ALTITUDE WIND TUNNEL SUPPORT BUILDINGS
(Microwave System Lab—Bldg. 7)
NASA Glenn Research Center at Lewis Field
Cleveland
Cuyahoga County
Ohio

Architectural Information
Altitude Wind Tunnel
Support Buildings

WRITTEN HISTORICAL AND DESCRIPTIVE DATA
PHOTOGRAPHS

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

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This document (HAER No. OH–134) is one of three HABS–HAER reports regarding a single test facility at the NASA Glenn Research Center. The facility was originally built as the Altitude Wind Tunnel (AWT) but was converted into the Space Power Chambers (SPC) in the early 1960s, as described in the first two reports—HAER No. OH–132 (AWT) and HAER No. OH–133 (SPC). The third report (HAER No. OH–134) describes the support buildings required to support the operations.

Contents

1.0 Overview

Location: National Aeronautics and Space Administration (NASA) John H. Glenn Research Center at Lewis Field 21000 Brookpark Road, Cleveland, Cuyahoga County, Ohio

The Altitude Wind Tunnel (AWT) support buildings are located in the wedge-shaped block of Ames, Moffett, Durand, and Taylor roads near the center of the NASA Glenn Research Center. The T-shaped Shop and Office Building faces north on Ames Road; the tunnel had formed a rectangle behind. The other remaining support buildings are in the immediate vicinity (Fig. 1).

Elevations: The Shop and Office Building (Bldg. 7, now the Microwave Systems Laboratory, MSL) was at 754'-0", the Refrigeration Building (Bldg. 9) was at 754'-0", the Exhauster Building (Bldg. 8—served as the Visitor Center until 2010; is currently the NASA Glenn Briefing Center) was at 755'-0", Cooling Tower No. 1 (Bldg. 10) was at 752'-0", and the Air Dryer Building was at 753'-0".[1]

UTM Coordinates: 17 427938E 4585154N (NAD83)
Latitude: 41.41471 Longitude: –81.86227 Quadrangle: Lakewood, Ohio

Present Owner: NASA John H. Glenn Research Center

Present Use: The AWT was demolished in 2009. The interior of the wind tunnel had not been used as a test facility since the mid-1970s, but its interior and the former wind tunnel test section (in Bldg. 7) had been used for storage by NASA Glenn's Communications Division in the 1990s and 2000s. Various large pieces of equipment had been stored inside the test section, and the surrounding test chamber room had been littered with excess equipment and supplies.

The tunnel's primary building, the Shop and Office Building (Bldg. 7), was not demolished in 2009. It is presently named the MSL and contains near-field and far-field antenna testing ranges operated by NASA Glenn's Communications Division. The chamber's overhead crane remains in working condition and is used by the MSL. The former tunnel control room on the mezzanine level has been gutted, and the space has been reconfigured as a storage room. The office portion of Building 7 is used primarily as office space by NASA Glenn's Educational Programs Office.

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The Refrigeration Building and Cooling Tower No. 1 continue to be used in their original roles of providing refrigeration for the Icing Research Tunnel (IRT). The exhauster equipment was removed from the Exhauster Building in late 1969. The building and its annex were converted into the Aerospace Information and Display Building in 1970. The displays were expanded, and it was renamed the Visitor Information Center in 1975. Since 2010, it has been the NASA Glenn Briefing Center.

In later years, the Circulating Water Pump House (Bldg. 78, which was renamed the Solar Power Annex) and the Vacuum Pump House created for the Space Power Chambers (SPC) were used for storage by the Educational Services Division. Both of these structures were demolished with the tunnel.

The Duct Lab, a 4" x 10" wind tunnel in the basement of Building 7, was used until 2007 and remains in working condition. It had been used for developing supersonic injectors, artificial intelligence methods, and non-intrusive laser systems, as well as for flow physics studies and investigations of continuous Mach 1.6 to 5.0 flow physics.[2] The Small Supersonic Wind Tunnels Building was demolished in the early 1980s.

1.1 Location Map

Figure 2 shows the location of the support buildings for the AWT in the U.S. Geological Survey (USGS) Lakewood, Ohio, quadrangle, and Figure 3 is a diagram of the AWT and it support buildings as they looked in 2007.

1.1.1 Original Plans

The AWT complex consisted of several structures. Building 7 (presently the MSL, but historically referred to as the Shop and Office Building) is a T-shaped building into the rear of which the tunnel entered from the west and exited to the east. The remainder of the tunnel formed a rectangle immediately behind. The Shop and Office Building originally contained the test chamber and control room, two floors of offices in the east wing, a shop area in the west wing, and a high-bay area with an overhead crane running north and south down the middle of the building (Fig. 4). The test chamber room in the rear was an open two-story space with the tunnel sunken in the floor.

The Exhauster Building (Bldg. 8), a two-story rectangular structure, was located immediately to the east of the wind tunnel. It contained the compressors and exhausters used to remove air from within the tunnel to recreate the thin atmosphere found at high altitudes. The equipment also removed the hot air exhausted by the engines being tested in the tunnel. In addition, the Exhauster Building contained the drive motors used to operate the large fan that created air speeds up to 500 miles per hour (mph) inside the tunnel.

The Refrigeration Building (Bldg. 9) is a rectangular structure that was located to the immediate west of the tunnel. It contained the compressors and other refrigeration equipment used to create the low temperatures inside the tunnel that corresponded with those found at high altitudes. It also cooled the new air added to the tunnel's airflow, and created chilled water for much of the laboratory.

The Air Dryer Building cooled and dried atmospheric air before it was introduced into the tunnel's airstream. Other related buildings include Cooling Tower No. 1 (Bldg. 10), the Steam Plant (Bldg. 12), and electrical Substation B (Bldg. 13). The Vacuum Pump House and the Circulating Water Pump House (Bldg. 78) were located underneath the tunnel. The former housed the vacuum pumps for the SPC in the 1960s. The latter supplied an exhaust gas cooler that was used to reduce the temperature of the engine exhaust before it was expelled.

The Small Supersonic Wind Tunnel Building, formerly located just off the southwest corner of the AWT, used the AWT's dry refrigerated air to operate three small supersonic wind tunnels. The Duct Lab in the basement of the Shop and Office Building initially used the tunnel's compressors and later the center's primary exhaust system to operate a 4" by 10" supersonic flow physics tunnel.

1.1.2 Project Information

This report was part of a wider effort to document the AWT/SPC facility prior to its demolition. Documentation was formally begun in May 2005 after Statement of Work 6.31 for the NASA Glenn History Program was finalized. The project included the gathering of records, images, films, oral histories, and researching the facility, its tests, and significance. The resulting information is being disseminated via a book, a website, a multimedia disk (CD–ROM), a documentary video, and this three-section construction report.

In 2005, NASA Glenn proposed to remove the entire tunnel circuit except for the test section within the high bay of Building 7. Building 7 and most of the other support buildings were not included in the demolition (Fig. 5). Although the AWT/SPC facility was unique on the basis of size alone, the maintenance costs for the facility became so high as to be justified only by the largest of research programs. Although mostly idle since the mid-1970s, this facility had had a rich history and had played an important role in NASA and aerospace history. For this reason, NASA Glenn decided to document the facility as thoroughly as possible before its demolition and to share the information with the public and within the Agency.

1.1.3 Construction Data Sheet

Date of Construction: 1942–43

The primary support buildings were built between 1942 and the end of 1943. The frame of the Shop and Office Building was in place by September 1942, and the building was largely built by September 1943. The building's test section and control room were complete in January 1944. The Refrigeration Building and Exhauster Building were completed in the fall of 1943. The facility conducted its first test run on February 4, 1944.[3–8] The Primary Pump House was added in 1951, and the Vacuum Pump House was constructed in 1961 and 1962. The Small Supersonic Wind Tunnels were built incrementally between 1945 and 1953.

Engineers: The design engineers were Alfred Young, Louis Monroe, Larry Marcus, Harold Friedman, Abe Silverstein, and others from the National Advisory

Committee for Aeronautics (NACA)[9,10] as well as engineers from the Carrier Corporation.

Contractors: The contractors were the Sam W. Emerson Company, the Pittsburgh–Des Moines Steel Company, the Carrier Corporation, Collier Construction Company, General Electric Company (GE), York Corporation, the Arthur E. Magher Company,[11] Armstrong Cork Company, Norris Brothers, and Robert M. Pelkey, Inc.

Owners: The AWT and its support buildings were originally constructed for the NACA's Aircraft Engine Research Laboratory (AERL). The laboratory became part of NASA on October 1, 1958. In March 1998, the laboratory was renamed the NASA John H. Glenn Research Center at Lewis Field.

Significance: The significance of the support buildings was their contribution to the operation of the AWT and SPC. The AWT was the only facility capable of testing full-scale engines in simulated flight conditions. It contributed greatly to the development of the early turbojet engines. The SPC was one of the first large vacuum chambers in the nation. It was used extensively for the successful Project Mercury and Centaur rocket programs.

In addition, the refrigeration system was the largest in the world when it came online in the 1940s. It was capable of cooling millions of cubic feet of air in the AWT to minus forty-seven degrees Fahrenheit. It continues to refrigerate the IRT.

2.0 Architectural Information

2.1 Shop and Office Building

The Shop and Office Building (Bldg. 7, (Fig. 6)) is a T-shaped building that served as the facility's center. It housed the tunnel's test section, control room, instrumentation, shop, and offices. The building is 1850'-7.25" wide,[12] the height of central portion of the building was originally 63'-7.75", and the wings are 28'-1.5" long. This center section is much wider and taller than either of the wings.[13]

The east wing contains two floors of offices and the west wing consists of a large two-story shop room. The three-story central portion of the building has two distinct areas. The northern front area, referred to as the "high bay," is constructed in the same style as the two wings. This section now contains the Near-Field Antenna Test Facility. The southern, rear portion, referred to as the test chamber, was constructed separately. It contained the AWT viewing platform on the third floor, the test section between the second and third floors, and the balance chamber below the test section. (Figs. 7 and 8 show plans for the three floors of the Shop and Office Building, and Fig. 9 shows a close-up aerial photograph.) In the early 1960s, a control room for SPC No. 1 was constructed in the balance chamber. In the 1980s, the area was reconfigured for the Far-Field Antenna Test Facility.

2.1.1 Building Exterior

The Shop and Office Building was constructed with blonde face brick matching the other buildings erected at the AERL. Between and along the tops and the bottoms of the windows, the bricks were rusticated (staggered so that some bricks protruded further than others, creating a pattern on the flat brick wall, (Fig. 10)). The roof was edged with a limestone coping.[14]

The original banded window scheme was identical for both the east and west wings. There were four identical 5'-7.75"-high twelve-pane horizontal sash windows running the length of the first and second floors. The second floor also contained a narrower eight-pane window near the center section. Below these on the east and west wing first floors were sets of metal and glass entrance doors. Two concrete steps led to the doors, and concrete canopies were overhead. The rows of windows in the wings had a continuous limestone sill along the bottom.[15] The building received a major rehabilitation in 1974 that included new windows, entrances, and other modifications.

The west-facing side of the building had a window design similar to that on the north side (Fig. 11). There were identical wide windows to the north and south of both floors with a narrower window in the center of the second floor. A metal and glass pedestrian entrance under a canopy was in the center on the first floor.[16] The building's eastern side was identical to the western except that instead of a doorway there was a narrow window identical to that on the second floor.[17]

The high bay had three sets of twelve windows vertically aligned on the upper levels of the north, east, and west walls. Each set was banded at the top, middle, and bottom with limestone coping.[18] A large truck entrance with a steel rolling door occupied the center area on the front (north) side providing direct access to the high bay, which ran from the front to the rear of the building (Fig. 12).[19] The front of the high bay was expanded in the early 1990s. The truck door was relocated to the west wall of the shop area, and the front facade was enclosed in 1990. The original front pedestrian doorways were immediately to the east and west of the truck door. There was another pedestrian entrance centered in the western wall of the shop area. Figures 13 and 14 are elevation drawings of the Shop and Office Building.

2.1.2 Chamber Exterior

The test chamber was in the rear of the high bay and had a design unique from the rest of the Shop and Office Building. The exterior walls were covered with transite. There were five bands of the material running horizontally around the building. A narrower band ran along the uppermost portion. Later, when the rear overhang was lowered, two additional bands of sheeting were added. Two parallel corrugated metal coverings ran vertically down the south side of the building to shield pipes. The 20'-0"-diameter throat section of the wind tunnel penetrated the west wall of the test chamber on the second floor and exited the east wall (Fig. 15). There were three twelve-pane square windows along top of the south wall and three longer thirty-six-pane windows along the top of the east and west walls.

In the rear of the building, the second floor of the test chamber portion of the building overhung the first and was braced by steel supports (Fig. 16). Beneath the overhang were nozzles and plumbing for a large carbon-dioxide tank resting on the ground. At some point, the overhang was lowered. This was presumably done for the addition of the SPC No. 1 control room in the early

1960s. Metal braces jutted out from the bottom of the overhang on the east and west sides and were attached to the side of the tunnel. Figures 17 and 18 show a room on the south wall of the test chamber and an aerial view of Shop and Office Building.

2.1.3 Office Wing

The eastern wing is separated from the other areas of the Shop and Office Building. This office wing is 61'-1.75" long and 44'-8" deep. The first floor originally contained two small offices and a restroom on south wall, one large and one small office on the north wall, and a long office that ran the entire length of the east wall. A north/south entrance vestibule entered just to the east of the wall separating the wing from the high bay. There was a slight extension off the rear of the building that included a stairwell and storage room in the eastern rear corner and a restroom and foreman's room in the western rear corner.[20]

The second floor originally included four small 13'-5" by 17'-2.75" offices along the north side and a long 16'-9.875" office that ran the entire length of the east wall. The south side included a large 27'-2" by 17'-2.75" office and a small1 4'-5.25" fan room. Directly to the south of that was an 8'-2"-wide dark room and a restroom. Access was provided by a stairwell in the south center area and a 3'-9"-wide hallway that extended north into the center of the wing and east through the offices.[21] Figures 19 to 22 show interior views of the Shop and Office Building.

During the SPC period, the first floor offices were combined and enlarged to form three offices along the south wall, three along the north wall, and one small one in the center of the east wall.[22] The second floor remained the same except for the long office along the east wall, which was divided in two.[23] This layout has remained unchanged since the early-1960s (Figs. 23 and 24).

In 1973 and 1974, the Office and Shop Building underwent a major renovation. The original multipaned sash windows were replaced with large single-paned windows with aluminum frames. New communications systems were installed, walls were repainted, the roof was repaired, new vents were installed, new office doorways were put in, and chalkboards were removed from the offices.[24–47]

2.1.4 Shop Area

The shop area is an open two-story space that occupies the entire western wing of the Shop and Office Building and opens up into the center high-bay area. Originally, it was 44'-8" wide and 42'-7.5" deep.[48] This large area was originally kept relatively empty except for a few workbenches and temporary test stands. A small office was located off the southwest corner of the room with access provided via the high-bay area.

The ceiling and walls are still unfinished, with pipes, trusses, and ducts exposed. A large ventilation duct ran along the south wall. Rows of fluorescent light fixtures were hung from the ceiling.[49] There were double glass and metal doors on the north and west walls for pedestrian entrance. There were originally nine twelve-paned sash windows along the north wall and four along the west wall with another eight-paned window above the door.

The shop area was used to build and disassemble engines prior to and after their test runs in the AWT. An overhead two-rail crane ran east and west and could transport items to and from the

high bay (Fig. 25). Besides moving items east and west, the crane could move north and south along its cross rail, allowing access to any area in the shop.

As part of a 1991 project that included modifications to the Engine Research Building (ERB) loading dock, the north face of the Office and Shop Building was expanded northward. The first floor of the Shop Area was expanded by 19'-0". The 24'-9" section closest to the high bay was extended an additional 5'-3" to make it even with the high bay. A new concrete apron was placed outside the doorway on the west wall.[50] The expansion resulted in two new offices, a large control room, and a smaller computer room along the north wall. There was a low roof on the exterior of the offices. A stand-alone office was built inside the shop area near the high bay (Fig. 26).[51]

In June 1961, a canisterlike trailer designed for the Mercury Evaporating Condensing Analysis experiment was installed in the southwest corner of the shop (Fig. 27). Double doors provided access to one end, and four viewing portals ran lengthwise along each side of the trailer. The rear of the trailer had a large exhaust pipe. Inside, a work table was set up with a mercury collector at one end connected by a narrow condensation tube to a boiler. The trailer was removed after the tests, and by 1972, an exhauster hood had been installed in the same area.[52] In the mid-1970s, the shop was used as a garage and work area for NASA Lewis's electric automobile research (Fig. 28). Every model electric vehicle available was tested.

2.1.5 High Bay

The three-story, 42'-0"-wide by 52'-7.25"-long high-bay area (Figs. 29 and 30) was used to transport test articles between the shop area in the western wing of the building and the test section in the rear.[53] Test articles were transported back and forth via an overhead ten-ton Shaw-Box crane that ran the length of the high bay (Fig. 31).

The crane continued rearward into the open test chamber area on the second floor. Originally there were no walls between the high bay and the shop or the upper level of the test chamber. A brick wall separated the high bay from the office wing. There was a window in the wall that provided a view of the truck door, high bay, and shop from the northwest second floor office.[54] The large open spaces in the high bay and shop areas were used to set up displays for various tours and inspections.

The shop and high bay were converted into the MSL in the early 1980s (Figs. 32 to 34) as the proposed rehabilitation of the tunnel was being considered. The MSL consisted of the Near-Field Antenna Test Facility and the Far-Field Antenna Test Facility. In 1983, the high bay was sealed off from the rear test section area. U-shaped, 36'-0"-high anechoic, radiofrequency-absorbing walls were built in the rear of the high bay. These walls, covered with row after row of foam pyramids to absorb any microwave rays that escaped the antenna, provided a precise test atmosphere that allowed researchers to scan a 22'-0" x 22'-0" area from just a few thousandths of an inch away from the surface.[55] The walls completely blocked the test section area to the south and partially blocked the shop area to the west. The brick wall to the east had always separated the room from the office wing. There remains access to the high bay from the shop via a pedestrian door at the south corner and an open passageway at the north corner.[56]

Originally there was a large truck door in the center of the north wall that was used to bring hardware, equipment, and test vehicles into the facility. In 1991, this truck entrance was sealed, and the 45.5'-0"-wide high bay was extended outward 20'-9". The first floor of the shop area also was extended at this time. A new concrete apron was placed outside the doorway on the west wall.[57] The exterior of the high-bay extension was covered with horizontal white metal panels that were framed by five vertical steel supports.[58]

The addition of 2400 square feet of floor space enabled larger antenna systems to be tested (Fig. 35). This shop addition was used for a small radiofrequency laboratory, a near-field scanner control room, and an office. The new office and laboratory space facilitated the integration of the near-field and far-field antenna groups. The rehabilitation included associated structural, mechanical, and electrical modifications.[59] In 2004, there was a new effort to renovate the interior of area between the high bay and test section, and the hallway and first floor offices were modernized.

2.1.6 Control Room and Other Areas

There is a 23'-4"-long, 73'-10"-wide area between the high bay and the tunnel's test section. This three-level area is linked vertically by an elevator and flight of stairs. The ground level of this area had an instrumentation room, an air lock into the tunnel's balance chamber, a restroom, and several other small rooms. Adjacent and to the east of this area was a 10'-3" by 12'-4" steam pit. The east end of this first floor area still connects to the eastern office wing of the building via both a stairwell to the second floor and a doorway leading to the building's first floor foyer. By 1992, the first floor rooms below the test section area had been remodeled and were being used for the Far-Field Antenna Test Facility.[60]

There is an open stairway located between the high bay and the second floor test chamber. To the south of this stairway on the mezzanine level had been the 12'-4.75" x 10'-3.75" control room (Fig. 36). This was expanded in 1965. On the shop area side, the fan room and a 14'-9.5" x 10'-3.75" section of roof is opposite of where the control room is located.[61] Figure 37 shows a hallway in the rear of the Shop and Office Building.

2.1.7 Basement

The ground below the shop, high bay, and offices was largely unexcavated. There was a corridor that ran beneath the front pedestrian door to the back of the building. This corridor included a pedestrian tunnel that connected the AWT to the ERB (Figs. 38 and 39). Adjacent to this was an area used for the Duct Lab wind tunnel. Underneath the test section are still two large storage rooms only accessible via a stairwell to the first floor.[62]

2.1.8 Duct Lab

A small supersonic wind tunnel called the Duct Lab was created in the AWT's basement corridor (Figs. 40 and 41). It was used primarily for flow physics and supersonic injector studies. Originally constructed in 1945 to take advantage of excess AWT vacuum capabilities, the tunnel is still in working condition and was used through 2007. It can reach speeds of Mach 1.6 to 5.0 and temperatures of 400 degrees Fahrenheit.[63] The original control room was replaced by a new control room in 1974.[64] That control room was renovated in 1990 as part of the expansion of Building 7.[65]

The 8'-0"-long, 4"-wide, 10"-high test section includes a hinged window for observation and to operate Schlieren apparatus. The removable Plexiglas or steel windows include rows of pressure taps.[66]

The Duct Lab was supplied with air from the AWT's makeup air system. The heated airflow entered a plenum chamber just upstream from the test section and was accelerated through a removable 50"-long nozzle.[67] After passing the text article, the air flowed through a 30"-long supersonic exhaust section with flexible walls[68] and was then decelerated by an 11'-7"-long variable-angle diffuser with a maximum diameter of 22.875".[69] The airflow was then drawn through a 42"-diameter duct that exited through the floor and back to the Exhauster Building.

2.2 Exhauster Building

The Exhauster Building (Bldg. 8—served as the Visitor Center until 2010; is currently the NASA Glenn Briefing Center) is a rectangular structure that was to the east of the AWT (Figs. 42 to 45). This building performed two crucial roles for the wind tunnel— it housed the drive motor that ran the tunnel's fan, and it contained the compressors that evacuated the tunnel to simulate the pressures at high altitudes.

The 91'-8.5"-wide, 148'-0"-long Exhauster Building consisted of three sections. The main portion of the building was a two-story open room that housed the exhausters. The area to the south of this was divided into several rooms that housed large generators. A three-story, 13-square-foot-8.5-square-inch tower off the southwest corner of the building had housed the drive motor for the wind tunnel.

The Exhauster Building was constructed by the Sam W. Emerson Company. Roots-Connersville supervised the installation of the exhausters, the Arthur E. Magher Company assembled the exhausters after their delivery from Worthington during the summer of 1943, and GE installed the drive motor.[70] Construction began in the summer of 1942 and was completed by September 1943.[71]

2.2.1 Exhausters

The main room, which housed the exhausters, was 29'-3.25" tall. A large wooden platform supported by trusses had originally spanned the rear of the room. The room housed four four-cylinder, 60"-bore, 30"-stroke Worthington reciprocating exhausters (Fig. 46) that were powered by a 1750-horsepower motor. These exhausters were tied to the air scoop inside the wind tunnel. After removing the air from the tunnel, the pumps would expel it into the atmosphere through ducts in the Exhauster Building walls. Each exhauster had two horizontal 36"-diameter exhaust pipes. The portal for each pipe was elevated 13'-0.5" from the ground and had a reinforced concrete collar and metal ring. An adjustable pipe roll stand was anchored just below the pipe to the wall.[72] Mufflers, perpendicular to the pipe and with concrete caps, were added to all eight of these pipes in 1945.[73]

A smaller rectangular addition was attached to the northeast corner of the building in 1951. This new addition contained three eight-cylinder Ingersoll-Rand reciprocating pumps.[74] The AWT exhausters were initially constructed to handle seven pounds per second at 50,000' and fifty-one pounds per second at 28,000'. With the new addition, the exhausters were upgraded to twelve

pounds per second at 50,000' and sixty-six pounds per second at 28,000'.[75] An exhaust gas cooler, pump house, and cooler pit were also installed underneath the air scoop where the tunnel exited the east side of Building 7.[76–86]

The addition was 93'-4.5" wide, 49'-10.5" long, and approximately 25'-2" high. The new compressors (Fig. 47) were positioned north and south and were joined together by a 48"-diameter pipe. The new compressors were linked to the new pump house via a 36"-diameter pipe that traveled through the original Exhauster Building.[87] The exterior was finished with a brick scheme identical to that on the original building. There was a vertical lift door on the east end of the north side, a pedestrian doorway on the west end of the north side, and another pedestrian entrance on the west end of the south side.[88] Figures 48 and 49 show the addition.

The air distribution system was modified again in 1956. A new 8'-0"-diameter, 228'-0"-long pipe was installed between the ERB and the AWT exhaust system.[89] In 1965, the Exhauster Building was renovated. The flooring was improved, obsolete hardware was removed from the walls, and a new sound-absorbing ceiling was installed.[90]

2.2.2 Generators

The rear portion of the Exhauster Building is 44'-0" tall and had consisted of two sections—a narrow open area for the two power generators (Fig. 50) and a two-level area for offices. The restrooms and a stairwell accessing the second floor were along the east wall behind the smaller generator. The second floor contained four small offices.[91]

This area was used as the Solar Power Laboratory in the 1960s after the generators were no longer needed to operate the wind tunnel fan. The laboratory's work included the rapid assembling of the components of a large Brayton Cycle Power System so that they could be tested in the Space Power Facility (SPF).[92] This room is presently used to store NASA educational publications.

2.2.3 Drive Motor

The southwest corner of the Exhauster Building was built like a three-story tower (Fig. 51). The first level housed a small generator that helped power the AWT's drive motor. The drive motor occupied the upper two levels. The drive shaft traveled from the upper level and into the tunnel shell on the east end of the facility. The tower rooms are 28'-6.25" wide and 23'-3" deep. These were accessible via an iron ladder in the northeast corner of the rooms.[93] The second level of the tower is 8'-6" above the first floor. The third level is another 16'-11" further. The second floor area had contained a secondary motor and fan that exhausted through a 6'-2.5" metal duct in the west wall.[94]

The primary drive motor was an 1800-horsepower, 4000-volt, 2180-ampere GE induction motor (Fig. 52). It sat on steel plates on the 6"-thick concrete base in the third level. There is another concrete slab along the north wall, but the remainder of the room's flooring consists of steel grating. The room has 3'-9.5"-wide windows on the north, south, and east walls.[95] The motor was 16'-3" wide at its base. The circular drive motor extended below the floor level and was supported by a concrete partition. The drive shaft (Fig. 53) rested on bases on either side of the motor.[96] The drive shaft traveled approximately 8'-4" between the exterior wall and the wind

tunnel wall.[97] The drive shaft was elevated approximately 28'-6" from the ground.[98] Figure 54 is a diagram of the motor drive room.

