development.* Np. On file at Technology Library, Picatinny Arsenal, NJ.

Reaction Motors Division (RMD)

1959-1966 *Thiokol, RMD Rocket*. In-house company newsletter. Reaction Motors Division, Thiokol Chemical Corporation, Denville, NJ.

nd *Safety and Reliability for Manned Space Flight.* Thiokol Chemical Corporation, Reaction Motors Division, Denville, NJ.

Reaction Motors, Inc. (RMI)

1945 *Reaction Motors, Inc.* Ms on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1948 Historical Background of Reaction Motors Incorporated, Dover, New Jersey. Typewritten ms. on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1951-1958 *The RMI Rocket.* In-house company newsletter. Reaction Motors Inc., Rockaway, NJ. Thiokol Chemical Corporation Annual Report. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1952-1957 *Reaction Motors, Inc. Annual Reports*. Reaction Motors, Inc., Rockaway, NJ.

ca. 1953 *Reaction Motors, Inc., Experience, Qualifications, Manpower & Facilities.* On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1955a *This is RMI*. Reaction Motors, Inc., Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1955b *New Rocket Engine Plant Dedicated.* October 7. News release from Reaction Motors, Inc., Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

ca. 1955 *RMI, a new Threshold for Engineering. . . .* Reaction Motors, Inc. Denville Plant, Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1957 *This is RMI, Power for Progress.* Reaction Motors, Inc., Denville, NJ.

Redmond, John A.
1957 *Reaction Motors, Inc., New Test Facility.* Fact Sheet. Reaction Motors, Inc., Denville, Plant, Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

Rosenberg, Edward B.
1955 "Reaction Motors Inc.: Bringing the Future into the Present." *New Jersey Business, The Magazine of Industry and Business* (October).

Seaman, R.W., and D.S. Smith
ca. 1957 *Flight Rating Test Demonstration of the XLR-99-RM-1 Rocket Engine.* ARS Paper No. 1409-60. Thiokol Chemical Corporation, Reaction Motors Division, Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

Seiler, Dayton A., Commander
1949 *U.S. Naval Aeronautical Rocket Laboratory, Progress Report No. 1-49.* U.S. Naval Aeronautical Rocket Laboratory, Lake Denmark, Dover, NJ. On file at the Scientific and Technical Information Branch, Picatinny Arsenal, Dover, NJ.

Shesta, John
1978 Reaction Motors Incorporated—First Large Scale American Rocket Company: A Memoir. Ms. of paper delivered at the XXIXth International Astronautical Congress, Dubrovnik, Yugoslavia. October. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

Stack, John P., LTC, U.S. Army
2008 Letter to Daniel Saunders, Deputy State Historic Preservation Officer, New Jersey Historic Preservation Office, Department of Environmental Protection, Trenton. Dated September 9. Office of Garrison Commander, Headquarters, U.S. Army Garrison, Picatinny Arsenal, NJ.

Thiokol
1959 *Thiokol Chemical Corporation Annual Report*. Thiokol Chemical Corporation, Bristol, PA. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1960 *A Short History of the Reaction Motors Division Packaged Liquid Rocket Thrust Units.* Thiokol Chemical Corporation, Bristol, PA. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1962 *Thiokol Chemical Corporation Annual Report*. Bristol, PA. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1997 *History of Thiokol Corporation.* Modified by Steve Lawson. Thiokol Corporation, Corporate Communications Office, Ogden UT. On file Senior Architectural Historian's Office, Mobile, AL.

U.S. Department of the Army
ca. 1983 Draft, National Register of Historic Places Inventory, Nomination Form for Picatinny Arsenal, New Jersey. U.S. Army, Picatinny Arsenal, NJ. On file in the Real Property Division, Picatinny Arsenal, NJ.

U.S. Naval Ammunition Depot
1948 Brochure of General and Descriptive Information, U.S. Naval Ammunition Depot, Lake Denmark, Dover, N.J. On file in Technology Library, Picatinny Arsenal, NJ.

Walker, Robert
1970 "Sun Sets on a Pioneer Space Age Company." *The New York Times,* 12 August:58.

Walter, Richard G., Chief, Engineering Plans and Services Division
1997a *Engineering Evaluation of Building 3617, Memorandum for the Record.* Engineering Plans and Services Division, Picatinny Arsenal. On file at Real Estate Office, Picatinny Arsenal, NJ.

1997b *Engineering Evaluation of Building 3625, Memorandum for the Record.* Engineering Plans and Services Division, Picatinny Arsenal. On file at Real Estate Office, Picatinny Arsenal, NJ.

Winter, Frank H., and Frederick I. Ordway
1982 *Reaction Motors, Incorporated from December 1941 through April 1958.* Ms. on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

2. Secondary Resources

BASF
2008 Grad Associates. Near Zero Energy Home-Patterson, N.J.: Contributors to the Near Zero Energy Home. BASF Group, Florham Park, NJ [online www]. Available URL: "http://www.betterhomebetterplanet.com/index.php?mode=contributors&section=primary&select=3" [accessed March 19, 2009].

Fitch, Virginia A., and Suzanne Glover
1990 *Army Materials Technology Laboratory Closure with Transfers to: Detroit Arsenal, Michigan, Picatinny Arsenal, New Jersey, Fort Belvoir, Virginia, and Supporting Documentation*. Originally submitted by The Public Archeology Laboratory, Inc., Pawtucket, RI, to Daylor Consulting Group, Boston, and Department of the Army, Corps of Engineers, New England Division, Waltham, MA, 1989.

Gaither, Steve
1997 *Looking Between Trinity and the Wall: Army Materiel Command Cold War Material Culture within the Continental United States 1945-1989.* U.S. Army Materiel Command Historical Context Series, Report of Investigation, Number 11. Geo-Marine, Inc.,

Plano, TX. Prepared for the U.S. Army Corps of Engineers, Fort Worth District, Fort Worth, TX.

Green, Constance McLaughlin, Harry C. Thompson, and Peter C. Roots
1990 *United States Army on World War II: The Technical Services, The Ordnance Department: Planning Munitions for War*. Center for Military History, U.S. Army, Washington, D.C.

Halsey, Edmund Drake
1882 *History of Morris County, 1739-1882*. W.W. Munsell and Co., New York.

Harrell, Pauline Chase
1993 *Final Report, Annotated Catalogue of Building Drawings and Evaluation of Architectural Features Picatinny Arsenal, Dover, New Jersey*. WCH Industries, Inc., Waltham, MA, and Boston Affiliates, Inc., Boston. Prepared for the U.S. Army Corps of Engineers, New York District, New York.

1994 *Revised Draft Report, Evaluation of Structures Built Prior to 1946 at Picatinny Arsenal, New Jersey*. WCH Industries, Inc., Waltham, MA, and Boston Affiliates, Inc. Prepared for the U.S. Army Corps of Engineers, New York District, New York.

Jenkins, Dennis R.
1996 *The History of Developing the National Space Transportation System: The Beginning through STS-75*. Walsworth Publishing Company, Marceline, MO.

Kaye, Seymour M.
1978 *Encyclopedia of Explosives and Related Items, PATR [sic] 2007.* Vol. 8. U.S. Army Armament Research and Development Command, Large Caliber, Weapons Systems Laboratory, Dover, NJ.

Myers, Manny
1984 Revolutionary War Origins of Picatinny Arsenal. In *A Remembrance of the Past... A Recognition by the Present: Historical Guide to Picatinny Arsenal, U.S. Army Armament Research and Development Center, Dover, New Jersey.* 3rd ed. Historical Office Picatinny Arsenal, NJ,

National Archives and Records Administration, Northeast Region (NARA)
nd Finding aids for the U.S. Naval Air Rocket Test Station, Lake Denmark, New Jersey, 3rd Naval District. National Archives and Records Administration, Northeast Region, Waltham, MA.

Naval Historical Center
1998 *Chronology of Significant Events in Naval Aviation.* Naval Aviation History Branch, Naval Historical Center home page, Department of the Navy, Washington Navy Yard, Washington, D.C. [online www]. Available URL: "http://www.history.navy.mil/branches/org4-5.htm" [accessed March 19, 2009]

Nelson, Jennifer L.
2006 "Grad Associates Celebrates 100 years," *New Jersey Business*, November 1 [online document]. Available URL: "http://findarticles.com/articles/mi_qa5311/is200611/ai_21401135" [accessed March 17, 2009].

Newarkology!
2008 Oheb Shalom Cemetery [Hillside, New Jersey]. Newarkology! Website, np [online www]. Available URL: "www.newarkhistory.com/ohebshalomcemetery.html" [accessed March 17, 2009].

Newark Public Library
2007 "A Salute to GRAD Associates: One Hundred Plus One: and A Selection of Great Books on Architectural History." Newark Public Library, Newark, NJ [online document]. Available URL: "http://npl.org/Pages/ProgramsExhibits/Exhibits/grad07.html" [accessed March 19, 2009]

The New York Times
1977 "Landmark Status Asked for Rocket Site of 1940's." *The New York Times*, August 19, unknown page.

1992 "Howard Grad Dies; An Ex-Engineer, 79." *The New York Times*, December 2 [online document]. Available URL: "http://query.nytimes.com/gst/fullpage.html?res=9E0CE0DC1F3EF931A35751C1A964958260" [accessed March 19, 2009]

2000 "Paid Notice: Deaths Grad, Bernard John," *The New York Times,* August 7 [online document]. Available URL: "http://query.nytimes.com/gst/fullpage.html?res=9B07E4DD103CF934A3575BC0A9669C8B63" [accessed March 19, 2009]

Nolte, Kelly, and Mark A. Steinback

2004 *Determination of Eligibility of Selected Buildings for Inclusion on the National Register of Historic Places, Picatinny Arsenal, Rockaway Township, Morris county, New Jersey.* Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for Picatinny Arsenal under a cooperative agreement with the U.S. Army Medical Research and Materiel Command, Fort Detrick, MD.

2008 *Historic American Buildings Survey Documentation of Pyrotechnic R&D Laboratory (Building 1510).* Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for Parson Infrastructure, San Antonio, TX.

Nolte, Kelly, Kelly Mahar, and Mark A. Steinback

2007 *Determination of Eligibility of 318 Buildings and Structures for Inclusion on the National Register of Historic Places, Picatinny Arsenal, Rockaway Township, Morris County, New Jersey.* Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for Picatinny Arsenal under a cooperative agreement with the U.S. Army Medical Research and Materiel Command, Fort Detrick, MD.

Nolte, Kelly, Mark A. Steinback, and Michael A. Cinquino

1999a *Architectural Assessment of Historic Structures at Picatinny Arsenal, Morris County, New Jersey*. Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for U.S. Army Corps of Engineers, New York District, New York.

1999b *Definition of Historic Districts for Picatinny Arsenal, Morris County, New Jersey*. Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for U.S. Army Corps of Engineers, New York District, New York.

Nolte, Kelly, Michele H. Hayward, Mark A. Steinback, and Elizabeth S. Burt

1999c *Development of a Treatment Strategy for and Addition Research Regarding Structures 3617, 3618 and Others at the Former Naval Air Rocket Test Station (NARTS), Test Area E,* *Picatinny Arsenal, Morris County, New Jersey*. Panamerican Consultants, Inc., Buffalo Branch, Depew, NY. Prepared for Northern Ecological Associates, Inc., Canton, NY under contract to U.S. Army Corps of Engineers, New York District, New York.

Ordway, Frederick I.
1952 "The Advance of Rocket Science." *Sky and Telescope*, Vol. XI (12):279-297 (October).

1985 *The Reaction Motors Division Chronology.* December 1. Ms on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1987 Pioneering Commercial Rockery in the United States of America: Thiokol's Reaction Motors Division, 1958-1972, Part 3: RMD Operational History. *Journal of the British Interplanetary Society* 40:389-404.

Ordway, Frederick I., and Frank H. Winter
1983 Pioneering Commercial Rockery in the United States of America, Reaction Motors, Inc. 1941-1958, Part I: Corporate History. *Journal of the British Interplanetary Society* 36:542-551.

1985 Pioneering Commercial Rockery in the United States of America, Reaction Motors, Inc. 1941-1958, Part 2: Projects. *Journal of the British Interplanetary Society* 38:155-168.

Picatinny
2006 "Picatinny designated as historic aerospace site." Picatinny Highlights, October 20 (online www]. Available URL: "http://www.pica.army.mil/picatiinypublic/highlights/archive/2006/10-20-06.asp" [accessed March 19, 2009]

Pitney, Henry C., Jr. (ed)
1914 *A History of Morris County New Jersey; Embracing Upwards of Two Centuries, 1710-1913*. Vol. 1. Lewis Historical Publishing, New York.

Rogers, J. A., Jr.
1931 *The History of Picatinny Arsenal*. Picatinny Arsenal, NJ.

Rutsch, Edward S.
1999 *The Story of Ironmaking Bloomery Forges at Picatinny Arsenal*. Historical Conservation and Interpretation, Inc., Newton, NJ.

Rutsch, Edward S., and Holly van Voorst
1991 *Cultural Resources Survey Report C of the Proposed Mt. Hope Pumped Storage Hydroelectric Facility and Transmission Lines Rockaway and Jefferson Townships, Morris County, New Jersey*. Historic Conservation and Interpretation, Inc., Newton, NJ. Prepared for TAMS Consultants, Inc., New York.

Rutsch, Edward S., William Sandy, Richard F. Porter, and Leonard G. Bianchi
1986 *Cultural Resource Investigation of the Proposed Mt. Hope Pumped Storage Hydroelectric Facility and Transmission Lines Rockaway and Jefferson Townships, Morris County, New Jersey*. Historic Conservation and Interpretation, Inc., Newton, NJ. Prepared for Tippetts-Abbett-McCarthy-Stratton, New York and Bloomfield, NJ.

Sandy, William, and Edward S. Rutsch
1992 *Stage One Cultural Resources Survey of Three Areas for the Proposed Mt. Hope Pumped Storage Hydroelectric Facility Rockaway and Jefferson Townships, Morris County, N.J*. Historic Conservation and Interpretation, Inc., Newton, NJ. Prepared for TAMS Consultants, Inc., New York.

Schultz, James
1992 *Winds of Change; Expanding the Frontiers of Flight.* For the National Aeronautics and Space Administration, Government Printing Office, Washington, D.C.

STV/Lyon Associates, Inc.
1994 *Installation Design Guide for Picatinny Arsenal, New Jersey*. STV/Lyon Associates, Inc., Baltimore. Prepared for U.S. Army Corps of Engineers, New York District, New York.

Thurber, Pamela, and Sandy Norman
1983 *Historic American Engineering Record, Picatinny Arsenal, New Jersey, HAER* # NJ-36. Picatinny Arsenal, NJ.

U.S. Department of the Navy

1997a "Chronology of Significant Events in Naval Aviation, 1946-1949." Naval Historical Center, Department of the Navy, Naval Aviation Branch, Washington Navy Yard, Washington, D.C. [online www]. Available URL: "http://www.history.navy.mil/branches/avchr6.htm" [accessed March 20, 2009]

1997b "Chronology of Significant Events in Naval Aviation, 1950-1953." Naval Historical Center, Department of the Navy, Naval Aviation Branch, Washington Navy Yard, Washington, D.C. [online www]. Available URL: "http://www.history.navy.mil/branches/avchr7.htm" [accessed March 20, 2009]

1997c "Chronology of Significant Events in Naval Aviation, 1960-1969." Naval Historical Center, Department of the Navy, Naval Aviation Branch, Washington Navy Yard, Washington, D.C. [online www]. Available URL: "http://www.history.navy.mil/branches/avchr9.htm" [accessed March 20, 2009]

Urquhart, Frank John

1913 "Frank Grad" in *A History of the City of Newark, New Jersey, 1666-1913,* pp 116-117. Volume III, The Lewis Historical Publishing Company, New York and Chicago.

U.S. Geological Survey

1981[1954] *Dover Quadrangle*. 7.5' Series (Topographic). U.S. Geological Survey, Reston, VA

Winter, Frank H.

1987 Pioneering Commercial Rocketry in the United States of America: Thiokol's Reaction Motors Division, 1958-1972. Part 4:RMD Project History. *Journal of the British Interplanetary Society* 40:405-416.

1988 "Bringing up Betsy." *Air & Space* 3(5):76-84.

1994a "Black Betsy": The 6000C-4 Rocket Engine, 1945-1989. Part I. *Acta Astronautical* 32(4):283-303.

1994b "Black Betsy": The 6000C-4 Rocket Engine, 1945-1989. Part II. *Acta Astronautical*, 32(4):305-318.

C. Supplemental Material:

1. **NARTS Area E Historic District Map.** NARTS Area E Historic District map showing locations of buildings (adapted from DPW, Picatinny Arsenal ndc)

2. **Color Photographs.** Color 35mm photographs of exterior and interior views of the Control House (Building 3617), taken by Ms. Kelly Nolte, Director, Architectural History Division, Panamerican Consultants, Inc.

3. **Scanned Photographs.** A collection of scanned historical photographs primarily from NARTS progress reports detailing the construction of NARTS Area E and the Control House (Building 3617).

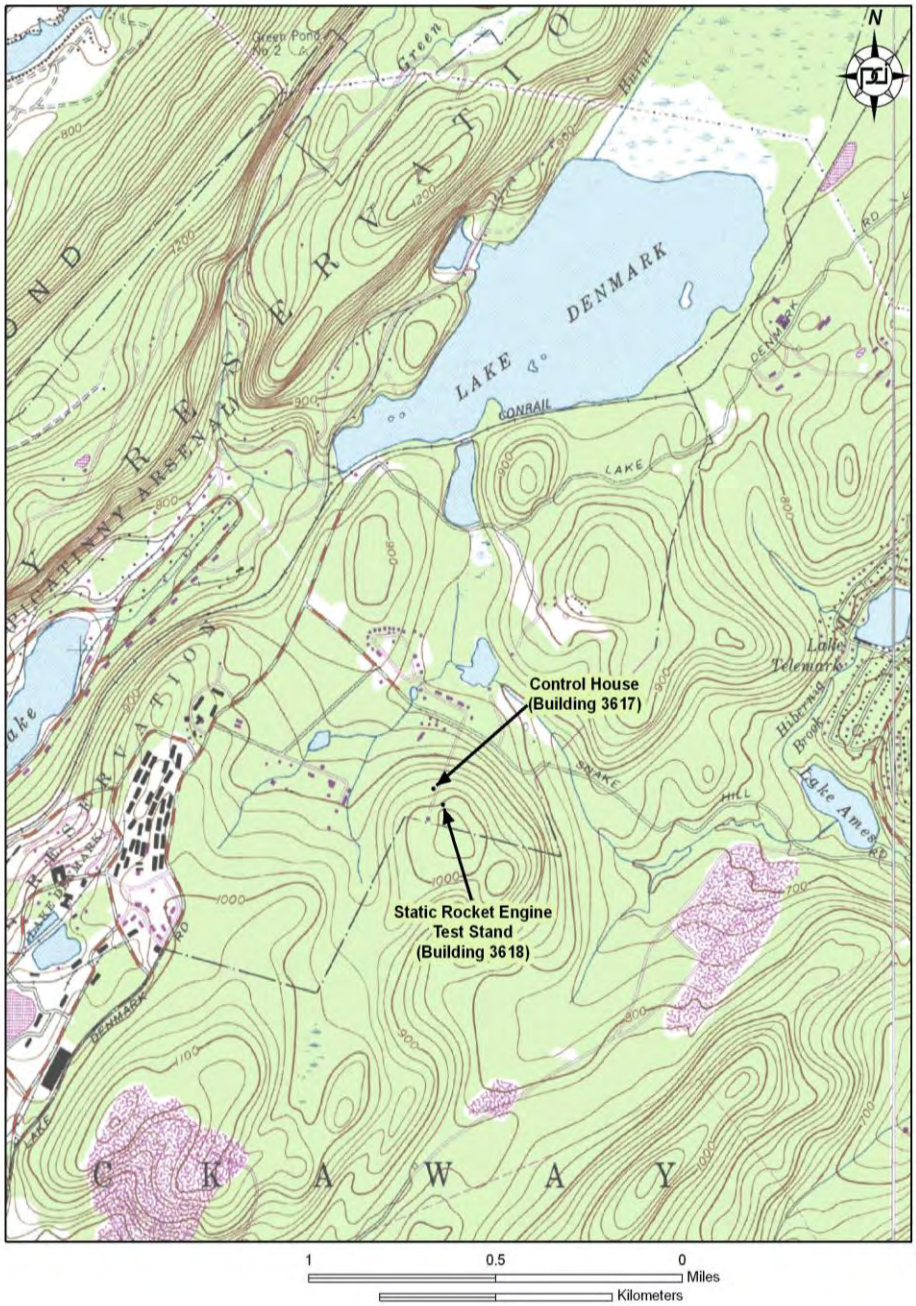
4. **Technical Brief.** *Description of Test Facilities at the Naval Air Rocket Test Station*. U.S. NARTS Technical Note No. 36 (Abramson et al. 1953).

5. **Technical Brief.** Rocket Test Mount Description, excerpted from NARTS Quarterly Report January-March 1953, Report No. 30 (April 1953) and *Mount Test For E-1 Test Stand.* U.S. NARTS Technical Note No. 23. U.S. NARTS (Jenkins 1953).

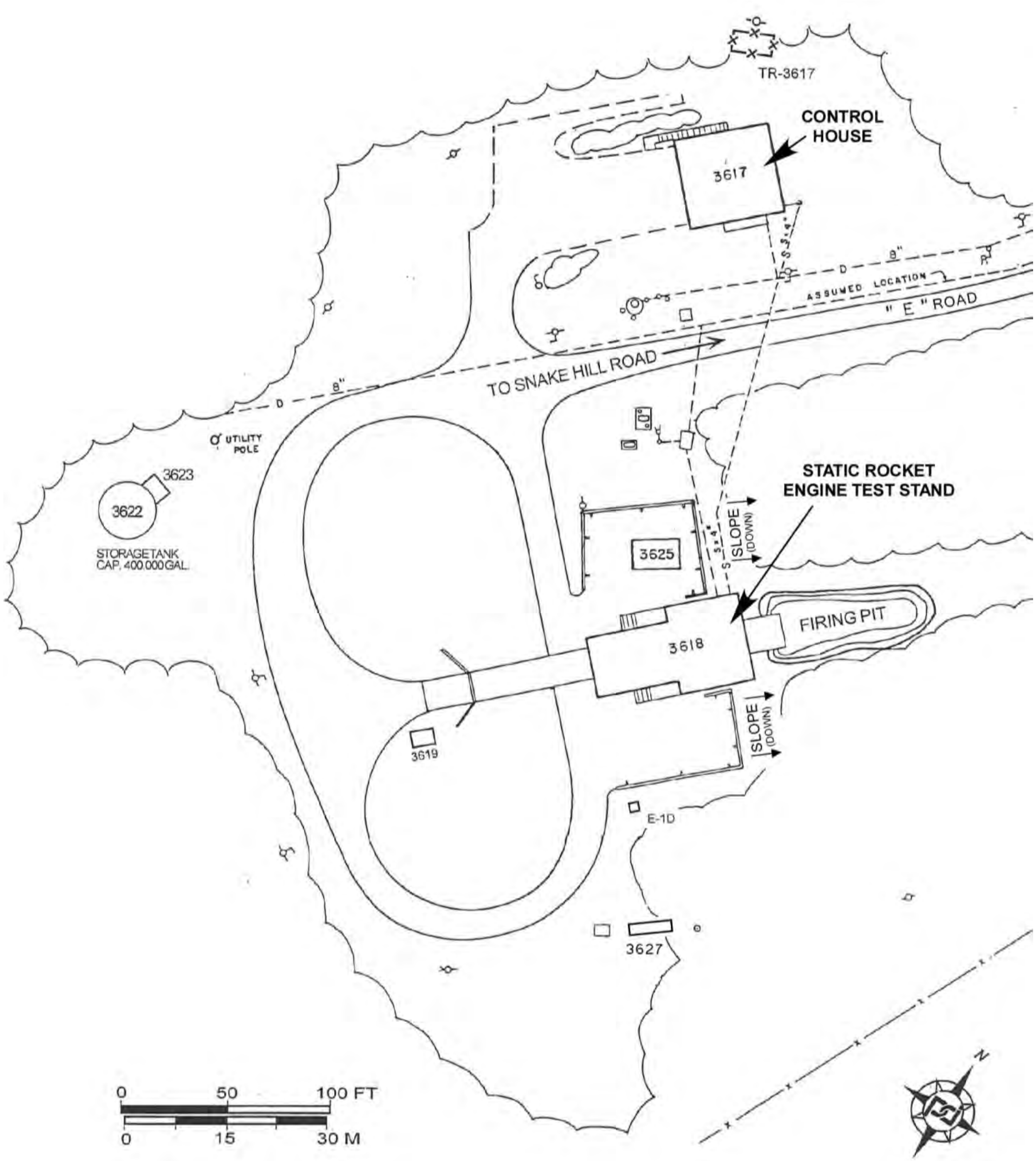
PART IV. PROJECT INFORMATION

The Control House (Building 3617) was recorded in November 2008 by Ms. Kelly Nolte, Director, Architectural History Division, Panamerican Consultants, Inc., Mr. Mark Drumlevitch, Photographer, Panamerican, and Mr. Mark A. Steinback, Panamerican. Ms. Nolte conducted the fieldwork, the historic research, and wrote most of the report. She also was responsible for the supplemental 35mm photography. Mr. Drumlevitch was responsible for the large-format photography. Mr. Steinback also conducted historic research and wrote a portion the report. The report was prepared under the supervision of Mr. Steinback. Dr. Michael A. Cinquino, Panamerican, was the Project Director.

This project could not have been completed without the help of many people at Picatinny. They include: Mr. Jason Huggan, Cultural Resources Coordinator; Mr. Jack Lyons, Real Property Specialist; Dr. Patrick Owens, Historian/Archivist; and a gaggle of military police. Mr. Daniel Saunders at the New Jersey Historic Preservation Office, Trenton, was also helpful.



Location of Control House (Building 3617) and Static Rocket Test Stand (Building 3618) *(USGS 7.5' topographic Quadrangle, Dover 1954 [photorevised 1981])***.**



NARTS Area E Historic District showing locations of buildings *(adapted from DPW, Picatinny Arsenal ndc)*

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

CONTROL HOUSE **HAER NO. NJ-XXX**
(Building 3617)
Northwest side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
PicatinnyMorris County
New Jersey

INDEX TO BLACK AND WHITE PHOTOGRAPHS

Mark Drumlevitch, Panamerican Consultants, Inc., Photographer November 2008

NJ-XXX-1 OBLIQUE VIEW OF NORTHWEST AND NORTHEAST ELEVATION OF CONTROL HOUSE (BUILDING 3617). NOTE SLOPE OF HILL USED AS PROTECTION ON NORTHEAST SIDE AND STAIRCASE LEADING TO THE UPPER LEVEL ON THE NORTH END OF THE NORTHWEST SIDE.

NJ-XXX-2 SOUTHWEST ELEVATION OF CONTROL HOUSE (BUILDING 3617). NOTE THE ANTENNA THAT WAS ADDED AT AN UNKNOWN, LATER DATE AND WOODEN ACCESS STAIRS TO THE ANTENNA.

NJ-XXX-3 NORTHWEST SIDE OF CONTROL HOUSE (BUILDING 3617), SHOWING DETAIL OF METAL AWNING WINDOW, METAL DOOR, AND CONCRETE STAIRCASE WITH METAL TUBULAR HAND RAIL LEADING TO THE UPPER LEVEL.

NJ-XXX-4 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), WORK ROOM, NORTHWEST CORNER, UPPER LEVEL, LOOKING NORTHEAST. NOTE LARGE WINDOWS AND EXPOSED PIPING.

NJ-XXX-5 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), WORK ROOM, NORTHWEST CORNER, UPPER LEVEL, LOOKING SOUTHWEST. NOTE VIEW INTO THE LARGE WORK ROOM AND OUT THROUGH THE SOUTHWEST VEHICLE ACCESS ROLLING DOOR.

NJ-XXX-6 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), WORK ROOM, VIEW OF NORTHEAST CORNER, UPPER LEVEL, LOOKING EAST, NOTE EXPOSED PIPES, HANGING LIGHT FIXTURES, AND CONCRETE WALLS, FLOORS AND CEILING.

NJ-XXX-7 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), WORK ROOM, NORTHEAST CORNER UPPER LEVEL, LOOKING NORTHWEST.

NJ-XXX-8 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), WORK ROOM, SOUTHEAST UPPER LEVEL, LOOKING SOUTHWEST. NOTE ROLLING VEHICLE DOOR AND PEDESTRIAN DOOR TO THE EXTERIOR, AS WELL AS THE OPEN DOOR TO THE STAIRCASE AND THE BATHROOM DOOR WHICH HAS "BOMB SHELTER" SIGN ABOVE IT.

NJ-XXX-9 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), WORK ROOM, SOUTHEAST, LOOKING NORTHEAST, UPPER LEVEL. NOTE THE ROOM WAS CREATED BY ADDING THE BACK, NORTHEAST WALL WHICH HAS A DOUBLE DOOR.

NJ-XXX-10 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), CONTROL ROOM, LOOKING NORTHEAST, LOWER LEVEL. NOTE THE ACCOUSTICAL TILE-LINED CEILING AND WALLS AS WELL AS THE MOUNT CASES FOR INSTRUMENTATION AND AIR CONDITIONING DUCTS ABOVE THE INSTRUMENTATION CASES.

NJ-XXX-11 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), CONTROL ROOM, LOOKING EAST, LOWER LEVEL. NOTE THE TWO PERISCOPE WINDOWS FOR VIEWING THE HOT FIRING OF ROCKET ENGINES AT THE STATIC ROCKET TEST STAND (BUILDING 3618).

NJ-XXX-12 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), CONTROL ROOM INSTRUMENTATION PANEL WITH SOME INSTRUMENTATION STILL IN PLACE, LOOKING NORTHEAST, LOWER LEVEL. NOTE THE PERISCOPE WINDOW AT RIGHT IN PHOTOGRAPH.

NJ-XXX-13 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), CONTROL ROOM, LOOKING SOUTHWEST, LOWER LEVEL. NOTE ACCOUSTICAL TILE-LINED CEILING AND WALLS, MOUNT CASES FOR INSTRUMENTATION, AND AIR CONDITIONING DUCTS ABOVE THE INSTRUMENTATION CASES.

NJ-XXX-14 INTERIOR VIEW OF CONTROL HOUSE (BUILDING 3617), BOILER ROOM, LOWER LEVEL, BOILER AND NEWER HVAC EQUIPMENT, LOOKING NORTHEAST.

NJ-XXX-15 ELECTRICAL SUBSTATION/TRANSFORMER BUILDING TR 3617, ASSOCIATED WITH CONTROL HOUSE (BUILDING 3617), LOOKING NORTHWEST, OUTSIDE THE LOWER LEVEL OF THE CONTROL HOUSE AT THE SOUTHWEST ELEVATION.

NJ-XXX-16 U.S. NAVAL AIR ROCKET TEST STATION, LAKE DENMARK, DOVER, N.J., CONTROL HOUSE [3617] PLANS, ELEVATIONS, SECTIONS [BLUEPRINT, AS BUILT], FEB. 5, 1952, FRANK GRAD & SONS, ARCHITECTS AND ENGINEERS, NEWARK, NEW JERSEY AND WASHINGTON D.C., DIRECTORATE OF PUBLIC WORKS, PICATINNY, NEW JERSEY.

HISTORIC AMERICAN ENGINEERING RECORD

SUPPLEMENTAL MATERIAL

CONTROL HOUSE **HAER No. NJ-XXX**
(Building 3617)
Northwest side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

INDEX TO 35mm COLOR PHOTOGRAPHS

Kelly Nolte, Panamerican, Consultants, Inc., Photographer November 2008

1. Interior view of Office area, lower level, looking east, Control House (Building 3617). Note the equipment cage on the right side of the photograph and the open door at the rear of the Office area that leads to the Control Room.

2. Interior view of Office area equipment cage, looking southwest, lower level, Control House (Building 3617). Note the open door on the right side of the photograph that leads to outside and the door on the left that leads to the stair.

3. Stairwell and window in southwest corner of the Control House (Building 3617), upper level, looking west.

4. Closet at bottom of stairs, lower level, Control House (Building 3617), looking east.

5. Sink and toilets in the lavatory of the Control House (Building 3617), looking northwest, upper level.

6. Entry area, lavatory in the Control House (Building 3617), looking west, upper level.

7. Drainage system, southeast of Control House (Building 3617), between the Control House and E Road. Note the Control House in the upper right background.

8. Circular pad, about 10’ wide, possibly part of the drainage system, southeast of Control House (Building 3617), between the Control House and E Road.

HISTORIC AMERICAN ENGINEERING RECORD

SUPPLEMENTAL MATERIAL

CONTROL HOUSE **HAER No. NJ-XXX**
(Building 3617)
Northwest side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

INDEX TO SCANNED HISTORICAL PHOTOGRAPHS

All sources available at the Picatinny Technical Library, Picatinny, Dover, New Jersey. Photograph source indicated in photograph caption

1S. Early construction activities and site overview in Test Area E *(NARTS 1952: Progress Report for March).*

2S. Site overview during early stage of construction of the Control House (Building 3617) in Test Area E *(NARTS 1952: Progress Report for March).*

3S. General frame and outer walls of Control House (Building 3617), note partially exposed southeast basement wall that will be eventually be made earth-fast *(NARTS 1952: Progress Report for July).*

4S. Steel frame of the Static Rocket Test Stand (Building 3618), with the unfinished Control House (Building 3617) in the lower right corner *(NARTS 1952: Progress Report for July).*

5S. Southwest and southeast elevations of the nearly complete Control House, (Building 3617) *(NARTS 1953: Progress Report for March)*.

6S. Interior of Control House (Building 3617), Control Room, looking northeast, preparing instrumentation racks for equipment (*NARTS 1952: Progress Report for October)*.

7S. Interior of Control House (Building 3617), Control Room, looking northeast, instrumentation racks waiting for equipment *(NARTS 1952: Progress Report for October).*

8S. Technician monitoring instrumentation in Control House (Building 3617) *(NARTS 1952: Progress Report for October).*

9S. Technicians adjusting instruments on Master Jack Panel, Control Room, Control House (Building 3617) *(NARTS 1952: Progress Report for October).*

10S. Technicians work on wall of instruments, Control Room, Control House (Building 3617)*(NARTS 1952: Progress Report for October).*

11S. Technician monitoring gauges on Firing Console No. 2, note the periscope observation window above the console, Control Room, Control House (Building 3617) *(NARTS 1953: Progress Report for January).*

12S. Close-up of Firing Console No. 3, Control Room, Control House (Building 3617) *(NARTS 1953: Progress Report for January).*

HISTORIC AMERICAN ENGINEERING RECORD

SUPPLEMENTAL MATERIAL

CONTROL HOUSE **HAER No. NJ-XXX**
(Building 3617)
Northwest side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

SUPPLEMENTAL MATERIAL
Rocket Test Mount Description

Excerpted from:
NARTS Quarterly Projects Report January-March 1953, Report No. 30 [April 1953]
and
Mount Test for E-1 Test Stand, E. Jenkins, Technical Note No. 23, U.S. NARTS (March 1953)

Description and Testing of Test Stand E-1 Rocket Mount
(from NARTS *Quarterly Projects Report* January-March 1953, Report No. 30 [April 1953]:22-23)

SI-211 ASSIST IN CONSTRUCTION OF 350,000 LB THRUST TEST STAND

2. PROGRESS
2-1 Test stand

2-1.1 A rocket mount specifically designed to accomodate [sic] the 50,000 lb thrust XLR-30-RM-2 rocket engine was installed and tested satisfactorily. It is shown in Fig 23 [not included in this section]. The design specification called for a maximum allowable stress of 20,000 psi with a load in the direction of thrust of 150,000 lbs and a load normal to the thrust axis of 45,000 lbs. The mount was designed as a box structure, with 32-in. and 40-in. diameter holes at top and bottom for the rocket motor and 20-in. access holes at both sides. When used, the rocket motor will be bolted to the mount through three load cells tied to the mount. The entire assembly swings on 12-in. diameter trunnions tied to the stand structure, and is locked through the use of a sector plate and locking pin at the left-hand side. This will permit firings at attitudes of vertical and 15^o, 30^o, 50^o, 60^o, 75^o, and 90^o from the vertical. The first two listed are the specified attitudes for the XLR-30-RM-2.

2-1.2 The mount was tested at two attitudes, horizontal and vertical, and with the load applied in two directions for each attitude. The direction of load application was at an angle of 16^o 45' from the thrust axis, to simulate 150,000 lbs of direct load plus 45,000 lbs side load, first parallel to the trunnion axis and then perpendicular to the trunnion axis. The load was applied by a hydraulic jack mounted on pads welded to the test stand structure, and was measured by a calibrated Bourdon pressure gage. Twelve strain gages mounted to various critical sections of the mount were used to measure the stresses in the structure. Over-all deflection was also measured. The highest measured stress for any of the tests was 3,500 psi, indicating that the actual factor of safety, for 50,000 lbs thrust, is about 50, based on ultimate tensile stress.

2-1.3 A revision to the rocket engine dimensions by Reaction Motors, Inc., the first users of the stand, required the procurement of a new operating floor under the thrust mount. The new floor will be one foot lower than the existing one, to allow clearance for the rocket nozzle. It will contain two pair of double doors along the plane of thrust either or both of which will open immediately before test firings. The doors will be actuated by geared-down electric motors hung below the stationary parts of the floor. Safety latches will be provided to protect personnel from accidental actuation of the doors.

Installation and Testing of Test Stand E-1 Rocket Mount
(from NARTS *Technical Note No. 23: Mount Test for E-1 Test Stand* [Jenkins 1953])

[redacted]D UNCLASSIFIED
Security Information

1. INTRODUCTION

The contract for the purchase of the rocket mount for the E-1 test stand calls for a maximum allowable stress of 20,000 psi for a 156,000 lb applied load. The mount was to be tested according to a given program when mounted on its trunnions and predetermined loads applied. NARTS supplied all necessary equipment and facilities for making the measurements and the contractor supplied the required location of the strain gages and the means for applying a known load.

2. INSTALLATION

-1 In order to take full advantage of the already installed instrumentation in the -1 test stand, dc excitation of the strain gages was used. Bakelite bonded strain gages were used, the difficulty of installation of this type gage being offset by the advantage gained. That is, there was less leakage to ground, less drift and better bonding. The basic circuit used for these tests is as shown in Fig 1.

2 The temperature compensating gage was mounted on a 3" x 3" x 1/8" piece metal of the same thermal characteristics as the metal in the mount proper. By using this compensating gage, drift of the bridge output, E_o, due to thermal expansion of the mount was virtually eliminated. For the sake of convenience resistors, R_1 and R_2, were also mounted on this plate as can be seen in Fig 2.

3 In order to use the bonded strain gage bridge as a method of measuring stress it is necessary to know accurately the bridge excitation voltage. In this mount, test measurement of this voltage was complicated by the fact that between the strain gage control and the strain gage there is a distance of about 300 ft. through wire of finite but unknown resistance. To measure the strain gage excitation voltage the circuit shown in Fig 3 was used.

4 Due to the high impedance of the voltage divider it can be shown that the effect line resistance of the measuring leads can be neglected. When the 10 mv chart recorder indicated 8 mv (showing 8 volts on the strain gage bridge) voltmeter, V, was read, and this value of voltage was used through the balance of tests. In order to eliminate any chance of error all chart recorders used in the test were calibrated individually using a high precision hand potentiometer.

Mounting of the strain gages on the mount and trunnion was accomplished using an r.f. induction heater to obtain the necessary heat for the curing cycle. The gages showed no leakage and the method appears practical for other tests of this type.

...ty Information

3. TEST PROCEDURE

Resultant loads were applied according to the following schedule which was ...ied by the contractor.

Load	Force from Jack (lbs)	Actual Load on Mount (lbs) Vertical	Horizontal
1	52,250	50,000	15,000
2	104,400	100,000	30,000
2-1/2	130,500	125,000	37,500
3	156,600	150,000	45,000

...ese loads were applied by means of a hydraulic jack placed between a beam ...stened to the structure of test stand and the mount. To insure that the proper ...ads were applied, NARTS calibrated the gage showing hydraulic pressure and ... piston diameter, both checks showing that the calibration was accurate for ... purpose of the test.

...2 The various tests were as follows:

1. Test No. 1 - The 150,000 lb vertical upward load combined with the 45,000 lb side load applied parallel with the trunnion.

2. Test No. 2 - Identical to test no. 1 except that the side load was perpendicular to the trunnion.

3. Test No. 3 - Identical in all respects to test no. 1 except that the mount was rotated to the horizontal and the index pin in the extreme location.

4. Test No. 4 - Identical in all respects to test no. 2 except the mount was in the position specified for test no. 3.

4. TEST RESULTS

...1 It can be shown that the output of a bridge with a single active arm for small ...ues of $\Delta R \leqq .02R$ is very nearly,

...TED
...Information

$$E_o = \frac{E_x}{4} \frac{\Delta R}{R} \quad (1)$$

...ndamental strain gage relationships are

$$K \frac{\Delta L}{L} = \frac{\Delta R}{R} \quad (2)$$

$$\frac{s}{M} = \frac{\Delta L}{L} \quad (3)$$

M = Young's modulus

E_x = excitation voltage measured at bridge

s = stress in psi

K = $\frac{\Delta R}{R} \Big/ \frac{\Delta L}{L}$ (K is given arbitrarily for each batch of gages.)

...bining equations 1, 2, and 3 to solve for s:

$$s = \frac{4E_oM}{E_xK} \quad (4)$$

...2 Equation 4 was used to calculate stress from the recorded values of bridge ...balance. The number of the gage corresponding to a given location is shown ... Fig 4. The results of the tests are shown in Table I.

5. CONCLUSIONS

...1 These results show that while the mount has a safety factor of about 6 over ...e design and contract limit of 20,000 psi at the points where strain gages were ...plied, it must be remembered that the locations of the strain gages were ...bitrary. Furthermore (as noted previously) these locations were, under terms ...the contract, specified by the contractor.

...2 The indicated millivolt outputs were visually read from the chart scale and ...corded by hand, the chart recording pens being non-operative due to an ...corrected design fault. There was no observable drift in output during the ...urse of the test.

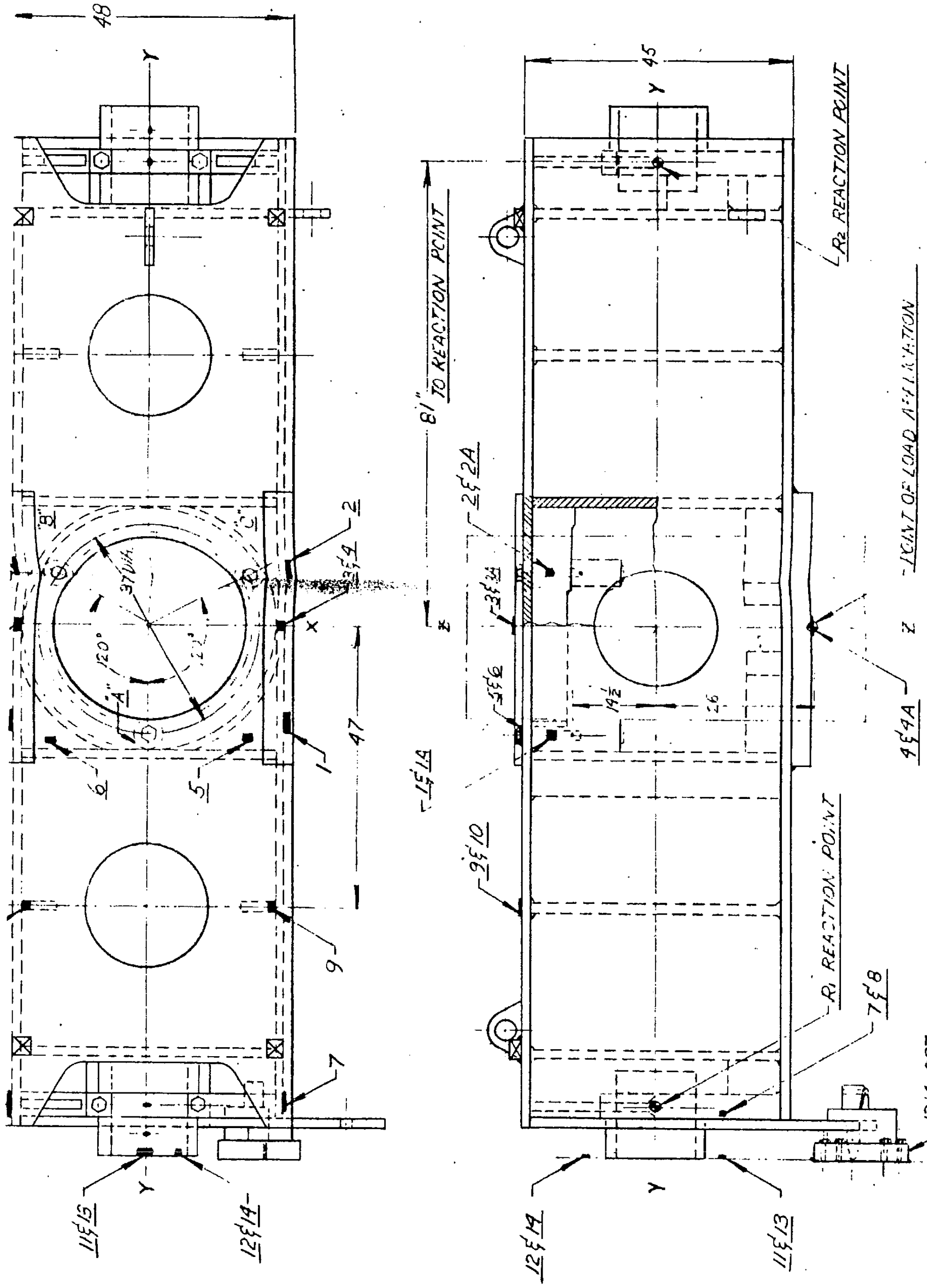


Fig 4. Mount diagram (showing arrangement of strain gages)

UNCLASSIFIED

HISTORIC AMERICAN ENGINEERING RECORD

SUPPLEMENTAL MATERIAL

CONTROL HOUSE **HAER No. NJ-XXX**
(Building 3617)
Northwest side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

SUPPLEMENTAL MATERIAL
Description of Test Facilities at the Naval Air Rocket Test Station

Excerpted from:

NARTS *Technical Note No. 36: Description of Test Facilities at the Naval Air Rocket Test Station* (Abramson et al. 1953)

U.S. Naval Air Rocket Test Station

Technical Note No. 36

DESCRIPTION OF TEST FACILITIES AT THE NAVAL AIR ROCKET TEST STATION

by
B.N. Abramson, D.S. Brandwein,
H.C. Menes

[December 1953]

Note: The figures that are referenced in the document were not included with the original document provided by Picatinny Arsenal.

2. BASIS OF DESIGN

2-1 One of the most difficult problems in the design of a large static thrust stand is that of exhaust disposal. Since most large rocket engines are fired vertically downward during their development, the problem becomes one of providing protection from the effects of the exhaust jet energy. This was done by selecting site on the steepest hill on the Government reservation. From inspection of existing large thrust stands, it was decided that the distance from the nozzle exit to the first point of impingement on the ground should be a minimum of 50 ft. Experiments by the Naval Air Rocket Test Station made in 1951 showed that a rocket exhaust flame could be nearly quenched by injection of moderate amounts of water into the core of the flame. As an additional safeguard, water headers were to be incorporated in the design to permit the injection of water just downstream of the rocket engine nozzle.

2-2 The slope of the site selected still did not permit a minimum of 50 ft clear distance, so a cantilevered design was chosen to provide the required additional distance. The requirements that the stand permit attitude firings of missiles from vertical to horizontal was also met by the cantilever arrangement. It was thought desirable to permit assembly and repair work on a missile in the horizontal position, thereby obviating a system a platforms and ladders such as is commonly found on fixed vertical stands. The stand now began to take the form of a long working area with the pivot point of the thrust mount cantilevered out from the supporting substructure.

2-3 The propellant feed system was to incorporate a bi-propellant tank system, pressure or pump fed. Once again the terrain dictated an arrangement of tank and cascade rooms under the working area of the stand. The room size was determined and a layout made which resulted in separate tank rooms and separate cascade rooms for the fuel and oxidizer, all susceptible to future expansion.

2-4 For safety reasons, consistent with previous experience, the control room was to be a separate structure, 250 ft from the stand, and placed underground. All test firing operations were to be controlled from this room. On the grade level of this building, a field maintenance shop would provide an assembly area for components. Personnel service areas, such as offices, sanitary facilities, and locker space were also to be included.

2-5 Consideration of climatic conditions the year round dictated a shelter over the working area. Light construction was to be used due to the possibility of an explosion. The tank and cascade rooms were to receive the same type of weather protection for ease of venting explosions and economy or replacement.

2-6 A system of roads was laid out which would permit direct truck access between all areas requiring transport of heavy equipment. Both tank rooms have parking areas adjacent to them for tank truck loading of propellants.

2-7 After a review of the above and other minor requirements, a complete set of specifications was drawn up by the Rocket Station which spelled out area and room sizes, loads, safety factors, utilities, and process details. Specifications for instrumentation, other than space and conduit requirements, were deliberately omitted since it was the intention that the complete instrumentation system would be handled by Station personnel. This set of specifications and a preliminary layout of the structures formed the basis for the design.

3. PRELIMINARY DESIGN

3-1 The preliminary layout of the test stand is shown in Fig 11. The structure is reinforced concrete, with the thrust load taken through steel members anchored to bed rock. Fig 12 shows the vertical members being erected.

3-1.1 The test stand structure is built in three levels: a basement, ground floor, and working floor. The ground floor contains the two propellant tank rooms and the two cascade rooms. The outside wall of each of the four rooms is fabricated of corrugated metal siding on light steel framing. In addition, a reinforced concrete barricade 8 ft high runs parallel to the outside face of the cascade rooms to protect personnel outside from gas pressure explosions.

3-1.2 The working level is one room, 94 ft 0 inches by 15 ft 10 inches by 17 ft 6 inches high. The thrust pivot point is 7 ft 6 inches from the face of the substructure. The roof of this room is movable, and can slide back 50 ft from the end of the cantilever, thus permitting erection of a missile tank section to the vertical. The dimensions of the cantilever floor are 18 ft 0 inches by 15 ft 0 inches. This floor is provided with bomb bay doors beneath the rocket centerline. To insure that the trunnion mounting will accommodate large propulsion units the trunnions are placed 12 ft 6 inches apart.

