

ROCKET ENGINE TEST FACILITY – GRC BUILDING No. 206 HAER No. OH-124-C
(Rocket Propulsion Test Facility – Cryogenic Vaporizer Facility Building 206)
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 – BUILDING 206 – CRYOGENIC VAPORIZER FACILITY (Rocket Propulsion Test Facility – Cryogenic Vaporizer Facility)

HAER No. OH-124-C

Location: NASA – Glenn Research Center
Cleveland
Cuyahoga County
Ohio
UTM: 17.427510.4584080
Quadrangle: Lakewood, Ohio 1:24,000

Date of Construction: 1968

Designer: NASA Lewis Research Center Engineering Staff

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

Present Use: Vacant/Not in use.

Significance: The Rocket Engine Test Facility Complex is a National Historic Landmark, and Building 206, the Cryogenic Vaporizer Facility, is included in the description of the site on the National Historic Landmark nomination form.¹ The floor of Building 206 is located at elevation 762.2' on the east bank of the creek bed above the test stand, about 200' northeast of Rocket Engine Test Facility Building 202. The Building 202 floor is at elevation 735.2', placing it 26.7' below the Cryogenic Vaporizer Facility. Building 206 was part of the gas distribution system for the Rocket Engine Test Facility. This building housed a liquid nitrogen vaporizer and a gaseous nitrogen compressor. Nitrogen was used in the facility to actuate pneumatic valves where electrically actuated solenoid valves controlling oxygen or hydrogen might be hazardous. Building 206 was constructed in 1968.

Project Information: This documentation was initiated on May 15, 2002, in accordance with a Memorandum of Agreement among the Federal Aviation Administration, National Aeronautics and Space Administration (NASA), 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

¹ Some maps and other sources refer to the original cryogenic vaporizer facility as “Building 206B,” to distinguish it from the more recently constructed Building 206A, which is located east of the Rocket Engine Test Facility water reservoir. This report refers to the cryogenic vaporizer facility simply as “Building 206.”

Engine Test Facility, located adjacent to the airport, must be removed before this expansion can be realized. To mitigate the removal of this registered National Historic Landmark, the National Park Service has stipulated that the Rocket Engine Test Facility be documented to Level I standards of the Historic American Engineering Record (HAER). This project was initiated to fulfill that requirement.

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

Description:

Building 206 was part of the gas distribution system for the Rocket Engine Test Facility. This structure housed a liquid nitrogen vaporizer and a gaseous nitrogen compressor. It may have been designed to handle other gases as well, since the wiring was protected against explosion. The one-story gable-roof building covers a surface area of 597 square feet and is sheathed in corrugated metal panels. Since ventilation was an important consideration for Building 206, a vent was constructed on the roof along the full length of the ridgeline. Louvered vents on the gable end of the building provided additional ventilation. An overhead coiling door on the building's gable end measures approximately 16' wide and provides access to the interior and equipment. An isolated concrete-block control room in the southwest corner features a small window that allowed personnel to monitor the machinery bay. The control room had a switchboard of twelve explosion-proof switches that controlled motors and fans in the building. Also, the structure was equipped with wiring, telephones, and lighting that were explosion-proof and would therefore not provide a source of ignition.

Function:

The most cost-effective means of transporting nitrogen was to transfer it in liquid form. Liquid nitrogen could be moved in large mobile Dewars,² which maintained the nitrogen below its boiling point of -195.8°C and limited loss through evaporation. Inert, non-flammable gaseous nitrogen was used in the Rocket Engine Test Facility to actuate solenoid valves and to pressurize the fire control and hydrocarbon fuel systems.

Liquid nitrogen had to be vaporized before it could be used in the facility. A nitrogen vaporizer essentially consisted of a heat exchanger.³ Liquid nitrogen was first fed through a pump/compressor, pressurized to 6,000 pounds per square inch (psi). The highly pressurized liquid then flowed through a network of pipes to the vaporizer. Fans pulled ambient air across

² Sir James Dewar invented the Dewar flask in 1892. This invention provided insulation against the transfer of heat through conduction, convection, or radiation. The Dewar flask was commercialized in 1904 as the "Thermos" flask.