2.2.4 Visitor Center

In the mid-1960s, the large exhausters were removed from the Exhauster Building, and the building was converted into the Solar Power Laboratory. In July 1970, the structure opened as the Aerospace Information Display (AID) building (Fig. 55). The AID contained NASA models, hardware, and exhibits, including large-scale models of an Apollo capsule, the Lunar Module, and all of NASA's launch vehicles.

In 1975, the AID was expanded and renamed the Visitor Information Center (later shortened to the Visitor Center). A large lobby area was created at the nexus of the original Exhauster Building and the 1951 annex. The large exhauster room was filled with displays, an electronics shop, and restrooms,[99] and the annex became a 170-seat assembly room with a stage along the east wall. It also included an office and coat room. The second level, which does not cover the building's entire footprint, is now used as offices for the Community and Media Relations Office and the Educational Programs Office. Its basement is used as storage for audiovisuals and educational displays.[100] The building served as the Visitor Center until 2010. Today it is the Briefing Center.

2.3 Refrigeration Building

2.3.1 Overview

The refrigeration system designed by the Carrier Corporation was one of the AWT's most vital and complex components. It could reduce the tunnel's temperature to minus forty-seven degrees Fahrenheit. In addition, it cooled the AWT's makeup air and fuel supply, as well as the IRT and the center's domestic chilled water (a centralized system for air conditioning buildings and laboratories). According to a 1944 *Aero Digest* article, "if used for ice-making, (the system) would manufacture ten thousand tons of ice each twenty-four hours."[101]

The Refrigeration Building (Figs. 56 to 59) contains the fourteen Carrier compressors and flash cooler that powered the cooling system. This rectangular, two-story brick structure was constructed in the same fashion as the Shop and Office Building. The building has a truck entrance in the center of the north face and pedestrian entrances on the south and east walls. An additional pedestrian entrance was installed on the north wall. Originally, the building contained two rows of sash windows along each wall. The second-level windows were later bricked over, and the lower-level windows were modernized.

The interior of the building is largely open with an excavated basement. There is a small control room along the western wall. The compressors are aligned in pairs facing east and west with the flash cooler running north and south between them. Several generators facing north are aligned near the rear of the building. There are two stairways leading to the basement, one near the control room, and the other near the front of the building.

2.3.2 Cooling System

The Carrier Corporation, based in Buffalo, New York, designed and constructed the refrigeration system. Originally, the NACA engineers wanted to use a new, untried cooling coil with

streamlined tubes. Willis Carrier convinced the agency that his coils were superior, and the task was turned over to his company.[102] A scale model of the tunnel was built in 1942 at the Carrier plant so that their engineers could find a way to optimize the distribution of the refrigeration.[103] The Pittsburgh-Des Moines Steel Company installed the refrigeration system, which included external coils and headers, liquid and vapor lines, expansion joints, and an exhauster trench.[104] Installation of the flash cooler began in mid-June 1943, and the entire building was completed in the fall of 1943.[105] Between the Refrigeration Building and the tunnel, approximately thirty different lines from the heat exchangers condensed into the four return pipes.

The fourteen 1500-horsepower Carrier centrifugal compressors and the flash cooler (Fig. 60) were modified to use Freon-12 refrigerant. Originally, the compressors changed the temperature of the Freon-12 by 20,000', which equals 150 degrees Fahrenheit. A four-stage compressor took in a volume of gas, then released the superheated and compressed gas into the condenser. The condenser took water from the cooling tower to cool its tubes while the superheated gas from the compressor was passed around the four tubes.[106] The circulating water removed the heat from the refrigeration equipment to the cooling tower where it was dissipated into the atmosphere. At its original capacity, 20,000 gallons of cooling water were required every minute.[107] Figure 61 shows some of the lines from the Refrigeration Building.

The two-stage cooler subcooled the condensed refrigerant as it passed from the condenser to the cooler. This process reduced the pressure and temperature to the pressure of the third-stage suction pressure, and the remaining refrigerant was evaporated. The horsepower-per-ton of refrigeration was substantially economized. The refrigerant was then pushed to the flash cooler where the suction gas was separated and the refrigerant was injected with hot gas. The refrigerant was subcooled in the flash cooler before the liquor pumps propelled it through the evaporator. The tunnel's heat also was absorbed by the latent heat contained in the excess refrigerant.[108]

The dampers, which were regulated by thermostats, controlled the refrigeration system's weight flow and thus its power. Heat exchangers in the tunnel's western leg were used to create the low temperatures found at higher altitudes. The AWT and IRT were cooled using almost identical heat exchangers. In an effort to maintain uniform temperature and frosting across the tunnel, engineers used eight identical heat exchangers that were four tubes deep.[109]

The heat exchangers were a collection of 260 copper-plated coils arranged in a zigzag design that covered almost the entire 51'-0" cross section of the tunnel (Fig. 62). A traditional cooling coil configuration, if used to cool such a large volume of air, would not have fit into the tunnel. The zigzag layout, however, created an area of airflow through the coils approximately four times the area of the tunnel cross section.[110]

During the cooling cycle, a series of valves distributed the refrigeration uniformly across the tunnel. Frost was created, and friction was caused by the coils. The heat exchanger vacuum was sustained during the defrosting cycle by valves located in two external float tanks. Two liquor pumps circulated the refrigerant from the flash cooler (Fig. 63) to the heat exchanger. The refrigerant gas was converted into liquor by compressors.[111] A purge recovery system evacuated any noncondensable gases, water, and air from the refrigeration system and gathered refrigerant mixed with the air. This resulted in ultimate efficiency and a clean refrigeration system.[112]

Three 1500-horsepower York compressors were used to chill the cooling coils in the Air Dryer Building. These compressors continue to supply domestic chilled water for air conditioning several nearby buildings including the ERB and the Administration Building. A natural gas compressor was installed for research in the Engine Components Research Laboratory. Five horizontal pumps and ten vertiline pumps distribute water from Cooling Tower No. 1 to Buildings 5, 8, 9, 11, 77, and 98.[113] The Refrigeration Building (Fig. 64) continues to provide cooling for the IRT.

2.4 Circulating Water Pump House

As part of the 1951 modernization project for the AWT, a pump house was built underneath the northeast leg of the tunnel (Figs. 65 and 66). The 54'-7.5"-long, 28'-1.5"-wide building ran in a diagonal southwest direction from the northeast portion of the tunnel near the exhaust scoop. The pump house contained four Ingersoll-Rand pumps, two 250-horsepower discharge pumps to the south, and two 300-horsepower spray pumps. Another seventy-five-horsepower spray pump was located in the northeast corner.[114] These pumps drew water from Cooling Tower No. 1 through two 24"- and one 16"-diameter underground lines that ran from the cooling tower and through the Refrigeration Building (Fig. 67).[115]

A large cylindrical cooler pit was installed underneath the exhaust scoop in the northeast leg of the tunnel. This cooler was connected to the new pump house (Fig. 68). The tunnel's air scoop funneled the contaminated air out the bottom of the tunnel and through this 10'-0"-long cooler.[116] A 72"-diameter exhaust pipe extended from the back of the cooler (Fig. 69). It traveled vertically approximately 26'-0", including an expansion joint, before splitting. One pipe turned horizontally through the Exhauster Building and into the new addition.[117] The other ran north across Ames Road and connected with the ERB's exhaust system.[118] Figure 70 shows the cooler pit.

During the 1960s, this structure was renamed the Solar Power Laboratory Annex and used by the Technical Services Division's Refrigeration Section for storage and as a shop and tool crib area (Figs. 71 to 73). The Solar Power Laboratory was located nearby in the southwest corner of the Exhauster Building.[119] In recent years, the pump house building had been used for storage by the Educational Services Division. The structure was demolished in 2009 as part of the AWT demolition.

2.5 Cooling Tower No. 1

Cooling Tower No. 1 sits behind the Refrigeration Building diagonally in a northwest direction along Moffett Road. It is a narrow rectangular structure with a square settling basin off the northeast side. Cooling Tower No. 1 originally had eight pairs of fans in its roof to draw the air upwards to remove heat from the higher temperature water that was delivered high in the cooling tower and cascaded water spray down into the 600,000-gallon basin at the bottom of the tower. In the mid-1950s, it could pump 63,000 gallons per minute.[120]

Currently, five underground lines run northward from the tower before forming right angles toward the IRT. Two lines, ranging from 6" to 18" in diameter, exit each of the larger lines and enter the north wall of the Refrigeration Building. These lines had exited the Refrigeration Building and connected to the Circulating Water Pump House through two 24"-diameter lines

and one 16"-diameter line.[121] Two other lines, 24" and 30" in diameter, currently exit the south side of the cooling tower and wrap around and connect to the ERB.[122]

In 1951, an additional cell was added to each end of the tower resulting in four new fans. There is an auxiliary water basin in the center off the north side, and a large tank area to the west of this basin contains three tanks (Fig. 74). Over several years, all of the cells were rehabilitated, and in the mid1980s, the facility was largely rebuilt.[123] It is still used by the IRT in conjunction with the Refrigeration Building (Figs. 75 and 76).

2.6 Air Dryer Building

The makeup air system was designed to replenish the air in the AWT that was removed by the exhaust scoop. The Air Dryer Building, located externally outside the tunnel's southwest corner, removed condensation and cooled the air to prevent shocks to the airflow as it entered the tunnel. The facility consisted of the air dryer tank and two sets of cooling coils (Fig. 77). The approximately 28'-8"-diameter tank was enclosed in a two-story brick building with cooling coils located before and after. It was connected in front and behind by large ducts to the Primary Coils Building and the Secondary Coils Building. The Primary Coils Building was 21'-3.5" wide and 25.25" long. The Secondary Coils Building was 24'-8" wide and 33'-8" long.[124]

Ambient air entered the Primary Coils Building from the south and passed through a damper, a bank of filters, the two cooling coils, an eliminator, and another damper, which reduced its temperature to about forty degrees Fahrenheit.[125] The air then entered the air dryer tank where four flat beds of activated alumina layered on top of one another absorbed moisture to a dew point of minus seventy degrees Fahrenheit.[126] The air then entered the Secondary Coils Building north of the dryer; this cooled the air to the desired tunnel temperature of approximately minus seventy degrees Fahrenheit. The dryer's cooling coils were cooled by twelve reciprocating York compressors located in the nearby Refrigeration Building. A large duct permitted airflow between the air dryer and the primary coils during cooling and activation.[127]

The alumina had to be reactivated between runs by running steam-heated air through the dryer in the reverse direction. It required approximately five hours to remove all the moisture from the alumina. The beds were then cooled by running chilled air through the dryer.[128]

The resulting cool, dry air was pumped to both the AWT and the adjacent Small Supersonic Wind Tunnels Building through a 48"-diameter pipe. The conditioned air was introduced into the AWT through pressure-sensitive valves in two portals in the western tunnel wall. The southern 48" portal allowed some of the air in, but a portion was redirected through a pipe that narrowed from 60" to 36" in diameter and was tied into the Refrigeration Building.[129] This uncontaminated air was then pumped from the refrigeration system into the tunnel upstream from the test section.[130]

During a 1948 upgrade, a new air tank was built on top of the existing tank and new cooling coils were installed on top of the existing Primary Coils Building, replacing the function of the original equipment (Fig. 78 to 80). The original duct was redirected to this upper chamber and a U-shaped reactivation duct connected the north side of this new chamber to the Primary Coils Building.[131] Based on aerial photographs, it appears that the makeup air line directed to the Refrigeration Building was removed in August 1985.[132] The air dryer tank was demolished

sometime prior to 1990. The Primary Coils Building (Bldg. 18–1) became the Fire Pump Building. The Secondary Coils Building (Bldg. 18–2) became the Gas Compressor Building. Figure 81 shows the Air Dryer Building as it looked in 1945.

2.7 Small Supersonic Tunnels Building

In the summer of 1945, the laboratory's first supersonic wind tunnel was built between the AWT and the IRT. Two other supersonic tunnels were added vertically to this structure in 1949 and 1951. The tunnels were housed in an L-shaped building directly behind the southwest corner of the AWT. The Small Supersonic Tunnels Building was informally known as the "Stack Tunnels" because its three tunnels were aligned vertically (Fig. 82).

Because of the arrangement made with the local electric company, the AWT only ran during the night, so its exhausters sat idle most of the day. Abe Silverstein, who was Chief of the Engine Installation Division at the time, decided to use the AWT exhausters to create a small supersonic tunnel. He designed the 2.25-square-foot open-circuit tunnel. GE was hired in May 1945 to provide the drive motors and auxiliary equipment. The first tunnel was built in just ninety days.[133]

The airflow for the tunnels was supplied by the AWT makeup air line. The line originated in the Air Dryer Building and was split at the southwest corner of the AWT (Fig. 83). One end fed conditioned air into the AWT, and the other end traveled east where it was ducted into one of the Small Supersonic Wind Tunnels. After passing through one of the test sections, the 48"-diameter exhaust line exited to the east then split (Fig. 84). One section tied directly into the AWT's south wall and the other ran 125'-7" to the AWT's exhaust cooler.[134]

The control room was in the basement of the building with a large collection of manometer boards. Half a story above the basement was Tunnel No. 1, which had an 18" x 18" test section and could reach Mach 1.91. Tunnel No. 2 was a Mach 3.96 tunnel that was 6'-0" long and had a 24" x 24" test section, and Tunnel No. 3 was a Mach 3.05 tunnel that was 4'-0" long and had a 18" x 18" test section.[135]

Early tests in Tunnel No. 1 focused on supersonic diffusers, supersonic ramjets (Fig. 85), and supersonic aerodynamics.[136] In 1959 and 1960, tests included inlet studies for North American (aircraft manufacturer) and light gas injection wing burning and high-altitude rocket ignition for NASA. Tunnel No. 2 was activated in September 1949 and included hydrogen peroxide fuel and gaseous nitrogen systems. Tunnel No. 3 came online in July 1951. The latter two tunnels were used for North American inlet tests, NASA noise studies, and drogue parachute configurations in 1959 and 1960.[137]

NASA Lewis became more and more involved with space, and despite modest annual operating costs of $1500 for Tunnel No. 1 and $3000 each for Tunnels No. 2 and No. 3, the facility had been deactivated by 1961.[138] Figure 86 shows where the Small Supersonic Wind Tunnels had tied into the AWT. The building was finally demolished sometime between 1982 and 1987.

3.0 Index of Support Building Photographs

Many C-numbered photographs are available from NASA's or NASA Glenn's image archives:

NASA Image eXchange (NIX, http://nix.nasa.gov/) GRC ImageNet http://grcimagenet.grc.nasa.gov/home/scr_main.cfm).

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Appendix—Figures and Images

Figure 1.—AWT complex including the Exhauster Building (Bldg. 8, left), the Shop and Office Building (Bldg. 7, center), and the Refrigeration Building (Bldg. 9, right), 2006 (OH_Cuyahoga_AWT-Support_001).

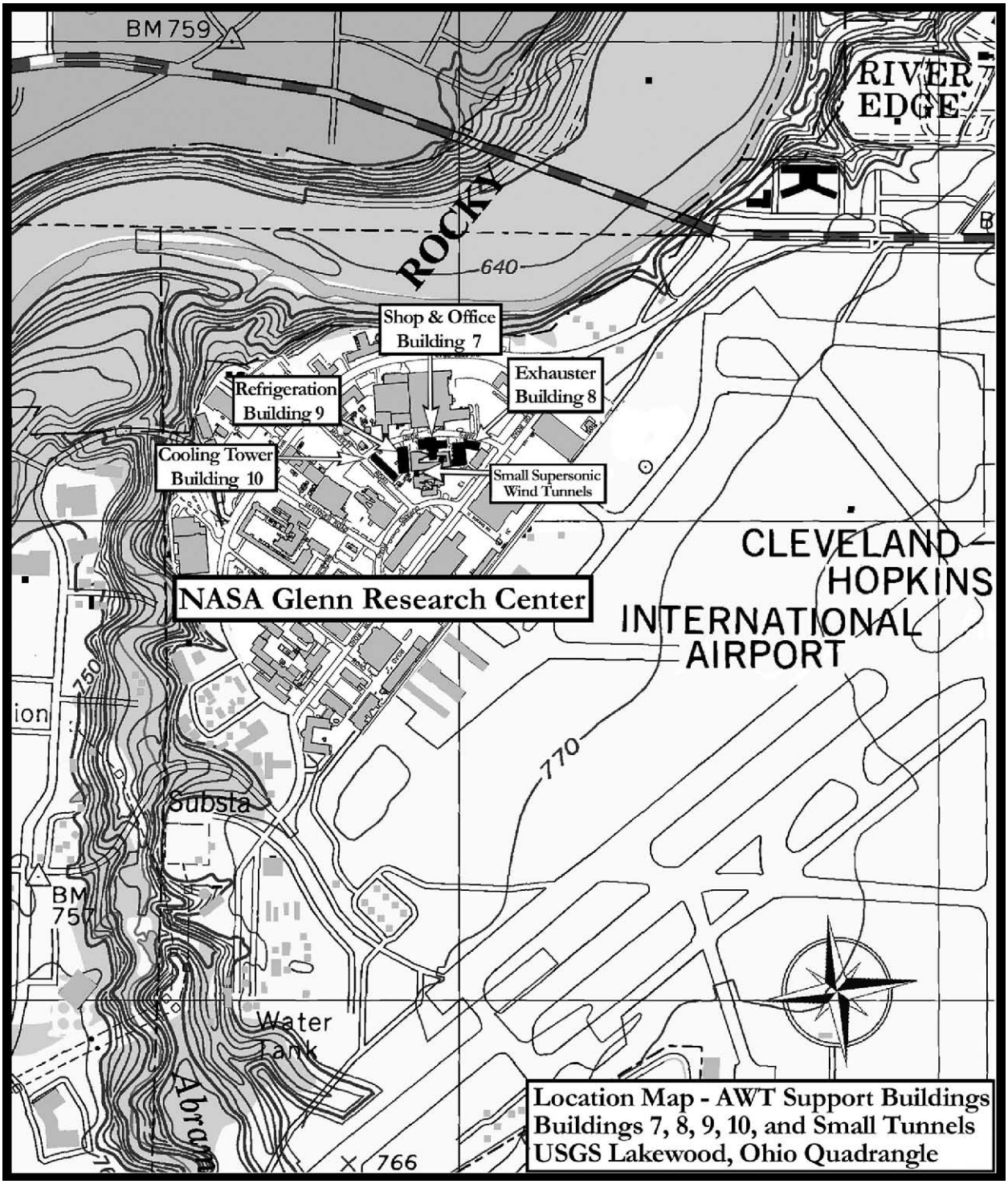

Figure 2.—Location map for the AWT support buildings, 2009 (OH_Cuyahoga_AWT-Support_002).

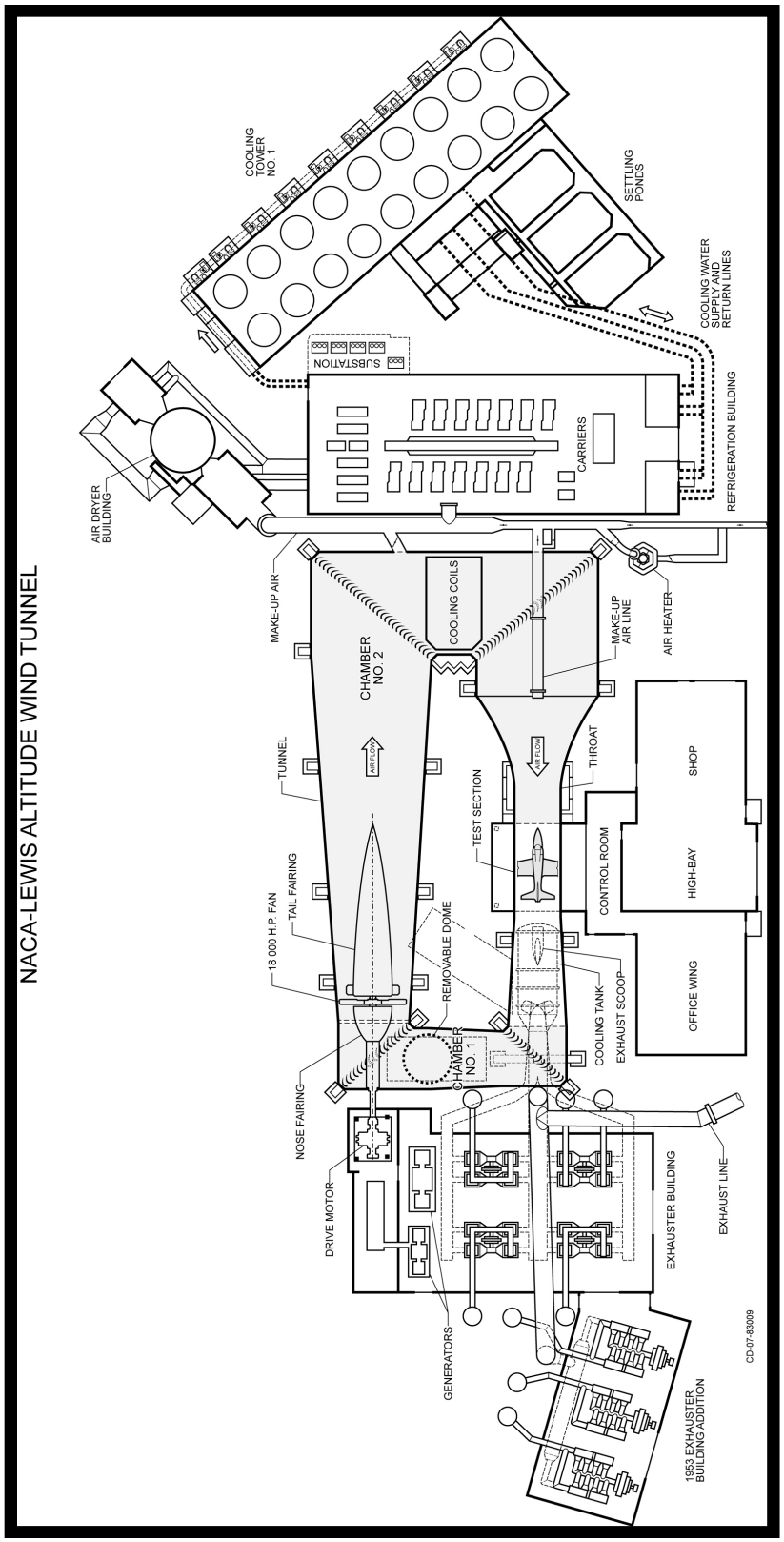

Figure 3.—AWT with its internal components and support buildings, 2007 (OH_Cuyahoga_AWT-Support_003).

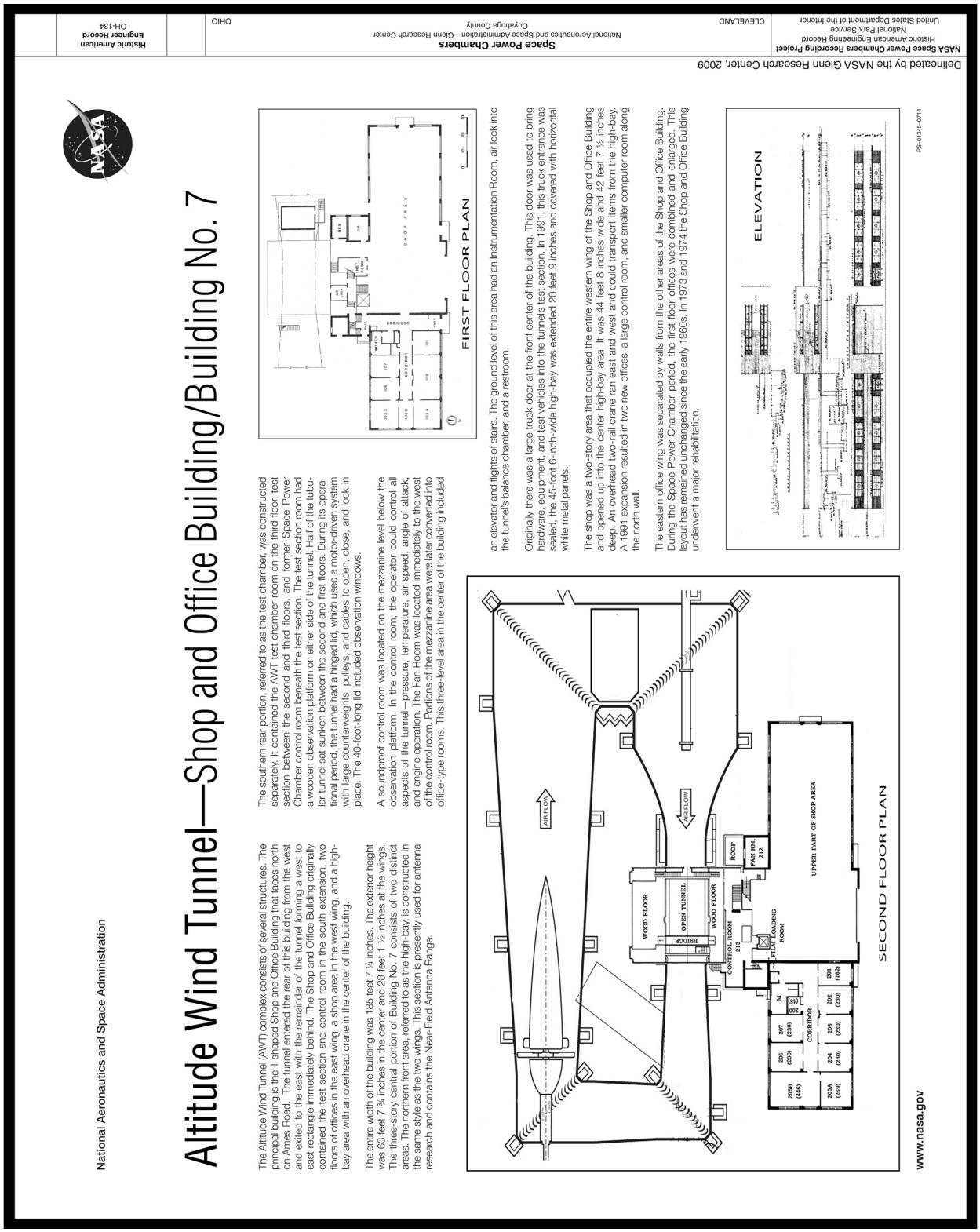

Figure 4.—Shop and Office Building, 2009 (OH_Cuyahoga_AWT-Support_004).

