ROCKET ENGINE TEST FACILITY – GRC BUILDING No. 100 HAER No. OH-124-D
(Rocket Propulsion Test Facility – Rocket Operations Building 100)
NASA Glenn Research Center
Cleveland
Cuyahoga County
Ohio

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Great Lakes Support Office
1709 Jackson Street
Omaha, Nebraska 68102

February 27, 2003

HISTORIC AMERICAN ENGINEERING RECORD

ROCKET ENGINE TEST FACILITY – GRC BUILDING No. 100
(Rocket Propulsion Test Facility – Rocket Operations Building 100)

HAER No. OH-124-D

Location: NASA Glenn Research Center
Cleveland
Cuyahoga County
Ohio
UTM: 17.427602.4584485
Quadrangle: Lakewood, Ohio 1:24,000

Date of Construction: 1957

Engineers: H. K. Ferguson Company

Architect: H. S. Kerline, et. al.

Present Owner: National Aeronautics and Space Administration – Glenn Research Center

Present Use: Building 100 is presently named the Research Projects Building. Portions of Building 100 are in use as office and shop space for various Glenn Research Center security programs. While some equipment in the rocket operations control room number 100 has been removed for use in other projects, the control panels and model boards are relatively intact. The northern half of the control room has recently been used for the control of a Densification Testing Program in Glenn Research Center's "South 40" testing area. The southern half of the control room has not been used since the Rocket Engine Test Facility was closed in June 1995.

Significance: The Rocket Engine Test Facility Complex is a National Historic Landmark, and Building 100 is included in the description of the complex on the National Historic Landmark nomination form. Building 100 is located 1,600' north of the Rocket Engine Test Cells in Building 202. Architects and engineers designed the facility using the aesthetic principles commonly applied to industrial and laboratory buildings. This building style conforms to that of the other structures at the Glenn Research Center. The building's significance lies not in its architecture but in the research that occurred in the control room area, which supported testing at the Rocket Engine Test Facility. The building's control room also shows several successful examples of adaptive reuse. Control technology and data acquisition here were frequently upgraded to take advantage of developments in computerization. Many controls and systems were built using the design skills of facility personnel who used highly innovative technology that was developed at the Rocket Engine Test Facility.

The control room provided a safe location for the equipment used to manage rocket engine tests. Test engineers monitored experimental runs through manual operation, programmed controllers, or full computer control. The control room also contained monitoring instrumentation, data acquisition devices, hydraulic servo systems, and controllers for valve operation. Programmable controllers and sequence timers regulated propellant flow, sequence timing, and automatic incremental, sequential, and cut-off control for the rocket engine being tested. Safety monitoring was also centralized in the control room. In 1957, National Aeronautics and Space Administration (NASA) personnel reduced acquired data using slide rules and manual computation. In later years they processed data through a 200-channel high-speed (31 KHz) digitizer multiplexer data acquisition system, and then transmitted the results to the NASA-Glenn central data processing system. Reduced data was immediately fed back to the control room computer monitors and printers. A closed-circuit television system and sound monitoring equipment allowed additional test observations. Most tests were photographed using 200 frame-per-second cinematography equipment.

Observers in an external blockhouse and in an observation post next to the test cell provided additional information on all engine performance tests until 1972. During that year the staff installed a closed-circuit television system and a camera on top of the blockhouse. Powerful lights illuminated the area and enabled viewers in the control room to observe tests on a monitor. This reduced the need for observers to be present inside the blockhouse. An intercom system, emergency communications set-up, and two telephone systems allowed two-way contact with test stand engineers and observers. These systems enabled collection of the real-time information needed to control and monitor rocket engine testing from a safe area. The control room and its systems represented a well-designed, safe facility for remotely controlling engine tests that used hazardous fuels and experimental engine designs. The performance of these tests could be unpredictable and dangerous.

The Rocket Engine Test Facility represented a significant advance in rocket engine testing because it was an integrated, dedicated facility designed specifically for testing liquid-fueled rocket engines and that had the ability to control and monitor operating parameters. The Rocket Engine Test Facility also could acquire and record operating conditions of engines being tested and preserve these data for later review and analysis. These capabilities represented a major advance over earlier test cells and rigs used for rocket engine testing. The engineering design information obtained at this control room was a major contribution to the development of space exploration vehicles.

Project Information: This documentation was initiated on May 15, 2002, in accordance with a Memorandum of Agreement among the Federal Aviation Administration, The National Aeronautics and Space Administration, The Ohio State Historic Preservation Officer, and the Advisory Council on Historic Preservation. The City of Cleveland plans to expand the Cleveland Hopkins International Airport. The NASA Glenn Research Center Rocket Engine Test Facility, located adjacent to the airport, must be removed to accommodate this expansion. To mitigate the removal of this registered National Historic Landmark, the National Park Service has stipulated that it be documented to Level I standards of the Historic American Engineering Record (HAER). This project was undertaken to fulfill that requirement.

Historian: Robert C. Stewart Historical Technologies, West Suffield, Connecticut

Site Description:

Building 100 is located on land now owned by NASA, but that was once part of the Cleveland Municipal Airport. From 1930-40, the airport expanded to cover more than 1,000 acres. During this period Cleveland Airport was home to the National Air Races, and the western portion of the airport served as a parking area during the races. In 1940 the National Advisory Committee on Aeronautics (NACA) decided to build its Aircraft Engine Research Laboratory on 200 acres of the airport site. This portion included the National Air Races parking lots and an adjacent strip of Cleveland Metropolitan Park land. In April 1947 the Aircraft Engine Research Laboratory was renamed the Flight Propulsion Research Laboratory to reflect its role in propulsion research. The name was changed again the next year to the Lewis Flight Propulsion Laboratory, in honor of George William Lewis.[1] In 1958 the name was modified to Lewis Research Center to reflect its becoming part of the new NASA, the core of which was NACA. In March 1999, the Lewis Research Center was officially renamed the NASA John H. Glenn Research Center at Lewis Field. Today, the Glenn Research Center at Lewis Field occupies more than 350 acres west of

[1]George Lewis served as Director of Aeronautical Research for the National Advisory Committee for Aeronautics (NACA) from 1923-47. Under his leadership, NACA's Langley Research Laboratory established its reputation for outstanding contributions to aeronautical knowledge, which included both basic engineering research and testing. Lewis was responsible for obtaining funding for NACA's many unique test facilities. During World War II he oversaw the building of two additional national aeronautical research laboratories. The Lewis Flight Propulsion Laboratory was named after Lewis because of his important role in NACA.

Cleveland Hopkins International Airport.[2] A map in the graphics section of this report can be used to locate the facility.

Building 100, the Rocket Engine Test Facility operations building, is on a flat, featureless area at an elevation of 761' above sea level. It stands close to the eastern edge of a steep ravine through which Abram Creek flows. Access to the site is through a driveway off Walcott Road in the NASA-Glenn complex at Lewis Field. The immediate area contains several other laboratory buildings, notably the Materials and Structures Laboratory and the High Temperature Composites Laboratory. Nearly all the buildings are of similar design and contribute to a harmonious setting that reflects their common function.

Description of Building 100:

The building has a T-shaped plan, in which the longer leg of the building houses offices while the shorter perpendicular section contains laboratories and the Rocket Engine Test Facility Control Room. Most of the building exterior is clad in buff-colored brick and is largely unornamented. The brick is laid in running or stretcher bond,[3] except in one area over the entrance canopy and over the granite planters at the main entrance. In these two areas, a soldier course of vertically laid brick accentuates the building features. The use of limestone trim, granite planters at the main entrance, and insulated metal wall panels with vertical corrugations on the high bay created a visually interesting building in harmony with its surroundings.

Most of the building is one story in height, but the southern part of the facility is a two-story, high-bay zone originally designed as a shop area. This part of the facility currently houses offices. The northern portion of the building contains the control room for the Rocket Engine Test Facility. A basement under the control room contains utilities, electrical switchgear, and an entry tunnel for steam pipes. The basement also provides access from below to the wiring chases, control console, and model board. The roof consists of a four-ply built-up membrane laid over 1" of insulation that rests on a steel deck.[4] Illustrations in the graphics section show the elevations and plan of the building.

Office Wing:

Except for the excavated basement beneath the control room, the building rises from a concrete foundation slab that measures 1' in thickness. The office section of the building consists of eight bays. The lower portion of the exterior wall is buff-colored brick that terminates in a sill course

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[2] National Aeronautics and Space Administration. *Lands of the Lewis Research Center* (Cleveland: National Aeronautics and Space Administration, 1978), 13-14.

[3] In a running bond all bricks are laid lengthwise with the vertical joints of one course centered between those of adjacent courses.

[4] Drawing CE-101440 – 6/29/55.

just below a cut limestone belt. This belt forms the sills and a visual anchor for the windows. Each bay has a fresh air intake in its center, just above the concrete slab. Cut limestone mullions visually separate the bays.

Lintels of cut limestone delineate the tops of windows. This continuous belt visually resembles a jack arch. Several courses of buff-colored brick extend between the top of the windows and a cut limestone coping that delineates the edge of the roof. Aluminum-frame windows are set on the limestone sill, and each window is divided into three sections in each bay. Each section in the longest facade of the wing has two lights. Three bays form the short or end facade of this wing. The two outer bays have the same aluminum-frame windows of similar overall dimensions, however, these windows are divided into four sections, while the center bay has a three-section window. The upper light, comprising approximately two-thirds of the area of all windows, is fixed. Lower lights are hinged at the top to open outward. All exterior glazing is of heat-absorbing glass.

Fourteen offices, each with a surface area of 226.5 square feet, are arranged along the long sides of this wing. The short or end section contains three offices, two of which have a surface area of 195 square feet, and one of which covers 144 square feet.

Lobby:

Entrances open into the north and south sides of the central portion of the building, where the two sections of the plan intersect. A small terrace on the north side of the building precedes the main entrance. Metal canopies protect both entryways. Originally there were exterior and interior sets of three single glass doors. These doors were replaced by single sets of double doors to create a wider opening and to comply with the requirements of the Americans with Disabilities Act. When the form of the door changed, the two steps leading to the small terrace were replaced with a ramp. Fixed granite planters flank the exterior doors and delineate the terrace. The doors open into a central lobby that measures 488 square feet and leads to the building wings and control room. A three-dimensional scale model of the Rocket Engine Test Facility is on display on one wall of the lobby. As originally designed, the central portion of the building housed men's and women's restrooms, janitor's closets, a stairway to the basement, and a locker room with shower that was accessible only from the high bay.[5]

High Bay:

The high bay is sheathed in corrugated metal panels with a rigid insulating material on the inside face. The vertical corrugations provide a pleasing contrast to the otherwise horizontal lines of the building. These panels originally formed a workspace measuring approximately 60' x 48', for a total surface area of 2,880 square feet. The high bay measures 21'-6" in height. Windows in the high bay area consist of two sections. The upper section is a fixed aluminum-frame sash that

[5] Drawing CE-101441 – 6/29/55.

measures about four feet square and contains six lights arranged in two columns of three lights. The lower section of one of these windows contains fourteen lights in an aluminum frame. The lowest, central, and uppermost lights are fixed and contain two lights, side by side. The two opening sashes between the fixed lights contain six lights arranged in two groups of three, side by side. These are contained in a frame that has a center horizontal pivot. Crank and lever systems within the high bay control the opening of these windows. The east side of the high bay has thirteen of these window arrangements centered on the facade of the building. The south facade of the building is marked by four of the same window arrangements, two on either side of a centrally located rolling service door that retracts upward to form an opening that measures 14 square feet.[6]

A pit measuring 12 square feet was centered along the north wall of the high bay area. Through this pit, equipment could be lowered into the basement area under the control room.[7] The original bridge crane, which travels along a north-south trajectory, moved heavy equipment around the mezzanine.[8] Around 1990, offices and laboratories were built in the high-bay area. Mezzanines, accessed by ladders, accommodate heating, ventilating, air conditioning, and electrical equipment over these offices.