³ John H. Perry, Ph.D., ed. *Chemical Engineers' Handbook* (New York: McGraw-Hill Book Company, 1950), 1733.

the exterior surface of the pipes. The liquid nitrogen in the pipes warmed and boiled, forming high-pressure nitrogen gas. The gas was then piped throughout the Rocket Engine Test Facility for use. Pressure reducers provided gaseous nitrogen at other pressure levels, including 3,000 or 4,000 psi gauge for test rigs. A system to supply high-pressure cooling water to test rigs was also pressurized with nitrogen.⁴

One major use for high-pressure nitrogen gas was the actuation of solenoid valves that controlled gaseous hydrogen, nitrogen, and helium. Nitrogen supplied to solenoids at hydrogen Dewars actuated those valves.⁵

The use of nitrogen under pressure to actuate remote valves located in proximity to flammable liquids or gases was common practice in the 1950s. Engineering texts of the period refer to pneumatic actuators as “pneumatic diaphragm motors.” Pneumatic actuators, generally operated by compressed air, gaseous nitrogen, or hydraulic fluid, were used to open sliding stem-controlled valves, dampers, rotary plug valves, and a variety of remotely controlled devices.⁶ Gas-actuated valves, controlled by electrically operated solenoids, could be rapidly opened or closed. Hydraulic fluid was used to pressurize the engine’s fire control systems.

The vacuum condition capabilities added to Test Stand B in 1986 were maintained by pressurized nitrogen. Nitrogen powered the ejectors used to simulate the vacuum of space in the test stand. Two gas ejectors powered by the facility’s nitrogen supply system created the desired extra-terrestrial conditions. Normally this type of ejector was steam-powered, but the availability of a high-pressure nitrogen supply on the site made the use of this gas cost-effective.⁷

History:

The site of Building 206 was left as undeveloped lawn space during the original construction phase of the Rocket Engine Test Facility from 1955-57. The location appears as empty space in a 1957 photograph of a scale model representing the facility as originally constructed.⁸ Historic

⁴ Drawing CE-183170 – 9/3/92.

⁵ *Ibid.*

⁶ Perry, 1328.

⁷ Ejectors use the venturi effect to create a vacuum. An ejector is a simple form of vacuum pump, with no moving parts. It consists of a gas nozzle that discharges a high-velocity jet of nitrogen across a suction chamber connected to the vacuum chamber. The nitrogen traps the gas to be evacuated and then passes into a venturi-shaped diffuser, which converts the velocity energy of the nitrogen into pressure energy. Ejectors normally used high-pressure steam to provide the energy necessary to create a vacuum. Since the Rocket Engine Test Facility had access to ample supplies of pressurized nitrogen, it was cost-effective to use this source rather than steam.

⁸ NASA Photograph Number C-45264 (1957).

aerial photographs of the facility taken in 1962 and 1965 also show the Building 206 site as empty lawn.⁹

An original construction drawing for Building 206 is dated August 23, 1968,¹⁰ and the facility appears on a 1971 aerial photograph of the Rocket Engine Test Facility.¹¹ Construction drawings indicate that NASA Lewis Research Center engineering staff members designed Building 206. The building shows little or no evidence of additions, remodeling, or other alterations. Building 206 continued to support the gas distribution system for the Rocket Engine Test Facility until the entire Rocket Engine Test Facility was closed in 1995. Building 206 has been vacant since the 1995 shutdown and is currently not in use. The Rocket Engine Test Facility, including Building 206, is scheduled for demolition to accommodate the expansion of Cleveland Hopkins International Airport.

Conclusion:

Building 206, the cryogenic vaporizer facility, housed equipment that served a critical function at the Rocket Engine Test Facility. This structure provided pressurized nitrogen gas to perform a variety of essential tasks, especially in environments where electrical motors or actuators could not be used safely. The building served in this capacity from the time of its construction in 1968 until the Rocket Engine Test Facility closed in 1995.

⁹ NASA Photograph Numbers C-60674 (1962), C-65-1270 (1965), and C-65-1271 (1965).

¹⁰ Drawing CF-101188, 8/23/68.

¹¹ NASA Photograph Number C-71-3283 (1971).

Sources of Information/Bibliography

A. Engineering Drawings:

NASA Lewis Research Center – Cleveland, Ohio 44135

Rocket Engine Test Facility
Gaseous Nitrogen System
South 40 – Building No. 202
3,000 psig Gaseous Nitrogen Supply System Schematic
Drawing No. CF-183170 – 9/3/92

NASA Lewis Research Center – Cleveland, Ohio 44135

Rocket Engine Test Facility
Gaseous Nitrogen System
South 40 – Building No. 202
6,000/4,000 psig Gaseous Nitrogen Supply System Schematic
Drawing No. CF-101541 – 9/3/92

B. Interviews:

Repas, George, Hardware Design Engineer
Interview by the author, 24 October 2002
West Suffield, Connecticut, Telephone interview, Hardlines Design Company
Columbus, Ohio

C. Secondary Sources:

Butowsky, Harry. "Rocket Engine Test Facility, National Register of Historic Places Nomination." Washington, D.C.: United States Department of the Interior, National Park Service, 1984.