3.2 The thrust structure was designed to carry a normal load of 350,000 lbs and a side load of 40,000 lbs under steady state conditions. As a safety in the event of an explosion, the design loads were multiplied by a factor of 3, and the steel work was then stressed to a maximum of 20,000 psi.

3-3 After a careful review of the economy versus accessibility, a direct ascent of the slope was decided upon. This resulted in an access road of 1400 ft in length with a maximum grade of 14.9%. Fig 13 shows the layout of roads and the areas serviced.

3-4 The layout of the upper and lower floors of the control house is shown in Fig 14. The control room proper contains the firing console and all recording instrumentation. Instrument signal cables are run underground from this room to the test stand termination room through hollow clay tile ducts in the general utility trench. Viewing is accomplished by a periscope arrangement of mirrors in a concrete areaway.

3-5 Since the first use of this stand is the development of an engine with a thrust less than the maximum rating of the stand, operating on the combination of anhydrous ammonia-liquid oxygen, a number of specific components in the installation were tailored to meet this use. The entire propellant feed system, discussed in the following section, was built for this engine. The engine mount and operating floor were designed around this engine.

3-5.1 The engine mount is basically a hollow beam of rectangular cross section bridging the space between the trunnions. The engine is attached to the beam through three load cells spaced at 120^0, thereby allowing measurement of eccentric thrust. The mount can be rotated about the trunnion centerline through an arc of 90^0 by means of a sector plate and locking pin on one end. Design loads and stresses had the same basis as the trunnions, that is an overload factor if 3, and a maximum allowable stress of 20,000 psi. The completed mount was loaded with a hydraulic jack in an orientation which was the resultant of the axial and side loads. Strain gauges showed the maximum stress in the steel to be 3300 psi. Unavailability of certain sizes of steel plate necessitated the use of heavier material which accounted for the overdesign. Fig 15 shows the mount in place.

3-6 he operating floor under the mount contains two sets of double doors hinged parallel to the centerline on the stand, either or both to be opened immediately before test firings. The doors are remotely actuated by an electric motor drive. Fig 15 shows the doors in open position.

3-7 On the front face of the stand are two 8-inch raw water feeders to supply jet cooling water to nozzles which will be immersed in the flame. These feeders can be seen in Fig. 15.

3-8 The principal load carrying steel members are: 4-24wf 94# beams in vertical tension, 2-24 wf 100# beams in vertical compression, and 4-36wf 300# horizontal beams. The trunnions are 13 inches in diameter and extend 15 inches from the face of the support.

3-9 Concrete walls vary from 18 inches to 3 ft in thickness. The concrete ramp leading to the working floor is an independent structure on concrete abutments.

4. PROCESS DETAILS

4-1 The process piping was designed primarily around the first use of the stand. Funds were not available to make the process piping "universal." The selection of sizes, materials, and methods of construction was made on an economic basis.

4-2 Propellants are fed to the engine by a pumped system, using the pumps designed for the engine by the development contractor. Consequently, tank pressure requirements were for suppression of cavitation and losses to the pump inlets only.

4-2.1 The propellant tanks were sized for one two-minute run at rated thrust. The 3000 gal ammonia tank is made of low carbon steel, is rated 225 psi working pressure, and is constructed according to the ASME Code for unfired pressure vessels. An available 2500 gal stainless steel tank, rated at 50 psi working pressure, is used for liquid oxygen.

4-2.2 In addition to the propellant tanks, a cooling water tank of 2400 gal capacity is located in the fuel tank room. This is used as the source of engine jacket cooling water. The tank is rated at 1500 psi working pressure, according to ASME Code construction, and is made of low carbon steel. Because of its size and pressure rating, it was most economical to make the tank spherical, with a wall thickness of 2-3/4 inches. Fig 18 shows the fuel and water tanks.

4-3 The basic process piping schematic is shown in Fig 17. Propellants are pressurized by gas, stored at 2000-2200 psi, reduced to proper values by remotely controlled regulators, and piped to the tops of the liquid tanks. The liquid outlets are piped directly to the working floor. Fill, vent, and overflow lines are provided. All valves used in firings are remotely operated.

4-4 Nitrogen gas, for pressurizing fuel and cooling water, is stored in a cascade of 80 [or 30] high pressure bottles, arranged in four banks. This arrangement was dictated by the availability of the bottles from surplus. Each bottle has six cu ft water volume, and is of multilayer construction. The bottles have a Navy pressure rating of 3000 psi, using a factor of safety of 2.1 based on yield stress. Fig 18 shows the nitrogen cascade.

4-4.1 Gaseous oxygen is used to pressurize the liquid oxygen. This was done to prevent dilution of the liquid oxygen by pressurizing nitrogen gas. The gaseous oxygen cascade consists of two boxes containing 25 bottles each, with a total water volume of 406 cu ft. These boxes were obtained from Charleston, S.C. Navy Yard, where they were in oxygen service. Fig 19 shows the oxygen cascade.

4-4.2 The liquid ammonia line is welded, flanged, carbon steel pipe. The liquid oxygen is hard drawn copper, type L or K, with silver solder joints. The gas piping is largely brass pipe with silver solder socket fittings. The small diameter piping for pneumatic controls is flared tubing, aluminum or stainless steel, with AN fittings. Because of the intermittent nature of the use of the stand, no insulation is used on the liquid oxygen system, except for the 6-inch outlet line from the liquid oxygen tank to the working floor. The section of line is insulated by a jacket connected to a vacuum pump. This is done to minimize boiling of liquid oxygen being pumped from the tank to the engine.

4-4.3 Liquid oxygen is delivered by the vendor’s truck to a 10,000 gal jacketed storage tank 130 ft from the tank room. It is gravity fed from there to the propellant tank through a 3-inch brass pipe. In addition, the feed will be pressurized by 5 psi by evaporating liquid oxygen from a coil exposed to outside air.

4-4.4 Ammonia is loaded into the propellant tank by making use of an existing 13,000 gal ammonia storage tank at the foot of the hill upon which the stand is located. Two pipe lines, a liquid line and a vapor return line, connect the tanks. A compressor at the storage tank pumps vapor from the propellant tank into the storage tank, creating a pressure differential between the tanks, and allowing ammonia to flow into the propellant tank.

4-4.5 Gaseous oxygen is supplied to the cascade by the vendor's truck. Gaseous nitrogen is piped from a high pressure pumping station which already serves the rest of the test areas.

4-5 With one exception, all valves and controls are commercial products. Remotely controlled valves are actuated pneumatically with solenoid pilots, using 150 psi control pressure. The non-commercial items are motor-operated Grove dome loaders. In this instance a NARTS-designed electrical drive is used to turn the handwheels of the dome loaders remotely from the control room. This avoids the lag in pressurizing tanks which would occur with dome loaders in the control house connected to the stand by 250 ft of tubing. Since there are no high pressure gas lines in the console, the hazard of gas pressure explosions is removed.

5. INSTRUMENTATION

5-1 Instruments are installed to measure the usual rocket engine parameters, pressure, force, flow rate, and temperature. Enough channels are provided to allow for any additional measurements which might be needed for complete engine test.

5-2 There are 96 signal input plugs in the test cell, each connected to a four-wire circuit. The total number of installed recording channels includes 35 potentiometer recorders, eight direct writing Sanborn recorders and a two-channel cathode ray oscilloscope. Terminations are also installed in the recording racks for two 18-channel magnetic oscillographic recorders. There are thus 79 allocated recording channels with 17 spare circuits available.

5-3 The basic system uses direct current excitation of the pressure and force pickups. Space is provided in the racks for incorporation of an A.C. carrier system termination if desired. The D.C. system requires no amplification with the usual strain gauge transducers, and sufficient output is available from these to excite a magnetic recording oscillograph element at frequencies to 100 cycles per second. The recording of pressure, thrust, and flow frequencies above 100 cps was deemed unessential in ordinary development of large engines.

5-3.1 The outputs from the transducers can be fed as desired to either self-balancing chart recorders, magnetic oscillographs, or direct writing pen recorders. A low gain D.C. amplifier was built into the system feeding the direct writing recorders, even though D.C. amplifiers generally have been avoided due to their drift. These D.C. amplifiers incorporated an input circuit giving automatic compensation for the D.C. level in the transducer output. Where a turbine type flowmeter is employed the signals are presented as an A.C. signal of varying frequency. This is converted to a steady D.C. voltage by means of six integrator channels. The D.C. voltage level varies with the signal frequency. The integrators are almost linear to 400 cps and include multivibrator count down circuits to handle higher frequencies.

5-3.2 The self-balancing chart recorders may be seen in the general view of the instrument consoles, Fig 20. Twenty-two of the thirty-five recorders have a one second pen traverse time and may be switched to definite ranges of 3, 10, 30 and 50 MV. The zero may be shifted smoothly over a range of ± 50 MV. This feature allows exact zero balance of a recorder by an operator prior to firing or calibration without resorting to the central jack panel. The main balance and control section of the jack panel contains thirty-six channels, each with individual voltage controls. The output signals from the main balance panel are terminated on the jack panel and are available as an input signal to any of the recorders. Thirteen of the recorders are normal 10 MV units with two second traverse rates which are generally useful where the signals are of reasonable level. They represented a considerable cost saving over the twenty-two multi-sensitivity, one second traverse recorders.

5-3.3 Calibration of this system is done by placing shunts across the bridge arms, by the use of remote controlled relays installed in the balance unit. Included in the equipment is a high precision potentiometer by which the chart recorders may be checked for linearity and absolute scale calibration.

5-3.4 In addition to the purely electrical calibration a pair of high precision Heise gauges are installed in the cable termination room. Overall system calibration of pressure pickups is effected with these, using controlled nitrogen pressure.

5-3.5 A 100-cycle high precision frequency standard is used to simulate turbine flowmeter signals. This gives an absolute calibration of frequency vs. D.C. millivolt output.

5-4 Temperature measurement will in most cases be made by means of thermocouples. A cold junction in the test cell allows the use of copper leads throughout. The low range of 3 MV is sufficient to give satisfactory sensitivity for the usual thermocouple voltages generated.

5-4.1 Each of the lead-covered main signal cables connecting the jack panels with the test cell junction boxes contain 30 pairs of wires. Each pair is twisted and individually shielded by metallized paper. Their exceedingly low leakage factor of 5000 megohms/mile is responsible in part for the stable operation of the system. Measurement of cross talk between adjacent pairs revealed that less than 1/20000 of the signal was transferred. These cables were also used extensively to interconnect the recorder racks in the control room.

5-4.2 Special care was given to the problem of noise and hum elimination in the signal circuits. All 60 cycle power and D.C. control lines are grouped in isolated conduits. D.C. excitation voltages for the pickups run in separate ducts with the signal circuit cables. All D.C. return paths are taken to common low resistance busses before returning to the negative of the D.C. power supply. Return currents from all relays in the instrument racks run to these negative busses.

5-4.3 The cell junction box is equipped with hermetically sealed plugs and protective caps to eliminate corrosion of the pins. The four-wire circuits terminated at these plugs run to the control room jack panel and connect to the standard receptacles. One receptacle is used for each pair of voltage excitation leads, the second for each pair of signal output leads. Considerable flexibility of connection is thereby possible.

5-5 All electrical functions in the test cell are controlled remotely through D.C. relays, powered by a Nobatron rectifier in the test cell. This obviates the use of heavy cables which would be required to avoid the presence of ground currents between the control room and the test cells. An A.C. relay controlled on the operator’s console, drawing its voltage from the test cell A.C. line, closes the main switches supplying power to the Nobatron. Thereafter all control switching utilized this test cell source of power. All solenoids are wired so that the operator’s control board shows no light until power is actually applied to the solenoid.

5-5.1 Tank and line pressures are indicated to the operator by a bank of sensitive panel meters whose scales are marked in increments of pressure. The signals for these meters are derived from miniature potentiometers actuated by modified bourdon tube gauges in the tank rooms. Using standard components, the overall accuracy of this telemetering system proved surprisingly high, ranging from 1% to 2%. Using the panel meters it is possible to indicate the signals recorded on the chart recorders, through transmitters and a separate jack panel.

5-5.2 Control of the potentiometer chart motor drives, the oscillograph motor drives, and the direct writing Sanborn chart drives is possible in three ways: at the unit itself, at the instrumental jack panel, and finally through the recorder switch in the controls console.

5-6 The first overall test of the instrument installation was made during stress tests of the engine mount, using strain gauges. Although the potentiometer chart recorders were used at their most sensitive setting of 3 MV, and the signal levels were extremely low, no observable drift or noise was noticed throughout the test.

6. UTILITIES

6-1 The main requirement for raw water is for jet cooling and fire fighting. Raw water is supplied to the stand from a 5,000,000 gal reservoir 1800 ft. away, through [number illegible] inch cast iron pipe laid underground. The reservoir is at an elevation of about 170 ft below the stand, making it necessary to use pumps. Three 1000 gpm, 125 psi pumps, driven by diesel engines, located at the reservoir are used.

6-1.1 Potable water, used for drinking, sanitary services, safety showers, hose outlets, and for filling the tankage as needed, is supplied through an 8-inch line. It is recognized that some of these functions could ordinarily use raw water, but it should be borne in mind that raw water is available only when the pumps are running, whereas potable water is available at all times.

6-1.2 The stand has a deluge system which supplies water to sprinklers and floor flushes in each tank room, and to the working floor. These can be actuated remotely from the control room by solenoid-operated quick-opening valves with manual reset. Station-operated fire trucks can be called through a Gamewell System. Hydrants are located at points around the stand for the use of firefighting equipment.

6-2 A central heating plant, located in the lower level of the control house, supplies steam to unit heaters in both buildings. The necessity of working for long periods with both ends of the room open, and the use of uninsulated sheet metal siding, presented a heating problem. However, a large unit heater is provided to afford some comfort to personnel during winter operations. The control room is air conditioned primarily to avoid instrumentation difficulties caused by high humidity. Other ventilation is standard, except for the tank rooms, which have forced draft blowers to aid in clearing out fumes.

6-3 Power is brought to the area by 2300 volt 75 KVA transmission line. A substation reduces this to 220- and 110-volt power. Lighting is standard, except for the firing balcony, which is lit by explosion-proof lights. Street lighting and floodlighting are provided for night work and security patrols.

7. CONSTRUCTION

7-1 Construction was started 19 November 1951. Completion of the stand, including installation of instruments and controls, was scheduled for 30 November 1952. By the end of February 1952 excavation had been completed, and structural steel and concrete were in the process of erection. By the end of August 1952 the basic structure was completed, the installation of the process piping, controls, and instrumentation remained to be done. Delays in the procurement of the large ammonia and water tanks, due to a steel strike, were the principal causes of the stretch-out of the completion date. The last major item, the coolant tank, was delivered early in April 1953. This was installed and checked immediately, and the stand was turned over to its first user for engine development on 1 May 1953. Fig 21 shows the stand during construction. Fig. 22 is the completed test facility.

7-2 In the construction of the stand 3830 yds of earth were excavated, 1500 yds of rock were blasted, 3230 yds of concrete were poured, and 650 tons of steel were used.

8. PARTICIPATION BY THE NAVAL AIR ROCKET TEST STATION

Aside from the overall direction of the project, the Naval Air Rocket Test Station was completely responsible for the instrumentation and control systems. The station designed, procured, fabricated, and installed all instrumentation. Pneumatic controls, including solenoid valves, dome loaders, and the interconnecting tubing were also designed and installed.

9. ACKNOWLEDGEMENTS

9-1 The preliminary and detailed structural design was done by Frank Grad & Sons, Raymond Commerce Building, Newark, New Jersey.

9-2 The general construction contractor was E.M. Waldron Company, 84 South Sixth Street, Newark, New Jersey.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-1

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-2

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

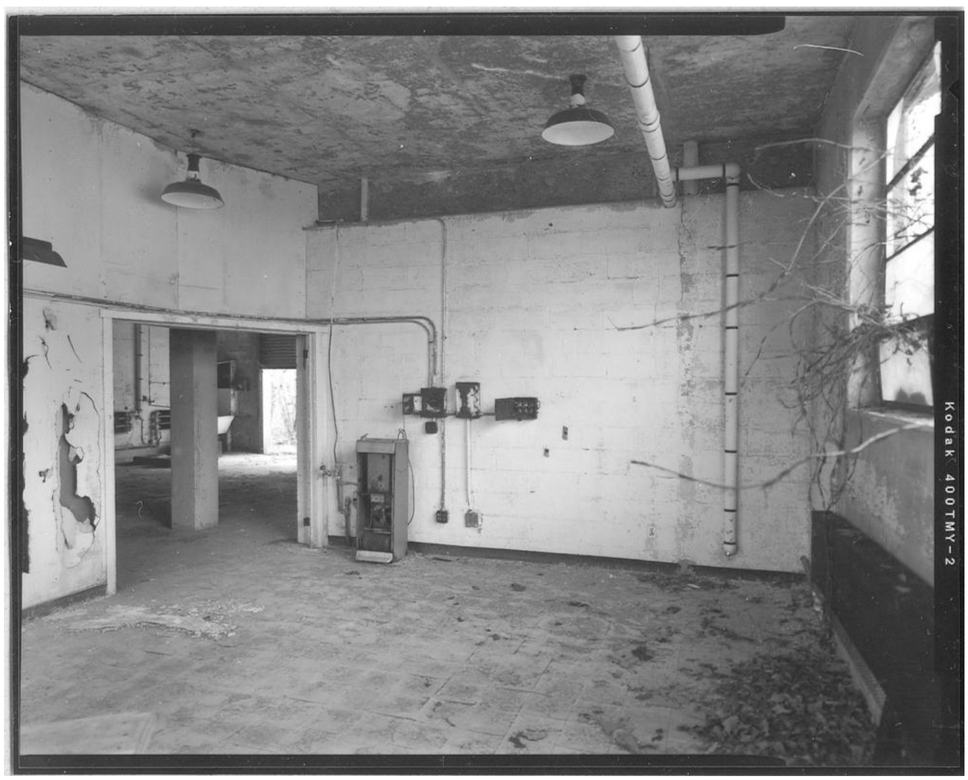
HAER No. NJ-XXX-3

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-4

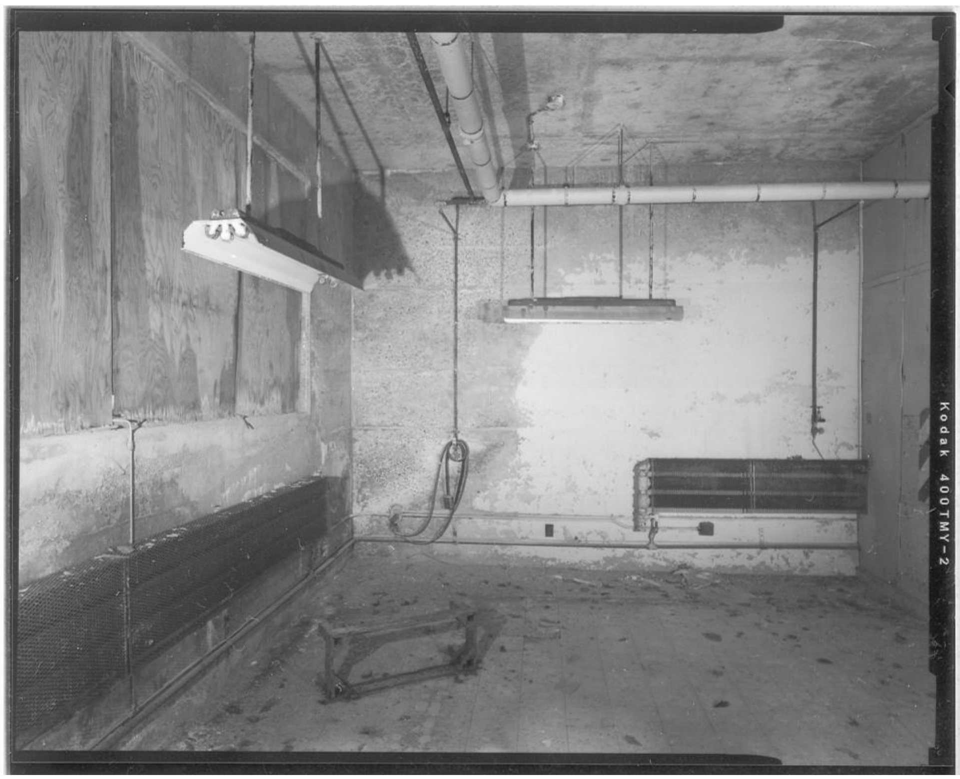
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-5



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-6



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-7

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-8

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-9

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

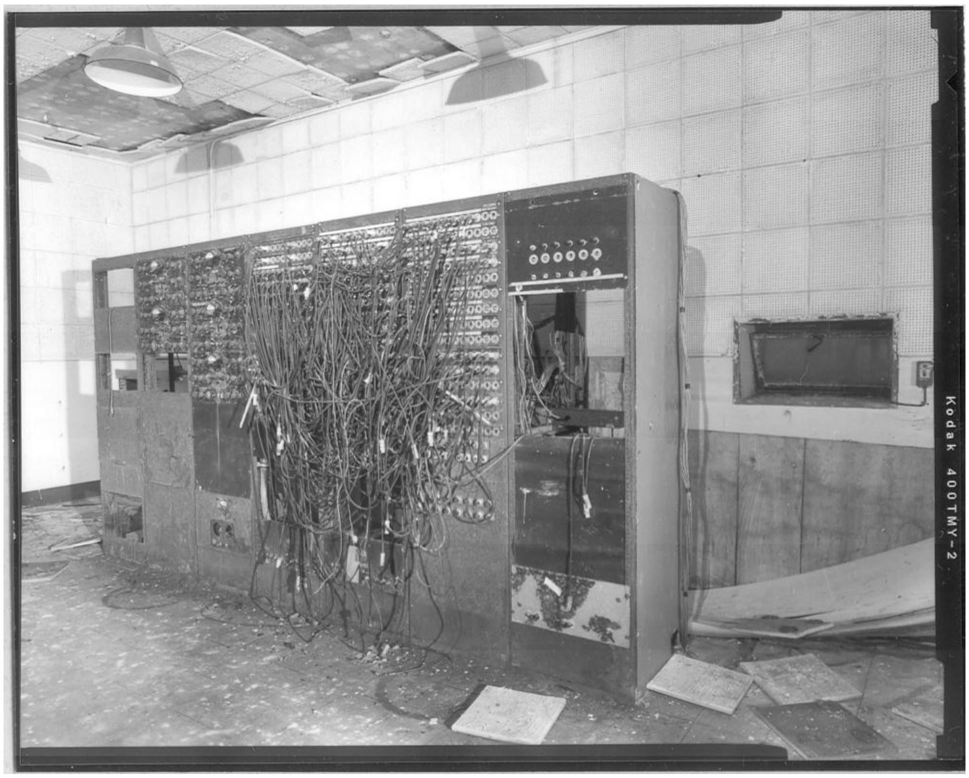
HAER No. NJ-XXX-10

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-11

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-12

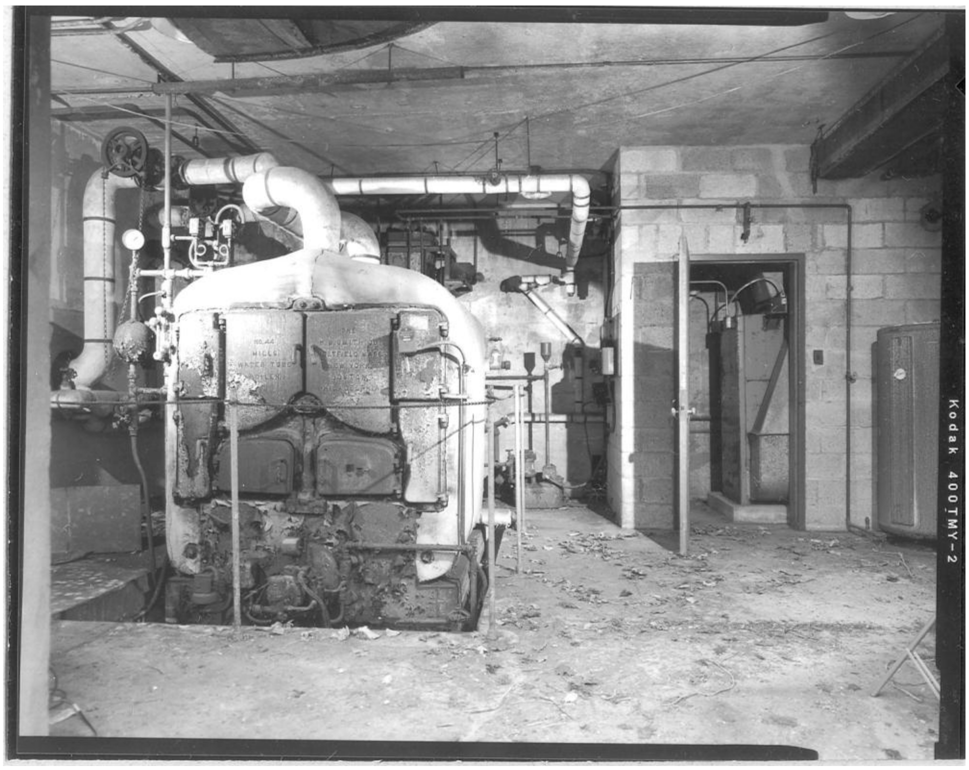


HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-13

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-14

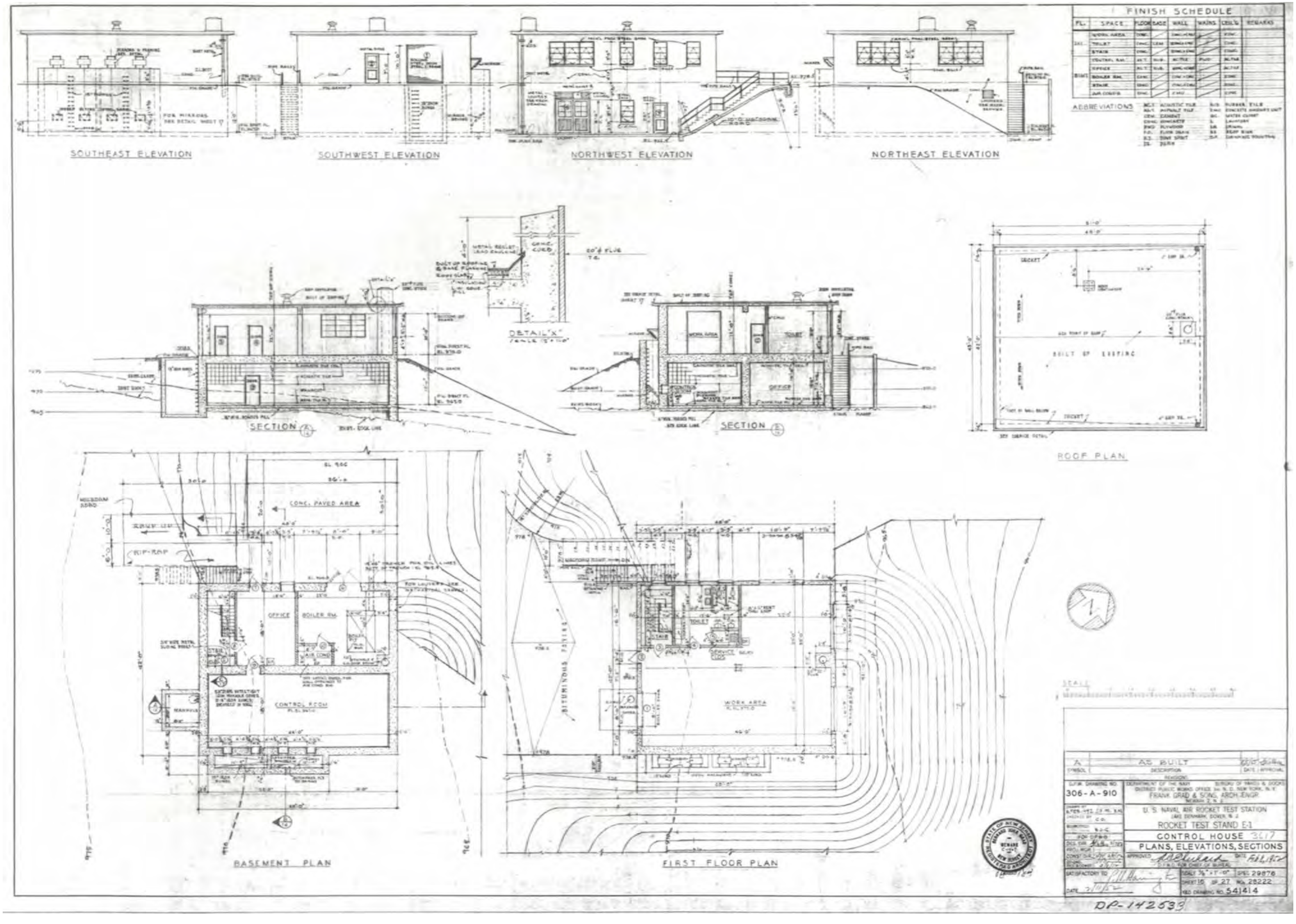


HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-15

HISTORIC AMERICAN BUILDINGS SURVEY
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HABS No. NJ-XXX-16
(SEE VERSO)


FINISH SCHEDULE
ABBREVIATIONS
SOUTHEAST ELEVATION
SOUTHWEST ELEVATION
NORTHWEST ELEVATION
NORTHEAST ELEVATION
DETAIL "X"
SECTION
SECTION
ROOF PLAN
BUILT UP ROOFING
CONC. PAVED AREA
RIP-RAP
OFFICE
BOILER RM.
AIR COND.
CONTROL ROOM
BITUMINOUS PAVING
WORK AREA
SERVICE
TOILET
STAIR
BASEMENT PLAN
FIRST FLOOR PLAN
SCALE
A
AS BUILT
SYMBOL
DESCRIPTION
DATE
APPROVAL
REVISIONS
D.P.W. DRAWING NO.
306-A-910
DEPARTMENT OF THE NAVY
BUREAU OF YARDS & DOCKS
FRANK GRAD & SONS, ARCH.-ENGR.
U. S. NAVAL AIR ROCKET TEST STATION
LAKE DENMARK, DOVER, N. J.
ROCKET TEST STAND E-1
CONTROL HOUSE 3617
PLANS, ELEVATIONS, SECTIONS
APPROVED
FOR CHIEF OF BUREAU
SATISFACTORY TO
DATE
SPEC. 29876
SHEET 16 OF 27 No. 28222
Y&D DRAWING NO. 541414
DP-142533

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 1.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 2.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 3.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 4.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 5.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 6.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 7.

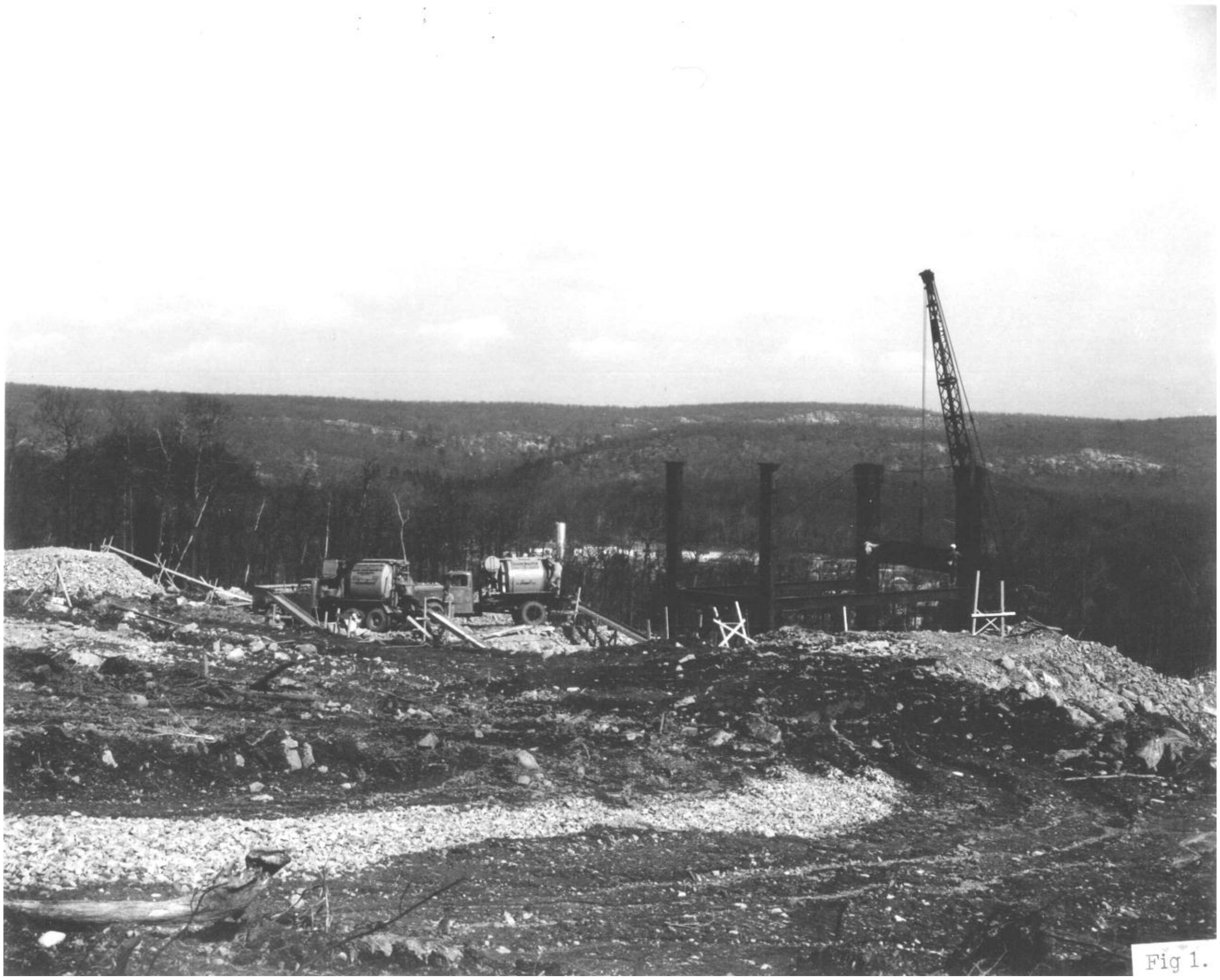
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 8.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

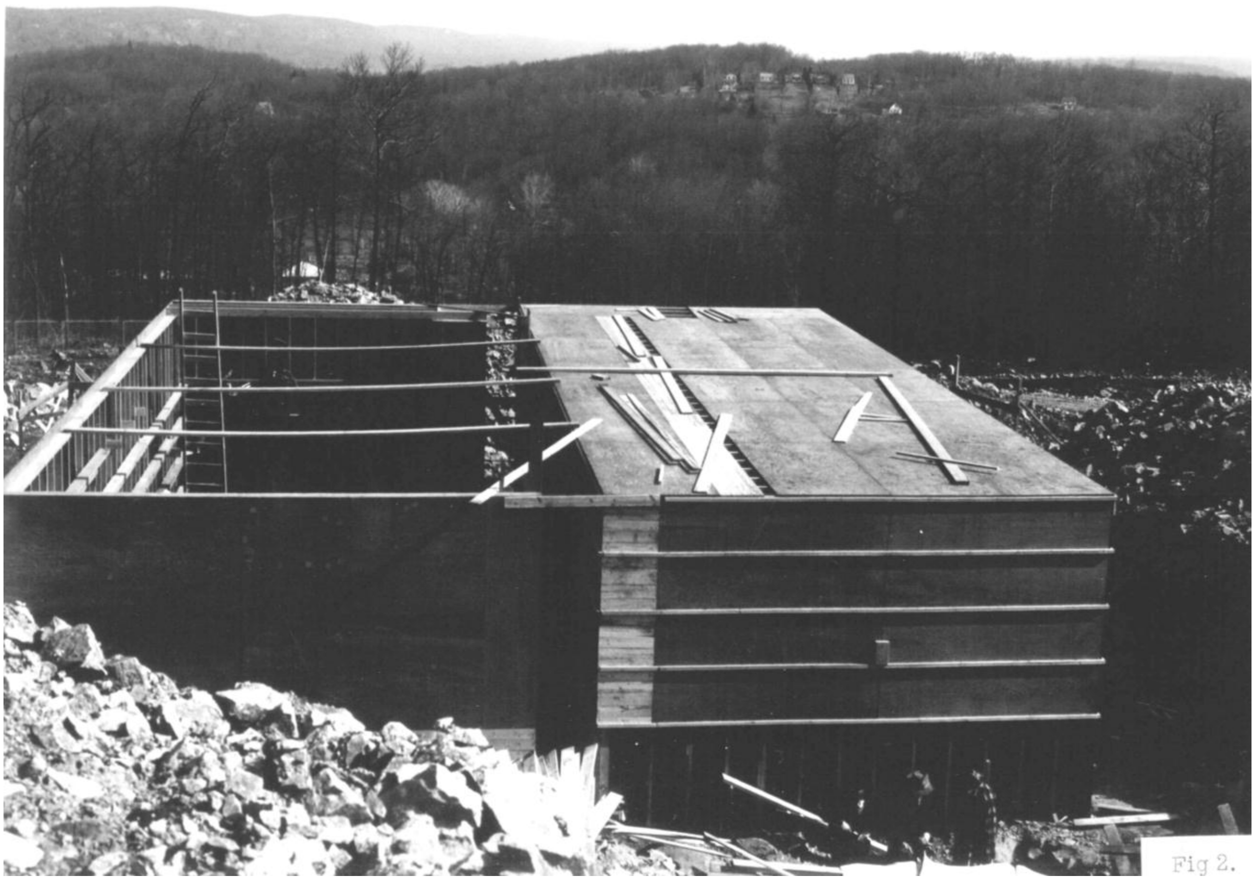
HAER No. NJ-XXX



Photograph 1S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 2S.

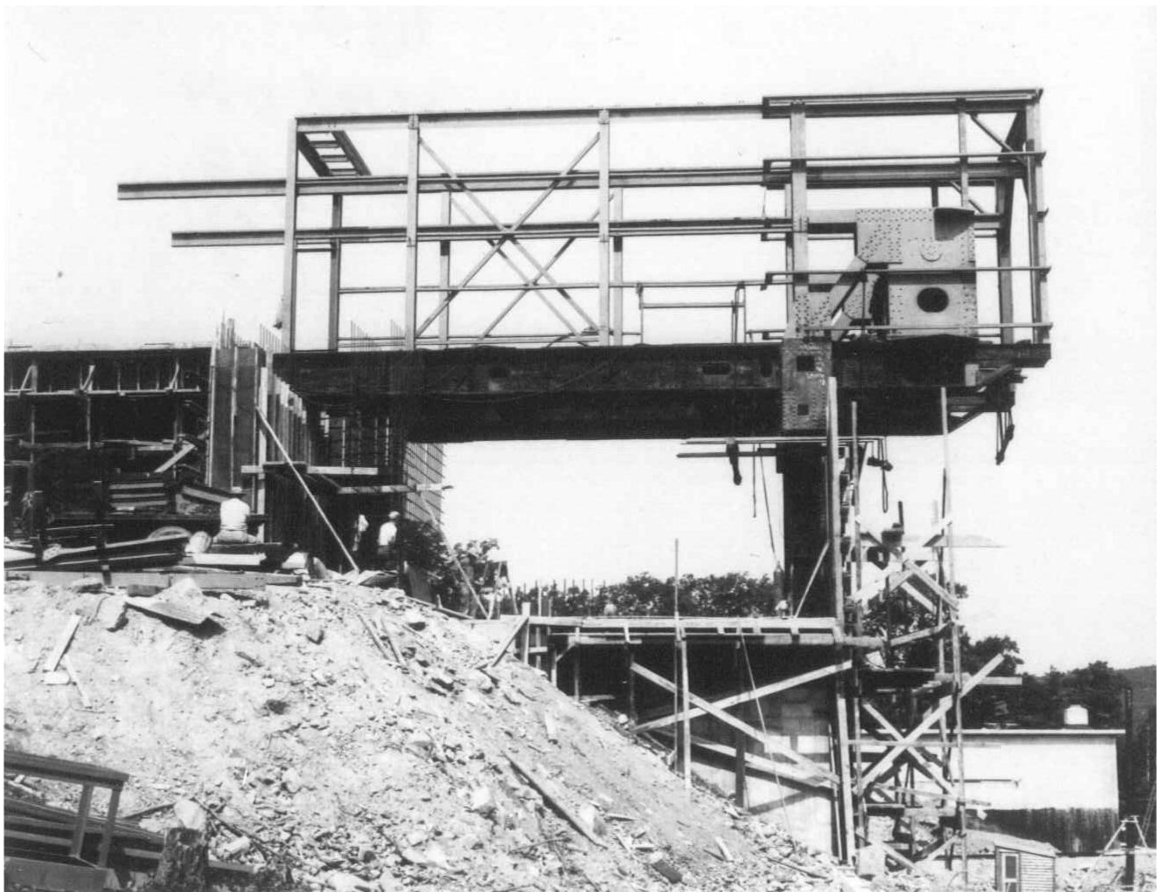
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 3S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 4S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 5S.

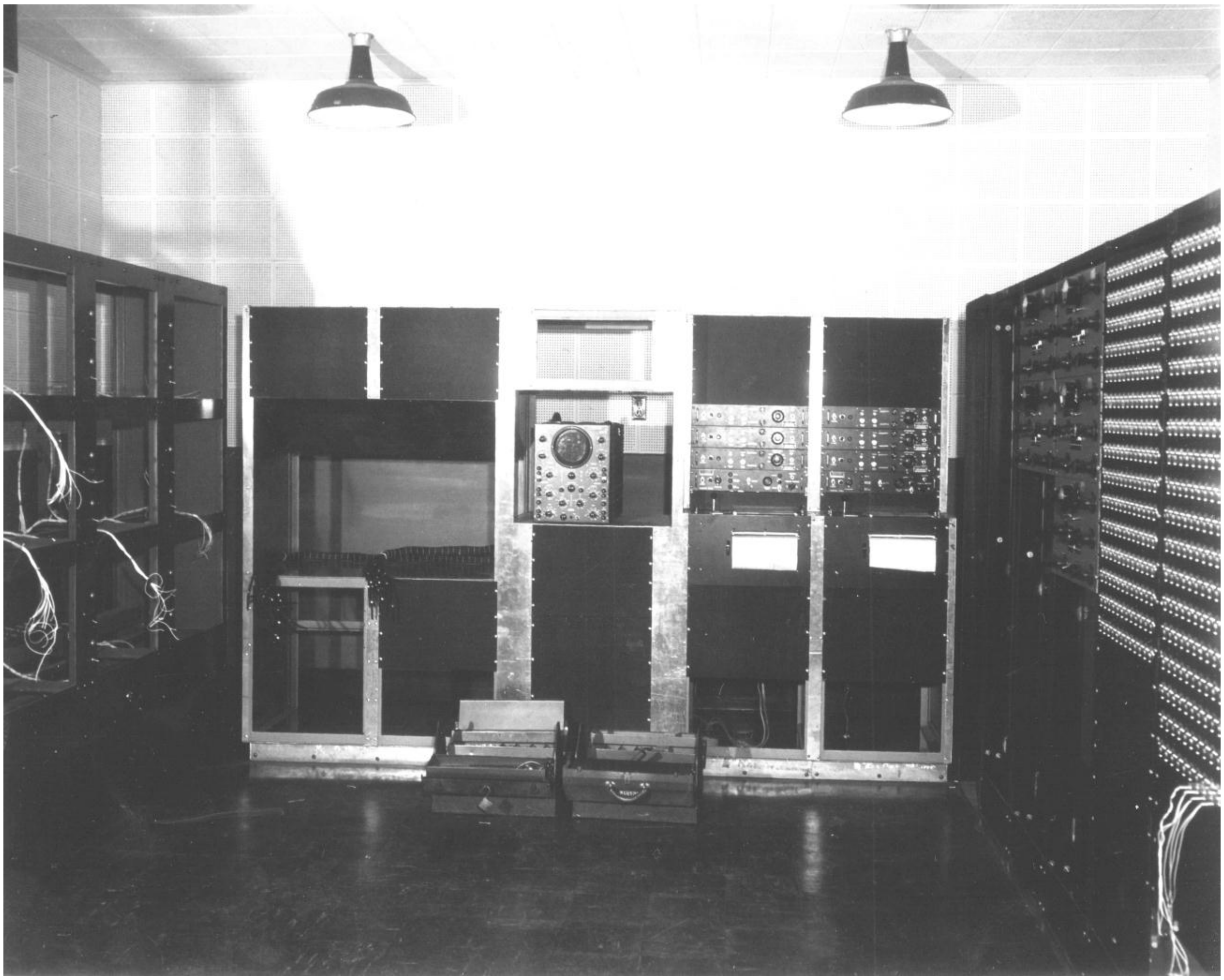
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 6S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 7S.

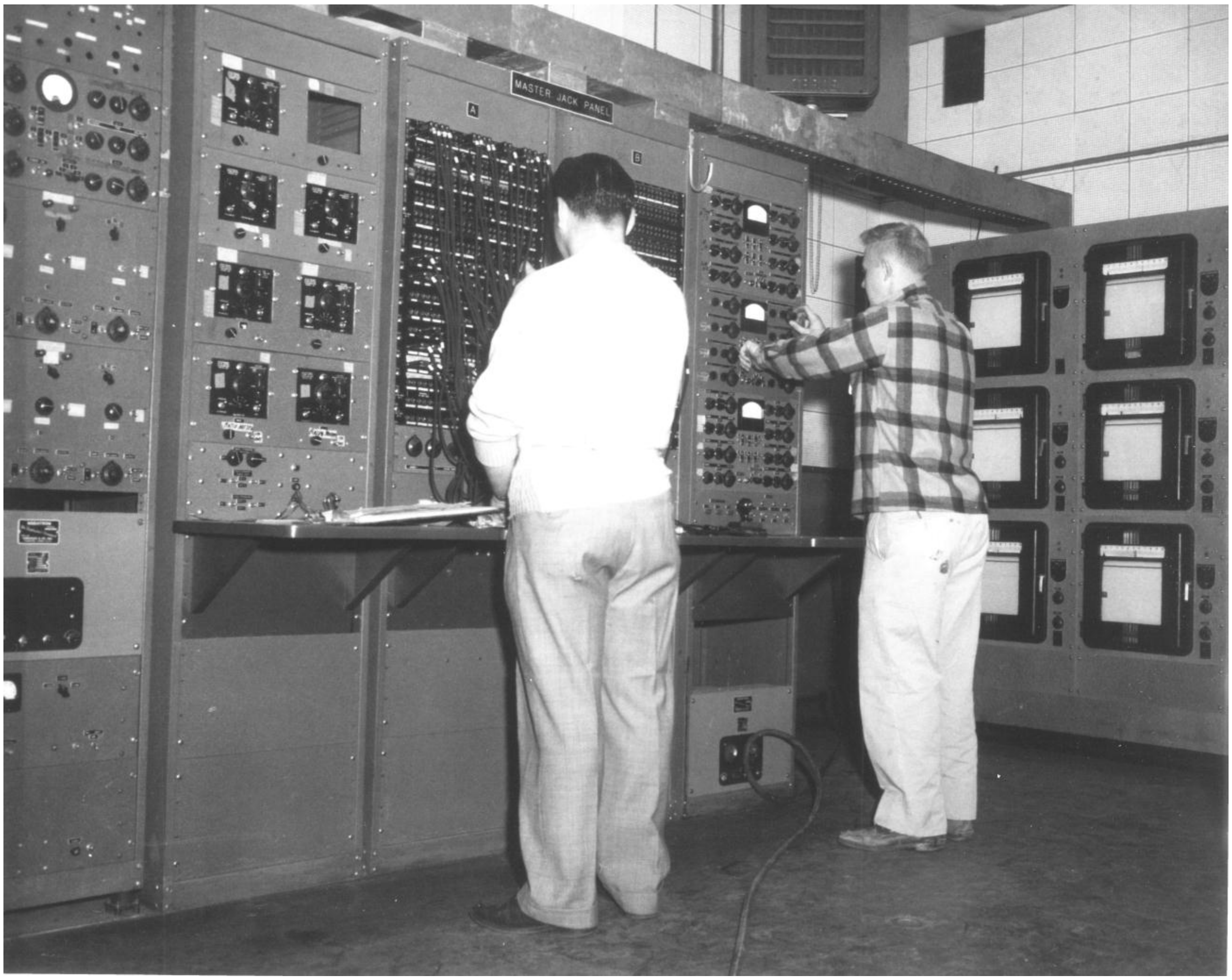
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 8S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

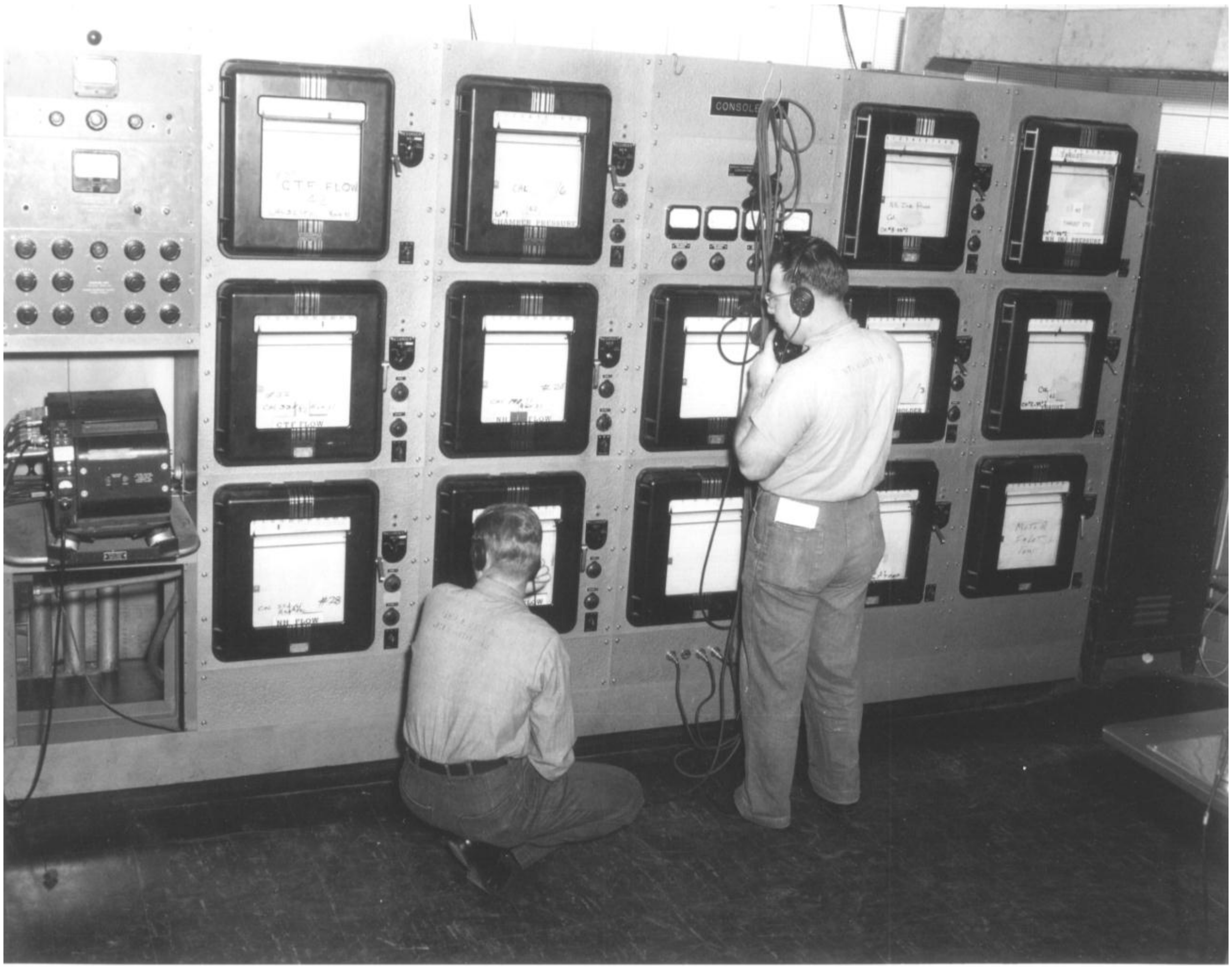
HAER No. NJ-XXX



Photograph 9S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 10S.