Primary Building Function – The Rocket Engine Test Facility Control Room:[9]

The northernmost wing of Building 100 houses the control room. A plan of the control room is included in the graphics section of this report. The windowless north and west facades of this facility are faced with brick. The east facade has four aluminum-frame windows that measure 4' x 2'-9" high. Three limestone panels, which measure 3.5' wide, separate these windows. The upper half of each window features a single fixed light. The lower half is an opening light that pivots at the top of the sash.

The control room is 60' long and 39' wide, and covers a total surface area of 2,340 square feet. A wall separates the office/work area from the main control room. This office/work area is 39' long and 12' wide. A stairwell in this room leads to the basement beneath the control room. The control room was a central location from which personnel managed the engine tests at Building 202. Fuels and oxidizers for the engine being tested were also partly monitored from the control room. This room also provided a facility for sensing, monitoring, and recording engine performance during tests. Testing new and unproven rocket engine designs using hazardous fuels

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[6] *Ibid*.

[7] Drawing CC-182645 – 5/24/90.

[8] Drawing CF-101896 – 7/17/91.

[9] The descriptive material on the control room and its operation was obtained during a videotaped tour of the facility conducted by George Repas, who was employed as a hardware design engineer at the Rocket Engine Test Facility during most of the years that it operated.

could be dangerous. A remote control facility enhanced safety and allowed the collection and storage of data in an area that was unlikely to sustain damage in the event of catastrophic engine failure. The protection of research data was essential in engineering development programs, since collected data enabled engineers to detect design inadequacies and use the results of experiments to develop advanced engines.

The design of the control room followed standard practice. The main control and instrument consoles were centrally located and were surrounded by model or control boards that showed the operating status of all major valves, pumps, motors, and actuators in the system. The control console and the model boards were schematic representations of the system, with colored lines representing pipes that carried the flow of reactants to the engine being evaluated. Removable panels in the floor allowed access to wiring chases. This design concealed the wiring between the control console, model boards, and data-recording units.[10] Electrical and electronic signals that conveyed control commands among the system components were carried over copper wire consisting of insulated single, multi-conductor, and coaxial cables. Data acquired by sensors was similarly transmitted over copper cables. The only program that used fiber-optic cable was a recent hydrogen densification program that operated in the upper area of the Rocket Engine Test Facility.

The model board on the southwest side of the room consisted of vertical aluminum panels measuring 0.25" thick. These panels faced the test engineer and were painted with a schematic representation of the Rocket Engine Test Facility's piping system. This graphic representation corresponded to the physical layout of the facility. The back of each panel formed a base for the pilot lights and cabling. A steel angle iron framework supported the panels. Indicator lights were positioned on the schematic diagram so that they corresponded to the locations of valves and actuators within the facility process piping. These pilot lights showed if the valve they depicted was open or closed.

The main control console was a similarly designed tilted panel with a schematic diagram of the system rendered in colored lines representing the reactant and fluid delivery systems. The main console was constructed at a working height convenient for the test engineer. The panel contained switches that remotely controlled valves, actuators, motors, and fans at the test stand. The operation of the engine being tested was complex since the testing period was relatively short, and rarely lasted more than a few minutes. During this brief duration transient events could occur that had implications for longer-term performance. The limitations of human reaction time precluded manual operation of an engine test. Real-time human operation and observation of a test did not yield much useful data, and close observation of rocket tests was dangerous. Consequently, the operation, sensing, and recording of engine tests were, for the most part, completed under the control of electro-mechanical devices or computers. The records of an experiment, including input factors such as timing and fluid flows, were stored. Experimental

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[10] Drawing No. CD-101455 – 5/17/56.

results were later analyzed and plotted against outputs such as thrust generated by the engine, engine temperatures and pressures, and other performance criteria.

In the pre-computer period of the late 1950s and early 1960s, runs were controlled using electro-mechanical devices such as Eagle Signal timers. These timers were clocks run by synchronous motors programmed to close or open switches on a preset schedule. During this period, run data were analyzed and reduced by employees who were referred to as "computers" using slide rules and manual computation. Later, in the 1970s, NASA designed and built solid-state logic circuits programmed using thumb wheel switches, which were made in many versions, to control engine test runs.[11]

Programmable controllers were developed during the late 1970s. These devices were originally known as "PCs." With the development of the personal computer they were renamed programmable logic controllers, or "PLCs." The Rocket Engine Test Facility control system used programmable logic controllers made by the Modicon Corporation to replace the earlier electro-mechanical devices. A programmer would configure the PLC to turn the valves and actuators controlling fuel, oxidant, and ignition sequence according to a predetermined time schedule. The engine test runs were nominally controlled by the PLC, but test engineers could use a manual override when necessary. The engineers could press a "panic button" located on the main control panel to initiate an automatic shutdown, under PLC control, in case of an emergency.[12]

Originally, the performance data of a run were recorded on magnetic tape, thermal paper linear recorders, multicolor pen recorders, or "Visicorders." Visicorders were made by Honeywell and could simultaneously record several events such as valve opening times, ignition, temperature, or pressure transients. In subsequent methodology developed during the 1980s, raw data were reduced using one of two programs: TRADAR or CADDE. Lewis Research Center personnel wrote these programs specifically for rocket engine testing. These data were fed by direct digital data link to the Research Analysis Center (RAC) in NASA-Glenn Building 142. In Building 142, the data were further processed by IBM 3033 TSS and Cray 1-S computers, and then transmitted to the control room for analysis.[13] This system provided on-line data processing facilities to the control room, hard copy terminals, and monitors located in the rocket operations building control room. The system gave engineers and technicians what was, in essence, real-time analysis.

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[11] Thumb wheel switches are available in many configurations: Decimal, single pole 10 position-Binary Coded Digital, Binary Coded Hexadecimal, or resistor decade. They were a technological step in the transition from electro-mechanical to computer control.

[12] George Repas, whose career as a hardware designer at the Rocket Engine Test Facility closely paralleled its years of operation, called this switch the "quiver point," because the engineer's hand would hover above this switch and "quiver" in readiness for an emergency shutdown.

[13] Email letter from Kevin P. Coleman, Records and Electronic Forms Manager, History Office Liaison, NASA, John H. Glenn Research Center at Lewis Field, Cleveland, Ohio.

The control room has undergone several re-configurations since 1957. Changing technology and the addition of a high-altitude rocket test stand and a turbo pump test stand required the addition of new controls and recording equipment. In 1985, the Rocket Engine Test Facility was modified to include a high-altitude rocket engine test facility, called Test Stand B. This was a chamber in which a rocket engine could be horizontally mounted. The chamber was then closed and evacuated to simulate the vacuum of space. Ejectors maintained the vacuum during the test period.[14] The ejector control panel was on the northeastern side of the control room, next to the high-altitude test stand controls. Some controls for the high-altitude test stand, primarily fuel and oxidant valving, were the same as the controls for Test Stand A and were also activated from the main control console.

A valve control rack was installed in the northwestern side of the control room. From this location, engineers could precisely manipulate valves under PLC control. Besides on, off, or partial settings, valves would be ramped up or down at controlled rates as required for any particular experiment.

In 1991 Test Stand C was added to Building 202. This new stand was used to test seal materials and designs for liquid oxygen pumps or other components. The initial test program tested seals on a turbo pump rig. The controls for Test Stand C were located in a rack on the southeastern side of the control room.

Conclusion:

The Rocket Engine Test Facility control room was an essential element in NASA's Apollo Program to land men on the moon. The work accomplished here was critical to the development of liquid hydrogen as a reliable and safe rocket fuel. The control and recording systems illustrate a successful approach, in large measure developed by the facility's staff, to problem solving and creating an efficient and cost-effective methodology for rocket engine testing.

[14] The ejectors at the Rocket Engine Test Facility are devices for removing air and rocket exhaust from the high-altitude test chamber. These ejectors are simplified vacuum pumps with no moving parts, and they consist of nozzles that discharge a high-velocity jet of nitrogen across a suction chamber connected to the test chamber. Air and rocket exhaust is entrained in the nitrogen and carried into a venturi-shaped diffuser that converts the velocity energy of the nitrogen into pressure energy. The Rocket Engine Test Facility ejectors are unusual in that they operate on nitrogen rather than steam.

