United States Department of the Interior
National Park Service

National Register of Historic Places Registration Form

This form is for use in nominating or requesting determinations for individual properties and districts. See instructions in National Register Bulletin, *How to Complete the National Register of Historic Places Registration Form.* If any item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions.
Place additional certification comments, entries, and narrative items on continuation sheets if needed (NPS Form 10-900a).

1. Name of Property

historic name Hughes Flying Boat (H-4 *Hercules*)

other names/site number Spruce Goose

Name of Multiple Property Listing N/A

(Enter "N/A" if property is not part of a multiple property listing)

2. Location

street & number 500 NE Captain Michael King Smith Way ☐ not for publication

city or town McMinnville ☐ vicinity

state Oregon code OR county Yamhill code 071 zip code 97128

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act, as amended,

I hereby certify that this **X** nomination ___ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60.

In my opinion, the property ☒ meets ___ does not meet the National Register Criteria. I recommend that this property be considered significant at the following level(s) of significance: **X national** ___ **statewide** ___ **local**

Applicable National Register Criteria: ___ **A** **X B** **X C** ___ **D**

08/28/24

Signature of certifying official/Title: Deputy State Historic Preservation Officer Date

Oregon State Historic Preservation Office

State or Federal agency/bureau or Tribal Government

In my opinion, the property ___ meets ___ does not meet the National Register criteria.

Signature of commenting official Date

Title State or Federal agency/bureau or Tribal Government

4. National Park Service Certification

I hereby certify that this property is:

___ entered in the National Register

___ determined eligible for the National Register

___ determined not eligible for the National Register

___ removed from the National Register

___ other (explain:) _____

Signature of the Keeper Date of Action

Hughes Flying Boat (H-4 Hercules) | Yamhill Co., OR
Name of Property | County and State

5. Classification

Ownership of Property
(Check as many boxes as apply.)

- [X] private
- [ ] public - Local
- [ ] public - State
- [ ] public - Federal

Category of Property
(Check only **one** box.)

- [ ] building(s)
- [ ] district
- [ ] site
- [X] structure
- [ ] object

Number of Resources within Property
(Do not include previously listed resources in the count.)

Contributing	Noncontributing	
		buildings
		site
1		structure
		object
1	0	**Total**

Number of contributing resources previously listed in the National Register

N/A

6. Function or Use

Historic Functions
(Enter categories from instructions.)

TRANSPORTATION: air-related

Current Functions
(Enter categories from instructions.)

RECREATION AND CULTURE: museum

7. Description

Architectural Classification
(Enter categories from instructions.)

OTHER: No Style

Materials
(Enter categories from instructions.)

foundation: N/A
walls: N/A
roof: N/A
other: Wood

Narrative Description

(Describe the historic and current physical appearance and condition of the property. Describe contributing and noncontributing resources if applicable. Begin with **a summary paragraph** that briefly describes the general characteristics of the property, such as its location, type, style, method of construction, setting, size, and significant features. Indicate whether the property has historic integrity).

Summary Paragraph

The H-4 *Hercules*, also known as the Hughes Flying Boat, is a unique seaplane prototype that flew only once on November 2, 1947. Conserved in a custom-built hangar, it serves as the centerpiece of a collection of historic aircraft on display at the Evergreen Aviation and Space Museum (EASM) in McMinnville, Oregon. Constructed of a wood-resin composite called Duramold, the seaplane has a single-hull, double-deck configuration, and served as a testbed for various aviation innovations from 1947 to 1953, the seaplane's period of significance. The Hughes Flying Boat has shoulder mounted wings spanning 319 feet, 11 inches. Each wing supports four 3,000 horsepower, four-bladed propeller-driven Pratt and Whitney R-4360 Wasp Major engines. Each wing also features a pontoon for water stability. The fuselage is 218 feet, 8 inches long, and the seaplane weighs 300,000 pounds when empty. The height from the bottom of the hull to the top of the tail is 79 feet, 3 3/8 inches. The seaplane has large control surfaces, including the elevator, rudder, ailerons and flaps, with a total area of 4,414 square feet. The Hughes Flying Boat retains its original design and engineering features, drydock cradle, operational and research equipment, and test tables from its period of significance. Changes occurred to the seaplane during the 1980s while on exhibit in Long Beach, California, enabling visitors to view both decks. EASM acquired the Hughes Flying Boat in 1992, relocated it to McMinnville, Oregon, restored its exterior and completed its reassembly on December 7, 2001. With minor exceptions, the Flying Boat retains its historic appearance reflective of the period of significance.

Narrative Description

The Setting

Entering the Evergreen Aviation and Space Museum (EASM) campus from the Highway 18 Bypass, one approaches the Aviation Building on a road designed as a runway, which appears at first to dead-end at the nose of the H-4 *Hercules*, then gently turns right and into the parking area. Once in the central parking area, the Space Building (completed in 2008) is located to the east, the Theater Building (completed in 2007) to the south and the Aviation Building to the west. Completed in 2001, EASM designed and constructed the 121,000 square foot, ten-story-tall, Aviation Building specifically to house the H-4. The hangar-like structure features a south curtain wall of glass windows, three hangar doors on the north side, which allow aircraft movement in and out of the building, and skylight windows at the center of the towering roof. The Aviation Building's walls and floor are concrete. The Flying Boat rests in a concrete pit designed intentionally for its graving dock[1] cradle, which effectively places the base of the seaplane's fuselage at floor level. The H-4 occupies an acre-and-a-half and sits on a timeline of aviation history, surrounded by historical aircraft from earliest human flight to the jet age. Visitors access the seaplane via stairs or electric lift to a platform located on the Flying Boat's port side under its left wing (see Photographs 1-2).