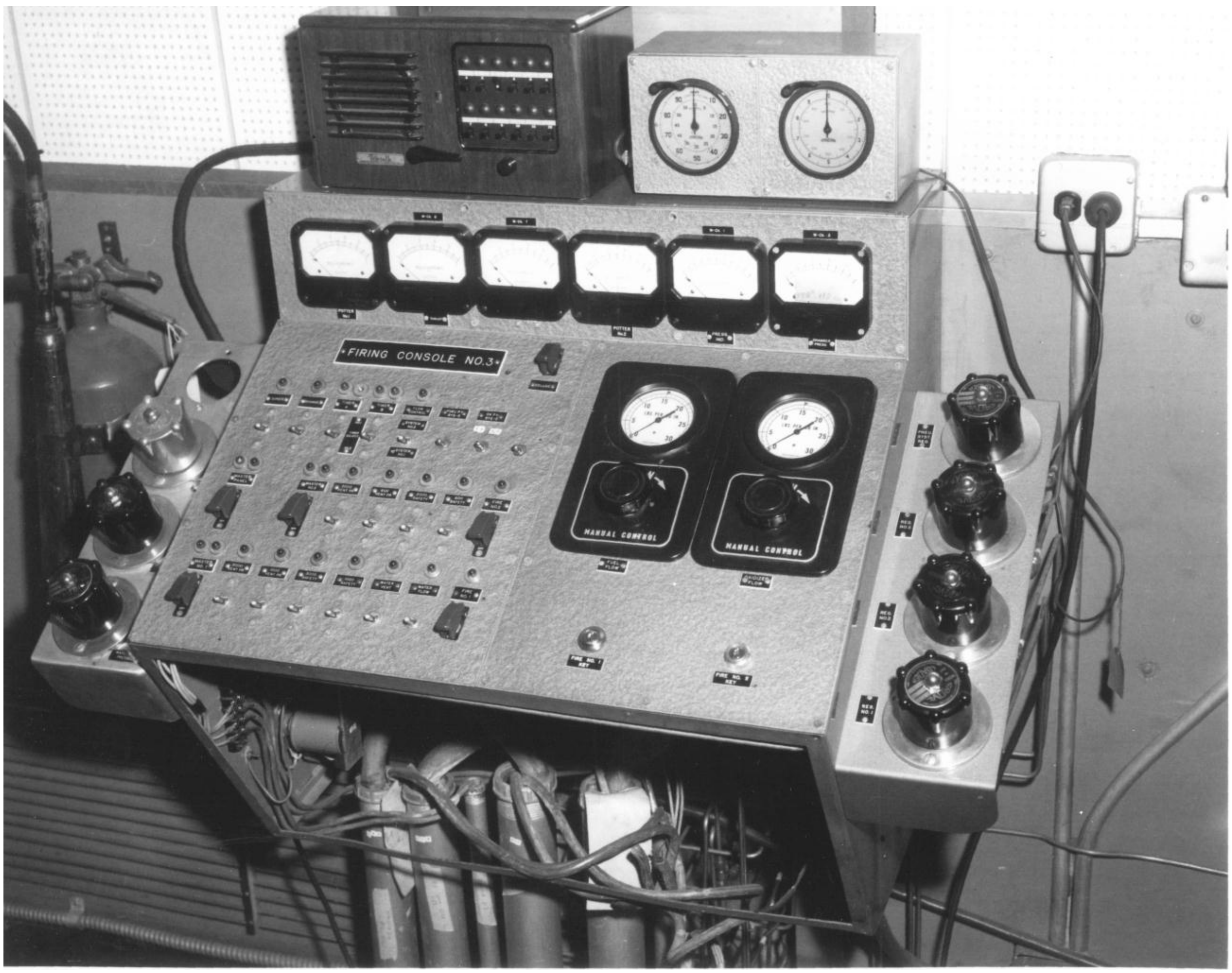
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 11S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 12S.

HISTORIC AMERICAN ENGINEERING RECORD

DOCUMENTATION OF THE CONTROL HOUSE (BUILDING 3617)

AND THE STATIC ROCKET TEST STAND (BUILDING 3618),

TEST AREA E HISTORIC DISTRICT

FORMER NAVAL AIR ROCKET TEST STATION (NARTS)

PICATINNY ARSENAL,

MORRIS COUNTY, NEW JERSEY

FINAL REPORT

Prepared for:

U.S. Army, Picatinny Arsenal, New Jersey

Through the U.S. Army Environmental Center,
Aberdeen Proving Ground, Maryland

Under a Cooperative Agreement with
U.S. Army Medical Research Acquisition Activity
Fort Detrick, Maryland

Prepared by:

Kelly Nolte, M.A., Senior Architectural Historian

Mark A. Steinback, M.A., Senior Historian/Technical Editor

Mark Drumlevitch, B.A., Photographer

PANAMERICAN CONSULTANTS, INC.
Buffalo Branch
2390 Clinton Street
Buffalo, New York 14227-1735
(716) 821-1650

June 2009

Management Summary

Panamerican Consultants, Inc. (Panamerican) was contracted by the U.S. Army Environmental Center (AEC) under a cooperative agreement with the U.S. Army Medical Research Acquisition Activity for the U.S. Army, Picatinny Arsenal, New Jersey, to prepare Historic American Engineering Records (HAER) Level II documentation of two buildings, as well as to evaluate 52 buildings and structures and the Picatinny Golf Course, including its associated buildings and structures, for National Register of Historic Places (NRHP) eligibility. This document presents the HAER recordations for the Control House (Building 3617) and the Static Rocket Test Stand (Building 3618), two structures within the Test Area E Historic District of the former Naval Air Rocket Test Station (NARTS), now within the Picatinny Arsenal reservation. The evaluation of the 52 buildings and structures and the Picatinny Golf Course will be submitted as a separate report.

The U.S. Army, as a federal agency, has management responsibilities concerning the protection and preservation of cultural resources on land it controls or uses. Federal statutes require the Army to identify and evaluate significant cultural resources on these properties, and include: the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et. seq) through 2000 (which includes Section 106 compliance); the National Environmental Policy Act of 1969 (42 U.S.C. 4371 et. seq.); the Historic Preservation Act of 1974 (16 U.S.C. 469-469c); the Advisory Council on Historical Preservation (ACHP) Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800); as well as Army Regulation (AR) 200-1 Environmental Protection and Enhancement.

In accordance with HAER Documentation Level II, each resource was documented through large-format photography and written historic data and description. One copy of this data is submitted on archival materials as a two stand-alone packets (one for each building). In addition, for the sake of organization and future storage, digital and non-archival copies of the documentation for each of the structures have been submitted as a single report with two sections.

The Panamerican project team included Ms. Kelly Nolte, M.A., Senior Architectural Historian and Principal Investigator; Mr. Mark Drumlevitch, Photographer; and Mr. Mark A. Steinback, Senior Historian/Technical Editor. Ms. Nolte conducted the fieldwork and historic research and wrote the majority of the report, and Mr. Drumlevitch was responsible for all the large-format photography. Mr. Steinback prepared most of the historical background and edited the report. Dr. Michael A. Cinquino served as Panamerican's Project Director.

Table of Contents

STATIC ROCKET TEST STAND HAER NO. NJ-XXX
(Building 3618; Test Stand E-1)
Southeast side E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

PHOTOGRAPHS

WRITTEN AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Mid-Atlantic Region
Custom House
2nd & Chestnut Street, Rm. 231
Philadelphia, PA 19106

June 2009

HISTORIC AMERICAN ENGINEERING RECORD

STATIC ROCKET TEST STAND
(Building 3618; Test Stand E-1)

Location: Static Rocket Test Stand (Building 3618; Test Stand E-1) is located on the southeast side of E Road intersecting with Snake Hill Road leading up to and through Test Area E, Naval Air Rocket Test Station (NARTS), off the installation proper, Picatinny, Rockaway Township, Morris County, New Jersey.

UTM: 18.540190.4533640
Quad: Dover 1981 [1954]

Date of Construction: 1953

Engineer/Architect: Frank Grad & Sons Architects and Engineers, Newark, New Jersey

Present Owner/ Occupant: United States Army, Picatinny (formerly known as Picatinny Arsenal), New Jersey

Present Use: Abandoned, not in use

Significance: The Static Rocket Test Stand (or Static Rocket Engine Test Stand [Building 3618]), its partner building, Control House (Building 3617), and their surrounding landscape have been determined eligible for the National Register of Historic Places under Criteria A and D as a historic district, the NARTS Area E Historic District. The Static Rocket Test Stand, which is a contributing element, is both nationally and regionally significant for its role in the Cold War (1946-1989) military-industrial complex and during the creation and testing of liquid and solid rocket fuels and engines, particularly the XLR-11 and XLR-99 engines.

Kelly Nolte, Senior Architectural Historian/Director Architectural History Division
Mark A. Steinback, Senior Historian

Panamerican Consultants, Inc.
Buffalo Office
2390 Clinton Street
Buffalo, New York 14227-1735

June 2009

PART I. HISTORICAL INFORMATION

A. Physical History:

1. Date of erection: 1953.

2. Architect/Engineer: Frank Grad & Sons, Architects and Engineers, Newark, New Jersey. Frank Grad (1883-1968) established his architectural firm in Newark, New Jersey, in 1906, becoming Newark's first Jewish architect (Newarkology! 2008). Grad was born March 27, 1883 in Austria to Oslos, a painter and decorator, and Minnie (Keinstreich) Grad. (Publications differ regarding the year of his birth, listing either 1882 or 1883 [Newarkolgy! 2008; Urquhart 1913]. Panamerican has chosen 1883 since the Urquhart publication seems to have been based on an interview with him.)

Grad attended a preparatory school in Austria and then studied mechanical engineering at a Vienna technical school, taking additional courses in architecture. After completing his studies, he worked as a draftsman in England for less than two years before emigrating to the United States. On December 24, 1902, at the age of 19, he arrived in New York, and immediately began working for Gould & Eberhart in Newark. After a year, he took a draftsman position with the Domestic Sewing Machine Company. Grad next gained employment with the firm of Laurence F. Weir, Architect, New York. He remained there for three years, learning the practice of architecture in the United States. Deciding to start his own architecture office, Grad passed the New Jersey state architecture examinations, and opened his private practice in Newark in 1906 (Urquhart 1913:116).

In 1907, Grad married Kitty Furst, daughter of Bernard and Dora Furst of Newark, and they had two sons, Bernard (1908-2000) and Howard (1913-1992) (Urquhart 1913; *The New York Times* 1992, 2000). Grad's meteoric rise was chronicled in a 1913 history of the City of Newark, which highlighted the wide variety of buildings he had designed in northern New Jersey between 1906 and 1912. These structures included: John F. Schrink's jewelry factory (Newark); a Main Street office building (Orange); Salny Brothers department store (Morristown); the residence of A.M. Rosenberg (Newark); Job De Camp Warehouse (Newark); an apartment block for Joseph Green (Bloomfield); Alderman Lewis Semel's amusement hall (Newark), as well as several apartment buildings and offices through

Newark (Urquhart 1913:117). Grad was fully integrated into the social and professional life of Newark, having joined the Masons, the Odd Fellows, and the Newark A.O.B.A (could not locate acronym) as well as professional associations, which likely helped him to identify prospective commissions (Urquhart 1913:117). For a 30-year-old, Frank Grad was a roaring success.

Grad's sons would later join his practice; first, Bernard in the late 1930s, and then Howard in 1945 (BASF 2008; *The New York Times* 1992, 2000). The firm became Grad & Sons, Architect and Engineers. Bernard ("Bernie"), an architect, was a graduate of the Newark Academy (1927) and the University of Pennsylvania (1932) and studied at the *École de Beaux-Arts* in Fontainebleau, France. He was a Fellow of the American Institute of Architects, and served as a member of the Board of Overseers for the New Jersey Institute of Technology (*The New York Times* 2000). Howard was an engineer, who, like his brother, graduated from the University of Pennsylvania (1934). Howard supervised the company's projects for the North Atlantic Treaty Organization (NATO) in France and Britain during the 1950s. During the 1980s, he was a managing partner of Grad Partnership (*The New York Times* 1992).

The firm has gone by a number of names including: Frank Grad (1906-late 1930s to mid-1940s); Frank Grad & Sons (late 1930s to mid-1940s–1968); Grad Partnership (1968-1990); Grad Associates (1990-2007); Grad Architects (2007–2009); and GRAD (2009-present). The company celebrated its 100th anniversary in 2006, which was marked by the Newark Public Library in 2007 with an exhibition called "A Salute to GRAD Associates: One Hundred Plus One." The exhibition was accompanied by a selection of books on architectural history from the library's collection (Nelson 2006; Newark Public Library 2007).

The period comprising the years of Frank Grad & Sons and Grad Partnership, when the three Grads were working and then later when it was just the brothers, witnessed a shift in the source of company contracts, which mirrored trends emerging in American society and business. In the early years of his practice, Grad produced a number of structures that are now considered landmark Newark buildings, including the Young Men's and Young Women's Hebrew Association, Mosque Theater (now Symphony Hall), and Beth Israel Hospital (Newark Public Library 2007). The firm was already creating in a variety building types, but in the 1920s it had begun venturing into a new arena—government contracts (GRAD 2009). Grad worked on Newark municipal public buildings during the 1920s and 1930s, but it was federal contracts that helped catapult Grad into the upper ranks of architectural firms (GRAD 2009; Nelson 2006; *The New York Times* 1992).

After World War II, Frank Grad & Sons became involved with large-scale national defense projects, one of which was the classified NARTS project at the former Lake Denmark Naval Ammunition Depot in New Jersey. During the 1950s, the firm held a contract for the construction of U.S. military installations in seventeen countries worldwide in association with NATO. Howard Grad was in charge of the firm's NATO projects at that time (Nelson 2006; *The New York Times* 1992). In the late 1960s and early 1970s, Grad Partnership led the design of two of the largest projects then undertaken by the federal government: the Headquarters (HQ) of the Department of Defense (DoD), James V. Forrestal Building Complex, Washington, D.C. (1.7 million square feet [sq.ft.]), and the U.S. Social Security Administration HQ, Baltimore, Maryland (1.8 million sq.ft.) (GRAD 2009).

Also during this period, Grad designed three entirely new college campuses for the state of New Jersey--University of Medicine and Dentistry of New Jersey, Newark, Essex County College, Newark, and Bergen County College, Paramus—in addition to projects at Rutgers, Kean, William Paterson and Monmouth universities. Grad's Seton Hall School of Law building is one of the tallest buildings in New Jersey (Nelson 2006). Grad has designed more than half of all the high-rise office towers in New Jersey that are more than 25 stories and is credited with designing the first tallest building in New Jersey—the Raymond Commerce Building—in 1922 (Nelson 2006; GRAD 2009).

The firm Frank Grad exists today as GRAD at Two Gateway Center in Newark, New Jersey. The firm boasts 35 architects and works worldwide on architectural, engineering, planning, design, and interior design projects (GRAD 2009).

3. Original and subsequent owners: United States Navy, Third Naval District (Third), Bureau of Aeronautics (BuAer), Naval Air Rocket Test Station (NARTS), New Jersey; United States Army, Picatinny, New Jersey.

4. Original and subsequent occupants: The building was constructed by the U.S. Navy and was used by the Navy and Reaction Motors, Inc. (RMI), the first commercial rocket-engine company in the United States, as the static, test-firing stand for the hot firing of rocket engines. The Static Rocket Engine Test Stand is located approximately 250' southeast of the Control House (Building 3617) across the asphalt access road (E Road) to the NARTS area. The Test Stand has been used for no other purpose and has stood idle since at least 1970 (Walker 1970; Walter 1997a).

5. Builder, Contractor, Suppliers:

E.M. Waldron Company, Newark, New Jersey, site preparation and construction;
Bethlehem Steel, Pennsylvania, all necessary steel;
Linde Air Products, a division of Union Carbide, installation of oxygen tank and nitrogen and oxygen cascades;
Muzillo Company, design and formulation of specifications for high-pressure tankage and piping;
Vimalert, Company, Newark, New Jersey, design, fabrication, installation and testing of rocket-engine mount;
Charleston Navy Yard, Charleston, South Carolina, trailers for oxygen cascade;
RMI, project consultant; and
BuAer, project consultant

(NARTS 1951: Monthly Progress Reports for September, October, November, and December; NARTS 1952: Monthly Progress Reports for March, July, October, November, and December; NARTS 1953: Monthly Progress Report for January).

6. Original plans and construction: A full set of blueprints for the Static Rocket Test Stand, (sometimes referred to as Static Rocket Engine Test Stand), Control House, and the general area are available at the Directorate of Public Works, Picatinny, New Jersey. The title blocks on all the blueprints read: "Department of the Navy, Bureau of Yards and Docks/District Public Works Office 3rd N.D. New York, NY/FRANK GRAD & SONS, ARCH-ENGR/Newark 2, New Jersey." Some of the blueprints indicate that Frank Grad also had offices in Washington, D.C.

The Control House and the Static Rocket Test Stand, while two separate buildings, have a symbiotic relationship; both structures were conceived as essential components of the same operation: to test rockets and motors. In many cases, the existing construction histories make no distinction between the two structures when discussing materials acquisition, site meetings, and other construction details. Because of this lack of distinction, the construction history that follows includes information about the Control House, the Static Rocket Test Stand, and the general area, known as Area E. The location of the original construction record/s is unknown; however, monthly and quarterly progress reports, still located in the Picatinny Technical Library, provided an excellent overview of the construction. These reports form the basis of the following construction history.

When the Navy began rocket development, contracts were loosely drawn because outcomes were uncertain, performance was conjectured, and the final design “was a balance between guesswork and the ability of the machine shop” (Durant 1951:74). During these early years, acceptance tests were conducted by a government representative at the contractor’s plant using that contractor’s instruments and formulas. The lack of instrumentation standardization and the inadequacy of testing procedures made the value of these tests doubtful. It was, therefore, desirable for the government to develop its own facilities at which trained personnel could test engines to specification using standardized methods of instrumentation.

Tests conducted at these government facilities would be unbiased and serve as a basis for comparison for various engines and the evaluation of hardware. With information gained from these testing facilities, the government could develop guidelines for new contracts that would ultimately lead to the development of superior rocket engines (Durant 1951). By 1950, the Navy had established three such testing facilities for air-related engines: the Naval Aeronautical Rocket Laboratory (NARL; at Lake Denmark, New Jersey) for the testing and evaluation of rocket engines; the Aeronautical Engine Laboratory (in Philadelphia, Pennsylvania) for the testing and evaluation of reciprocating engines; and the Aeronautical Laboratory (in Trenton, New Jersey) for the testing and evaluation of turbojet engines.

In addition to testing and evaluation activities, the Navy found it desirable to actually provide test facilities at NARL for rocket-engine contractors or other governmental agencies with inadequate or insufficient test facilities of their own. This was particularly true for engines with more than 10,000 pounds (lbs) of thrust. As the thrust capacity of engines grew, construction costs for the test stand, tankage and instrumentation, which were expensive initially, increased significantly, making the creation of large stands prohibitive for many companies. Some companies also were located so close to general habitation areas that the firing of very large engines was precluded because they were a public nuisance (Durant 1951).

When NARL and the adjacent ammunition depot became the Naval Air Rocket Test Station in 1950, the Navy undertook an extensive engineering study to create a master plan for the facility. The Navy requested $7,500,000 for the expansion and modernization of the existing test facilities; to purchase more land to better integrate their current holdings; to improve and standardize instrumentation; to provide for an underground propellant storage system; to create more housing; and to outfit specialized shops and laboratories (NARTS 1950: Progress Report for January; Durant 1951).

NARTS began a serious expansion program that included the construction of Test Area E, a site for the testing of rocket engines up to 350,000 lbs of thrust and which served as the location for a number of important research and design projects. The earliest projects (actually assigned to NARL), most of which were classified as restricted or confidential, included the development of methods and equipment for testing liquid propellant rocket engines (project no. ARL PP-201); various applications as related to the LARK guided-missile rocket engine (ARL PP-202 and ARL PP-202.1); and the acceptance tests and evaluation of the XLR-18-K-2 booster assembly rocket (ARL PP-203 and ARL PP-203.1) (Seiler 1949).

Prior to 1950, NARL had a number of temporary test stands that were made from Quonset Huts. At these temporary stands, the Navy with RMI had tested the rocket engines or components for the Douglas SKYROCKET, the Bell X-1 and the LARK. The Navy also had a large test stand for the development of the 20,000-lb thrust VIKING engine, for tests of the Consolidated-Vultee (Convair) MX-774 (a preliminary Intercontinental Ballistic Missile [ICBM]), and for certain tests on the SKYROCKET. The large stand, called the Viking Stand, was originally built in 1946 for engines with a capacity of 6,000 lbs thrust and was later converted for 20,000 lbs thrust (NARTS 1950: Progress Report for January). These facilities were in need of renovation and modernization and the demand for a large test stand was pressing.

In December 1949, BuAer asked NARL to recommend the most practical method of providing a testing facility for a 50,000-lb thrust rocket using ammonia and oxygen as propellants. The creation of such an engine was under consideration at the time and the problem of supplying an adequate test facility was an important factor influencing the decision. BuAer had three alternatives for NARL to consider: 1) modify the existing Viking Stand, which stood in RMI Area D and had only a 20,000-lb thrust capability; 2) modify an existing booster stand that had a 100,000-lb thrust capacity but its tank rooms only allowed motor testing; 3) construct a new stand. After consultation with the parties affected, NARTS believed that a new stand with an exceptionally high thrust capability must be constructed (NARTS 1952: Quarterly Progress Report for April).

A number of factors influenced the decision to build a new stand. BuAer also was considering the development of a rocket engine with a capability of 350,000 lbs of thrust and a larger stand was required to adequately test a booster assembly of this size. If the two existing stands were modified, the result would be a stand so specialized that it could be used for almost nothing else. The cost of any such modification would approach the cost of constructing a new multi-purpose stand (NARTS 1952: Quarterly Progress Report for April).

As a result, in September 1950, BuAer made the decision to proceed with the erection of a new attitude test stand with the capacity to test a 350,000-lb thrust missile assembly, and gave the go-ahead to prepare preliminary specifications and designs. The stand was to have propellant tank rooms integral with the structure so that motor testing alone also could be undertaken. The initial tank and piping installation was to accommodate liquid ammonia and liquid oxygen (LOX) as propellants in quantities sufficient to supply 100,000 lb-min of impulse (NARTS 1952: Quarterly Progress Report for April).

By May 1951, Frank Grad & Sons of Newark, New Jersey, had completed a preliminary design study for the construction of a 350,000-lb test stand and NARTS had assigned the project the number SI-211. Completion of the project, entitled “Assist in construction of 350,000 lb thrust test stand,” and delivery of the test stand to RMI for engine development tests was slated for March 1952 (NARTS 1951: Monthly Progress Report for May). The project was marked as restricted. In July 1951, NARTS received a copy of the letter from the Chief, Bureau of Yards and Docks (BuDocks), to the Commandant, Third Naval District (Third), which approved the allocation of funds for the engineering, construction and instrumentation of a 350,000-lb thrust rocket test stand (designated as Test Stand E-1). Grad’s design was approved by NARTS, BuAer and RMI after modifications had been made to the design of the trunnion mount, the mount that actually held the engine. RMI was then engaged in the testing of a 50,000-lb rocket and wanted a separate, special mount included in the test stand’s design (NARTS 1951: Monthly Progress Report for July).

NARTS and RMI agreed that the final completion date for Test Area E would be June 1, 1952.

During August, a series of conferences was held between NARTS and RMI to determine the instrumentation required. NARTS agreed that the amplifying, indicating, and recording equipment would be furnished by them and that the sensing instruments, because they were expendable equipment, would be furnished by RMI under their development contract (NARTS 1951: Monthly Progress Report for July). Throughout the summer RMI, NARTS, BuAer, BuDocks, and the Third hashed out the various equipment needs and obligations. The engineering contractor was scheduled to begin August 27 (NARTS 1951: Monthly Progress Reports for August and September).

By September 1951, Frank Grad & Sons was given the detailed engineering report of the test stand by NARTS as well as general layout of the instrument panels and conduits. In order to expedite the start of construction, District Public Works Office (DPWO) and the Third began discussing terms for a negotiated contract with E.M. Waldron Company, Newark, New Jersey, for the construction of the stand (NARTS 1951: Monthly Progress Report for September).

The negotiations between E.M. Waldron Company, the Third, and DPWO yielded a contract dated October 18, 1951. BuDocks began the purchasing process for the necessary steel from Bethlehem Steel. During the month of October, NARTS, DPWO, RMI, and Frank Grad & Sons met to discuss the structures in Area E. It seems that originally NARTS wanted a separate Field House, Control House and Test Stand in the area. In October, all parties agreed that the Field House and the Control House should be combined into a single two-story structure; RMI and NARTS had agreed on the purchase of equipment; and BuAer authorized NARTS to begin the purchasing of the instrumentation (NARTS 1951: Monthly Progress Report for October). The Field House was never constructed.

In November, E.M. Waldron Company began clearing the site and NARTS continued to work out last-minute details on the design of the test stand, including the schematic piping diagram and a valve and control parts list for the fuel, oxidizer and water systems. Actual construction started on November 19. With these additional details, Frank Grad & Sons hoped to have the final test-stand design completed by the beginning of December. NARTS also began the design of the recording racks in the Control

House. After two conferences to establish specifications, Linde Air Products, then a division of Union Carbide, was selected for the installation of the oxygen storage tank and the nitrogen and oxygen cascade (NARTS 1951: Monthly Progress Report for November).

In December, the completion date for the project was pushed back to June 13, 1952 as a result of a number of design delays. With the test-stand design completed, E.M. Waldron's bid for construction was expected the first week of January. Waldron began excavations for the stand footings, clearing and grubbing the road and structure sites, and rough grading the road and parking areas. RMI continued to ask NARTS for more machinery and instrumentation concessions. NARTS, believing that these last-minute changes would greatly increase the total cost of the project, struck a deal for additional equipment with RMI. If NARTS did not have the requested equipment on hand, as either stock or surplus, RMI would be required to purchase the requested equipment out of their development contracts. Linde Air Products estimated that the installation of the required equipment would cost $13,000. NARTS requested that the costs be defrayed by BuAer in their new contract for LOX that was to go into effect on or about January 1, 1952 (NARTS 1951: Monthly Progress Report for December).

Construction continued though January 1952, and a number of delays pushed the project back ten days. BuAer apparently balked at including Linde Air Product's cost into their contract because NARTS began to investigate a new design for the cascade pressure sensing lines in the Control Room that would greatly reduce the cost of piping. NARTS continued to design the instrument racks, although the process slowed to accommodate higher priorities (NARTS 1952: Monthly Progress Report for January).

During February, as construction continued, subcontracts for clearing, grubbing, and blasting the site were nearly complete and contracts for structural and reinforced steel were let. The specific company or companies involved were not identified in the documentation. The new design for pressure sensing lines proved feasible in preliminary tests prompting NARTS to draw new specifications. Despite the slowdown in the design of the instrument racks, it was still proceeding ahead of schedule. Overall completion was estimated at 13 percent (NARTS 1952: Monthly Progress Report for February).

By March, the site of Test Area E was shaping up and NARTS recorded this progress in four photographs included in its March report. Copies of these photographs are included in this documentation. During this month, a NARTS engineer was sent to Muzillo Company, a local firm associated with RMI, to assist in the design and formulation of specifications for the high-pressure tankage and piping. NARTS continued to design the instrument racks, began fabrication of the pressure regulators, and placed orders for last-minute instruments (NARTS 1952: Monthly Progress Report for March).

By April 1952, the overall completion rate of the test stand was estimated at 22 percent. In that month, 68 tons of cast-iron pipe was received, presumably for the water and sewage system. As NARTS continued in its fabrication work related to instrumentation in April, the final completion date was moved to August 30, 1952 with three additional months required for the installation and testing of equipment (NARTS 1952: Monthly Progress Report for April, Quarterly Report dated April).

By May, the Control House and test stand were easily identifiable in site photographs (NARTS 1952: Monthly Progress Report for May). Copies of these photographs are included in this documentation. In June construction of the test stand continued with overall project completion estimated as 45 percent. In an effort to bolster spirits, the report noted that it was "encouraging to note that all heavy structural steel [had] been delivered to the site" (NARTS 1952: Monthly Progress Report for June, p. 7).

As July progressed, the two 25-bottle trailers for the oxygen cascade were received from the Charleston Navy Yard, South Carolina, and were installed. The Control Room of the Control House was completed and ready for instrument installation. NARTS had assembled a preliminary specification list for the engine mount in the test stand and was in the process of reviewing it so that a request for bids on design, fabrication, installation, and testing could be let (NARTS 1952: Monthly Progress Report for July). Photographs in the July report illustrated that all the structural steel was in place. Copies of these photographs are included in this documentation.

Despite a target date of August 30 for project completion and site turnover to RMI, the August progress report noted that the construction of the test stand was still continuing. The target date for completion passed unmet. By then, the instrumentation in the Control Room was still being installed. By August, NARTS had completed the design specifications for the rocket-mount assembly and the specifications were let out for bid to seven firms.

The seven firms were not noted in the documentation. The mount was designed to adapt the RMI engine to the E-1 trunnions (NARTS 1952: Monthly Progress Report for August).

As construction stretched into the autumn of 1952, the wiring of the Control Room continued through September and the test stand began to resemble its final configuration. Of the seven firms that had been asked to bid the motor assembly, three declined the request. NARTS had already received one bid and believed it would get three more. During September, the final completion date was set at February 1, 1953 as a result of problems encountered in the high-pressure fuel and water tanks (NARTS 1952: Monthly Progress Report for September, Quarterly Report dated September).

In October the rocket-motor mount job was awarded to Vimalert Company, Newark, New Jersey. Vimalert's bid was $26,000 and included the design, fabrication, installation, and testing of the mount. The bid was based on NARTS' preliminary mount design work. The scheduled completion date of the mount was estimated to be January 31, 1953. The October photographs show the test stand partially clad in its metal blow-off panels; grading equipment was still visible (NARTS 1952: Monthly Progress Report for October). Copies of these photographs are included in this documentation.

The November report noted that the construction of the stand was "virtually complete" (NARTS 1952: Monthly Progress Report for November), with only the electrical piping, tank and hardware installation remaining to be completed by the contractor. As Vimalert proceeded on the mount design, procurement of the steel for the mount had begun. Even as the stand neared completion, NARTS was still making design changes. It was decided that the water nozzle used to cool engine blasts should be an exhaust jet water cooling nozzle and NARTS began the process of designing it (NARTS 1952: Monthly Progress Report for November).

As December waned, Vimalert's mount design was approved for fabrication with an installation date set for January 5, 1953. Because of the nature of the mount, Vimalert believed that a special test floor should be installed directly beneath the thrust mount. The new floor, which was one foot lower than the old one, allowed for the clearance of the rocket nozzle. This new floor was actually a set of double doors that would be opened immediately before test firings. The doors were actuated by geared down electric motors hung below stationary parts of the floor. Safety latches were added to protect workers from accidentally opening the doors (NARTS 1953: Quarterly Report for January-March). By December, the Control House and Test Stand looked ready for action (NARTS 1952: Monthly Progress Report for December; Quarterly Report for October-December 1952).

As predicted, the actual completion of the test stand was delayed until February as a result of the lag in the delivery of the water and fuel tanks. In January, the Vimalert mount was installed, instrumented and tested with satisfactory results. Vimalert's proposal for the new mount test floor was accepted and the estimated delivery time was 60 days from contract. The floor was described as "being similar to a bomb bay with a 60" [inch] opening to permit vertical firing" (NARTS 1953: Monthly Progress Report for January). For more information on the rocket-test mount please see Supplemental Material.

In February, as wiring and instrumentation continued, the fuel tank for the test stand was delivered and installation began. By March, the water tank still had yet to be delivered, although it was expected daily. Pressure testing for the piping in the fuel room was initiated and all control systems were in the process of being checked. The operating floor vendor reported delays in procuring the door actuators and this held up the job. NARTS called the subcontractors of these items in an effort to prod the process along. The delivery date for the floor was estimated for April 30, 1953 (NARTS 1953: Monthly Progress Reports for February and March).

The two remaining major items—the floor and the water tank—were delivered in April. The water tank was installed and piped in. During the latter part of April, the floor was installed and operated satisfactorily. By May 1, the test stand was considered complete enough to turn over to RMI for its instrumentation set-up. NARTS personnel would remain on the job for two to three weeks on a number of minor clean-up jobs (NARTS 1953: Monthly Progress Report for April). With the test stand turned over to RMI, the project was "considered complete" (NARTS 1953: Quarterly Report, dated July) and was no longer discussed in subsequent monthly or quarterly reports.

When completed, Test Stand E-1, the Static Rocket Test Stand, was one of the largest static test stands on the East Coast, and the Control House recorded all information gained from the hot firing of engines in the stand.

7. Alterations and additions: At an unknown date a concrete-block, three-sided room with roof was added to the upper walkway, northwest side of the building toward the north, firing, end of the Test Stand. This shelter, which was apparently added to cover instrumentation, was originally placed on the exterior of the building. Communication among the small room, the Control House, and the Test Stand was accomplished through a telephone connection.

Blueprints do not show any other additions or changes to the Test Stand. However, it is probable that instrumentation was changed during the life of the structure.

B. Historical Context:

1. Introduction: Picatinny Arsenal (referred to as Picatinny) is a government-owned, government-operated facility in the Green Pond Brook valley in the Highlands of northwestern New Jersey. The U.S. Army established the Dover Powder Depot on more than 900 acres in 1880. Originally constructed for storage of powder and other munitions, the Dover Powder Depot became Picatinny Arsenal in 1907 with the construction of the first Army-owned smokeless powder factory. During the twentieth century, Picatinny Arsenal emerged as the leading facility for the research, development, engineering, and production of munitions. The installation was reenvisioned following a catastrophic explosion at the Navy's contiguous Lake Denmark Powder Depot that destroyed much of the Navy's facility. During World War II and the subsequent Cold War, Picatinny continued its leading role in the research, development, and engineering of munitions and weapons systems.

The Lake Denmark Powder Deport was established by the U.S. Navy on February 24, 1891 as its primary powder depot on the East Coast, and was at one time the Navy's largest storage facility. In 1926, as the Navy was building up the depot, lightning struck one of the storage magazines, causing a series of fires and sympathetic explosions that killed 19 people. The explosions sent shock waves through the Green Pond Brook valley, destroying everything within a 3,000' radius of the epicenter and causing great damage beyond the epicenter. The Navy depot, the adjacent Picatinny Arsenal, and many nearby non-military residences were impacted (Rogers 1931:Chapter IX; Fitch and Glover 1990:B/171-174).

The Navy and the Army both investigated the incident and a series of ammunition storage procedures and standards emerged from the findings. New magazine forms were developed—the most notable was the now ubiquitous, earth-covered igloo magazine that was designed to explode up and not out. Both investigations recommended that the Lake Denmark Ammunition Depot and Picatinny Arsenal undergo significant redesign. Between 1927 and 1937 both installations were completely rebuilt.

At the end of World War II, the Navy determined that the ammunition depot was excess to its needs and started to deactivate the facility. At about the same time, the Navy's BuAer decided to establish a centralized, East Coast rocket-engine test center with applications for naval aviation. In 1948, the U.S. Naval Aeronautical Rocket Laboratory (NARL) was established at Lake Denmark. Two years later, the facility was redesignated the Naval Air Rocket Test Station (NARTS), which operated alongside the Navy's commercial partner, Reaction Motors, Incorporated (RMI). The Navy disestablished NARTS in 1960, after less than ten years of service, and transferred all its property, test buildings and structures to Picatinny Arsenal. Although RMI continued to use some of the buildings until 1970, the Army never used the area for it intended purpose.

Picatinny and the Navy Ammunition Depot have long been of historic and architectural interest and since the 1980s numerous architectural surveys have been completed at Picatinny Arsenal (Thurber and Norman 1983; Ashby et al. 1984; Fitch and Glover 1990; Harrell 1993, 1994; Nolte et al. 1999a, 1999b, 2007; Nolte and Steinback 2004, 2007). All of these documents concur that the Control House (Building 3617) and Static Rocket Test Stand (Building 3618), located in NARTS Area E, are eligible for listing in the National Register of Historic Places (NRHP), although the specific justifications for the inclusion vary among the investigator.

Historic American Buildings Survey (HABS)/Historic American Engineering Record (HAER) Level IV Inventory Cards (Ashby et al. 1984) reveal that Buildings 3617 and 3618 were given a priority three rating (e.g., historic properties of *Value* [sic] which contribute to the cultural heritage or visual harmony and interest of the installation and its environs and which should be preserved if possible [U.S. Army Regulation (AR) 420-40 and Technical Manual (TM) 5-801-1]). The cards for both structures noted that the structures "possess significance as part of the post-World War II testing of the X-15 rocket engine" (Ashby et al. 1984).

A draft NRHP nomination form was completed for Picatinny Arsenal ca. 1983 but was never submitted (U.S. Department of the Army ca. 1983). This nomination form divides the installation into a number of historic areas but does not designate the NARTS area as one of them. Further, it states that three buildings within the facility are individually eligible for the National Register, but does not identify them. However, Harrell's 1994 report, which also cites three structures as individually eligible, lists two of them as Buildings 3617 and 3618. It was Harrell's belief that the two buildings needed:

> further research to evaluate the significance of these structures to the development of the X-15 Rocket Engine, and testing of liquid and solid rocket fuels. Buildings 3617 and 3618 may be individually eligible for listing on the National Register of Historic Places under Criterion A, as Cold War or Space Age research facilities, and under Criterion D for their ability to reveal information valuable to understanding development and testing of rocket engines [1994:E-459].

Panamerican Consultants, Inc.'s (Panamerican) reevaluation of more than 500 structures within Picatinny Arsenal in 1997, which included buildings 3617 and 3618, concluded that the entire NARTS Test Area E formed a single district with Buildings 3617 and 3618, which were still surrounded by their original landscape design, as the two most important structures within it (Nolte et al. 1999b:99-119). Nolte et al. (1999b:131) reported that,

> [g]iven the historic importance of Test Area E, … both nationally and regionally, and the information it might potentially supply about the military-industrial complex's role in the early Cold War, the New Jersey HPO [Historic Preservation Office] ruled that this site is eligible for the NRHP and the New Jersey Register of Historic Places as a district under Criteria A and D. Clearly this is a site that illustrates the symbiotic relationship of private industry and government agencies in the creation of the vital military-industrial complex that sent the United States into space.

Despite the two structures' significance, Panamerican was concerned about their apparent poor condition; the structures exhibited much exposed and rusted rebar, significant areas of spalling concrete, and leaking roofs. Because of the buildings' perceived poor condition, Panamerican recommended that a full structural assessment be conducted to determine if they were sound. If buildings are not structurally sound, they have lost integrity and, therefore, are not eligible for listing in the NRHP. Nevertheless, Panamerican believed that the buildings were significant enough to warrant HABS/HAER recordation, even if they were not sound (Nolte and Steinback 1999a:131).

On July 2, 1999, the New Jersey HPO concurred that Test Area E was eligible for listing on the NRHP and the New Jersey Register of Historic Places as a district under Criteria A and D (Guzzo 1999).

2. History: Prior to the Army's and Navy's residency in the area, settlement of the Highlands, including the project area, was associated with the iron industry. Mining is reputed to have occurred at both Mount Hope mine (adjacent to Picatinny) and Dickerson mine (west of Picatinny) as early as 1710, making these sites the oldest iron-mining operations in both New Jersey and the thirteen colonies (Rutsch and van Voorst 1991:13; Rogers 1931:2-3; Fitch and Glover 1990:B/145-146). By 1737, the northern portion of Hunterdon County (which at that time consisted of the present counties of Morris, Warren and Sussex) had an approximate population of 1,750 whites and 70 African slaves (Pitney 1914:4). During the mid-eighteenth century, three forges were established either near or within what would become the Picatinny Arsenal reservation:

- Picatinny Forge, founded about 1749 and called Middle Forge after 1772;
- Mount Pleasant Forge, founded around 1750 and subsequently known as Lower Forge; and
- Burnt Meadow or Denmark Forge, founded in 1750 and known as Upper Forge.

Although there is little agreement about the structures that may have existed at these forges, Halsey inferred that these sites were "bloomary forges," where charcoal, ore, and limestone were shoveled into a furnace to create a "bloom" or semi-molten mass of metal and slag. While still hot, this mass was hammered to remove the slag and produce wrought iron (Halsey 1882:48-56; Rutsch 1999).

An important element to the successful operation of these establishments was that the necessary raw materials—iron ore, limestone, and charcoal—were found easily nearby. Mount Hope and Hibernia mines were located in the hills just east of these forges, while at least two limestone extraction pits were utilized within what is now Picatinny, and several charcoal kilns were adjacent to it (Rogers 1931:7; Fitch and Glover 1990:B-150; Sandy and Rutsch 1992:69; Rutsch et al. 1986:184-186).

The iron industry would expand into the Green Pond Brook valley when Jonathan Osborn (or Osbourne) erected a dam at the southern end of what is now Picatinny Lake and established one of the earliest forges in New Jersey in 1749. Within the boundaries of what is now Picatinny, Osborn's forge was called Picatinny Forge, but later became known as Middle Forge. The forge may have used ores from the nearby Mount Hope mine (Rogers 1931:7; Halsey 1882:41). Establishing his forge at the foot of Picatinny Peak near Green Pond Brook, Osborn created Picatinny Lake by damming the brook for his forge. Machinery and other implements from Middle Forge are on display at the installation museum (Rogers 1931:6; Myers 1984:7).

The following year (1750), Colonel Jacob Ford, Sr., who had purchased Mount Hope mine about the same time, established a forge at Mount Pleasant. Since this forge was south of Osborn's forge, it was sometimes referred to as the Lower Forge. In order to erect another forge. Ford, a leader in the colonial iron-working industry in New Jersey, constructed a dam on Burnt Meadow Brook in 1750, creating Lake Denmark in the process. Subsequently located near the southern end of Lake Denmark, this forge is referred to as the Upper Forge, or, later, as John Harriman's Iron Works or Burnt Meadow Forge. Jacob Ford, Jr., who would continue the family business of owning numerous iron operations in the Green Pond Brook valley, reacquired Middle Forge in 1772 (Fitch and Glover 1990:B-146; Rogers 1931:6-7; Halsey 1882:41).

Known as the Denmark Tract, Jacob Ford, Jr.'s tract contained approximately 6,231 acres and was located west of Mount Hope and east of Green Pond Mountain (or in the middle of the Green Pond Brook valley). Sources reported that the property was "returned to Courtland Skinner and John Johnson" on June 21, 1774 (Halsey 1882:334; Rogers 1931:5). Skinner and Johnson appeared to have purchased this tract for Ford, Jr. (Sandy and Rutsch 1992:43). The substantial tract included Mount Pleasant, Washington Forge, the Spicer properties, Middle Forge and Denmark lands, and portions of it remained in the Ford family until 1806, when it was purchased by Benjamin Holloway, who rebuilt the abandoned forge.

Ironmaster John Jacob Faesch, a Swiss, formerly employed by the American Iron Company (also known as the London Company), began to dominate the valley's iron industry. Southeast of the future arsenal near the village of Dover, he established the Mount Hope Furnace in 1772. Also in 1772, Faesch purchased a large tract of land in the Green Pond Brook valley. After demolishing two standing mills (a gristmill and a hemp mill) to construct the Mount Hope furnace on the best location for waterpower, Faesch increased his holdings by renting contiguous properties from Jacob Ford, Jr. He purchased Middle Forge from the Ford heirs in 1778 as well as over 1,900 acres of forested land adjacent to his forges. Faesch, like the Fords, acquired other forges in the Green Pond Brook valley as well as the Mount Hope mine. Moreover, he operated his forges, including Middle Forge, in conjunction with Mount Hope mine until his death in 1799 (Rutsch et al. 1986:46-49; Fitch and Glover 1990:B-146, B-150; Rogers 1931:7; Halsey 1882:41, 53). The historical records are unclear regarding the relationship between Ford's Denmark Tract and Faesch's tract, which, upon initial review, seems either to overlap or to be contiguous.

Faesch's various iron works played an important role in the Revolutionary War by providing the Continental Army with iron materiel, such as "cannon, shot, bar iron, shovels, axes and other iron implements" (Myers 1984:7). George Washington visited the ironworks at Mount Hope, and approved the transfer of a number of Hessian prisoners to Faesch in order to work at the facilities (Myers 1984:7; Fitch and Glover 1990:B-150; Rogers 1931:5; Rutsch et al. 1986:48). Within Picatinny's boundaries, the Walton Family Cemetery (known alternatively as the Walton Burial Ground or the Hessian Cemetery) lies near Picatinny's Mount Hope Gate and is reputed to contain graves of several of the Hessian prisoners. Since most of the graves in the cemetery are marked with fieldstones, following early custom, the Hessian connection is extrapolated from prisoner work at the local forge and those Hessians who remained in the area after the war. It is further alleged that three other Revolutionary War veterans, besides Peter Doland, are buried there, as well as a possible Civil War veteran, whose grave is unknown (U.S. Army Armament Research, Development, and Engineering Center [ARDEC] Historical Office nd:Item 19; Rutsch et al. 1986:55).

During the nineteenth century, the vicissitudes of the iron industry resulted in valley land changing hands often as the fires of forges burned less and less brightly (Sandy and Rutsch 1992:46-51; Halsey 1882:45, 334; Fitch and Glover 1990:B-150, B-154; Rogers 1931:5-6: Rutsch et al. 1986:59). Despite a depletion of forest timber (and subsequently charcoal), which began in the 1820s and contributed to the volatility of early nineteenth-century iron markets, Middle and Upper Forges continued to operate until the 1850s. Other factors reflecting the general volatility of the industry included frequent ownership changes and a continuous pattern of forge shutdowns and start-ups. On the other hand, providing new blood to the region's sclerotic economy, the Morris Canal was built between 1825 and 1831. Passing just south of Picatinny through Rockaway and Dover, the canal connected Jersey City on the Hudson River to Phillipsburg on the Delaware River by 1865. Constructed to carry cheap coal from Pennsylvania to the industrial centers developing along the New Jersey coast, the canal also provided coal to fuel the iron forges and furnaces in the Highlands, replacing the depleted timber supply. While anthracite coal traveled east, ore from the New Jersey Highlands was shipped westward in great quantities to newer furnaces constructed in Pennsylvania near the Delaware River (Rutsch et al. 1986:65-66; Halsey 1882:68-69; Fitch and Glover 1990:B/150-151).

By 1882, Denmark Forge was no longer in operation and was followed into inactivity five years later by the Denmark mine (Sandy and Rutsch 1992:53). As the profitability of the iron industry declined after 1880, the population of the region declined in tandem, to a low of 2,423 in 1940 (Rutsch et al. 1986:27-29, 35). By the beginning of the twentieth century, only 20 iron mines in the Highlands were in operation, including the Mount Hope mine, which had passed to the control of the Empire Steel & Iron Company. The decline of the iron industry continued through the twentieth century, and resulted in a continual ebbing of the region's population over the next forty years (Fitch and Glover 1990:B-155; Sandy and Rutsch 1992:37). While the Highlands' lakes continued to be popular as resorts and vacation spots, the area around Picatinny Arsenal became attractive to suburban development with improvements in the automobile and the region's transportation infrastructure. Population surged following World War II with the construction of Interstate routes 80 and 287, the development of suburban residential communities and ancillary commercial construction (Fitch and Glover 1990:B-155; Rutsch 1999).

***Picatinny Arsenal/Lake Denmark Powder Depot*.** Picatinny Arsenal was established on September 6, 1880 as the Dover Powder Depot under the command of Major Francis H. Parker of the Ordnance Department. Picatinny's initial purpose was the storage of "powder, projectiles, and explosives, both for reserve supply and for issue; also for the preparation and issue of these stores" (Rogers 1931:53). A board of Ordnance Department officers chose the Green Pond Brook valley near Dover as the site of the depot based on several criteria: the site had to be a sparsely populated region near New York City, capable of storing a large amount of powder, and accessible by train. Between 1880 and 1881, the government acquired 1,866.12 acres from various owners for a total of $62,750, or about $34 per acre. After Major Parker requested that the installation's name be changed, the new depot became Picatinny Powder Depot on September 10, 1880, with construction beginning six days later (Fitch and Glover 1990:B-160; Rogers 1931:10-11).