Sources of Information/Bibliography

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National Advisory Committee for Aeronautics – Lewis Flight Propulsion Laboratory – Cleveland, Ohio
Building No. 100 – Rocket Engine Research Facility
Architectural – Operations Building
First Floor Plan – Drawing No. CE-101441 – 6/29/55

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Building No. 100 – Rocket Engine Research Facility
Architectural – Operations Building
North and East Elevations – Drawing No. CE-101442 – 6/29/55

National Advisory Committee for Aeronautics – Lewis Flight Propulsion Laboratory – Cleveland, Ohio
Building No. 100 – Rocket Engine Research Facility
Architectural – Operations Building
South and West Elevations – Drawing No. CE-101443 – 6/29/55

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Building No. 100 – Rocket Engine Research Facility
Architectural – Operations Building
Control Room – Drawing No. CD-101455 – 5/17/56

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Building No. 100 – Rocket Engine Research Facility
Architectural – Operations Building
Basement and Roof Plans – Drawing No. CD-101440 – 6/29/55

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Building No. 100 – Rocket Engine Research Facility
Instrument and Control Panels
Room Plan and Suggested Framing Plan
Control Room – Drawing No. CD-101736 – 3/21/56

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Building No. 100 – Rocket Engine Research Facility
Television System
Plan – Location of TV Equipment – Control Room
Control Room – Drawing No. CD-101753 – 7/19/56

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First Floor Plan – Architectural – Drawing No. CF-101896 – 7/17/91

NASA Lewis Research Center – Cleveland, Ohio 44135
Research Projects – Building No. 100
Basement Floor Plan – Architectural – Drawing No. CF-101895 – 7/17/91

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Building No. 100
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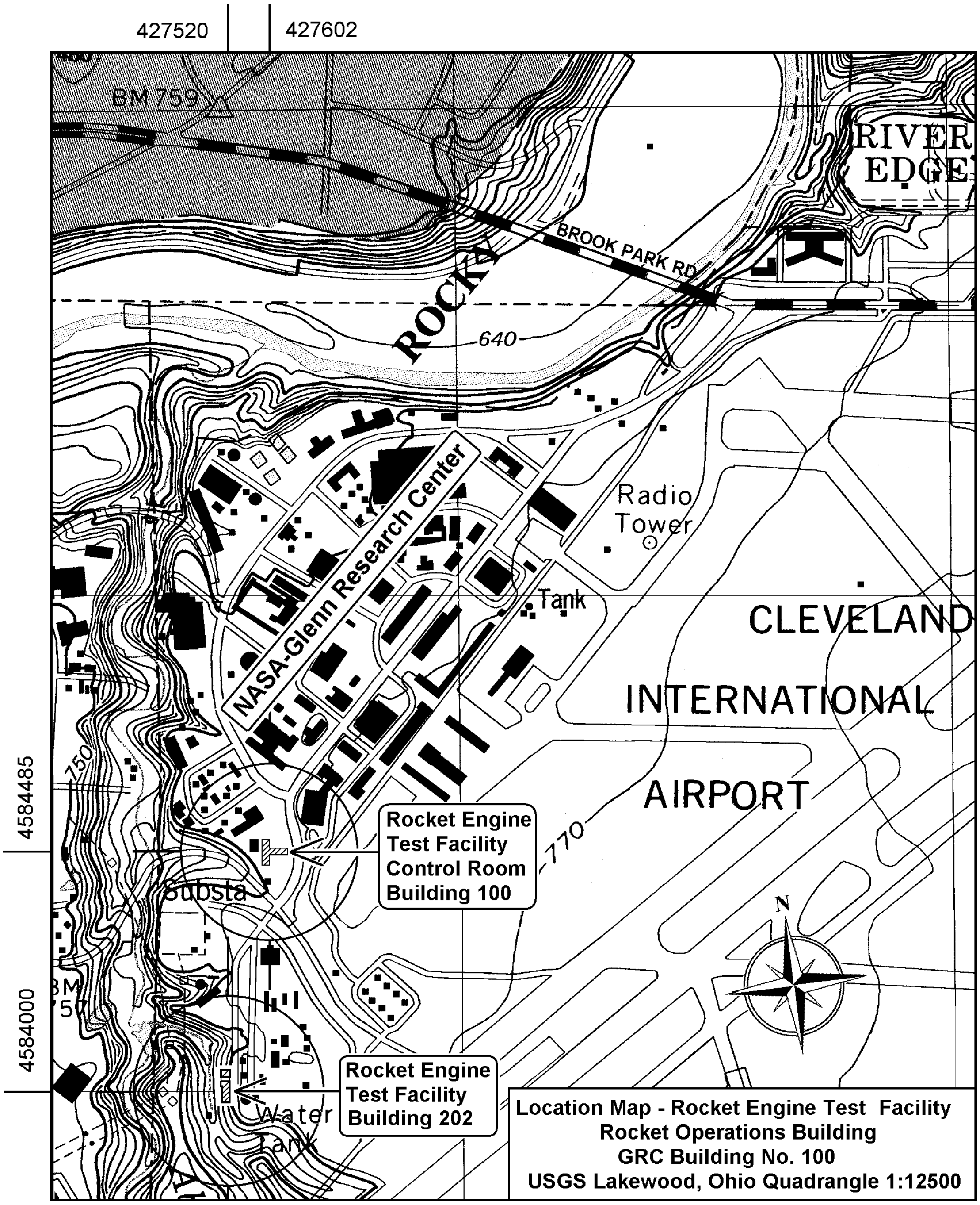
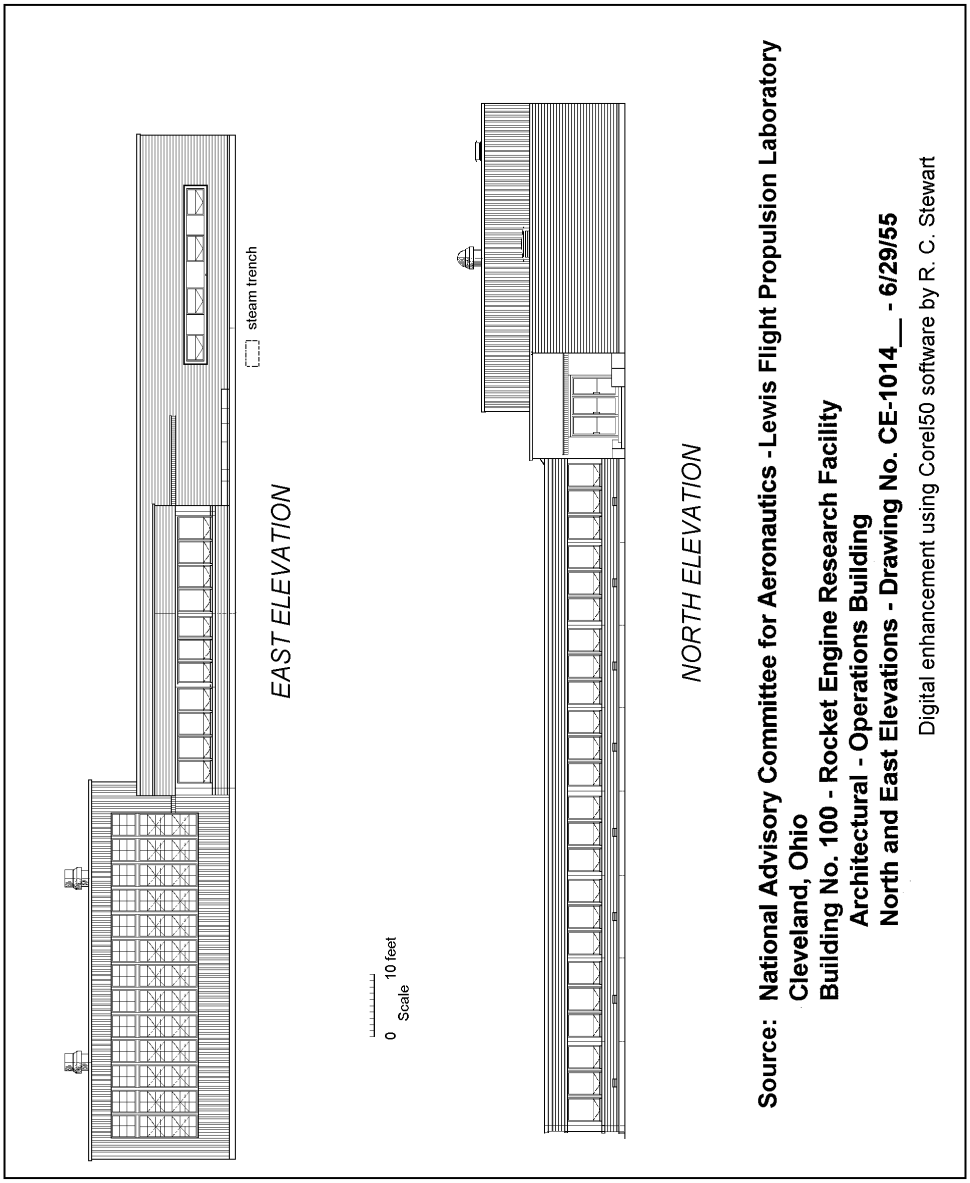
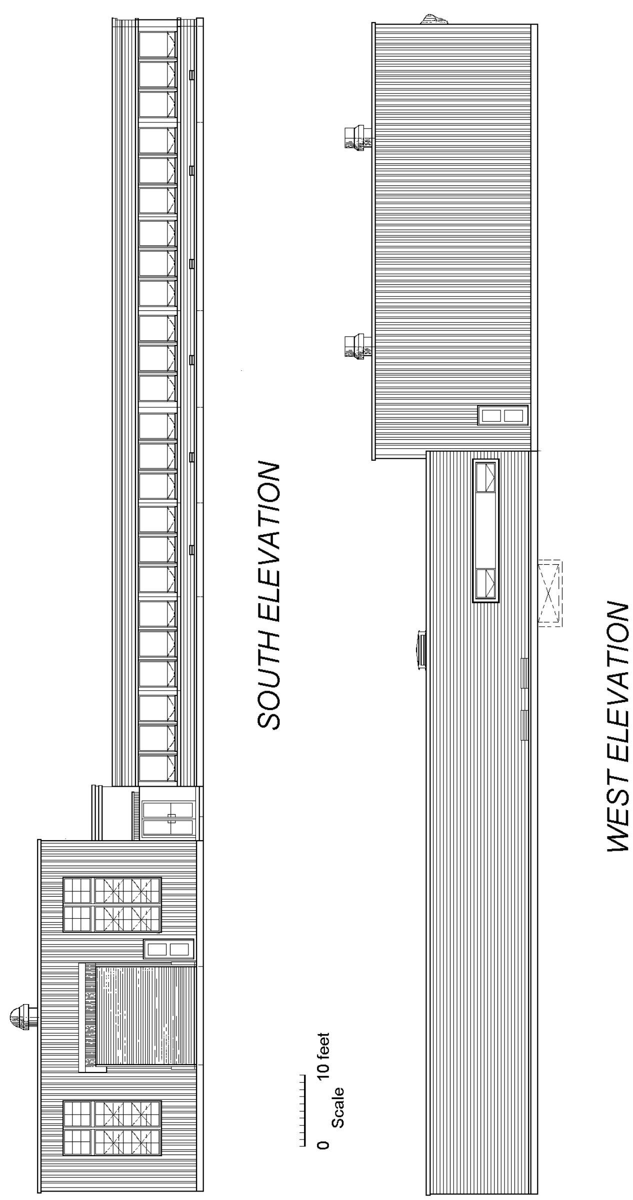