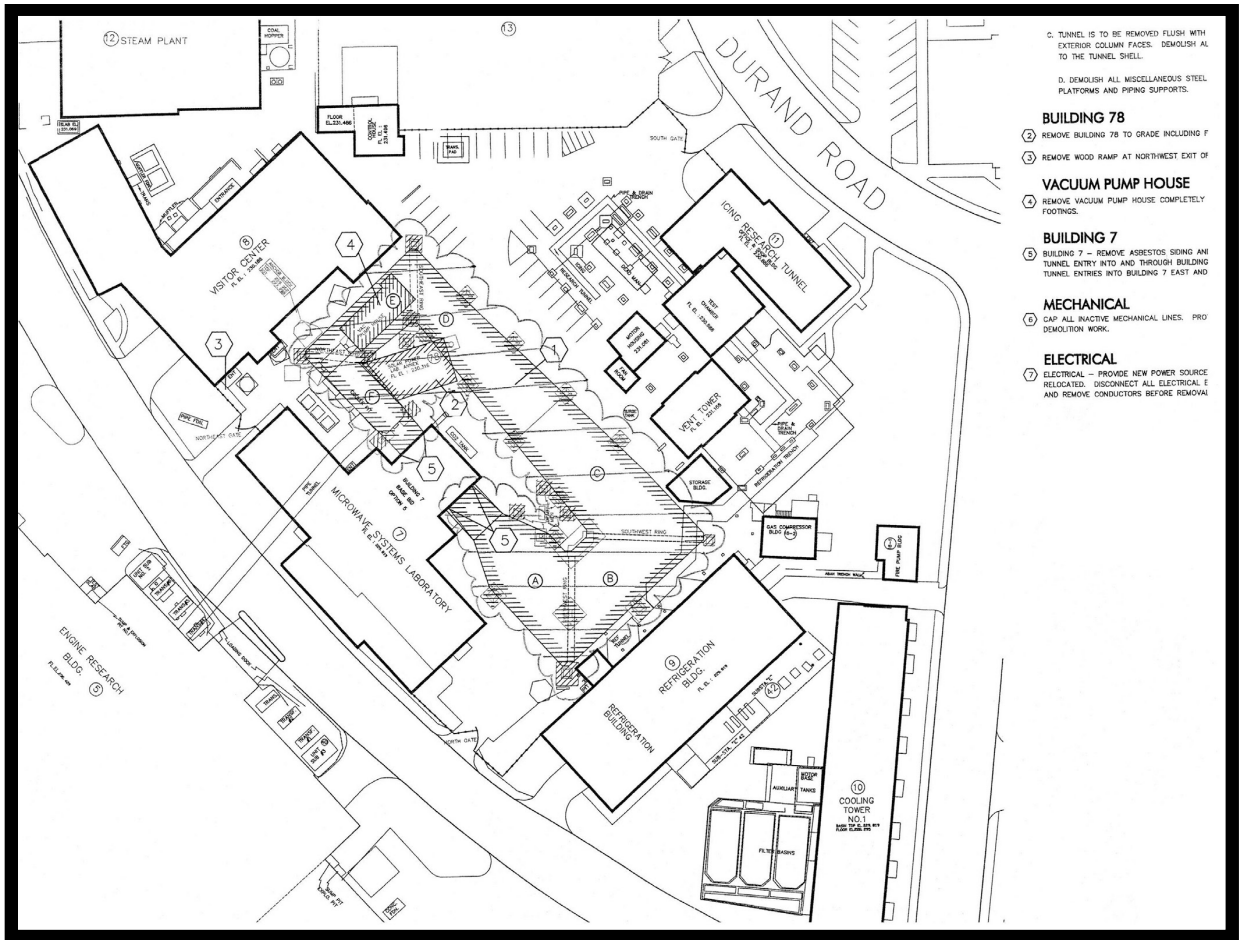

Figure 5.—Demolition plan for the AWT. Areas that were demolished are indicated by hash marks, 2005 (OH_Cuyahoga_AWT-Support_005).

Figure 6.—Shop and Office Building, with the shop area in the foreground (viewed from the northwest), 1944 (OH_Cuyahoga_AWT-Support_006).

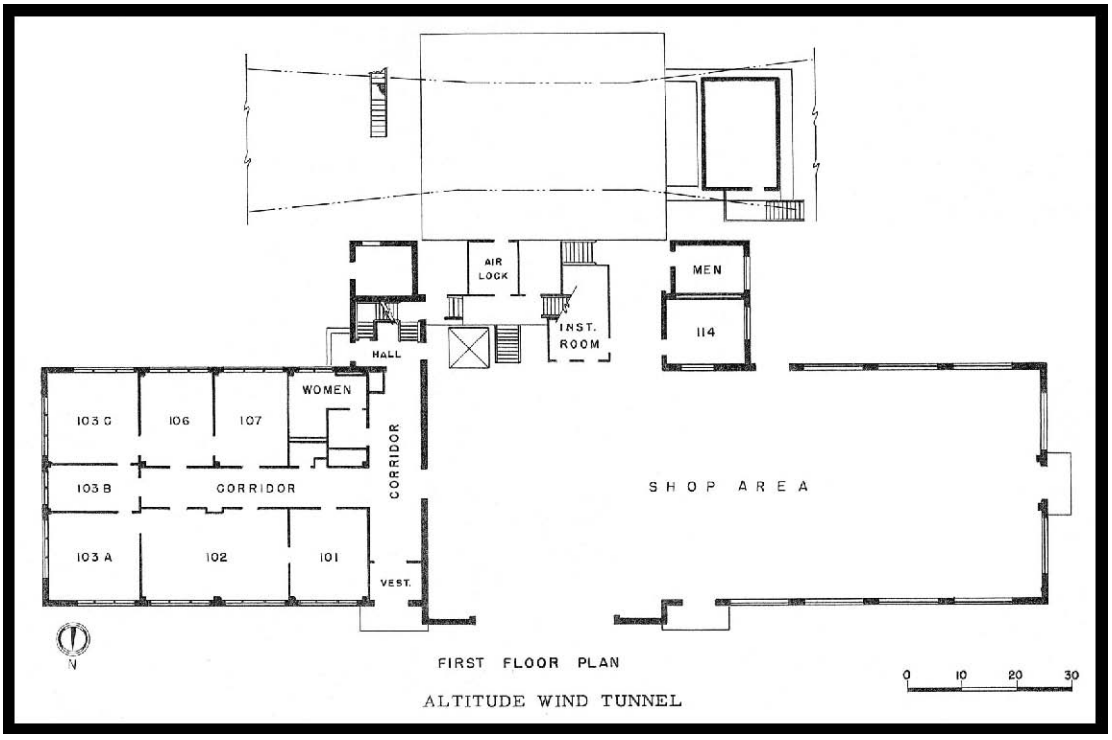

Figure 7—Plan of the first floor of the Shop and Office Building, 1967 (OH_Cuyahoga_AWT-Support_007).

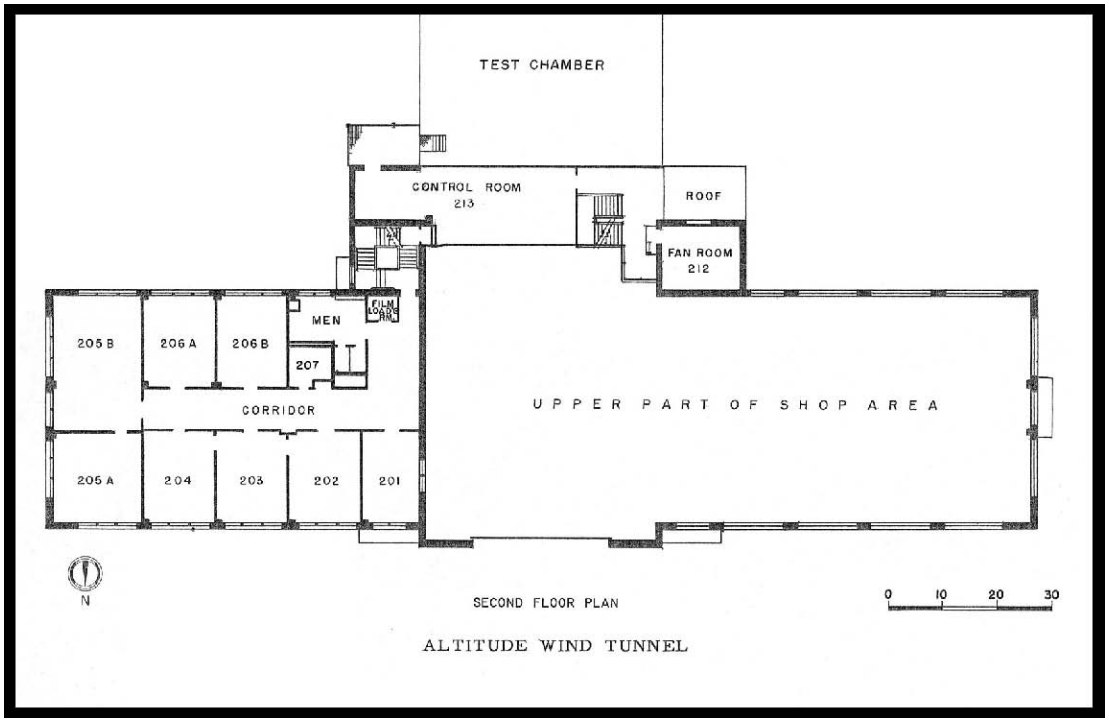

Figure 8—Plan of the second and third floors of the Shop and Office Building, 1967 (OH_Cuyahoga_AWT-Support_008).

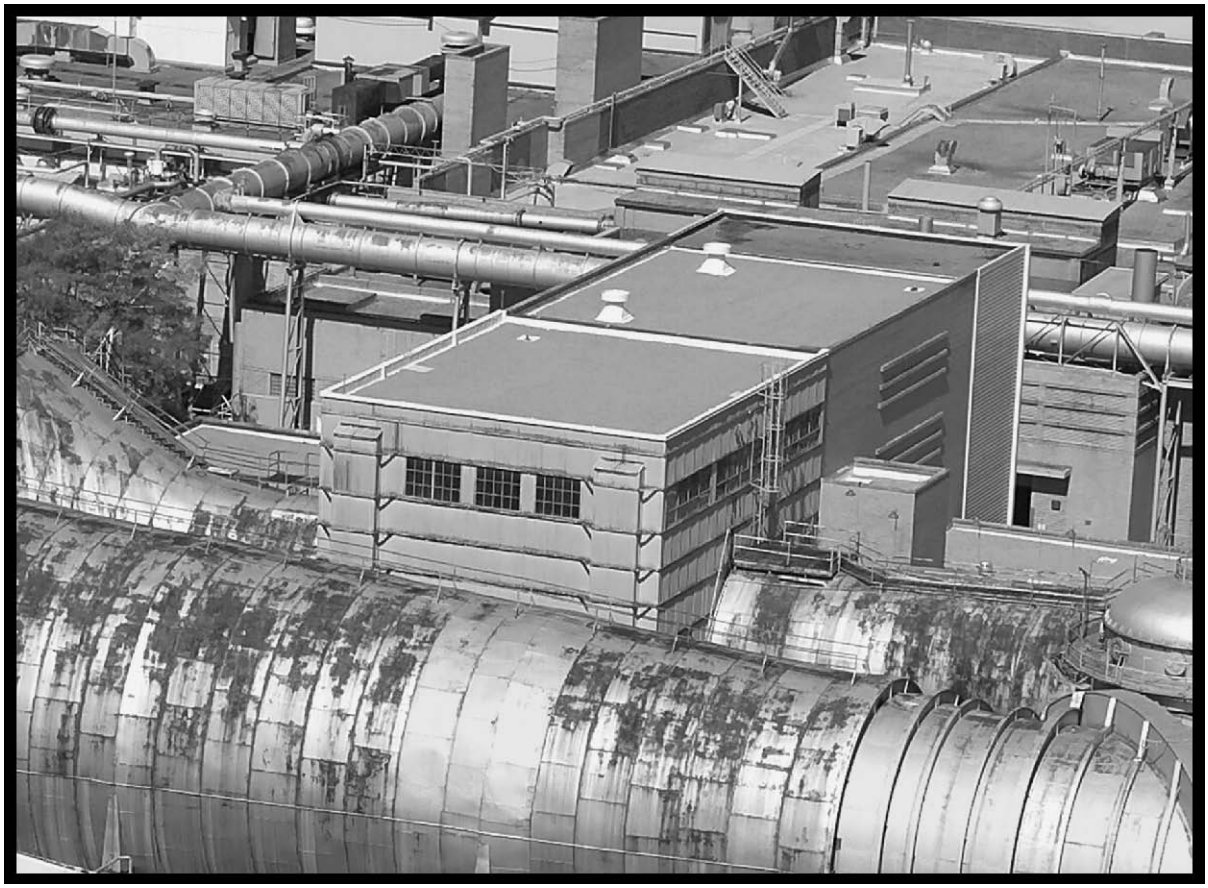

Figure 9.—Design differences in the test chamber and high bay of the Shop and Office Building (viewed from the south), 2005 (OH_Cuyahoga_AWT-Support_009).

Figure 10.—Original sash windows and rustication pattern in the brick on the exterior of the Shop and Office Building, 1944 (OH_Cuyahoga_AWT-Support_010).

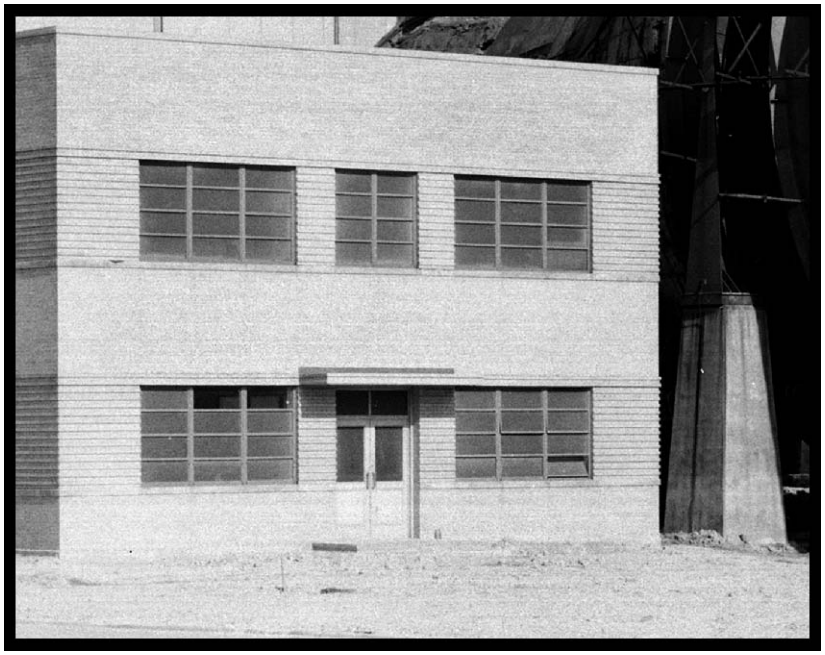

Figure 11.—Original west-facing exterior of the Shop and Office Building. The eastern end was similar without the doorway, 1944 (OH_Cuyahoga_AWT-Support_011).

Figure 12.—Original high bay exterior with truck and pedestrian entrances (viewed from the northwest), 1944 (OH_Cuyahoga_AWT-Support_012).

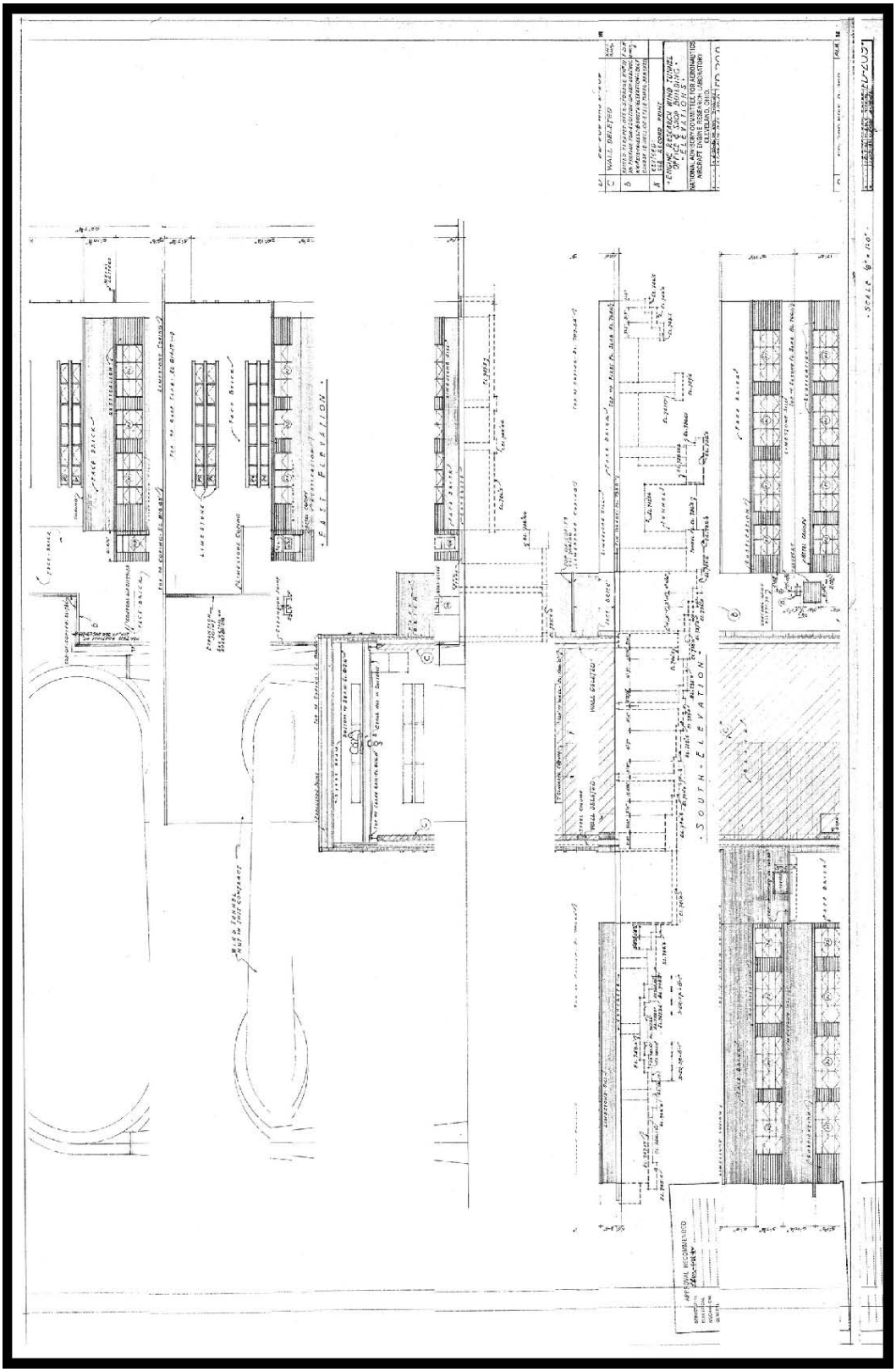

Figure 13.—Elevation drawing of Shop and Office Building, 1942 (OH_Cuyahoga_AWT-Support_013).

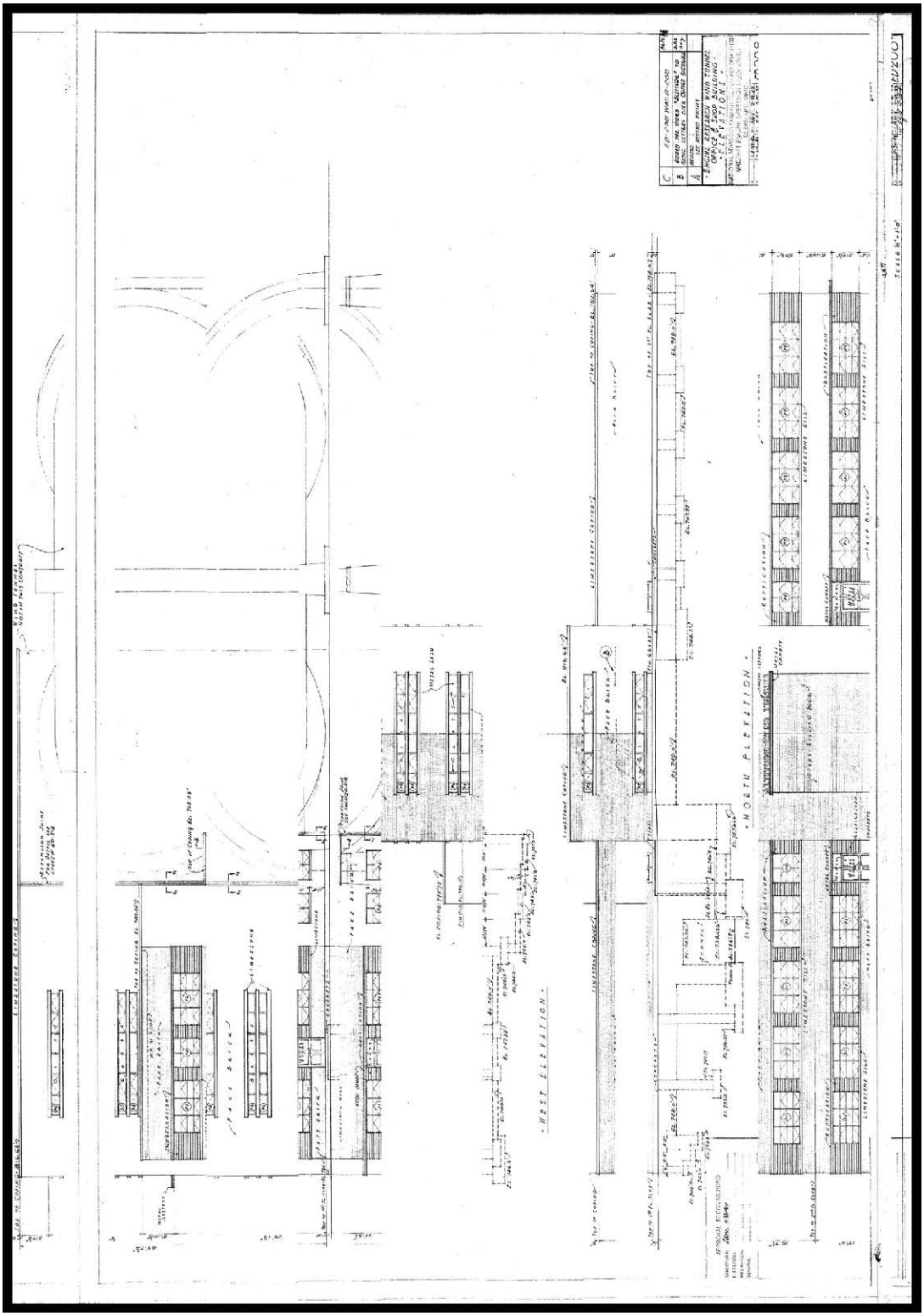

Figure 14.—Elevation drawing of Shop and Office Building, 1942 (OH_Cuyahoga_AWT-Support_014).

Figure 15.—Exterior of the test chamber in the Shop and Office Building (viewed from the west), 1945 (OH_Cuyahoga_AWT-Support_015).

Figure 16.—Test chamber overhang in the rear of the Shop and Office Building (viewed from the east), 2005 (OH_Cuyahoga_AWT-Support_016).

Figure 17.—Inside a room on the south wall of the test chamber next to the tunnel test section (viewed from the west), 2007 (OH_Cuyahoga_AWT-Support_017).

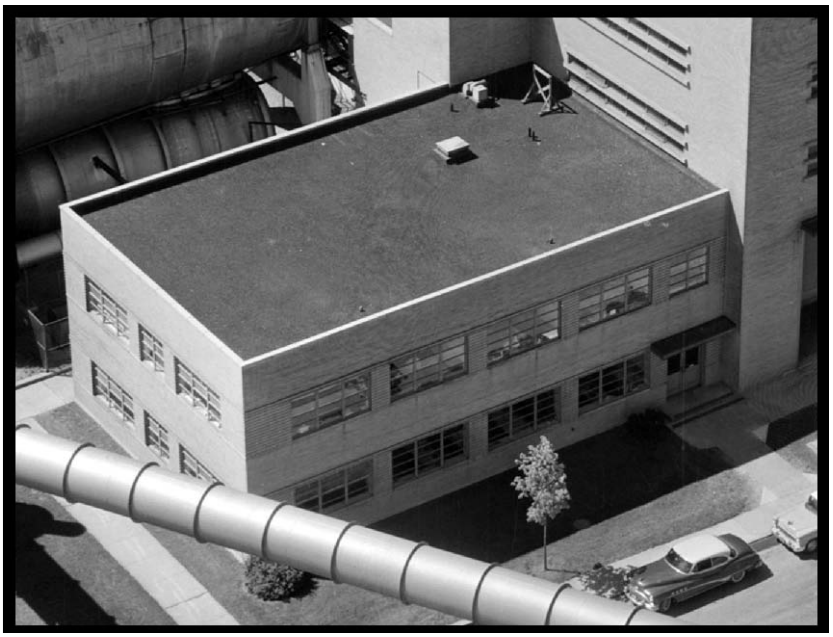

Figure 18.—Exterior of the Shop and Office Building's office wing (viewed from the northwest), 1955 (OH_Cuyahoga_AWT-Support_018).

Figure 19.—First floor hallway in the office wing of the Shop and Office Building (viewed from the west), 1974 (C–1974–00351, NASA Glenn).

Figure 20.—Original entrance vestibule in the office wing of the Shop and Office Building (viewed from the south), 1972 (OH_Cuyahoga_AWT-Support_020).

Figure 21.—Interior of an office with original windows in the office wing of the Shop and Office Building, 1972 (OH_Cuyahoga_AWT-Support_021).

Figure 22.—New windows and light fixtures after the 1974 renovation of the Shop and Office Building, 1974 (OH_Cuyahoga_AWT-Support_022).