Between 1880 and 1890, construction activities focused on the erection of storage magazines, officer's quarters, and service facilities. The first powder-storage magazine was completed in 1881 with the storage capacity of 10,000 pounds of black powder. With four powder magazines completed by November 1886, the depot received its first shipment of powder (300,000 pounds) for storage later that month. To facilitate access to the installation and the general shipment of freight, the Morris County Railroad began building a rail line through the depot in 1886. In 1887, 23½ miles of track traversed the powder depot and connected it to the Delaware, Lackawanna & Western Railroad and the Dover Central Railroad of New Jersey at Wharton. A privately owned line called the Northern & Wharton Railroad also ran through the depot and maintained five associated stations. Seventy men were employed at the depot and 900,000 pounds of powder were stored at the facility by that time. From 1893 until 1907, the facility was known as the United States Powder Depot (Fitch and Glover 1990:B/164-166; Rogers 1931:53-54, 71; Rutsch 1999:19-21).

In June 1891, 315 acres of Picatinny Powder Depot land near Lake Denmark were ceded to the United States Navy for the establishment of a Navy powder depot. (This area is now part of Picatinny.) After vacating its powder magazine on Ellis Island in New York harbor, the Navy utilized the Lake Denmark facility as its primary depot on the East Coast. Storing powder, ammunition, high explosives, and artillery shells, the Lake Denmark Powder Depot was enlarged when the Navy acquired more than 146 additional acres in two purchases in 1902. By 1892, a shell house, a storage magazine and three residential structures were completed (Rogers 1931:29-31; Fitch and Glover 1990:B/166-168; Harrell 1994:6).

Historical development within Picatinny has been concentrated in the areas south and east of Picatinny Lake, which included most of the areas initially purchased by the federal government in 1880-1881 (Rogers 1931: 58-61, 77; Harrell 1994). Construction phases at the post dovetailed with the installation's manufacturing activities and changes in its mission over time. The initial phase of development covered the depot/storage period from 1880 until 1907. The depot's first phase of operation involved powder storage and increasing involvement in the assembly of cannon charges. In 1897, workers at the depot assembled powder charges that included manufacturing and filling the storage bags. Between 1902 and 1906 armor-piercing shells were assembled at the depot, where projectiles were filled with explosives, such as Maximite and Explosive "D" (Rogers 1931:54; Fitch and Glover 1990:B-168; Harrell 1994:6).

A major change in the installation's mission occurred in 1907 with the construction of the first Army-owned smokeless powder factory. This activity resulted in the redesignation of the depot as Picatinny Arsenal, and marked the beginning of the Picatinny's important manufacturing phase, which continued until the early years of World War II. Manufacturing increased gradually in the years before World War I as Congress approved continual expansion of the arsenal's production facilities. Picatinny maintained sole responsibility for the assembly of fixed ammunition over .50-caliber by 1909. By 1913, the arsenal was operating a plant for the manufacture of Explosive "D," which was used in armor-piercing projectiles. An Officer's Training School was established in late 1911 to provide training in chemistry, explosives and ballistics, as well as ammunition manufacturing processes. When the United States entered World War I, Picatinny Arsenal saw a rapid development of its physical plant both around Picatinny Lake and Lake Denmark to meet the exigencies of preparing for war and to accentuate its storage capabilities. During this time, the development of the arsenal as a research and administrative installation also began as the Picatinny personnel provided technical assistance to the private sector producing explosives for the war effort. During the 1920s, munitions experimentation and training had replaced powder production as the arsenal's mission, foreshadowing the later expansion of the facility into a complete ammunition arsenal (Rogers 1931:54-56; Kaye 1978; Fitch and Glover 1990:B/168-170; Harrell 1994:7).

While the Ordnance Department was transforming Picatinny Arsenal into a center for explosives research and development through an extensive renovation and construction program, the Navy was constructing additional powder-storage magazines at its Lake Denmark installation. On Saturday afternoon, July 10, 1926, lightning struck the 461-acre Lake Denmark Powder Depot, causing a series of fires and sympathetic explosions throughout the southwest end of the depot. These explosions killed 19 people, including eleven Marines fighting the fires, and sent shock waves throughout the Green Pond Brook valley, destroying everything within a 3,000' radius of the epicenter. Beyond this radius many structures were severely damaged, both within the Navy depot and the adjacent arsenal as well as among the nearby non-military residences (Rogers 1931:Chapter IX; Fitch and Glover 1990:B/171-174).

Once the fires were extinguished, the Navy appointed a Court of Inquiry to investigate the incident. The results of the investigation led to changes in safety and ammunition-storage procedures and standards. Since Picatinny stored material similar to that stored by the Navy at Lake Denmark and had been damaged by the explosions, a board of Army officers also investigated the incident. This commission recommended that Picatinny Arsenal not only be reconstructed but also enlarged for the purpose of consolidating the Army's ordnance activities in northern New Jersey. Devised with the safe handling of explosives as a top priority, plans for rebuilding the arsenal called for the division of the arsenal into zones based on the function or activity occurring in that zone (Rogers 1931:94-96; Fitch and Glover 1990:B/174-176). These functional zones were:

- powder and explosives production and handling;
- powder and explosives storage;
- powder and explosives testing; and,
- non-hazardous manufacturing and offices for administration and research (Rogers 1931:94).

Between 1927 and 1937 both the Navy Ammunition Depot and Picatinny Arsenal were completely rebuilt. With rehabilitation nearly complete in 1931, Picatinny became not only the major ammunition arsenal of the U.S. Army, but was an important center of ammunition research, development, and manufacturing, which included operation of experimental and production plants for the development of a range of propellants and explosives. By the time of the entry of the United States into World War II, the arsenal contained 567 buildings and was producing smokeless powder, high explosives, fuzes and primers, assembled rounds of artillery ammunition, bombs and grenades, and pyrotechnics (e.g., airplane flares and signal smokes), all at experimental or peace-time levels (Thurber and Norman 1983:28-29; Fitch and Glover 1990:B/177-180; Harrell 1994). In addition, the arsenal was responsible for the standardization of new designs for artillery fuzes and for the development of nose and tail-bomb fuzes. Arsenal personnel also improved the design of artillery primers, trench mortars and rounds of chemical and tracer ammunition. The Research and Chemical Branch developed fuze powders, primer mixtures, pyrotechnic compositions, propellant compositions, and new high explosives. Picatinny's mission also called for the development of new munitions designs utilizing the latest technology and, in the event of a national emergency, to provide private industry with production plans and testing. For example, during the 1930s, researchers at DuPont and Picatinny developed flashless, non-hygroscopic (i.e., non-water absorbent) powders or FNH. DuPont developed M1 powder, and Picatinny developed M3 powder, both of which were tested for composition and specific weapons at the arsenal (Thurber and Norman 1983:29; Green et al. 1990; Kaye 1978).

During World War II, many important advances, new products or simplified methods of production were made at the arsenal in its newly constructed laboratories and testing facilities. As the importance of Picatinny's research and development (R&D) activities grew, more emphasis was placed on this R&D function, which it would retain after the war. In one year the job-training methods, research projects, and improved work developments originating at Picatinny and passed along to other plants saved the United States more than $30 million (Kaye 1978). While expanding production capabilities to meet the munitions requirements of fighting a two-front war, the arsenal continued to conduct research on tetryl manufacturing and nitrocellulose powder. It also provided explosives and powder production training to both civilian and military personnel.

The responsibility of the Mechanical Branch of the Technical Division was the development and design of ammunition and special bombs for specific jobs. During the war, a number of special components were designed and tested at Picatinny, including both aboveground and long-delay bomb fuzes. In addition, the Mechanical Branch created pyrotechnic devices, such as flares and signals (Thurber and Norman 1983:32-33; Kaye 1978; Fitch and Glover 1990:B/179-183). One of the most important bombs developed for a particular need was created to blow up the Ploesti oil fields in Romania, a vital source of oil for Nazi forces. The bombs created by Picatinny for this mission obliterated the Ploesti installations (Kaye 1978).

In addition to the development and evaluation of new explosives, the Chemical Engineering Section, part of the Technical Division, was responsible for improvements in the performance of regularly used, standard military explosives. The invention of Haleite, named for Dr. George C. Hale, chief chemist at Picatinny, is regarded as its most significant accomplishment. Although just entering production at the end of the war, Haleite (ethylenedinitramine or EDNA) could be press-loaded into small shells without a desensitizing agent and its derivative, ednatol, could be melt-loaded into large shells. Manufacturing problems, however, prevented Haleite from being used in combat (Green et al. 1990; Thurber and Norman 1983:33). During research subsequent to the development of Haleite, Picatinny's chemists created another explosive, PTX-2 (Picatinny Ternary Explosive), a combination of PETN (pentaerythritol tetranitrate), RDX ("Research Department Explosive"), and TNT (trinitrotoluene). Preliminary firings at the arsenal revealed that it was adaptable to shaped-charged ammunition, although by the end of the war PTX-2 was still in the testing stage (Green et al. 1990).

During the war, Lake Denmark Ammunition Depot continued to operate as the Navy's propellant and projectile storage area (Fitch and Glover 1990: B/179-183). Several sources suggested that the 3400 Area of the Lake Denmark Depot was built to house prisoners-of-war, but no evidence has been located to document whether POWs were ever held there (Thurber and Norman 1983; Fitch and Glover 1990:B-183) and it appears likely that no POWs were ever held there.

The post-war years were marked by both the Cold War with the Soviet Union and hot wars in Asia and the Middle East. During this period, Picatinny continued as a center for R&D for new weapons systems and advances in production processes. Innovations in these areas and the development of new materials had occurred consistently at the arsenal over its history. These types of innovations increased after the war and included the development of photoflash cartridges and bombs, the study of plastics and adhesives in the packaging of ammunition, the research on warheads for the NIKE, HONEST JOHN, SERGEANT, and other nuclear and conventional missile programs, and the production of a tank-piercing rocket for the 3.5-inch bazooka, and an atomic shell for the 250-millimeter (mm) gun (Fitch and Glover 1990:B/182-184; Gaither 1997:94, 102).

After World War II, the Navy's BuAer decided to establish a rocket-engine test center on the East Coast, and initiated modifications to the existing facilities at Lake Denmark. On July 1, 1948, NARL was established there. Less than two years later, the Naval Ammunition Depot was officially disestablished, and the NARL was redesignated the NARTS on April 1, 1950. All physical facilities of the former Lake Denmark depot were made a part of NARTS. As it evolved, NARTS had three major work categories: qualification tests, preliminary investigations, and technical services; all of which were included in its mission “to test, evaluate and conduct studies pertaining to rocket engines, their components and propellants” as assigned by the Chief of Naval Operations (U.S. Department of the Navy 1997a, 1997b; Nolte et al. 1999c).

The history of NARTS is intimately associated with the history of Reaction Motors, Inc. (RMI). RMI was formed in 1941 and was the first enterprise devoted to the commercialization of the rocket engine (Shesta 1978; Nolte et al. 1999c). By the middle of 1946, all of RMI’s activities had been transferred to Lake Denmark, where a construction program for rocket test stands was underway. By 1958, RMI and Thiokol Chemical Corporation merged and RMI became a division within the company (RMD). In 1956, RMI was awarded the contract to develop the XLR-99 liquid rocket engine for eventual use in the X-15. The initial testing, including test firings, of that engine was conducted at Lake Denmark, much to the displeasure of the local residents. In 1960, the Navy decommissioned NARTS and the facilities became part of Picatinny Arsenal under the Ammunition Development Division of the Ammunition group at Picatinny. Renamed the Liquid Rocket Propulsion Laboratory, the entire facility was leased almost immediately to the Thiokol Chemical Corporation, RMD. As a result of changes in the rocket industry during the 1960s, RMD at Lake Denmark was shutdown by 1972. The rocket test areas of the Lake Denmark site were abandoned to the Army and have been largely unused since, except as backdrops for training exercises or as spaces for other types of activities (Shesta 1978; Nolte et al. 1999c; U.S. Department of the Navy 1997c).

By 1977, most production of weapons and ammunition had ceased at the arsenal and its activities focused on R&D. At that time the Army established the U.S. Army Armament Research and Development Command (ARRADCOM), headquartered at Picatinny, to be responsible for developing new and improving old weapons and munitions. In 1983, ARRADCOM was disestablished and its mission was transferred to the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island Arsenal, Illinois. The munitions and weapons R&D activities remaining at Picatinny were renamed the U.S. Army Armament Research and Development Center

(ARDC). In 1986, ARDC was renamed the U.S. Army Armament Research, Development, and Engineering Center (ARDEC) with its headquarters at Picatinny. ARDEC was transferred from AMCCOM to the U.S. Army Tank-Automotive and Armaments Command (TACOM) in 1994. Representing the technical expertise of the U.S. government in guns and ammunition of all sizes, from pistols to howitzers, ARDEC played an essential role in developing items and technologies as diverse as warheads, gun fire control, mines, and smart ammunition, among other responsibilities (ARDEC 1995). In the mid-1990s, over 1,000 buildings were spread out over Picatinny's nearly 6,500 acres, making Picatinny "the largest Army installation devoted solely to research and development" (STV/Lyon Associates, Inc. 1994). In 2003, ARDEC was transferred from TACOM to the U.S. Army Research, Development and Engineering Command (RDECOM). As the Army's "Center of Lethality," ARDEC at Picatinny is "the Army's principal researcher, developer and sustainer of current and future armament and munitions systems" (ARDEC 2008).

In October 2006, Picatinny was recognized by the American Institute of Aeronautics and Astronautics (AIAA) for its "vast work done with rockets and propulsion during the arsenal's history" and designated as an historic aerospace site (AIAA 2006; Picatinny 2006). A small park area in front of Buildings 1 and 94 recognizes this designation with a plaque that reads:

A GATEWAY TO SPACE
At Picatinny Arsenal's Lake Denmark Area, Reaction Motors Inc.
Produced and Tested the XLR-11 Rocket Engine that Powered
Capt. Chuck Yeager's Supersonic Flight In The Bell X-1 Airplane
on 14 Oct. 1947.
XLR-11's Powered The First 24 Flights of the Record Setting X-15
Rocket Plane and a Family of Lifting Bodies Whose Flight Data
Influenced The Design of The Space Shuttle and Provided a
"Gateway To Space."

Picatinny joins other prestigious sites such as Auburn, Massachusetts (the site of Robert Goddard's first liquid rocket launch), the Boeing Red Barn in Seattle, and Farnborough, England (the site of the Royal Aircraft Research Establishment). These early rocketry sites are quickly disappearing thereby making their identification and designation more difficult. On the occasion of the designation, AIAA Region I Director Thomas Milnes commented,

> Our recent technological heritage is more difficult to acknowledge, mainly because so many advancements have happened so quickly that it is hard to gain the perspective needed to judge a site's historic impact. Because of this difficulty, many sites that have helped define aerospace in the 20th century have been lost. Luckily, Picatinny Arsenal still exists [Picatinny 2006].

3. Naval Air Rocket Test Station (NARTS): Although Picatinny Arsenal had a long history of conducting cutting-edge military R&D projects, its sister installation, Lake Denmark Naval Ammunition Depot (NAD), had served the Navy simply as a storage facility since its inception on February 24, 1891. While the pace of its activities ebbed and flowed with peace and war, NAD was never involved in any special research until after World War II, when the Department of the Navy decided to locate a rocket-testing facility at its extreme northeastern corner not far from Lake Denmark. The research and testing carried out in this small area would in many ways rival the best work ever done at Picatinny (Durant 1951:76; Baranowski 1959). Every architectural study completed at Picatinny has highlighted this area as significant (Thurber and Norman 1983; Ashby et al. 1984; Fitch and Glover 1990; and Harrell 1993, 1994; Nolte et al. 1999b).

At the end of World War II, the Department of the Navy Bureau of Ordnance (BuOrd) determined that Lake Denmark NAD, at one time the Navy's largest storage depot, was excess for then-current needs, and started to deactivate the facility. However, the BuAer recognized the opportunity to establish a centralized, East Coast rocket-engine test center with applications for naval aviation, and initiated steps to receive management control of NAD. After modifications to existing facilities, the U.S. NARL was established at Lake Denmark on July 1, 1948 with functions similar to those at the Air Force Rocket Test Facility at Muroc, California (later, Edwards Air Force Base). The Officer-in-Charge (OIC) of NARL reported to the Commanding Officer of NAD for command and BuAer for management. Its mission was the "evaluation and development of rocket engines and their components" (NARTS 1950: Progress Report for January; Baranowski 1959). The first (and only) OIC of NARL was Commander Dayton A. Seiler, who served from July 12, 1948 to April 1, 1950.

Lake Denmark was selected as the site for the laboratory because the depot met the necessary criteria for a successful testing facility. The Navy had occupied the site since the 1890s (as an ordnance depot) and had already invested in the facility's infrastructure for such items as roads, utilities, barracks, and potentially convertible warehouses. Lake Denmark was located in a fairly isolated area, but had excellent transportation connections up and down the East Coast. The depot was situated in a highly industrialized portion of the country that made the hiring of specialized personnel and the procurement of materials easier. Empty buildings could be easily adapted to rocket-testing functions, and the Navy had already leased a number of them to Reaction Motors, Inc., the pioneer firm for the commercialization of rockets. Moreover, propellant storage facilities, high pressure inert gas storage, and test stands had been constructed by the Navy for RMI. The site was close enough to Washington, D.C., for liaison with the Bureau of Naval Weapons (BuWeps) and the newly organized Department of Defense (DoD), as well as other East Coast rocket manufacturers (Seiler 1949; NARTS 1950: Project Report for January; Durant 1951:76).

RMI, initially incorporated at Pompton Plains, New Jersey, in December 1941, worked closely with the Navy during the war, but required additional facilities to meet the accelerated demands of post-war jet-engine development. The Navy offered the use of buildings and land formerly associated with the NAD ordnance battalion area for manufacturing shops and offices.

> The RMI administration area at the Naval Ammunition Depot's main gateway features two large buildings where research and development engineers and manufacturers produce rocket engines; in one building the engines are designed and models made; in the other, the approved designs are put in production. Nearby are separate buildings for the administration offices, cafeteria, security section and other facilities. The testing area, gleaming with the huge new power and supply plants, illustrates the rapid growth of [the] organization ... [RMI 1948:2-3].

By the middle of 1946, all of RMI's activities had been transferred to Lake Denmark, where a construction program for rocket test stands was underway (*The RMI Rocket* December 1951).

Scheduled for completion in December 1949, the construction of additional test facilities included one booster test stand of 100,000-lb thrust capacity, and two test stands of 20,000-lb. thrust capacity. Plans for the renovation and expansion of the facility were included in the budget for the following year (Seiler 1949). NARL personnel comprised seven officers, 36 enlisted men, and 123 civilian employees. The earliest projects assigned to NARL, most of which were restricted or confidential, included the development of methods and equipment for testing liquid propellant rocket engines (project no. ARL PP-201); various applications as related to the LARK guided-missile rocket engine (ARL PP-202 and ARL PP-202.1); and the acceptance tests and evaluation of the XLR-18-K-2 booster assembly rocket (ARL PP-203 and ARL PP-203.1) (Seiler 1949; NARTS 1950: Progress Report for January).

In addition to testing and evaluation activities, the Navy found it desirable to actually provide test facilities at NARL for rocket-engine contractors or other governmental agencies with inadequate or insufficient test facilities of their own. This was particularly true for engines with more than 10,000 lbs of thrust. As the thrust capacity of engines grew, the costs of construction for the test stand, tankage, and instrumentation, which were costly to begin with, increased significantly making the creation of large stands cost prohibitive for many companies. In addition, some companies were located so close to general habitation that the firing of very large engines was precluded because they were a public nuisance (Durant 1951).

On April 1, 1950, NAD was officially disestablished and NARL was redesignated NARTS under the command and coordination control of the Commandant, Third Naval District, and management control under BuAer. Its purpose was to test and evaluate rocket engines, components and propellants as well as train service personnel in the handling, servicing and operation of rocket engines. All physical facilities of the former Lake Denmark depot were made a part of NARTS, but as a result of the large amount of ordnance still stored on site, a number of buildings were retained by BuOrd and the facility received the additional task of acting as an ordnance reserve stock point (Baranowski 1959).

In the early 1950s, the Navy undertook an extensive engineering study to create a master plan for the facility. The Navy requested $7,500,000 for the expansion and modernization of the existing test facilities; to purchase more land to better integrate their current holdings; to improve and standardize instrumentation; to provide for an underground propellant storage system; to create more housing; and to outfit specialized shops and laboratories (NARTS 1950: Progress Report for January; Durant 1951). NARTS began an expansion program that included the construction of Test Area E, a site for the testing of rocket engines up to 350,000 lbs thrust, and which undertook a number of important research and design projects (NARTS 1951, 1952: various Monthly Progress Reports).

By 1952, RMI had constructed its main rocket-engine test area at NARTS, operated by permit. The area contained an administration building, and storage buildings, as well as 17 test cells, which had maximum thrust operation ranging from 10,000 to 50,000 lbs. Adjacent to RMI's test area, NARTS maintained four test cells and was planning what would become Test Area E. RMI also owned 237 acres adjacent to NARTS (RMI ca. 1953:15-16). At this time, the Naval installation consisted of 760 acres and represented a multimillion-dollar investment. It was anticipated that the staff would double in the next decade. The facility's earliest work had been devoted primarily to liquid propulsion, but was beginning to include evaluation of rocket engines and rocket systems, development of methods for analyzing rocket propellants, and the collaboration with private industry on a wide range of experiments and safety manuals. All these functions were a part of NARTS' mission as assigned by the Chief of Naval Operations: "to test, evaluate and conduct studies pertaining to rocket engines, their components and propellants" (NARTS ca. 1959a).

As it evolved, NARTS developed three major work categories: qualification tests, preliminary investigations, and technical services, all of which were included in its assigned mission (Durant 1951:76-77; Naval Historical Center 1998; NARTS ca. 1959a). Qualification tests included the actual qualification tests themselves; safety and reliability determinations; evaluations of contractor products, age-test programs; and investigations of performance deficiencies in production items in operational use. In the early 1950s, NARTS completed qualification programs on the engines, and arresting landing and simulated catapulting systems for BULLPUP (engine XLR 58-RM-2) and SPARROW (engine XLR 44-RM-2) as well as the engines on the Air Force SIDEWINDER. NARTS worked on a number of major preliminary investigations including: damage control of propellant oxidizers; a variable thrust engine for spacecraft application; ultra high-density propellant systems; and the investigation of monopropellants as gas generates (NARTS ca. 1959b, ca. 1960).

Technical services were provided by the Rocket Propulsion Laboratory for the BuWeps, other government agencies and private contractors. These services included the development of specifications and procedures for mixed amine fuel (a group of organic compounds of nitrogen that may be considered ammonia derivatives in which one or more of the hydrogen atoms has been replaced by a hydrocarbon radical). In the 1950s, technical services were provided to the Standard Oil Company, Fulton Irgon Corporation, Camin Labs, Aerojet-General, Olin Industries, Phillips

Petroleum, Grand Central Rocket Co., Sperry Gyroscope, and RMI, to name a few (NARTS ca. 1959b, ca. 1960).

The heart of the NARTS organization was the Rocket Propulsion Laboratory. All other departments—Administration, Supply and Fiscal, Public Works, Security, Medical and Industrial Relations—served the needs of the Rocket Propulsion Laboratory. The Laboratory itself was grouped into four divisions: Propellant, Rocket Engine, Engineering Services, and a more loosely organized Project Group. The Propellant Division was responsible for analytical chemistry and propellant evaluation as well as physical chemistry and propellant synthesis. The Rocket Engine Division was responsible for design, creation, instrumentation and testing of rocket engines. The Engineering Services Division was responsible for material control, photography, as well as technical publications and a large library. The Project Group was responsible for following through on new ideas and testing hypotheses (NARTS ca. 1959b).

The military and civilian personnel that staffed NARTS in the mid-1950s held impressive credentials. Dr. John D. Clark, NARTS chief chemist from 1949 to mid-1950s, headed the Propellants Division. Clark, a Stanford Ph.D., was best known for the creation of a new family of monopropellants and for developing a simplified technique for determining theoretical rocket-engine performance as well as the invention of a device for in-field use in the analysis of white fuming nitric acid. The Rocket Engine Division, which encompassed the Design, Shops, Test and Instrumentation branches, was directed by John J. Canavan. The Project Group included Frederick R. Hickerson, the inventor of a unique variable thrust rocket engine. The director of the Station itself was Commander Donald T. Jensen, USN. Jensen, a Naval Academy graduate, had worked on the LARK project. The Station's technical director was Irving Forsten, who had worked with Ranger and Grumman and had served as a research scientist with the National Advisory Committee on Aeronautics (NACA, the predecessor of the National Aeronautics and Space Administration [NASA]) (NARTS ca. 1959a).

The NARTS facilities began as a small liquid propellant test stand, but by the late 1950s the facilities were spread out over more than 700 acres in many buildings, firing bays and other structures. Growth was expected to continue and about 1957 NARTS published a recruitment brochure aimed at luring new college engineering graduates to work at Lake Denmark (NARTS ca. 1957). The amount and types of projects had greatly increased. Liquid and solid rocket engines could now be test fired and analyzed at the facility.

The test facilities were generally grouped into six test areas, two used especially by and for NARTS projects and the others leased to RMI. Test Areas A, B, and C—completed in 1947—and G were leased by RMI. NARTS used Test Areas D and E and sometimes G. Test Area E, completed in 1953, was considered the “elite” among the many facilities at NARTS (NARTS ca. 1959b). It was here that the Navy fired liquid propellant rocket engines with a thrust up to 350,000 lbs. from one of the largest static test stands on the East Coast (NARTS ca. 1959b). Areas R and S, which occupied 263 acres immediately north of the Navy test areas, were owned by RMI but were connected to A, B, C, and E areas by Lake Denmark Road (Redmond 1957).

NARTS and Reaction Motors, Inc. Reaction Motors, Inc. was formed by James H. Wyld, Lovell Lawrence, Jr., John Shesta, and Franklin Pierce, all early members of the American Rocket Society who spent their Sunday afternoons experimenting with rocket engines in the garages of their New Jersey homes. Wyld overcame a major problem of rocket design by developing the first American regeneratively cooled engine, one that cooled its combustion chamber by circulation of its propellants. Wyld’s principle, formulated in 1938, was close to the solution discovered about the same time by German scientists working on the development of the V-2 missile (Ordway and Winter 1983: 542-544; Shesta 1978).

Awareness of German rocket advances led the United States to start a formal rocket research program. Wyld’s new engine was of particular interest to the Navy’s BuAer. After several successful test runs of the Wyld engine—and the bombing of Pearl Harbor—a contract was awarded to a newly formed company named Reaction Motors, Inc. after the motors it was to build (Shesta 1978; Ordway and Winter 1983:542-544).

One week before Christmas 1941, the four founders of RMI pooled their resources and with $5,000 formed the company making it the first enterprise devoted to the commercialization of the rocket engine (Thiokol 1997). The company began working in the basement of Shesta’s house. From there they moved into a small shop in Pompton Plains, New Jersey, where in nine months the company designed and produced ten different types of rocket engines ranging in size from 50 lbs. to 1,000 lbs. of thrust (Shesta 1978; RMI 1957; Winter and Ordway 1982:np).

> By 1946 the local population of Pompton Plains, N.J. had become resentful of the noise made by our rockets, as well as the noxious fumes from our nitric acid motors[,] which we also tested from time to time. We thus moved once more, this time to Lake Denmark, N.J., to the Naval Ammunition Depot. The Navy had some unoccupied buildings there[,] which were made available to us. This move might be looked upon as a milestone in RMI's progress. Almost overnight we had become a large concern—at least in our estimation [Shesta 1978:np].

RMI located their new engine design, model construction and production facilities to the former ordnance battalion area at NAD. Engine testing occurred at a secluded location on a narrow dirt road between Hibernia and NAD. The new RMI site was located "in a natural 'bowl' of surrounding hills insulated by thousands of acres of Government property acquired specifically for ammunition storage and testing [and] provides one of the best areas on the Eastern seaboard for rocket engine testing" (Winter and Ordway 1982). Shortly after the company's relocation, it purchased 237 acres adjacent to the Navy-owned test area. By 1951, the Navy was in the process of planning and designing a new area at the renamed NARTS to test engines with a larger thrust capacity—Test Area E (Winter and Ordway 1982).

In November 1953, Mathieson Chemical Corp purchased a controlling interest in RMI, and merged with Olin Industries, Inc. in May 1954, forming the Olin Mathieson Chemical Corp. By the end of 1954, RMI had sales of $4.7 million and a work backlog of more than $7.5 million (Ordway and Winter 1983:549; Winter and Ordway 1985). By 1957, one year before it merged with Thiokol Chemical Corporation, RMI organized into six divisions—Applications Engineering and Contracts, Project Engineering, Component Development, Production, Finance, and Administration—had sales of about $24.5 million dollars and had 1,639 employees. Quality Control was conducted by a military inspector, while an in-plant BuAer representative served as RMI-DoD liaison (Thiokol 1997; Ordway and Winter 1983:549; RMI 1957). With an interest in Flight Refueling, Inc., RMI had offices in Denville, New Jersey, Washington, D.C., Dayton, Ohio, and Los Angeles, California.

The principal work of RMI was the development and production of solid and liquid propellant rocket powerplant (engine) systems and related components. In addition to the development of specific products, RMI was involved in basic research and state-of-the-art technology work. By 1957, Reaction Motors occupied 350,000 sq.ft. of enclosed space and owned 60 acres for the future expansion of the company. The company had a $4,000,000 plant in Denville, New Jersey, that was one of the most modern and complete rocket facilities in the United States. The 200,000-sq.ft. plant featured administrative offices, research activities and pilot production facilities. It maintained 150,000 sq.ft. of engineering, manufacturing and test facilities at NARTS at Lake Denmark (RMI 1957).

In 1957, RMI's main test area consisted of almost 300 acres (50,000 sq.ft. enclosed) at Lake Denmark just seven miles from its Denville plant. This included 21 test stands for the static hot firing of rocket engines and components; 18 stands with thrust capacities from zero to 20,000 lbs; and three large stands with capacities from 50,000 to 1,000,000 lbs. thrust. Environmental test facilities, instrumentation areas, offices and propellant-handling and storage facilities were also located at Lake Denmark (RMI 1957; Redmond 1957).

The engine test stands could hold complete rocket-engine systems for simulated flight trials. Engine, propellant lines, tanks and any related equipment could be mounted in the precise locations they occupied on a plane or a missile. Following successful trial runs at Lake Denmark, the engines were released for field testing (RMI 1957). State-of-the-art testing facilities included tank rooms, firing rooms, and control rooms, all constructed to permit the visual observation of items under test. The instrumentation areas used the highest standards for quality and accuracy in the industry. Equipment could measure for pressure, flow, force, temperature, linear and angular displacement, and acceleration in the form of vibration. A rapid tape-recording and playback system facilitated the analysis and evaluation of data (RMI 1957). The activities of RMI dovetailed with the mission of NARTS, which as stated in December 1956 was to "conduct tests and evaluation of rocket engines, their components and propellants," performed in support of technical research and development for BuAer (NARTS 1956). NARTS still served as a technical ordnance reserve stock point, an assignment, the document noted, not devoted to its R&D mission (NARTS 1956).

On April 30, 1958, RMI and Thiokol Chemical Corporation merged and RMI became a division within the company (Reaction Motors Division [RMD]). Thiokol had its beginning in 1926, when a serendipitous laboratory experiment formulated the world's first synthetic rubber. Three years later, in 1929, the Thiokol Chemical Corporation was formally created, taking its name from the Greek words for sulfur and glue, the products used to create synthetic rubber. The liquid polymer rubber was used extensively as an indestructible sealant for gun turrets, fuel tanks, and seams of all kinds. Scientists at Cal Tech's Jet Propulsion Laboratory discovered that Thiokol's polymer sealant made the best solid propellant fuel binder available at the time. Thiokol was suddenly in the rocket business (Thiokol 1997; Winter and Ordway 1982).

Thiokol opened its first small-scale rocket operations in Elkton, Maryland, and, by 1950, had facilities at the U.S. Army's Redstone Arsenal, Huntsville, Alabama, in the old Redstone Ordnance Plant's production lines. In 1952, it won a contract to refurbish and operate the Longhorn Army Ammunition Plant in Marshall, Texas. By 1958, Thiokol had a contract with the U.S. Air Force to build the first stage rocket motor for the revolutionary Minuteman intercontinental ballistic missile (ICBM) at their Brigham City, Utah, rocket motor plant (Thiokol 1997).

On October 14, 1947, Chuck Yeager became the first human to break the sound barrier, flying the Bell X-1, powered by RMI's 6000C-4 engine (also known as the XLR-11 [its U.S. Air Force designation] and "Black Betsy") (Winter 1988:83-84, 1994a). In 1956, RMI was awarded the contract to develop the XLR-99 liquid rocket engine for eventual use in the X-15. Much to the annoyance of local residents, the initial testing, including test firings, of the XLR-99 was conducted at Lake Denmark at NARTS Test Area E, which RMI leased from the Navy (*The Citizen* 1958-1960; NARTS ca. 1959a; Winter 1987:410). Building on the knowledge gained from the development of the XLR-11, the XLR-99 (also known as "the Pioneer") was the most powerful, most complex, and safest man-rated (safe to carry a human), throttle-able rocket propulsion system in the world. The engine would prove exceptionally reliable and extraordinarily safe despite its long development period (Thiokol 1997; Jenkins 1996:9-11, 40-41). The X-15, the experimental hypersonic aircraft, was a joint NACA, Navy, and Air Force project. "The X-15 program contributed significantly to the U.S. manned space program in general, and was the only existing database on winged manned reentry vehicles available when the development of the Space Shuttle was begun in the 1970s" (Jenkins 1996:11).

NARTS and Test Area E. Conceptualized and constructed between 1951 and 1953, Test Area E was considered by the Navy to be its premier rocket-engine testing area. NARTS engineers completely designed the original plan for the test area in consultation with RMI. They drew up the preliminary specifications and maintained an active role during the final architectural detailing and construction. The architectural and engineering firm chosen was Frank Grad & Sons, an old firm with an outstanding reputation from Newark, New Jersey, which also had offices in Washington, D.C. The development of the Test Area E project was considered one of the major accomplishments of the NARTS engineering staff. When the Test Stand was first put into use it was one of the largest static test stands on the East Coast (NARTS ca. 1959b).

In a public relations brochure on NARTS and its facilities, the Navy described Test Area E:

> Static firings can be made at any attitude on Test Stand E-1 with the test engine 'tied' to a mount fastened to trunnions 15 ft apart and located on a cantilevered balcony 60 ft above grade. The engine mount is basically a hollow beam of rectangular cross-section bridging the space between the trunnions. A sliding roof permits vertical erection of missiles up to 90 ft in length.
>
> Two sets of double doors (like a bomb bay) are affixed in the operating floor under the mount. Located under the floor are separate tank rooms for fuel and oxidizer and separate cascade rooms for individual pressurizing of propellants. The liquid oxygen tank capacity is 2500 gal and is rated at 50 psi while the working pressure of the 3000 gal ammonia tank is 225 psi. Also located in the propellant tank room is a 2400 gal water tank, rated at 1500 psi, which is used to cool the engine jacket. Propellants are pressurized by gas stored at 2000-2200 psi. Nitrogen gas is used for pressurizing fuel and cooling water and gaseous oxygen is used for pressurizing the liquid oxygen.
>
> The control room for Test Stand E-1 is located below grade in a concrete building 250 ft away. Instrumentation provides measurement of all the usual rocket engine parameters—pressure, force, flow rate and temperature. The total number of installed recording channels includes 35 potentiometer recorders, eight direct writing Sanborn recorders, and a 2-channel cathode ray oscilloscope. Terminations are also installed in the recording racks for two 18-channel magnetic oscillographic recorders. Thus there are 79 allocated recording channels with 17 spare channels available [NARTS ca. 1959a].

In addition to testing the XLR-99 motor, NARTS compiled an impressive record of notable contributions to rocket engine and propellant R&D. These accomplishments included:

1951-1954	Development of analytical methods for hydrazine, methyl hydrazine, butyl mercaptan and mixed acid
1952	Development of methods for inhibiting corrosion of nitric acid
1953	Design and construction of largest rocket test stand in the East
1954	Discovery of the mechanism of corrosion of stainless steel by nitric acid
1954	First complete qualification test of rocket engine by a government laboratory
1955	Origination of Mollier charts for decomposition of hydrogen peroxide
1955	Developing a shorthand method for rocket propellant performance calculation [NARTS ca. 1957].

The brochure advertising these accomplishments quickly added that these were just the achievements “that can be named” publicly (NARTS ca. 1957). Further research might uncover a host of then-classified NARTS achievements.

Despite the success of RMI/RMD and the accomplishments of NARTS, the Naval Air Rocket Test Station, Lake Denmark was disestablished on August 1, 1960, and the facilities reverted to the U.S. Army for incorporation into Picatinny Arsenal. With this new acquisition, Picatinny Arsenal obtained major capabilities in liquid fuel programs and renamed the entire area the Liquid Rocket Propulsion Laboratory (LRPL) (Picatinny Arsenal ca. 1960). Navy liquid propellant development projects were transferred to the Naval Ordnance Test Station, China Lake, California, the Naval Propellant Plant, Indian Head, Maryland, and the Naval Weapons Laboratory, Dahlgren, Virginia (Naval Historical Center 1998). Although the Army had expressed great hopes for the area, the Lake Denmark Test Area was almost immediately leased by Thiokol (Picatinny Arsenal ca. 1960). A *Test Facilities Data Book* prepared by Thiokol (Edson 1962) provides an excellent overview of the facilities at that time. This volume was intended for use by test area operating personnel, engineering and management personnel of RMI, other divisions of Thiokol, and industrial companies interested in using the facilities, and presented an illustration of Test Area E’s layout during the first years of the Army's command over the facility, although the configuration of the structures probably had not changed since the mid-1950s (Edson 1962).

During the mid-to-late 1960s, changes in rocket development, notably switching from liquid to solid propellants, resulted in a decline in business at the Denville plant. Efforts were made to retool and to undertake new, more profitable projects (Walker 1970; Thiokol 1997). RMD's location undermined its ability to attract clients, such as NASA, which sought to build larger and more powerful rocket engines. Although the Lake Denmark area was secluded in 1949, population trends of the period (i.e., suburban sprawl) less than ten years later produced the same problems for RMD that afflicted RMI at Pompton Plains during World War II: complaints from area residents about noise and damage from shock waves. Moreover, the New Jersey State Supreme Court ruled that Thiokol Chemical Corporation, as RMD's parent, was liable for property damage caused by testing the X-15 engine (Winter 1987:415). The company that began by developing Jet-Assisted Take-Off (JATO) engines; motors for America's first missiles (the LARK and GORGON); and engines or propulsion systems for the VIKING rocket, the Bell X-1, the MX-774, the Republic XF-91, the Rocket-on-Rotor (ROR) for the HRS-2 helicopter, the North American X-15, the BULLPUP, CORVUS and CONDOR missiles, and the Surveyor spacecraft control system, discontinued work in the liquid propulsion field by 1970 and ceased operations less than two years later (Shesta 1978; Ordway 1985, 1987). The rocket test areas of the Lake Denmark site were abandoned to the Army and have only recently been used for various Army activities not related to rockets or rocket-engine testing.

4. NARTS Area E Historic District: The NARTS Area E Historic District was determined eligible for the NRHP in 1999 under Criteria A, contributing to the broad patterns of history, and Criteria D, providing information about a little known or understood period of history (Guzzo 1999). This site illustrates the symbiotic relationship between private industry and government agencies in the creation of the vital military-industrial complex that propelled the United States into space. The NARTS Area E Historic District's period of significance is the Cold War (1946-1989), in this case, the height of the Cold War, 1950-1969.

The buildings that contribute to the district are listed below.

3617 (1953) Control House

3618 (1953)	Static Rocket Test Stand, Test Stand E-1 including firing pit
3619 (1953)	Liquid Oxygen (LOX) pad; erroneously assigned a separate number, it is part of 3618

Road network
Retaining walls
Visual aspects of drainage, ventilation and access structures within the landscape

Buildings that are noncontributing to the district are:

3622 (ca. 1960)	Water Tower
3623 (ca. 1960)	Water Tower Support Building
3625 (ca. 1960)	Maintenance Building, Test Stand E-1A
3627 (ca. 1960)	Control Room
E-1D (ca. 1960)	Control Room, gun turret.

NARTS Area E is located off Picatinny proper in the Snake Hill Road area of the former Naval Ammunition Depot. A map of NARTS Area E Historic District is included as part of this documentation. Test Area E occupies 14 acres on a precipitous slope that was used to advantage in the construction of Buildings 3617 and 3618. In addition to its two major buildings—3617 (Control House), and 3618 (Static Rocket Test Stand)—the area also includes the remnants of Building 3619, the LOX tank pad and remaining tank supports at the foot of the bridge portion of Building 3618; Buildings 3622 and 3623, a 400,000-gal Water Tower and attached Support Building; Building 3625, Maintenance Building; Building 3627, Control Room/Support Building; and Building E-1D, Control Room, made from an old Navy gun turret. The area is accessed by E Road, an asphalt road off of Snake Hill Road that climbs the slope and circles around the rear, south, of the Rocket Test Stand, passing under the bridge that extends from the LOX pad to the rear entry of the Test Stand. In addition to the road, other landscape features that comprise the district include: the Test Stand firing pit; Buildings 3619 and 3625; rock and concrete retaining walls; and a number of concrete drains and earth-fast ventilation shafts. The entire area is enclosed in a chain-link fence that is now secured with a padlock. The chain-link fence forms the boundary of the district.

Original blueprints of the NARTS Area E show that a spot was initially set aside for a water tank, which was later built and is still extant (Buildings

3622/3623). The water tank was an important addition since large amounts of water were needed to cool the blasts from the engines tested. The three other structures—Building 3625 (Maintenance Building), Building 3627 (Control Room/Support Building) and Building E-1D (Control Room), a former gun turret—were probably constructed in the early 1960s. The reuse of gun turrets was a common practice and several are still in use throughout the installation. The LOX pad was constructed by NARTS at the same time as the Static Rocket Test Stand and served as an auxiliary part of the stand. When the Army absorbed the NARTS facility in 1960, the exact purposes of the specific structures were not known and the connection between the structures was lost to Army administrators. As a result, the LOX area was treated as a separate building and assigned its own number. A similar confusion seems to have applied to Building 3625. The Army identified it as a maintenance facility (Walter 1997b), while RMD of the Thiokol Company referred to the structure as Test Stand E-1A (Edson 1962).

NARTS Area E Historic District is associated with a much larger NARTS complex, frequently called the Lake Denmark Test Area, which is located off Snake Hill Road in the extreme southeastern end of Picatinny. The Lake Denmark Test Area was broken into smaller test area segments called Areas A, B, C, D, E, G and later S and R, all of which were operated by RMI/RMD with the exception of Area D.

NARTS Area D was the exclusive purview of the U.S. Navy's East Coast rocket center. It is here, presumably, that the Navy tested its contractors' work, conducted independent tests, wrote guidelines, and experimented with any number of rocket-related activities such as the decay time for hydrogen peroxide. It was the area where the majority of the NARTS projects were conducted (NARTS 1959a). In connection with Test Area E, the largest static rocket test stand on the East Coast, Area D served as the nerve center for various Navy rocket projects, the most important of which was the testing of the XLR-99 rocket engine, which was conducted with RMD. In 2004, the New Jersey HPO concurred that NARTS Test Area D was eligible for listing to the NRHP as a district under Criteria A, contributing to the broad patterns of history, C, architecture/industrial significance, and D, providing information about a little known or understood period of history through Criteria Consideration G, exceptional importance for a property less than 50 years of age (Nolte and Steinback 2004; Guzzo 2004). NARTS Test Area D is immediately adjacent to, and southeast of NARTS Area E Historic District.

Picatinny's 1500 Area off Lake Denmark Road is northwest of and almost immediately adjacent to (less than 2,000' from) NARTS Area E. The 1500 Area was the U.S. Army's Rocket Test Area. This 20-acre site played a key role in the Army's initial forays into space including the development of some of the most important rocket and missile programs ever devised—HONEST JOHN (the first tactical nuclear missile), REDSTONE, LITTLE JOHN, and NIKE AJAX, to name a few. In 2008, the New Jersey HPO concurred that the Rocket Test Area Historic District was eligible for the NRHP under Criteria A and C, through Criteria Consideration G (Nolte et al. 2007; Nolte and Steinback 2008; Stack 2008). Although the Army's rocket area lies adjacent to the Navy's rocket area, it is not known if the two services collaborated. However, in the early, heady days of rocket work, there were few scientists and engineers with any expertise and it can be assumed that rocket information was shared in some way.

NARTS Area E Historic District is surrounded by other NRHP eligible districts and by work areas that once serviced and tested rockets, missiles and engines. At present, NARTS Area E Historic District, NARTS Area D Historic District, and the Rocket Test Area Historic District all attest to the Lake Denmark area's past as an important rocket center.

5. Static Rocket Engine Test Stand (Building 3618): The Static Rocket Engine Test Stand was built in 1953 as part of a special NARTS facility for the testing of rocket engines with up to 350,000 lbs of thrust and could be modified to test engines up to 1,000,000 lbs thrust. The Test Stand dominates the site. The structure itself has no discernable style or ornamentation. It is a rectangular, steel-framed, reinforced concrete, multilevel structure with a partially retractable metal roof. The building is cantilevered out from a precipitous slope so that a rocket engine can be fired straight down the slope into an excavated pit. The first level of the building houses various liquids, gases, and chemicals used in rocket firing and the second level, the operations floor, which is totally utilitarian, is where the engine is mounted, fueled and fired.

The Static Rocket Engine Test Stand, also known as Test Stand E-1, has only one function, and is designed for only one function, the hot firing (actually firing and running) of large, over 350,000 lbs thrust, rocket engines. When it was completed in 1953, it was the largest all attitude rocket-engine test stand on the East Coast. While the fueling of the engine occurred in the Test Stand and was monitored there, the actual firing, running, abort mission, and all other controlling actions took place in and from the Control House (Building 3617), located approximately 250' northwest across E Road.

During the construction of the Test Stand, 3,830 yards of earth were excavated, 1,500 yards of rock were blasted, 3,230 yards of concrete were poured, and 650 tons of steel were used (Abramson et al. 1953). The Static Rocket Test Stand was in reality a specialized, large, fire-proof holder—for rocket engines. It is utilitarian in the extreme, since there are no bathrooms and no facilities for human comfort at all (e.g., water fountains, office spaces, etc.); all spaces were carefully measured and set aside for one use and that use only. The building was never painted, landscaped in any formal way or given any special (memorial) name.

PART II. ARCHITECTURAL INFORMATION

A. General statement:

1. Architectural Character: The building has no particular architectural style. It is significant instead for the activities it sheltered and the work that it supported in the early days of rocketry, not its look or style.

2. Condition of fabric: Poor. The building has been empty since the early 1970s and has had no real caretaker. The concrete is spalling and crumbling, plant life has metastasized in every crevice and crack, and numerous doors stand open or are broken. Portions of the fixed roof and the retractable roof have rusted through in places, which allows precipitation, dirt, and other debris to collect on the Operations Floor. In addition, thieves have been stealing exposed copper piping and wiring. The building was in poor condition in 1997, when it was formally evaluated, and was recommended for demolition (Walter 1997a). It is in worse condition in 2009.

B. Description of Exterior:

1. Overall Dimensions: In 1962, the structure was described as

> basically a 2-story reinforced concrete and corrugation [sic] enclosed structural steel building. The ground level concrete sub-structure includes space with massive walls for tank rooms, gas storage, equipment rooms and utility areas. The structural steel second level contains the motor room and adjacent work area.

> The motor room exhaust exit is fitted with a roll up doorway. For vertical firings a floor section is retracted allowing the engine, which overhangs the hillside, to fire into a 65' deep pit. The roof is retractable to allow space for 40' long test units [rocket engines] in the vertical attitude. The engine mount and rotating structure are rated at 350,000 lbs. in any attitude. The 2nd level motor room [Operations Floor] is serviced by vehicles along a 100' long concrete access ramp [Edson 1962].

The Test Stand building from its southern end to its northern end firing or engine bay measures approximately 100'. The firing bay itself is cantilevered out 18' from the structure. The concrete access ramp to the Test Stand, which is actually a separate structure, also measures approximately 100' (Abramson et al. 1953).

Immediately to the southwest of the access ramp was the LOX tank elevated on four concrete piers on a poured pad. Although this feature was given a separate building number by Picatinny (e.g., Building 3619), it was originally considered part of the Static Rocket Test Stand. The tank itself is now gone, but the pad, the piers, and the piping are still in place.

2. Foundations: The foundations of the building are actually massive, poured, reinforced concrete walls and slabs that serve as a foundation and sit on the site's bedrock. The building's structural steel is embedded in this concrete foundation and not into the bedrock, assuring an effective transfer of stresses. A 3'-thick center wall serves as the backbone of the foundation and is capable of resisting horizontal and vertical shears and resulting diagonal tension. The entire Test Stand rests on rock, carrying an estimated capacity of 40 tons per square foot. The whole concrete structure is knit together with structural steel members and reinforcing bars; it may be considered an internal rigid unit. The design of the structure was based on withstanding a rocket thrust of 1,100,000 lbs vertically or horizontally and a side thrust of 60,000 lbs outward on each side of the stand (Frank Grad & Sons 1952a).

The access ramp, which was constructed as a separate structure but was considered part of the Test Stand, was built on the same principle.

3. Walls: The Static Rocket Engine Test Stand has two principle types of walls: blow-off and explosion deflecting, blast walls. The walls on the second story, around the Operations Floor, are all blow-off, to minimize destruction if an engine exploded from the middle of the building toward the engine bay. These blow-off walls are simply corrugated metal sheets affixed directly to the steel support beams. From the middle of the building back toward the access ramp, the walls are poured, reinforced concrete.

The walls on the ground floor are a combination of blow-off and blast, depending upon the uses of the rooms. The two rooms on the southeastern end, north and south rooms, hold oxygen and nitrogen cascades—gases under pressure. Both of these rooms are surrounded by exterior blast walls that measure 3'-thick and 8'-high and extend around two sides. The explosion from the cascades, essentially horizontal racks holding high-pressure bottles, would be straight out, and could be devastating to a human (Abramson et al. 1953). The cascade exterior walls are blast-off corrugated metal riveted to the frame. The walls on the northwest end of the stand are a combination of blast-off, green, corrugated fiberglass and riveted steel. Only the room on the northwest side of the Test Stand is in use, holding exceptionally large oxygen, water, and fuel (type undesignated) tanks. This room has riveted steel exterior walls serving as a blast wall.