Exterior

The H-4 *Hercules* is the largest seaplane, largest wooden aircraft, and largest propeller plane ever built. Until 2019, when it was bested by the Scaled Composites Model 351 Stratolaunch, it also had the largest wingspan, 320 feet tip to tip, of any aircraft ever flown. [2] The H-4 is sheathed in Duramold, an

[1] See the glossary in the "Additional Documentation" section for a list of construction, aviation and nautical terms as applied to the H-4 *Hercules*.
[2] Norris McWhirter, *Guinness Book of World Records*, American ed. (Bantam: New York, 1979), 316; *Largest Aircraft by Wingspan,* Guinness World Records, https://www.guinnessworldrecords.com/world-records/largest-

experimental wood composite material chosen for its strength and durability. Duramold consists of plies of wood veneer combined with durable resin, compressed in multiple layers under pressure and heat, and molded into various shapes. The large, curved pieces (e.g., the formers and stringers)[3] required the use of Gunite molds as vessels for layering the wood and glue to achieve the necessary thickness, and kiln drying the resulting components. The wood used to create the Duramold for the H-4 *Hercules* is 94 percent yellow birch, and one percent each ash, balsa, basswood, maple, poplar and spruce.[4] After assembling the curved pieces into the airframe structures (e.g., fuselage, wings, tail), carpenters covered them with Duramold skin, securing it with glue and nails until cured, then removing each nail by hand.[5] The H-4 has a smooth aerodynamic exterior surface coated with silver-aluminum paint. The H-4's vertical stabilizer towers to nearly eight-stories and its wings span the length of a football field plus ten-feet into both end zones. A 1903 Wright *Flyer* replica, suspended near the port side of the seaplane, illustrates the first powered, controlled and sustained flight of 120 feet – traveling less than the distance of *just one wing* on the enormous, wooden Flying Boat (see Photograph 2).

Although the H-4's airframe and skin consist of Duramold, its mechanical and systems equipment and fittings are metal. For example, metal engine mounts secure eight, 3,000-horsepower (hp) Pratt & Whitney R-4360 28-cylinder engines to the leading edge of the seaplane's giant wings. Each engine features a Hamilton Standard four-bladed metal propeller measuring 17-feet, 2-inches in diameter. Combined, the engines have the capacity to generate 24,000 hp and produce an estimated top speed of 218-miles-per-hour (mph), cruising speed of 150 mph, and a landing speed of 87 mph (see Photograph 3).

The seaplane's enormous control surfaces, including the elevator, rudder, ailerons and flaps, cover 4,414 square feet. All control surfaces except the flaps are fabric covered. The wings have two main control surfaces mounted side-by-side and located on the trailing edge: Flaps (installed closest to the fuselage) and Ailerons (installed next to the flaps and extending to the wing tips). Flaps, used during takeoff and landing, reduce speed for safe operation and increase the lift and drag of the wings. Ailerons control the roll of the seaplane and allow the pilot to turn it. Each wing also features a pontoon, which provided stability and buoyancy for the seaplane when taking off and landing on the water. The tail features both horizontal and vertical stabilizers. The horizontal stabilizers have control surfaces called elevators, used to change the angle of the seaplane's pitch (up or down) to regulate its altitude. The vertical stabilizer kept the seaplane from rolling side to side with a control surface called a rudder, to steer it left or right. This is very important on a seaplane because the water surface can be unpredictable, and the plane needs to be able to maneuver quickly and precisely.

The fuselage of the H-4 contains three levels: Flight Deck, Cargo Deck and Bilge. The Flight Deck serves as the operations center of the seaplane and includes the Pilot and Co-Pilot, Engineer and Assistant Engineer, and Radio Operator stations: the Auxiliary Power Unit, electrical distribution system and oil storage tank. It also features stations used during the research and development phase (1947–1953), including Propeller Test Equipment, Flight Test Strain Gauge and Temperature Recording, and Flight Test Oscillograph tables. There are Observers Seats and a unique Docking Elevator on the Flight Deck, as well as access to the engines, gas and oil tanks and supporting systems (electrical wiring, fuel, oil, hydraulic and CO_2 lines) housed in the port and starboard wings. The Cargo-to-Flight-Deck Companionway provides access between the Cargo and Flight decks at the seaplane's center starboard

aircraft-by-wingspan, accessed January 23, 2023; *The Top 10 Largest Planes Ever Made*, Simple Flying, August 24, 2022.

[3] Ibid.

[4] Charles Barton, *Howard Hughes and His Flying Boat* (Charles Barton, Inc.: Vienna, Virginia, revised 1998), 86; Katherine Huit, Research Notes and *Dream to Fly* Interview with Bill Roddis, 2003. The Roddis Family owned Roddis Manufacturing in Wisconsin and had a contract with Hughes for wood veneer made of both yellow birch and basswood.

[5] Dr. David D. Hatfield, *Howard Hughes H-4 Hercules* (Northrup Institute of Technology, Inglewood, California, 1972), 22 – 25; Barton, 82. The 'The Duramold sheets, or skin, averaged a three-ply thickness, with each ply measuring $^1/_8$ of an inch.

side. The Cargo Deck contains the Standby Hydraulics System and Battery Cutoff Station, the CO_2 cannisters and Fire Suppression System, ascending ladder access to the trailing edge of the wings, and the vertical and horizontal stabilizers of the tail section. The Cargo Deck also provides descending ladder access to the Bilge, which contains 18 water-tight compartments and eight fuel tanks (see Photographs 5-18).

Interior

Flight Deck

Facing the Flight Deck's port side from the Companionway, there are three rows of Observers Seats. While on exhibit in the Long Beach dome from 1982-1992, the seaplane underwent a slight external modification with the removal of a section of the Duramold skin and two exit doors on the port side of the Flight Deck. Replacing the skin and two doors with Plexiglas created a large window for viewing purposes from an external platform, while also exposing the seaplane's Duramold framework. Originally located just forward of the Observers Seats and just aft of the Auxiliary Flight Engineer's Station, the two doors are on exhibit at floor level near the port side of the Flying Boat's nose (see Photographs 4 and 10). Located aft on the seaplane's Flight Deck, is the 281-gallon Oil Storage Tank and Pump Station, which hangs from a ceiling-mounted platform just outside the port side wing's leading-edge access door. Aft center of the Flight Deck, a ladder ascends to the Docking Elevator, which lifts through the Upper Hatch to the top of the seaplane where the wings join above the fuselage. Equipped with a microphone connected to the aircraft's communications network, an operator supervised the launching and docking of the Flying Boat from this vantage point atop the fuselage (see Photographs 11-12).

