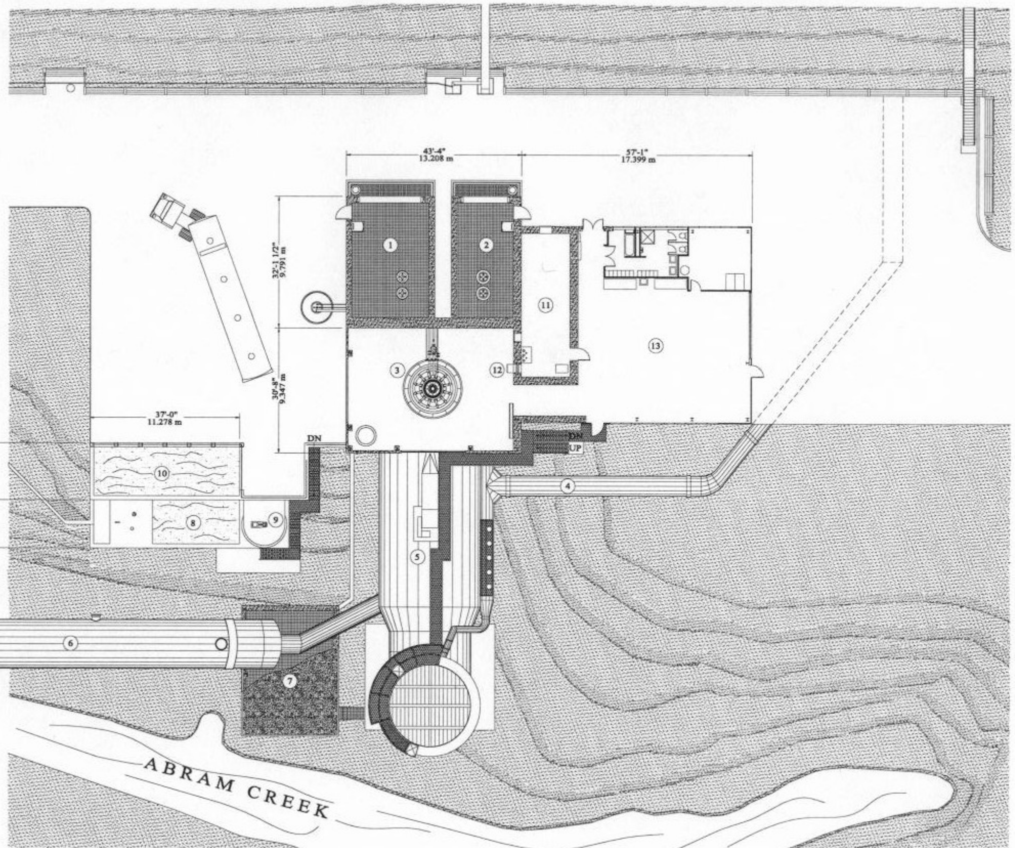
As originally designed and built from 1955 to 1957, the Rocket Engine Test Facility (RETF) could test engines using petroleum fuels and liquid propellants with liquid oxygen as the oxidizer. Early fuel research was completed using gasoline brought to the site in a tanker trailer. There were two main components to the facility: a fuel pit (1), which was a structure that housed cylindrical tanks for fuels, and an ox (oxidizer) pit with the double-walled tanks for storing liquid oxygen (2). The liquid oxygen tanks were jacketed in an outer tank that contained liquid nitrogen. The stand for supporting rocket engines during tests was located inside the test cell (3).

A significant feature of the RETF was the ability to remove contaminants from the rocket exhaust stream by trapping chemical pollutants in water sprays inside the scrubber. A pipe (4) supplied water to the scrubber (5) from a 500,000 - gallon reservoir. A detention tank (6) collected and held water drained from the scrubber. A pump (7) then transferred the water to a treatment basin tank (8). Chemicals were added at the mixer (9), and the treated water was finally pumped to a collector basin tank (10) before discharge to a municipal wastewater treatment facility.



The terminal room (11) housed amplifiers, thermocouple junctions, and equipment for transmitting test data to the control room in Building 100. The terminal room also provided a safe area for personnel to observe testing through a periscope built into the wall (12) between the terminal room and test cell. A small machine shop and office area (13) provided a space for technicians to assemble rigs and rocket engines for testing.

Notes: Plan depicts building as configured ca. 1955.

BUILDING 202 FLOOR PLAN

3/32"=1'-0" 0 5 10 20 FT

1:128 0 1 2 3 4 5 6M

NORTH

DELINEATED BY: Hardlines Design Company, 2003

NASA ROCKET ENGINE TEST FACILITY RECORDING PROJECT

ROCKET ENGINE TEST FACILITY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER

CLEVELAND CUYAHOGA COUNTY OHIO

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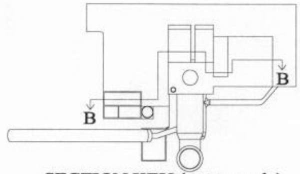
HISTORIC AMERICAN ENGINEERING RECORD OH-124-D

This delineation shows a section through the Rocket Engine Test Facility (RETF) looking west. The functional layout of the RETF facilitated rocket engine testing and the efficient management of reactants, waste products, and other materials. In the service area (1), operators assembled the engines and attached sensors, thermocouples, and other instrumentation. Personnel also used the equipment in the small machine shop to modify components and to make special hardware that met specific requirements. Technicians and engineers also had offices in this area.