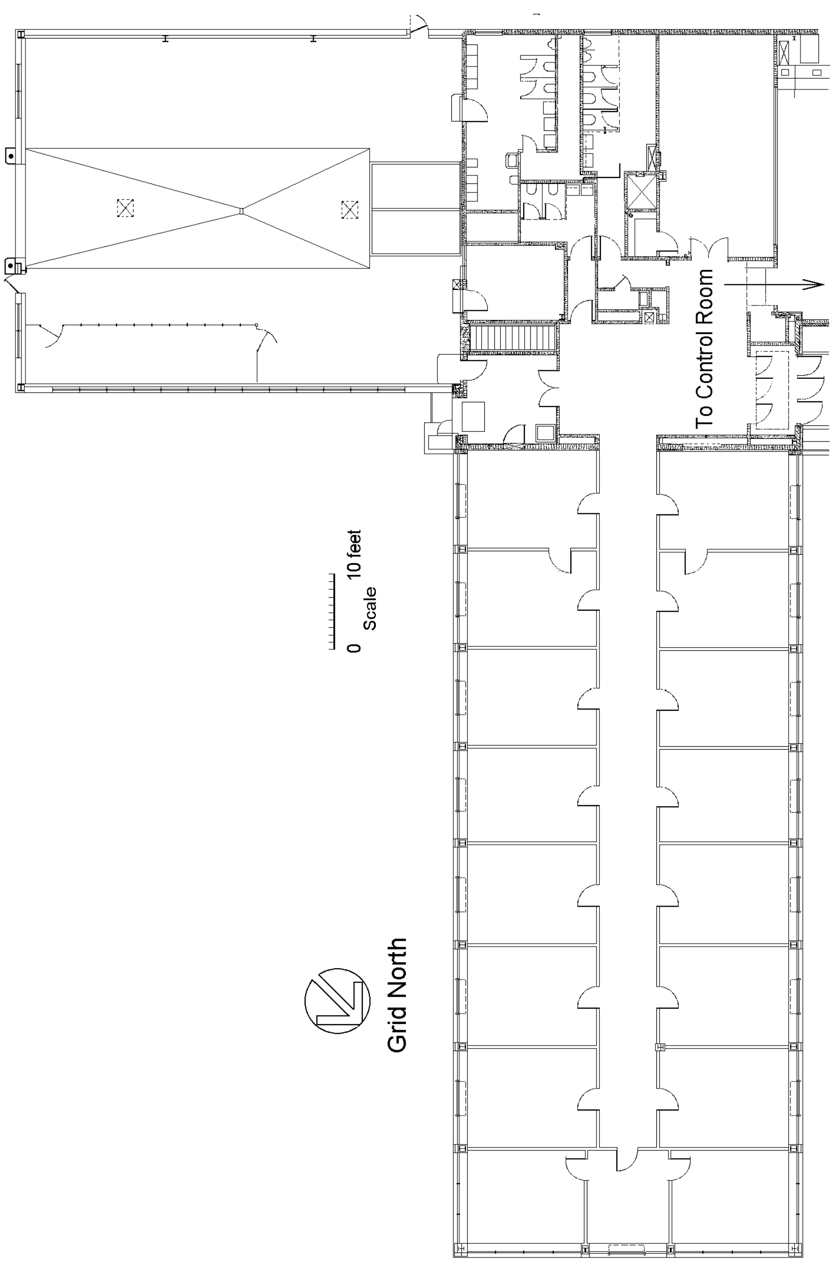
Location Map - Rocket Engine Test Facility
Rocket Operations Building
GRC Building No. 100
USGS Lakewood, Ohio Quadrangle 1:12500


EAST ELEVATION
steam trench
NORTH ELEVATION
0 10 feet
Scale
Source: National Advisory Committee for Aeronautics -Lewis Flight Propulsion Laboratory
Cleveland, Ohio
Building No. 100 - Rocket Engine Research Facility
Architectural - Operations Building
North and East Elevations - Drawing No. CE-1014__ - 6/29/55
Digital enhancement using Corel50 software by R. C. Stewart



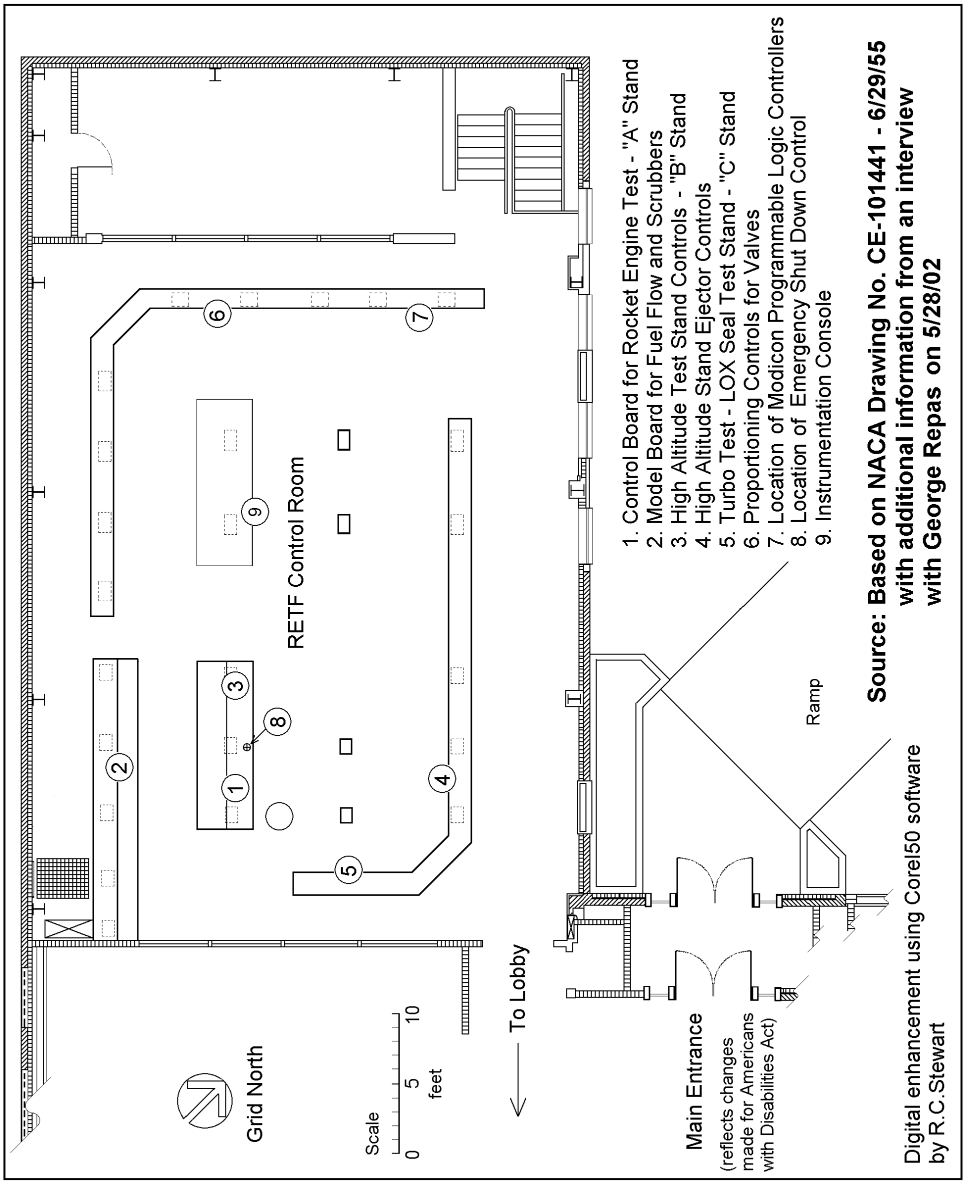
Source: National Advisory Committee for Aeronautics -Lewis Flight Propulsion Laboratory
Cleveland, Ohio
Building No. 100 - Rocket Engine Research Facility
Architectural - Operations Building
South and West Elevations - Drawing No. CE-101___ - 6/29/55

Digital enhancement using Corel50 software by R. C. Stewart



**Source: National Advisory Committee for Aeronautics -Lewis Flight Propulsion Laboratory
Cleveland, Ohio
Building No. 100 - Rocket Engine Research Facility
Architectural - Operations Building
First Floor Plan - Drawing No. CE-101441 - 6/29/55**

Digital enhancement using Corel 50 software by R.C. Stewart


RETF Control Room
1. Control Board for Rocket Engine Test - "A" Stand
2. Model Board for Fuel Flow and Scrubbers
3. High Altitude Test Stand Controls - "B" Stand
4. High Altitude Stand Ejector Controls
5. Turbo Test - LOX Seal Test Stand - "C" Stand
6. Proportioning Controls for Valves
7. Location of Modicon Programmable Logic Controllers
8. Location of Emergency Shut Down Control
9. Instrumentation Console
Source: Based on NACA Drawing No. CE-101441 - 6/29/55
with additional information from an interview
with George Repas on 5/28/02
Ramp
Main Entrance
(reflects changes
made for Americans
with Disabilities Act)
To Lobby
Scale
0
5
10
feet
Grid North
Digital enhancement using Corel50 software
by R.C.Stewart
1
2
3
4
5
6
7
8
9

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

ROCKET ENGINE TEST FACILITY, GRC BUILDING 100 HAER No. OH-124-D
NASA Glenn Research Center
Cleveland
Cuyahoga County
Ohio

Jeff Bates, Hardlines Design Company Photographer, May 2002

OH-124-D-1	BUILDING 100 AND ANNEX, CONTEXT OF NORTHWEST CORNER LOOKING SOUTHEAST FROM PARKING LOT
OH-124-D-2	NORTHEAST CORNER OF BUILDING 100, LOOKING SOUTHWEST FROM PARKING LOT
OH-124-D-3	SOUTHWEST CORNER OF BUILDING 100, LOOKING NORTHEAST FROM EDGE OF PARKING LOT
OH-124-D-4	SOUTH ELEVATION OF BUILDING 100, LOOKING NORTHEAST FROM PARKING LOT
OH-124-D-5	BUILDING 100, ENTRANCE ON NORTHEAST CORNER OF BUILDING, LOOKING SOUTHWEST
OH-124-D-6	INTERIOR VIEW OF BUILDING 100 SHOWING LOBBY, LOOKING NORTHWEST WITH SCALE MODEL OF TEST FACILITY COMPLEX VISIBLE ON WALL
OH-124-D-7	INTERIOR VIEW OF BUILDING 100 SHOWING CONTROL ROOM, LOOKING SOUTHWEST
OH-124-D-8	INTERIOR VIEW OF BUILDING 100 SHOWING DETAIL OF PANEL IN CONTROL ROOM, LOOKING SOUTHWEST
OH-124-D-9	HISTORIC CONSTRUCTION VIEW OF BUILDING 100. 1956. ON FILE AT NASA PLUMBROOK RESEARCH FACILITY, SANDUSKY, OHIO.

OH-124-D-10 HISTORIC EXTERIOR VIEW OF BUILDING 100. AUGUST 22, 1957. ON FILE AT NASA PLUMBROOK RESEARCH FACILITY, SANDUSKY, OHIO. NASA PHOTO NUMBER C-45766.

OH-124-D-11 HISTORIC VIEW OF BUILDING 100 CONTROL ROOM, SHOWING PERSONNEL OPERATING ROCKET ENGINE TEST CONTROLS AND OBSERVER WATCHING ACTIVITY FROM OBSERVATION ROOM. MAY 27, 1957. ON FILE AT NASA PLUMBROOK RESEARCH FACILITY, SANDUSKY, OHIO. NASA PHOTO NUMBER C-45020.