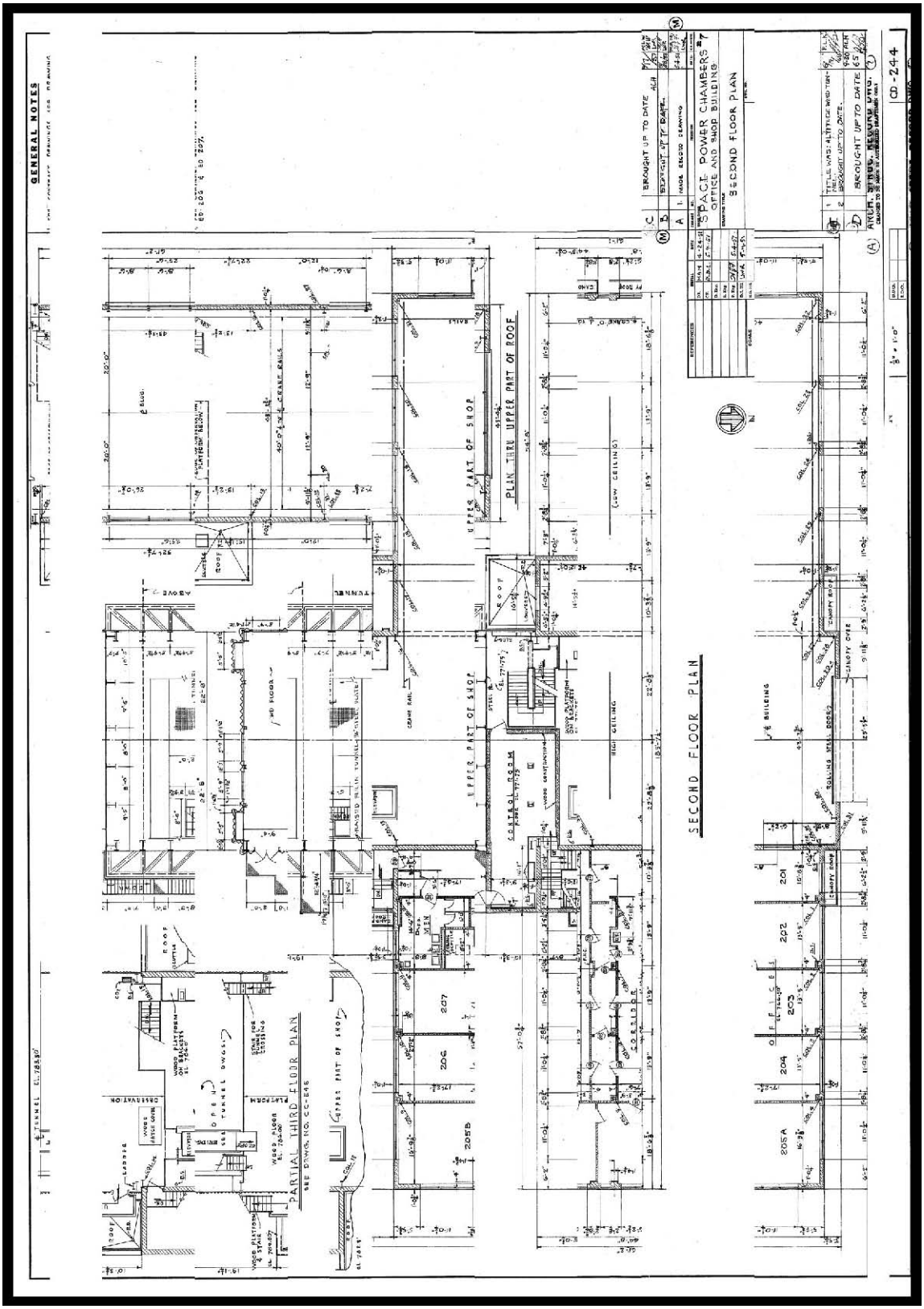

Figure 23.—Shop and Office Building during the 1960s, drawing updated 1968 (OH_Cuyahoga_AWT-Support_023).

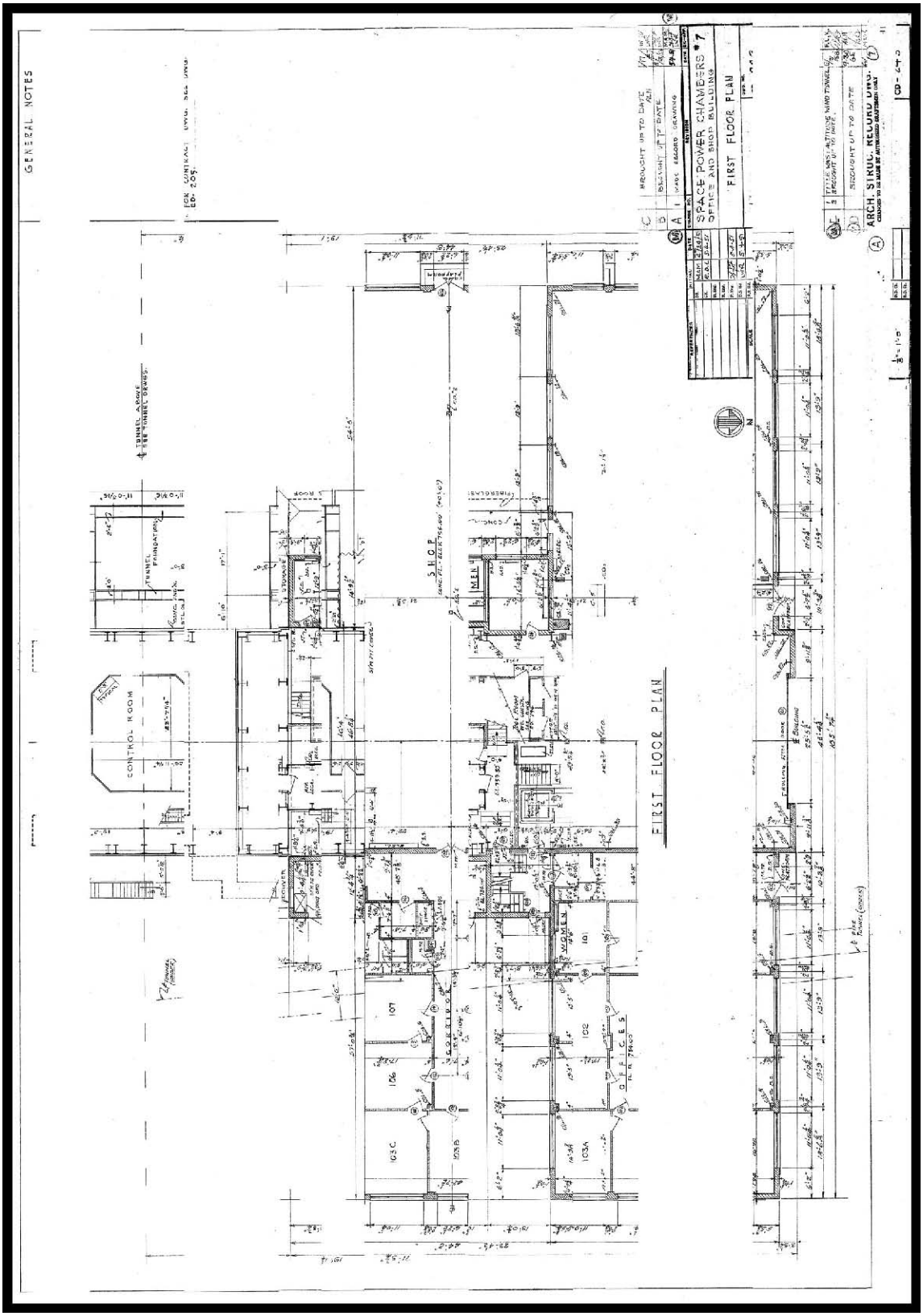

Figure 24.—Shop and Office Building during the 1960s, drawing updated 1968 (OH_Cuyahoga_AWT-Support_024).

Figure 25.—Shop area in the AWT Shop and Office Building showing the overhead crane (viewed from the northeast), 1972 (OH_Cuyahoga_AWT-Support_025).

Figure 26.—Original first floor shop office with the main shop area visible through the window and doorway, 1972 (OH_Cuyahoga_AWT-Support_026).

Figure 27.—Mercury Evaporating Condensing Analysis experiment installed in the southwest corner of the shop area, 1961 (OH_Cuyahoga_AWT-Support_027).

Figure 28.—Electric vehicle research in the shop area during the mid-1970s, 1977 (OH_Cuyahoga_AWT-Support_028).

Figure 29.—Interior of the high bay where it connects with the shop area in the Shop and Office Building, 1972 (OH_Cuyahoga_AWT-Support_029).

Figure 30.—High bay showing a window to the office wing and elevator; stairs to the test chamber are to the right (viewed from the west), 1945 (OH_Cuyahoga_AWT-Support_030).

Figure 31.—Overhead ten-ton crane that ran from the high bay into the test chamber, 2007 (OH_Cuyahoga_AWT-Support_031).

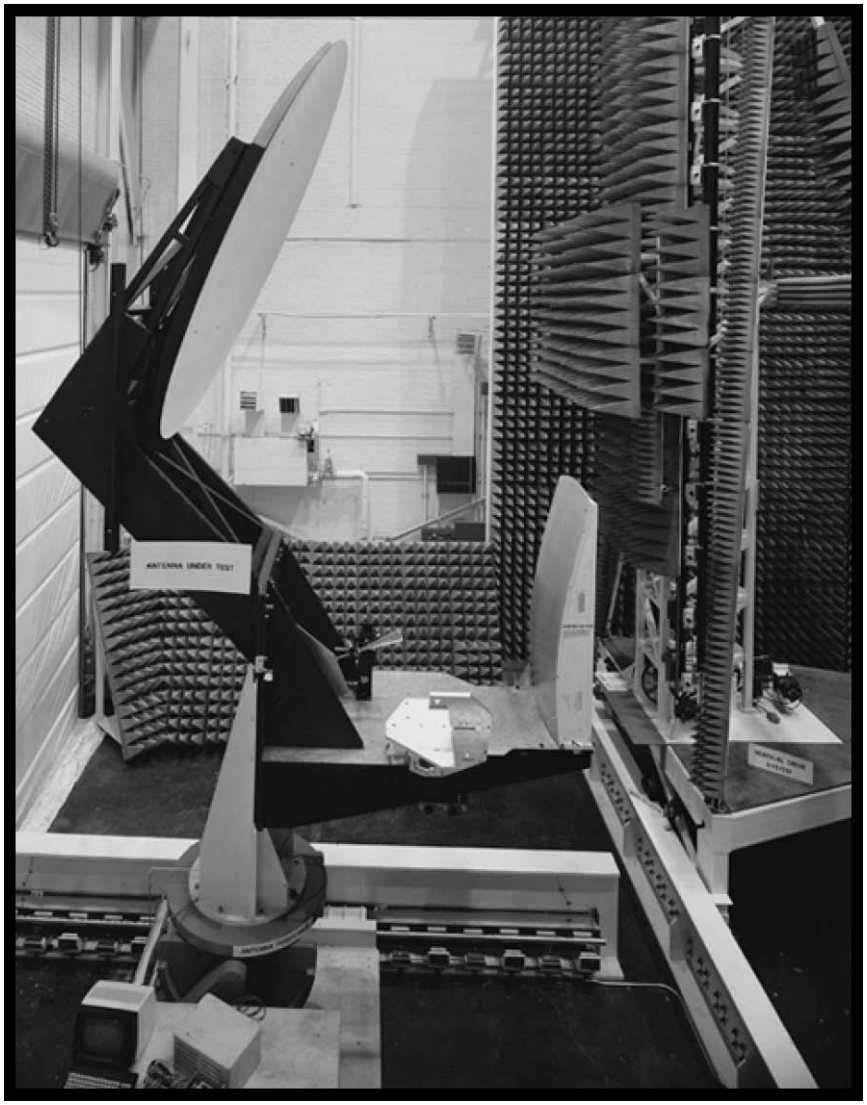

Figure 32.—Near-Field Antenna Test Facility installed in the high-bay area of the Shop and Office Building, 1984 (OH_Cuyahoga_AWT-Support_032).

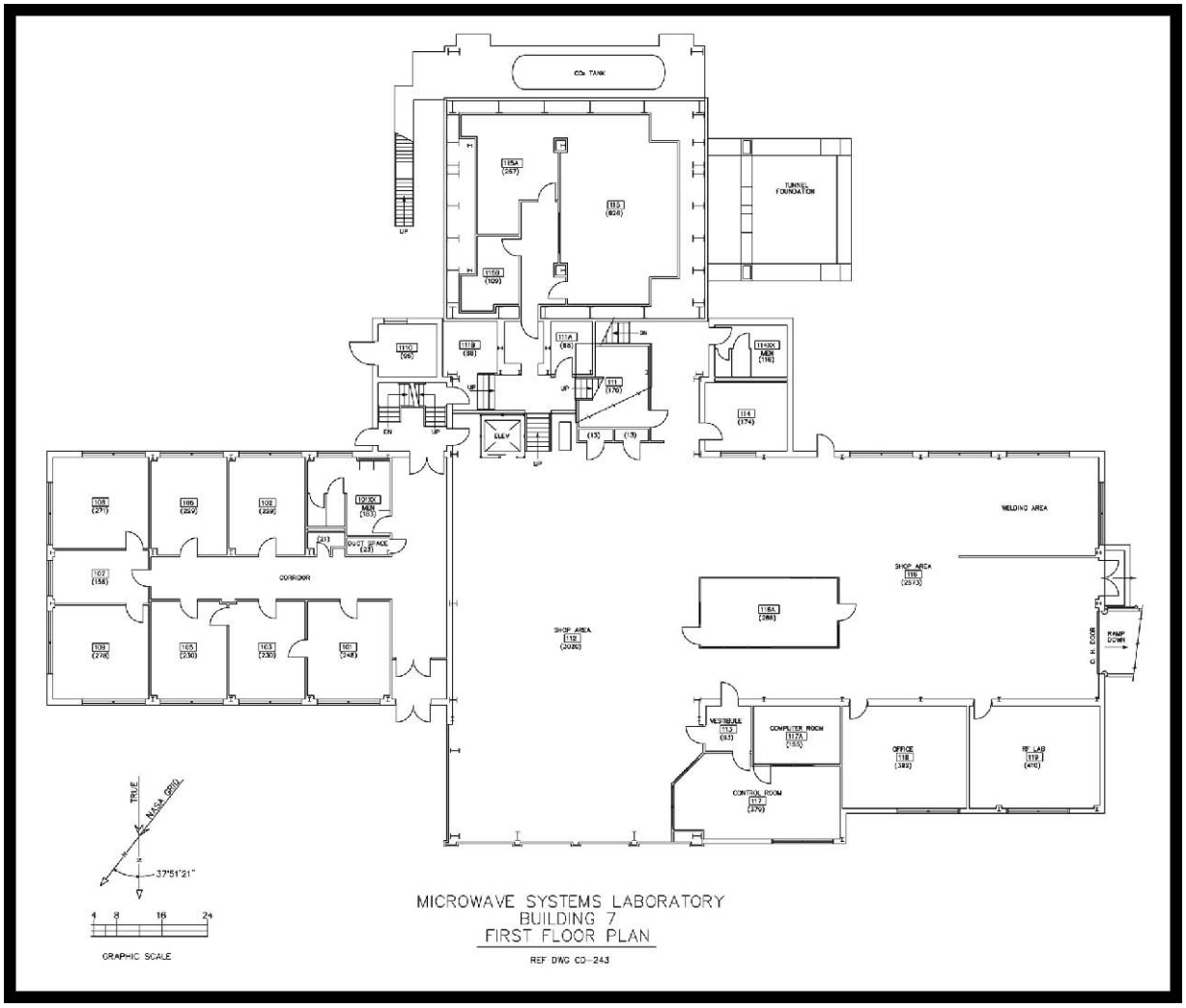

Figure 33.—Building 7 after its conversion to the Microwave Systems Laboratory (MSL) and the expansion of the shop, 1992 (OH_Cuyahoga_AWT-Support_033).

Figure 34.—Wall built between the high bay and the test chamber for the Near-Field Antenna Test Facility, 2007 (OH_Cuyahoga_AWT-Support_034).

Figure 35.—The 1991 extension of the high bay and shop area (viewed from the north), 2005 (OH_Cuyahoga_AWT-Support_035).

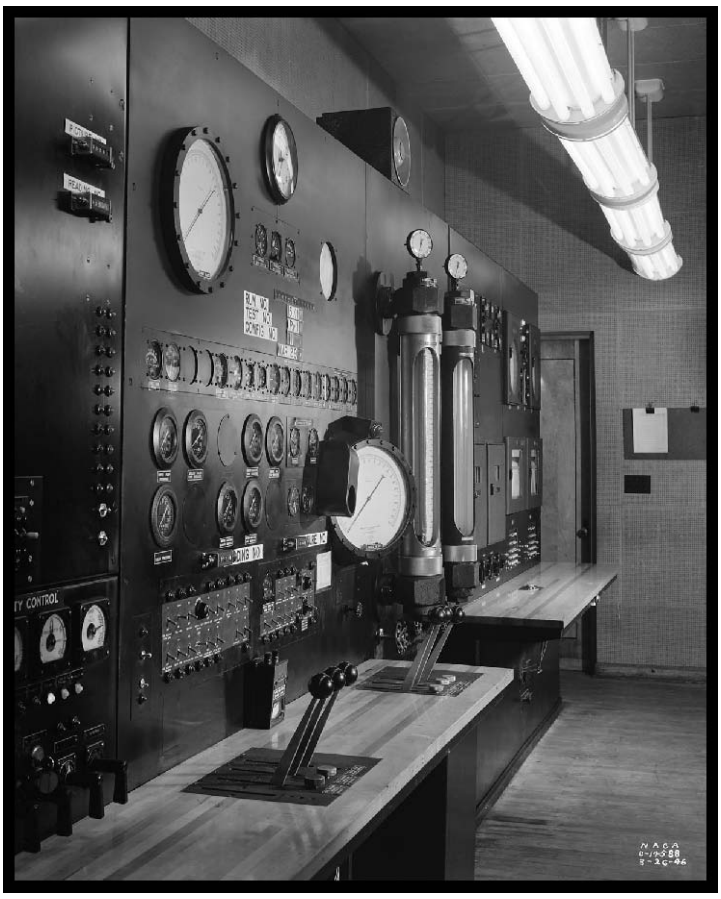

Figure 36.—Original AWT control room inside the Shop and Office Building, 1946 (OH_Cuyahoga_AWT-Support_036).

Figure 37.—Hallway at the rear of the office wing and stairs leading to the basement and the second floor of offices, 1974 (OH_Cuyahoga_AWT-Support_037).

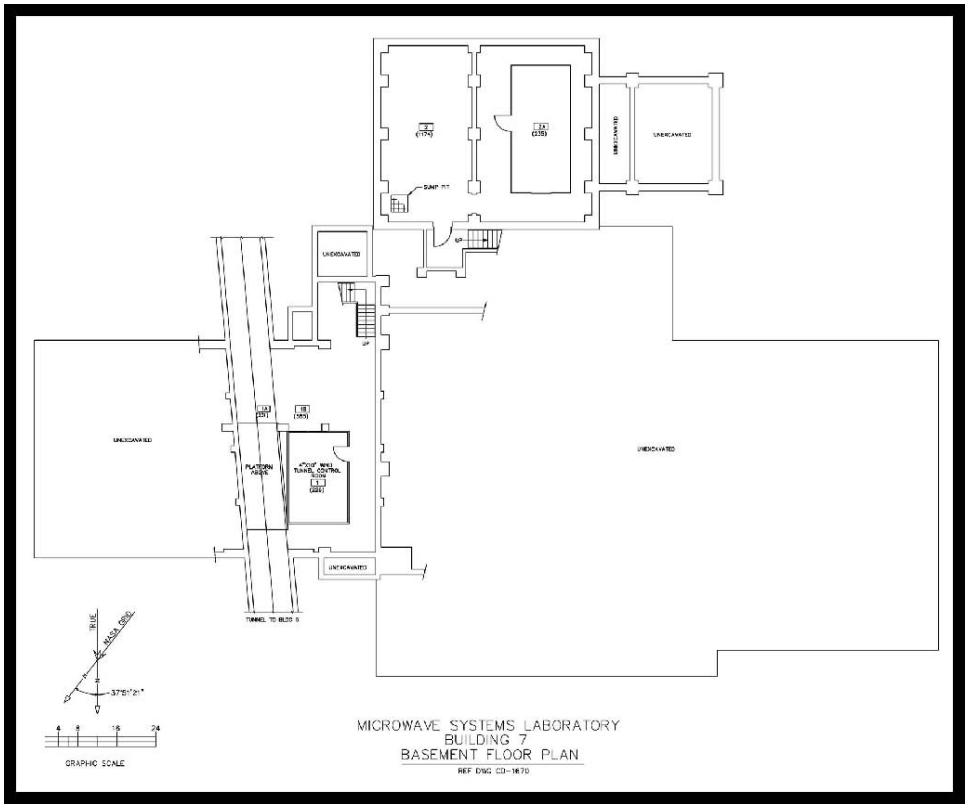

Figure 38.—Basement floor plan showing excavated areas and the Duct Lab tunnel, 1992 (OH_Cuyahoga_AWT-Support_038).

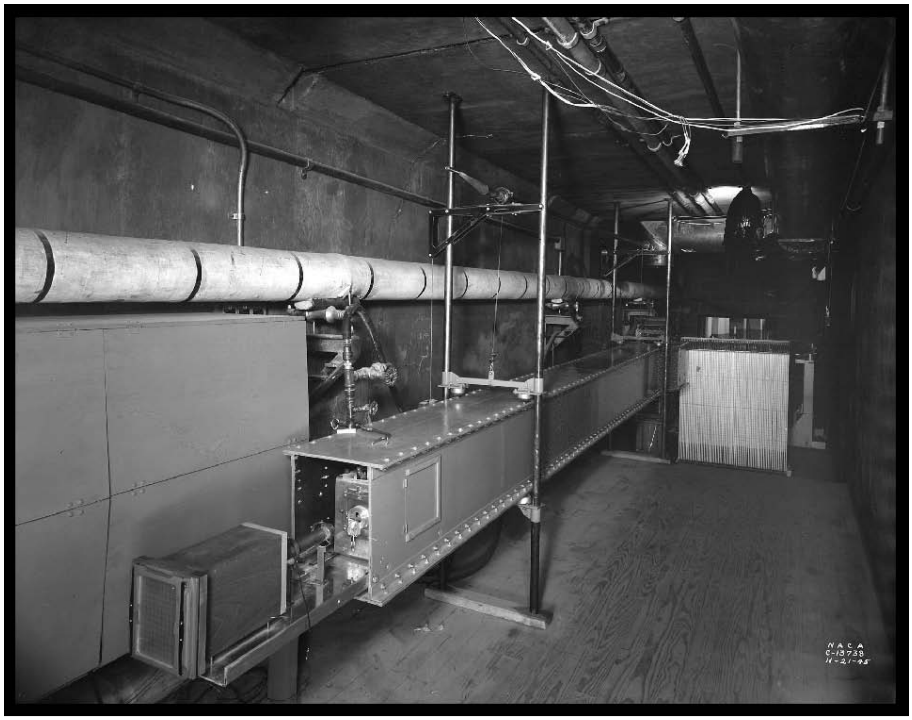

Figure 39.—Basement corridor with the Duct Lab beneath the Shop and Office Building, 1945 (OH_Cuyahoga_AWT-Support_039).

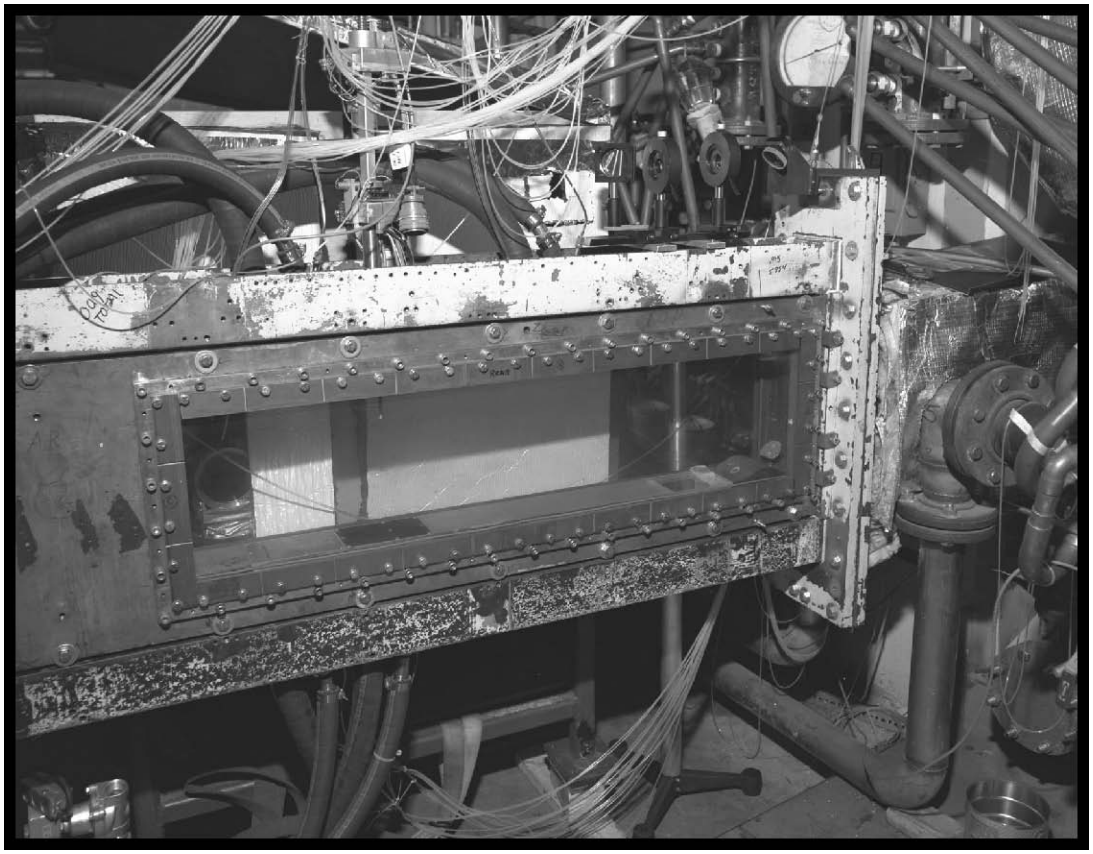

Figure 40.—Duct Lab, a 4" x 10" wind tunnel, in the basement corridor beneath the Shop and Office Building, 1995 (OH_Cuyahoga_AWT-Support_040).

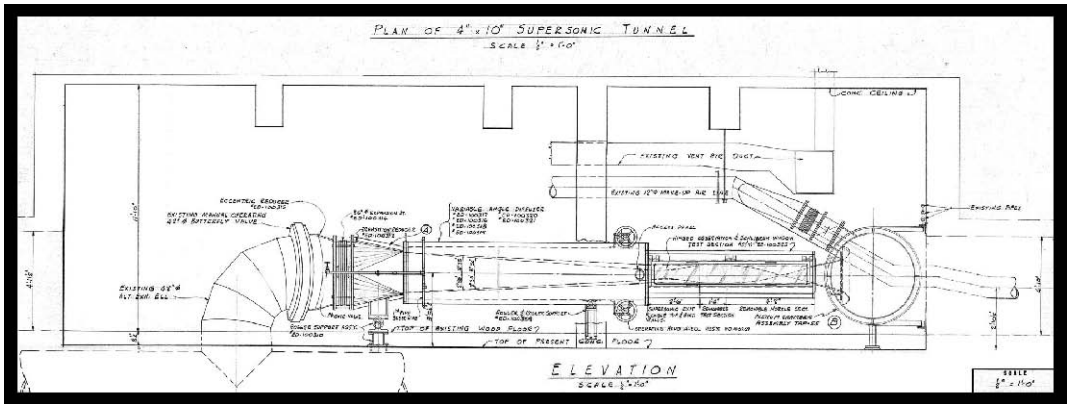

Figure 41.—Elevation drawing of the Duct Lab supersonic wind tunnel, 1946 (OH_Cuyahoga_AWT-Support_041).