The observation room (2) housed connections, amplifiers, and data transmission equipment. Raw data transmitted from instruments attached to the test engines went to terminal boards and connectors in this area. The terminal boards then transmitted the test data to the monitoring and recording equipment in the Building 100 control room. The observation room also provided a safe location from which observers could monitor tests. A glass window and periscope on the wall adjacent to the test cell (3) provided an indirect view of the test stand and engine. In addition, the observation window was mounted at a lower elevation than the rocket engine, so that the window was not directly in line with the exploding engine during catastrophic test failures.

The oxidant pit, also known as the "ox pit" (4), housed tanks for liquid oxygen (5) and other oxidants. These tanks were double-walled. The inner tank contained the oxidant, while the outer tank was filled with liquid nitrogen. Liquid notrogen boils at -195.8°C, and liquid oxygen boils at -183°C, so the liquid nitrogen maintained the oxygen in a liquid state and prevented significant oxygen loss. This system also facilitated the accurate measure of actual oxidant usage. The tanks were mounted on a suspension system with load cells, which transmitted data on the weight of the tanks to the control room.



SECTION KEY (not to scale)

1/8"=1'-0" 0 5 10 20 FT

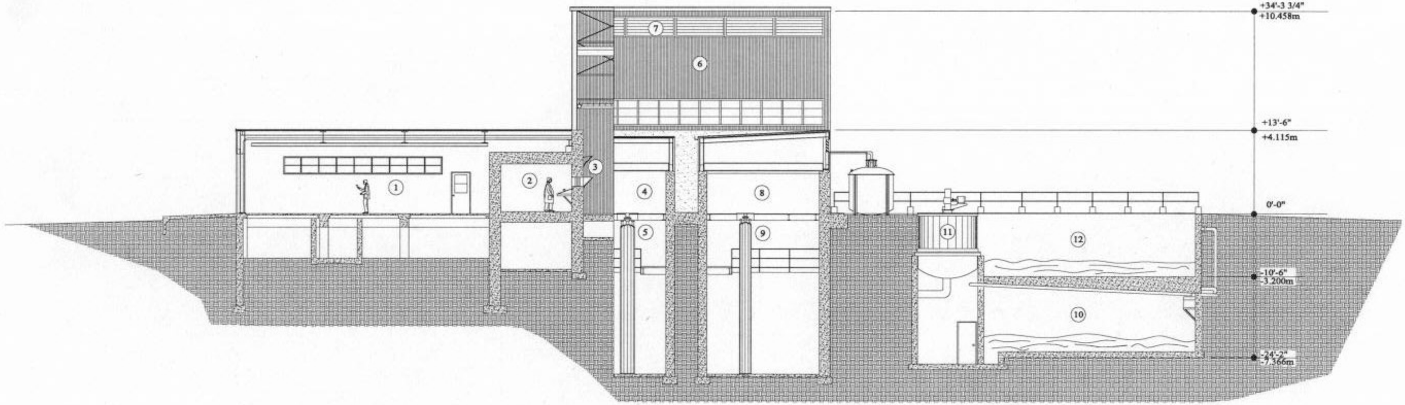
1 : 96 0 1 2 3 4 5 6M

The view in this delineation shows the northeastern wall of the test cell (6). Shutters (7) at the top of the cell housing could be opened to vent the cell during engine tests. The exterior panels of the cell were made of "Transite," a combination of asbestos and cement. Translucent fiberglass panels later replaced the original Transite. In the event of an explosion, these panels blew away to relieve blast pressure. The panels were then easily replaced.

The fuel pit area is shown at (8). From 1957 to 1959, the fuel tank (9) contained gasoline or other petroleum fuels. Weight and rate of fuel use from the tank could be determined from load cells incorporated into the tank's support system.

The treatment basin tank (10) retained water from the scrubber detention tank. Technicians tested water in the treatment basin tank to determine the quantity of chemicals needed to neutralize the wastewater. The mixing chamber shown at (11) was used to apply these neutralizing chemicals to the scrubber wastewater. A vertical shaft propeller mixer assured that the neutralizing chemicals were evenly dispersed throughout the wastewater.

The collector tank (12) retained treated water pumped from the neutralizing tank. Technicians tested the water in this tank to confirm that treatment had been adequate. Once the water met treatment standards, it was pumped to a municipal waste treatment plant.