OH-124-D-12 HISTORIC VIEW OF BUILDING 100 CONTROL ROOM, SHOWING TELEVISION MONITORING OF TESTS AND PERSONNEL OPERATING ROCKET ENGINE TEST CONTROLS. MAY 27, 1957. ON FILE AT NASA PLUMBROOK RESEARCH FACILITY, SANDUSKY, OHIO. NASA PHOTO NUMBER C-45021.

OH-124-D-13 HISTORIC VIEW OF BUILDING 100 CONTROL ROOM, SHOWING PERSONNEL WITH DATA RECODRING INSTRUMENTATION. 1957. ON FILE AT NASA PLUMBROOK RESEARCH FACILITY, SANDUSKY, OHIO. NASA PHOTO NUMBER C-46211.

OH-124-D-14 HISTORIC VIEW OF ENGINEER IN BUILDING 100 CONTROL ROOM EXAMINING DATA PRINTOUT. 1957. ON FILE AT NASA PLUMBROOK RESEARCH FACILITY, SANDUSKY, OHIO. NASA PHOTO NUMBER C-46210.

OH-124-D-15 HISTORIC VIEW OF ENGINEER IN BUILDING 100 CONTROL ROOM EXAMINING DATA PRINTOUT. AUGUST 28, 1962. ON FILE AT NASA PLUMBROOK RESEARCH FACILITY, SANDUSKY, OHIO. NASA PHOTO NUMBER C-61500.

OH-124-D-16 VIEW OF BUILDING 100 CONTROL ROOM. 1987. ON FILE AT NASA GLENN RESEARCH CENTER, CLEVELAND, OHIO.

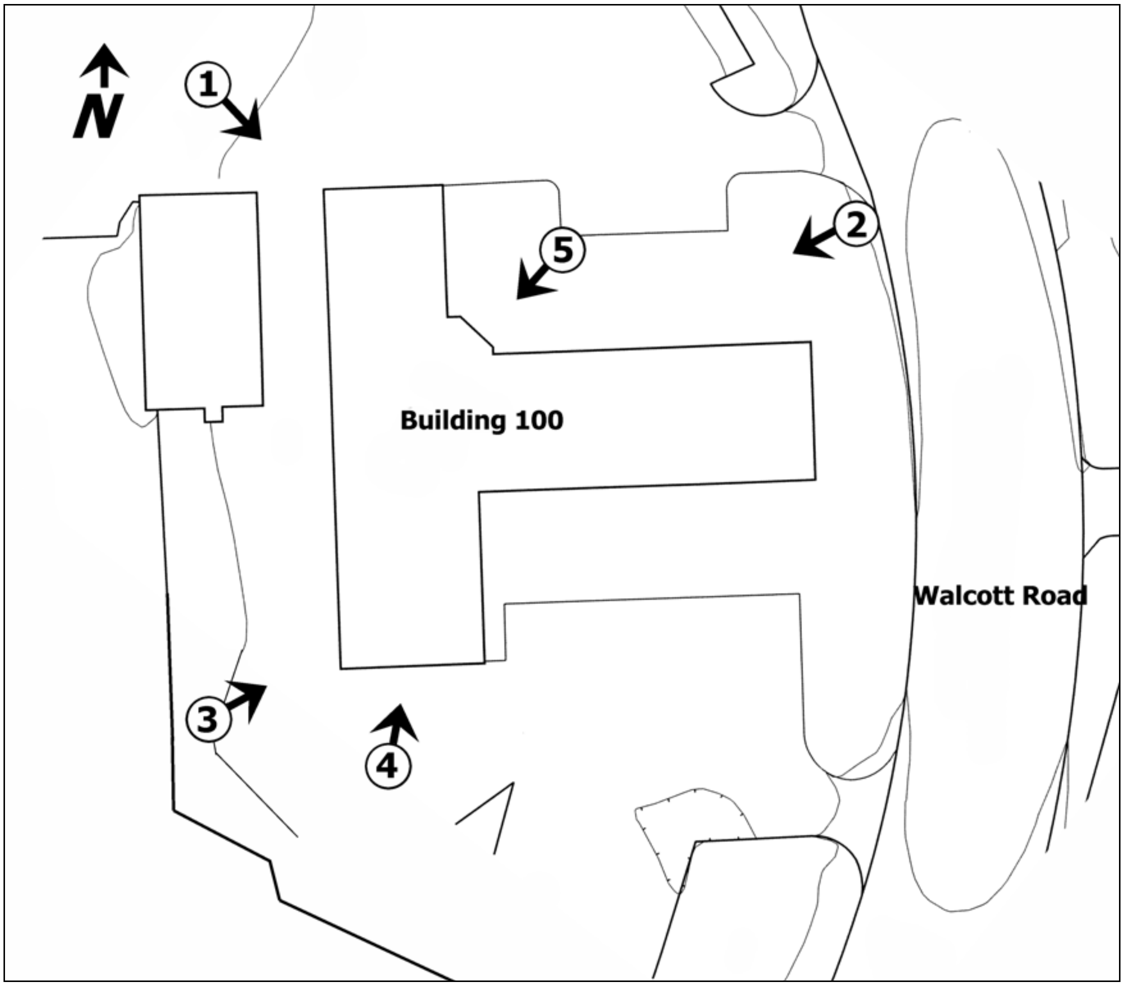
OH-124-D-17 HISTORIC PLAN OF BUILDING 100. JUNE 29, 1955. NASA GRC DRAWING NUMBER CE-101441. (ON FILE AT NASA GLENN RESEARCH CENTER).

OH-124-D-18 HISTORIC PLAN OF BUILDING 100 CONTROL ROOM. MARCH 21, 1956. NASA GRC DRAWING NUMBER CE-101736. (ON FILE AT NASA GLENN RESEARCH CENTER).

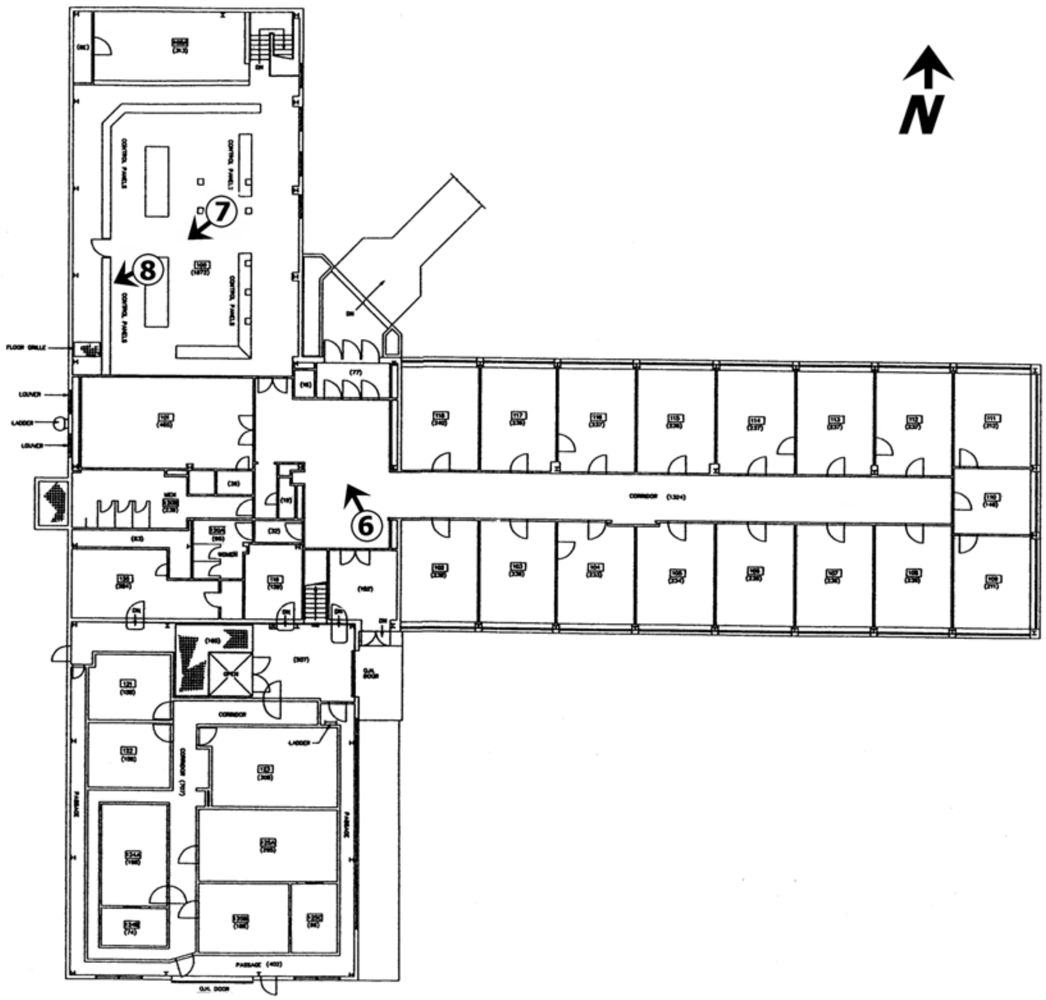
OH-124-D-19 HISTORIC NORTH AND EAST ELEVATION DRAWING OF BUILDING 100. JUNE 29, 1955. NASA GRC DRAWING NUMBER CE-101442. (ON FILE AT NASA GLENN RESEARCH CENTER).

OH-124-D-20 HISTORIC SOUTH AND WEST ELEVATION DRAWING OF BUILDING 100. JUNE 29, 1955. NASA GRC DRAWING NUMBER CE-101443. (ON FILE AT NASA GLENN RESEARCH CENTER).

OH-124-D-21 HISTORIC SECTION DRAWING OF BUILDING 100. JUNE 29, 1955. NASA GRC DRAWING NUMBER CE-101444. (ON FILE AT NASA GLENN RESEARCH CENTER).



Exterior Photo Key for Building 100



Interior Photo Key for Building 100

BUILDING 100 - CONTROL BUILDING

Building 100 is located 1,600 feet north of the rocket engine test cells, which are housed in Building 202. Building 100 provided a safe place from which operators could remotely control engine tests that used hazardous or toxic fuels. From this protected control room, Rocket Engine Test Facility (RETF) personnel could collect data from tests of experimental engine designs.

Building 100 was designed by H. S. Kerline and built by the H. K. Ferguson Company of Cleveland, Ohio. The architect designed this facility using aesthetic principles commonly applied to industrial or laboratory buildings. NASA engineers designed the innovative control room systems.

The building stands on a flat, featureless area of the NASA-Glenn Research Center that is located at an elevation of 761 feet above sea level. The facility has a "T"- shaped footprint. The long leg of the "T" consists of a corridor. Seventeen offices line both sides of this corridor and wrap around its east end. The cross portion of the "T" consists of a high bay, observation area, and the RETF control room.