Dawson, Virginia P. "Rocket Propulsion Research at Lewis Research Center," 28th Joint Propulsion Conference AIAA/SAE/ASME/ASEE, July 6-8, 1992, AIAA-92-31230. NASA Contractor Report 189187.

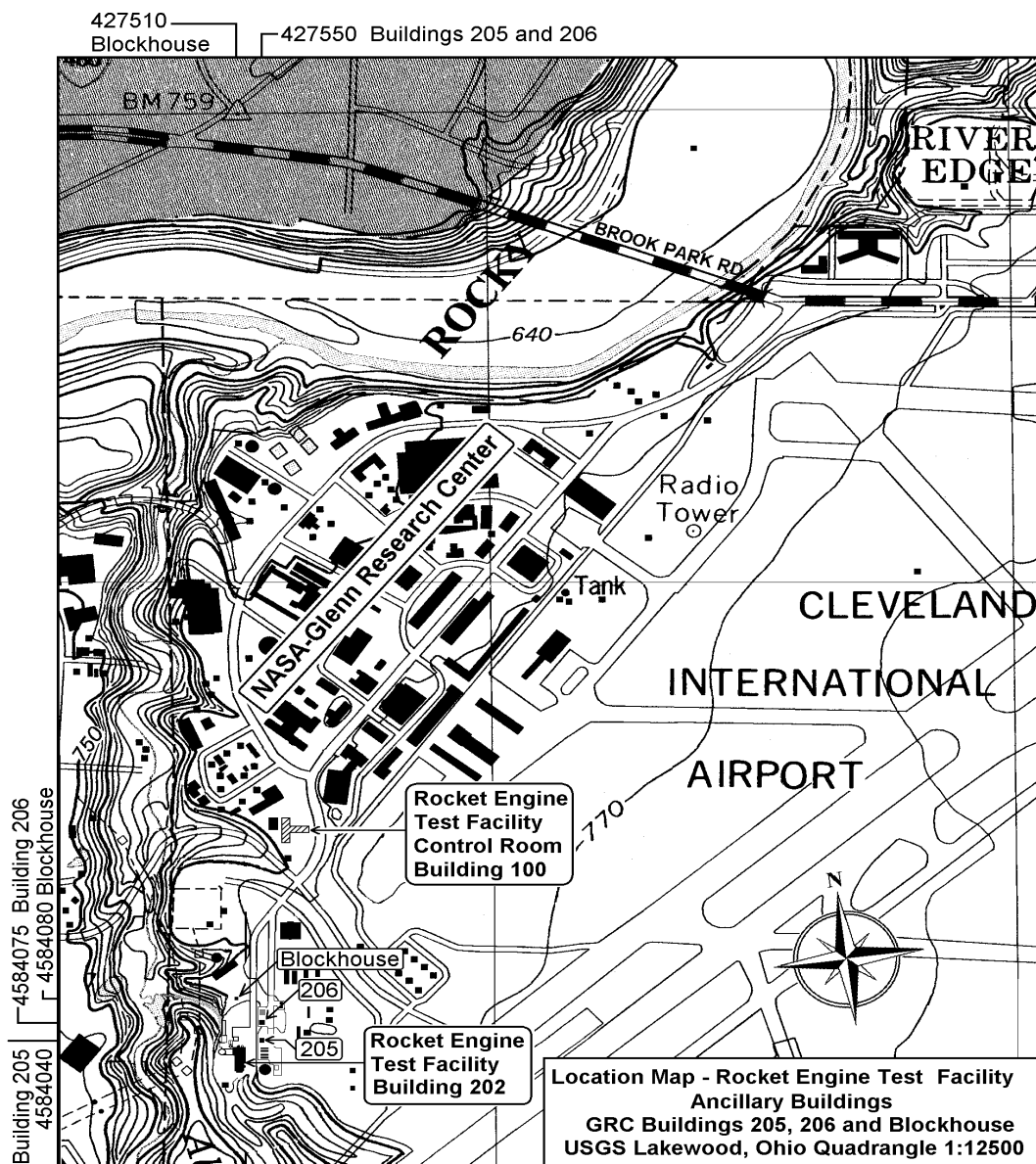
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Perry, John H., Ph.D., ed. *Chemical Engineers' Handbook*. New York: McGraw-Hill Book Company, 1950.