On the seaplane's aft starboard side, next to the Docking Elevator ladder, is the Main Electrical Distribution Panel. Neatly bundled electrical wiring travels from the panel forward on both port and starboard sides of the Flight Deck and into the port and starboard wings. It descends from the panel to the Cargo Deck where it runs fore and aft, descending further into the bilge and ascending up to the vertical and horizontal stabilizers of the tail.[6] Looking toward the seaplane's aft starboard side is the Auxiliary Power Unit (APU), next to the starboard wing's leading-edge access door. Besides the electrical wiring, pipes for carrying hydraulic fluid, fuel and oil, and carbon dioxide (CO_2) extend into both wings. Each wing holds one 300-gallon fuel tank, with one feeding the four inboard engines and the other feeding the four outboard engines. Both wings also hold four 31-gallon oil lubricating tanks (one for each engine). Just forward of the APU is an exit door (see Photograph 13).

There are five main crew stations on the Flight Deck: Pilot and Co-Pilot, Radio Operator, Flight Engineer and Assistant Flight Engineer. At the front of the seaplane are the Pilot (port side) and Co-Pilot (starboard side) Stations. The Flight Engineer sat aft of the Co-Pilot and the Radio Operator sat aft of the Pilot. The Auxiliary Flight Engineer sat on the port side in the second row of Observers Seats. Each station features analog instruments, including gauges, dials and switches for various aspects of the seaplane's navigation, communication and operation. Made from metal, glass and plastic materials, the Flying Boat's navigation instruments include altimeters, airspeed indicators, magnetic compasses, turn and bank indicators, and fuel gauges. The Pilot and Co-Pilot positions also include control wheels and foot pedals for navigational purposes. Communication instruments included two-way radios and a Morse code transmitter. Switches and levers controlled the engines, fuel systems, flaps, and navigation lights. The metal control levers have on and off positions and feature color-coded, plastic knobs, which indicate function, such as red for emergency or blue for normal operation. A windscreen wraps around the area in front of and above the Pilot and Co-Pilot chairs and features venting windows that open above each position (see Photographs 10, and 15-18).

[6] Huit, Research Notes and *Dream to Fly* Interview with Merle Coffee, March 11, 2003. Coffee was a flight crew member and electrician, and stated there is approximately 300 miles of wiring installed the H-4 *Hercules* to distribute power to all the mechanical equipment and systems.

As a research platform, the H-4 *Hercules* also features test stations, including the Propeller Test Equipment Station located just aft starboard of the Companionway. Forward of the Observers Seating on the seaplane's port side is the Flight Test Strain Gauge and Temperature Recording Stations, and forward of those is the Fight Test Oscillograph Station, which includes two metal boxes that contain graph paper and a measurement device similar to that used by earthquake detection equipment (see Photograph 14).

Cargo Deck

In 2002, after completing the seaplane's reassembly, museum staff created a new Cargo Deck Access Platform, replacing that featured in the dome exhibit (1982-1992) and engineering it to support a plexiglass viewing cube suspended on the interior of the Flying Boat's Cargo Deck so that it does not rest on the seaplane's interior structure.(See Photograph 2) An exhibit case contained within the Cargo Deck viewing cube displays artifacts and facsimiles from the Flying Boat's history, such as the flight log, and a short video provides a tour of the seaplane's internal areas that shows its instrumentation and mechanical control systems. Beyond the cube there is a unique smell of Duramold-processed wood and the original silver-aluminum paint applied on the interior structure has aged to a patina green color. Looking aft from the viewing cube, one marvels at the perspective of the wood structure as it tapers toward the tail (see Photograph 5).

Bundles of electrical wiring, piping and tubing used for hydraulic fluid, fuel, oil and CO_2, travel the length of the Cargo Deck's ceiling, port and starboard sides. A group of eight hydraulic tubes travel at floor level next to the wooden walkway, which extends slightly upward as it approaches the tail section. Inside the tail, a ladder ascends the vertical stabilizer, providing access to the horizontal stabilizer as well. A fire alarm and sprinkler system run along the upper center portion of the Cargo Deck and other areas in the seaplane. Looking back toward the viewing cube, there is another ladder that provides access to the trailing edge of the wings from the Cargo Deck. Toward the center of the Cargo Deck and forward of the wing-access ladder are 36 red CO_2 cannisters and the Fire Suppression System, which provided primary and auxiliary fire control to the Flying Boat's eight fuel tanks and each of its eight engines. If required, the Fire Suppression System could discharge the contents of the CO_2 cannisters into several areas at the same time or into one area for maximum effectiveness (see Photographs 5-6).

Located near the nose at the center front of the seaplane, the Standby Hydraulic Station serves as part of the redundant, "artificial feel system". The Flying Boat was the first aircraft to feature this new technology, which allowed the pilot to move the gigantic control surfaces with the same ease as those of a smaller aircraft. For example, for each pound of pressure exerted on the Flying Boat's control wheel, the elevator received 1,500 pounds of pressure to move it. To the port and starboard sides of the Standby Hydraulic Station are exit doors, located just aft of the seaplanes nose, which also displays its skeletal wooden structure and the patina green silver-aluminum paint (see Photograph 7).

Forward of the Cargo Deck Viewing Cube is the Battery Disconnect Station, which includes a cabinet containing gauges for monitoring the seaplane's power use, a chair and a lever to disconnect the power. On the seaplane's starboard side, forward of the Viewing Cube, is the Cargo-to-Flight Deck Companionway, a steep set of steps joined to a circular stairway, which provides access between the Cargo and Flight decks (see Photographs 8-9).

The Bilge

Just aft of the viewing cube, a ladder descends into the Bilge, which contains 18 watertight compartments (baffles), 12 of which allowed for flooding to adjust the seaplane's weight distribution and control its buoyancy and stability during takeoff and landing. The Bilge also contains eight, 1,020-gallon fuel tanks.

Integrity of the H-4 *Hercules*

The H-4 *Hercules* retains excellent integrity of design, materials, workmanship, feeling, and association. The H-4 served as a research platform for increased safety measures, mechanical engineering, and systems improvement and redundancy until 1953 (the end of the period of significance). Today, the Flying Boat appears much as it did in 1953. The seaplane wears its flight color, silver. Slight modifications include the removal of a section of Duramold and two doors at the Flight Deck, which were replaced by Plexiglas in the 1980s; and installation of a suspended Plexiglas viewing cube inside the Cargo Deck that replaced a less appropriate access platform from the 1980s. Neither of these changes altered the structure of the H-4, nor did they affect in any way the historic integrity of the instrumentation and equipment that reflect the H-4's engineering importance during its period of significance (see Photographs 2 and 10).