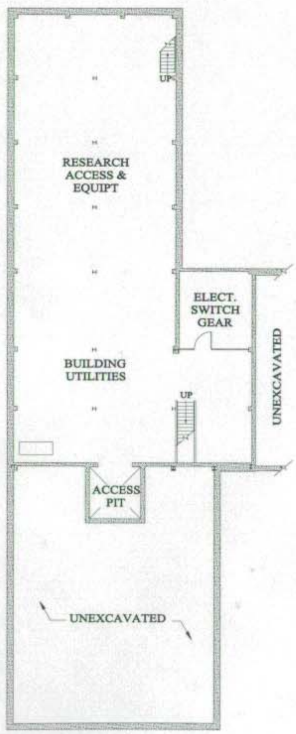
The northern arm of the plan's cross portion contains the control room, an office, and work area. The basement beneath the control room houses utilities, electrical switchgear, and an entry tunnel for steam pipes. This basement also allows access to the wiring chases, control consoles, and model board in the control room above. The southern arm of the crossbar contains a high-bay area that rises to twenty-one feet, six inches in height. A twelve-foot square pit in the floor of the high bay allows heavy equipment to be lowered into the basement beneath the control room.

The entrances into Building 100 are located in the angles where the two sections of the "T" intersect. A small terrace leads to the main entrance, which is located between the northern arm of the "T" and the office corridor. On the terrace outside this main entrance, granite planters flank the exterior doors. A secondary entrance is located between the southern arm of the "T" and the office corridor. Metal canopies protect both entryways. These entrances lead into a central lobby and vestibule that form a transition between the office corridor and the cross arm of the "T." This central area contains restrooms, closets, locker room, and showers.

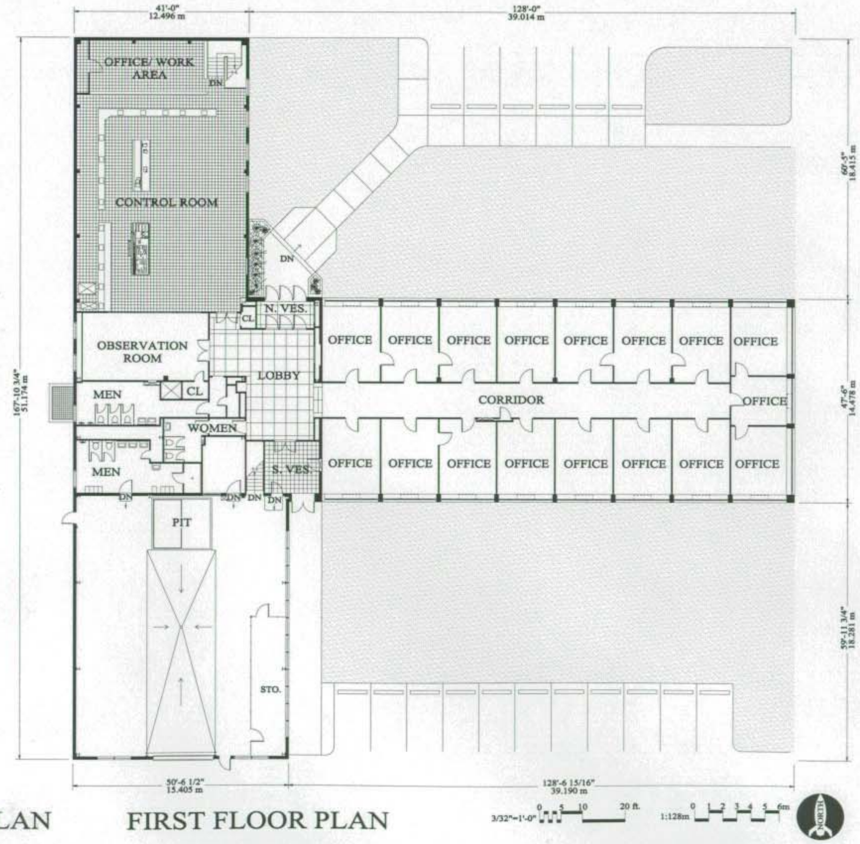
The building exterior is clad in buff-colored brick laid in running bond. Limestone trim and the granite planters at the main entrance add visual interest to the exterior. The steel-framed high bay to the south is sheathed with metal panels, the exteriors of which are vertically corrugated and provide a pleasing contrast to the horizontal lines prevalent throughout the building.

Building 100 is a utilitarian facility where different parts of the structure house distinct functions. This design created an efficient work environment for early rocket engine testing.

Note: Plans depict building as configured ca. 1955.



BASEMENT FLOOR PLAN



FIRST FLOOR PLAN

DELINEATED BY: Hardlines Design Company, 2002

NASA ROCKET ENGINE TEST FACILITY RECORDING PROJECT	CLEVELAND	ROCKET ENGINE TEST FACILITY NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER CUYAHOGA COUNTY	OHIO	SHEET 10-12	HISTORIC AMERICAN ENGINEERING RECORD OH-124-D

BUILDING 100 - CONTROL BUILDING

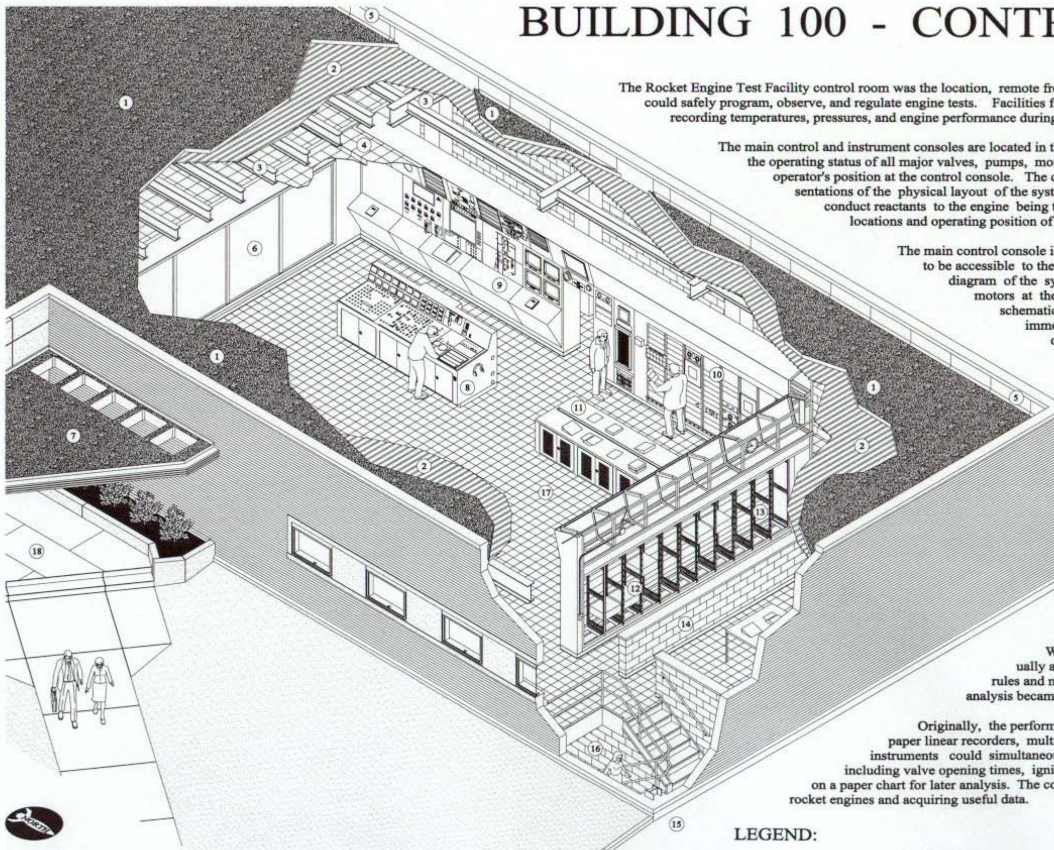
The Rocket Engine Test Facility control room was the location, remote from the Building 202 test cell, where engineers and operators could safely program, observe, and regulate engine tests. Facilities for controlling fuel and oxidizer flow, and for measuring and recording temperatures, pressures, and engine performance during tests, are also located in this facility.

The main control and instrument consoles are located in the center of the room. The vertical model board that shows the operating status of all major valves, pumps, motors, actuators, and exhaust scrubbers in the system faces the operator's position at the control console. The control console and the model board display schematic representations of the physical layout of the system. Color-coded lines and symbols represent the pipes that conduct reactants to the engine being tested. Pilot lights in the various schematic lines show the locations and operating position of control valves in the system.

The main control console is similar to the model board, but it is labeled and positioned to be accessible to the test operator. Color-coded lines depict a schematic piping diagram of the system. Switches that remotely control valves, actuators, and motors at the test stand are located at appropriate points along the schematic of reactant flow lines. In case of an emergency requiring immediate shut down, the operator could push a "panic button" on the console to end the run. Closed-circuit television and dedicated telephone lines allowed the control room personnel to observe tests and communicate with operating personnel at the test cell.

The operating time of the engineer working during the test was generally limited to a few minutes. Significant transient events causing longer performance could occur during a test, and slow human reaction time made manual sequencing of an engine test almost impossible. Additionally, real-time observation of a test by operators and engineers would yield limited data. Consequently, operation of engine tests was controlled by electro-mechanical timers, binary - coded thumbwheel switches, or subsequently by programmable logic controllers. Data acquisition was also automated. The records of a run, including input factors such as timing and reactant flow, was later analyzed and plotted against outputs such as engine thrust, temperatures, pressures, and other performance criteria. When the test facility went on line in 1957, operators manually analyzed and reduced paper charts of run data using slide rules and manual computation. As the facility evolved over time, data analysis became increasingly automated.

Originally, the performance data of a run were recorded on magnetic tape, thermal paper linear recorders, multicolor pen recorders, or Honeywell "Visicorders." These instruments could simultaneously record the timeline of most events and conditions, including valve opening times, ignition point, engine thrust, temperature, or pressure transient, on a paper chart for later analysis. The control room performed a vital function in testing experimental rocket engines and acquiring useful data.