BUILDING 202 LONGITUDINAL SECTION B-B

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NASA ROCKET ENGINE TEST FACILITY RECORDING PROJECT

ROCKET ENGINE TEST FACILITY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER

CLEVELAND CUYAHOGA COUNTY OHIO

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HISTORIC AMERICAN ENGINEERING RECORD OH-124-D

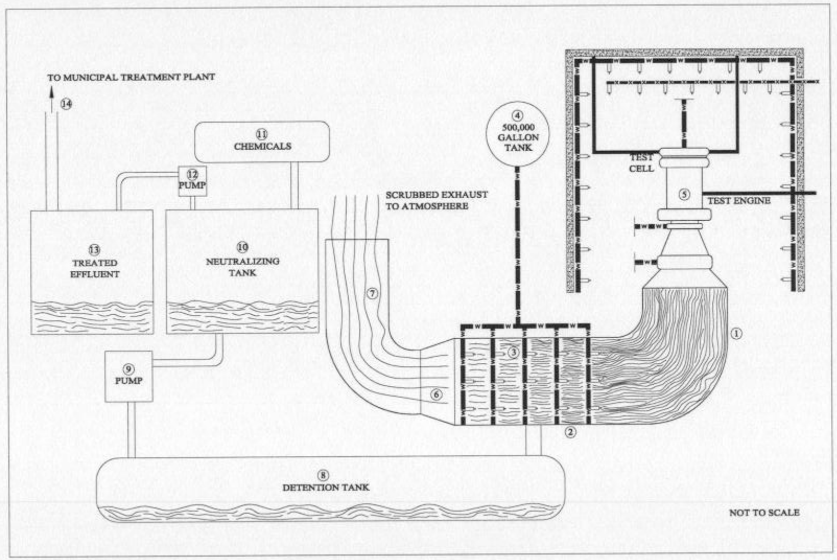
ROCKET EXHAUST FLOW CHART

The Rocket Engine Test Facility (RETF) is located near the Cleveland Municipal Airport, a number of metropolitan parks, and a series of residential neighborhoods. Because of this urban setting, it was essential to control the exhaust emissions and loud noises generated during rocket engine tests. NASA addressed these problems by including mufflers and silencers in the original design. In addition, both the original high-thrust vertical test stand and the low-thrust horizontal stand added in 1984 discharged exhaust into a scrubber/ silencer. This device removed combustion by-products from the rocket engine exhaust and decreased noise levels.

Scrubbers ① are devices that use a liquid to remove gases and dispersed particles from an exhaust stream. At the RETF, the scrubber condensed the hot exhaust produced by rocket engine tests. As the exhaust cooled and reached its dew point, the condensed exhaust was trapped in water and sprayed into the scrubber's chamber. The water was then collected for treatment and disposal.

The RETF scrubber was mounted on concrete foundations designed to support engines capable of producing up to 100,000 lbs. of thrust. However, the collective weight of mounts, plumbing controls, and instrumentation limited the facility's capability to testing engines that exerted less than 20,000 lbs. of thrust.

The main component of the scrubber system was a horizontal tank ② measuring 100' long by 25' in diameter. The tank contained five water spray bars ③ fitted with nozzles that produced a heavy aerosol spray. During test runs, water from a nearby reservoir ④ flowed through the aerosol nozzles at a rate of 50,000 gallons per minute. Rocket engines ⑤ mounted on the original test stand vertically exhausted hot gases into one end of the tank. The engines discharged this exhaust at velocities ranging from 9,000 to 12,000 feet per second (fps), and at temperatures of approximately 6,000°F. This exhaust was trapped in the water spray coming from the nozzles. Inside the tank, the exhaust stream velocity slowed to 25 fps, and much of the exhaust was converted to steam.



Additional water sprays condensed the steam. The other end of the tank ended in a transition elbow ⑥ that led to a vertical stack ⑦. This stack measured 20' in diameter and rose to 79'7" in height. Any remaining water vapor and non-condensable exhaust gas exited the vertical stack at a temperature of 160°F and a velocity of 20 fps. Several burners near the rocket exhaust source ignited any hydrogen or other fuel not consumed by the engine. These burners prevented unburned fuel from building to explosive levels inside the scrubber.

Water, condensed steam, and combustion by-products trapped by the scrubber drained into a 20,000 - gallon detention tank ⑦ located adjacent to Abram Creek, at the lowest point in the RETF complex.

Wastewater was retained in this tank until the day's test program was completed, when the wastewater was pumped ⑨ to a neutralizing tank ⑩. Chemical technicians analyzed the wastewater and determined the quantity and type of additive needed to neutralize acidity or alkalinity, so that the pH value would meet municipal wastewater standards.

Chemicals ⑪ added to the neutralizing tank reacted with combustion by-products in the wastewater. Some fuel/ oxidizer combinations produced highly corrosive acidic by-products. The use of fluorine created hydrofluoric acid by-products, and mixing a calcium compound with the hydrofluoric acid/ water mixture in the neutralizing tank produced a stable, solid precipitate of calcium fluoride. The wastewater was then re-tested and pumped ⑫ into a holding tank ⑬. The treated water was finally pumped into the municipal wastewater treatment system ⑭.