As a moveable object, the H-4 is not required to meet integrity of location. Please see the discussion at the end of Section 8 that addresses the setting changes the H-4 has experienced in its history and how that affects the integrity and eligibility of the seaplane.

Hughes Flying Boat (H-4 Hercules) | Yamhill Co., OR
Name of Property | County and State

8. Statement of Significance

Applicable National Register Criteria
(Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing.)

- [ ] A Property is associated with events that have made a significant contribution to the broad patterns of our history.
- [x] B Property is associated with the lives of persons significant in our past.
- [x] C Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components lack individual distinction.
- [ ] D Property has yielded, or is likely to yield, information important in prehistory or history.

Criteria Considerations
(Mark "x" in all the boxes that apply.)

Property is:

- [ ] A Owned by a religious institution or used for religious purposes.
- [ ] B removed from its original location.
- [ ] C a birthplace or grave.
- [ ] D a cemetery.
- [ ] E a reconstructed building, object, or structure.
- [ ] F a commemorative property.
- [ ] G less than 50 years old or achieving significance within the past 50 years.

Areas of Significance
(Enter categories from instructions.)

AVIATION (Criterion B)
ENGINEERING (Criterion C)

Period of Significance
1947 - 1953

Significant Dates
1947: H-4 *Hercules* test flight

Significant Person
(Complete only if Criterion B is marked above.)

Howard Robard Hughes, Jr.

Cultural Affiliation (if applicable)
N/A

Architect/Builder
Howard Robard Hughes, Jr.

Period of Significance (justification)

The period of significance begins in 1947, which includes the date of completed construction, three taxi tests and a brief flight, and ends in 1953, the last year that Howard Robard Hughes, Jr., used the seaplane as a research and testing platform.

Criteria Considerations (explanation, if necessary)

N/A

Statement of Significance Summary Paragraph (Provide a summary paragraph that includes level of significance, applicable criteria, justification for the period of significance, and any applicable criteria considerations).

The H-4 *Hercules*, also known as the Hughes Flying Boat, is nationally significant under Criterion B, for its association with Howard R. Hughes, Jr., one of the most influential figures in American aviation history, and under Criterion C for the seaplane's service as a research and testing platform for innovative mechanically engineered systems that became standard in large aircraft after the Second World War. Among his many ventures, Hughes designed aircraft and through his company, Hughes Aircraft, was a leader in the defense and communications industries during the mid-twentieth century. During the period of significance, 1947-1953, the Hughes team developed multiple hydraulic components; redundant fire suppression systems; innovative instrumentation and console layout, and modified fuel and oil systems that led to many standard systems on today's large-scale commercial and cargo aircraft and aerospace vehicles. The Flying Boat embodies remarkable aviation and mechanical engineering achievements; it is exceptionally significant as a singular historic structure within aerospace history. No comparable cultural or historical resource exists. Although the H-4 has experienced multiple setting changes in its history, it remains eminently able to convey its historical associations reflected by both areas of significance, under both criteria, during its period of significance, while meeting the requirements for eligibility noted in National Register Bulletin "Guidelines for Evaluating and Documenting Historic Aviation Properties," within which the H-4 is specifically featured.

Narrative Statement of Significance (Provide at least **one** paragraph for each area of significance.)

The Second World War was the first to use air power as the high ground. It was a significant era for advancements in aircraft design and applications, which led to increased use of aircraft as weapons platforms. For example, before the war, biplanes ruled the air. Monoplanes came into service during the Second World War as scout platforms, fighters, and bombers. Aerodynamic designs; the use of light-weight metals, such as aluminum, for aircraft construction; enclosed cockpits, retractable landing gear, aircraft pressurization, and the use of radar technology and jet engines all came out of the Second World War. The H-4 *Hercules* illustrates the response to a need for super-sized air transports to carry personnel and materiel over great distances quickly and safely. Before its taxi tests and flight, no one had designed and flown an aircraft of its size, and the post-flight research, testing and innovative improvements in mechanically engineered and redundant systems led to the safer and more accurate systems used in large aircraft today.

In July 1942, during the launching of the Liberty Ship *Harvey S. Scott* from his Portland, Oregon, shipyard, Henry J. Kaiser noted the troubling loss of Allied vessels to German U-boats and promoted the idea of a fleet of flying boats to overcome the menace. Learning about Kaiser's proposal, Howard R. Hughes, Jr., an aviation hero and skilled aircraft designer, joined with the industrialist to create the Kaiser-Hughes Corporation.[7] On November 16, 1942, Kaiser-Hughes contracted with the United States' Defense Plant Corporation to design and fabricate three prototype flying boats (two designed for flying and the third suitable for static tests) capable of hauling two Sherman tanks or an equivalent in weight of soldiers and materiel; or serving as a transport platform equipped to accommodate 350 litter-bound patients and a medical team to care for them.[8]

Considering the war-time contract's restrictions on access to aviation professionals, the Kaiser-Hughes venture was fortunate to employ a team of aeronautical and mechanical engineers through their respective companies.

[7] Barton, 13-16. The idea originated with the War Production Board's planning committee member, F. H. Hoge, Jr. U-boat is an abbreviation for Unterseeboot, German for undersea boat or, in essence, a German submarine.
[8] Hatfield, 1-5.

Kaiser's expertise was with mass production, so he left the aircraft design work to Hughes and his team of engineers.