SCALE 1/4" = 1'-0"
METERS 1:48

ISOMETRIC OF CONTROL ROOM

LEGEND:

1. ROOF
2. METAL DECKING
3. ROOF BEAMS
4. ACOUSTICAL CEILING
5. PARAPET
6. OBSERVATION WINDOW
7. ENTRY CANOPY
8. A-STAND CONTROL PANEL
9. A-STAND MODEL BOARD
10. ELECTRICAL CONTROLS
11. INSTRUMENT CONSOLE
12. MODICON PROGRAMMABLE LOGIC CONTROLLERS
13. PROPORTIONING CONTROLS FOR VALVES
14. LOW DIVIDER WALL
15. PARKING LOT
16. BASEMENT STAIRWELL
17. ASBESTOS FLOOR TILE
18. STONE ENTRY STOOP

DELINEATED BY: Hardlines Design Company, 2002

NASA ROCKET ENGINE TEST FACILITY RECORDING PROJECT

ROCKET ENGINE TEST FACILITY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER
CLEVELAND CUYAHOGA COUNTY OHIO

SHEET 11 = 12

HISTORIC AMERICAN ENGINEERING RECORD OH-124-D

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-1

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-2

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-3

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-4

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-5

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

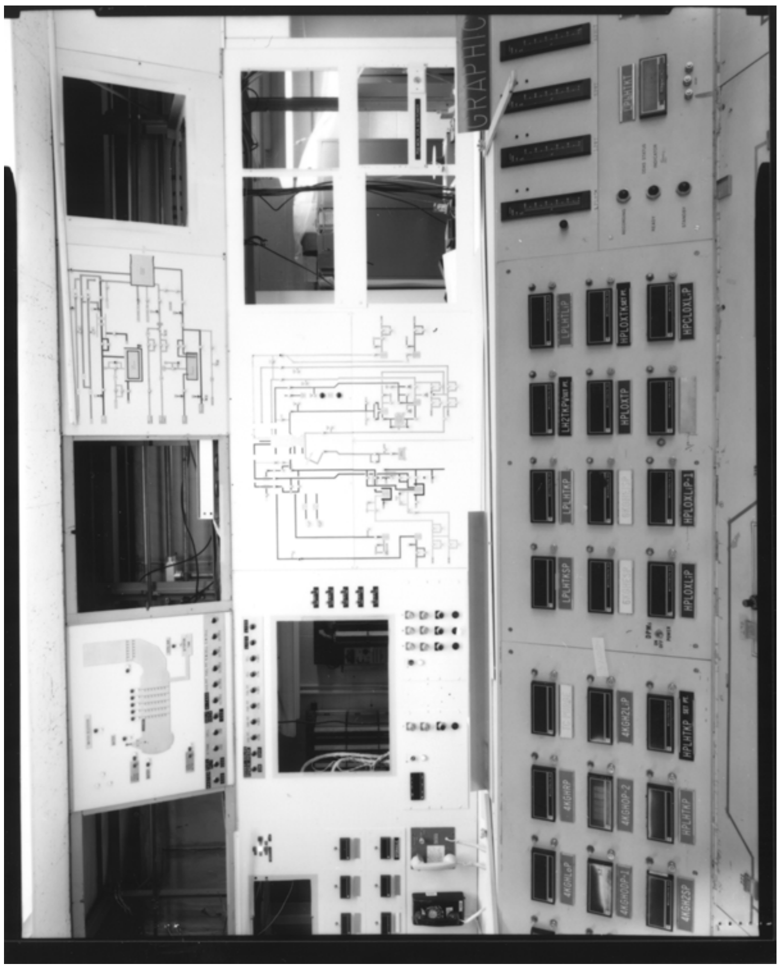
HAER No. OH-124-D-6

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-7

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-8



HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-9

C-141D-1956

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-10

C-45766

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-11

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-12

NACA C-45021

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-13

National Advisory Committee for Aeronautics

C-1958-46210

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-14

National Advisory Committee for Aeronautics
Lewis Flight Propulsion Laboratory

C-1958-46210

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

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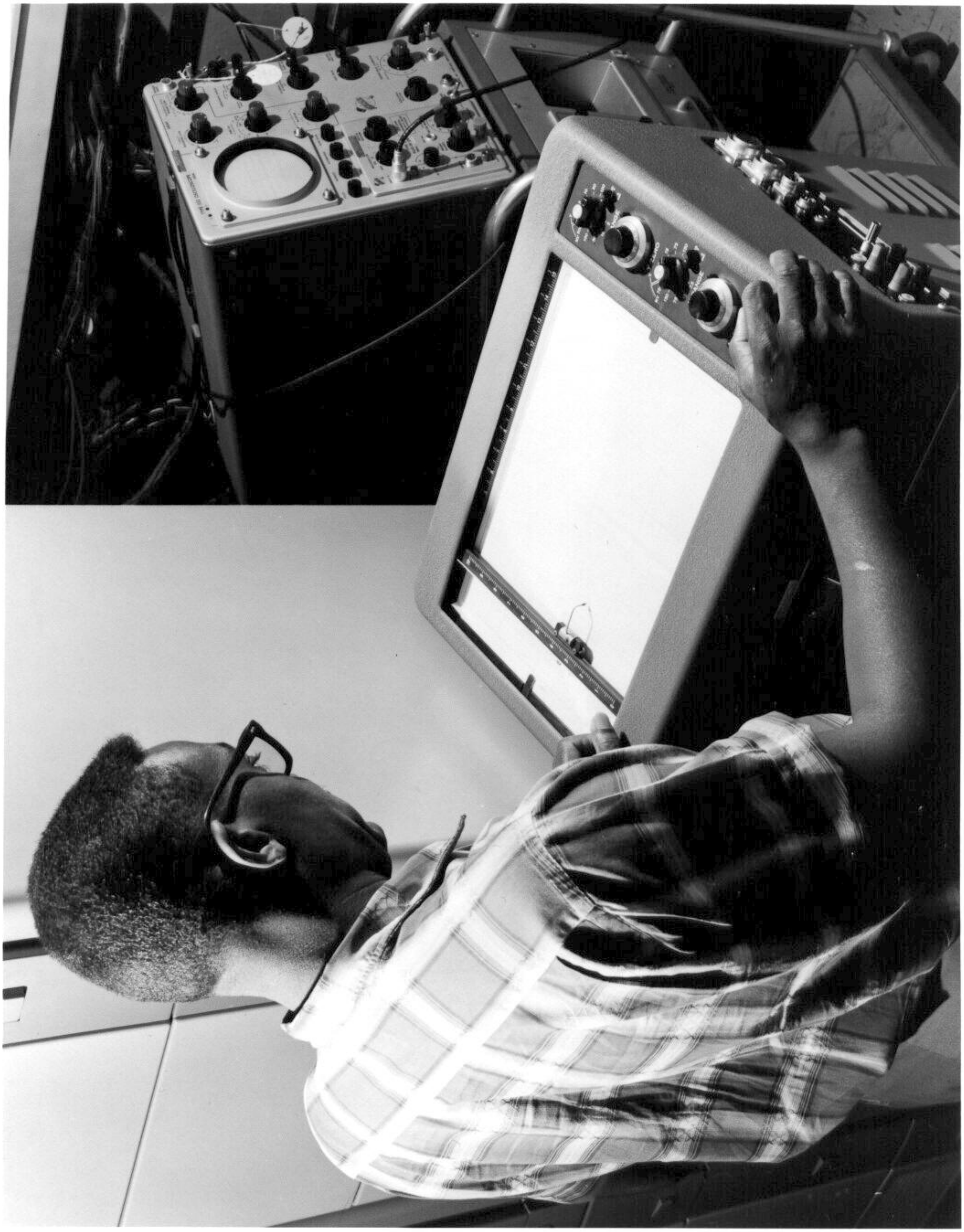


NASA
C-61500

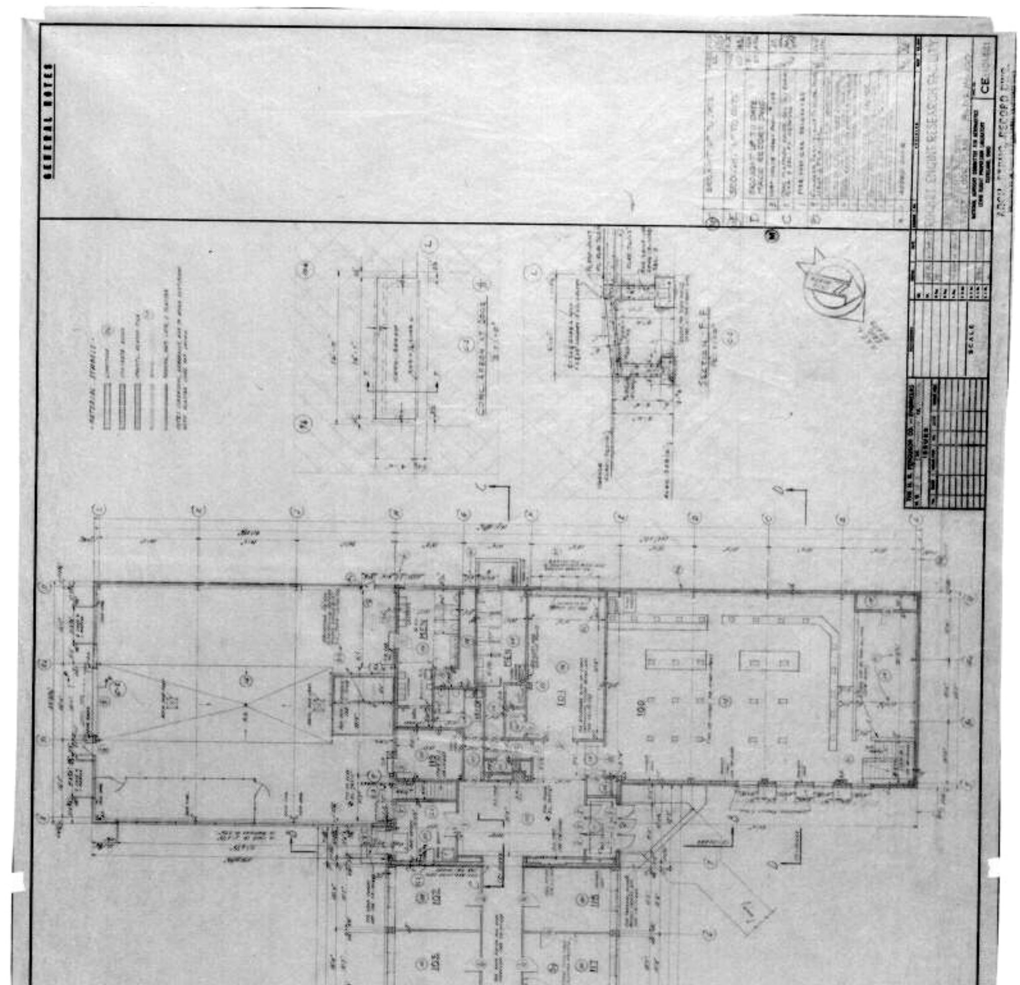
HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-16

1987-1181

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

HAER No. OH-124-D-17



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SEE INDEX TO PHOTOGRAPHS FOR CAPTION