The center walls that rest on the "foundation" backbone carry the two, recessed, concrete winding staircases, on the southeast and northwest sides of the building.

The northeast wall under the firing (engine) bay is lined with steel plates. This protected the stand from the blast and fire of the engine. The steel plates alone were not sufficient to protect the Test Stand, so two eight-inch raw water feeders were sprayed into the flame (Abramson et al. 1953). Photographs taken during and immediately after the construction of the Test Stand showed this wall without the steel plates. It is not known when these plates were added.

All of the exterior walls are covered with a bewildering array of conduit, junction boxes, louvers, fans, man-cages, and electrical connections. These items even cover the blow-off walls.

4. Structural systems, framing: The ground level has massive concrete framing walls that divide the four primary rooms. The second level, the Operations Floor, is framed in structural steel. The structural steel was embedded in the massive, reinforced concrete "foundation." The structural steel members and reinforcing bars work with the concrete foundation to form an internal rigid unit to help keep the structure from overturning. The dead weight of the concrete in center, the backbone, is sufficient to prevent overturning, which indicates that the steel columns need not be anchored into bedrock. In general, all steel in the system was riveted. The design of the structure was based on withstanding a rocket thrust of 1,100,000 lbs vertically or horizontally and a side thrust of 60,000 lbs outward on each side of the Test Stand (Frank Grad & Sons 1952a).

The ground floors are concrete and the second level floors are steel plates laid on, but not riveted to the support joists.

The access ramp that extends from E Road to the Test Stand rests on concrete abutments and piers (Abramson et al. 1953). Several of the piers have been used to create storage rooms and cages.

5. Openings:

a. Doorways and doors: On the ground level, northwest side, there are two doors, one led into the Fuel Bay Room and one into the Nitrogen Cascade Room. The door to the Fuel Bay is a single metal door and the door to the Nitrogen Cascade is a double metal door. On the southeast side, there are three doors, one into the Oxygen Cascade, and two into the Oxidant Bay. The door into the Oxygen Cascade is a double metal door, and the two doors into the Oxidant Bay are single metal doors.

The entryways into both the Nitrogen and Oxygen Cascade rooms (one for each) are unusual. Each entry is up a set of three shallow steps into a large contained exterior space created by the two sides of the blast wall and the side of the Test Stand itself. The double doors then opened into the cascade rooms, almost on top of the cascade racks. It is not clear how the tanks were serviced, given the stairs and very tight quarters.

The second level has two single, metal pedestrian doors in the middle of the Operations Floor at the top of each staircase on both the northwest and southeast sides. On the southeast side of the building, a pedestrian, metal door is located at the west end of the building. The southwest end of the building is dominated by a single rolling steel door. This door is at the end of the concrete access ramp and was used to move rocket engines, vehicles, and large pieces of equipment onto the Operations Floor. The rocket-engine firing bay is at the northeastern end of the building. Its roof and floor can open at the same time or individually. A rolling metal door serving as the roof pulls back, and a door in the floor, which is hinged like a bomb bay in an airplane, drops open. When the roof above is retracted an engine can be manipulated at any attitude.

b. Windows: There are no windows in the Static Rocket Engine Test Stand.

6. Roof: The roof is a flat, metal two-part system; the southwest end is fixed, and the northeast end is retractable. The northeast retractable roof is motorized and slides back and forth over the fixed southwest portion of the roof. The roof is retractable so that rocket motors can be fired in all attitudes.

The roof has no overhang, and the gutter system and drain are no longer discernable.

7. Other:

a. Stairs: The Static Rocket Test Stand has a number of sets of exterior stairs. On the northwest side of the building at the middle of the building, a broad set of three shallow steps with a metal pole balustrade on each side leads to a long landing. The doorway to the Fuel Bay and a recessed stair tower leading to the second level are on this landing. The southeast side of the building has an identical arrangement. On the southwest end of the building, at the Nitrogen and Oxygen Cascade rooms, a series of three shallow stairs must be used to access these areas. It is not clear why it is necessary to step up into the rooms or the staircase, but it probably has to do with the concrete "foundation" height.

Two stair towers, one on the northwest and one on the southeast, are recessed in the middle of the building to provide shelter from the elements but are clearly visible. The first section of winding stairs is visible to the first landing, but as it turns to approach the next landing at the Operations Floor, the solid back of the case only can be seen. The stairs funnel foot traffic through a metal door and onto the Operations Floor or the catwalk that surrounds the exterior of the Operations Floor. The catwalk is itself surrounded by solid, 1'-thick, approximately 4'-high, concrete balustrade on the northeastern portion of the walk and on the southwestern portion of the walk by an approximately 4'-high pipe railing. The exterior catwalk around the Operations Floor appears to have a built-in drainage system that uses downspouts. However, the edges of the catwalk have spalled significantly and it is difficult to determine exactly how the drainage system worked. Available blueprints did not cover building drainage.

b. Lighting: There is some exterior lighting on the Static Rocket Engine Test Stand, but it seems to be an afterthought. A single light in an explosion cage is located to side the second level door on the southeast side of the Test Stand, and a single light in a flared metal shade is found to the side of the second level door on the northwest side of the stand. There are no other exterior lights on the building.

Test Area E originally had some street lighting for security, but that lighting is no longer hooked into a grid. The entire area is unlit at night.

C. Description of the Interior:

1. Floor plans: The original floor plans are included in this document. The current floor plans have not changed from the original floor plans. The total floor area of the Static Rocket Engine Test Stand is 5,313 sq.ft. with the largest amount of open space in the Operations Floor (Edson 1962). The ground floor level has four rooms, two on each side of the Test Stand. On the northwest side, the rooms are the Nitrogen Cascade in the south corner, and the Fuel Bay, containing 500 sq.ft., in the north corner (Edson 1962). The Nitrogen Cascade holds wooden racks with nitrogen tanks (four tiers of 20 tanks each, totaling 80 tanks) piped (copper) and under pressure fed to the fuel tank in the Fuel Bay. The Fuel Bay holds three large tanks, designed for the space. They included: a 200,000-gallon raw water tank, which is pumped by electric motor from the Water Tower (Building 3623) in Area E; a 3,000-gallon fuel tank; and an oxygen tank that is fed from the Oxygen Cascade and the LOX tank outside the Test Stand (Frank Grad & Sons 1952b).

Two rooms are located on the southeast side of the ground floor. The south room is the Oxygen Cascade and the north room is the Oxidizer Bay. Enclosed in two steel boxes, the Oxygen Cascade itself comprises four tiers of tanks, under pressure, fifteen tanks per tier. Then tanks are fed to the oxygen tank in the Fuel Bay (Frank Grad & Sons 1952b). The Oxidizer Bay was originally designed to hold the oxygen tank, but it never held anything. It is just a large room that was subsequently subdivided with a steel-plate partition. A ceiling-mounted heater was added at an unknown date. The exact use of the room is not known.

The second level of the Test Stand is the Operations Floor. It is one large open room that extends the entire length of the upper level. This space is the site where rocket engines were mounted, fueled, and prepared for firing. The room opens on the southwest end to a large concrete access ramp from E Road and could be entered by truck for the off-loading of the engine to be tested, for the delivery of the new equipment delivery, or to make necessary repairs.

There are no bathrooms, break rooms, offices, or storage areas in the Test Stand.

2. Flooring: The flooring on the first level is concrete. The flooring on the second level is steel plate laid but not riveted on the steel floor joists. The steel plates can be moved, if necessary, but are so heavy that they stay in place even with great loads putting pressure on only parts of the plates.

The steel flooring at the engine bay on the Operations Floor is designed like a bomb bay in an airplane. Two large plates, hinged on the outside edges, can be opened and dropped straight down to accommodate the rocket-engine blast.

3. Wall and ceiling finish: The exterior walls are the interior walls in the Static Rocket Engine Test Stand. Since this was a testing facility, no attempt was made a finishing walls or ceilings. On the first level, the walls in the Nitrogen Cascade Room are concrete and blast-off corrugated metal, and the ceiling is concrete. In the Fuel Bay, the walls are a combination of concrete and steel plate and the ceiling is concrete. The walls in the Oxygen Cascade Room are a combination of concrete and blast-off corrugated metal, and the ceiling is concrete. In the Oxidizer Bay, the walls are a combination of concrete and blast-off corrugated fiberglass, and the ceiling is concrete.

On the second level, the Operations Floor walls are blast-off corrugated metal and ceiling is a partially fixed and partially retractable metal roof.

4. Mechanical equipment:

a. Heating, air conditioning, ventilation: The Static Rocket Test Stand was not air conditioned and was originally heated only on the Operations Floor (Abramson et al. 1953). Apparently ventilation was not a problem on the first level since any ventilation occurred passively. On the second level, the Operations Floor would be open at the engine bay, which provided ventilation.

On the first level, at an unknown date, the Oxidizer Bay on the north end of the southeast side of the stand was fitted with both a large floor-level exhaust fan that vented to the outside and a large ceiling-mounted heater. It is unclear what activities happened in this space, especially since the exterior walls were corrugated fiberglass.

The LOX tank, a possible explosion concern, was located well away from the building in the open, which negated the need for ventilation.

b. Lighting: Electrical lighting at the Test Stand is a combination of single bulbs within explosion cages, some mounted on the ceiling and some on the walls, and single-bulb hanging lights with flared metal shades. On the Operations Floor, there is a combination of the fixtures.

c. Plumbing: Raw water was used in the test firing of rocket engines in the Test Stand. Water was electrically pumped from the Area E Water Tower (Building 3623) to the Water Tank in the Fuel Bay. It was then sprayed on the engine flame during the actually firing. The water was conducted from the tower by an 8'' pipe (Abramson 1953). The Test Stand has no bathrooms or drinking fountains, so there is no potable water hook up.

The entire Static Rocket Test Stand has plumbing for a number of actions including: receiving ammonia from off site; receiving nitrogen, oxygen and LOX; receiving rocket fuels of various types and strengths; and receiving steam for heaters from the Control House (Building 3617).

d. Other: The Static Rocket Test Stand is connected to the Control House (Building 3617) through as series of underground pipes that carry steam for heating and wiring for the master control of all functions related to the firing and monitoring of the rocket engine. The stand also is connected to the Control House by intercom and telephone. The actual work of the Test

Stand could not be completed without the Control House, which is located approximately 250' northwest of the Test Stand across E Road.

D. Site:

1. Historic landscape design: The Static Rocket Test Stand (Building 3618) is located off Picatinny proper, along E Road from Snake Hill Road in the NARTS Area E Historic District. A copy of the NARTS Area E Historic District map is included in this documentation. The district, which is enclosed by a fence, is generally inaccessible without a key. It is adjacent to the NARTS Test Area D Historic District and less than 2,000' from the 1500 Rocket Test Area Historic District. The structures in the district are purposely perched on a precipitous slope that they used to maximum effect. The slope is the defining natural landscape element of the district.

A single asphalt road (E Road) leads up to Area E. Although the road has been paved, the slope is significant and a four-wheel drive vehicle is required in bad weather. The road passes between the two largest buildings in the test area, the Control House (Building 3617) and the Static Rocket Test Stand (Building 3618). The road then loops to the southeast and passes the access ramp to the Test Stand and returns under the ramp to the Control House. Originally, an ammonia line paralleled the road up to the Test Stand and floodlights were placed at intervals along the road. The path of the road passed all of the primary structures within Area E when it was active and is the defining manmade landscape element.

The Test Stand, which is approximately 250' southeast of the Control House, sits higher on the slope than the Control House. The Control House controlled and monitored activities at the Test Stand and used the slope to shield its first floor from blast/engine emissions (e.g., heat, exhaust, smoke, fire) stemming from testing at the stand. The Test Stand also used the slope of the area to advantage. A rocket engine was actually cantilevered from the Test Stand and fired down the side of the slope into a pit area dug 65' into the slope. The slope itself provides insulation and protection from the blast.

In order for the Test Stand to fully utilize the slope, the structure was poised right at the edge of the slope. Some excavation occurred at the base of the slope, to deepen the exhaust pit. In order for the plan to work, the slope at the firing end at the stand (northeast side) had to be shored up with a concrete retaining wall and a rubble wall. The pit itself was lined with rubble and naturally held water at various times of the year.

When completed and in use, the areas around the Test Stand and the Control House were completely devoid of trees and shrubs; anything that could burn or get in the way of observing an engine test was removed. The bare ground was probably seeded to prevent erosion, but everything else was cut down. The Test Stand originally had parking areas on its southeast and northwest sides. However, at some unknown date, but before 1962, the northwest parking area was eliminated and replaced with Test Stand E-1A (Building 3625).

Test Area E contains a number of other structures in addition to the Control House and the Static Rocket Test Stand. These structures are: Buildings 3622 (ca. 1960) Water Tower; 3623 (ca. 1960) Water Tower Support Building; 3625 (ca. 1960) Maintenance Building, Test Stand E-1A; 3627 (ca. 1960) Control Room; and E-1D (ca. 1960) Control Room, a gun turret. However, they are not original (i.e., 1953) to the site and are noncontributing elements to the district. When in use, they too would have been in cleared areas with unobstructed sight lines to the Static Rocket Test Stand.

The area at present is completely overgrown and it is difficult to comprehend how the buildings worked with each other. Large trash-trees, shrubbery, and a deteriorating site conspire to further undermine understanding of the site as a whole
.

2. Outbuildings: As noted, the area contains a number of other structures in addition to the Control House and the Test Stand. These structures are: Buildings 3622 (ca. 1960) Water Tower; 3623 (ca. 1960) Water Tower Support Building; 3625 (ca. 1960) Maintenance Building, Test Stand E-1A; 3627 (ca. 1960) Control Room; and E-1D (ca. 1960) Control Room, a gun turret.

The Water Tower (Building 3622) and the adjacent Water Tower Support Building (Building 3623) were originally associated with the Test Stand's need for raw water to control the flame and heat of a rocket engine during testing. An electrical pump was used to fill a water tank in the Fuel Bay of the Test Stand, and water was then pumped from the tank to each side of the engine bay where it was sprayed on the flame of the engine exhaust. The water, which was carried from the Water Tower to the tank in an 8" pipe, moved only when the pump was on (Abramson et al. 1953). It is not a contributing element to the historic district.

Maintenance Building (Building 3625; Test Stand E-1A) is northwest of the Static Rocket Test Stand and was used by RMI as a 50,000-lb thrust rocket-engine firing stand. Situated at ground level, it consists of a massive, reinforced concrete reaction base entirely underground. Stand E-1A is covered by a steel-plate and corrugated metal building that measures 14’ x 19’ x 16‘ and has a total floor area of 266 sq.ft. (Edson 1962). It is connected to the Static Rocket Test Stand by a grounded, open conduit, covered with steel plates, presumably to channel, fuel, gases, and water to the stand. The stand was built sometime after the original Static Rocket Test Stand, but prior to 1962, and is not a contributing element to the historic district.

Control Room E-1D and Building 3627, which actually has two parts, are the two remaining outbuildings. Information could not be found on these structures. Control Room E-1D was made from a Navy gun turret, a common practice at Picatinny. Building 3627 also appears to have been created, at least partially, from a used turret that has been made earth-fast and expanded. It is connected to a separate control panel. Navy gun turrets can be found all over Picatinny’s ranges and test areas, and they are used for a surprising number of activities. Neither Control Room E-1D nor Building 3627 have a view of the firing bay of the Static Rocket Test Stand. The Static Rocket Test Stand also blocks a view of Test Stand E-1A, therefore, it is not clear what these structures were controlling or viewing.

PART III. SOURCES OF INFORMATION

A. Architectural Drawings: The Directorate of Public Works (DPW), Picatinny has a collection of blueprints related to the Static Rocket Test Stand (Building 3618), a number of which were photographed and used in this document or were cited as bibliographic references. These blueprints are easily accessed through the Picatinny Cultural Resources Coordinator and DPW.

B. Bibliography:

1. Primary and unpublished sources:

Abramson, B.N., D.S. Brandwein, and H.C. Menes
1953 *Description of Test Facilities at the Naval Air Rocket Test Station.* U.S. Naval Air Rocket Test Station, Technical Note No. 36. U.S. NARTS, Lake Denmark, Dover, NJ. December. On file in the Technical Library, Picatinny Arsenal, NJ.

American Institute of Aeronautics and Astronautics (AIAA)
2006 *Picatinny Arsenal and Marine Park Designated Historic Aerospace Sites* [press release]. American Institute of Aeronautics and Astronautics Communications Office, Reston, VA [online document]. Available URL: "http://intranet.aiaa.org/industryresources/PDF/HistoricSitePicatinnyMarinePark.pdf" [accessed March 17, 2009].

Army Armament Research, Development and Engineering Center (ARDEC)
1995 *ARDEC 95*. U.S. Army Armament Research, Development and Engineering Center, Picatinny Arsenal, NJ. U.S. Government Printing Office, Washington, D.C.

2008 Armament Research, Development & Engineering Center: The Army's Center of Lethality. U.S. Army Research, Development and Engineering Command, Picatinny Arsenal, NJ [online www] Available URL: "http://w4.pica.army.mil/PicatinnyPublic/organizations/ardec/index.asp" [accessed March 19, 2009].

ARDEC Historical Office
nd *Points about Picatinny.* ARDEC Historical Office, Picatinny, NJ.

Ashby, David E., David Buchanan, Robie Lange, John D. Mocum, Pamela J. Thurber, and Debra Wolf
1984 HABS/HAER Inventory Cards for Picatinny Arsenal, NJ. HABS/HAER Pilot DARCOM Project, Picatinny Arsenal, NJ.

Baranowski, John J., Capt. (Commanding Officer, NARTS)
1959 *Command Histories.* U.S. NARTS, Lake Denmark, Dover, NJ. July 31. On file at the Naval History Center, Annapolis, MD.

The Citizen
1958-1960 *The Citizen of Morris County* (newspaper). Denville, NJ.

Directorate of Public Works (DPW), Picatinny Arsenal

nda Military Real Property Card Files, 405-90f. On file at Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

ndb Vertical building drawing files and blueprints, by building number. On file at Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

ndc Maps. Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

Durant, Frederick Clark, Lieut. Comdr.

1951 The Naval Air Rocket Test Station—Purpose and Progress. *American Rocket Society Journal* (June):74-79.

Edson, D.

1962 *Test Facilities Data Book.* Thiokol Chemical Corporation, Reaction Motors Division, np.

Frank Grad & Sons

1952a *U.S. Naval Air Rocket Test Sta., Lake Denmark-Dover, N.J., Rocket Test Stand E-1, Sections & Computations* [Blueprint]. Dated February 8. Frank Grad & Sons, Newark, NJ. On file at Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

1952b *U.S. Naval Air Rocket Test Sta., Lake Denmark-Dover, N.J., Rocket Test Stand E-1, Schematic Flow Diagram, Rocket Test Piping* [Blueprint, As Built]. Dated April 15. Frank Grad & Sons, Newark, NJ. On file at Directorate of Public Works, Picatinny Arsenal, Dover, NJ.

GRAD

2009 Grad. Grad Associates, P.A., Newark, NJ [online www]. Available URL: “http://www.gradarchitects.com” [accessed March 17, 2009].

Guzzo, Dorothy P., Deputy State Historic Preservation Officer

1999 Letter to Ronald J. Kraus, Director, Public Works, Picatinny Arsenal. Re: HPO-G00-10, Identification of Historic Properties, including Test Area E, Naval Air Rocket Test Station District NRHP eligiblity. Dated July 12. Department of Environmental Protection, Historic Preservation Office, State of New Jersey, Trenton.

2004 Letter to Paul T. Seitz, LT. COL., U.S. Army Garrison Commander, Picatinny Arsenal, NJ. Re: Identification of Historic Properties. Dated

April 12. Department of Environmental Protection, Historic Preservation Office, State of New Jersey, Trenton.

Jenkins, E.
1953 *Mount Test For E-1 Test Stand.* U.S. Naval Air Rocket Test Station, Technical Note No. 23. U.S. NARTS, Lake Denmark, Dover, NJ. March. On file in Technical Library, Picatinny Arsenal, NJ.

Naval Air Rocket Test Station (NARTS)
1949 (September)-1953 (April) Monthly Progress Reports. U.S. NARTS, Lake Denmark, Dover, NJ. On file in the Technical Library, Picatinny Arsenal, NJ.

1956 *Long Range Plan for Fiscal Years 1957-1960.* December. U.S. NARTS, Lake Denmark, Dover, NJ. On file at the Technical Library, Picatinny Arsenal, NJ.

ca. 1957 *Prospect Careerwise; Engineering Opportunities at U.S. Naval Air Rocket Test Station, Lake Denmark, Dover, New Jersey.* Technical Information Branch, U.S. NARTS, Lake Denmark, Dover, NJ (on file in the Naval Historical Center, Annapolis, MD).

ca. 1959a *All About NARTS Engineering Facilities; U.S. Naval Air Rocket Test Station, Lake Denmark, Dover, N.J.* Technical Publications Branch, U.S. NARTS, Lake Denmark, Dover, NJ. On file at the Command Historian's Office, Picatinny Arsenal, NJ.

ca. 1959b *Test Evaluation.* Np. On file at the Naval Historical Center, Annapolis, MD.

1959a *Foundational Research Program.* Quarterly Progress Report 1-60. June. U.S. NARTS, Lake Denmark, Dover, NJ. On file at the Technical Library, Picatinny Arsenal, NJ.

1959b *Variable Thrust Rocket Engine for Spacecraft Application, Proposal.* U.S. NARTS, Lake Denmark, Dover, NJ. On file at the Technical Library, Picatinny Arsenal, NJ.

ca. 1960 *Test Evaluation.* Np. On file at the Naval Historical Center, Washington, DC.

Picatinny Arsenal

1956a *Picatinny Arsenal, Dover, NJ.* Np. January. On file in Technology Library, Picatinny Arsenal, NJ.

1956b *Functions and Facilities of Picatinny Arsenal, Dover, NJ.* Np. On file in Technology Library, Picatinny Arsenal, NJ.

ca. 1960 *Picatinny Arsenal, Armament Technology Ordnance Development.* Np. On file at Technology Library, Picatinny Arsenal, NJ.

Reaction Motors Division (RMD)

1959-1966 *Thiokol, RMD Rocket*. In-house company newsletter. Reaction Motors Division, Thiokol Chemical Corporation, Denville, NJ.

nd *Safety and Reliability for Manned Space Flight.* Thiokol Chemical Corporation, Reaction Motors Division, Denville, NJ.

Reaction Motors, Inc. (RMI)

1945 *Reaction Motors, Inc.* Ms on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1948 Historical Background of Reaction Motors Incorporated, Dover, New Jersey. Typewritten ms. on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1951-1958 *The RMI Rocket.* In-house company newsletter. Reaction Motors Inc., Rockaway, NJ. Thiokol Chemical Corporation Annual Report. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1952-1957 *Reaction Motors, Inc. Annual Reports*. Reaction Motors, Inc., Rockaway, NJ.

ca. 1953 *Reaction Motors, Inc., Experience, Qualifications, Manpower & Facilities.* On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1955a *This is RMI*. Reaction Motors, Inc., Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1955b *New Rocket Engine Plant Dedicated.* October 7. News release from Reaction Motors, Inc., Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

ca. 1955 *RMI, a new Threshold for Engineering. . . .* Reaction Motors, Inc. Denville Plant, Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1957 *This is RMI, Power for Progress.* Reaction Motors, Inc., Denville, NJ.

Redmond, John A.
1957 *Reaction Motors, Inc., New Test Facility.* Fact Sheet. Reaction Motors, Inc., Denville, Plant, Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

Rosenberg, Edward B.
1955 "Reaction Motors Inc.: Bringing the Future into the Present." *New Jersey Business, The Magazine of Industry and Business* (October).

Seaman, R.W., and D.S. Smith
ca. 1957 *Flight Rating Test Demonstration of the XLR-99-RM-1 Rocket Engine.* ARS Paper No. 1409-60. Thiokol Chemical Corporation, Reaction Motors Division, Denville, NJ. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

Seiler, Dayton A., Commander
1949 *U.S. Naval Aeronautical Rocket Laboratory, Progress Report No. 1-49.* U.S. Naval Aeronautical Rocket Laboratory, Lake Denmark, Dover, NJ. On file at the Scientific and Technical Information Branch, Picatinny Arsenal, Dover, NJ.

Shesta, John
1978 Reaction Motors Incorporated—First Large Scale American Rocket Company: A Memoir. Ms. of paper delivered at the XXIXth International Astronautical Congress, Dubrovnik, Yugoslavia.

October. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

Stack, John P., LTC, U.S. Army
2008 Letter to Daniel Saunders, Deputy State Historic Preservation Officer, New Jersey Historic Preservation Office, Department of Environmental Protection, Trenton. Dated September 9. Office of Garrison Commander, Headquarters, U.S. Army Garrison, Picatinny Arsenal, NJ.

Thiokol
1959 *Thiokol Chemical Corporation Annual Report*. Thiokol Chemical Corporation, Bristol, PA. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1960 *A Short History of the Reaction Motors Division Packaged Liquid Rocket Thrust Units.* Thiokol Chemical Corporation, Bristol, PA. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1962 *Thiokol Chemical Corporation Annual Report*. Bristol, PA. On file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1997 *History of Thiokol Corporation.* Modified by Steve Lawson. Thiokol Corporation, Corporate Communications Office, Ogden UT. On file Senior Architectural Historian's Office, Mobile, AL.

U.S. Department of the Army
ca. 1983 Draft, National Register of Historic Places Inventory, Nomination Form for Picatinny Arsenal, New Jersey. U.S. Department of the Army, Picatinny Arsenal, NJ. On file in the Real Property Division, Picatinny Arsenal, NJ.

U.S. Naval Ammunition Depot
1948 Brochure of General and Descriptive Information, U.S. Naval Ammunition Depot, Lake Denmark, Dover, N.J. On file in Technology Library, Picatinny Arsenal, NJ.

Walker, Robert
1970 "Sun Sets on a Pioneer Space Age Company." *The New York Times,* 12 August:58.

Walter, Richard G., Chief, Engineering Plans and Services Division
1997a *Engineering Evaluation of Building 3618, Memorandum for the Record.* Engineering Plans and Services Division, Picatinny Arsenal. On file at Real Estate Office, Picatinny Arsenal, NJ.

1997b *Engineering Evaluation of Building 3625, Memorandum for the Record.* Engineering Plans and Services Division, Picatinny Arsenal. On file at Real Estate Office, Picatinny Arsenal, NJ.

Winter, Frank H., and Frederick I. Ordway
1982 *Reaction Motors, Incorporated from December 1941 through April 1958.* Ms. on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

2. Secondary Resources

BASF
2008 Grad Associates. Near Zero Energy Home-Patterson, N.J.: Contributors to the Near Zero Energy Home. BASF Group, Florham Park, NJ [online www]. Available URL:
"http://www.betterhomebetterplanet.com/index.php?mode=contributors&section=primary&select=3" [accessed March 19, 2009].

Fitch, Virginia A., and Suzanne Glover
1990 *Army Materials Technology Laboratory Closure with Transfers to: Detroit Arsenal, Michigan, Picatinny Arsenal, New Jersey, Fort Belvoir, Virginia, and Supporting Documentation*. Originally submitted by The Public Archeology Laboratory, Inc., Pawtucket, RI, to Daylor Consulting Group, Boston, and Department of the Army, Corps of Engineers, New England Division, Waltham, MA, 1989.

Gaither, Steve
1997 *Looking Between Trinity and the Wall: Army Materiel Command Cold War Material Culture within the Continental United States 1945-1989.* U.S. Army Materiel Command Historical Context Series, Report of Investigation, Number 11. Geo-Marine, Inc.,

Plano, TX. Prepared for the U.S. Army Corps of Engineers, Fort Worth District, Fort Worth, TX.

Green, Constance McLaughlin, Harry C. Thompson, and Peter C. Roots
1990 *United States Army on World War II: The Technical Services, The Ordnance Department: Planning Munitions for War*. Center for Military History, U.S. Army, Washington, D.C.

Halsey, Edmund Drake
1882 *History of Morris County, 1739-1882*. W.W. Munsell and Co., New York.

Harrell, Pauline Chase
1993 *Final Report, Annotated Catalogue of Building Drawings and Evaluation of Architectural Features Picatinny Arsenal, Dover, New Jersey*. WCH Industries, Inc., Waltham, MA, and Boston Affiliates, Inc., Boston. Prepared for the U.S. Army Corps of Engineers, New York District, New York.

1994 *Revised Draft Report, Evaluation of Structures Built Prior to 1946 at Picatinny Arsenal, New Jersey*. WCH Industries, Inc., Waltham, MA, and Boston Affiliates, Inc. Prepared for the U.S. Army Corps of Engineers, New York District, New York.

Jenkins, Dennis R.
1996 *The History of Developing the National Space Transportation System: The Beginning through STS-75*. Walsworth Publishing Company, Marceline, MO.

Kaye, Seymour M.
1978 *Encyclopedia of Explosives and Related Items, PATR [sic] 2007.* Vol. 8. U.S. Army Armament Research and Development Command, Large Caliber, Weapons Systems Laboratory, Dover, NJ.

Myers, Manny
1984 Revolutionary War Origins of Picatinny Arsenal. In *A Remembrance of the Past... A Recognition by the Present: Historical Guide to Picatinny Arsenal, U.S. Army Armament Research and Development Center, Dover, New Jersey.* 3rd ed. Historical Office Picatinny Arsenal, NJ,

National Archives and Records Administration, Northeast Region (NARA)
nd Finding aids for the U.S. Naval Air Rocket Test Station, Lake Denmark, New Jersey, 3rd Naval District. National Archives and Records Administration, Northeast Region, Waltham, MA.

Naval Historical Center
1998 *Chronology of Significant Events in Naval Aviation.* Naval Aviation History Branch, Naval Historical Center home page, Department of the Navy, Washington Navy Yard, Washington, D.C. [online www]. Available URL: "http://www.history.navy.mil/branches/org4-5.htm" [accessed March 19, 2009]

Nelson, Jennifer L.
2006 "Grad Associates Celebrates 100 years," *New Jersey Business*, November 1 [online document]. Available URL: "http://findarticles.com/articles/mi_qa5311/is200611/ai_21401135" [accessed March 17, 2009].

Newarkology!
2008 Oheb Shalom Cemetery [Hillside, New Jersey]. Newarkology! Website, np [online www]. Available URL: "www.newarkhistory.com/ohebshalomcemetery.html" [accessed March 17, 2009].

Newark Public Library
2007 "A Salute to GRAD Associates: One Hundred Plus One: and A Selection of Great Books on Architectural History." Newark Public Library, Newark, NJ [online document]. Available URL: "http://npl.org/Pages/ProgramsExhibits/Exhibits/grad07.html" [accessed March 19, 2009]

The New York Times
1977 "Landmark Status Asked for Rocket Site of 1940's." *The New York Times*, August 19, unknown page.

1992 "Howard Grad Dies; An Ex-Engineer, 79." *The New York Times*, December 2 [online document]. Available URL: "http://query.nytimes.com/gst/fullpage.html?res=9E0CE0DC1F3EF931A35751C1A964958260" [accessed March 19, 2009]

2000 "Paid Notice: Deaths Grad, Bernard John," *The New York Times,* August 7 [online document]. Available URL: "http://query.nytimes.com/gst/fullpage.html?res=9B07E4DD103CF934A3575BC0A9669C8B63" [accessed March 19, 2009]

Nolte, Kelly, and Mark A. Steinback
2004 *Determination of Eligibility of Selected Buildings for Inclusion on the National Register of Historic Places, Picatinny Arsenal, Rockaway Township, Morris county, New Jersey.* Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for Picatinny Arsenal under a cooperative agreement with the U.S. Army Medical Research and Materiel Command, Fort Detrick, MD.

2008 *Historic American Buildings Survey Documentation of Pyrotechnic R&D Laboratory (Building 1510).* Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for Parson Infrastructure, San Antonio, TX.

Nolte, Kelly, Kelly Mahar, and Mark A. Steinback
2007 *Determination of Eligibility of 318 Buildings and Structures for Inclusion on the National Register of Historic Places, Picatinny Arsenal, Rockaway Township, Morris County, New Jersey.* Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for Picatinny Arsenal under a cooperative agreement with the U.S. Army Medical Research and Materiel Command, Fort Detrick, MD.

Nolte, Kelly, Mark A. Steinback, and Michael A. Cinquino
1999a *Architectural Assessment of Historic Structures at Picatinny Arsenal, Morris County, New Jersey*. Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for U.S. Army Corps of Engineers, New York District, New York.

1999b *Definition of Historic Districts for Picatinny Arsenal, Morris County, New Jersey*. Panamerican Consultants, Inc., Buffalo Branch, Buffalo. Prepared for U.S. Army Corps of Engineers, New York District, New York.

Nolte, Kelly, Michele H. Hayward, Mark A. Steinback, and Elizabeth S. Burt
1999c *Development of a Treatment Strategy for and Addition Research Regarding Structures 3617, 3618 and Others at the Former Naval Air Rocket Test Station (NARTS), Test Area E,*

Picatinny Arsenal, Morris County, New Jersey. Panamerican Consultants, Inc., Buffalo Branch, Depew, NY. Prepared for Northern Ecological Associates, Inc., Canton, NY under contract to U.S. Army Corps of Engineers, New York District, New York.

Ordway, Frederick I.

1952 "The Advance of Rocket Science." *Sky and Telescope*, Vol. XI (12):279-297 (October).

1985 *The Reaction Motors Division Chronology.* December 1. Ms on file at Frederick I. Ordway III Collection, archives room, U.S. Space and Rocket Center, Huntsville, AL.

1987 Pioneering Commercial Rockery in the United States of America: Thiokol's Reaction Motors Division, 1958-1972, Part 3: RMD Operational History. *Journal of the British Interplanetary Society* 40:389-404.

Ordway, Frederick I., and Frank H. Winter

1983 Pioneering Commercial Rockery in the United States of America, Reaction Motors, Inc. 1941-1958, Part I: Corporate History. *Journal of the British Interplanetary Society* 36:542-551.

1985 Pioneering Commercial Rockery in the United States of America, Reaction Motors, Inc. 1941-1958, Part 2: Projects. *Journal of the British Interplanetary Society* 38:155-168.

Picatinny

2006 "Picatinny designated as historic aerospace site." Picatinny Highlights, October 20 (online www]. Available URL: "http://www.pica.army.mil/picatiinypublic/highlights/archive/2006/10-20-06.asp" [accessed March 19, 2009]

Pitney, Henry C., Jr. (ed)

1914 *A History of Morris County New Jersey; Embracing Upwards of Two Centuries, 1710-1913*. Vol. 1. Lewis Historical Publishing, New York.

Rogers, J. A., Jr.

1931 *The History of Picatinny Arsenal*. Picatinny Arsenal, NJ.

Rutsch, Edward S.
1999 *The Story of Ironmaking Bloomery Forges at Picatinny Arsenal*. Historical Conservation and Interpretation, Inc., Newton, NJ.

Rutsch, Edward S., and Holly van Voorst
1991 *Cultural Resources Survey Report C of the Proposed Mt. Hope Pumped Storage Hydroelectric Facility and Transmission Lines Rockaway and Jefferson Townships, Morris County, New Jersey*. Historic Conservation and Interpretation, Inc., Newton, NJ. Prepared for TAMS Consultants, Inc., New York.

Rutsch, Edward S., William Sandy, Richard F. Porter, and Leonard G. Bianchi
1986 *Cultural Resource Investigation of the Proposed Mt. Hope Pumped Storage Hydroelectric Facility and Transmission Lines Rockaway and Jefferson Townships, Morris County, New Jersey*. Historic Conservation and Interpretation, Inc., Newton, NJ. Prepared for Tippetts-Abbett-McCarthy-Stratton, New York and Bloomfield, NJ.

Sandy, William, and Edward S. Rutsch
1992 *Stage One Cultural Resources Survey of Three Areas for the Proposed Mt. Hope Pumped Storage Hydroelectric Facility Rockaway and Jefferson Townships, Morris County, N.J*. Historic Conservation and Interpretation, Inc., Newton, NJ. Prepared for TAMS Consultants, Inc., New York.

Schultz, James
1992 *Winds of Change; Expanding the Frontiers of Flight.* For the National Aeronautics and Space Administration, Government Printing Office, Washington, D.C.

STV/Lyon Associates, Inc.
1994 *Installation Design Guide for Picatinny Arsenal, New Jersey*. STV/Lyon Associates, Inc., Baltimore. Prepared for U.S. Army Corps of Engineers, New York District, New York.

Thurber, Pamela, and Sandy Norman
1983 *Historic American Engineering Record, Picatinny Arsenal, New Jersey, HAER* # NJ-36. Picatinny Arsenal, NJ.

U.S. Department of the Navy

1997a "Chronology of Significant Events in Naval Aviation, 1946-1949." Naval Historical Center, Department of the Navy, Naval Aviation Branch, Washington Navy Yard, Washington, D.C. [online www]. Available URL: "http://www.history.navy.mil/branches/avchr6.htm" [accessed March 20, 2009]

1997b "Chronology of Significant Events in Naval Aviation, 1950-1953." Naval Historical Center, Department of the Navy, Naval Aviation Branch, Washington Navy Yard, Washington, D.C. [online www]. Available URL: "http://www.history.navy.mil/branches/avchr7.htm" [accessed March 20, 2009]

1997c "Chronology of Significant Events in Naval Aviation, 1960-1969." Naval Historical Center, Department of the Navy, Naval Aviation Branch, Washington Navy Yard, Washington, D.C. [online www]. Available URL: "http://www.history.navy.mil/branches/avchr9.htm" [accessed March 20, 2009]

Urquhart, Frank John

1913 "Frank Grad" in *A History of the City of Newark, New Jersey, 1666-1913,* pp 116-117. Volume III, The Lewis Historical Publishing Company, New York and Chicago.

U.S. Geological Survey

1981[1954] *Dover Quadrangle*. 7.5' Series (Topographic). U.S. Geological Survey, Reston, VA

Winter, Frank H.

1987 Pioneering Commercial Rocketry in the United States of America: Thiokol's Reaction Motors Division, 1958-1972. Part 4:RMD Project History. *Journal of the British Interplanetary Society* 40:405-416.

1988 "Bringing up Betsy." *Air & Space* 3(5):76-84.

1994a "Black Betsy": The 6000C-4 Rocket Engine, 1945-1989. Part I. *Acta Astronautical* 32(4):283-303.

1994b "Black Betsy": The 6000C-4 Rocket Engine, 1945-1989. Part II. *Acta Astronautical*, 32(4):305-318.

C. Supplemental Material:

1. **NARTS Area E Historic District Map.** NARTS Area E Historic District map showing locations of buildings (adapted from DPW, Picatinny Arsenal ndc)

2. **Color Photographs.** Color 35mm photographs of exterior and interior views of Static Rocket Test Stand (Building 3618), taken by Ms. Kelly Nolte, Director, Architectural History Division, Panamerican Consultants, Inc.

3. **Scanned Photographs.** A collection of scanned historical photographs primarily from NARTS progress reports detailing the construction of NARTS Area E and the Static Rocket Test Stand (Building 3618).

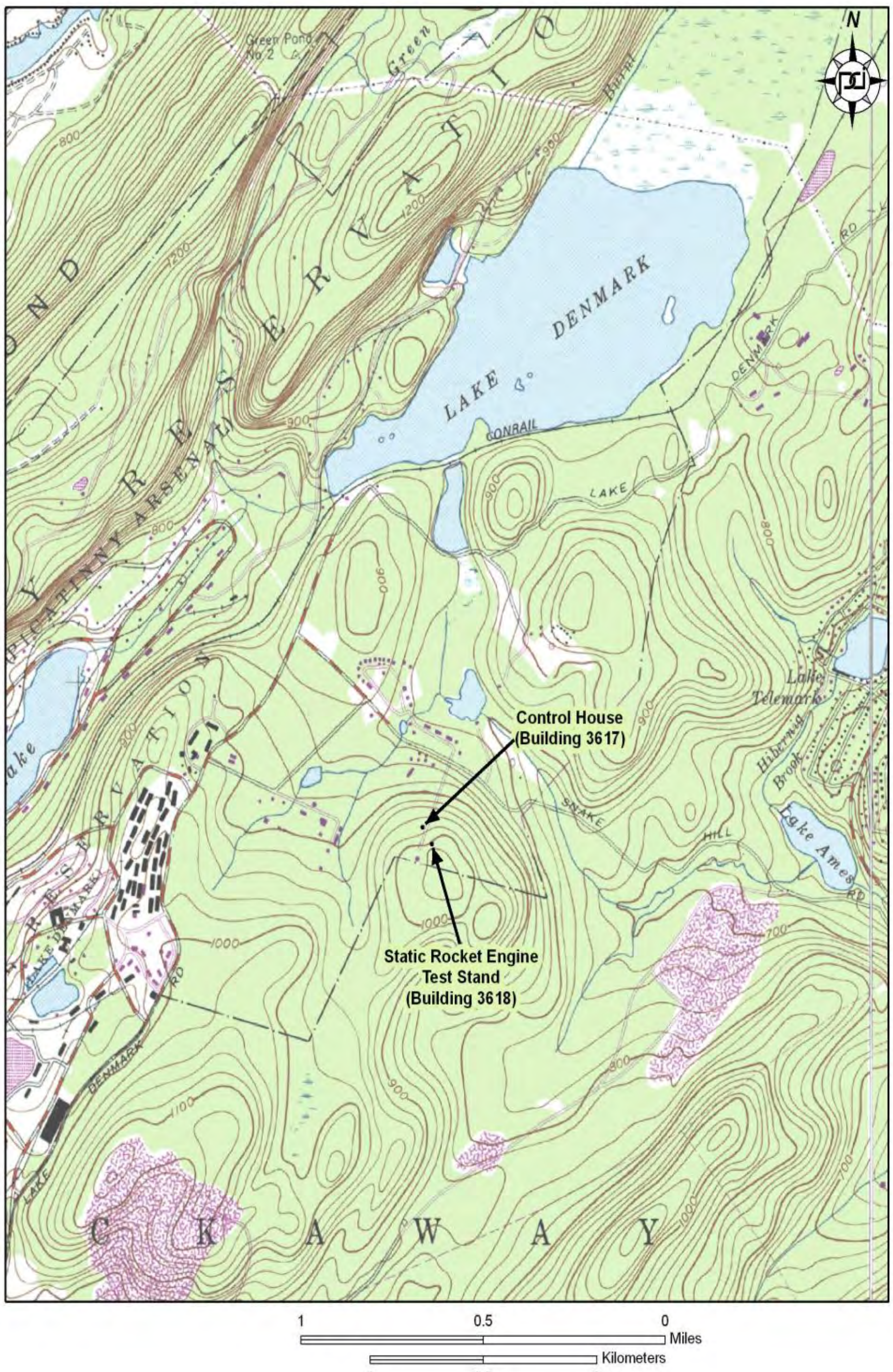
4. **Technical Brief.** *Description of Test Facilities at the Naval Air Rocket Test Station*. U.S. NARTS Technical Note No. 36 (Abramson et al. 1953).

5. **Technical Brief.** Rocket Test Mount Description, excerpted from NARTS Quarterly Report January-March 1953, Report No. 30 (April 1953) and *Mount Test For E-1 Test Stand.* U.S. NARTS Technical Note No. 23. U.S. NARTS (Jenkins 1953).

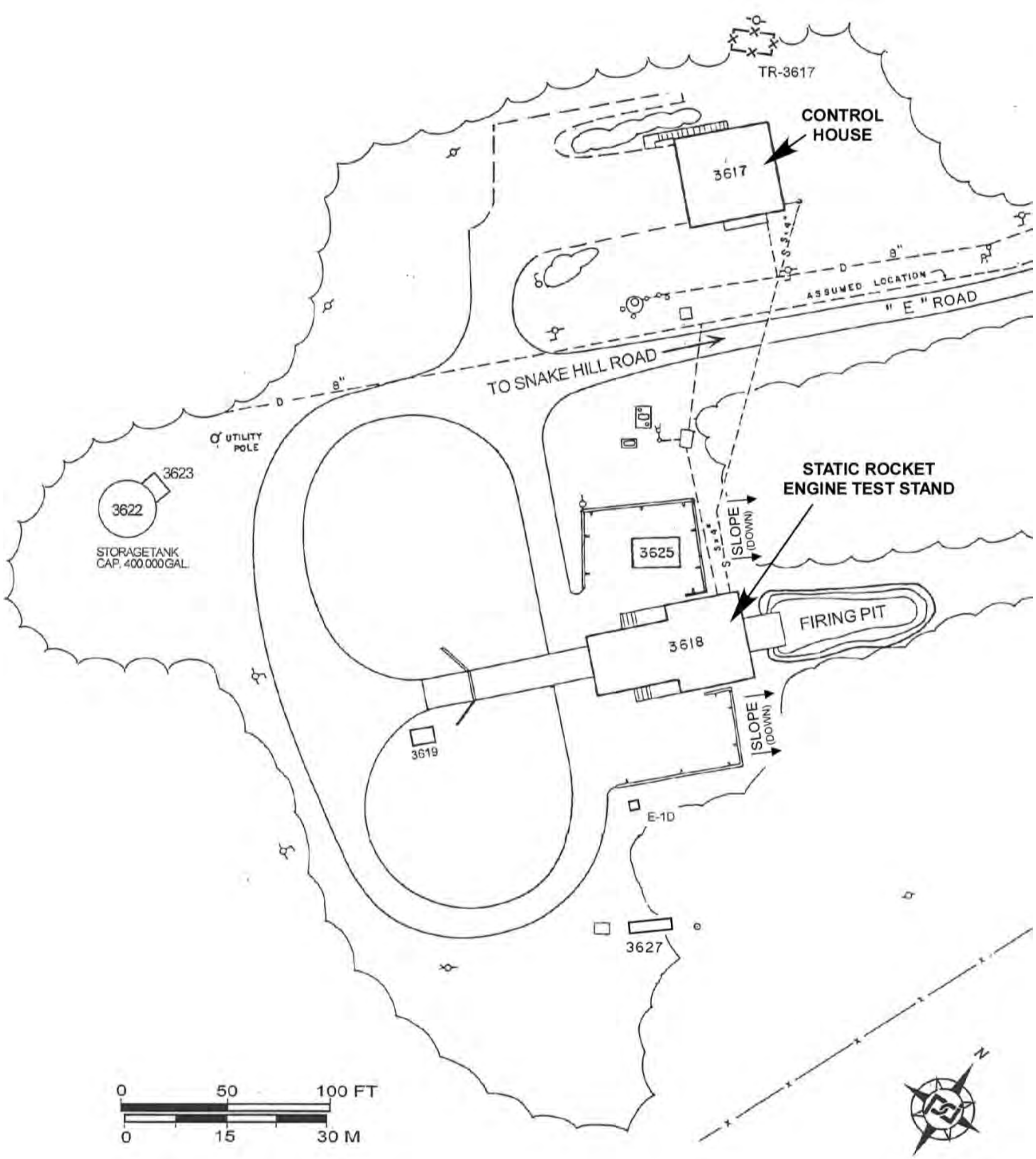
<u>PART IV. PROJECT INFORMATION</u>

The Static Rocket Test Stand (Building 3618) was recorded in November 2008 by Ms. Kelly Nolte, Director, Architectural History Division, Panamerican Consultants, Inc., Mr. Mark Drumlevitch, Photographer, Panamerican, and Mr. Mark A. Steinback, Panamerican. Ms. Nolte conducted the fieldwork, the historic research, and wrote most of the report. She also was responsible for the supplemental 35mm photography. Mr. Drumlevitch was responsible for the large-format photography. Mr. Steinback also conducted historic research and wrote a portion the report. The report was prepared under the supervision of Mr. Steinback. Dr. Michael A. Cinquino, Panamerican, was the Project Director.

This project could not have been completed without the help of many people at Picatinny. They include: Mr. Jason Huggan, Cultural Resources Coordinator; Mr. Jack Lyons, Real Property Specialist; Dr. Patrick Owens, Historian/Archivist; and a gaggle of military police. Mr. Daniel Saunders at the New Jersey Historic Preservation Office, Trenton, was also helpful.



Location of Static Rocket Test Stand (Building 3618) and Control House (Building 3617) *(USGS 7.5' Topographic Quadrangle, Dover 1954 [photorevised 1981]***).**



NARTS Test Area E Historic District with locations of buildings *(adapted from DPW, Picatinny Arsenal ndc)*

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

STATIC ROCKET TEST STAND **HAER NO. NJ-XXX**
(Building 3618; Test Stand E-1)
Southeast side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

INDEX TO BLACK AND WHITE PHOTOGRAPHS

Mark Drumlevitch, Panamerican Consultants, Inc., Photographer November 2008

NJ-XXX-1 SOUTHEAST ELEVATION OF STATIC ROCKET TEST STAND (BUILDING 3618), LOOKING NORTHWEST SHOWING EXTERIOR STAIRS TO UPPER LEVEL, OPERATING FLOOR.

NJ-XXX-2 NORTHWEST ELEVATION OF STATIC ROCKET TEST STAND (BUILDING 3618), LOOKING SOUTHEAST SHOWING EXTERIOR STAIRS TO UPPER LEVEL, OPERATING FLOOR, AND DOORWAY TO FUEL BAY.

NJ-XXX-3 SOUTHWEST END, LOWER LEVEL, OF STATIC ROCKET TEST STAND (BUILDING 3618), UNDER RAMP, LOOKING NORTHEAST. STAIRS TO THE OXYGEN CASCADE ARE AT RIGHT AND STAIRS TO THE NITROGEN CASCADE ARE AT LEFT.

NJ-XXX-4 SOUTHWEST, REAR, UPPER LEVEL, OF STATIC ROCKET TEST STAND (BUILDING 3618), LOOKING NORTHEAST, ALONG THE ACCESS RAMP FROM E ROAD TO THE ROLLING DOORS THAT ACCESS THE OPERATING FLOOR.

NJ-XXX-5 SOUTHEAST SIDE OF UPPER LEVEL CATWALK, STATIC ROCKET TEST STAND (BUILDING 3618), LOOKING NORTHEAST TOWARD ENGINE BAY. NOTE BLOW-OFF WALL PANELS.

NJ-XXX-6 SOUTHEAST SIDE STEEL STRUT-SUPPORT BEAMS ON THE ENGINE BAY, UPPER LEVEL, STATIC ROCKET TEST STAND (BUILDING 3618), LOOKING NORTH. NOTE BLOW-OFF WALL PANELS.