Howard R. Hughes, Jr., Aviator

Howard R. Hughes, Jr. first made aviation history in 1935, achieving a world land-plane speed record in a racing plane of his own design (see Figure 7). That plane, the H-1 *Racer*, resides today in the Smithsonian's National Air and Space Museum. In 1936, Hughes set the transcontinental speed record in a Northrop *Gamma* owned by famed aviator Jacqueline Cochran. President Franklin D. Roosevelt presented the 1937 International Harmon Trophy to Hughes for his efforts. After breaking his own transcontinental record, Hughes received the Harmon Trophy a second time in 1938. Shortly thereafter, Hughes received the Collier Trophy from President Roosevelt for his around-the-world flight in the Lockheed 14-N2 *Super Electra* nick-named *New York World's Fair 1939*, achieving the deed in three days, 19 hours and 17 minutes. Hughes and his team broke pilot Wiley Post's 1935 around-the world flight record of seven-and-a-half days. Other notable pilots who made the momentous journey include the 1932 flight by German pilot Wolfgang von Gronau in a Dornier Wal flying boat. Tragically, Amelia Earhart and Fred Noonan, who attempted an around-the-world flight in a Lockheed *Electra*, failed the attempt and disappeared in 1937. Hughes received an honorary Congressional medal for this achievement and a "tickertape" parade in New York City comparable to that received by Charles Lindbergh upon his return from a solo Atlantic crossing in 1927.

Hughes educated himself about commercial aviation by posing as pilot "Charles Howard" for the entire summer of 1932, co-piloting Fokker Trimotors from Fort Worth, Texas to Cleveland, Ohio; and in 1935, he co-piloted Douglas DC-2s for Trans-World Airlines (TWA). He purchased TWA in 1940 and contributed to the development of commercial air travel, focusing on its accessibility and affordability.

Hughes' funding came largely from the Hughes Tool Company and its pioneering rotary drill bit. Known as a motion picture producer, an innovator in the electronics industry, and a real estate developer, Hughes' daredevil piloting and development of special--purpose aircraft of original design especially captured the public's attention and imagination. During the Second World War, material shortages resulted in the resourceful use of wood in aircraft development, such as the all-wood British *Mosquito*. Besides his wooden-winged *Racer*, Hughes designed the D-2 and D-5 bombers, constructing both out of Duramold, a product developed by his friend, Sherman Fairchild of the Fairchild Aircraft Corporation (see Figure 8). The D-5 transitioned to the XF-11, a twin-engine, photo reconnaissance plane. On July 7, 1946, Hughes taxied the XF-11 down the runway for a test flight (see Figure 9). With extra fuel in the tank, he flew for 40 minutes before experiencing a hydraulic leak in the counter rotating blades of the Hamilton Standard propeller system. This malfunction caused the XF-11 to crash and the extra fuel resulted in a fiery explosion. Hughes barely escaped alive, and his life-threatening injuries resulted in extreme pain for the rest of his life. He went on to successfully test fly another XF-11 model – without the counter rotating propellers – on April 4, 1947, just months before his successful taxi tests and brief flight of the H-4 *Hercules* (see Figure 10). The seaplane's design called for four sets of counter rotating propellers placed on the inboard engines for use in docking procedures; however, following his experience with the hydraulic leak on the XF-11, Hughes declined to install them on the Flying Boat.

Collaborating with Kelly Johnson, designer of Lockheed's SR-71 *Blackbird*, and his colleague Jack Real, Hughes helped improve the design and flight tested the Lockheed *Constellation.*[9] On April 17, 1944, Hughes and Jack Frye, president of TWA, piloted a *Constellation* from Burbank, California to Washington, D.C. in six hours and 57 minutes, setting a new cross-country speed record. Hughes also had a hand in developing and conducting test flights in the first pressurized aircraft in the world, Boeing's 307 *Stratoliner*, flying with Civil

[9] Katherine Huit, *Dream to Fly: Howard Hughes and the Flying Boat*, Documentary Video, Narrated by Walter Cronkite, 2005. Research notes and Interviews, 1999-2004. Interview with Jack Real, October 21, 2002 and December 4, 2003.

Aeronautics Administration (CAA) Flight Standards test pilot George Haldeman, who later served as the CAA representative on the Hughes Flying Boat.

Over his lifetime Howard Hughes had a hand in developing aircraft weaponry, radar systems, missiles, helicopters, communications satellites and spacecraft. For example, in the late 1930s, he developed the continuous chain link feeder and booster motor for 20-milimeter machine guns, which became standard aboard US bombers during the Second World War. Hughes also developed Fire Control Radar for use on fighter planes in the late 1940s; launched the wire-controlled Falcon Missile in the early 1950s and his giant XH-17 helicopter, the largest helicopter outside of Russia at the time, began test flights in 1955. Hughes launched the first communications satellite – known as the Hughes *Early Bird* – for commercial use in 1965, and in 1966, the Hughes *Surveyor* made the first soft landing on the Moon. His numerous contributions to the advancements in American aviation technology earned him a place in the National Aviation Hall of Fame on December 14, 1973. Yet, today, the public's imagination identifies Howard R. Hughes, Jr. with his famous Flying Boat – commonly known as the *Spruce Goose* – more than any of his other accomplishments.[10]

HK-1 Prototype to H-4 *Hercules*

Faced with war-time limitations on access to materials, such as aluminum, Hughes engineered the flying boats for construction out of a wood laminate developed by the Fairchild Aircraft Company called Duramold. Hughes purchased the rights to use Duramold in the design of large aircraft structures and improved Fairchild's method using Gunite molds to compress the material in multiple layers under pressure and heat to create the gigantic joints and large angled components for the Flying Boat's frame. Gunite is a patented process for placing concrete mortar with compressed air, which produced difficult shapes easily at a relatively low cost.[11] Thinner plies of layered veneer created the seaplane's skin covering (see Figures 11-12).

Many in the aviation design field rejected the idea that a wooden aircraft of the size designed by Hughes could fly; no one had ever achieved flight at the proposed scale (see Figures 5-6). Because of its design as a seaplane with the purpose of transporting personnel and materiel across large bodies of water, quickly and safely, the H-4 had to be both hydro- and aero-dynamic. Water and air are both fluids and making sure the seaplane could float and fly was critical in the design stage. Finalizing the hull shape, Hughes immediately put craftsman to work building several test models at different scales for aero- and hydro-dynamic testing. One of these, a perfectly proportioned dynamic test model, went to Langley Field, Virginia, for testing in the National Advisory Committee for Aeronautics' towing basin. In February 1943, the experts at Langley noted the model as the finest ever received from a contractor. In testing, the Hughes Flying Boat fuselage model showed outstanding aerodynamic and hydrodynamic results, and a wing section, tested in the low-turbulence wind