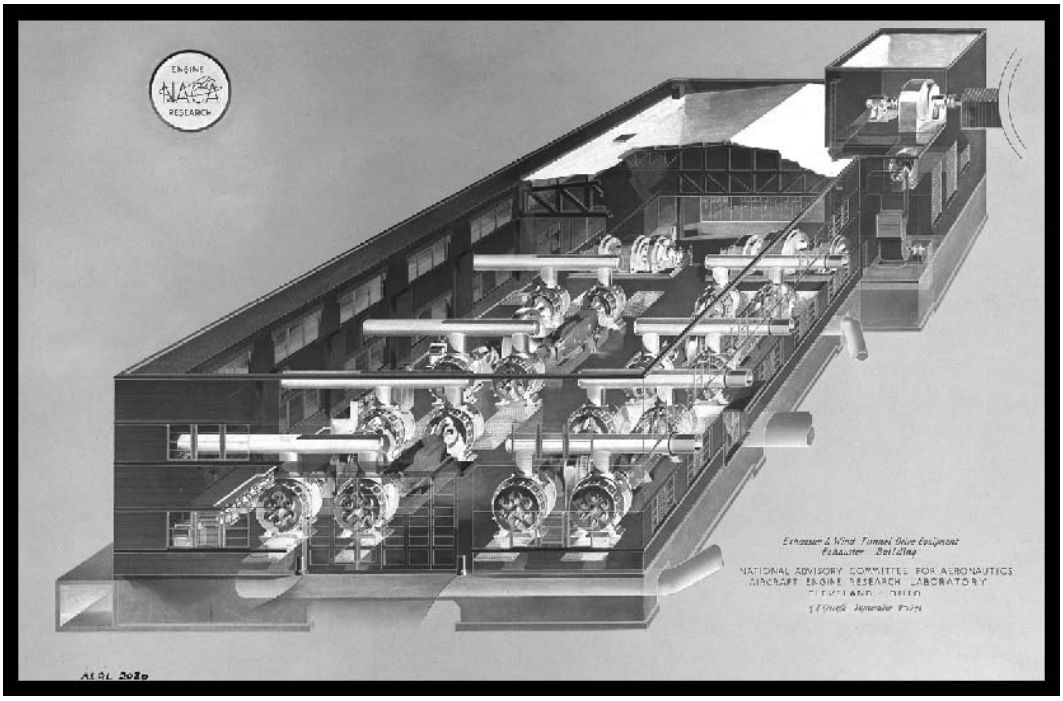

Figure 42.—Isometric drawing of original layout of AWT Exhauster Building, 1943 (OH_Cuyahoga_AWT-Support_042).

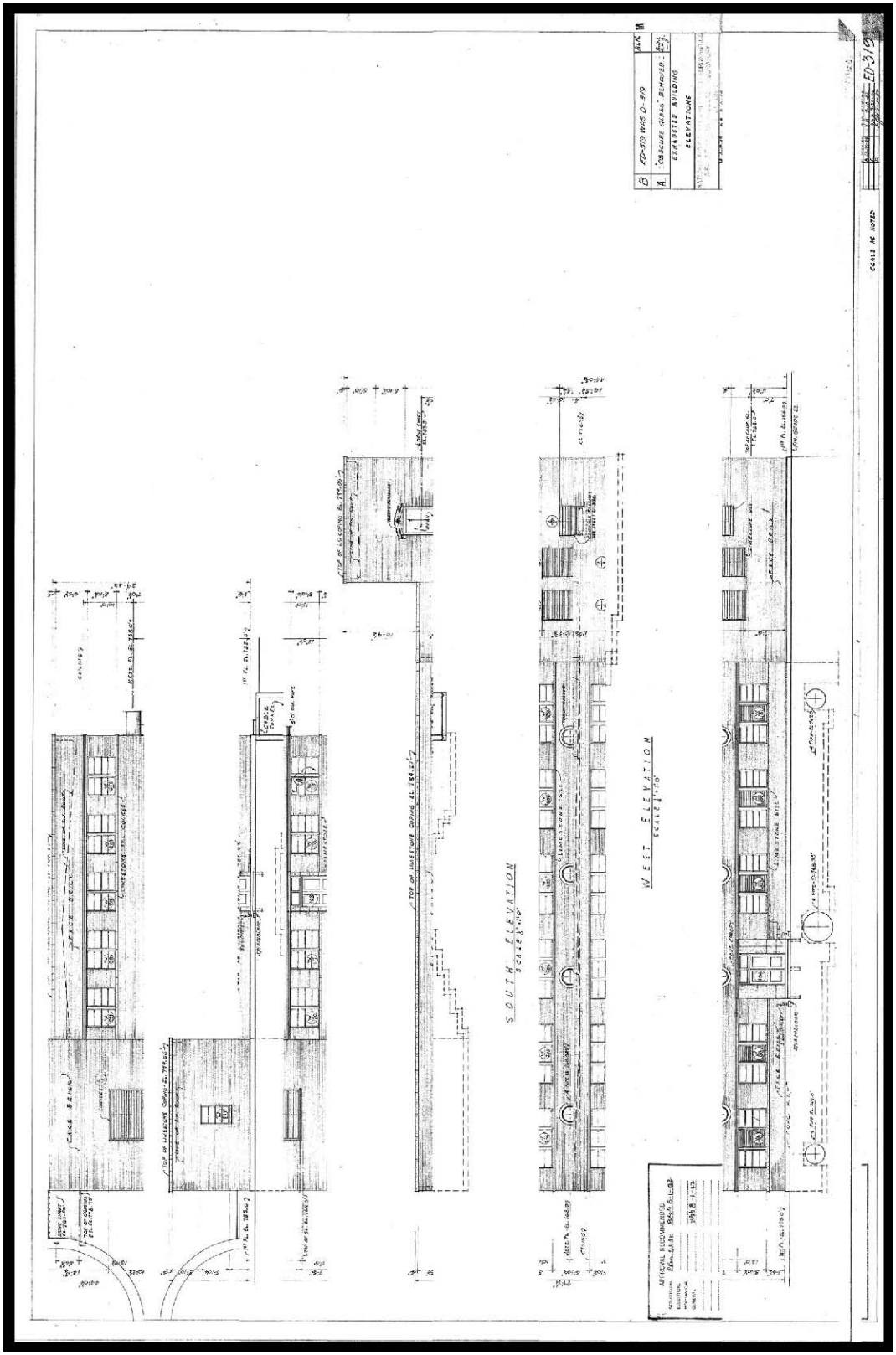

Figure 43.—Elevation drawing of the Exhauster Building, 1942 (OH_Cuyahoga_AWT-Support_043).

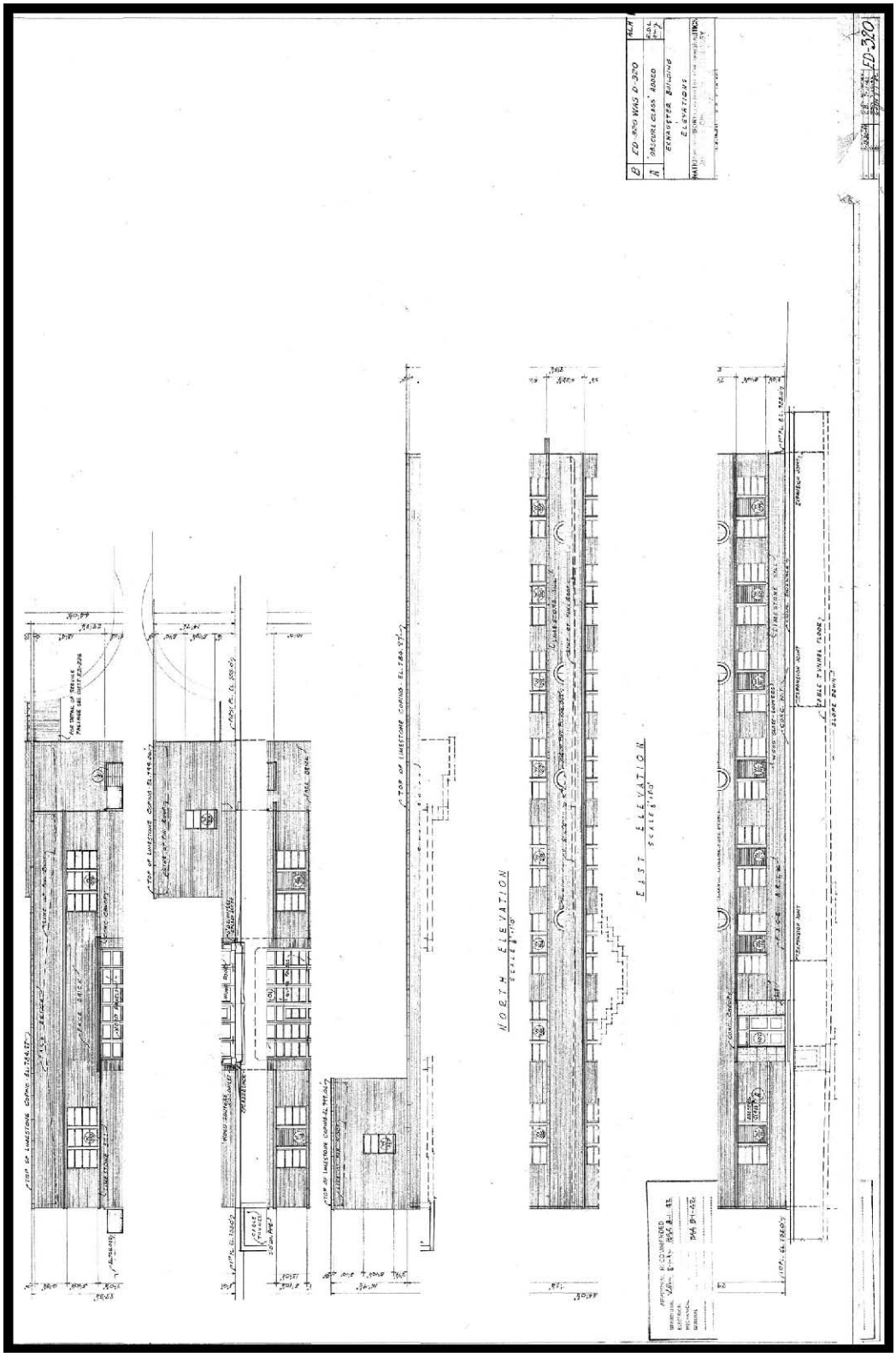

Figure 44.—Elevation drawing of the Exhauster Building, 1942 (OH_Cuyahoga_AWT-Support_044).

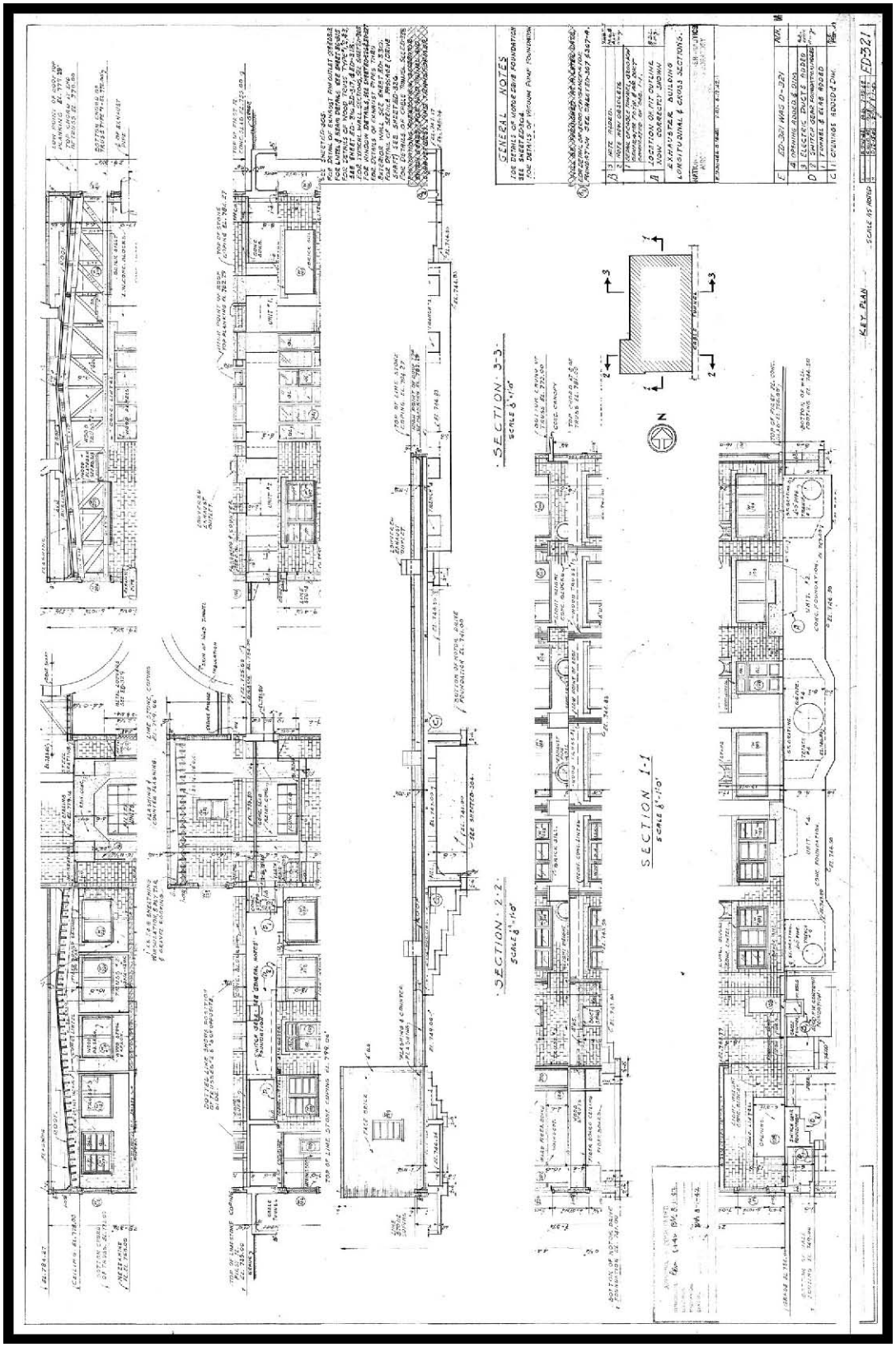

Figure 45.—Elevation drawing of the Exhauster Building, 1942 (OH_Cuyahoga_AWT-Support_045).

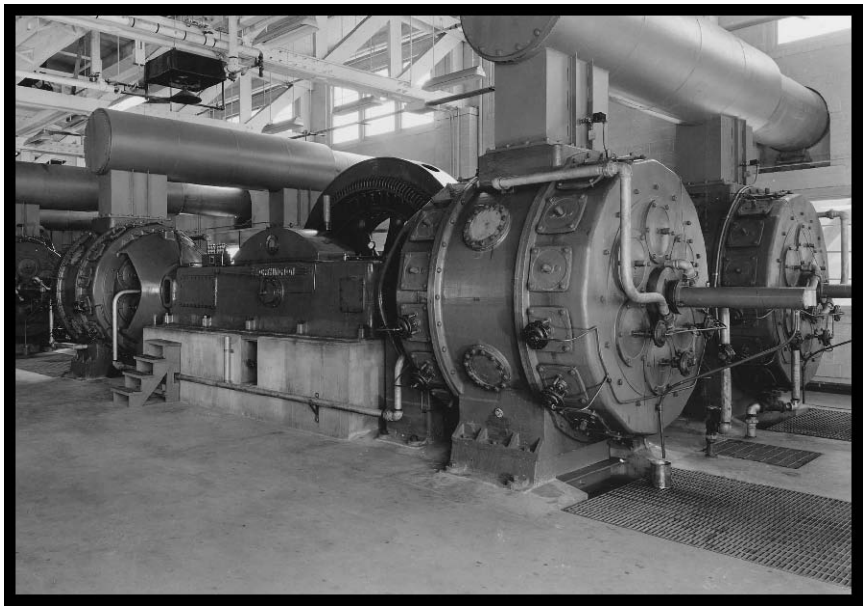

Figure 46.—One of four Worthington exhausters with its two 36"-diameter exhaust pipes in the Exhauster Building, 1944 (OH_Cuyahoga_AWT-Support_046).

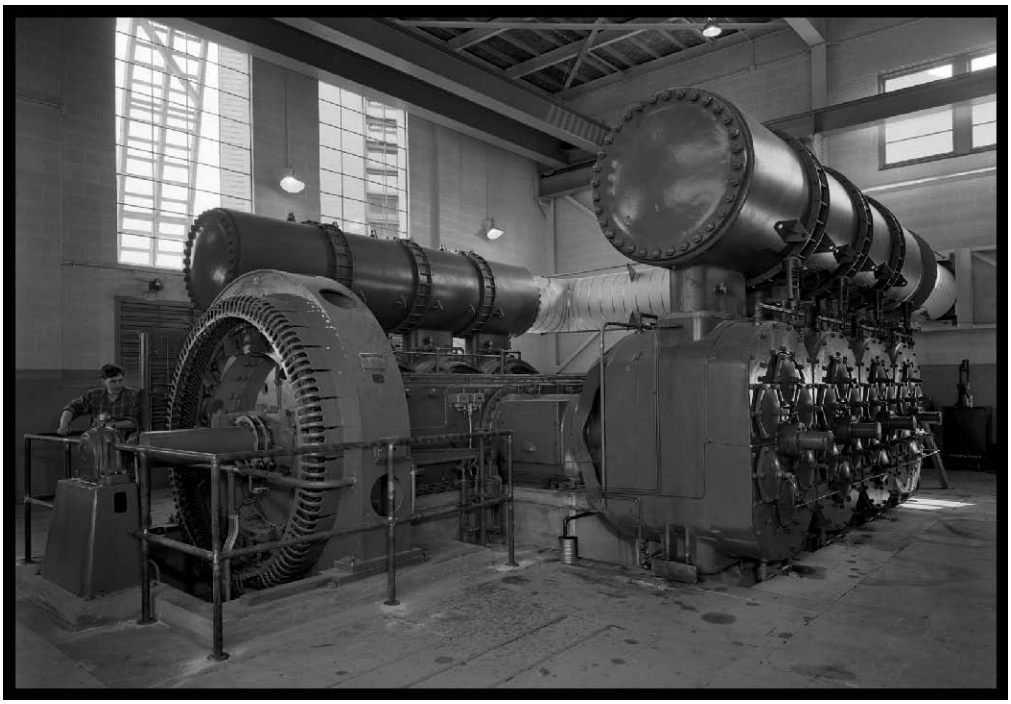

Figure 47.—Ingersoll-Rand exhausters in the 1951 addition to the Exhauster Building, 1952 (OH_Cuyahoga_AWT-Support_047).

Figure 48.—Former Exhauster Building, with the 1951 addition off the northeast corner (viewed from the north), 2005 (OH_Cuyahoga_AWT-Support_048).

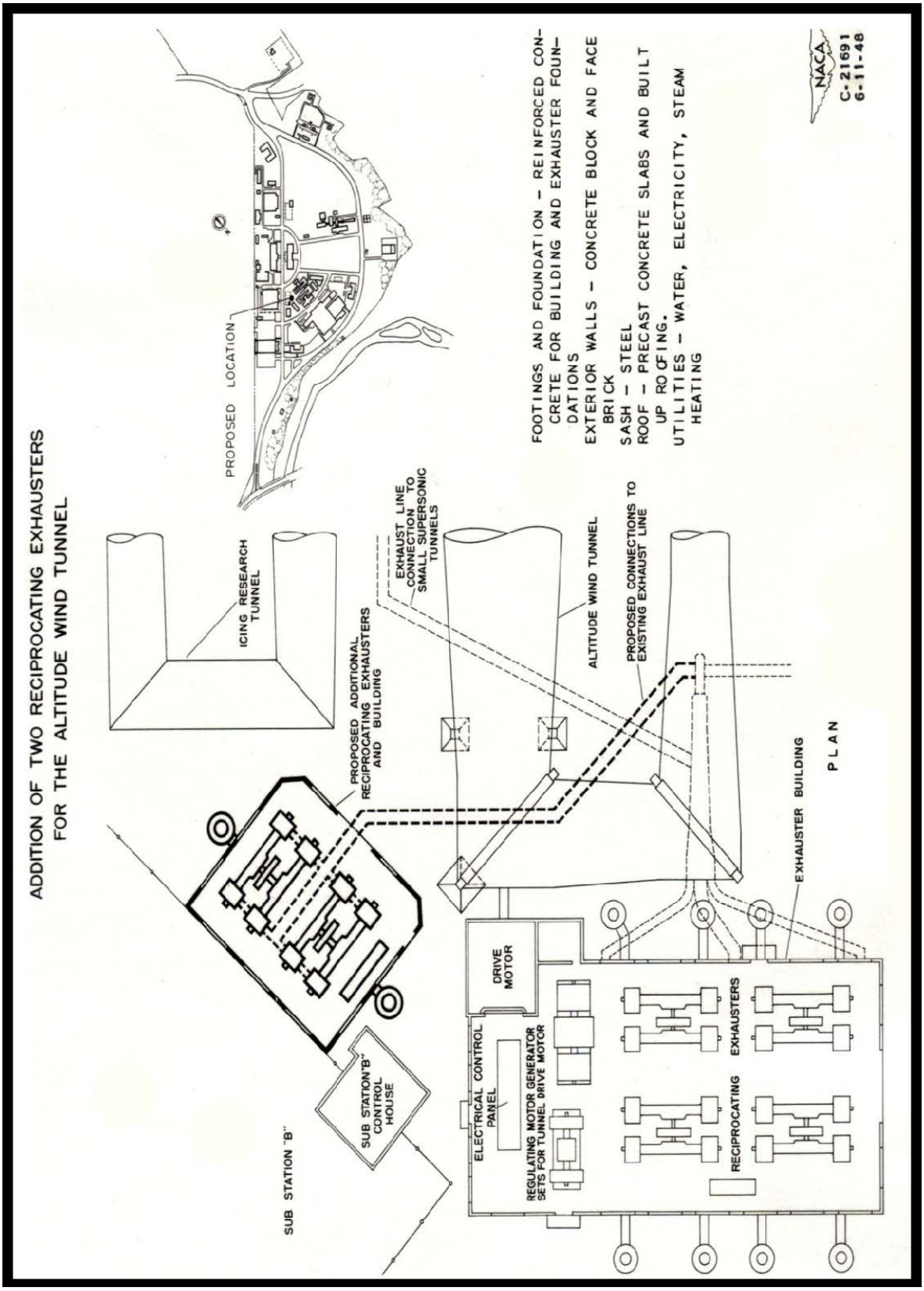

Figure 49.—Two exhausters added to the Exhauster Building, 1948 (OH_Cuyahoga_AWT-Support_049).

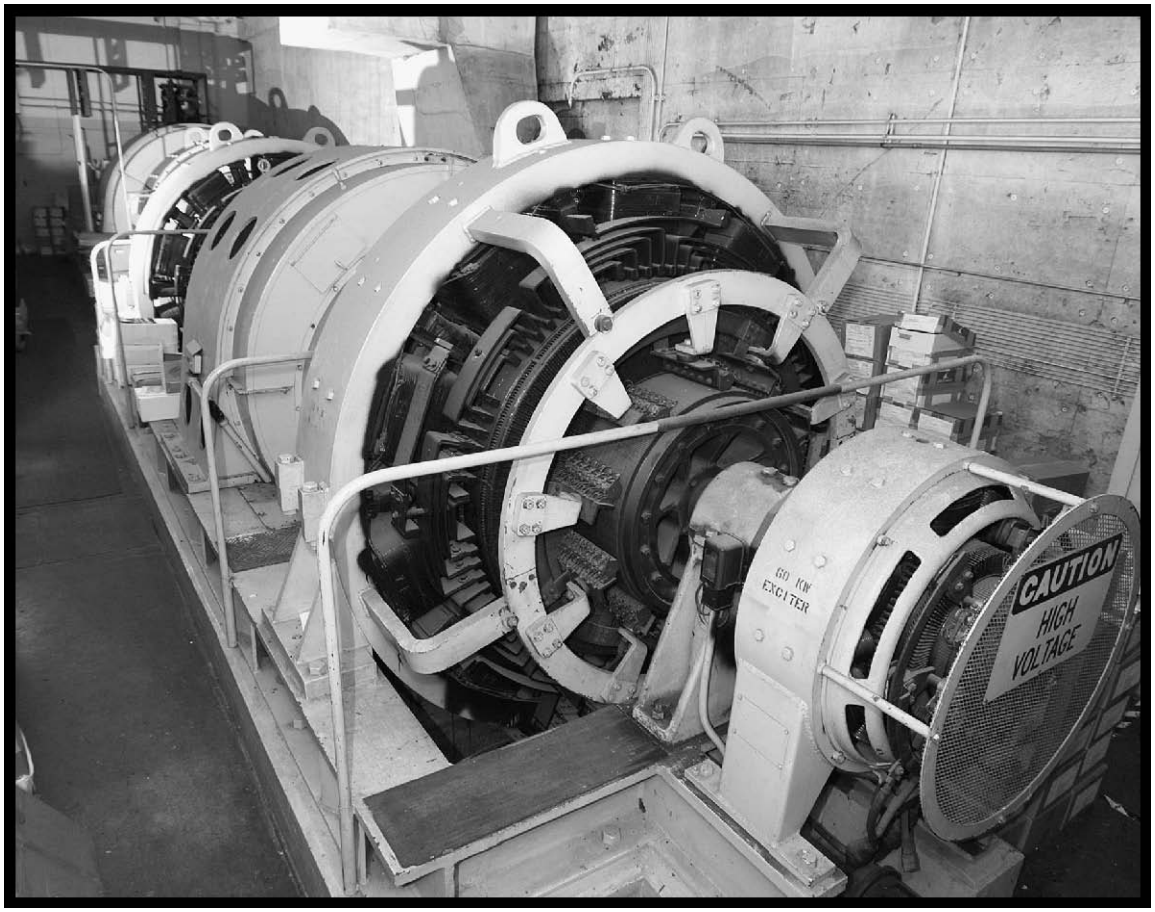

Figure 50.—One of two generators in the Exhauster Building that were used to help power the AWT drive motor, 2005 (OH_Cuyahoga_AWT-Support_050).