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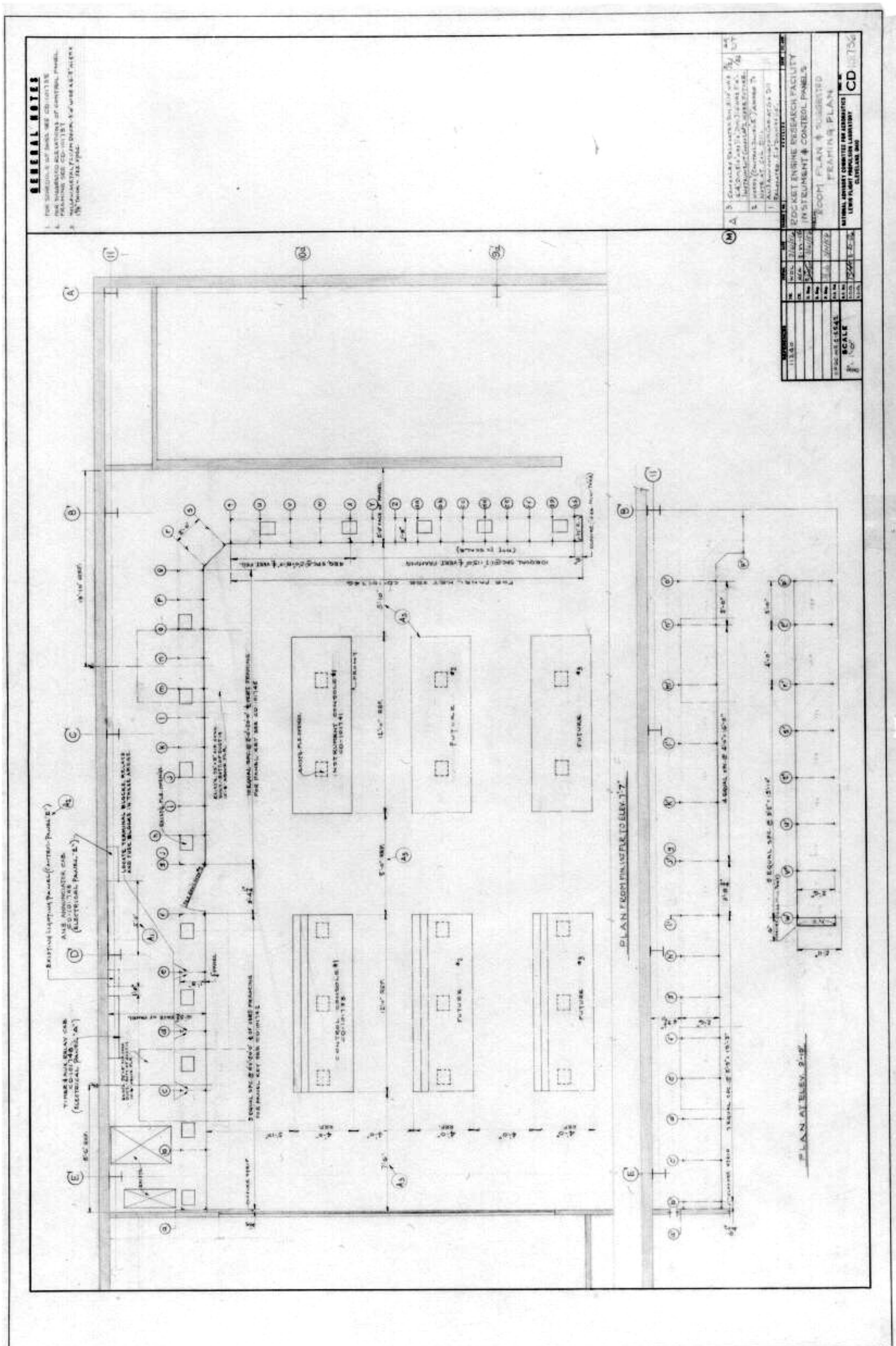

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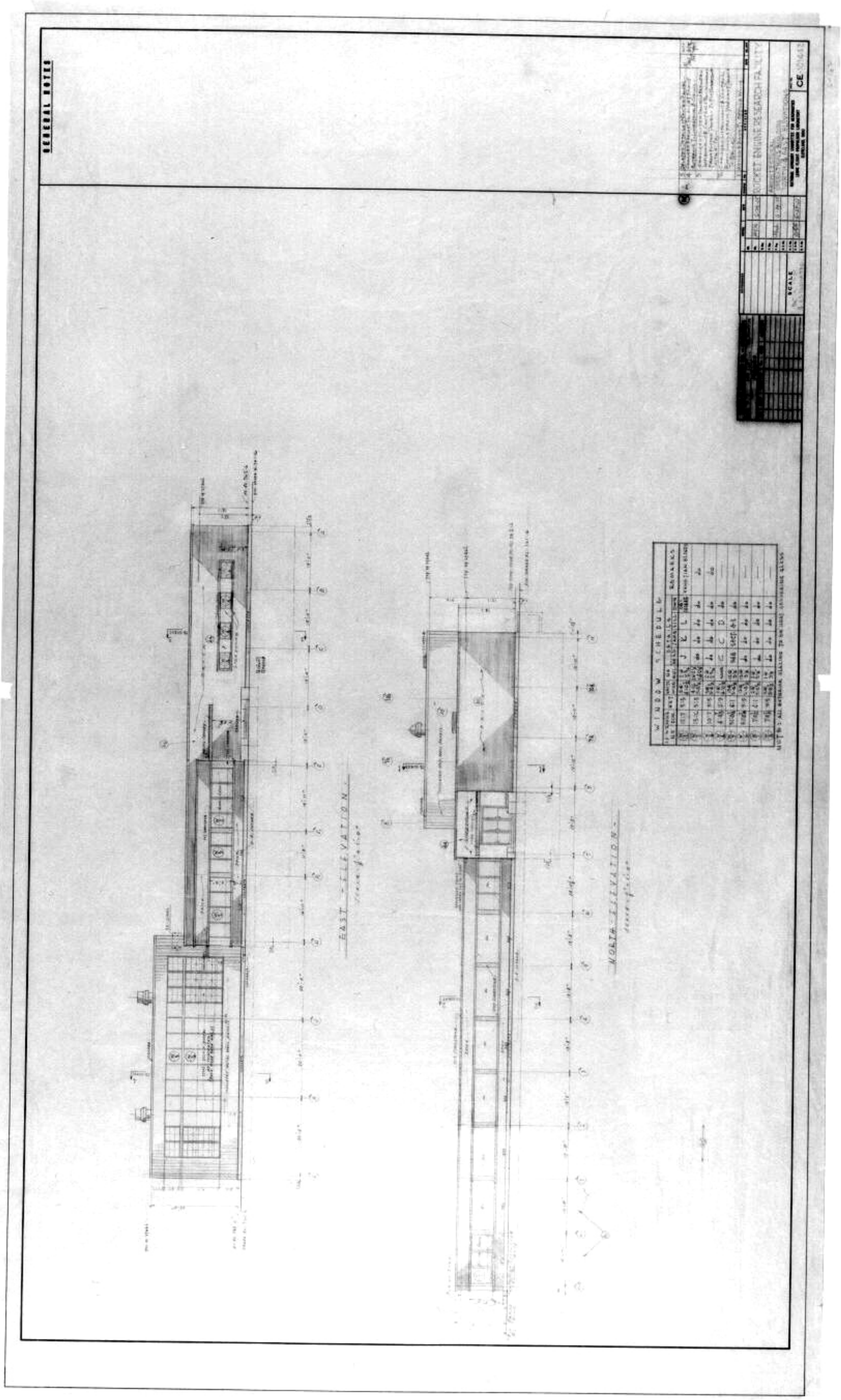

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

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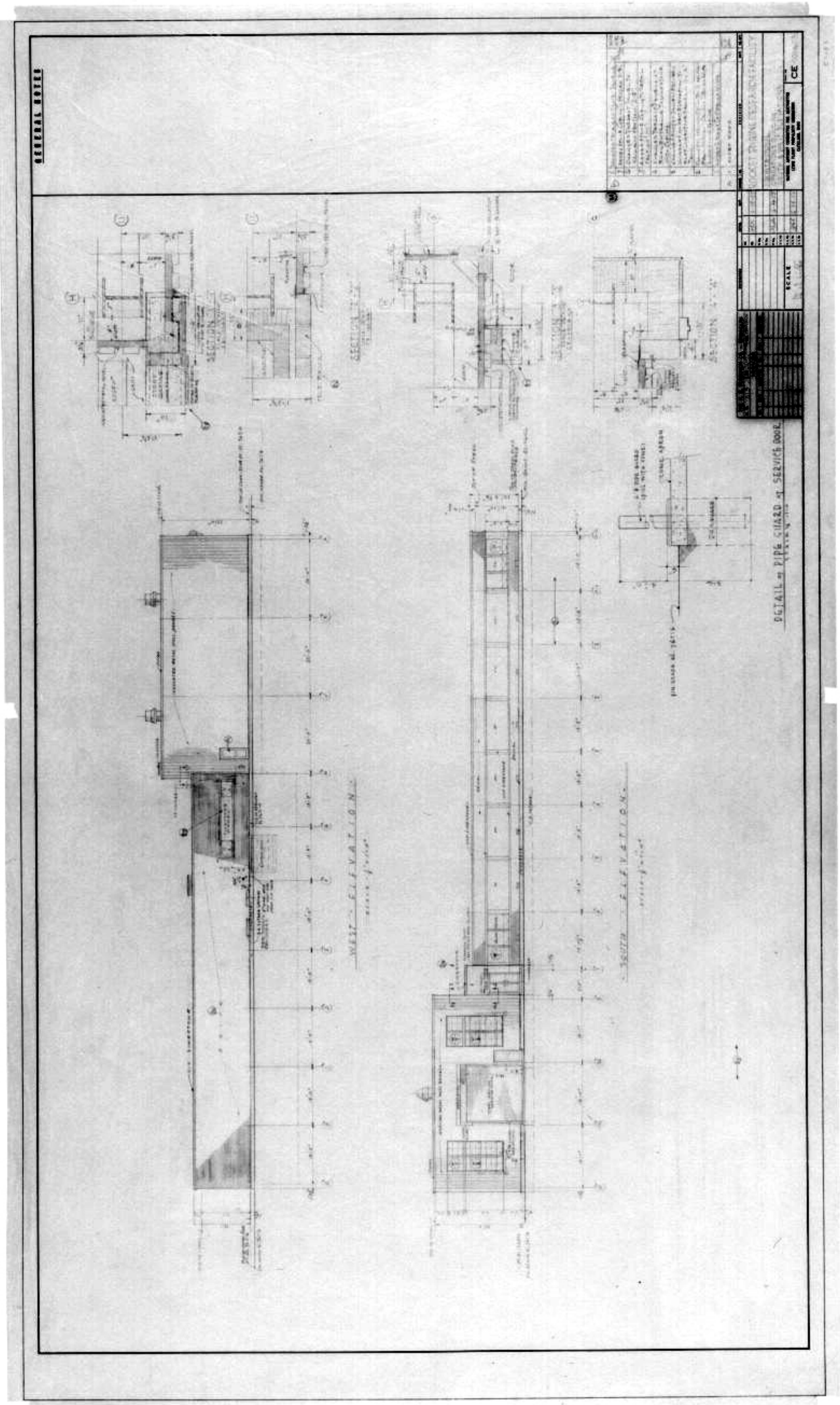

HISTORIC AMERICAN ENGINEERING RECORD
SEE INDEX TO PHOTOGRAPHS FOR CAPTION

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