[10] There are numerous books and other secondary sources about Howard R. Hughes, Jr.'s life. The references in this document focus upon Hughes' milestones and contributions to aviation as a test pilot, aeronautical engineer and aircraft designer, including Barton, 19-51; Tony Blackman, *Flight Testing to Win*, (Blackman Associates: London, United Kingdom, 2005) 169-188; Noah Dietrich and Bob Thomas, *Howard, the Amazing Mr. Hughes* (Fawcett: Greenwich, Connecticut, 1972) 171-175, 209-216; Albert B. Gerber, *Bashful Billionaire*. (Lyle Stuart: New York. 1967) 45-63; John Keats, *Howard Hughes. (*Pyramid Books: New York, New York, 1972) 159-160, 165-166, 177-182, 212-222, 232 and 274; George Marrett, *Howard Hughes: Aviator* (Naval Institute Press: Annapolis, Maryland, 2004) 15-132; Thomas Wildenberg and R.E.G. Davis, *Howard Hughes: An Airman, His Aircraft, and His Great Flights* (Paladwr Press: McLean, Virginia, 2006) 8-9, 24-79, 84-85. Additional reference to Hughes as a pilot includes Huit, *Dream to Fly* interviews with Jack Real (October 21, 2002, and December 4, 2003) and H-4 *Hercules* flight crew members Merle Coffee (March 11, 2003), Don Smith and John Glenn (July 21, 2003).

[11] Barton, 82-86.

tunnel, proved to be one of the "finest low drag, high lift sections" constructed. Langley even mentioned hopes of using the Flying Boat after the war as a research aircraft because of its outstanding qualities.[12]

The limitations of the war-time contract also effected the buildings necessary for construction of the seaplanes. To accommodate the project, Hughes constructed several new wooden buildings on Hughes Tool Company property, located west of Culver City, California, including Building 15, the largest structure of its time, completed in 1943.[13] More than 800 woodworkers from the United Brotherhood of Carpenters joined Hughes to assist with what became the HK-1 project.

Acknowledging the project's experimental and developmental nature and realizing the design and construction of the seaplanes would not move quickly enough to mass produce a fleet of flying boats for use during the war, Henry Kaiser moved on from the project in 1944. The Defense Production Corporation allowed Hughes to carry on; however, it reduced the prototype requirements to just one seaplane – known by 1945 as the H-4 *Hercules*.[14] Hughes had already nearly exceeded the funding allowance of $18 million and was infusing his own funds into the Flying Boat project by this time.

Construction and Assembly

As the woodworkers joined the large curved and angled pieces together, eight very large sections (the fuselage, two wings, two pontoons, two horizontal stabilizers and the vertical stabilizer) took shape (see Figures 13 and 14). The woodworkers covered each section with sheets of fresh Duramold (not yet cured), secured with nails driven by specially designed nail guns that caused minimal impact to the wood. Once the Duramold glue had cured, they removed the nails one-by-one with nail pullers – also developed not to scar the wood. Next, craftsman used a technique developed by Hughes, which involved a coat of wood filler followed by a coat of sealer and the application of very thin tissue paper, then two coats of spar varnish before finishing the surface with silver-aluminum paint.[15]

Germany surrendered on May 8, 1945, followed a few months later by Japan's surrender on September 2, 1945, which officially ended the Second World War. By then it was obvious the H-4 *Hercules* would not serve as a large transport vessel for the war effort. Hughes focused on use of the seaplane as a vessel for research and to advance aviation technology, including avionics (electronic systems used on aircraft), which monitored the aircraft's many advanced mechanically engineered systems.

The Hughes team finished construction on the H-4 in June 1946 and moving crews transported the eight gigantic sections from the Culver City construction site to a specially prepared graving dock at Berth 120 on

[12] Barton, 66. See also, NASA Technical Reports Server (NTRS), *Resistance Tests of a 1/16 Size Model of the Hughes-Kaiser Flying Boat, NACA Model 183*, accessed January 6, 2023, https://ntrs.nasa.gov/citations/19930093029 for the digitized 43-page report about the tank tests conducted during January and February 1944.
[13] Hatfield, 20. When complete, the building measured 750 feet long, 250 feet wide, 100 feet high, and covered eight acres. See also *Cargo Building*, Hughes News Employee Newsletter, (Hughes Tool Company, Hughes Aircraft Division, March 8, 1945) 1; E. Lois J. Weinman and Gary Stickel, *Los Angeles – Long Beach Harbor Areas Cultural Resource Survey*, (United States Army Corps of Engineers: Los Angeles District, Los Angeles, April 1978) 119; and Hughes Industrial Historic District, *Historical Development of the Hughes Historic District,* accessed January 6, 2023, *https://www.hugheshistoric.com/historical-development-of-the-district*. The Hughes property, located west of Culver City on the Ballona wetlands, housed Hughes Tool Company operations and became the home of the Hughes Aircraft Division. Hughes constructed Buildings 2, 3, 14, 15 and 16 expressly for the purpose of designing and constructing the H-4 *Hercules*, with Building 15 serving as the primary construction site of the Flying Boat. Now listed in the California Register of Historical Resources as contributing structures in a district, the historic buildings are also eligible individually for the National Register of Historic Places.
[14] Barton, 101. After Kaiser moved on from the project (1944), Hughes called the seaplane the H-4 Flying Boat. Hughes' employees held a naming contest for the seaplane, which resulted in the name *Hercules.*
[15] Barton, 148.