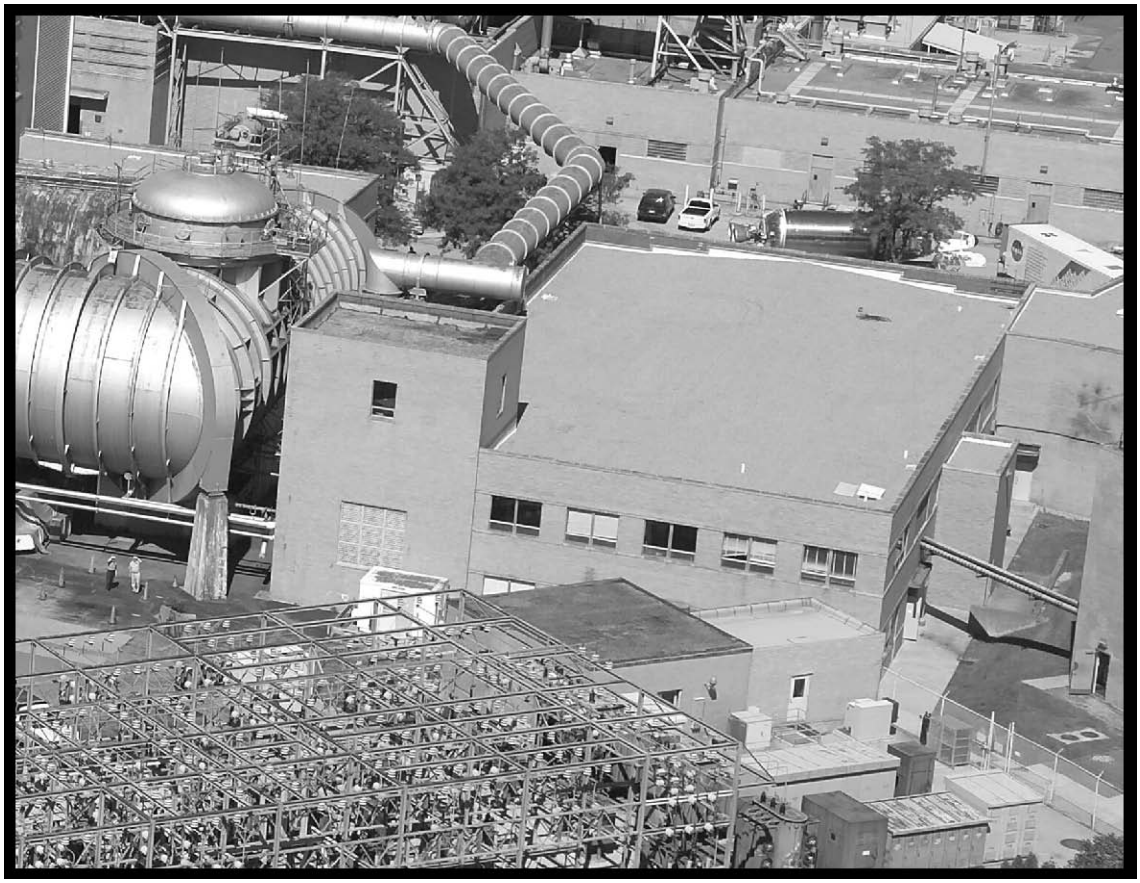

Figure 51.—Drive motor tower in rear of the Exhauster Building (viewed from the south) (OH_Cuyahoga_AWT-Support_051).

Figure 52.—General Electric induction motor that was used to drive the AWT fan (viewed from the northeast), 2005 (OH_Cuyahoga_AWT-Support_052).

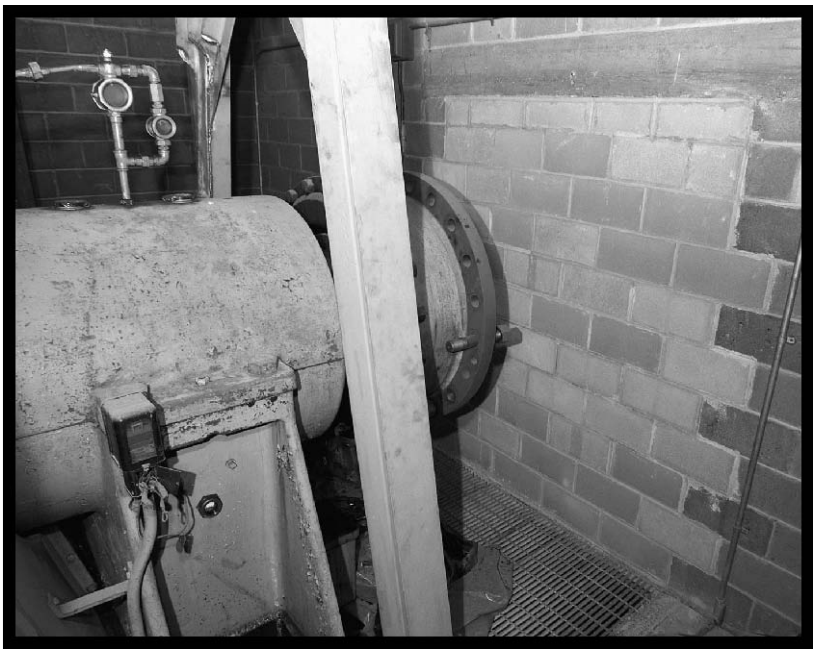

Figure 53.—Drive shaft that formerly exited this western wall of the Exhauster Building to rotate the AWT fan, 2005 (OH_Cuyahoga_AWT-Support_053).

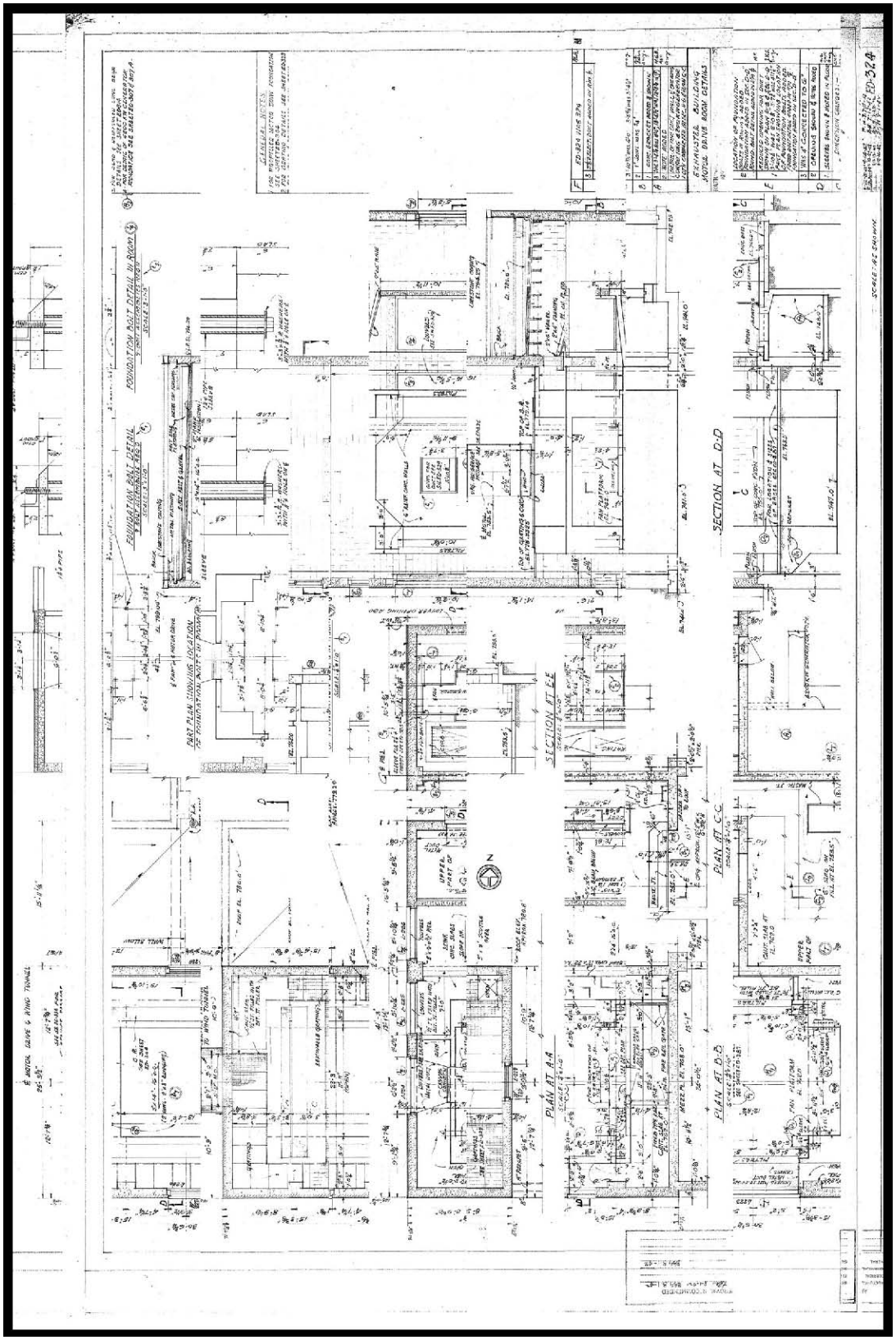

Figure 54.—Motor drive room in Exhauster Building, 1942 (OH_Cuyahoga_AWT-Support_054).

Figure 55.—AID in the former Exhauster Building, 1970 (OH_Cuyahoga_AWT-Support_055).

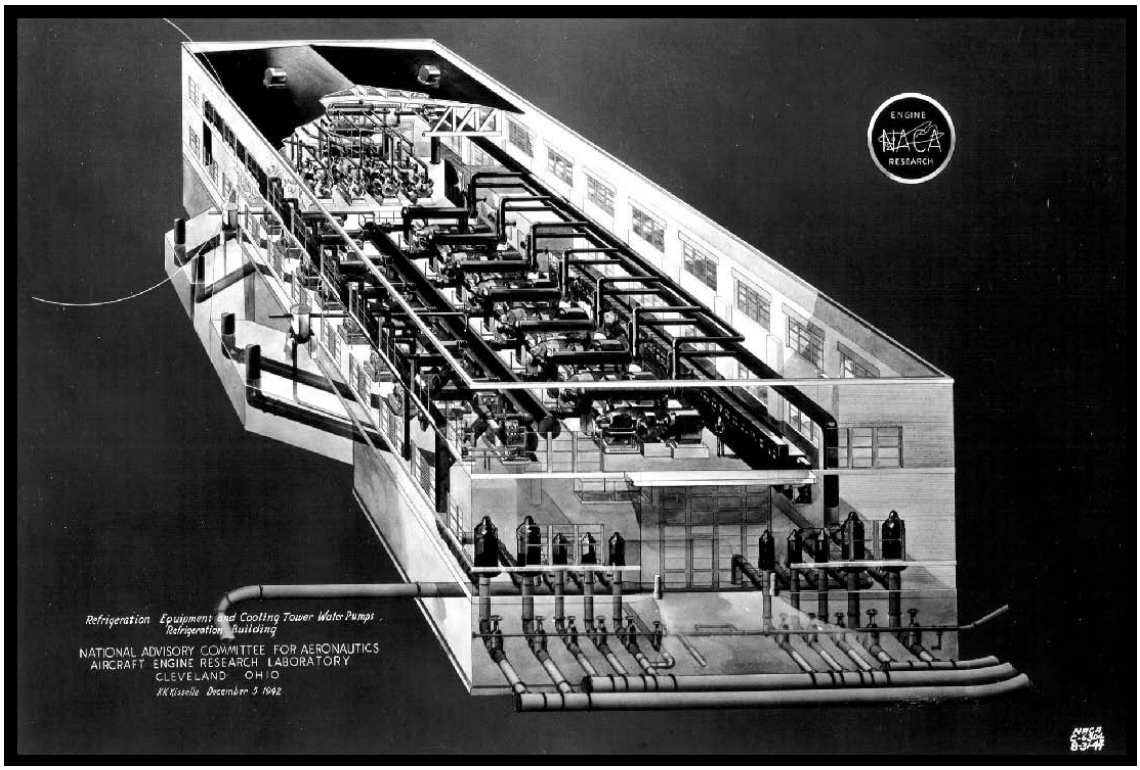

Figure 56.—Isometric drawing of the Refrigeration Building, which housed the cooling system for the AWT and the Icing Research Tunnel, 1944 (OH_Cuyahoga_AWT-Support_056).

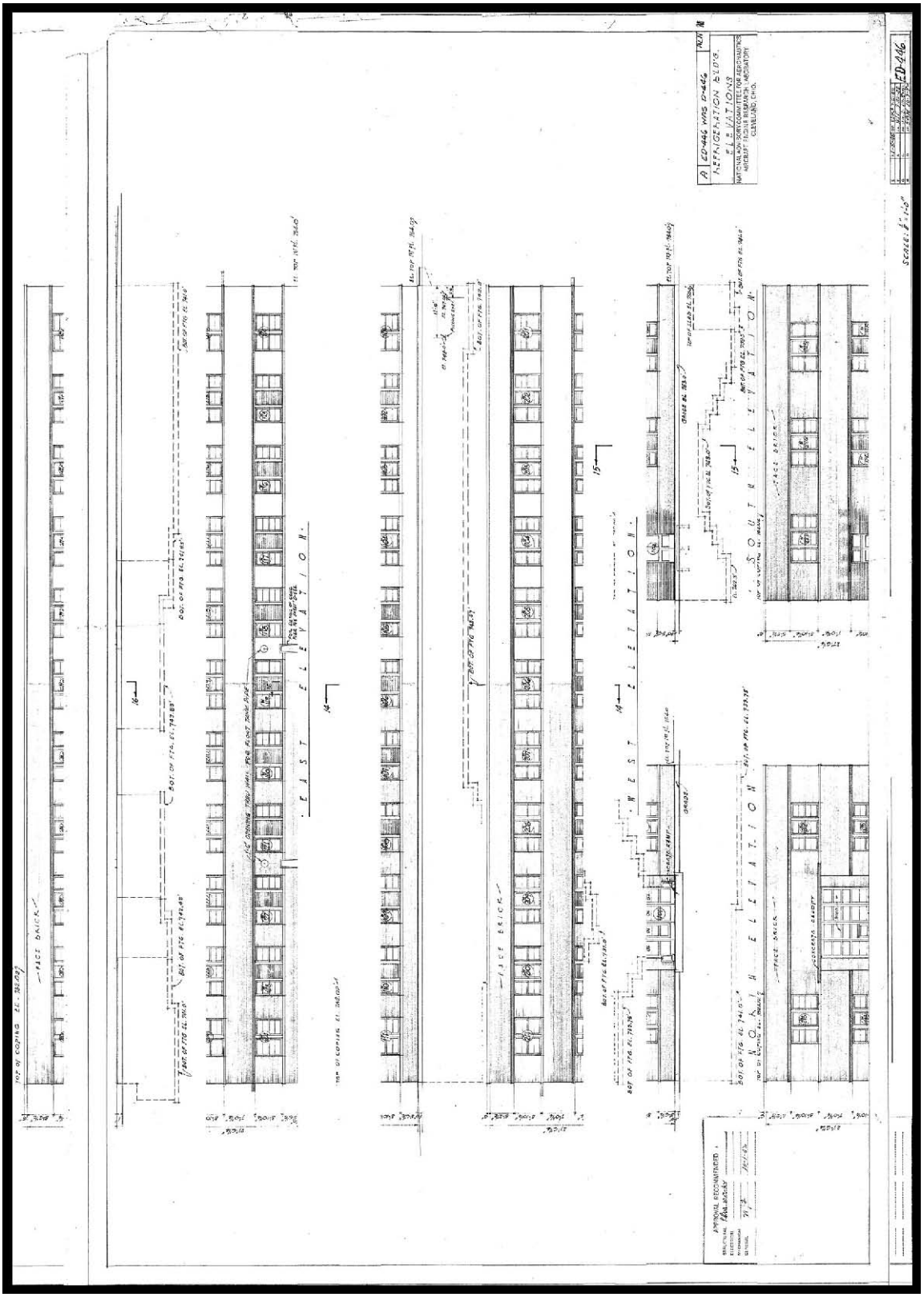

Figure 57.—Elevation drawing of the Refrigeration Building, 1942 (OH_Cuyahoga_AWT-Support_057).

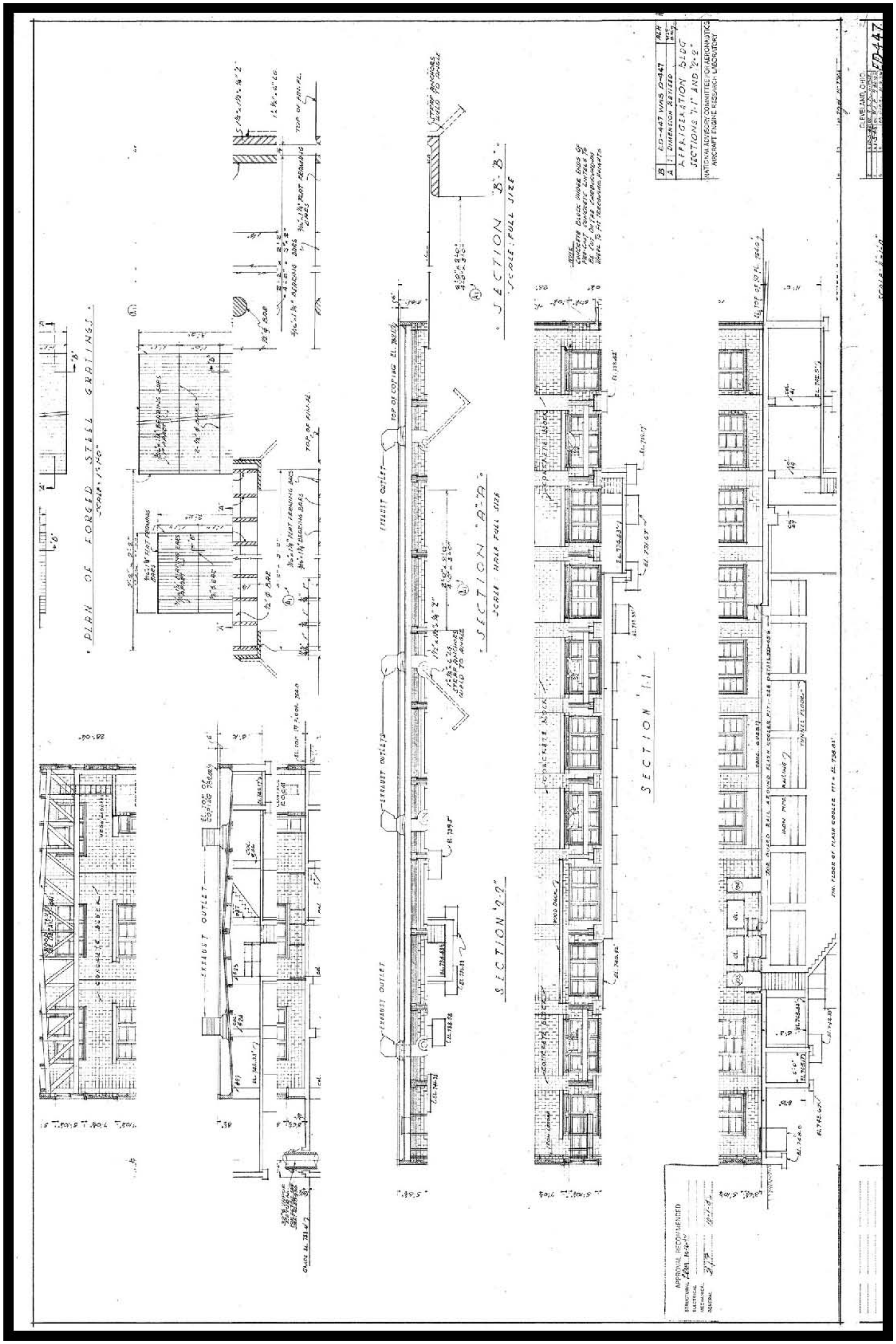

Figure 58.—Sections and cross sections of the Refrigeration Building, 1942
(OH_Cuyahoga_AWT-Support_058).

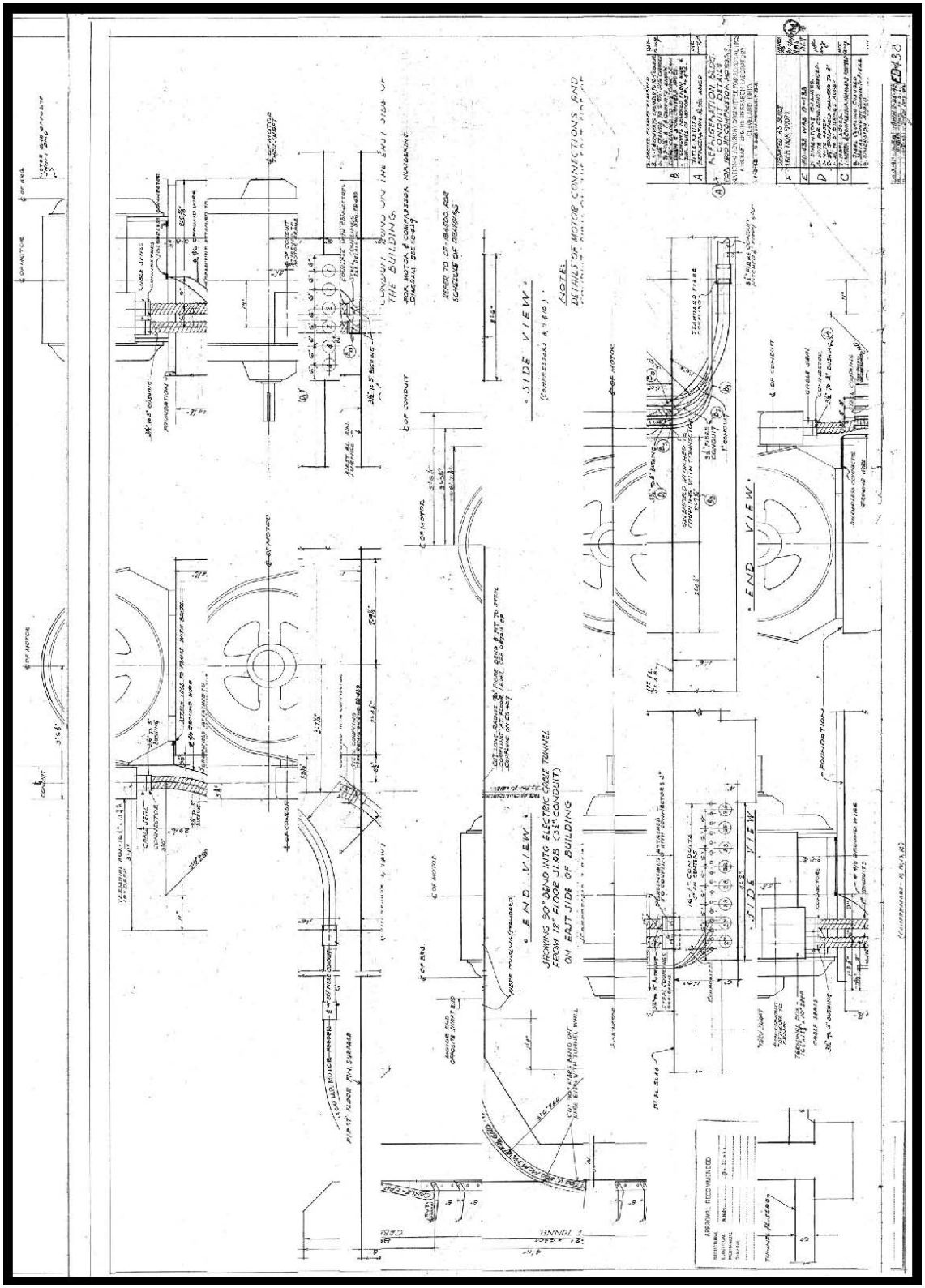

Figure 59.—Sections of the Refrigeration Building, 1942 (OH_Cuyahoga_AWT-Support_059).

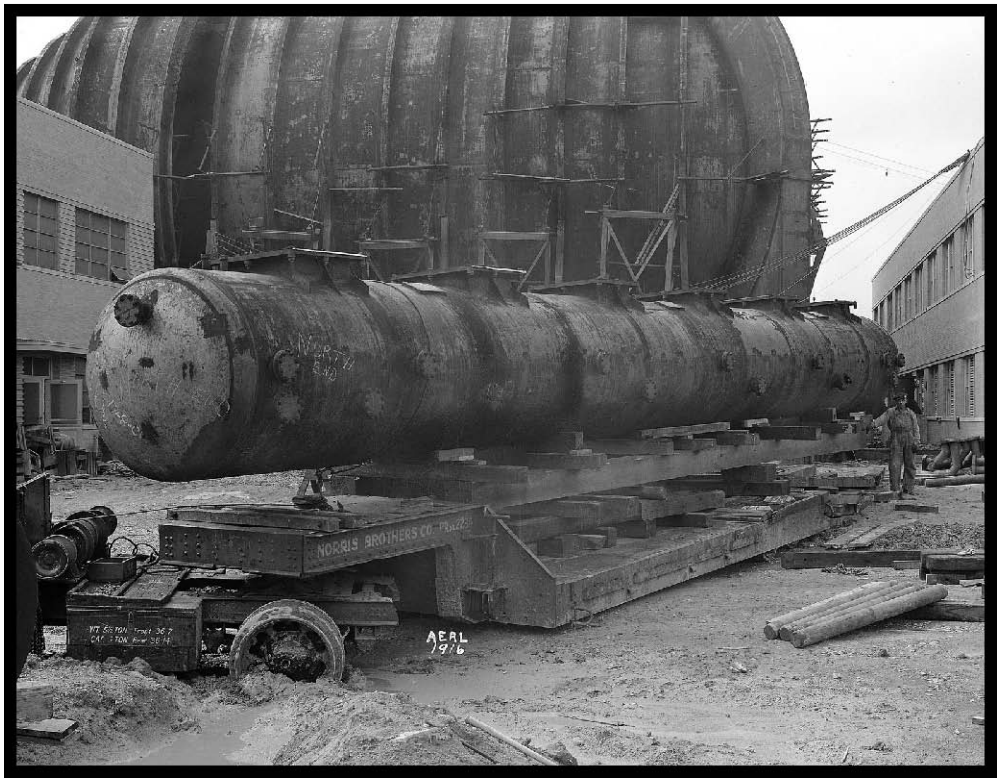

Figure 60.—Flash cooler being prepared for installation in the Refrigeration Building in July 1943 (OH_Cuyahoga_AWT-Support_060).