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Thomas, Wayne. "Description of the Rocket Engine Test Facility." Cleveland, Ohio:
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NASA Glenn Research Center
Cleveland
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Jeff Bates, Hardlines Design Company, Field Photographer, May 2002
NASA Information Technology Center (ITC), Copywork Photographer, July 2002

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| OH-124-C-1 | CONTEXT VIEW OF BUILDING 206, LOOKING SOUTHWEST FROM ACCESS ROAD. |
| OH-124-C-2 | CONTEXT VIEW OF BUILDING 206, LOOKING NORTHWEST FROM TANK FARM AREA. |
| OH-124-C-3 | CONTEXT OF NORTHEAST CORNER OF BUILDING 206, LOOKING SOUTHWEST FROM ACCESS ROAD. |
| OH-124-C-4 | NORTHWEST CORNER OF BUILDING 206, LOOKING SOUTHEAST. |
| OH-124-C-5 | SOUTHEAST CORNER OF BUILDING 206, LOOKING NORTHWEST. |
| OH-124-C-6 | EAST ELEVATION OF BUILDING 206, LOOKING WEST FROM ENTRANCE ROAD. |
| OH-124-C-7 | INTERIOR OF BUILDING 206, LOOKING NORTHWEST. |
| OH-124-C-8 | HISTORIC PLAN, SECTION, ELEVATION, AND DETAIL DRAWING OF BUILDING 206, AUGUST 26, 1968. NASA GRC DRAWING NUMBER CE-101188 (ON FILE AT NASA GLENN RESEARCH CENTER). |

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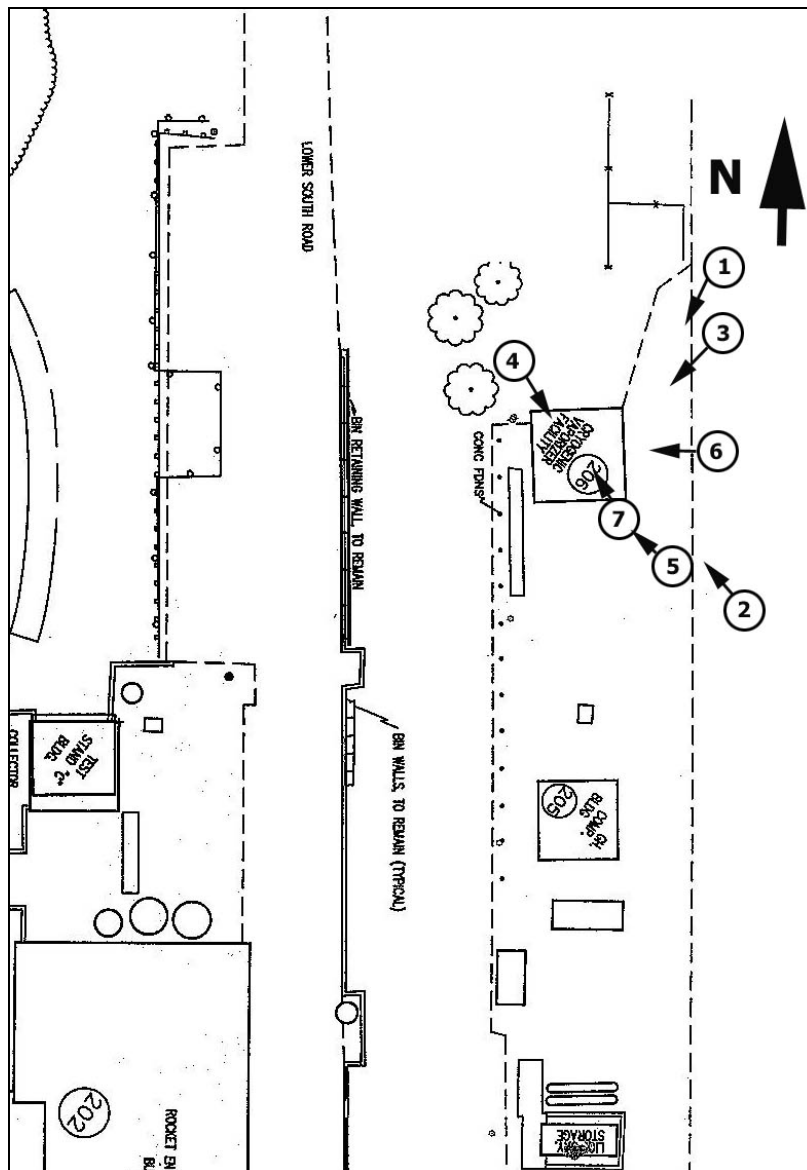
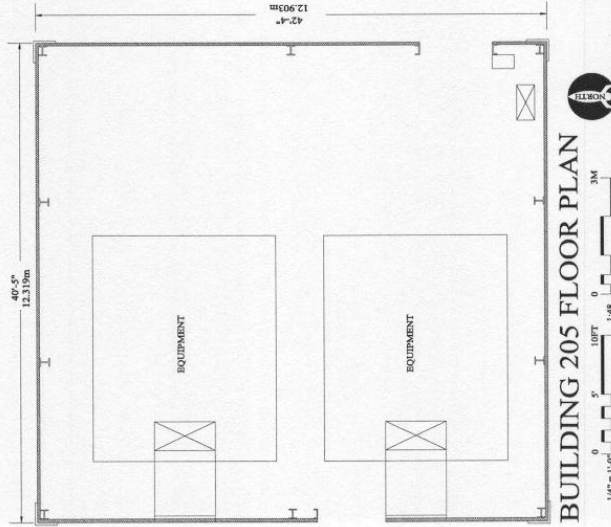