Engineers monitored the scrubber/ silencer system from the control room in Building 100. Pilot lamps on a control board panel represented the scrubber layout and enabled technicians and engineers to observe the system's operating status. From 1957-1959, RETF testing was restricted to engines using rocket propellant (RP), a refined grade of kerosene, and liquid oxygen as the reactant. In the 1960s, RETF researchers used reactants such as nitrogen tetroxide, unsymmetrical dimethyl hydrazine, and fluorine. Use of these chemicals required an extension of the scrubber's exhaust stack to guarantee thorough exhaust treatment. A transition cone was mounted on top of the original 1957 exhaust stack, which reduced the diameter of the stack opening to 6' and extended the height to 118' above grade. A flare stack at the top of the scrubber stack was installed to burn residual hydrogen.

The RETF scrubber/ silencer was an engineering solution to a significant waste treatment problem. This system was crucial to maintaining a clean, low-noise environment near the RETF.

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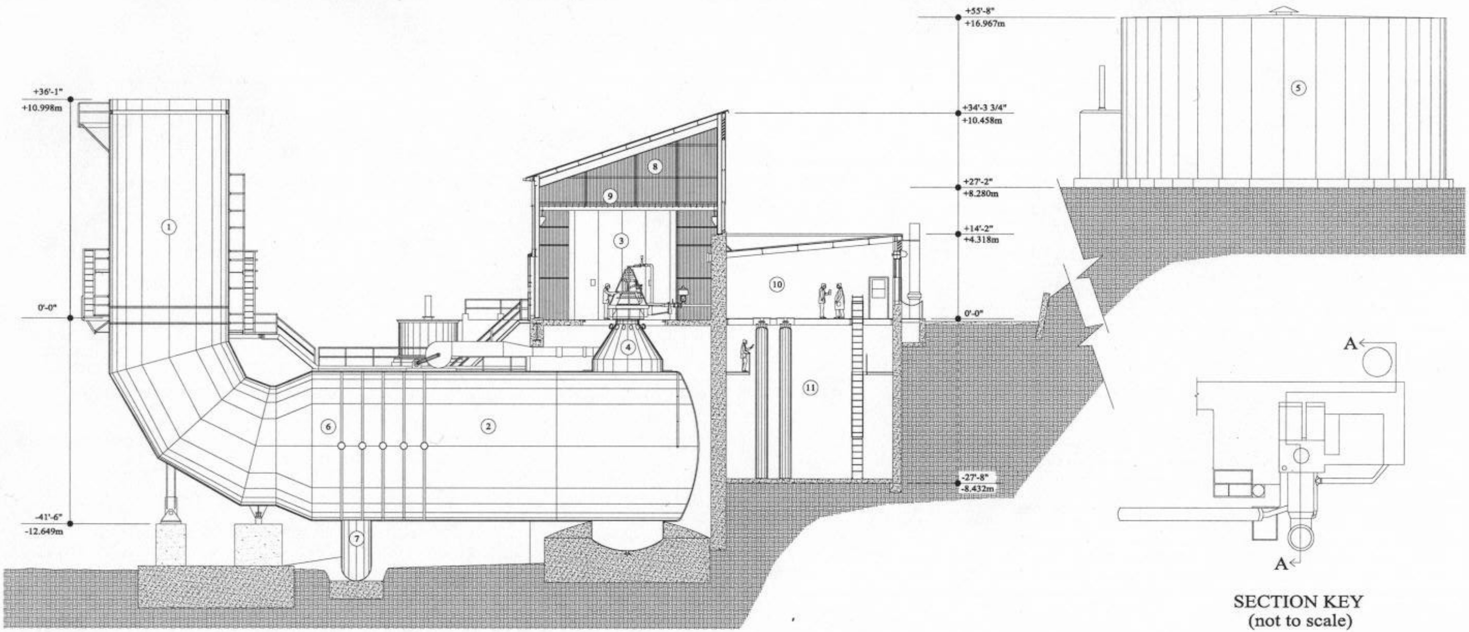
This delineation is a section view of Rocket Engine Test Facility (RETF) Building 202. The viewer is looking north along an imaginary axis through the center of the building's scrubber/silencer (1). This view shows the construction of the horizontal, transitional, and vertical sections of the scrubber. The horizontal section (2) was a cylinder measuring 100' long and 25' in diameter. During testing, researchers positioned the rocket engine on Stand A inside the test cell (3) using variously sized mounts. The exhaust was directed downward into the scrubber. Stand A was instrumented with load cells that sent engine thrust data to the observation room terminals and on to the control room in Building 100. Sensors also measured temperature and pressures at critical points on the engine.