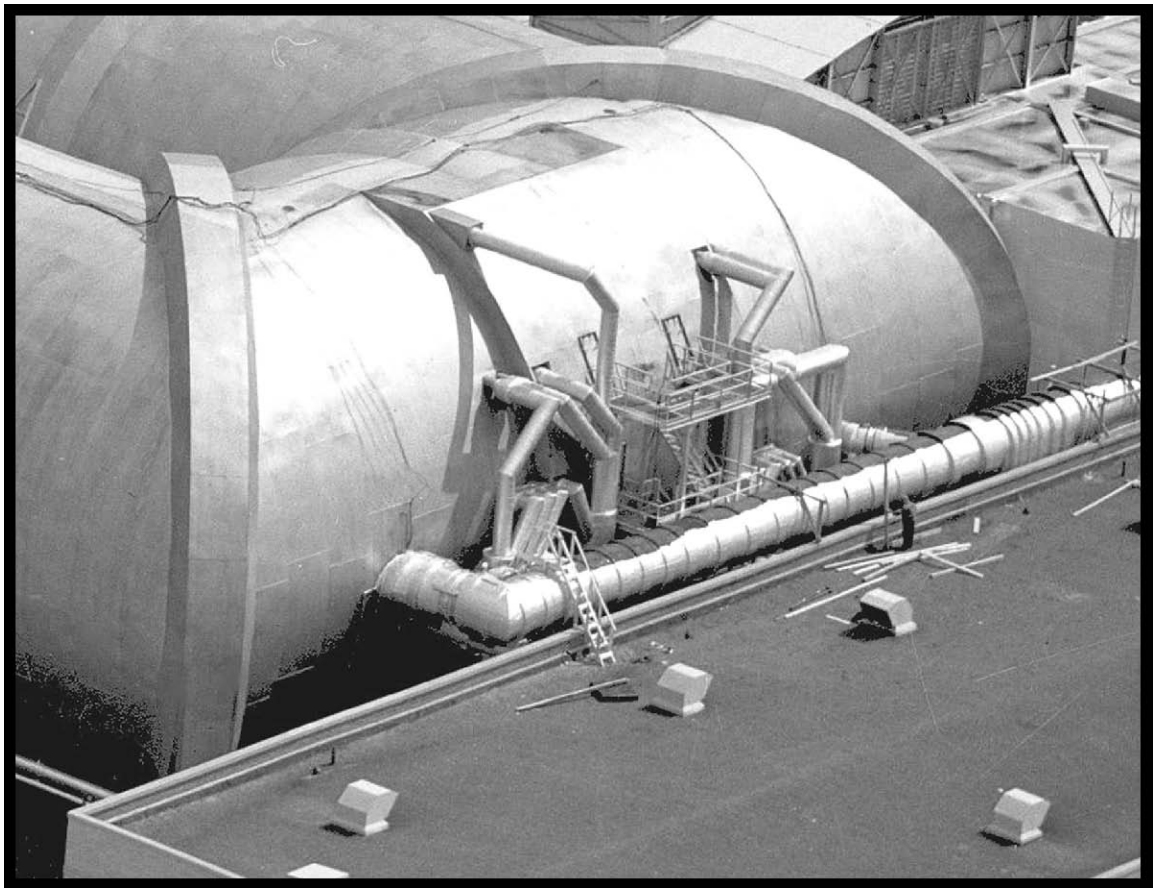

Figure 61.—Lines from the Refrigeration Building entering the west wall of the AWT (viewed from the northwest), 1945 (OH_Cuyahoga_AWT-Support_061).

Figure 62.—Accordion-shaped banks of cooling coils inside the AWT, 1950 (OH_Cuyahoga_AWT-Support_062).

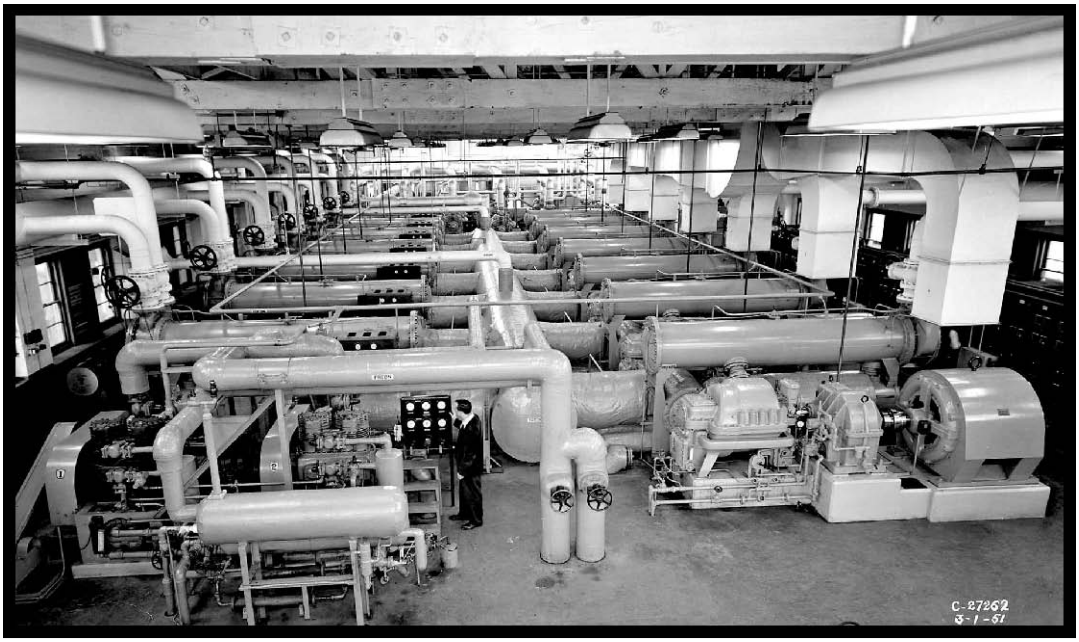

Figure 63.—Flash cooler and Carrier compressors inside the Refrigeration Building (viewed from the south), 1951 (OH_Cuyahoga_AWT-Support_063).

Figure 64.—Refrigeration Building, with the AWT to the left in the background (viewed from the north), 2005 (OH_Cuyahoga_AWT-Support_064).

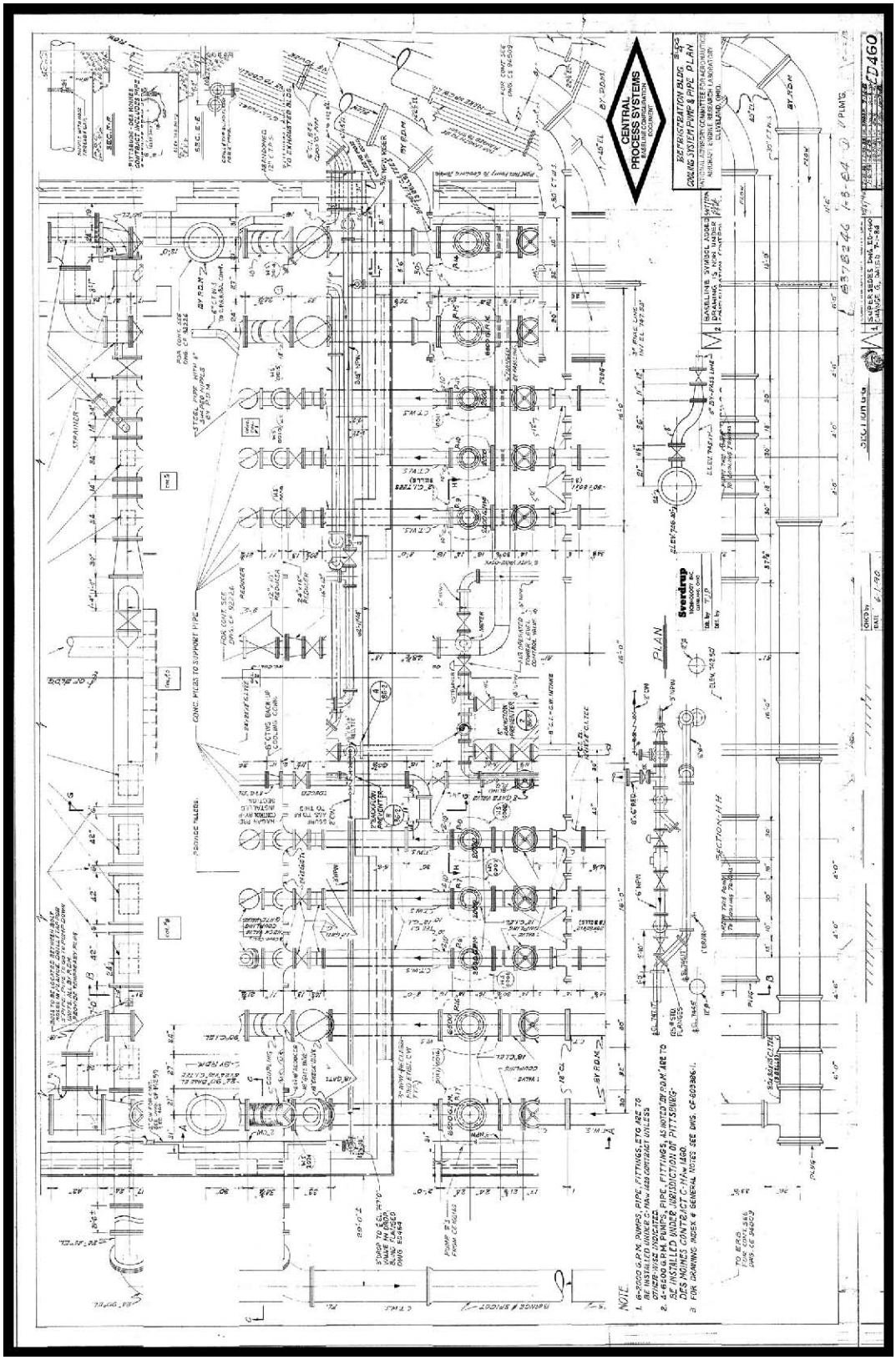

Figure 65.—Piping and sumps for the Circulating Water Pump House, 1943 (OH_Cuyahoga_AWT-Support_065).

Figure 66.—Former Circulating Water Pump House beneath the AWT (viewed from the west), 2007 (OH_Cuyahoga_AWT-Support_066).

Figure 67.—Three of four sump pumps inside the Circulating Water Pump House during its construction in 1951 (OH_Cuyahoga_AWT-Support_067).

Figure 68.—Installation of the exhaust gas cooler under the northeast tunnel section during the upgrade of the AWT, 1951 (OH_Cuyahoga_AWT-Support_068).

Figure 69.—72"-diameter pipe connecting the cooler pit to the Exhauster Building and the ERB, 2005 (OH_Cuyahoga_AWT-Support_069).

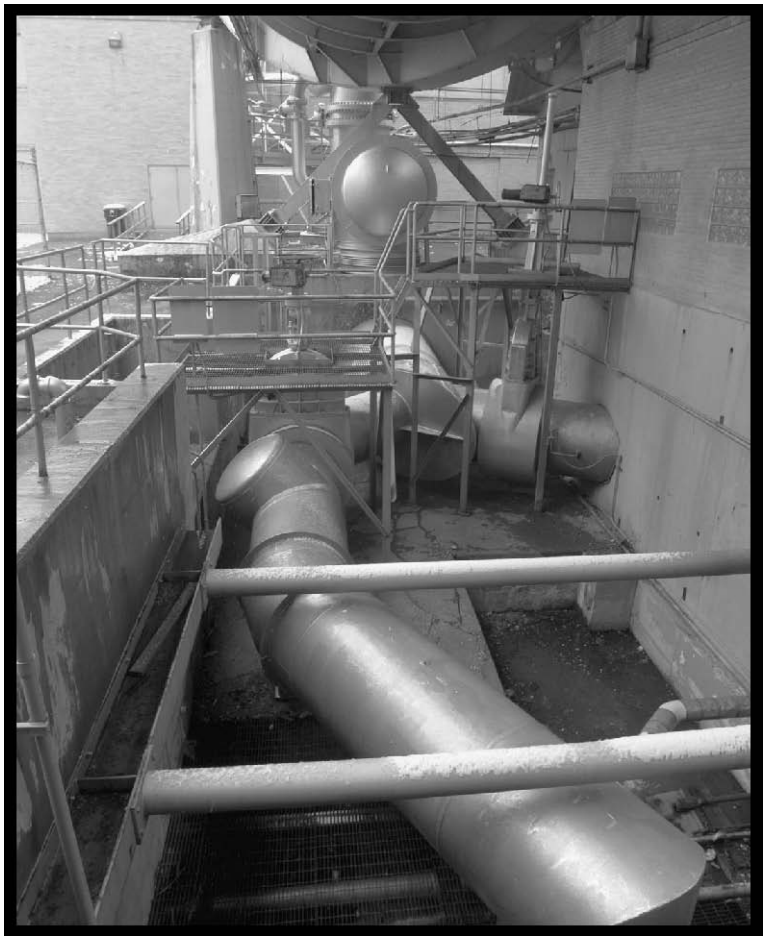

Figure 70.—Cooler pit area under the northeast portion of the tunnel (viewed from the west), 2007 (OH_Cuyahoga_AWT-Support_070).

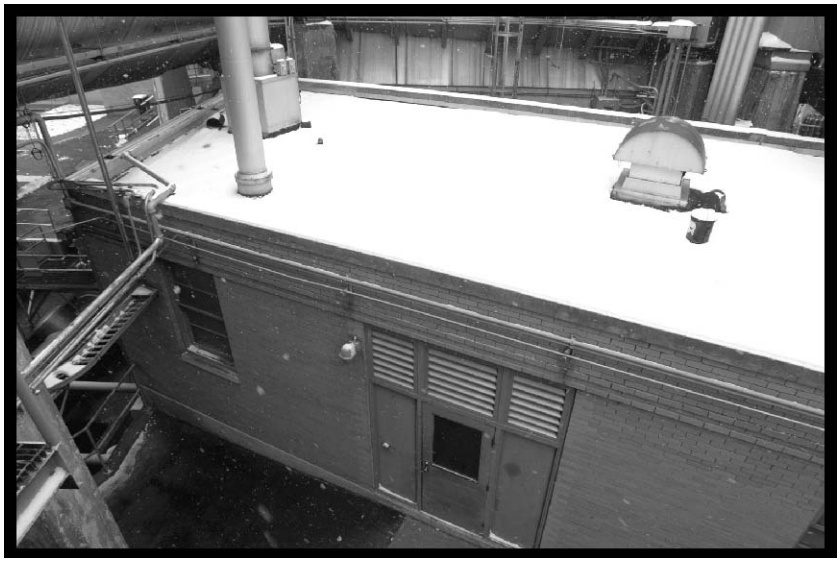

Figure 71.—Former Circulating Water Pump House (viewed from the west), 2007 (OH_Cuyahoga_AWT-Support_071).

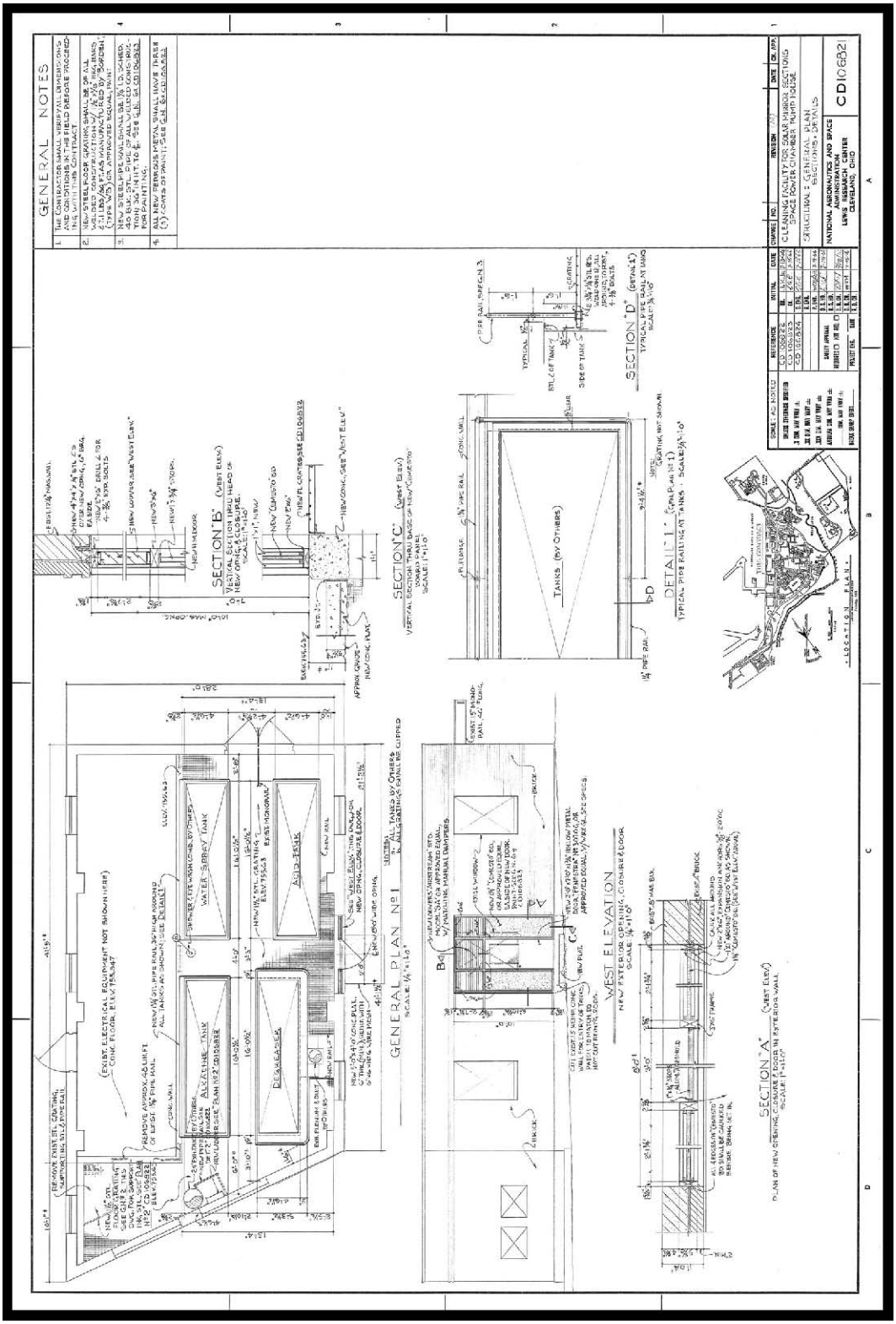

Figure 72.—Cleaning section for the solar power mirrors in the old pump house, 1966 (OH_Cuyahoga_AWT-Support_072).

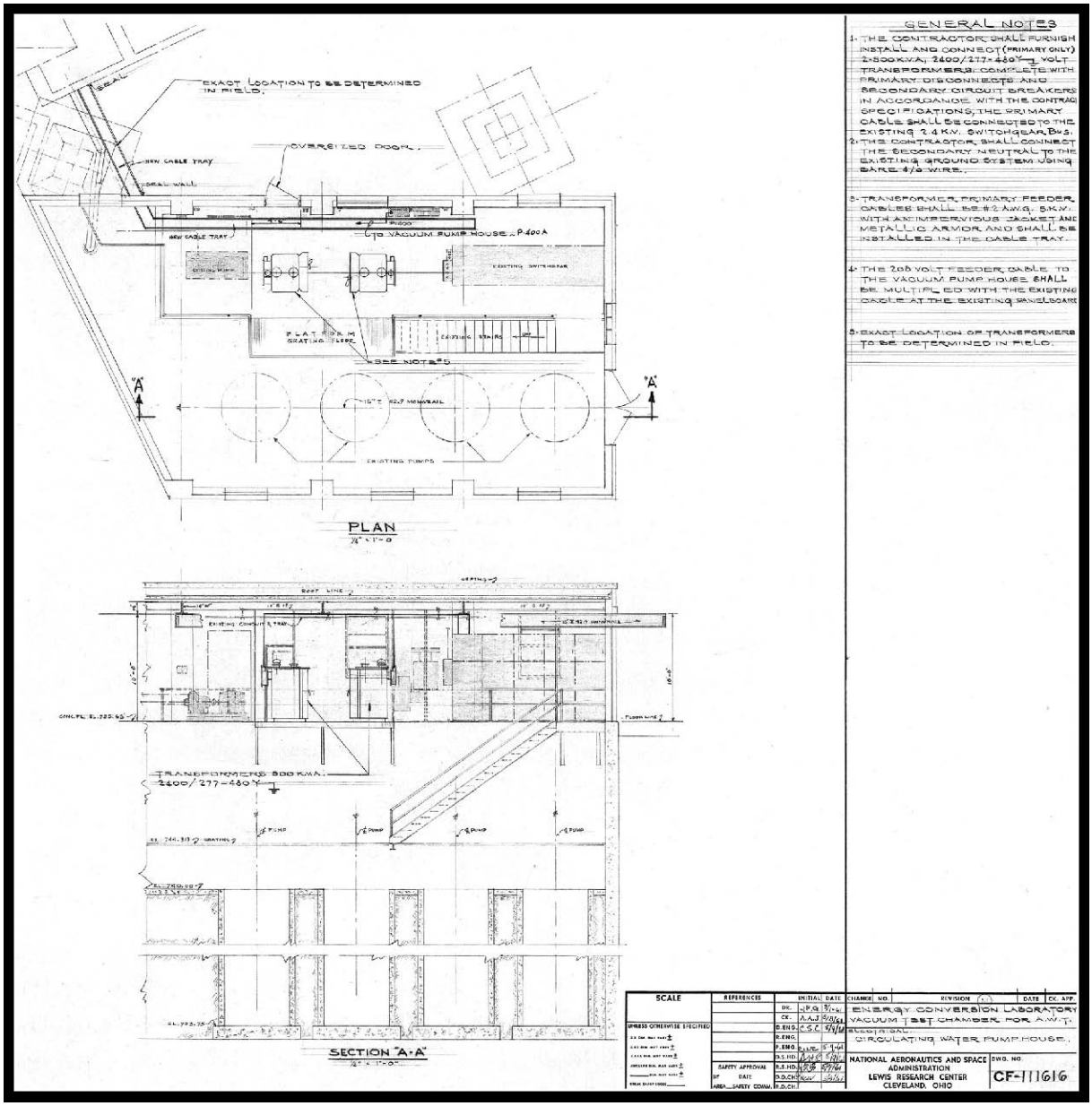

Figure 73.—Elevation drawing for the Circulating Water Pump House, 1961 (OH_Cuyahoga_AWT-Support_073).

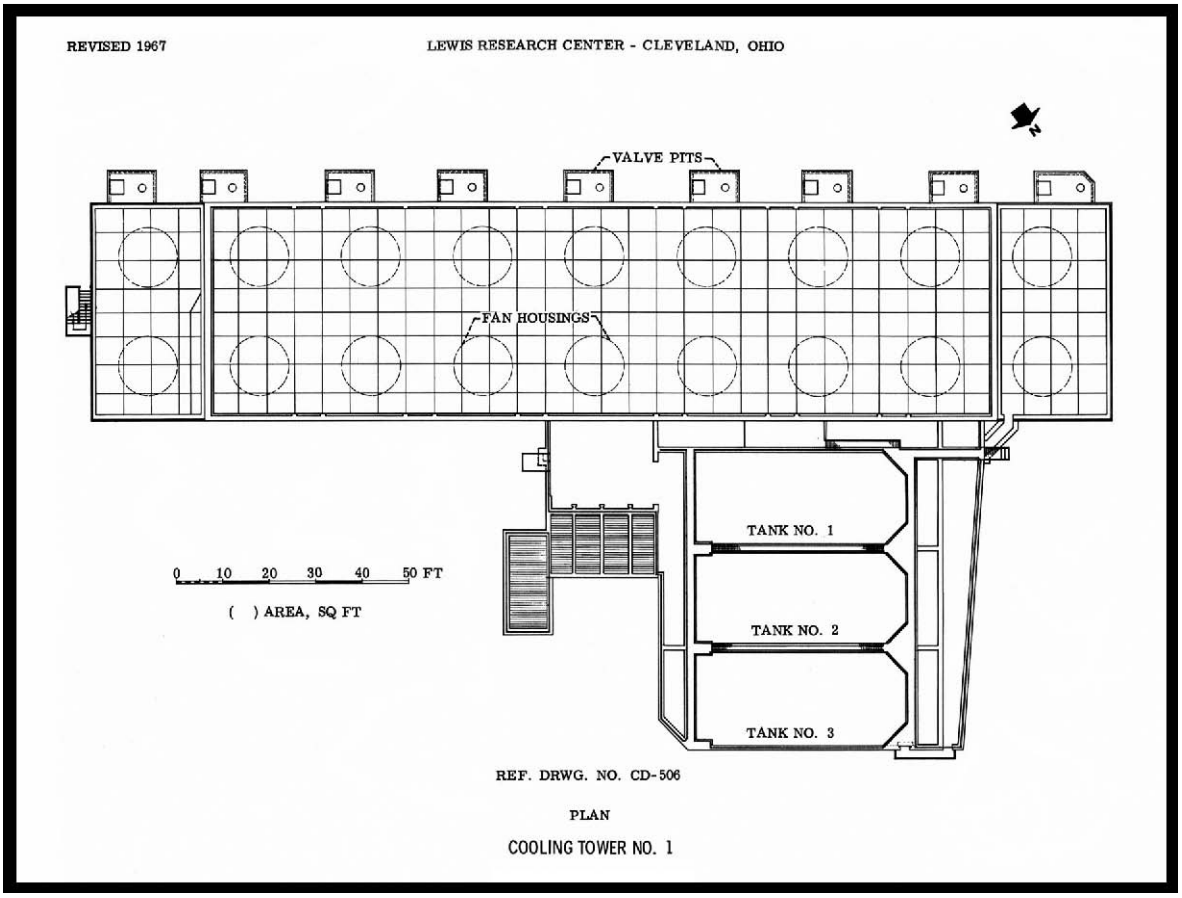

Figure 74.—Cooling Tower No. 1 plan, revised 1967 (OH_Cuyahoga_AWT-Support_074).

Figure 75.—Cooling Tower No. 1 (viewed from the southwest), 2005 (OH_Cuyahoga_AWT-Support_075).