NJ-XXX-7 SOUTHEAST SIDE STEEL STRUCTRUAL SUPPORT BEAMS, STEEL STRUT-SUPPORT BEAMS ON THE ENGINE BAY, AND CONCRETE-

BLOCK INSTRUMENTATION ROOM ADDITION, UPPER LEVEL, STATIC ROCKET TEST STAND (BUILDING 3618), FROM UPPER LEVEL WALKWAY LOOKING NORTH. NOTE BLOW-OFF WALL PANELS.

NJ-XXX-8 NORTHWEST SIDE OF UPPER LEVEL WALKWAY SHOWING STEEL SUPPORT BEAMS, AND METAL WALKWAY BALUSTRADE, STATIC ROCKET TEST STAND (BUILDING 3618), LOOKING NORTHEAST.

NJ-XXX-9 INTERIOR VIEW OF THE STATIC ROCKET TEST STAND (BUILDING 3618), LOOKING NORTHEAST ACROSS THE OPERATING FLOOR FROM THE METAL ROLLING ENTRY DOOR TOWARD THE RAISED ENGINE BAY. NOTE THE OVERHEAD CRANE SYSTEM, THE EXPOSED STRUCTURAL SYSTEM, THE BLOW-OFF WALL PANELS, AND GUARDRAIL SYSTEM ALONG THE INSIDE EDGE OF THE FLOOR THAT PREVENTS THE ENGINE FROM CRASHING INTO AND THROUGH THE WALLS DURING MOVING.

NJ-XXX-10 INTERIOR VIEW OF THE STATIC ROCKET TEST STAND (BUILDING 3618), SHOWING RAISED ENGINE BAY AREA, LOOKING NORTHEAST. NOTE EXPOSED PIPING FOR NITROGEN, OXYGEN, AMMONIA, FUEL, AND OTHER COMPONENTS; THE STEEL, THREE-SIDED SHIELD AT THE BASE OF THE STAIRS FOR THE PROTECTION OF WORKERS DURING ROCKET FIRING; THE OVERHEAD CRANE SYSTEM; AND THE ROLLING METAL DOOR THAT OPENED DURING ROCKET FIRING.

NJ-XXX-11 INTERIOR VIEW OF STATIC ROCKET TEST STAND (BUILDING 3618), RAISED ENGINE BAY AREA, SHOWING SPECIALLY DESIGNED ROCKET MOUNT, LOOKING NORTHEAST.

NJ-XXX-12 INTERIOR VIEW OF STATIC ROCKET TEST STAND (BUILDING 3618), RAISED ENGINE BAY AREA, SHOWING SPECIALLY DESIGNED ROCKET MOUNT, LOOKING NORTHEAST. NOTE THE ACCESS HOLES IN THIS BOX-LIKE STRUCTURE THAT ALLOWED THE ENGINE TO BE BOLTED IN PLACE AND FIRED AT ANY ATTITUDE.

NJ-XXX-13 INTERIOR VIEW OF STATIC ROCKET TEST STAND (BUILDING 3618), RAISED ENGINE BAY AREA, SHOWING SPECIALLY DESIGNED ROCKET MOUNT, LOOKING NORTHEAST. NOTE THE FLOOR UNDER THE MOUNT; THE MOUNT COULD BE SHIFTED INTO ANY ATTITUDE.

NJ-XXX-14 INTERIOR VIEW OF OPERATING FLOOR FROM RAISED ENGINE BAY AREA, LOOKING SOUTHEAST TOWARD ROLLING REAR ACCESS DOOR, STATIC ROCKET TEST STAND (BUILDING 3618). NOTE ENGINE-HOLDING FIXTURE (AT LEFT), THE EXPOSED PIPING FOR VARIOUS COMPONENTS USED IN THE ENGINE-FIRING PROCESS, AND THE OVERHEAD CRANE SYSTEM.

NJ-XXX-15 INTERIOR VIEW OF THE OPERATING FLOOR LOOKING SOUTH-SOUTHWEST TOWARD REAR ACCESS DOOR FROM THE RAISED ENGINE BAY AREA, STATIC ROCKET TEST STAND (BUILDING 3618).

NJ-XXX-16 VIEW OF NITROGEN CASCADE ROOM IN THE SOUTHWEST, LOWER LEVEL CORNER OF STATIC ROCKET TEST STAND (BUILDING 3618), LOOKING NORTHWEST.

NJ-XXX-17 VIEW OF ROOM CREATED AT A LATER DATE UNDER THE ACCESS RAMP SUPPORT BEAMS, LOOKING NORTHEAST, STATIC ROCKET TEST STAND (BUILDING 3618).

NJ-XXX-18 REMAINING LIQUID OXYGEN (LOX) TANK SUPORTS AND PAD ON THE SOUTH SIDE OF THE TEST STAND ACCESS RAMP NEAR THE INTERSECTION OF E ROAD AND THE ACCESS RAMP, LOOKING NORTHEAST, STATIC ROCKET TEST STAND (BUILDING 3618).

NJ-XXX-19 VIEW OF E-1D, CONTROL ROOM, A NAVY GUN TURRET, LOOKING NORTHEAST. NOTE THE SOUTHEAST SIDE OF THE STATIC ROCKET TEST STAND (BUILDING 3618) IN THE LEFT BACKGROUND.

NJ-XXX-20 VIEW OF CONTROL ROOM (BUILDING 3627), LOOKING NORTHWEST IN THE NARTS TEST AREA E HISTORIC DISTRICT. NOTE THE SOUTHEAST SIDE OF THE STATIC ROCKET TEST STAND (BUILDING 3618) IN THE RIGHT BACKGROUND.

NJ-XXX-21 VIEW OF CONTROL ROOM (BUILIDNG 3627) AND COVERED INSTRUMENTION PANEL, LOOKING NORTH IN THE NARTS AREA E HISTORIC DISTRICT. NOTE THE SOUTHEAST SIDE OF THE STATIC ROCKET TEST STAND (BUILDING 3618), IN THE RIGHT BACKGROUND.

NJ-XXX-22 VIEW OF MAINTENANCE FACILITY/TEST STAND E-1A (BUILDING 3625), LOOKING NORTH, IN THE NARTS AREA E HISTORIC DISTRICT. NOTE THE CONTROL HOUSE (BUILDING 3617) AT THE LOWER LEFT.

NJ-XXX-23 U.S. NAVAL AIR ROCKET TEST STA., LAKE DENMARK, DOVER, N.J., ROCKET TEST STAND E-1, ELEVATIONS [3618], DEPARTMENT OF THE NAVY, BUREAU OF YARDS & DOCKS, DISTRICT PUBLIC WORKS OFFICE, 3RD N.D. NEW YORK, N.Y., FRANK GRAD & SONS, ARCHITECTS-ENGINEERS, NEWARK, N.J. – WASHINGTON, D.C. [BLUEPRINT]. DIRECTORATE OF PUBLIC WORKS, PICATINNY, NEW JERSEY.

NJ-XXX-24 U.S. NAVAL AIR ROCKET TEST STA., LAKE DENMARK, DOVER, N.J., ROCKET TEST STAND E-1, PLANS [3618], DEPARTMENT OF THE NAVY, BUREAU OF YARDS & DOCKS, DISTRICT PUBLIC WORKS OFFICE, 3RD N.D. NEW YORK, N.Y., FRANK GRAD & SONS, ARCHITECTS-ENGINEERS, NEWARK, N.J. – WASHINGTON, D.C. [BLUEPRINT]. DIRECTORATE OF PUBLIC WORKS, PICATINNY, NEW JERSEY.

NJ-XXX-25 U.S. NAVAL AIR ROCKET TEST STATION, LAKE DENMARK, DOVER, N.J., ROCKET TEST STAND E-1, TEST BUILDING [3618], EAST & SOUTH ELEVATIONS, DEPARTMENT OF THE NAVY, BUREAU OF YARDS & DOCKS, DISTRICT PUBLIC WORKS OFFICE, 3RD N.D. NEW YORK, N.Y., FRANK GRAD & SONS, ARCHITECTS-ENGINEERS, NEWARK, N.J. – WASHINGTON, D.C. [BLUEPRINT]. DIRECTORATE OF PUBLIC WORKS, PICATINNY, NEW JERSEY.

NJ-XXX-26 U.S. NAVAL AIR ROCKET TEST STATION, LAKE DENMARK, DOVER, N.J., ROCKET TEST STAND E-1, TEST BUILDING [3618], WEST & NORTH ELEVATIONS, DEPARTMENT OF THE NAVY, BUREAU OF YARDS & DOCKS, DISTRICT PUBLIC WORKS OFFICE, 3RD N.D. NEW YORK, N.Y., FRANK GRAD & SONS, ARCHITECTS-ENGINEERS, NEWARK, N.J. – WASHINGTON, D.C. [BLUEPRINT]. DIRECTORATE OF PUBLIC WORKS, PICATINNY, NEW JERSEY.

NJ-XXX-27 U.S. NAVAL AIR ROCKET TEST STA., LAKE DENMARK, DOVER, N.J., ROCKET TEST STAND E-1, SECTIONS – ROOF PLANS [3618], DEPARTMENT OF THE NAVY, BUREAU OF YARDS AND DOCKS, DISTRICT PUBLIC WORKS OFFICE, 3RD N.D. NEW YORK, N.Y., FRANK GRAD & SONS, ARCHITECTS-ENGINEERS, NEWARK, N.J. – WASHINGTON, D.C. [BLUEPRINT]. DIRECTORATE OF PUBLIC WORKS, PICATINNY, NEW JERSEY.

NJ-XXX-28 U.S. NAVAL AIR ROCKET TEST STA., LAKE DENMARK, DOVER, N.J., ROCKET TEST STAND E-1, TRUNNION SUPPORT DETAILS [3618],

DEPARTMENT OF THE NAVY, BUREAU OF YARDS & DOCKS, DISTRICT PUBLIC WORKS OFFICE, 3RD N.D. NEW YORK, N.Y., FRANK GRAND & SONS, ARCHITECTS-ENGINEERS, NEWARK, N.J. – WASHINGTON, D.C. [BLUEPRINT]. DIRECTORATE OF PUBLIC WORKS, PICATINNY, NEW JERSEY.

HISTORIC AMERICAN ENGINEERING RECORD

SUPPLEMENTAL MATERIAL

STATIC ROCKET TEST STAND **HAER No. NJ-XXX**
(Building 3618)
Southeast side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

INDEX TO 35mm COLOR PHOTOGRAPHS

Kelly Nolte, Panamerican, Consultants, Inc., Photographer November 2008

1. Door-opening mechanism for rolling door, raised bay area, Operating Floor, Static Rocket Test Stand (Building 3618), looking northeast.

2. Interior view of concrete-block addition, northwest side, upper level, near the front bay, northeast end, Static Rocket Test Stand (Building 3618), looking northeast. Note telephone used as communications device between the Control House (Building 3617) and the Test Stand.

3. Oxidant Bay Room, lower level, northeast corner, Static Rocket Test Stand (Building 3618), looking southeast. Note the blow-off panels and the two large floor fans.

4. Oxygen Cascade, lower level, southeast corner, Static Rocket Test Stand (Building 3618), looking north. Note the open door at the end of the cascade that leads into an empty room.

5. Interior view of Fuel Bay showing tanks, from left to right, oxygen, water, and fuel, northwest corner, Static Rocket Test Stand (Building 3618), looking northeast.

6. Interior view of Fuel Bay showing water tank, northwest corner, Static Rocket Test Stand (Building 3618), looking northeast.

7. Interior view of Control Room (Building 3627), part of Navy gun turret made earth-fast, NARTS Test Area E Historic District, looking northwest.

8. View of instrumentation shed associated with Control Room (Building 3627), NARTS Test Area E Historic District, looking northwest.

9. Interior view of E-1D, Control Room, a former Navy gun turret, NARTS Test Area E Historic District, looking northwest.

10. Rear view of the Maintenance Building/Test Stand E-1A (Building 3625), NARTS Test Area E Historic District, looking southwest.

11. Maintenance Building/Test Stand E-1A (Building 3625), showing open conduit between Test Stand and Test Stand E-1A, NARTS Test Area E Historic District, looking down from the upper level walkway of the northwest side of the Static Rocket Test Stand (Building 3618).

12. Interior view of the Maintenance Building/Test Stand E-1A (Building 3625), NARTS Test Area E Historic District, looking northeast.

13. Landscape view showing the rear and southeast side of Static Rocket Test Stand (Building 3618), looking north. Note the tall metal poles that originally carried the liquid oxygen to the Test Stand from a tank that is outside of the photograph.

14. Poured concrete retaining wall with additional shoring provided by rise and native rock, to the northwest of the Static Rocket Test Stand (Building 3618), and behind, northeast of Maintenance Building/Test Stand E-1A (Building 3625), looking southeast.

15. Drainage system, northwest of Maintenance Building/Test Stand E-1A (Building 3625) between Building 3625 and E Road, looking north. Note the edge of the concrete retaining wall in the right middle ground of the photograph.

16. Ventilation system, northwest of Maintenance Building/Test Stand E-1A (Building 3625) between Building 3625 and E Road, looking east. Note the edge of rock-lined firing pit associated with the Static Rocket Engine Test Stand (Building 3618) in the right upper and middle ground of the photograph.

HISTORIC AMERICAN ENGINEERING RECORD

SUPPLEMENTAL MATERIAL

STATIC ROCKET TEST STAND **HAER No. NJ-XXX**
(Building 3618)
Southeast side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

INDEX TO SCANNED HISTORICAL PHOTOGRAPHS

All sources available at the Picatinny Technical Library, Picatinny, Dover, New Jersey. Photograph source indicated in photograph caption

1S. Early construction activities and site overview in NARTS Test Area E (*NARTS 1952: Progress Report for March)*.

2S. Workers erecting steel frame and creating concrete "foundation" walls and blocks of Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for March)*.

3S. Structural steel framing being erected, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for March)*.

4S. Firing pit excavation area, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for May)*.

5S. Access ramp and structural steel framing of the Test Stand. Note the concrete blast wall at ground level for the future Oxygen Cascade Room, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for May)*.

6S. View of steel frame for the Operations Floor. Note the rocket-engine mount in the cantilevered engine bay and the Control House (Building 3617), northwest of Test Stand at the lower right (can be seen under access ramp), Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for May)*.

7S. View along partially completed access ramp into partially competed Test Stand; note structural steel supports for the cantilevered engine bay sticking out like wings at the end of the stand, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for August)*.

8S. View of Test Stand from edge of access ramp showing the entry into the Oxygen Cascade Room, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for August)*.

9S. Engine bay with falsework, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for September)*.

10S. Southeast elevation showing an almost completed Test Stand. Note the truck on the access ramp partially inside the Operations Floor. The view shows the Oxygen Cascade Room, behind the concrete blast wall, without its blow-off panels but with its metal cascade box in place, in addition to the Oxidizer Bay without its blow-off panels. Just beyond the stand, in the lower left under the access ramp, the Control House (Building 3617) can be seen, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for August)*.

11S. Northwest elevation showing an almost completed Test Stand. Note the Nitrogen Cascade Room behind the concrete blast panel without its blow-off walls, and the Fuel Bay without its steel exterior plate. Note the rubble-lined firing pit under the firing bay and as yet uncompleted earth mound on the stand’s northwest side, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for August)*.

12S. Southeast elevation of almost completed Test Stand showing E Road as it loops around and under the access ramp. The Control House (Building 3617) is visible under ramp, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for November)*.

13S. Southeast elevation showing the Engine Bay with falsework and just beyond the almost completed Control House (Building 3617). Note the periscope windows in the Control House that would be used to observe the engine firing in the Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1952: Progress Report for November)*.

14S. Water Tank and piping, Fuel Bay, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1953: Progress Report for April)*.

15S. Fuel tank, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1953: Progress Report for February)*.

16S. Nearly completed Test Stand, southeast side, only the blow-off panels are missing from the lower exterior walls, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1953: Progress Report for March)*.

17S. Engine Bay doors in open position; note the two raw water nozzles that were used to help douse and cool the engine's flame, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1953: Progress Report for April)*.

18S. Firing Bay of Test Stand at completion. Note that the roof has been retracted, the rolling door opened, the bay floor dropped, and the engine mount moved into place as if a rocket engine were prepared for firing. Also note the two water nozzles on the front wall that partially doused and cooled the engine flame, Static Rocket Test Stand (Building 3618), NARTS Test Area E (*NARTS 1953: Quarterly Report dated July)*.

19S. A view of the completed Test Stand showing the LOX tank, pad, and supports (Building 3619). Note that the area on the northwest side of the stand was used for parking before Maintenance/Test Stand E-1A (Building 3625) was constructed, Static Rocket Test Stand (Building 3618), NARTS Test Area E (RMI 1955).

20S. The Test Stand in action. Note the open Engine Bay roof, bay doors, and bay floor, Static Rocket Test Stand (Building 3618), NARTS Test Area E (RMI 1955).

HISTORIC AMERICAN ENGINEERING RECORD

SUPPLEMENTAL MATERIAL

STATIC ROCKET TEST STAND **HAER No. NJ-XXX**
(Building 3618)
Southeast side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

SUPPLEMENTAL MATERIAL
Rocket Test Mount Description

Excerpted from:
NARTS Quarterly Projects Report January-March 1953, Report No. 30 [April 1953]
and
Mount Test for E-1 Test Stand, E. Jenkins, Technical Note No. 23, U.S. NARTS (March 1953)

Description and Testing of Test Stand E-1 Rocket Mount
(from NARTS *Quarterly Projects Report* January-March 1953, Report No. 30 [April 1953]:22-23)

SI-211 ASSIST IN CONSTRUCTION OF 350,000 LB THRUST TEST STAND

2. PROGRESS
2-1 Test stand

2-1.1 A rocket mount specifically designed to accomodate [sic] the 50,000 lb thrust XLR-30-RM-2 rocket engine was installed and tested satisfactorily. It is shown in Fig 23 [not included in this document]. The design specification called for a maximum allowable stress of 20,000 psi with a load in the direction of thrust of 150,000 lbs and a load normal to the thrust axis of 45,000 lbs. The mount was designed as a box structure, with 32-in. and 40-in. diameter holes at top and bottom for the rocket motor and 20-in. access holes at both sides. When used, the rocket motor will be bolted to the mount through three load cells tied to the mount. The entire assembly swings on 12-in. diameter trunnions tied to the stand structure, and is locked through the use of a sector plate and locking pin at the left-hand side. This will permit firings at attitudes of vertical and 15^{o}, 30^{o}, 50^{o}, 60^{o}, 75^{o}, and 90^{o} from the vertical. The first two listed are the specified attitudes for the XLR-30-RM-2.

2-1.2 The mount was tested at two attitudes, horizontal and vertical, and with the load applied in two directions for each attitude. The direction of load application was at an angle of 16^{o} 45' from the thrust axis, to simulate 150,000 lbs of direct load plus 45,000 lbs side load, first parallel to the trunnion axis and then perpendicular to the trunnion axis. The load was applied by a hydraulic jack mounted on pads welded to the test stand structure, and was measured by a calibrated Bourdon pressure gage. Twelve strain gages mounted to various critical sections of the mount were used to measure the stresses in the structure. Over-all deflection was also measured. The highest measured stress for any of the tests was 3,500 psi, indicating that the actual factor of safety, for 50,000 lbs thrust, is about 50, based on ultimate tensile stress.

2-1.3 A revision to the rocket engine dimensions by Reaction Motors, Inc., the first users of the stand, required the procurement of a new operating floor under the thrust mount. The new floor will be one foot lower than the existing one, to allow clearance for the rocket nozzle. It will contain two pair of double doors along the plane of thrust either or both of which will open immediately before test firings. The doors will be actuated by geared-down electric motors hung below the stationary parts of the floor. Safety latches will be provided to protect personnel from accidental actuation of the doors.

Installation and Testing of Test Stand E-1 Rocket Mount
(from NARTS *Technical Note No. 23: Mount Test for E-1 Test Stand* [Jenkins 1953])

[redacted]D UNCLASSIFIED
Security Information

1. INTRODUCTION

The contract for the purchase of the rocket mount for the E-1 test stand calls for a maximum allowable stress of 20,000 psi for a 156,000 lb applied load. The mount was to be tested according to a given program when mounted on its trunnions and predetermined loads applied. NARTS supplied all necessary equipment and facilities for making the measurements and the contractor supplied the required location of the strain gages and the means for applying a known load.

2. INSTALLATION

2-1 In order to take full advantage of the already installed instrumentation in the E-1 test stand, dc excitation of the strain gages was used. Bakelite bonded strain gages were used, the difficulty of installation of this type gage being offset by the advantage gained. That is, there was less leakage to ground, less drift and better bonding. The basic circuit used for these tests is as shown in Fig 1.

2-2 The temperature compensating gage was mounted on a 3" x 3" x 1/8" piece of metal of the same thermal characteristics as the metal in the mount proper. By using this compensating gage, drift of the bridge output, E_o, due to thermal expansion of the mount was virtually eliminated. For the sake of convenience resistors, R_1 and R_2, were also mounted on this plate as can be seen in Fig 2.

2-3 In order to use the bonded strain gage bridge as a method of measuring stress it is necessary to know accurately the bridge excitation voltage. In this mount, test measurement of this voltage was complicated by the fact that between the strain gage control and the strain gage there is a distance of about 300 ft. through wire of finite but unknown resistance. To measure the strain gage excitation voltage the circuit shown in Fig 3 was used.

2-4 Due to the high impedance of the voltage divider it can be shown that the effect of line resistance of the measuring leads can be neglected. When the 10 mv chart recorder indicated 8 mv (showing 8 volts on the strain gage bridge) voltmeter, V, was read, and this value of voltage was used through the balance of tests. In order to eliminate any chance of error all chart recorders used in the test were calibrated individually using a high precision hand potentiometer.

2-5 Mounting of the strain gages on the mount and trunnion was accomplished using an r.f. induction heater to obtain the necessary heat for the curing cycle. The gages showed no leakage and the method appears practical for other tests of this type.

y Information

3. TEST PROCEDURE

Resultant loads were applied according to the following schedule which was ...ied by the contractor.

Load	Force from Jack (lbs)	Actual Load on Mount (lbs) Vertical	Horizontal
1	52,250	50,000	15,000
2	104,400	100,000	30,000
2-1/2	130,500	125,000	37,500
3	156,600	150,000	45,000

...ese loads were applied by means of a hydraulic jack placed between a beam ...stened to the structure of test stand and the mount. To insure that the proper ...ads were applied, NARTS calibrated the gage showing hydraulic pressure and ... piston diameter, both checks showing that the calibration was accurate for ... purpose of the test.

...2 The various tests were as follows:

1. Test No. 1 - The 150,000 lb vertical upward load combined with the 45,000 lb side load applied parallel with the trunnion.

2. Test No. 2 - Identical to test no. 1 except that the side load was perpendicular to the trunnion.

3. Test No. 3 - Identical in all respects to test no. 1 except that the mount was rotated to the horizontal and the index pin in the extreme location.

4. Test No. 4 - Identical in all respects to test no. 2 except the mount was in the position specified for test no. 3.

4. TEST RESULTS

...1 It can be shown that the output of a bridge with a single active arm for small ...ues of $\Delta R \leqq .02R$ is very nearly,

...TED
...Information

$$E_0 = \frac{E_x}{4} \frac{\Delta R}{R} \qquad (1)$$

...ndamental strain gage relationships are

$$K \frac{\Delta L}{L} = \frac{\Delta R}{R} \qquad (2)$$

$$\frac{s}{M} = \frac{\Delta L}{L} \qquad (3)$$

M = Young's modulus

E_x = excitation voltage measured at bridge

s = stress in psi

K = $\frac{\Delta R}{R} \Big/ \frac{\Delta L}{L}$ (K is given arbitrarily for each batch of gages.)

...bining equations 1, 2, and 3 to solve for s:

$$s = \frac{4E_0 M}{E_x K} \qquad (4)$$

...2 Equation 4 was used to calculate stress from the recorded values of bridge ...balance. The number of the gage corresponding to a given location is shown ... Fig 4. The results of the tests are shown in Table I.

5. CONCLUSIONS

...1 These results show that while the mount has a safety factor of about 6 over ...e design and contract limit of 20,000 psi at the points where strain gages were ...plied, it must be remembered that the locations of the strain gages were ...bitrary. Furthermore (as noted previously) these locations were, under terms ...the contract, specified by the contractor.

...2 The indicated millivolt outputs were visually read from the chart scale and ...corded by hand, the chart recording pens being non-operative due to an ...corrected design fault. There was no observable drift in output during the ...urse of the test.

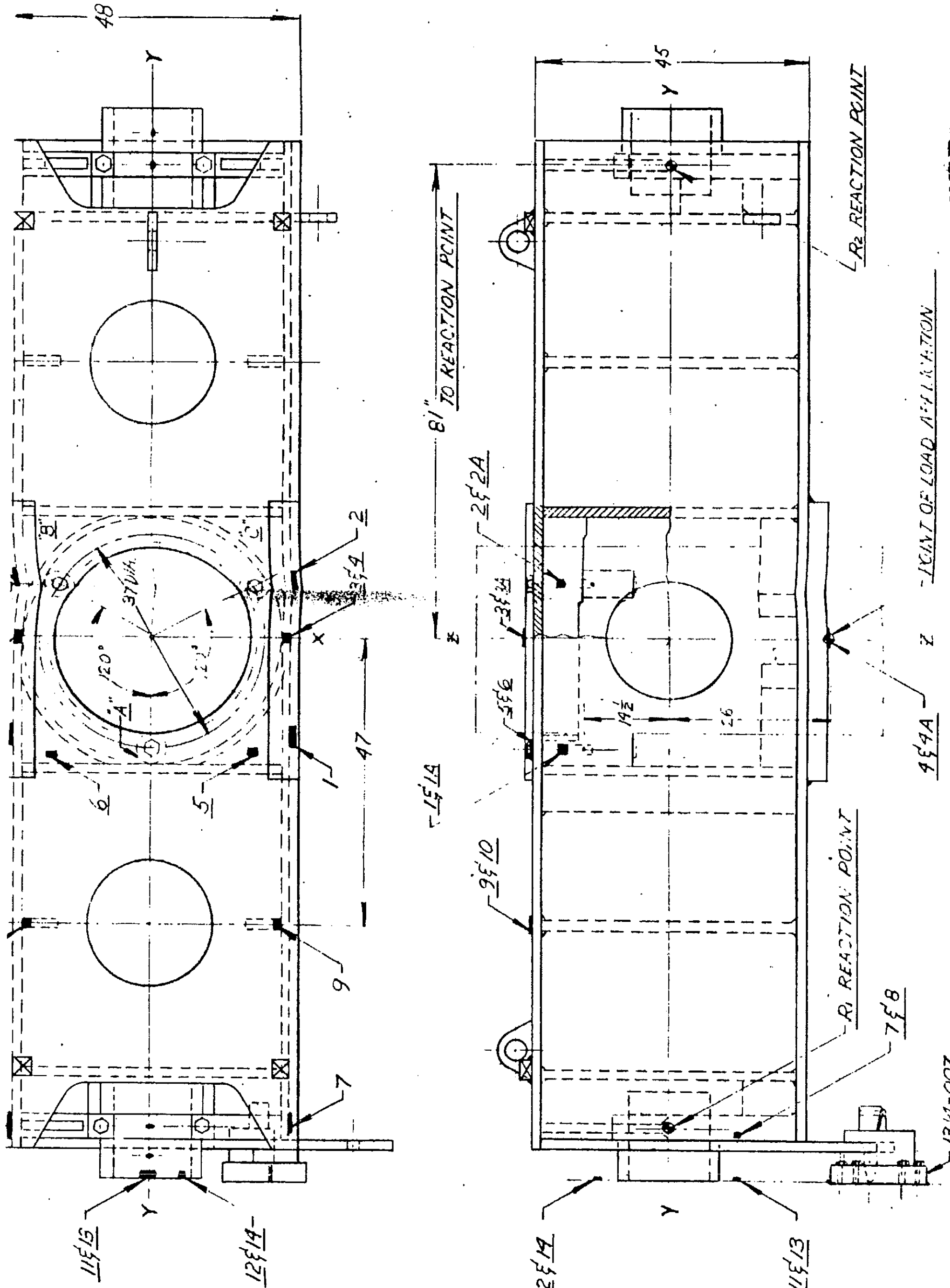


Fig 4. Mount diagram (showing arrangement of strain gages)

HISTORIC AMERICAN ENGINEERING RECORD

SUPPLEMENTAL MATERIAL

STATIC ROCKET TEST STAND **HAER No. NJ-XXX**
(Building 3618)
Southeast side of E Road
Test Area E Historic District
Former Naval Air Rocket Test Station (NARTS)
Picatinny
Morris County
New Jersey

SUPPLEMENTAL MATERIAL
Description of Test Facilities at the Naval Air Rocket Test Station

Excerpted from:

NARTS *Technical Note No. 36: Description of Test Facilities at the Naval Air Rocket Test Station* (Abramson et al. 1953)

U.S. Naval Air Rocket Test Station

Technical Note No. 36

DESCRIPTION OF TEST FACILITIES AT THE NAVAL AIR ROCKET TEST STATION

by
B.N. Abramson, D.S. Brandwein,
H.C. Menes

[December 1953]

Note: The figures that are referenced in the document were not included with the original document provided by Picatinny Arsenal.

2. BASIS OF DESIGN

2-1 One of the most difficult problems in the design of a large static thrust stand is that of exhaust disposal. Since most large rocket engines are fired vertically downward during their development, the problem becomes one of providing protection from the effects of the exhaust jet energy. This was done by selecting site on the steepest hill on the Government reservation. From inspection of existing large thrust stands, it was decided that the distance from the nozzle exit to the first point of impingement on the ground should be a minimum of 50 ft. Experiments by the Naval Air Rocket Test Station made in 1951 showed that a rocket exhaust flame could be nearly quenched by injection of moderate amounts of water into the core of the flame. As an additional safeguard, water headers were to be incorporated in the design to permit the injection of water just downstream of the rocket engine nozzle.

2-2 The slope of the site selected still did not permit a minimum of 50 ft clear distance, so a cantilevered design was chosen to provide the required additional distance. The requirements that the stand permit attitude firings of missiles from vertical to horizontal was also met by the cantilever arrangement. It was thought desirable to permit assembly and repair work on a missile in the horizontal position, thereby obviating a system a platforms and ladders such as is commonly found on fixed vertical stands. The stand now began to take the form of a long working area with the pivot point of the thrust mount cantilevered out from the supporting substructure.

2-3 The propellant feed system was to incorporate a bi-propellant tank system, pressure or pump fed. Once again the terrain dictated an arrangement of tank and cascade rooms under the working area of the stand. The room size was determined and a layout made which resulted in separate tank rooms and separate cascade rooms for the fuel and oxidizer, all susceptible to future expansion.

2-4 For safety reasons, consistent with previous experience, the control room was to be a separate structure, 250 ft from the stand, and placed underground. All test firing operations were to be controlled from this room. On the grade level of this building, a field maintenance shop would provide an assembly area for components. Personnel service areas, such as offices, sanitary facilities, and locker space were also to be included.

2-5 Consideration of climatic conditions the year round dictated a shelter over the working area. Light construction was to be used due to the possibility of an explosion. The tank and cascade rooms were to receive the same type of weather protection for ease of venting explosions and economy or replacement.

2-6 A system of roads was laid out which would permit direct truck access between all areas requiring transport of heavy equipment. Both tank rooms have parking areas adjacent to them for tank truck loading of propellants.

2-7 After a review of the above and other minor requirements, a complete set of specifications was drawn up by the Rocket Station which spelled out area and room sizes, loads, safety factors, utilities, and process details. Specifications for instrumentation, other than space and conduit requirements, were deliberately omitted since it was the intention that the complete instrumentation system would be handled by Station personnel. This set of specifications and a preliminary layout of the structures formed the basis for the design.

3. PRELIMINARY DESIGN

3-1 The preliminary layout of the test stand is shown in Fig 11. The structure is reinforced concrete, with the thrust load taken through steel members anchored to bed rock. Fig 12 shows the vertical members being erected.

3-1.1 The test stand structure is built in three levels: a basement, ground floor, and working floor. The ground floor contains the two propellant tank rooms and the two cascade rooms. The outside wall of each of the four rooms is fabricated of corrugated metal siding on light steel framing. In addition, a reinforced concrete barricade 8 ft high runs parallel to the outside face of the cascade rooms to protect personnel outside from gas pressure explosions.

3-1.2 The working level is one room, 94 ft 0 inches by 15 ft 10 inches by 17 ft 6 inches high. The thrust pivot point is 7 ft 6 inches from the face of the substructure. The roof of this room is movable, and can slide back 50 ft from the end of the cantilever, thus permitting erection of a missile tank section to the vertical. The dimensions of the cantilever floor are 18 ft 0 inches by 15 ft 0 inches. This floor is provided with bomb bay doors beneath the rocket centerline. To insure that the trunnion mounting will accommodate large propulsion units the trunnions are placed 12 ft 6 inches apart.

3.2 The thrust structure was designed to carry a normal load of 350,000 lbs and a side load of 40,000 lbs under steady state conditions. As a safety in the event of an explosion, the design loads were multiplied by a factor of 3, and the steel work was then stressed to a maximum of 20,000 psi.

3-3 After a careful review of the economy versus accessibility, a direct ascent of the slope was decided upon. This resulted in an access road of 1400 ft in length with a maximum grade of 14.9%. Fig 13 shows the layout of roads and the areas serviced.

3-4 The layout of the upper and lower floors of the control house is shown in Fig 14. The control room proper contains the firing console and all recording instrumentation. Instrument signal cables are run underground from this room to the test stand termination room through hollow clay tile ducts in the general utility trench. Viewing is accomplished by a periscope arrangement of mirrors in a concrete areaway.

3-5 Since the first use of this stand is the development of an engine with a thrust less than the maximum rating of the stand, operating on the combination of anhydrous ammonia-liquid oxygen, a number of specific components in the installation were tailored to meet this use. The entire propellant feed system, discussed in the following section, was built for this engine. The engine mount and operating floor were designed around this engine.

3-5.1 The engine mount is basically a hollow beam of rectangular cross section bridging the space between the trunnions. The engine is attached to the beam through three load cells spaced at 120^0, thereby allowing measurement of eccentric thrust. The mount can be rotated about the trunnion centerline through an arc of 90^0 by means of a sector plate and locking pin on one end. Design loads and stresses had the same basis as the trunnions, that is an overload factor if 3, and a maximum allowable stress of 20,000 psi. The completed mount was loaded with a hydraulic jack in an orientation which was the resultant of the axial and side loads. Strain gauges showed the maximum stress in the steel to be 3300 psi. Unavailability of certain sizes of steel plate necessitated the use of heavier material which accounted for the overdesign. Fig 15 shows the mount in place.

3-6 he operating floor under the mount contains two sets of double doors hinged parallel to the centerline on the stand, either or both to be opened immediately before test firings. The doors are remotely actuated by an electric motor drive. Fig 15 shows the doors in open position.

3-7 On the front face of the stand are two 8-inch raw water feeders to supply jet cooling water to nozzles which will be immersed in the flame. These feeders can be seen in Fig. 15.

3-8 The principal load carrying steel members are: 4-24wf 94# beams in vertical tension, 2-24 wf 100# beams in vertical compression, and 4-36wf 300# horizontal beams. The trunnions are 13 inches in diameter and extend 15 inches from the face of the support.

3-9 Concrete walls vary from 18 inches to 3 ft in thickness. The concrete ramp leading to the working floor is an independent structure on concrete abutments.

4. PROCESS DETAILS

4-1 The process piping was designed primarily around the first use of the stand. Funds were not available to make the process piping “universal.” The selection of sizes, materials, and methods of construction was made on an economic basis.

4-2 Propellants are fed to the engine by a pumped system, using the pumps designed for the engine by the development contractor. Consequently, tank pressure requirements were for suppression of cavitation and losses to the pump inlets only.

4-2.1 The propellant tanks were sized for one two-minute run at rated thrust. The 3000 gal ammonia tank is made of low carbon steel, is rated 225 psi working pressure, and is constructed according to the ASME Code for unfired pressure vessels. An available 2500 gal stainless steel tank, rated at 50 psi working pressure, is used for liquid oxygen.

4-2.2 In addition to the propellant tanks, a cooling water tank of 2400 gal capacity is located in the fuel tank room. This is used as the source of engine jacket cooling water. The tank is rated at 1500 psi working pressure, according to ASME Code construction, and is made of low carbon steel. Because of its size and pressure rating, it was most economical to make the tank spherical, with a wall thickness of 2-3/4 inches. Fig 18 shows the fuel and water tanks.

4-3 The basic process piping schematic is shown in Fig 17. Propellants are pressurized by gas, stored at 2000-2200 psi, reduced to proper values by remotely controlled regulators, and piped to the tops of the liquid tanks. The liquid outlets are piped directly to the working floor. Fill, vent, and overflow lines are provided. All valves used in firings are remotely operated.

4-4 Nitrogen gas, for pressurizing fuel and cooling water, is stored in a cascade of 80 [or 30] high pressure bottles, arranged in four banks. This arrangement was dictated by the availability of the bottles from surplus. Each bottle has six cu ft water volume, and is of multilayer construction. The bottles have a Navy pressure rating of 3000 psi, using a factor of safety of 2.1 based on yield stress. Fig 18 shows the nitrogen cascade.

4-4.1 Gaseous oxygen is used to pressurize the liquid oxygen. This was done to prevent dilution of the liquid oxygen by pressurizing nitrogen gas. The gaseous oxygen cascade consists of two boxes containing 25 bottles each, with a total water volume of 406 cu ft. These boxes were obtained from Charleston, S.C. Navy Yard, where they were in oxygen service. Fig 19 shows the oxygen cascade.

4-4.2 The liquid ammonia line is welded, flanged, carbon steel pipe. The liquid oxygen is hard drawn copper, type L or K, with silver solder joints. The gas piping is largely brass pipe with silver solder socket fittings. The small diameter piping for pneumatic controls is flared tubing, aluminum or stainless steel, with AN fittings. Because of the intermittent nature of the use of the stand, no insulation is used on the liquid oxygen system, except for the 6-inch outlet line from the liquid oxygen tank to the working floor. The section of line is insulated by a jacket connected to a vacuum pump. This is done to minimize boiling of liquid oxygen being pumped from the tank to the engine.

4-4.3 Liquid oxygen is delivered by the vendor’s truck to a 10,000 gal jacketed storage tank 130 ft from the tank room. It is gravity fed from there to the propellant tank through a 3-inch brass pipe. In addition, the feed will be pressurized by 5 psi by evaporating liquid oxygen from a coil exposed to outside air.

4-4.4 Ammonia is loaded into the propellant tank by making use of an existing 13,000 gal ammonia storage tank at the foot of the hill upon which the stand is located. Two pipe lines, a liquid line and a vapor return line, connect the tanks. A compressor at the storage tank pumps vapor from the propellant tank into the storage tank, creating a pressure differential between the tanks, and allowing ammonia to flow into the propellant tank.

4-4.5 Gaseous oxygen is supplied to the cascade by the vendor's truck. Gaseous nitrogen is piped from a high pressure pumping station which already serves the rest of the test areas.

4-5 With one exception, all valves and controls are commercial products. Remotely controlled valves are actuated pneumatically with solenoid pilots, using 150 psi control pressure. The non-commercial items are motor-operated Grove dome loaders. In this instance a NARTS-designed electrical drive is used to turn the handwheels of the dome loaders remotely from the control room. This avoids the lag in pressurizing tanks which would occur with dome loaders in the control house connected to the stand by 250 ft of tubing. Since there are no high pressure gas lines in the console, the hazard of gas pressure explosions is removed.

5. INSTRUMENTATION

5-1 Instruments are installed to measure the usual rocket engine parameters, pressure, force, flow rate, and temperature. Enough channels are provided to allow for any additional measurements which might be needed for complete engine test.

5-2 There are 96 signal input plugs in the test cell, each connected to a four-wire circuit. The total number of installed recording channels includes 35 potentiometer recorders, eight direct writing Sanborn recorders and a two-channel cathode ray oscilloscope. Terminations are also installed in the recording racks for two 18-channel magnetic oscillographic recorders. There are thus 79 allocated recording channels with 17 spare circuits available.

5-3 The basic system uses direct current excitation of the pressure and force pickups. Space is provided in the racks for incorporation of an A.C. carrier system termination if desired. The D.C. system requires no amplification with the usual strain gauge transducers, and sufficient output is available from these to excite a magnetic recording oscillograph element at frequencies to 100 cycles per second. The recording of pressure, thrust, and flow frequencies above 100 cps was deemed unessential in ordinary development of large engines.

5-3.1 The outputs from the transducers can be fed as desired to either self-balancing chart recorders, magnetic oscillographs, or direct writing pen recorders. A low gain D.C. amplifier was built into the system feeding the direct writing recorders, even though D.C. amplifiers generally have been avoided due to their drift. These D.C. amplifiers incorporated an input circuit giving automatic compensation for the D.C. level in the transducer output. Where a turbine type flowmeter is employed the signals are presented as an A.C. signal of varying frequency. This is converted to a steady D.C. voltage by means of six integrator channels. The D.C. voltage level varies with the signal frequency. The integrators are almost linear to 400 cps and include multivibrator count down circuits to handle higher frequencies.

5-3.2 The self-balancing chart recorders may be seen in the general view of the instrument consoles, Fig 20. Twenty-two of the thirty-five recorders have a one second pen traverse time and may be switched to definite ranges of 3, 10, 30 and 50 MV. The zero may be shifted smoothly over a range of ± 50 MV. This feature allows exact zero balance of a recorder by an operator prior to firing or calibration without resorting to the central jack panel. The main balance and control section of the jack panel contains thirty-six channels, each with individual voltage controls. The output signals from the main balance panel are terminated on the jack panel and are available as an input signal to any of the recorders. Thirteen of the recorders are normal 10 MV units with two second traverse rates which are generally useful where the signals are of reasonable level. They represented a considerable cost saving over the twenty-two multi-sensitivity, one second traverse recorders.

5-3.3 Calibration of this system is done by placing shunts across the bridge arms, by the use of remote controlled relays installed in the balance unit. Included in the equipment is a high precision potentiometer by which the chart recorders may be checked for linearity and absolute scale calibration.

5-3.4 In addition to the purely electrical calibration a pair of high precision Heise gauges are installed in the cable termination room. Overall system calibration of pressure pickups is effected with these, using controlled nitrogen pressure.

5-3.5 A 100-cycle high precision frequency standard is used to simulate turbine flowmeter signals. This gives an absolute calibration of frequency vs. D.C. millivolt output.

5-4 Temperature measurement will in most cases be made by means of thermocouples. A cold junction in the test cell allows the use of copper leads throughout. The low range of 3 MV is sufficient to give satisfactory sensitivity for the usual thermocouple voltages generated.

5-4.1 Each of the lead-covered main signal cables connecting the jack panels with the test cell junction boxes contain 30 pairs of wires. Each pair is twisted and individually shielded by metallized paper. Their exceedingly low leakage factor of 5000 megohms/mile is responsible in part for the stable operation of the system. Measurement of cross talk between adjacent pairs revealed that less than 1/20000 of the signal was transferred. These cables were also used extensively to interconnect the recorder racks in the control room.

5-4.2 Special care was given to the problem of noise and hum elimination in the signal circuits. All 60 cycle power and D.C. control lines are grouped in isolated conduits. D.C. excitation voltages for the pickups run in separate ducts with the signal circuit cables. All D.C. return paths are taken to common low resistance busses before returning to the negative of the D.C. power supply. Return currents from all relays in the instrument racks run to these negative busses.

5-4.3 The cell junction box is equipped with hermetically sealed plugs and protective caps to eliminate corrosion of the pins. The four-wire circuits terminated at these plugs run to the control room jack panel and connect to the standard receptacles. One receptacle is used for each pair of voltage excitation leads, the second for each pair of signal output leads. Considerable flexibility of connection is thereby possible.

5-5 All electrical functions in the test cell are controlled remotely through D.C. relays, powered by a Nobatron rectifier in the test cell. This obviates the use of heavy cables which would be required to avoid the presence of ground currents between the control room and the test cells. An A.C. relay controlled on the operator's console, drawing its voltage from the test cell A.C. line, closes the main switches supplying power to the Nobatron. Thereafter all control switching utilized this test cell source of power. All solenoids are wired so that the operator's control board shows no light until power is actually applied to the solenoid.

5-5.1 Tank and line pressures are indicated to the operator by a bank of sensitive panel meters whose scales are marked in increments of pressure. The signals for these meters are derived from miniature potentiometers actuated by modified bourdon tube gauges in the tank rooms. Using standard components, the overall accuracy of this telemetering system proved surprisingly high, ranging from 1% to 2%. Using the panel meters it is possible to indicate the signals recorded on the chart recorders, through transmitters and a separate jack panel.

5-5.2 Control of the potentiometer chart motor drives, the oscillograph motor drives, and the direct writing Sanborn chart drives is possible in three ways: at the unit itself, at the instrumental jack panel, and finally through the recorder switch in the controls console.

5-6 The first overall test of the instrument installation was made during stress tests of the engine mount, using strain gauges. Although the potentiometer chart recorders were used at their most sensitive setting of 3 MV, and the signal levels were extremely low, no observable drift or noise was noticed throughout the test.

6. UTILITIES

6-1 The main requirement for raw water is for jet cooling and fire fighting. Raw water is supplied to the stand from a 5,000,000 gal reservoir 1800 ft. away, through [number illegible] inch cast iron pipe laid underground. The reservoir is at an elevation of about 170 ft below the stand, making it necessary to use pumps. Three 1000 gpm, 125 psi pumps, driven by diesel engines, located at the reservoir are used.

6-1.1 Potable water, used for drinking, sanitary services, safety showers, hose outlets, and for filling the tankage as needed, is supplied through an 8-inch line. It is recognized that some of these functions could ordinarily use raw water, but it should be borne in mind that raw water is available only when the pumps are running, whereas potable water is available at all times.

6-1.2 The stand has a deluge system which supplies water to sprinklers and floor flushes in each tank room, and to the working floor. These can be actuated remotely from the control room by solenoid-operated quick-opening valves with manual reset. Station-operated fire trucks can be called through a Gamewell System. Hydrants are located at points around the stand for the use of firefighting equipment.

6-2 A central heating plant, located in the lower level of the control house, supplies steam to unit heaters in both buildings. The necessity of working for long periods with both ends of the room open, and the use of uninsulated sheet metal siding, presented a heating problem. However, a large unit heater is provided to afford some comfort to personnel during winter operations. The control room is air conditioned primarily to avoid instrumentation difficulties caused by high humidity. Other ventilation is standard, except for the tank rooms, which have forced draft blowers to aid in clearing out fumes.

6-3 Power is brought to the area by 2300 volt 75 KVA transmission line. A substation reduces this to 220- and 110-volt power. Lighting is standard, except for the firing balcony, which is lit by explosion-proof lights. Street lighting and floodlighting are provided for night work and security patrols.

7. CONSTRUCTION

7-1 Construction was started 19 November 1951. Completion of the stand, including installation of instruments and controls, was scheduled for 30 November 1952. By the end of February 1952 excavation had been completed, and structural steel and concrete were in the process of erection. By the end of August 1952 the basic structure was completed, the installation of the process piping, controls, and instrumentation remained to be done. Delays in the procurement of the large ammonia and water tanks, due to a steel strike, were the principal causes of the stretch-out of the completion date. The last major item, the coolant tank, was delivered early in April 1953. This was installed and checked immediately, and the stand was turned over to its first user for engine development on 1 May 1953. Fig 21 shows the stand during construction. Fig. 22 is the completed test facility.

7-2 In the construction of the stand 3830 yds of earth were excavated, 1500 yds of rock were blasted, 3230 yds of concrete were poured, and 650 tons of steel were used.

8. PARTICIPATION BY THE NAVAL AIR ROCKET TEST STATION

Aside from the overall direction of the project, the Naval Air Rocket Test Station was completely responsible for the instrumentation and control systems. The station designed, procured, fabricated, and installed all instrumentation. Pneumatic controls, including solenoid valves, dome loaders, and the interconnecting tubing were also designed and installed.

9. ACKNOWLEDGEMENTS

9-1 The preliminary and detailed structural design was done by Frank Grad & Sons, Raymond Commerce Building, Newark, New Jersey.