Rocket engines mounted on Stand A discharged exhaust at velocities of up to 12,000 feet per second (fps) and at temperatures of 6,000°F. A counter-flowing water spray (4) inside the scrubber intercepted the engine exhaust. To feed this spray, water flowed from a 500,000-gallon reservoir (5) located on a hill approximately 100' east of Building 202. RETF personnel have not confirmed that the water was gravity-fed, but there are no pumps in that part of the system, and a gravity-fed system would not have been vulnerable to power interruptions. This water circulated into a manifold, and then to the nozzles mounted on a series of pipes inside the scrubber (6). The nozzles produced a heavy mist or aerosol of water that cooled the exhaust and removed soluble gases from the gas stream. The water also purged cumbustion particles, approximately 10 to 10,000 angstroms in size, which were dispersed in the exhaust stream. The condensation of water vapor during combustion also reduced the velocity of the exhaust stream. Rapid condensation and the large diameter of the scrubber tank in comparison to that of the rocket nozzle further decreased the exhaust velocity to 25 fps. Additional water sprays condensed steam, and the combined flow of condensed steam and water from the spray drained (7) into a detention tank. Non-condensable gas emerged from the exhaust stack at temperatures below 160°F and at velocities of 20 fps or less.

The stand inside the test cell (3) secured and supported the rocket engine during testing. The test cell could be closed and heated to provide a dry, sheltered area that protected the engine, associated sensors, and other instruments. Before firing the engine, engineers opened the cell's blast doors and shutters, effectively providing open-air conditions for the test. Explosions frequently resulted from the testing of experimental engines and fuels. To minimize the destructive effects of these explosions, Building 202 was sheated in panels of "Transite," (8) a mixture of asbestos and cement. Translucent fiberglass panels later replaced the original transite. In the event of an explosion, the panels blew away and quickly relieved pressure. The panels were easily replaced afterwards to re-sheath and enclose the test cell. The portion of the test cell's inner perimeter near the roofline contained a fire suppression system (9). In case of fire, some of this piping and the associated nozzles sprayed water from the 500,000 - gallon reservoir into the test cell, while others flooded the cell with carbon dioxide.

A section through the fuel pit is delineated at (10). The fuel pit housed two tanks (11) that contained petroleum-based fuels, chiefly gasoline, from 1957 to 1959. These tanks were equipped with load cells that gathered data on the weight of the tanks. By analyzing this data, engineers could monitor fuel consumption rates and determine the quantity of fuel left in the tanks.

To cool the rocket nozzles after testing, the 500,000 - gallon water tank (5) east of Building 202 fed pumps that had a capacity of either 650 or 1,400 gallons per minute. Water from this reservoir also cooled a rocket altitude simulation system added to the RETF in 1984.



SECTION KEY
(not to scale)

1/8"=1'-0" 0 5 10 20 FT

1 : 96 0 1 2 3 4 5 6M

BUILDING 202 TRANSVERSE SECTION A-A

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NASA ROCKET ENGINE TEST FACILITY RECORDING PROJECT

CLEVELAND

ROCKET ENGINE TEST FACILITY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER

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HISTORIC AMERICAN ENGINEERING RECORD

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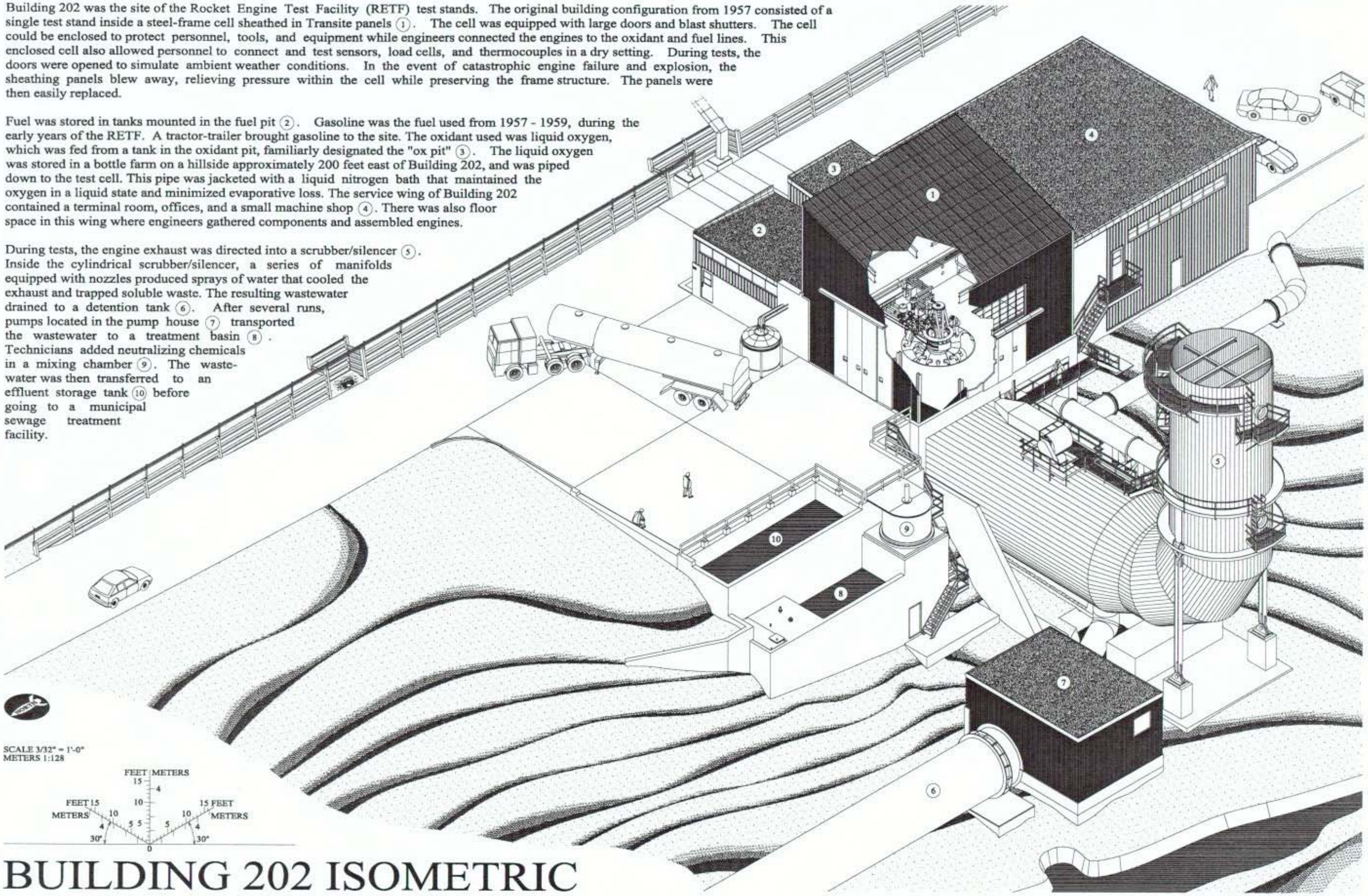
Building 202 was the site of the Rocket Engine Test Facility (RETF) test stands. The original building configuration from 1957 consisted of a single test stand inside a steel-frame cell sheathed in Transite panels (1). The cell was equipped with large doors and blast shutters. The cell could be enclosed to protect personnel, tools, and equipment while engineers connected the engines to the oxidant and fuel lines. This enclosed cell also allowed personnel to connect and test sensors, load cells, and thermocouples in a dry setting. During tests, the doors were opened to simulate ambient weather conditions. In the event of catastrophic engine failure and explosion, the sheathing panels blew away, relieving pressure within the cell while preserving the frame structure. The panels were then easily replaced.