Pier E (now Pier T) on Terminal Island at the Port of Long Beach in Long Beach, California, where Hughes had leased a 7.2-acre site (see Figure 15).[16] The 25-mile journey took two days and involved tree trimming along with cutting and splicing of power lines and telephone wires enroute. Upon arrival, crews positioned the wings and then placed the fuselage into the graving dock (see Figure 16). Next, they assembled the wings, mounting them at the top of the fuselage to keep the engines dry and the giant 17-foot, two-inch-diameter propellers out of the water. After aligning the wings, mechanics installed and tested the seaplane's eight government-issued Pratt & Whitney R-4360 engines and associated Hamilton Standard propeller system. Next, the giant control surface installation took place, including the flaps and ailerons on the trailing edge of the wings, the rudder on the tail's vertical stabilizer and the elevators on the horizontal stabilizers. Crews conducted a thorough check of all mechanical systems and instrumentation before launching the vessel out of its graving dock on October 31, 1947 (see Figure 17).[17]

The Seaplane's Names

Originally designated the HK-1 for the Hughes-Kaiser joint venture's first aircraft design, it became the H-4 (Hughes' fourth aircraft design) when Kaiser withdrew from the project. A company naming contest resulted in the moniker "Hercules" and the official nomenclature of H-4 *Hercules*. US Senate War Investigating Committee (SWIC) hearings, held during 1947 and 1948, focused on Hughes' wartime contracts and cost overruns for the XF-11 and the H-4. Tempers flared during SWIC questioning and testimony, which resulted in several derogatory terms used to describe Hughes' gigantic seaplane, including "Flying Lumberyard" and "Spruce Goose". The latter name stuck with frequent use by the press; however, Howard Hughes despised the name, referring to the wooden craft simply as his Flying Boat.[18]

Period of Significance (1947-1953): Use as A Post-War Research and Testing Platform

Hughes orchestrated a publicity campaign for the planned launch of the experimental prototype H-4 *Hercules* on November 1, 1947; however, he cancelled the tests due to unfavorable wind conditions in the harbor. Around noon the following day, November 2, 1947, with improved wind conditions, Hughes boarded the seaplane with the flight crew. A total of 34 passengers, including a flight crew of 19, government observers, a representative from Pratt and Whitney, and members of the press and radio, joined Hughes as he piloted the seaplane through two taxi test runs. The seaplane performed well. Before the third taxi run, anxious reporters deplaned to file news stories about the successful taxi runs. Hughes continued, conducting a third test over the choppy waters of San Pedro Bay, during which he requested the flaps lowered to 15 degrees. The witnesses on board later commented how noisy it was in the Flying Boat as it taxied over the harbor surface; then hearing only the engines they realized the Flying Boat was airborne.[19] The seaplane achieved stable flight for approximately 30 seconds at an average elevation of about 25 feet, covering less than a mile and proving an aircraft of its size and structure could fly (see Figures 18-20).

After the successful taxi runs and brief flight, Hughes returned the Flying Boat to its graving dock, and had a custom-made hangar constructed over it to prevent weather damage. From late 1947 through 1953, Hughes and his

[16] Peter P. Smongeski and Charles F. Connors, "Pier E and US Naval Base Consisting of Berths 116-127 and Backlands North to Seaside Blvd and US Naval Station, Shipyard, & Mole," April 1983 in R.R. Riffenburgh's "Chronological History of the Port of Long Beach by Pier, 1909-2002, https://polb.com/port-info/history/#historical-publications.
[17] Weinman, 120; Barton, 101.
[18] Barton, 101; *Aircraft Contracts (Hughes Aircraft Co. and Kaiser-Hughes Corp.)* Part 40, 1947 and *Aircraft Contracts, Hughes Aircraft Co.,* Part 43, 1948, Special Committee to Investigate the National Defense Program, 80th Congress, 1st Session.
[19] James C McNamara, *Broadcast from the Flight Deck of the H-4 Hercules* (KLAC News Radio, Los Angeles, California, November 2, 1947). The Hughes Flying Boat Archive and Artifact Collection, housed at the Evergreen Aviation and Space Museum (EASM), contains an original acetate LP recording of McNamara's minute by minute description of the flight while on board the H-4 *Hercules* including the audible reaction of the flight crew and other sounds during the historic event. See also the only entry in the *H-4 Hercules Flight Log*, Hughes Flying Boat Archive and Artifact Collection, housed at EASM. Flight Engineer Don E. Smith signed the log. Interestingly, he was also a seaplane pilot; however, the co-pilot, David Grant was a hydraulics engineer, not a pilot.

engineering team continued using the seaplane as a research platform, extensively testing new methods in mechanical engineering, adding redundancy, improving electrical, hydraulic and fuel systems, and increasing safety measures. The Hughes team focused on various functional systems, including the addition of redundant fire extinguishing, auxiliary hydraulic, fuel and flight control systems, as well as new flying tabs for the control surfaces. Engineers converted the formerly pneumatically actuated engine controls to electrical operation and developed an automatic fuel line sealing system to prevent the danger and damage in case of possible engine nacelle loss (see Figures 22-25).

Hughes had the aircraft repainted in white and made various modifications to the internal layout, including the replacement of a vertical ladder with a Companionway between the Cargo and Flight decks, in 1952 (see Figure 21). Aside from the change in exterior color, Hughes retained the seaplane's original external appearance. The alterations made to the H-4 *Hercules* between 1947 and 1953 are of a type normally undertaken during the experimental stages of an aircraft's development, for safety of flight purposes, and did not affect the seaplane's historic integrity.[20] Hughes reflected on the purpose of the seaplane in a statement issued to his employees in May 1948:

> *It should be understood clearly that the Hercules is considered only a research aircraft. It will never be used in competition with military or commercial machines, but will, in my estimation, be worthwhile because problems which will concern really big airplanes of the future will be solved here. The Hercules will point the way for really good big airplanes.*[21]

Although activity ceased in 1953, the technical aspects and mechanical engineering involved in the design and testing of the Hughes Flying Boat include the following advancements, many of which became the standard systems on today's commercial and cargo aircraft.

- **Wooden Construction**: The Hughes Flying Boat is significant for the pioneering use of engineering practices applied to large scale structures. Adhering to the government mandate not to use materials critical to the war effort (such as aluminum), the Hughes team constructed the Flying Boat out of an early wood composite material. Created by the Fairchild Aircraft Company for use in small aircraft design and construction, Hughes purchased the rights to adapt the Duramold process to large aircraft structures. The principal structural material used for the protype seaplane was birch veneer due to its superiority in terms of weight reduction in high stress applications. Hughes' design engineers used 94 percent yellow birch, and one percent each ash, balsa (used in the fairings), basswood (used in the skin), maple, poplar (used in the stringers) and spruce (found only in the wing spars). The Hughes team created Gunite molds to manufacture the angled pieces necessary for the Flying Boat's framework. The design, construction and assembly process consumed more than five years; yet, upon completion, the Hughes Flying Boat proved immediately airworthy. Today we find many aircraft designed using advanced composite materials (see Figures 11-14).