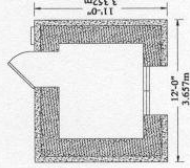
Photo Key for Rocket Engine Test Facility Building 206

BUILDINGS 205, 206 AND OBSERVATION BLOCKHOUSE



Building 205 is located approximately 170 feet northeast of the Rocket Engine Test Cell in Building 202. The structure covers a surface area of about 1,710 square feet. This building is lightly constructed, with a framing of pipe uprights and a roof of steel channel iron cross members. Light steel I-beams support the roof. The side of the building is finished with opaque fiberglass panels, while translucent fiberglass panels cover the roof.

The significance of Building 205 lies in its relationship to the reactant distribution system for the Rocket Engine Test Facility (RETF). Building 205 housed a compressor and an automated control system used to pressurize helium gas to 6,000 psi for distribution throughout the complex. Liquid oxygen boils at -183°C , which can make pumping and distribution of this substance difficult. Mechanical pumps available at the time for handling cryogenic fluids were not ideally designed for forcing liquid oxygen at high flow rates into test engines. To force liquid oxygen through the piping system and into test engines, the designer of RETF developed a pumping system powered by pressurized helium gas supplied by the compressor in Building 205. An inlet at the top of the main liquid oxygen outlet pipe was located below the liquid level. Control valves admitted pressurized helium at 4,000 psi that flowed at up to 3.5 pounds per second into the tank and forced liquid oxygen into the test rig.



OBSERVATION BLOCKHOUSE FLOOR PLAN

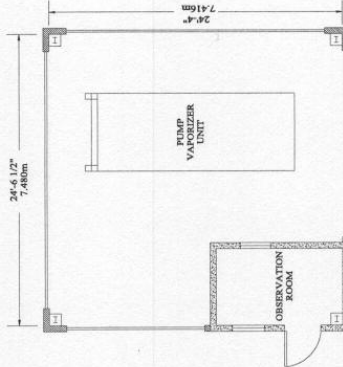
During the early years of operation at the Rocket Engine Test Facility (RETF), technicians and engineers relied on direct observation of engine firing tests to supplement instrument readings. One observation post was a large periscope in the terminal room of Building 202, which was adjacent to the test cell. A second viewing location was the Observation Blockhouse, which was a plain reinforced concrete bunker located approximately 260 feet north of the test cell. The blockhouse protected observers from flying debris in case of catastrophic engine failure during testing.

Built from 1955-1957, the Observation Blockhouse covers 132 square feet, and its reinforced concrete walls are 6" thick. Observers entered the bunker through a door in the north elevation. A ladder next to this door led to the roof. The south elevation had a deeply recessed thick glass window that measures approximately 18" high and 18" wide. The window was protected by a metal grate. The window was divided into two sections by a vertical mullion. The window is about 18" high and allowed observers stationed inside the blockhouse to watch engine tests in Building 202. The blockhouse was equipped with an intercom system, emergency communications, and a telephone system to allow two-way contact with test stand engineers. The blockhouse also had a small switch panel with an "abort" button positioned below the observation window.