9-2 The general construction contractor was E.M. Waldron Company, 84 South Sixth Street, Newark, New Jersey.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

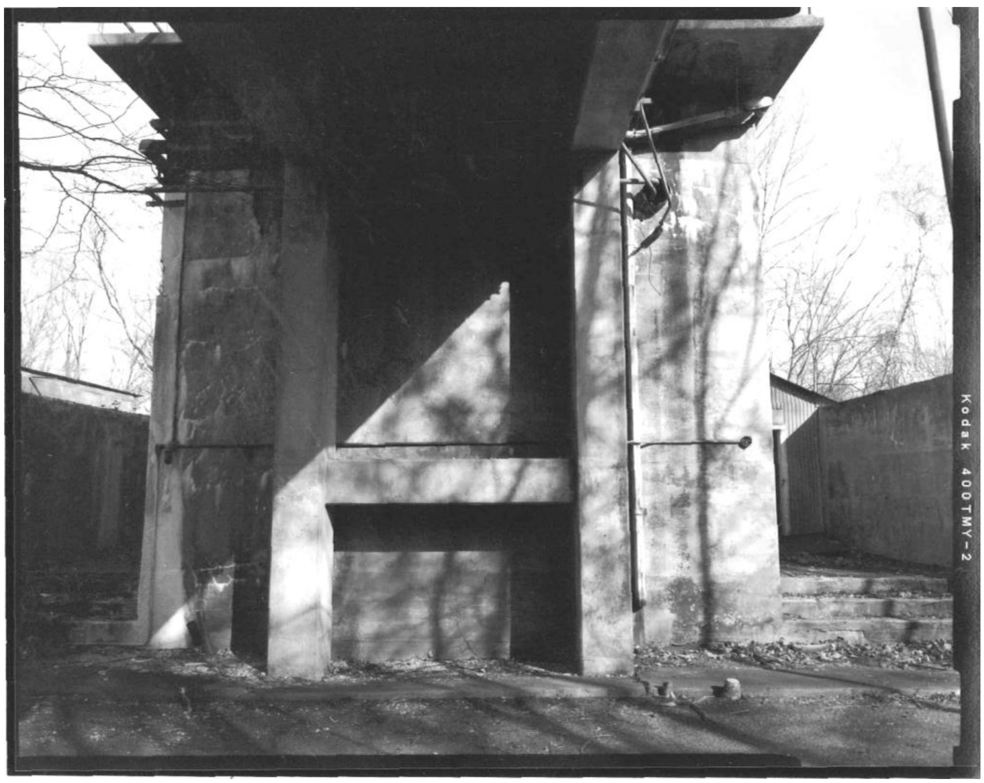
HAER No. NJ-XXX-1

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-2

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-3



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-4

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-5

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-6

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-7

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-8

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

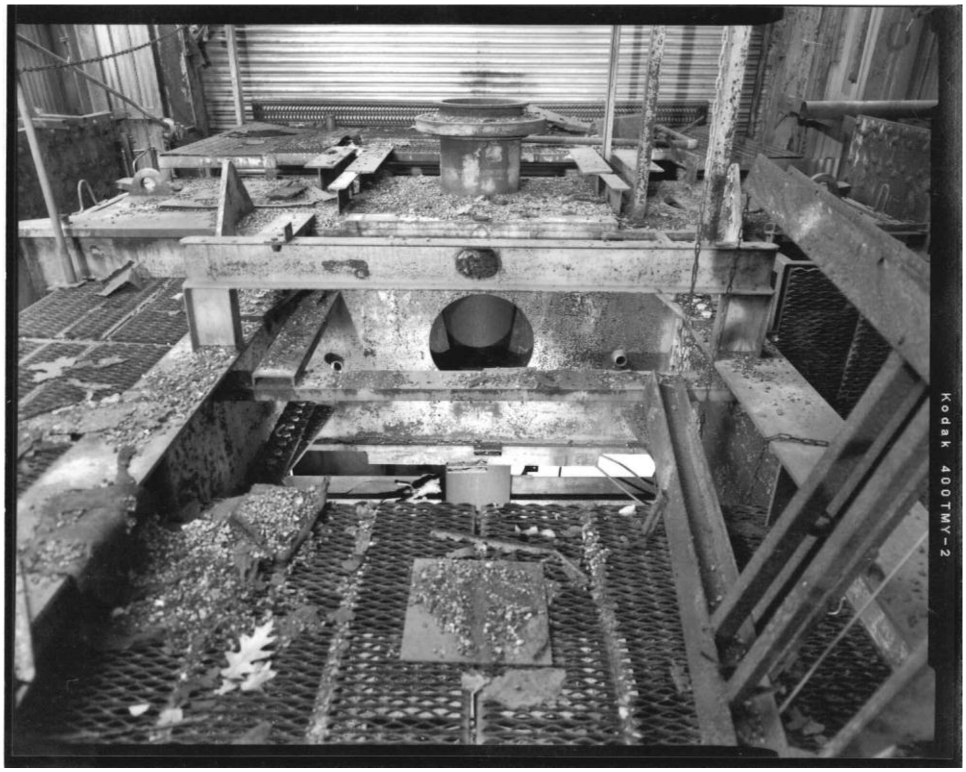
HAER No. NJ-XXX-9

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-10

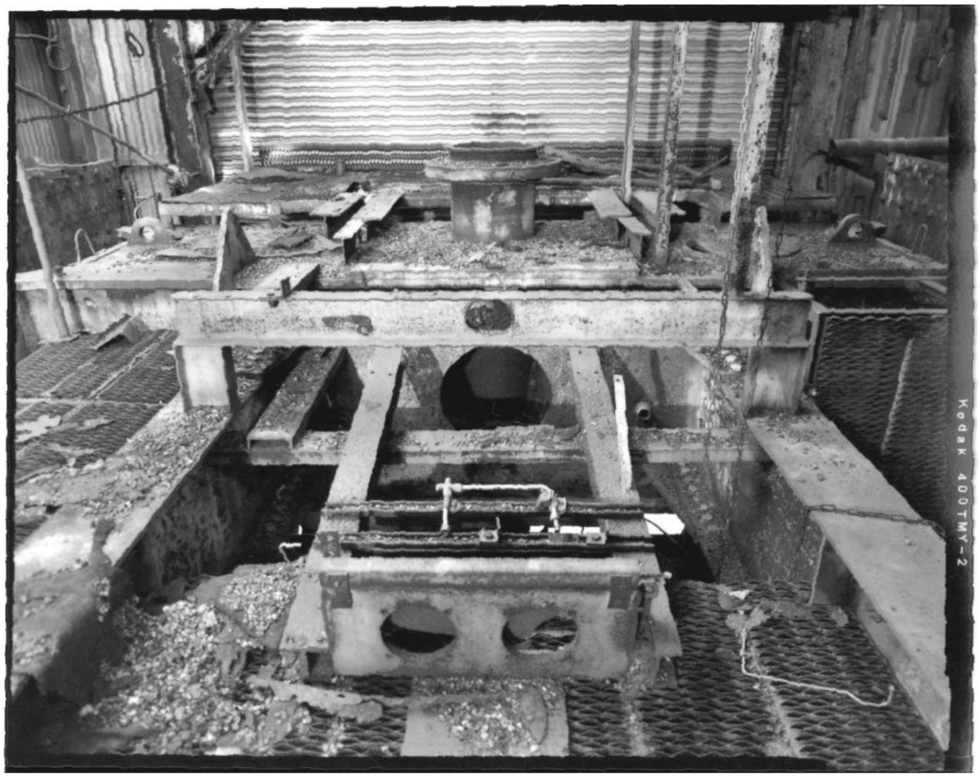
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-11



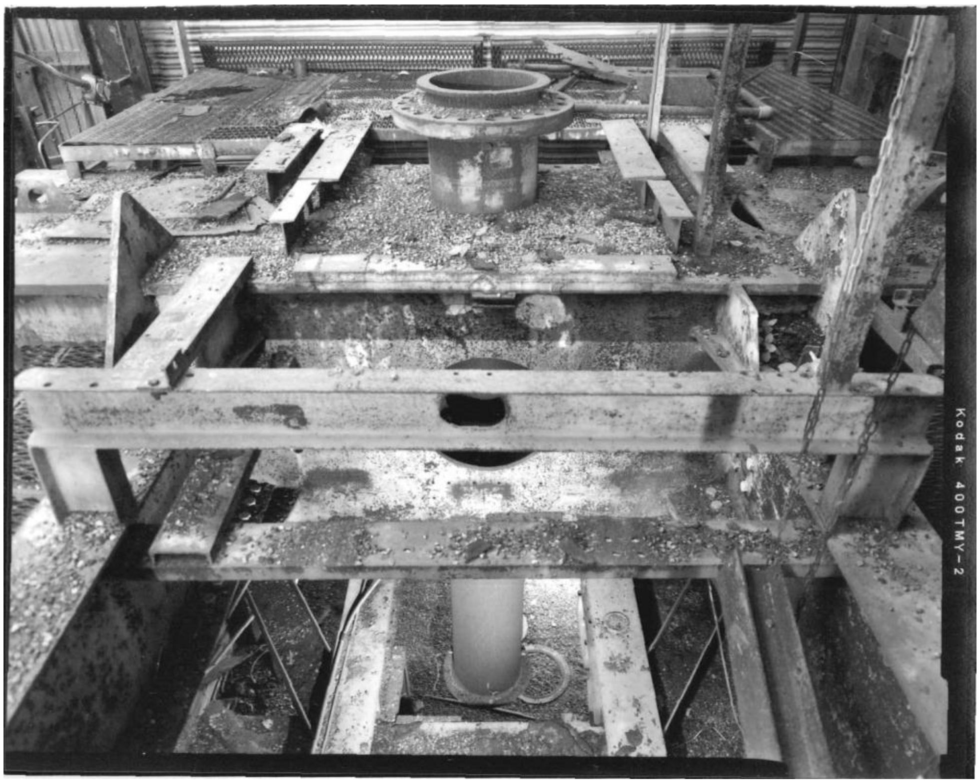
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-12



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-13



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

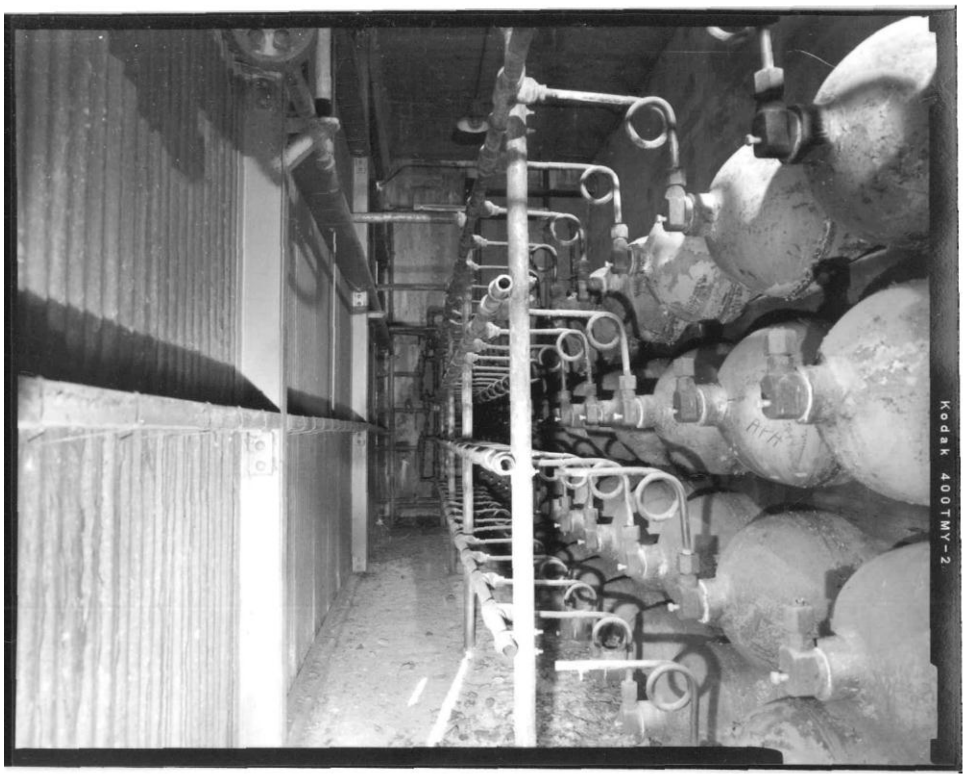
HAER No. NJ-XXX-14

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-15

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-16



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-17

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-18

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-19

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-20

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

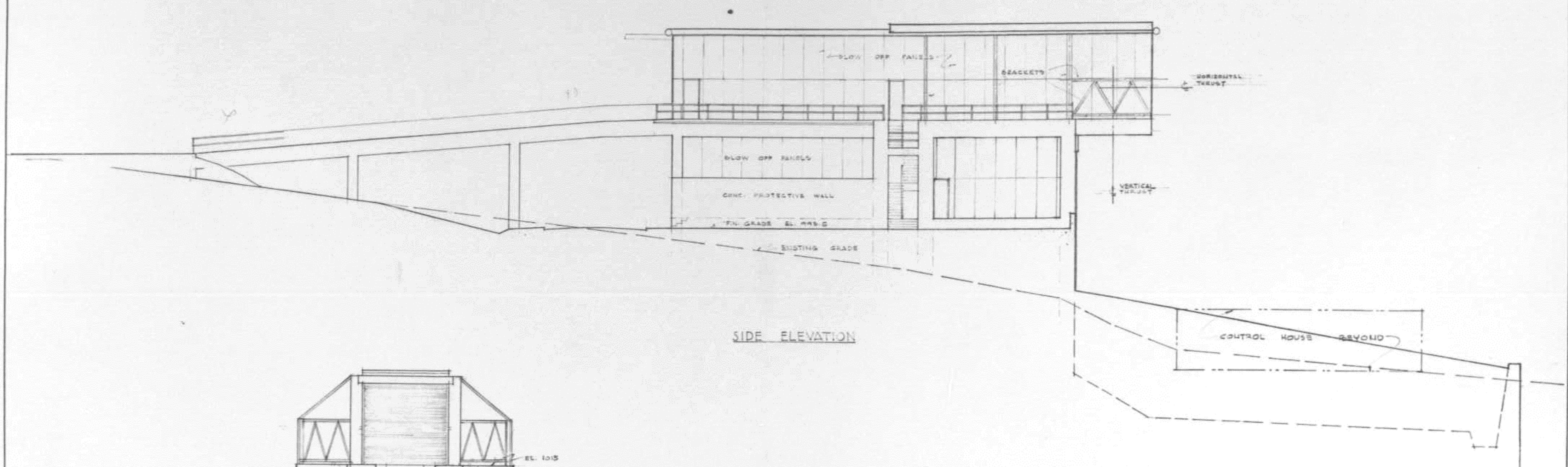
HAER No. NJ-XXX-21

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

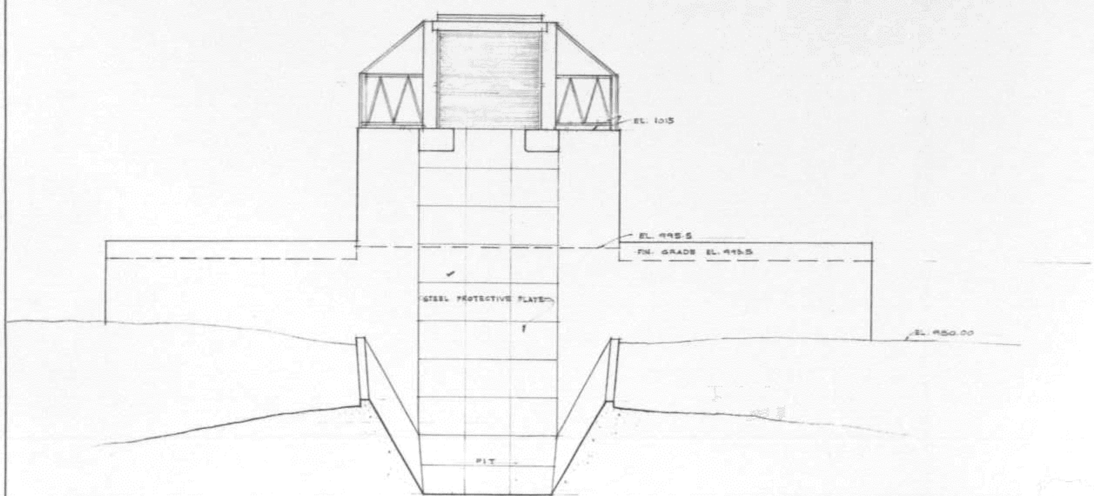
HAER No. NJ-XXX-22

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

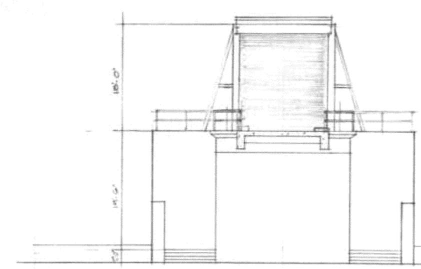
HAER No. NJ-XXX-23
(SEE VERSO)



SIDE ELEVATION



FRONT ELEVATION



REAR ELEVATION

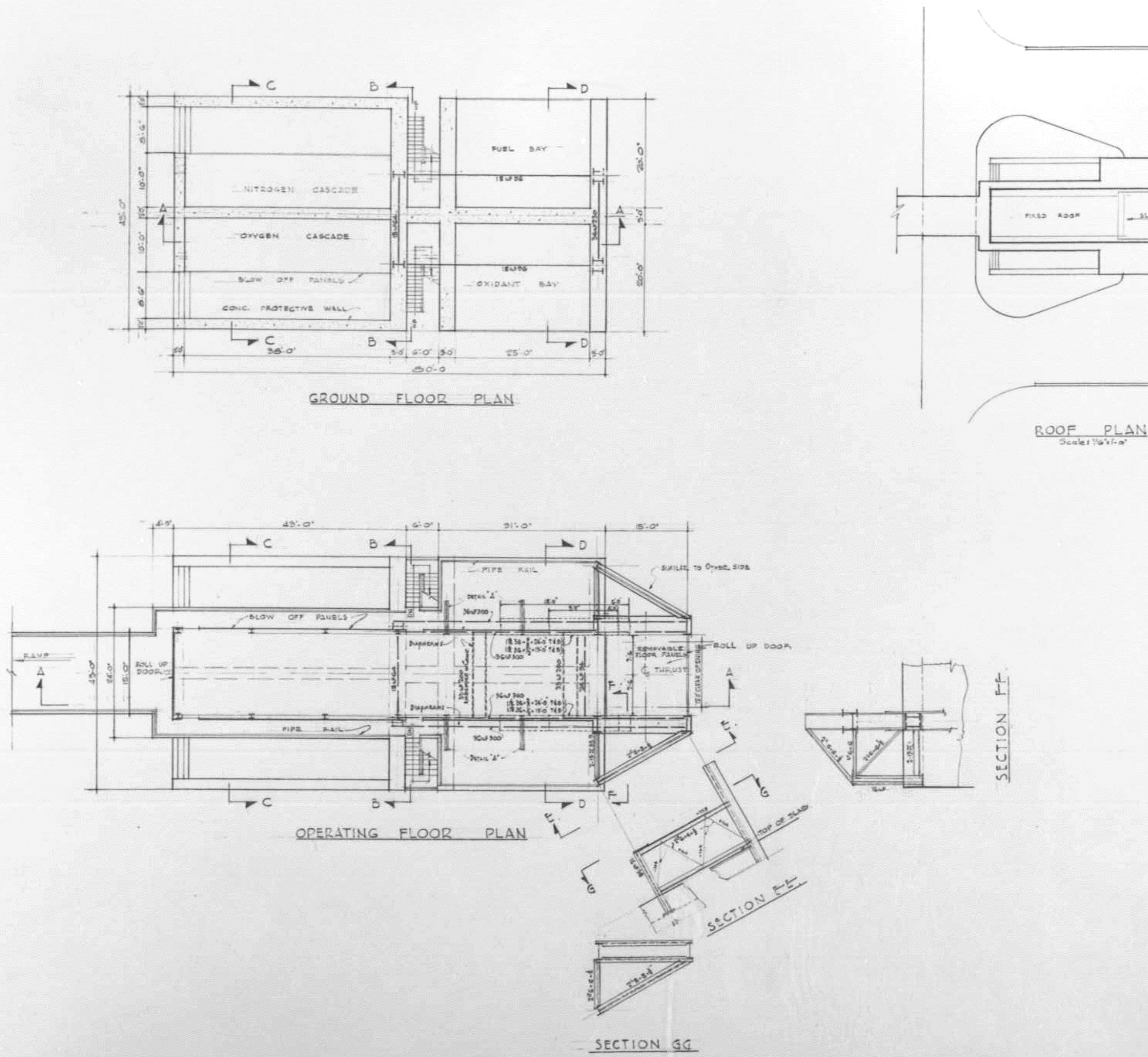
SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE NAVY — BUREAU OF YARDS & DOCKS
DISTRICT PUBLIC WORKS OFFICE - 3RD N.D. NEW YORK, N.Y.
FRANK GRAD & SONS - ARCHITECTS - ENGINEERS
NEWARK, N. J. - WASHINGTON, D. C.

DRAWN BY Q.K.	US. NAVAL AIR ROCKET TEST STA.
CHECKED BY C.D.	LAKE DENMARK DOVER N.J.
DATE 16 MAY '51	ROCKET TEST STAND E-1
SUBMITTED	
D.P.W. DRAWING NO 306-A-926	ELEVATIONS 3618
DIR. OF DES.	
PROJ. MGR.	APPROVED — DATE
COORD OF DES. & CONST.	
SATISFACTORY TO Chief Bur. Yards & Docks	SCALE 1/8" = 1'-0" SPEC.
DATE LETR. 15 AUG 1951	SHEET 3 OF 7 NOY
	Y & D DRAWING NO

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-24
(SEE VERSO)



SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE NAVY — BUREAU OF YARDS & DOCKS
DISTRICT PUBLIC WORKS OFFICE — 3RD N.D. NEW YORK, N.Y.
FRANK GRAD & SONS — ARCHITECTS-ENGINEERS
NEWARK, N.J. — WASHINGTON, D.C.

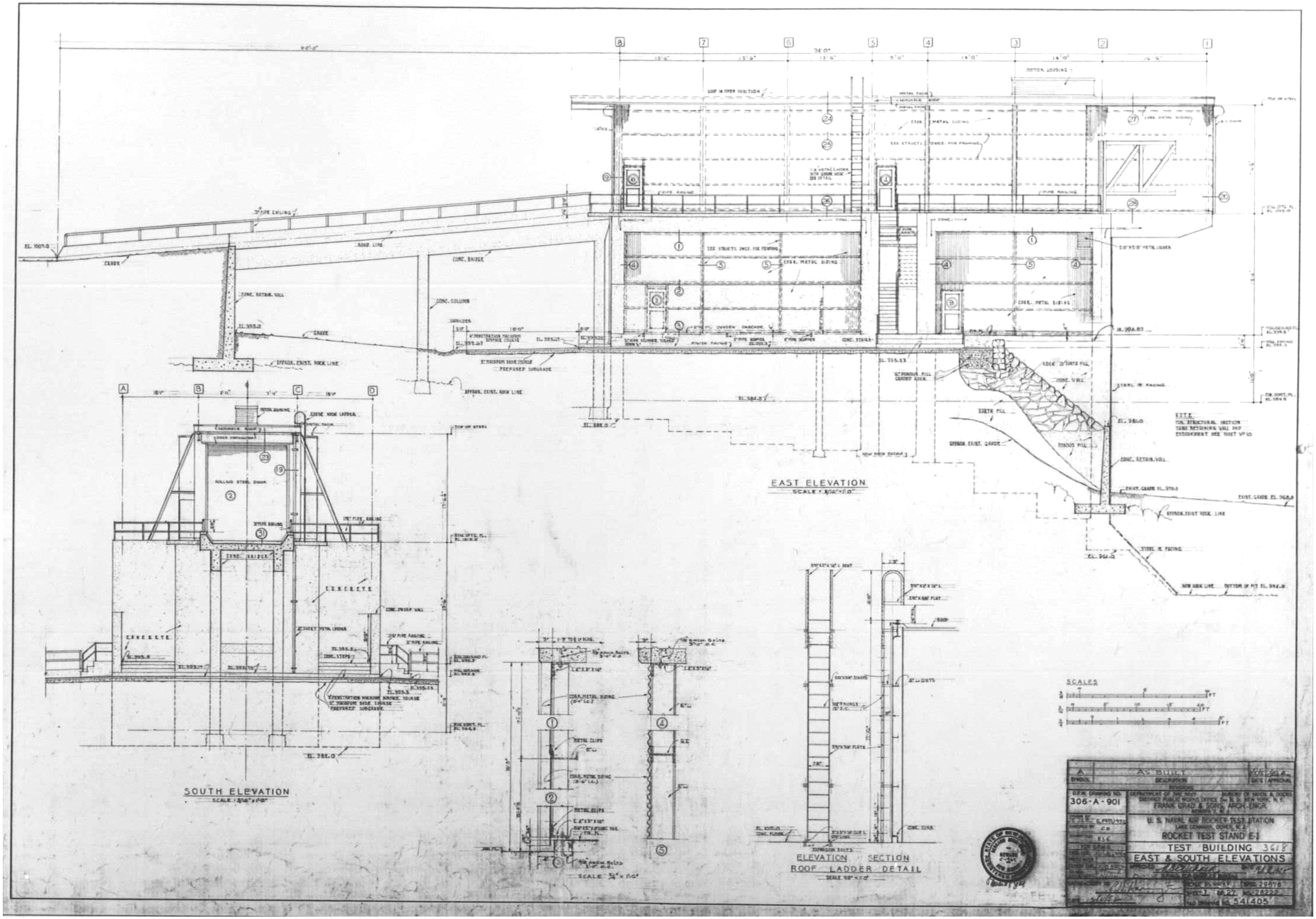
DRAWN BY G.K.E.L.F.
CHECKED BY H.P.M.
DATE 16 MAY 51
SUBMITTED
D.P.W. DRAWING NO. 306-A-925
DIR. OF DES.

US NAVAL AIR ROCKET TEST STA.
LAKE DENMARK-DOVER, N.J.
ROCKET TEST STAND E-1
PLANS 3618

PROJ. MGR.
COORD. OF DES. & CONST.
APPROVED
DATE Feb 8 1952
SATISFACTORY TO
CHIEF BUR. YARDS & DOCKS
DATE 15 Aug 1951
SCALE 1/8"=1'-0"
SPEC.
SHEET 3 OF 7
NOY
Y. & D. DRAWING NO.

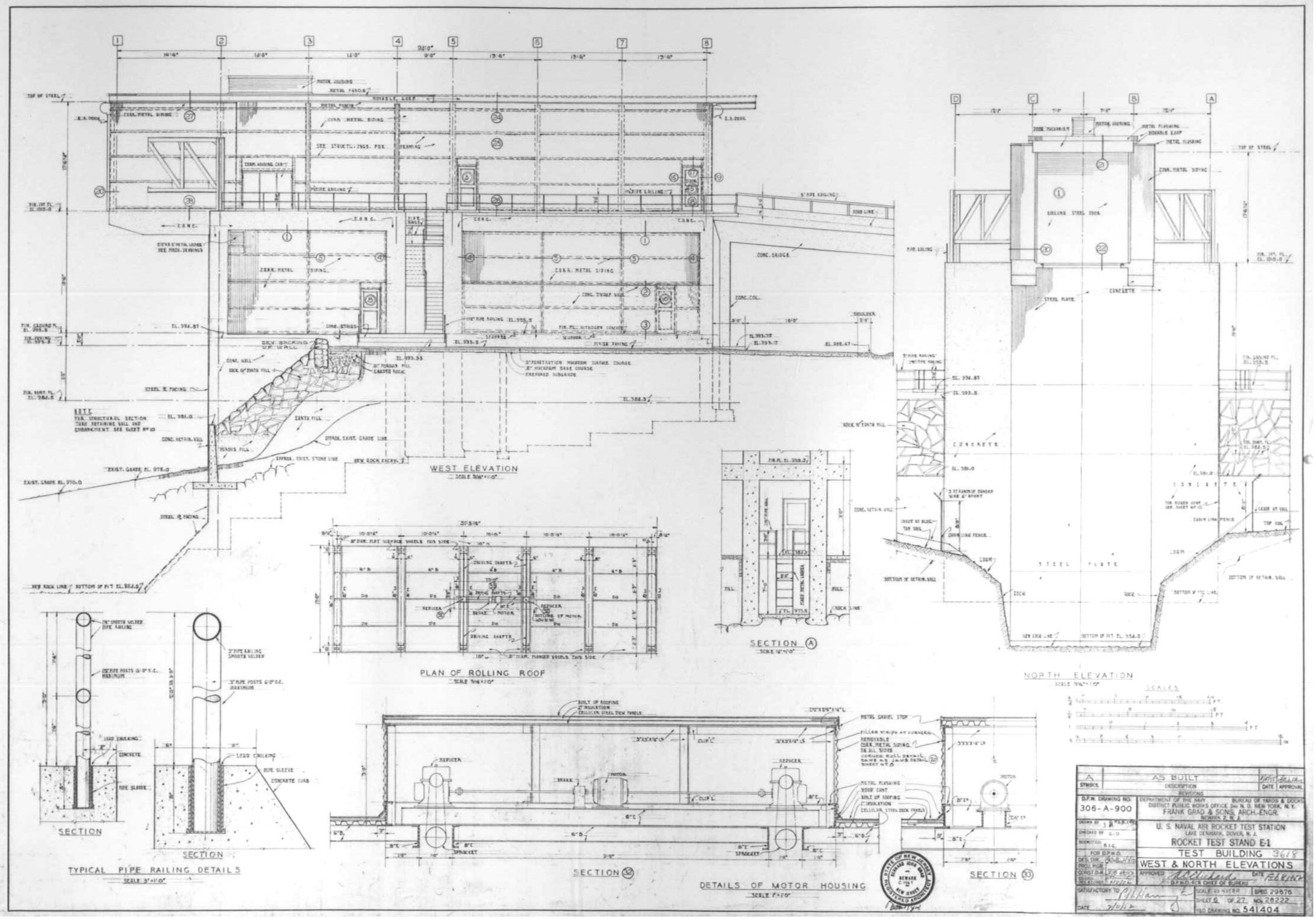
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-25
(SEE VERSO)


EAST ELEVATION
SCALE 3/16" = 1'-0"
SOUTH ELEVATION
SCALE 3/16" = 1'-0"
ELEVATION
SECTION
ROOF LADDER DETAIL
SCALE 3/8" = 1'-0"
SCALES
CONC. BRIDGE
CONC. COLUMN
CONC. RETAIN. WALL
ROLLING STEEL DOOR
CONCRETE
APPROX. EXIST. ROCK LINE
A
AS BUILT
SYMBOL
DESCRIPTION
DATE
APPROVAL
REVISIONS
D.P.W. DRAWING NO.
306-A-901
DEPARTMENT OF THE NAVY
BUREAU OF YARDS & DOCKS
FRANK GRAD & SONS, ARCH.-ENGR.
U. S. NAVAL AIR ROCKET TEST STATION
ROCKET TEST STAND E-1
TEST BUILDING 3618
EAST & SOUTH ELEVATIONS
SPEC. 29676
541405

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

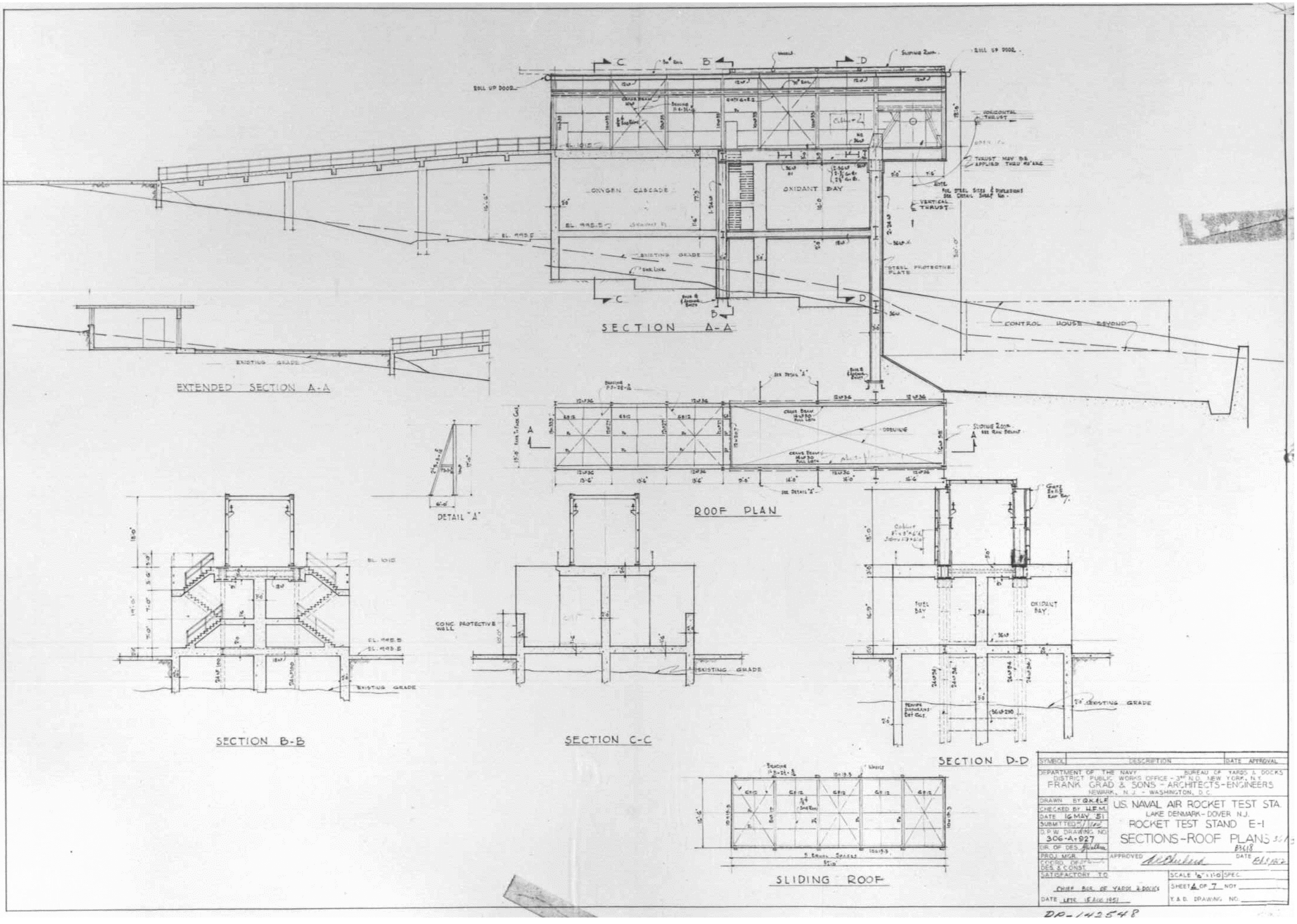
HAER No. NJ-XXX-26
(SEE VERSO)



WEST ELEVATION
SCALE 3/16"=1'-0"
NORTH ELEVATION
SECTION (A)
PLAN OF ROLLING ROOF
TYPICAL PIPE RAILING DETAILS
SCALE 3"=1'-0"
SECTION
SECTION
SECTION (32)
SECTION (33)
DETAILS OF MOTOR HOUSING
SCALE 1"=1'-0"
SCALES
A
AS BUILT
SYMBOL
DESCRIPTION
DATE
APPROVAL
REVISIONS
D.P.W. DRAWING NO.
306-A-900
DEPARTMENT OF THE NAVY
BUREAU OF YARDS & DOCKS
DISTRICT PUBLIC WORKS OFFICE 3RD N. D. NEW YORK, N.Y.
FRANK GRAD & SONS, ARCH.-ENGR.
NEWARK 2, N. J.
U. S. NAVAL AIR ROCKET TEST STATION
LAKE DENMARK, DOVER, N. J.
ROCKET TEST STAND E-1
TEST BUILDING 3618
WEST & NORTH ELEVATIONS
APPROVED
FOR CHIEF OF BUREAU
SATISFACTORY TO
SPEC. 29876
SHEET 6 OF 27 NO. 28222
Y&D DRAWING NO. 541404

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

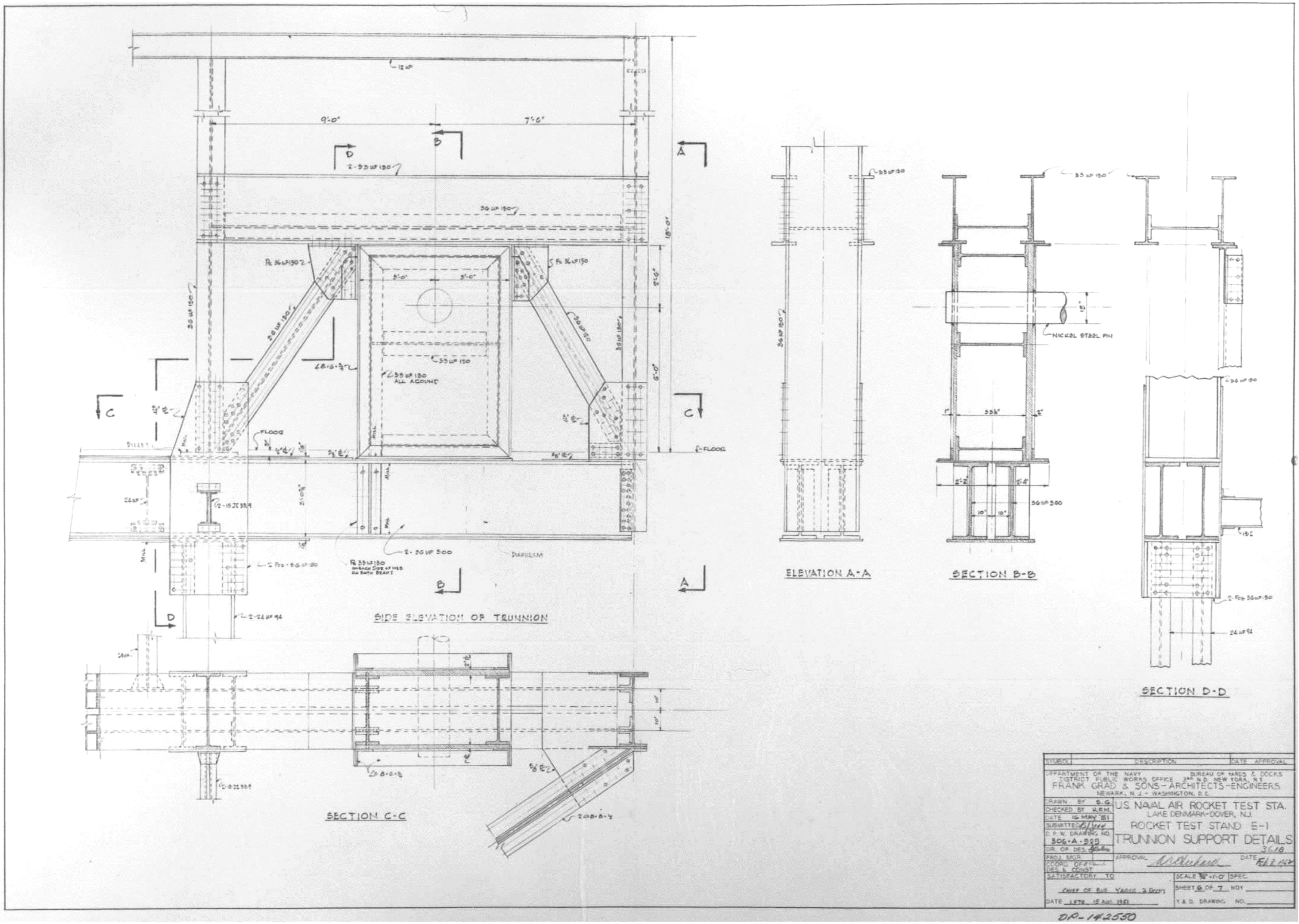
HAER No. NJ-XXX-27
(SEE VERSO)



SECTION A-A
EXTENDED SECTION A-A
ROOF PLAN
DETAIL "A"
SECTION B-B
SECTION C-C
SECTION D-D
SLIDING ROOF
OXYGEN CASCADE
OXIDANT BAY
FUEL BAY
CONTROL HOUSE BEYOND
STEEL PROTECTIVE PLATE
HORIZONTAL THRUST
VERTICAL THRUST
THRUST MAY BE APPLIED THRU 45° ANG.
EXISTING GRADE
CONC PROTECTIVE WALL
ROLL UP DOOR
SLIDING ROOF
EL. 1010
EL. 995.5
EL. 993.5
DEPARTMENT OF THE NAVY BUREAU OF YARDS & DOCKS
DISTRICT PUBLIC WORKS OFFICE - 3RD N.D. NEW YORK, N.Y.
FRANK GRAD & SONS - ARCHITECTS-ENGINEERS
NEWARK, N.J. - WASHINGTON, D.C.
U.S. NAVAL AIR ROCKET TEST STA.
LAKE DENMARK - DOVER N.J.
ROCKET TEST STAND E-1
SECTIONS-ROOF PLANS
DRAWN BY G.K.L.F.
CHECKED BY H.E.M.
DATE 16 MAY 51
D.P.W. DRAWING NO. 306-A-927
SCALE 1/8" = 1'-0"
SHEET 6 OF 7
CHIEF BUR. OF YARDS & DOCKS
DATE LTR. 15 AUG 1951
DR-142548

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. NJ-XXX-28
(SEE VERSO)


SIDE ELEVATION OF TRUNNION
ELEVATION A-A
SECTION B-B
SECTION C-C
SECTION D-D
NICKEL STEEL PIN
DIAPHRAGM
DEPARTMENT OF THE NAVY BUREAU OF YARDS & DOCKS
DISTRICT PUBLIC WORKS OFFICE 3RD N.D. NEW YORK, N.Y.
FRANK GRAD & SONS - ARCHITECTS - ENGINEERS
NEWARK, N.J. - WASHINGTON, D.C.
U.S. NAVAL AIR ROCKET TEST STA.
LAKE DENMARK-DOVER, N.J.
ROCKET TEST STAND E-1
TRUNNION SUPPORT DETAILS
SHEET 6 OF 7
DR-142550

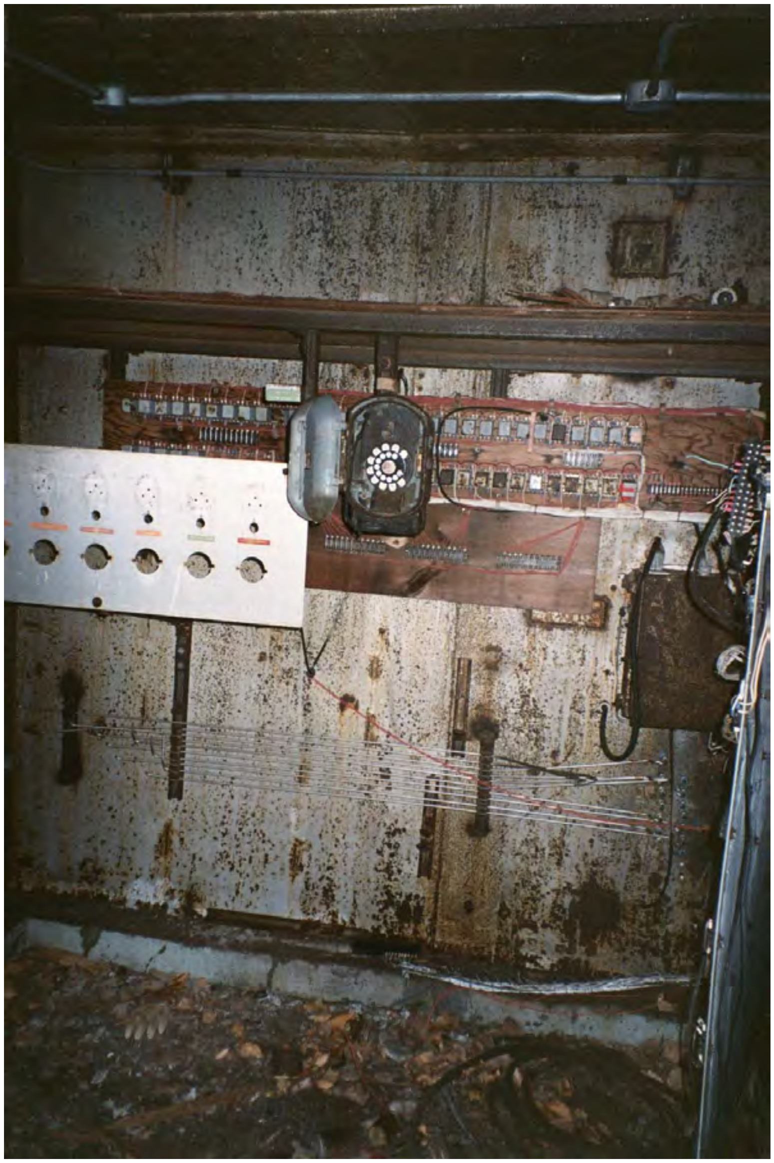
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 1.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 2.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 3.

Photograph 4.

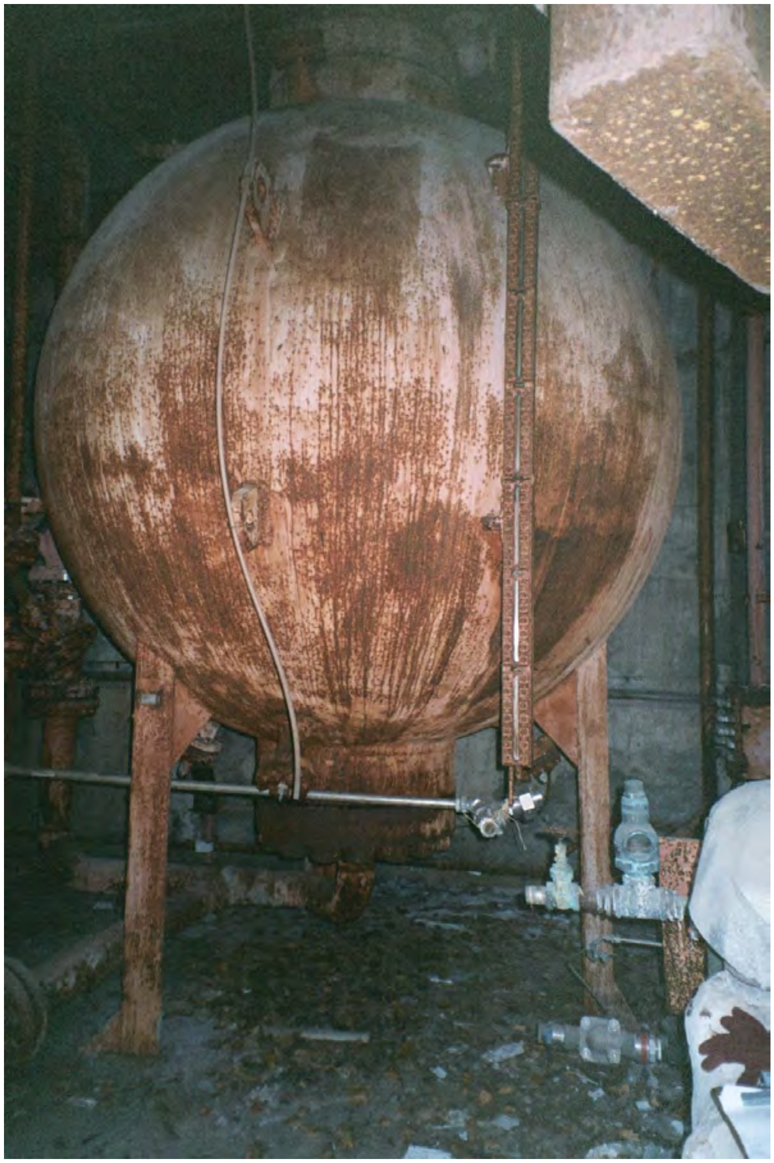
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 5.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 6.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 7.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 8.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 9.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 10.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 11.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 12.

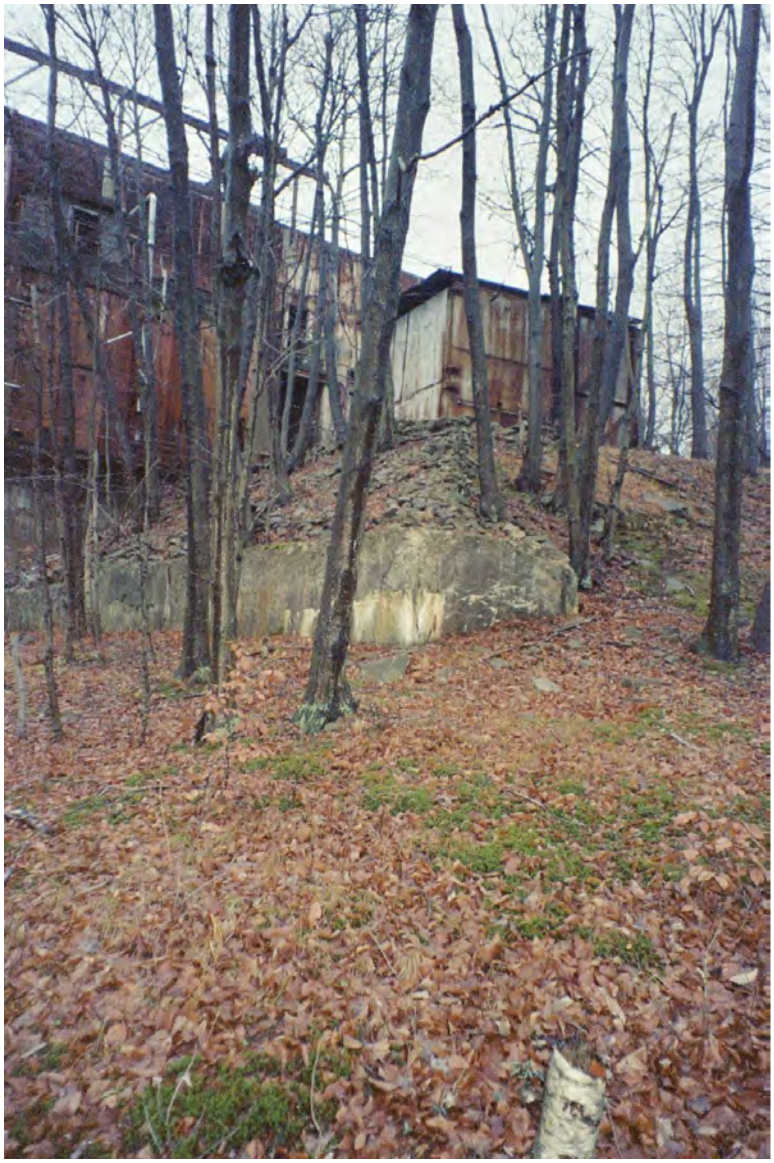
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 13.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX



Photograph 14.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 15.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 16.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

(SEE VERSO)

Photograph 1S.

Fig 1.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

(SEE VERSO)

Photograph 2S.