Fuel was stored in tanks mounted in the fuel pit (2). Gasoline was the fuel used from 1957 - 1959, during the early years of the RETF. A tractor-trailer brought gasoline to the site. The oxidant used was liquid oxygen, which was fed from a tank in the oxidant pit, familiarly designated the "ox pit" (3). The liquid oxygen was stored in a bottle farm on a hillside approximately 200 feet east of Building 202, and was piped down to the test cell. This pipe was jacketed with a liquid nitrogen bath that maintained the oxygen in a liquid state and minimized evaporative loss. The service wing of Building 202 contained a terminal room, offices, and a small machine shop (4). There was also floor space in this wing where engineers gathered components and assembled engines.

During tests, the engine exhaust was directed into a scrubber/silencer (5). Inside the cylindrical scrubber/silencer, a series of manifolds equipped with nozzles produced sprays of water that cooled the exhaust and trapped soluble waste. The resulting wastewater drained to a detention tank (6). After several runs, pumps located in the pump house (7) transported the wastewater to a treatment basin (8). Technicians added neutralizing chemicals in a mixing chamber (9). The wastewater was then transferred to an effluent storage tank (10) before going to a municipal sewage treatment facility.



BUILDING 202 ISOMETRIC

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HISTORIC AMERICAN ENGINEERING RECORD