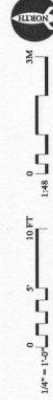
While there is photographic evidence that a closed-circuit television system was installed in the test cell as early as 1957, observers in the blockhouse were still needed to supplement electronic and video data. In 1972, however, RETF staff installed an additional closed-circuit television camera on top of the blockhouse. Additional lights installed in Building 202 enabled viewers in the RETF Building 100 control room to observe tests on a monitor. These modifications reduced the need to station observers in the blockhouse. As sensors, instrumentation, and computerized data reduction became more sophisticated, the information that could be provided by observers in a protected area was limited, and use of the blockhouse became increasingly rare.

Constructed in 1968, Building 206 was part of the gas distribution system for the Rocket Engine Test Facility (RETF). This building housed a liquid nitrogen vaporizer and a gaseous nitrogen compressor. This building covers 597 square feet and is sheathed in corrugated metal panels. Ventilation was an important consideration in the design of the building, so a vent was incorporated into the roof along the full length of the ridge line. Louvered vents on the gable end of the building provided additional ventilation. A rolling shutter door about 16' wide on the building's gable end allowed access to the interior and machinery. An isolated control room featured a small window through which operators monitored the machinery bay. The control room had a switchboard of 12 explosion-proof switches for controlling motors and fans in the building. The building was also equipped with explosion-proof wiring, telephones, and lighting.

A nitrogen vaporizer essentially functions as a heat exchanger. Liquid nitrogen flowed through a network of pipes, the external surfaces of which were largely exposed. Fans drew ambient air over the exterior surface of this piping. The liquid nitrogen in the tubes then warmed and boiled to form gaseous nitrogen, which was then pressurized to 6,000 psi and piped throughout the RETF complex.



BUILDING 206 FLOOR PLAN



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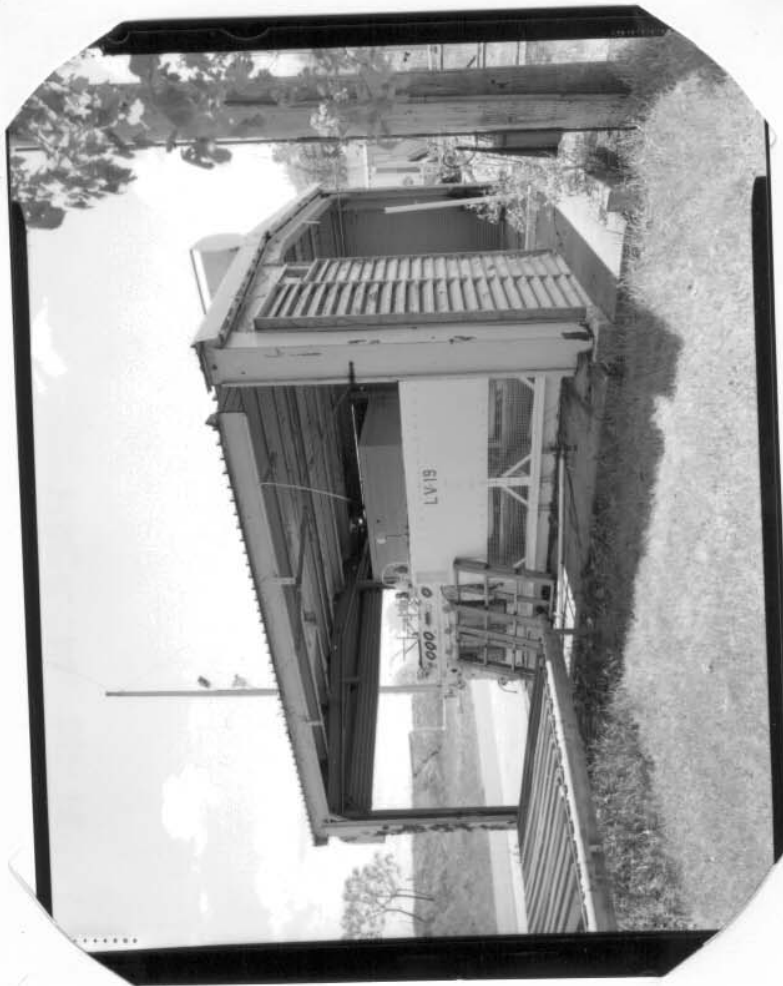
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