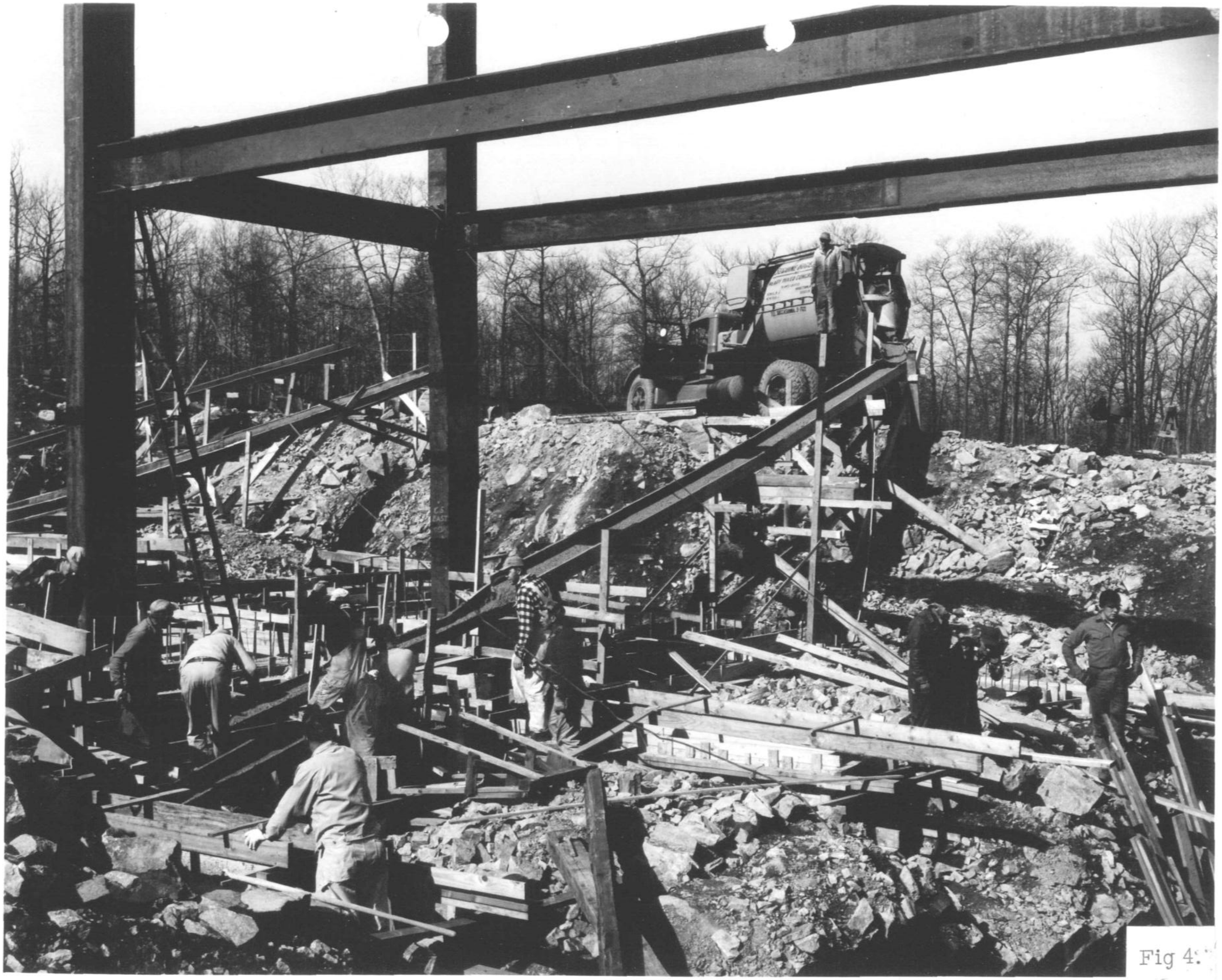


Fig 4.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

(SEE VERSO)

Photograph 3S.

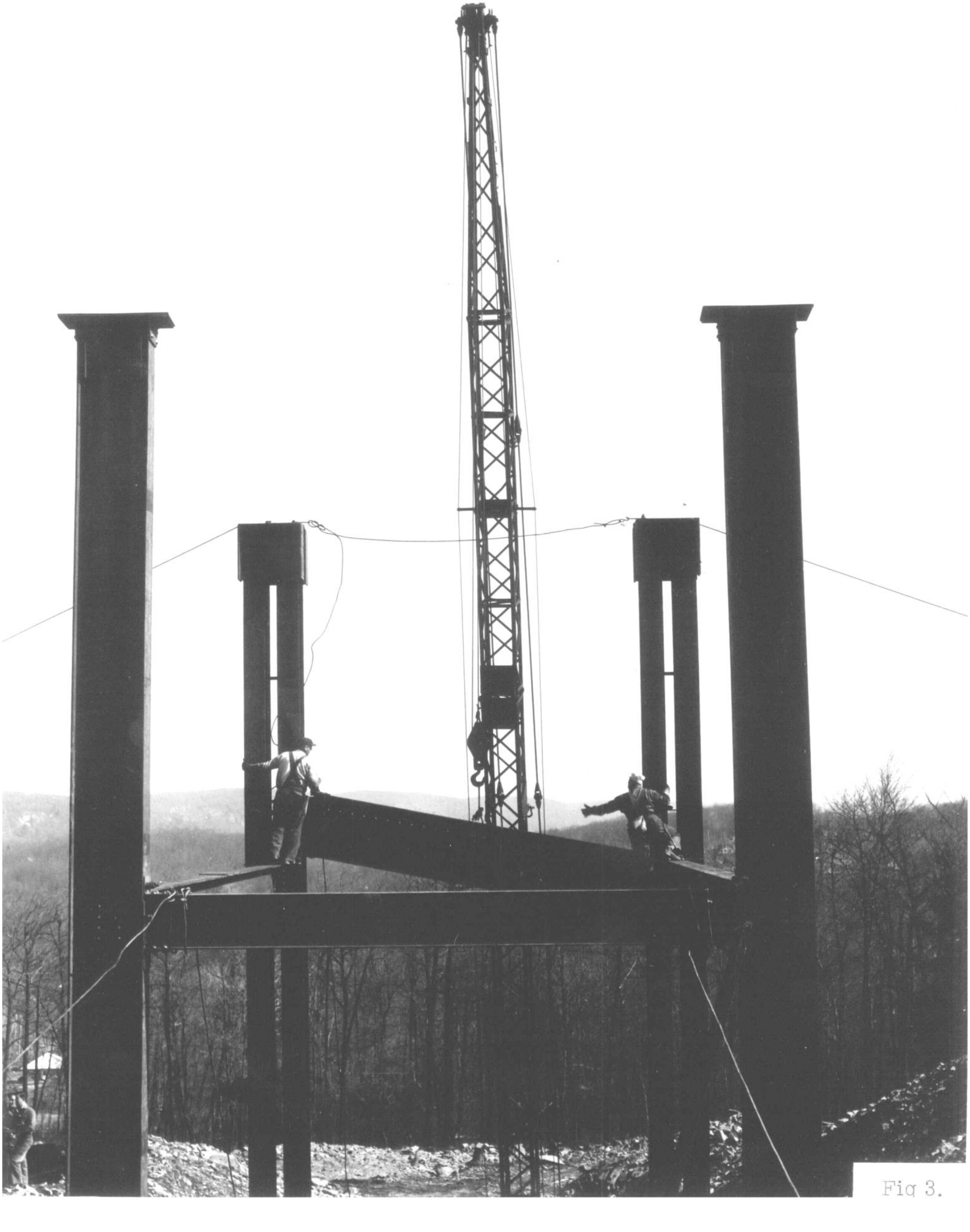
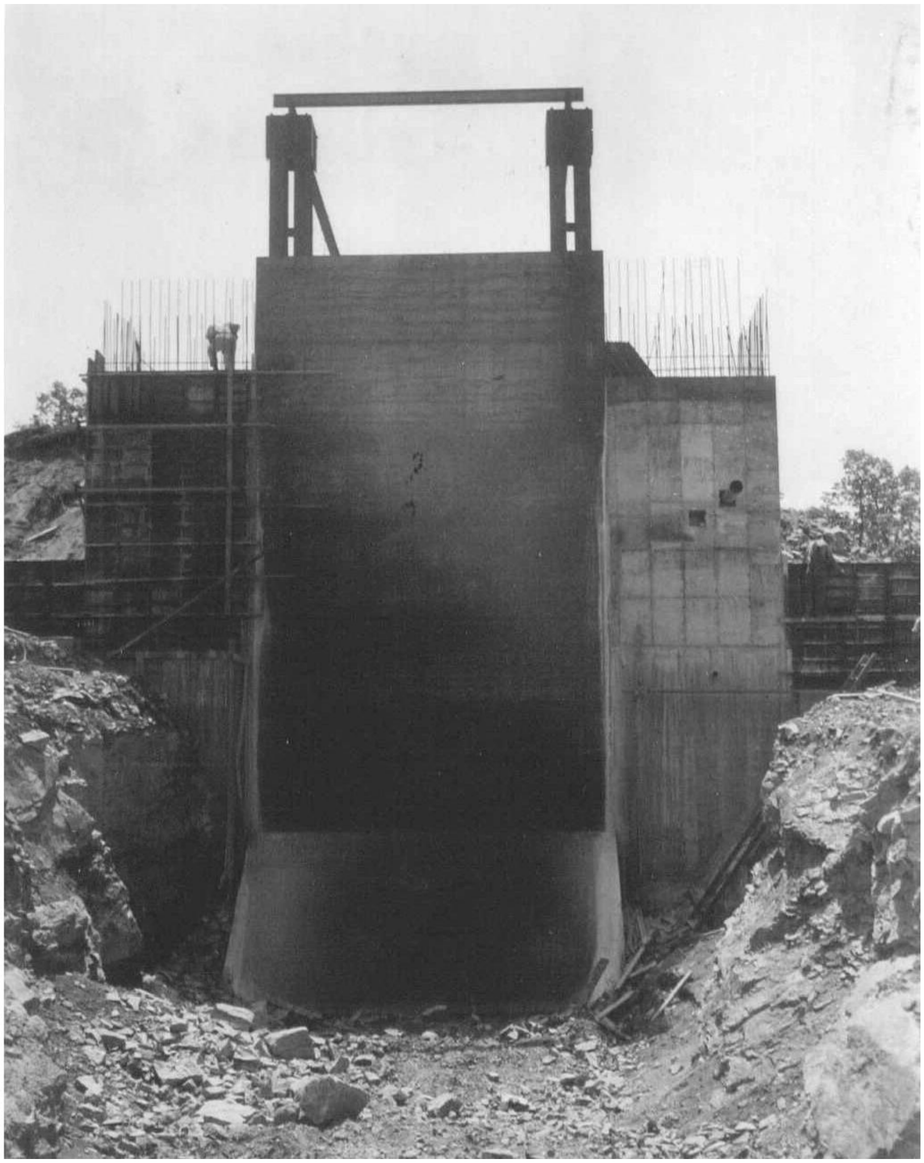


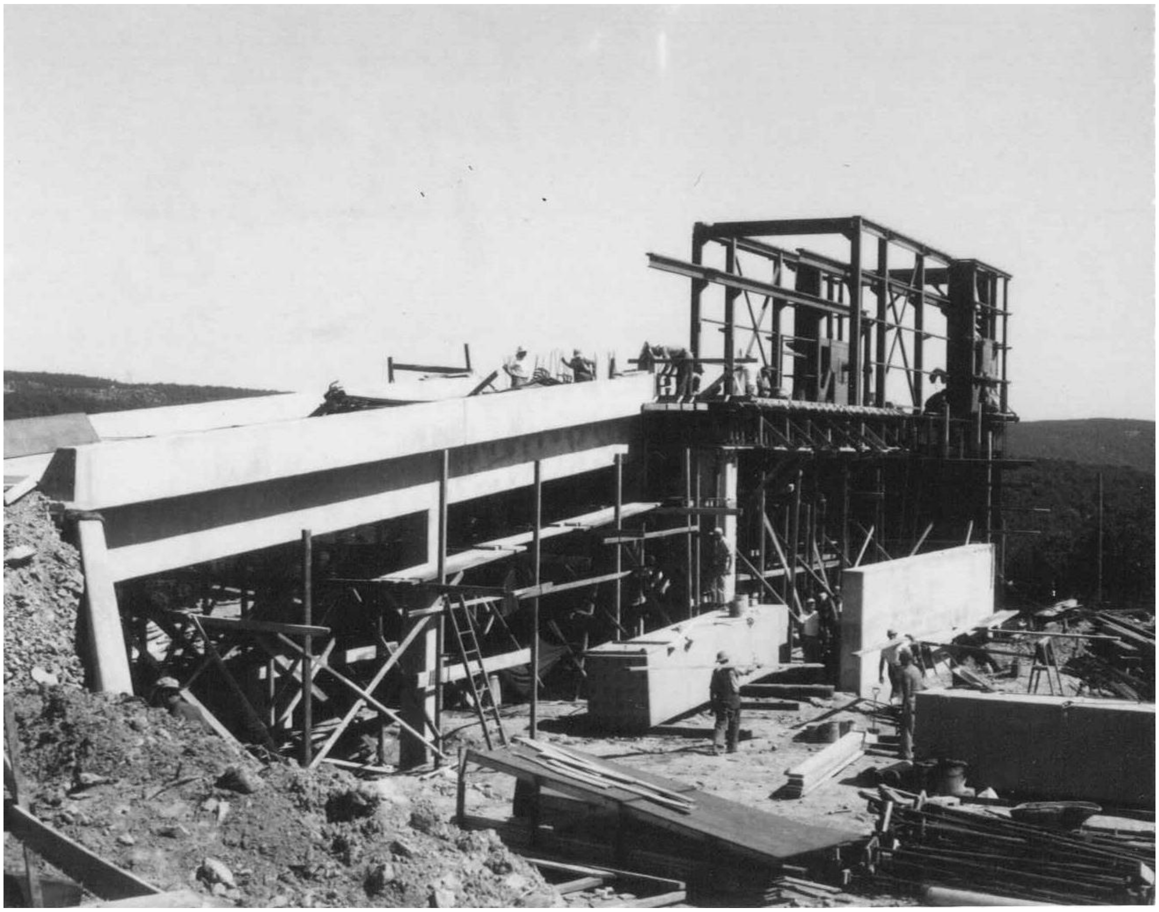
Fig 3.



Photograph 4S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

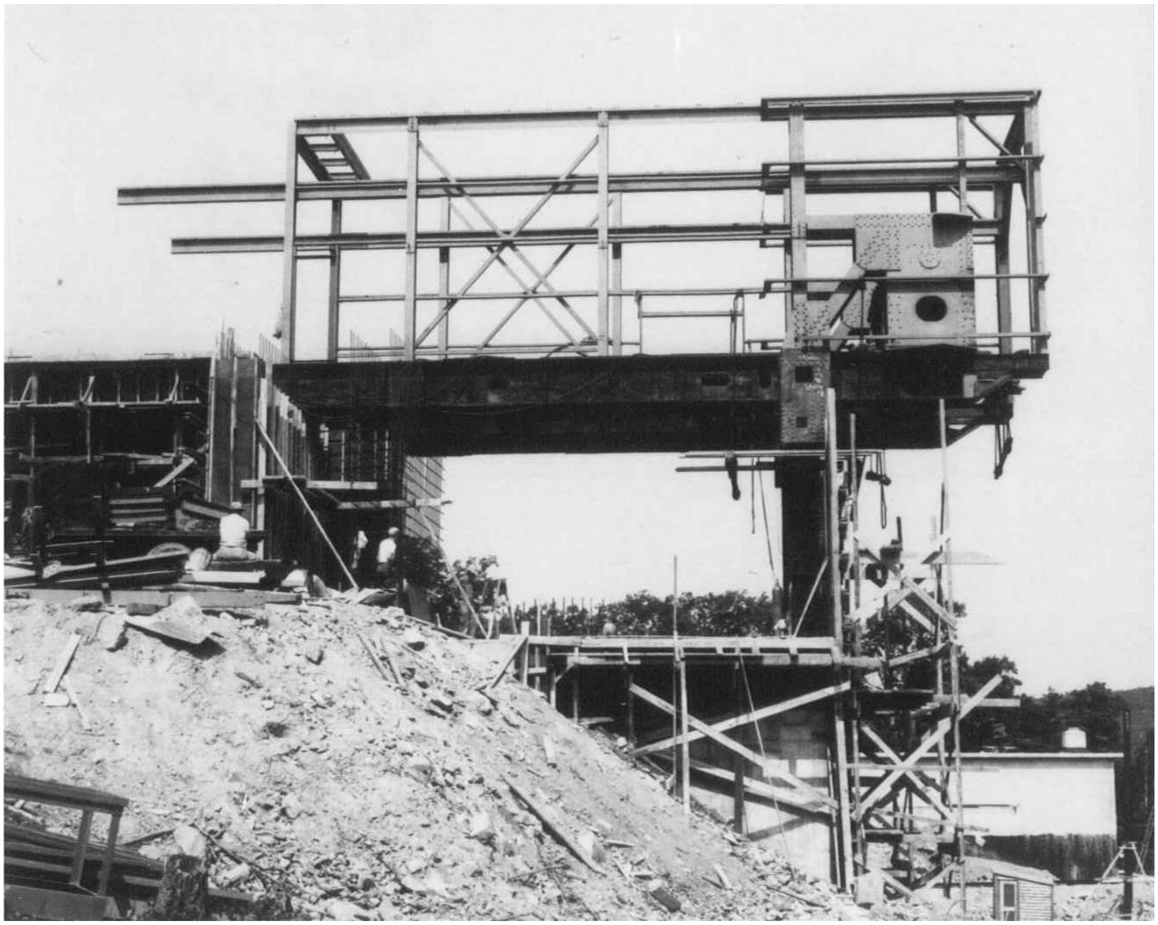
HAER No. NJ-XXX



Photograph 5S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX



Photograph 6S.

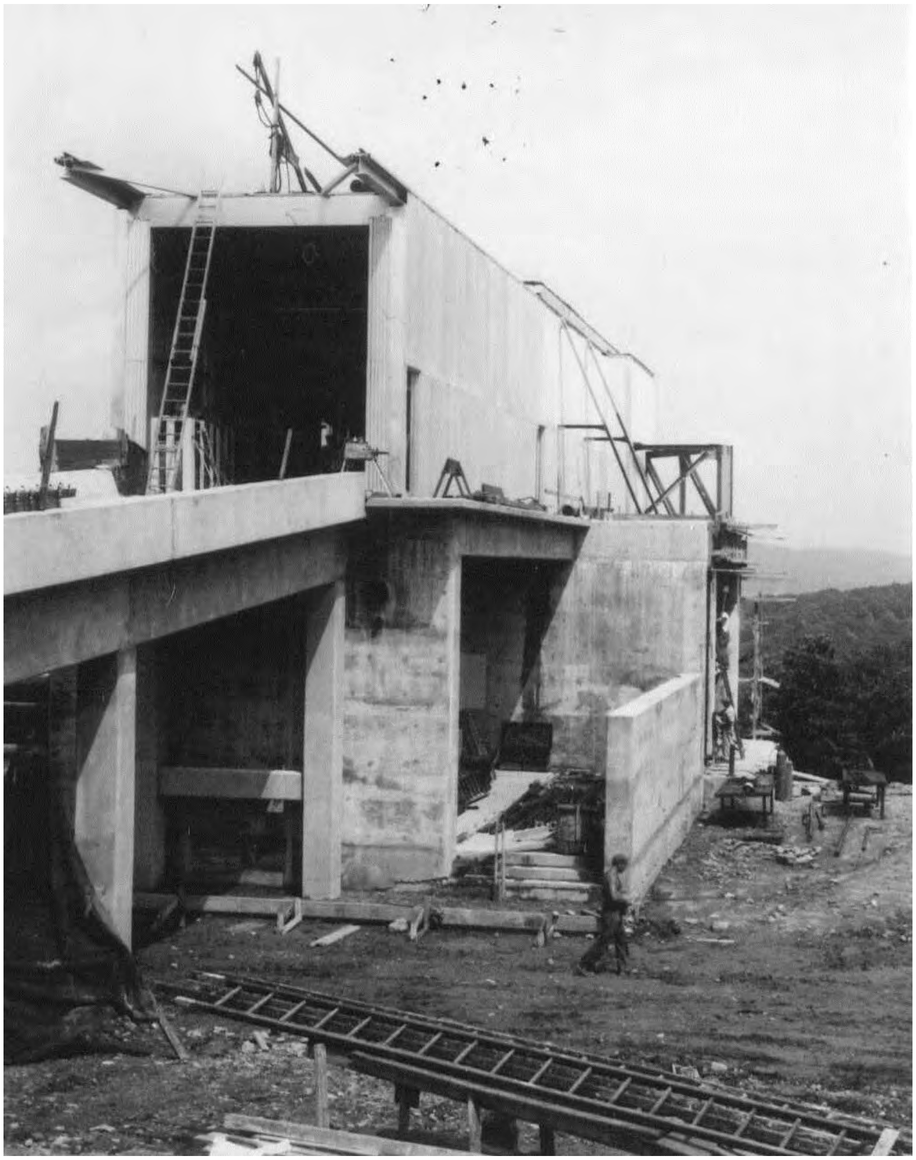
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 7S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

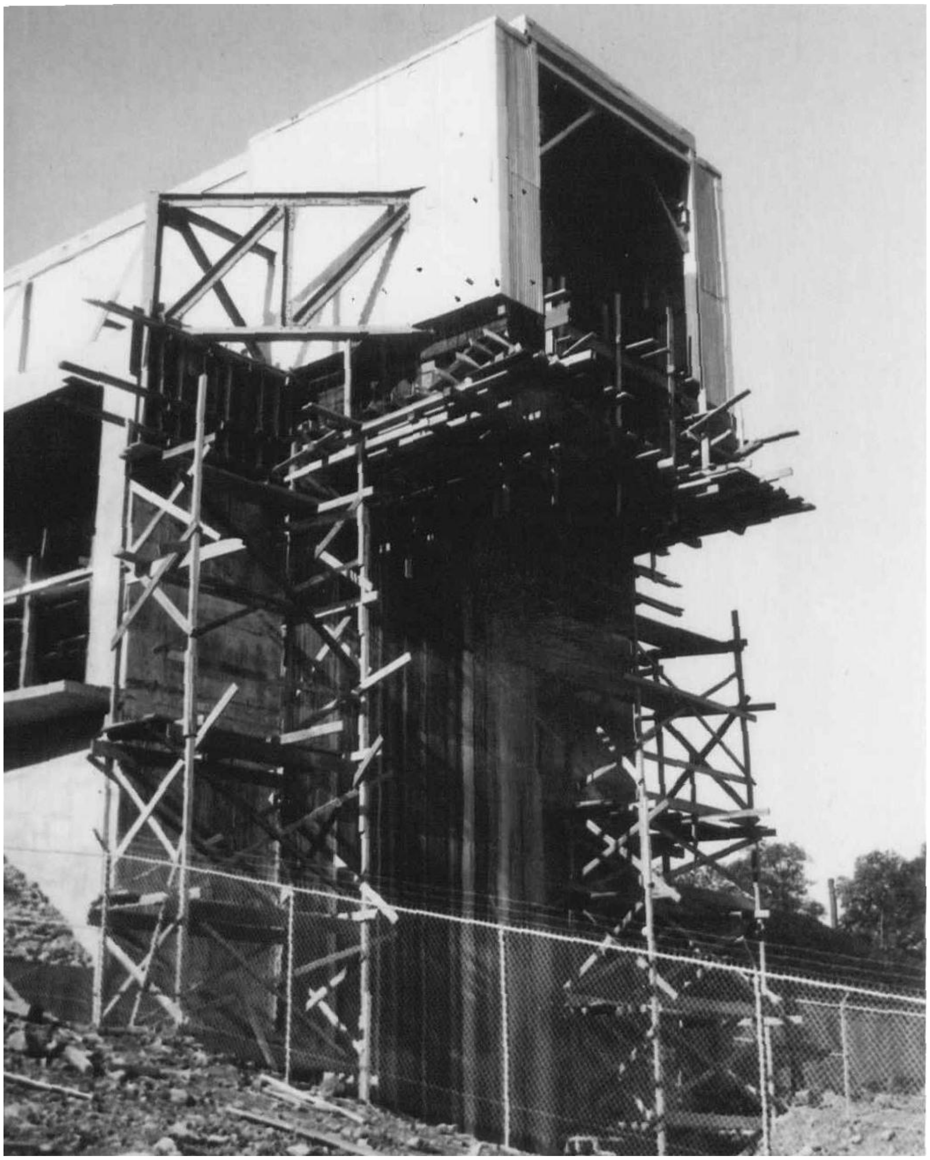
HAER No. NJ-XXX



Photograph 8S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

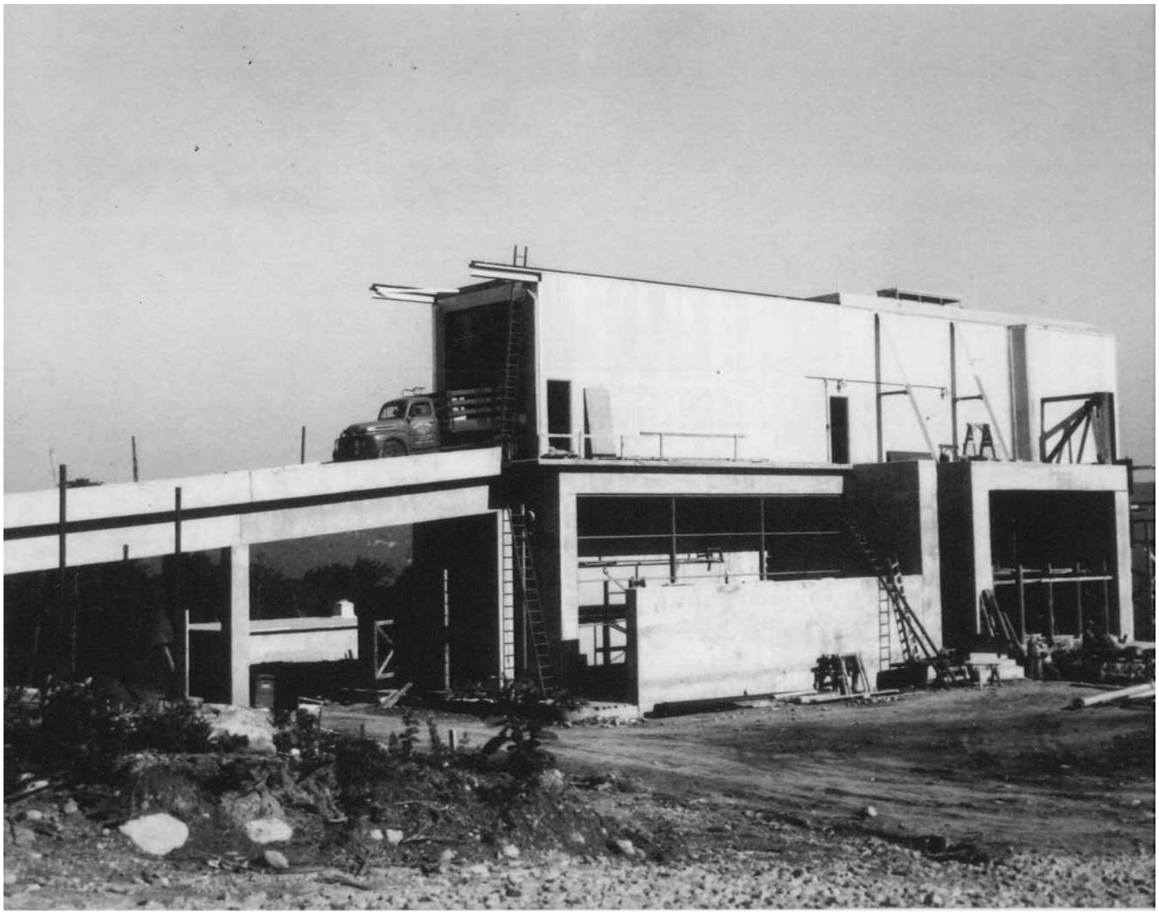
HAER No. NJ-XXX



Photograph 9S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 10S.

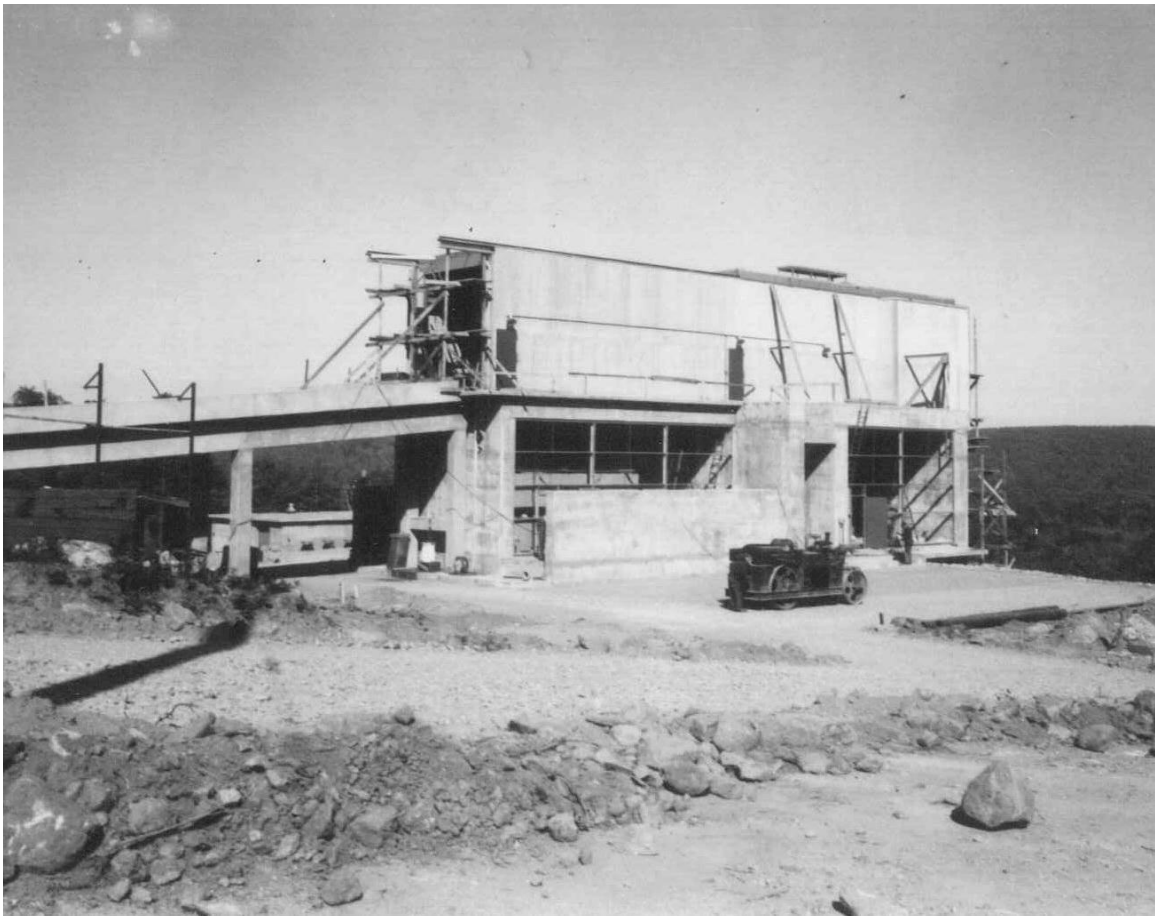
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 11S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

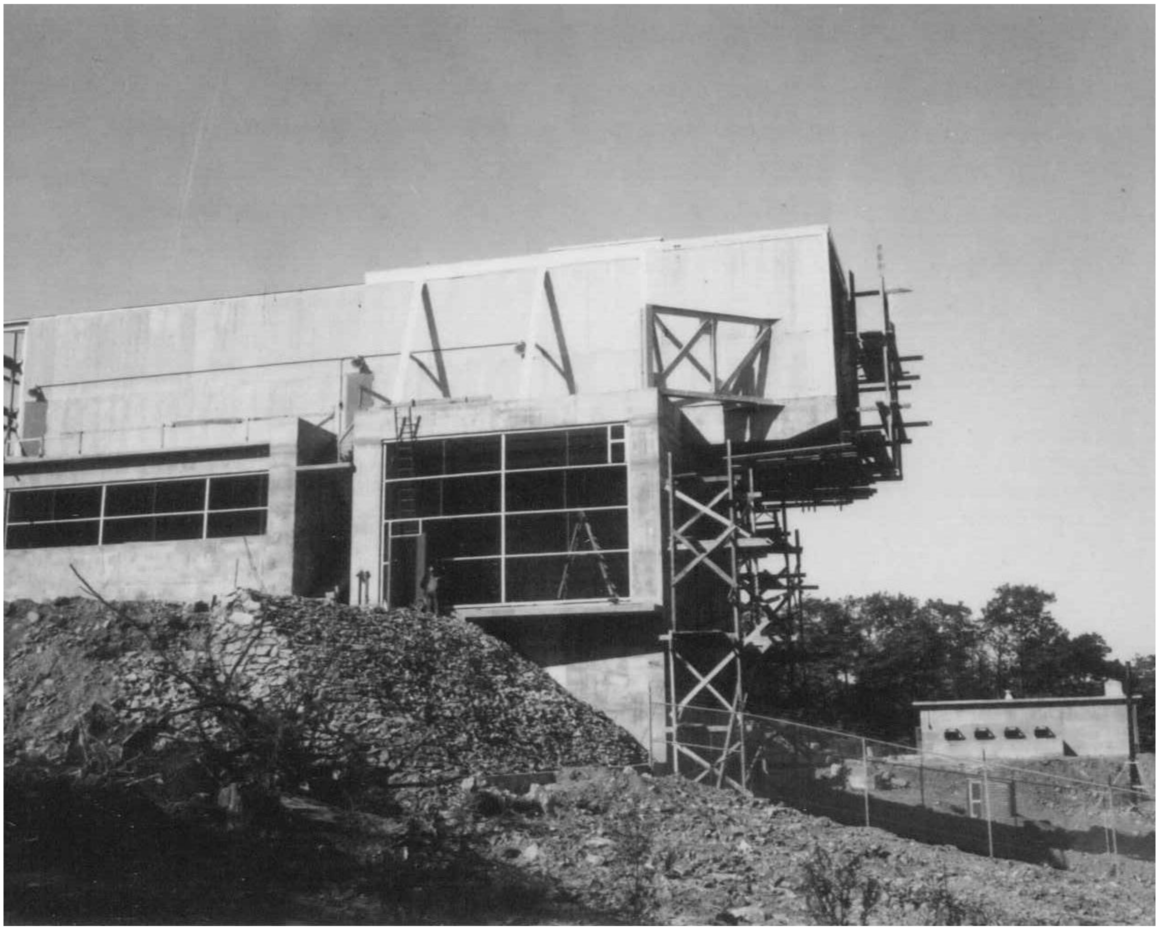
HAER No. NJ-XXX



Photograph 12S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

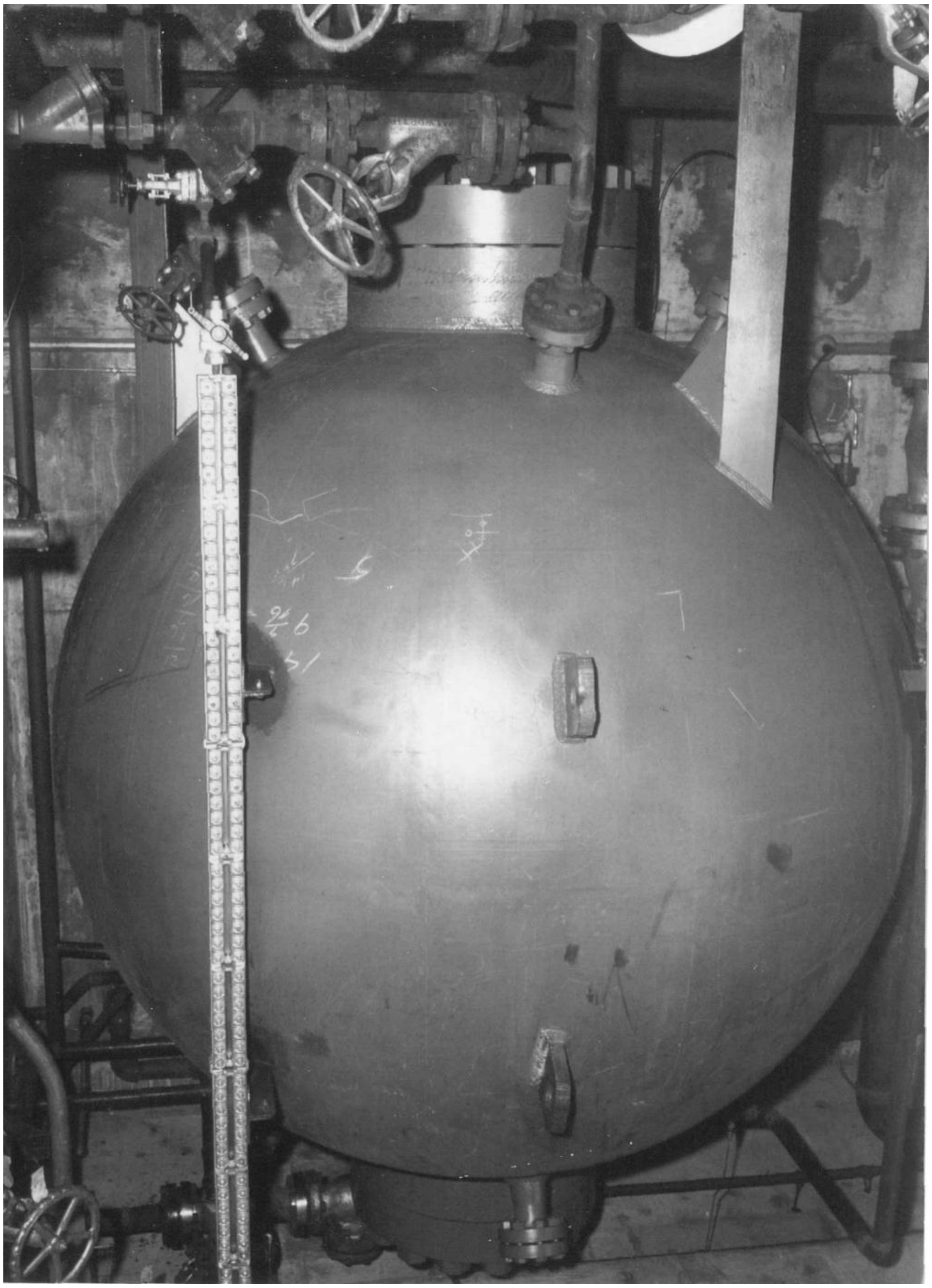
HAER No. NJ-XXX



Photograph 13S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

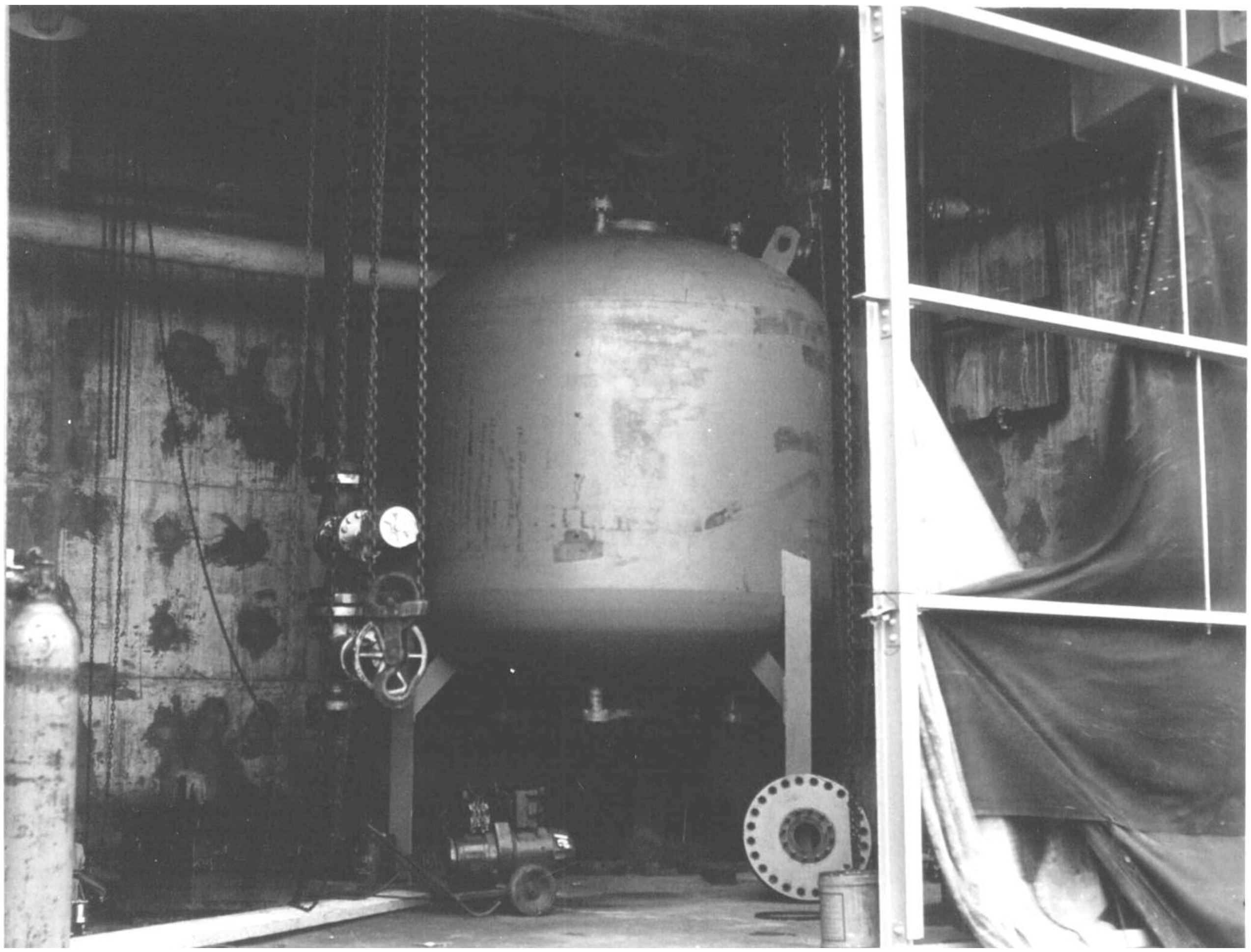
HAER No. NJ-XXX



Photograph 14S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX



Photograph 15S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR CAPTION

HAER No. NJ-XXX

Photograph 16S.

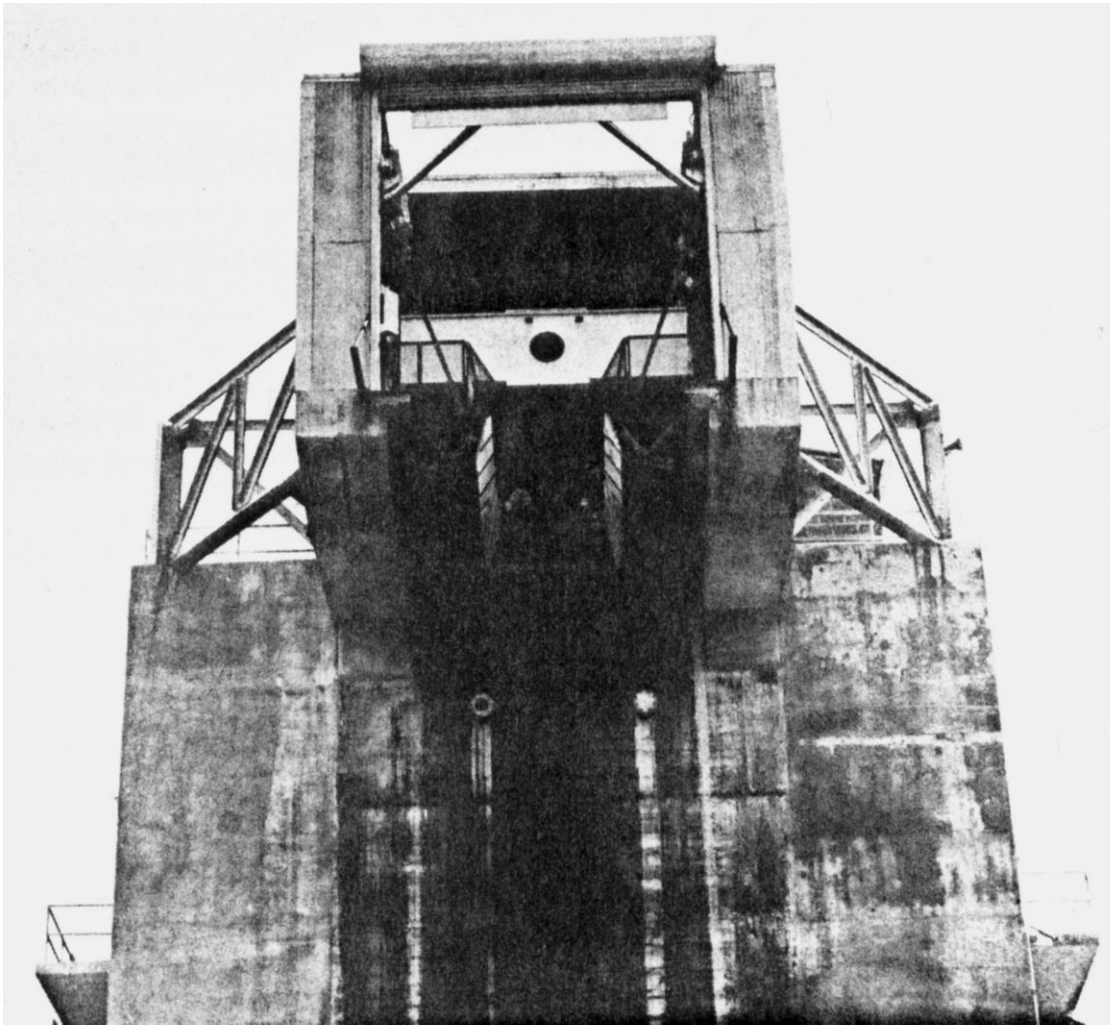
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX

Photograph 17S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

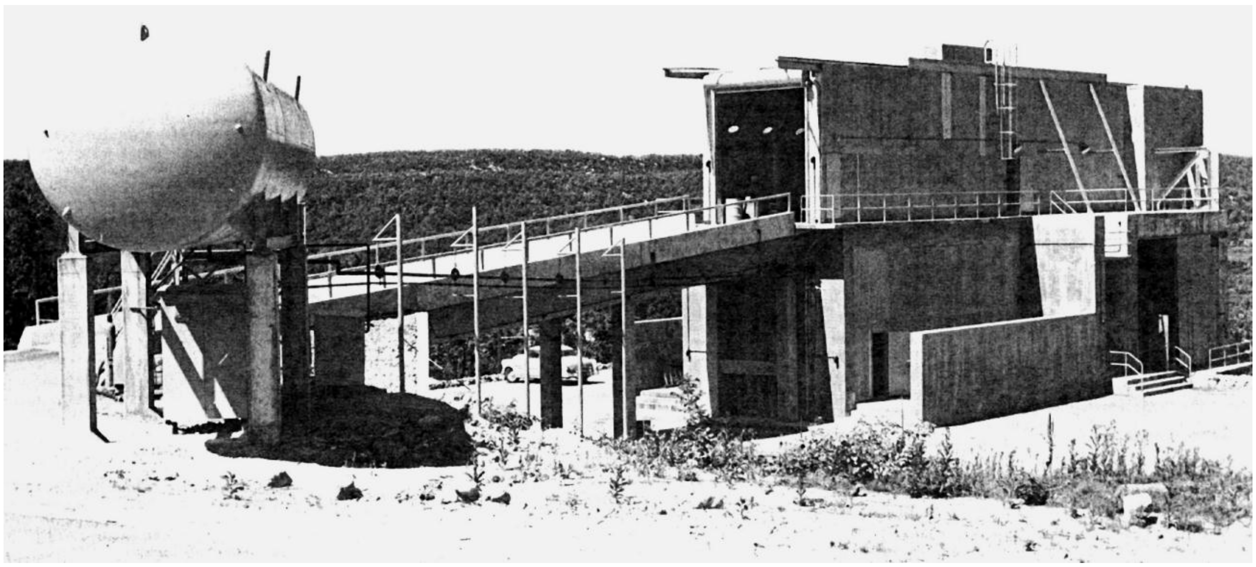
HAER No. NJ-XXX



Photograph 18S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

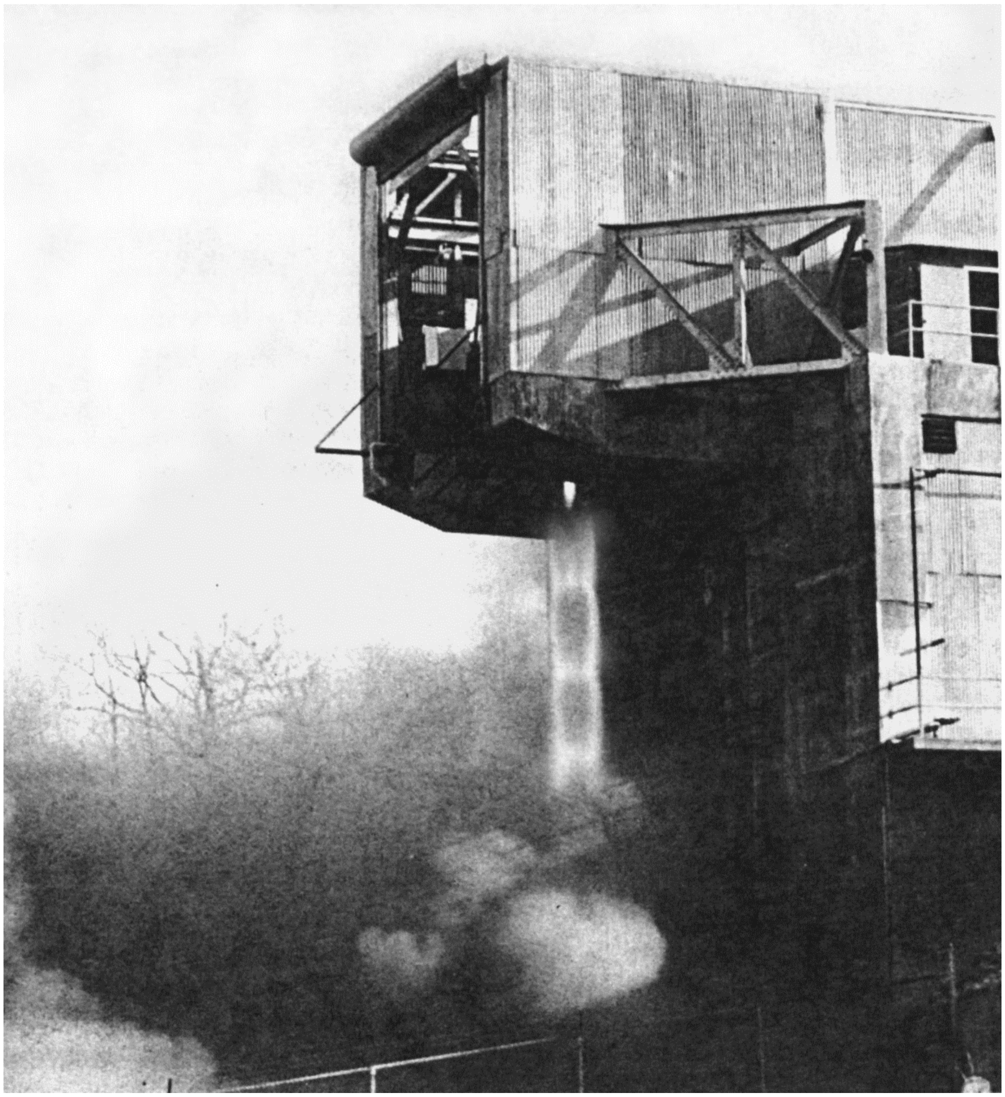
HAER No. NJ-XXX



Photograph 19S.

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO SUPPLEMENTAL MATERIAL FOR
CAPTION

HAER No. NJ-XXX



Photograph 20S.