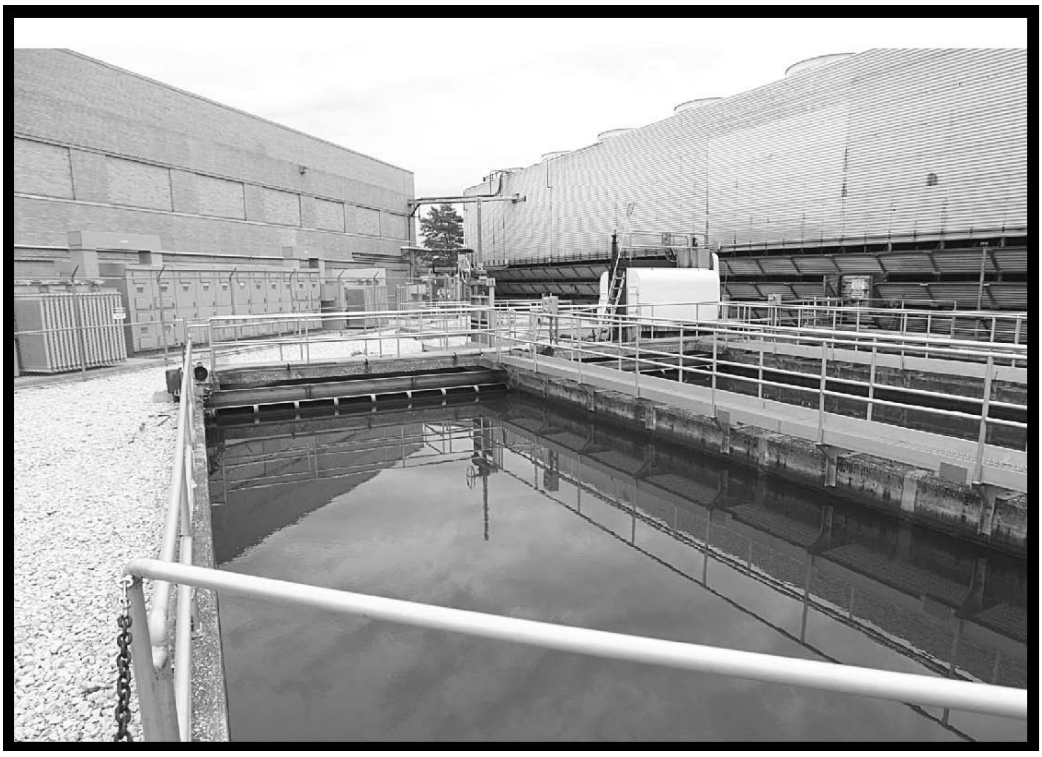

Figure 76.—Cooling Tower No. 1 with its settling basins in the foreground (viewed from the northwest), 2005 (OH_Cuyahoga_AWT-Support_076).

Figure 77.—Original air dryer setup with the secondary coils (left), dryer tank (center), and primary coils (right) (viewed from the west), 1945 (OH_Cuyahoga_AWT-Support_077).

Figure 78.—Air Dryer Building after a new dryer tank and primary coils were added on top (viewed from the northwest), 1955 (OH_Cuyahoga_AWT-Support_078).

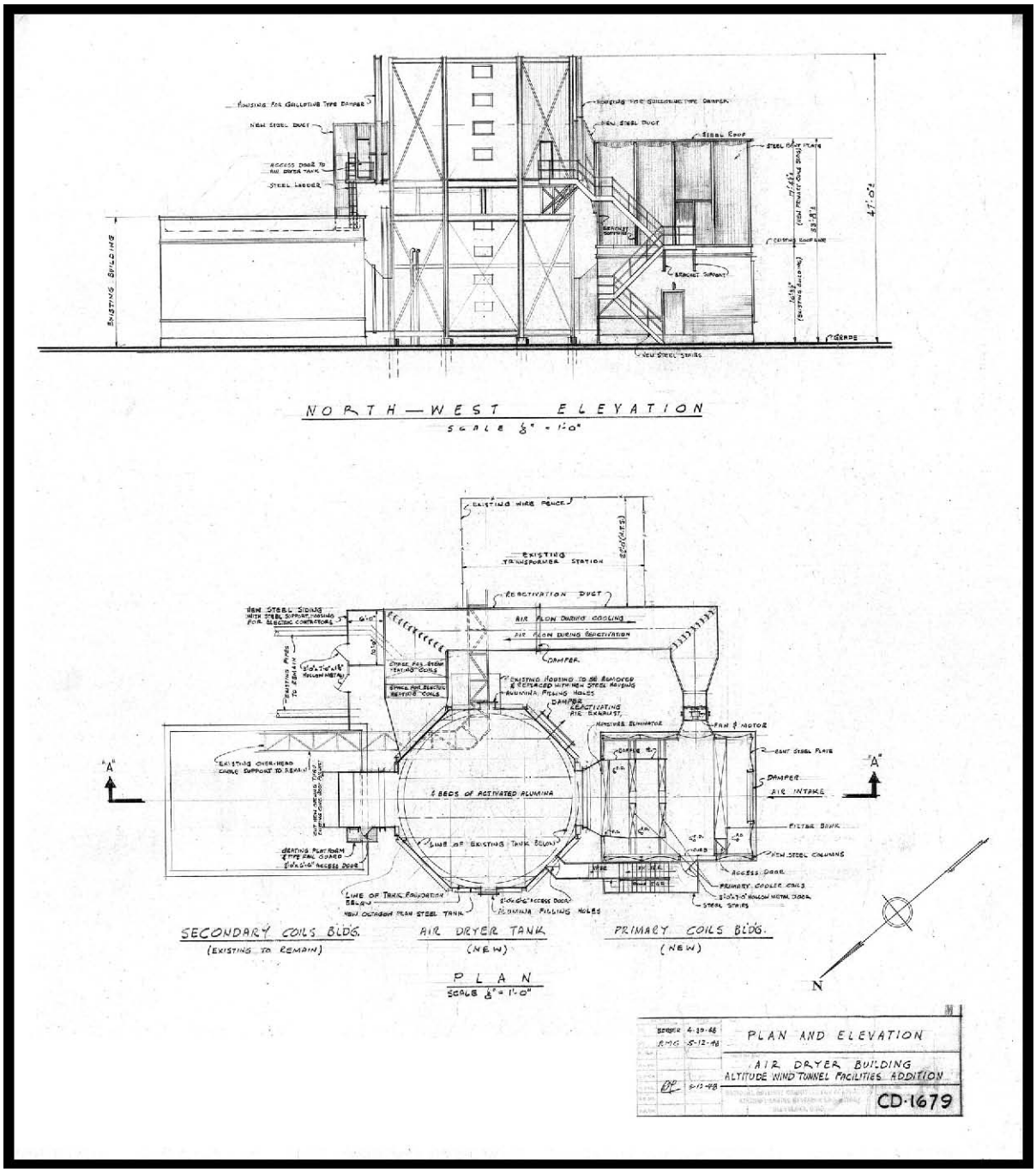

Figure 79.—Plan and elevation drawing for the Air Dryer Building addition, 1948 (OH_Cuyahoga_AWT-Support_079).

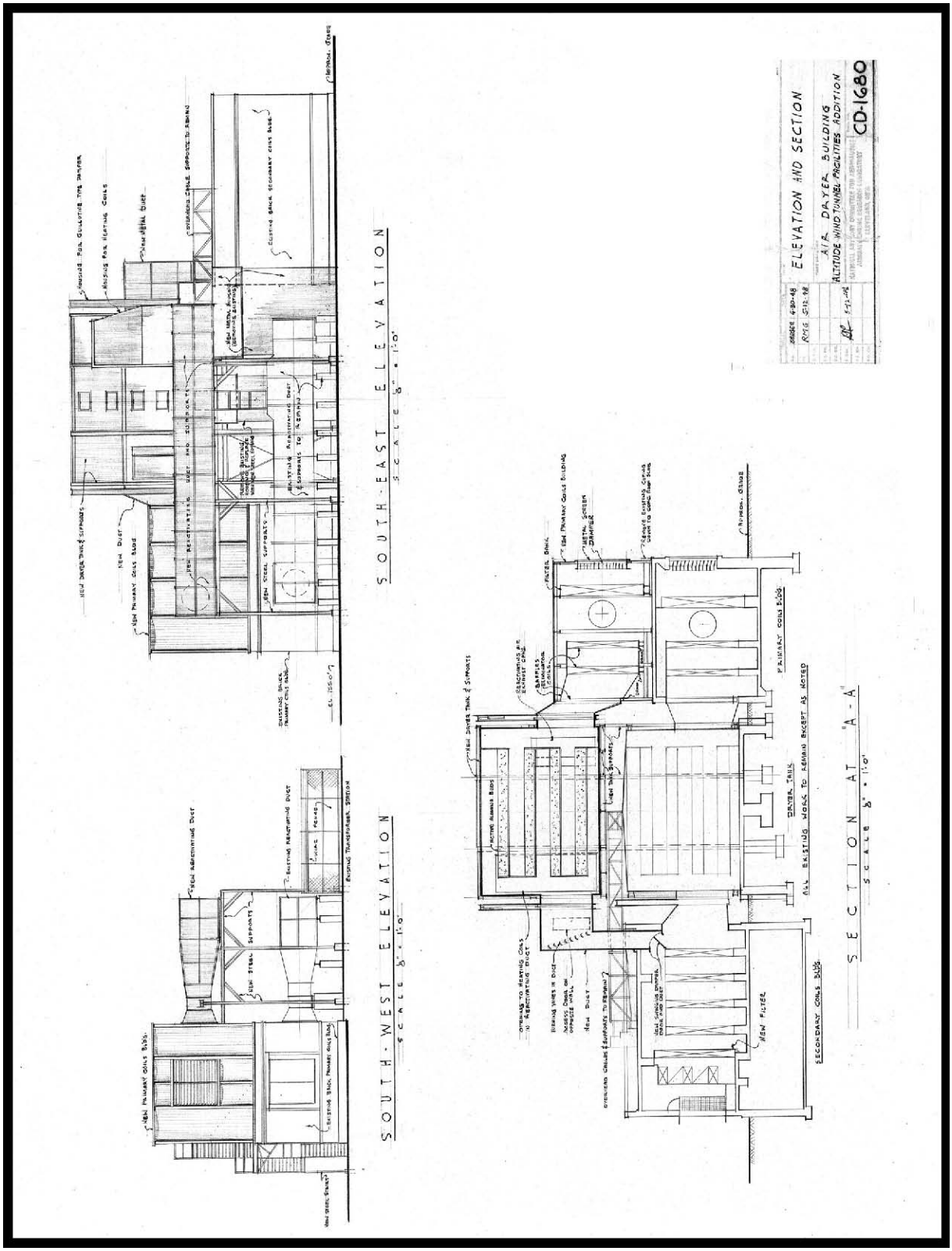

Figure 80.—Elevation drawings of the Air Dryer Building, 1948 (OH_Cuyahoga_AWT-Support_080).

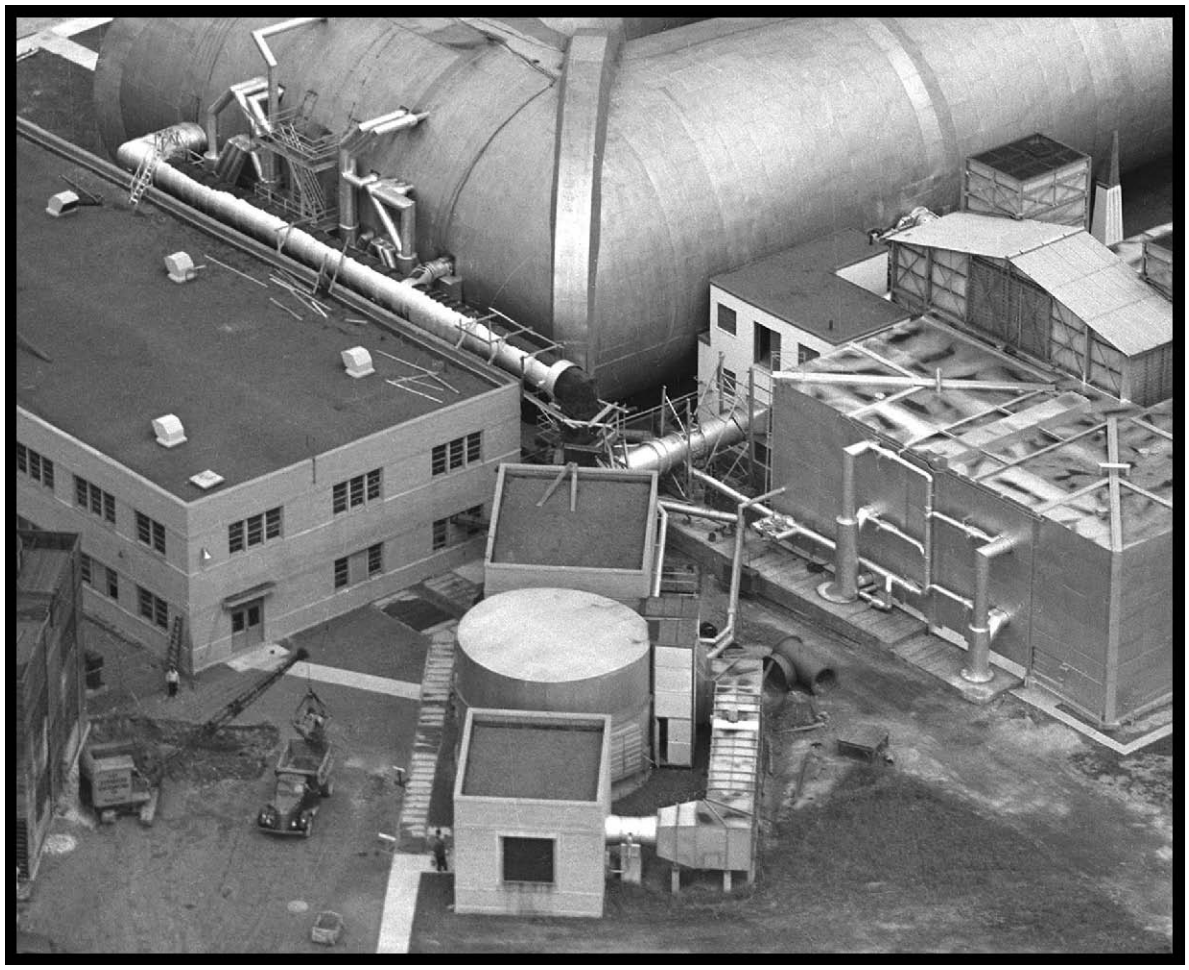

Figure 81.—Air Dryer Building showing air pipes feeding the AWT (left) and the Small Supersonic Tunnels (right) (viewed from the southwest), 1945 (OH_Cuyahoga_AWT-Support_081).

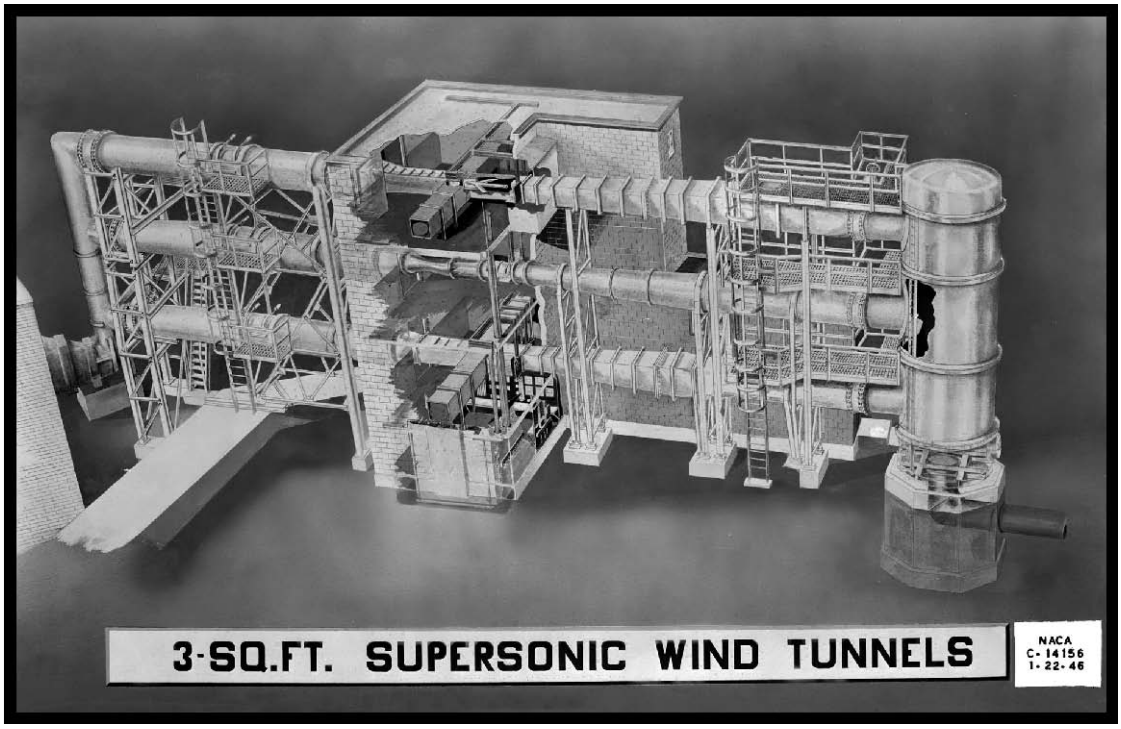

Figure 82.—Isometric drawing of the Small Supersonic Wind Tunnels Building as envisioned in 1946 (OH_Cuyahoga_AWT-Support_082).

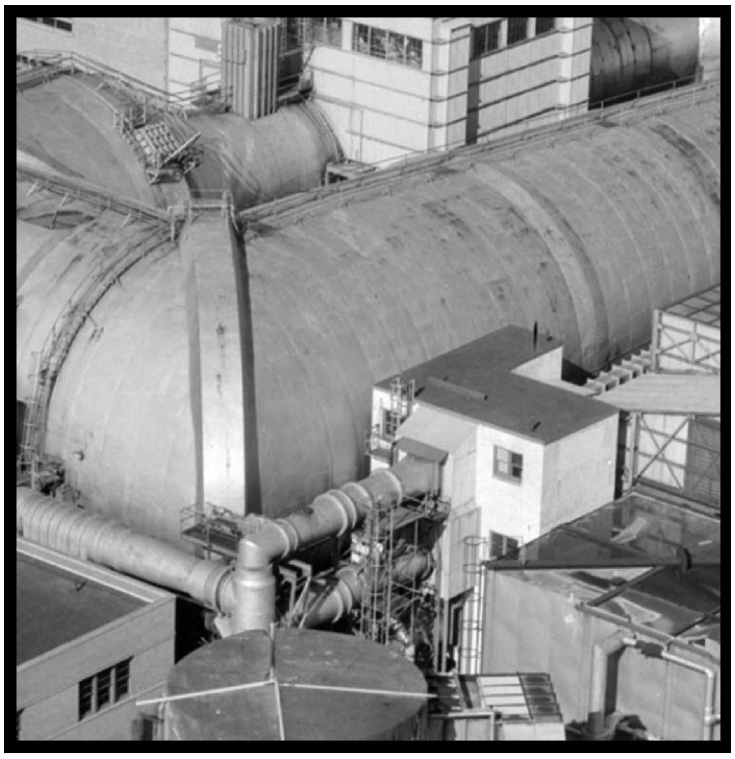

Figure 83.—Line from the air dryer feeding the Small Supersonic Wind Tunnels (viewed from the southwest), 1955 (OH_Cuyahoga_AWT-Support_083).

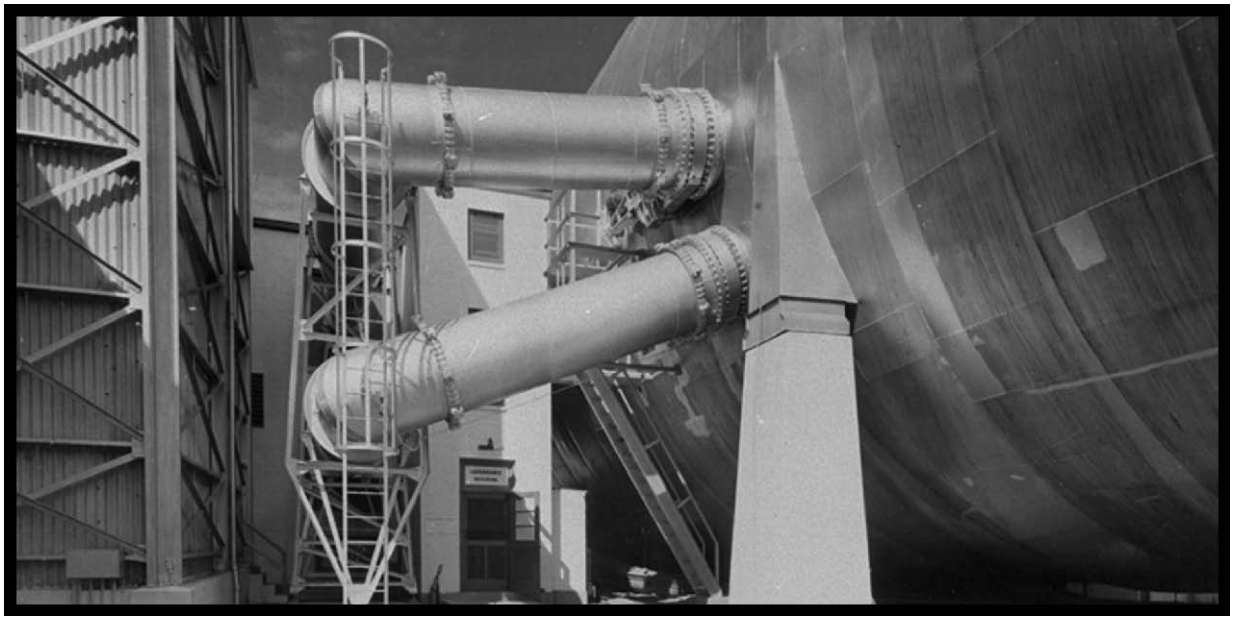

Figure 84.—Small Supersonic Wind Tunnels' exhaust tie-in with the AWT (viewed from the east), 1946 (OH_Cuyahoga_AWT-Support_084).

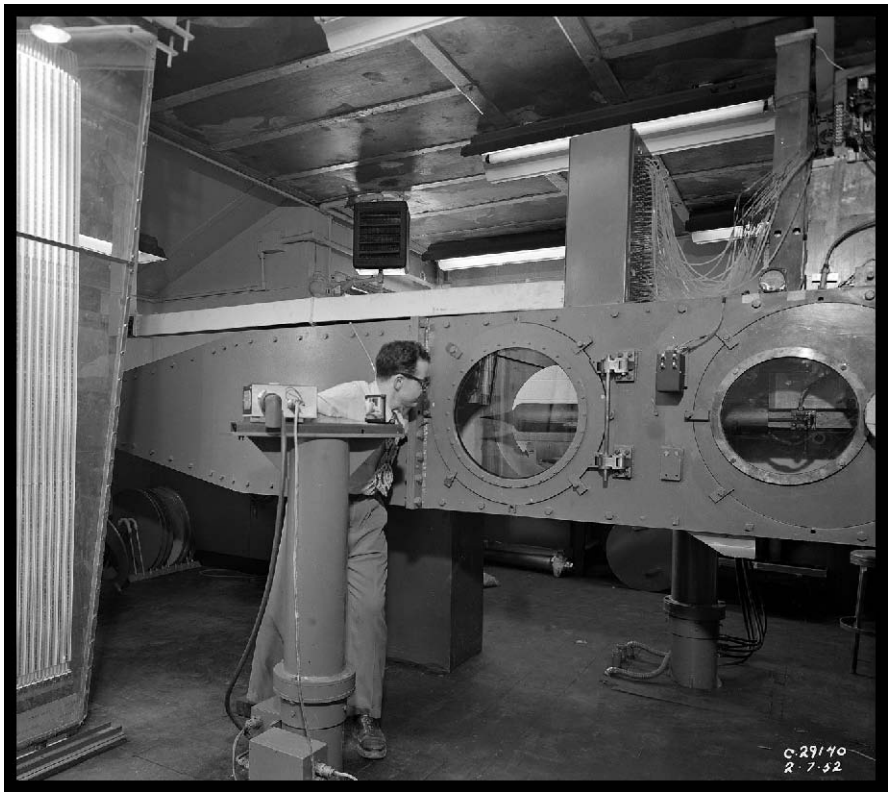

Figure 85.—Ramjet model in Tunnel No. 2, the 24" x 24" Small Supersonic Wind Tunnel, 1952 (OH_Cuyahoga_AWT-Support_085).

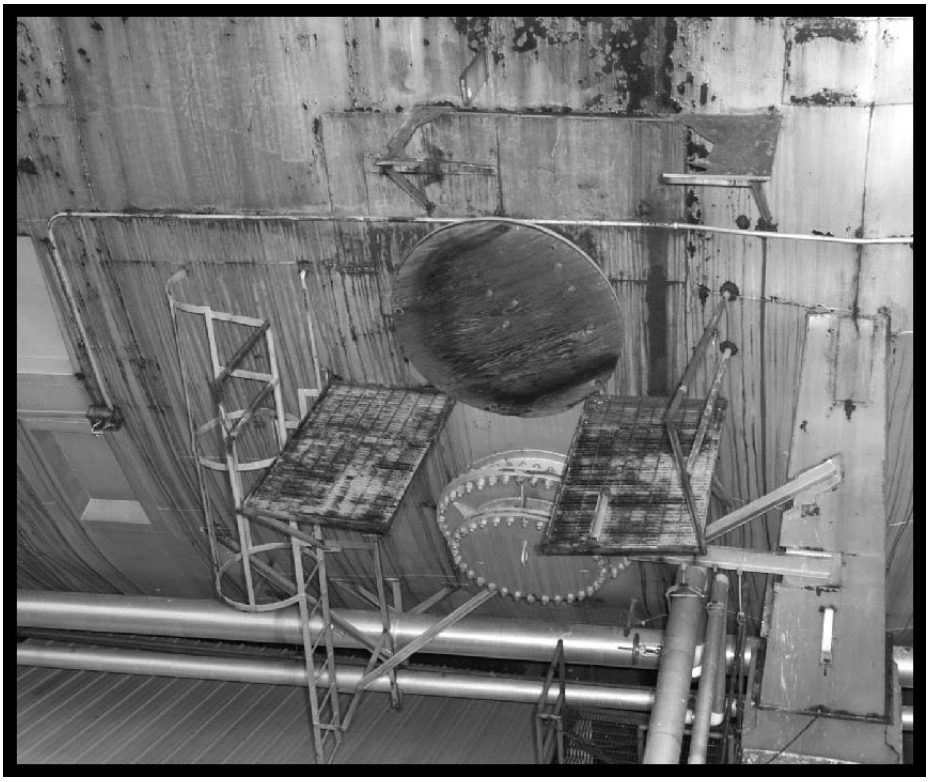

Figure 86.—Portals in the south leg of the AWT where the Small Supersonic Wind Tunnels formerly tied in, 2005 (OH_Cuyahoga_AWT-Support_086).