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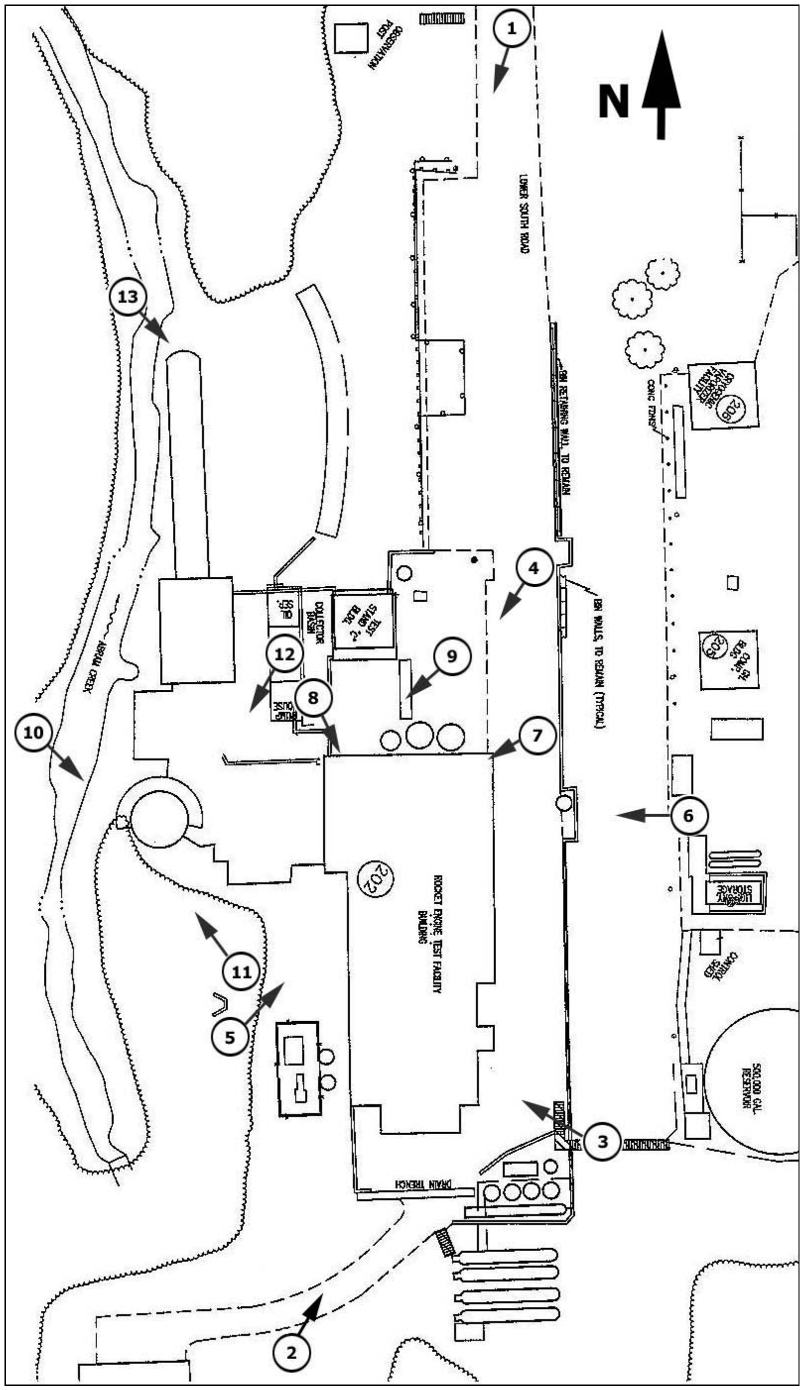
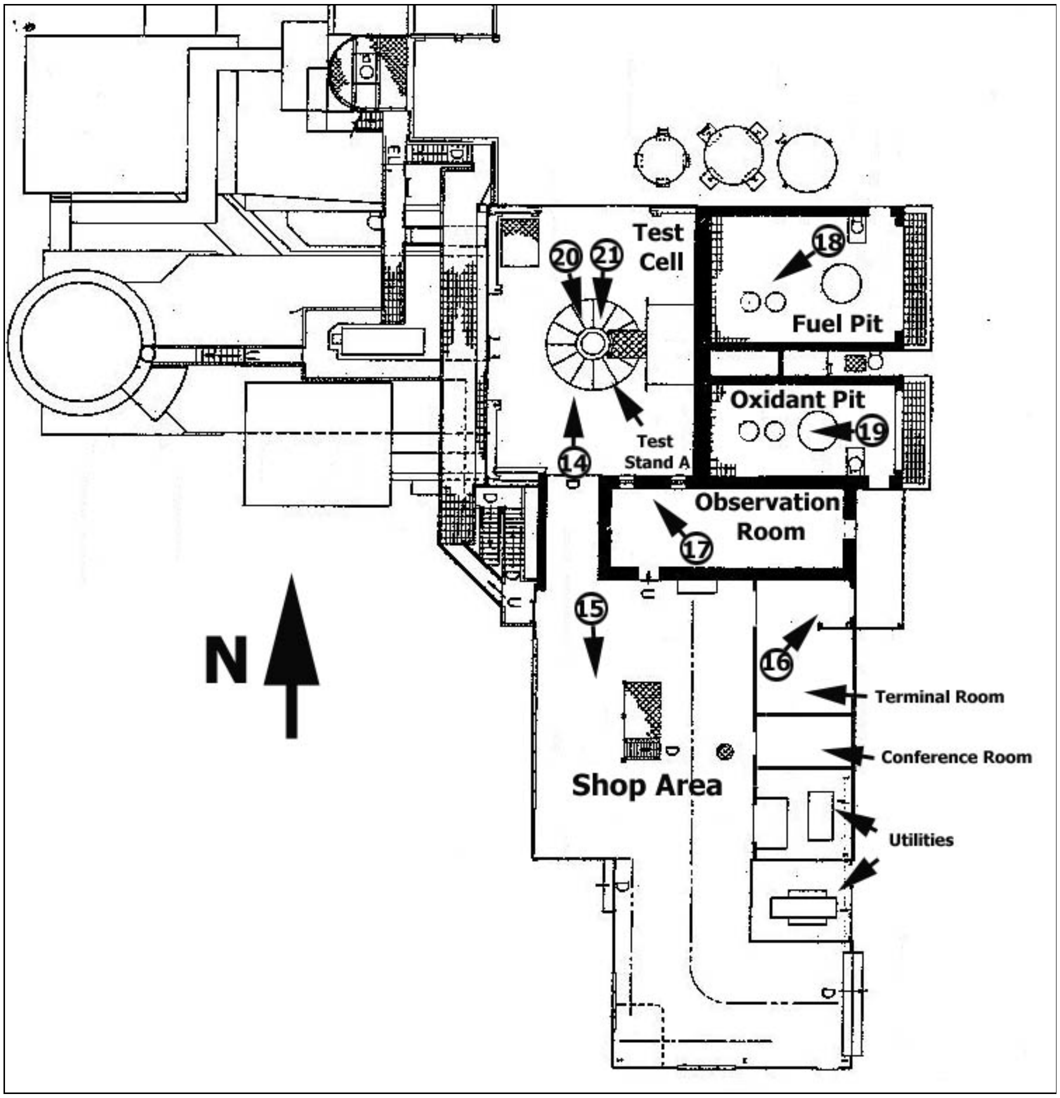
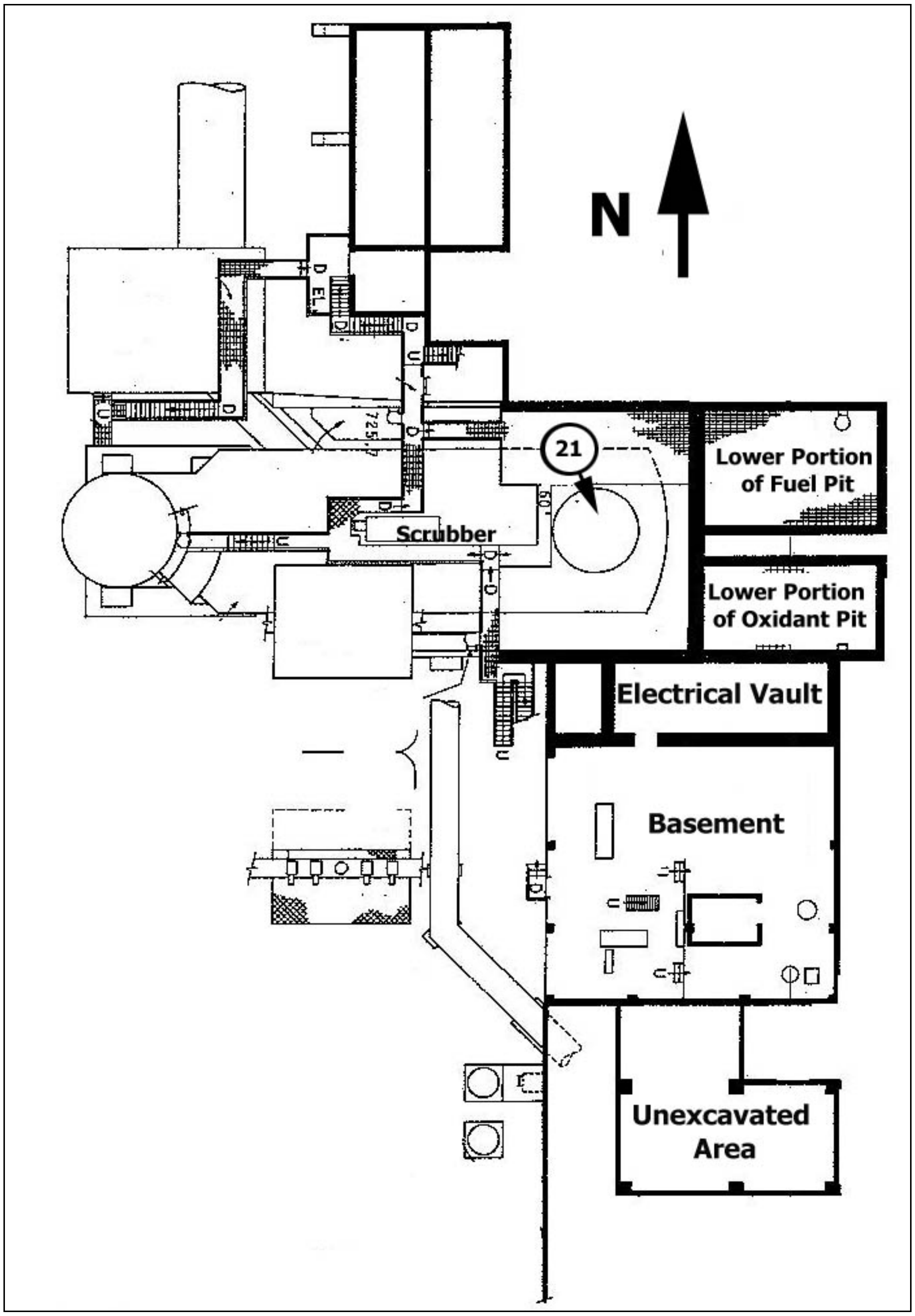


Key to Exterior Photos



Key to Interior Photos on Main Level of Building 202



Key to Interior Photo on Basement Level of Building 202