- **Fire Suppression System**: The wooden construction made fire protection a high priority. The Hughes engineers developed a redundant fire suppression system that used carbon dioxide (CO_2), which works as a gas to effectively smother a fire. Located on the cargo deck, 36 CO_2 pressure cannisters provided both primary and auxiliary fire control to the eight fuel tanks (in the bilge) and to each of the eight engines. A complex manifold allowed a controller to direct the CO_2 to various areas of the seaplane, as needed. If required, the controls could direct all 36 bottles to discharge into one area for maximum effectiveness (see Figures 23a and 23b).

[20] Katherine Huit, American Society of Mechanical Engineers (ASME) *Hughes Flying Boat "Spruce Goose": Historical Mechanical Engineering Landmark Designation* (Evergreen Aviation Museum: McMinnville, Oregon, 2002), 2-4.
[21] Barton, 23.

- **Electrical System**: Considering the wooden seaplane's weight, Hughes and his team of engineers discarded the idea of using the conventional and heavy 24-volt direct current (D.C.) system. They designed a new 120-volt, three wire, redundant D.C. system, resulting in a 75 percent weight reduction. The Hughes team also took care to ensure the performance of all the electrical relays at high altitudes. Two 30-kilowatt generators provided backup electrical power, and emergency battery power consisted of ten 12-volt batteries in two banks.

- **Fuel System**: Eight 1,020-gallon fuel tanks, located in the seaplane's bilge (below the cargo deck) supplied the eight giant Pratt and Whitney R-4360 Wasp Major radial engines. Hughes engineered the system to transfer fuel from the bilge tanks to the two 300-gallon wing tanks. One wing tank fed the four inboard engines, while the other fed the four outboard engines. The Flying Boat also featured an emergency fuel transfer and supply system in case of leakage or pump failure. The Hughes engineering team equipped the fuel lines with "slip" joints and "floating" fairleads to allow for wing deflection. Wing deflection is the bending or flexing of an aircraft's wings due to external forces such as wind, turbulence, or maneuvers. Slip joints and floating fairleads on fuel lines in an aircraft serve to absorb the movement and vibration of the fuel lines caused by aircraft maneuvers and turbulence. A slip joint allows the fuel line to move slightly without causing stress or tension on the rest of the system, while floating fairleads ensure the fuel line remains in the correct position and does not become tangled or damaged. This helps to prevent fuel leaks and ensures the safe and efficient operation of the aircraft (see Figure 22).

- **Engine Oil Supply System:** Each of the seaplane's eight engines has a 31-gallon oil lubricating tank. A central 281-gallon tank located at the rear of the flight deck replenished each of the oil lubricating tanks. The oil supply system could operate automatically with a float in each individual tank or manually. The oil piping in each engine nacelle consisted of a main engine-oil pipe, reserve-oil supply lines, vent lines and propeller-feathering piping. The engines also featured carburetor inlet scoops, fitted with oil coolers, placed below the nacelles, and enclosed by the air-scoop fairings and temperature regulating doors.

- **Engine Controls:** Originally designed with four throttles - one for each pair of engines –Hughes changed the design to eight after the flight, one for each individual engine. At first, all engines operated on a pneumatic system, using compressed air; however, Hughes found it difficult to control them precisely, and no two valves would operate the same with identical pressure. After the flight, Hughes had electric throttles installed, along with servos for throttle control on all eight engines, which supplemented the electric throttles and gave them a response time of 1/300th of a second (see Figures 26-30).

- **Flight Controls:** Hughes and his team of engineers developed the first "artificial feel system" in the pilot's control yoke, which produced the sensation of flying a smaller aircraft. For example, for each pound of pressure exerted on the control yoke by the pilot, the elevator received 1,500 pounds of pressure to move it. The Flying Boat required two auto-pilot systems and Howard Hughes' passion for safety resulted in five hydraulic control systems, which included two main systems, two auxiliary systems, a hand pump system, plus, an emergency flying-tab system (small components of the larger control surface system consisting of the flaps, ailerons, elevator and rudder) in case of complete hydraulic failure. Although conventional control cables directly connected the pilot and co-pilot to the control surfaces, they did not move them; they only provided a follow-up to ensure the proper relationship between the control positions and the actual deflections of the control surfaces. Hughes engineers used electrically driven, high-pressure hydraulic pumps that provided the operating power for the systems. When the pilot moved the controls, he actuated sensitive relay valves that transmitted metered, pressurized hydraulic fluid into tubing, which led to receiving relay valves located at the control surfaces. The receiving valves permitted pressurized oil to flow to the power cylinders, which moved the control surfaces. Additionally, two independent, self-contained telecontrol

systems, supplied with electric power from two separate generators, operated each control surface, which ensured complete safety (see Figures 24 and 25).

- **Flareless Tubing Connectors:** The Flying Boat was the first aircraft to utilize flareless tubing connectors in the hydraulic lines. Flareless tubing connectors are mechanical fittings that connect hydraulic lines without the need for flares (threaded nuts). These connectors use a compression mechanism to create a tight seal between the tubing and the connector. This design reduced the chance of leakage and eliminated the need for skilled personnel to install the tubing.

- **Docking Elevator:** Hughes designed a novel elevator equipped with guardrails, located in the rear portion of the flight deck, to lift personnel through a top-opening hatch. Equipped with headphones and a microphone connected to the aircraft's communications network, the operator supervised the launching, docking and mooring of the seaplane from an elevated position above the fuselage.

The advanced mechanical engineering, most notably the redundant flight control and safety systems – first used on the Flying Boat and now common features in modern passenger and cargo aircraft – earned the Hughes Flying Boat recognition as an American Society of Mechanical Engineers Historic Landmark on July 20, 2002.[22]

Transitions in Status and Ownership

By the early 1950s, Terminal Island was knee-deep in a subsidence crisis. Decades of pumping oil from under San Pedro Bay left Pier E and others riddled with earthen dikes, concrete walls and other remedial works to protect low areas from flooding. In September 1953 an earthen dike on a neighboring property burst in the middle of the night, allowing tons of mud, silt and water to crash through a fence and pour into the H-4's hangar and drydock. Thirty feet of muck lifted the seaplane out of its dock and crushed it against the hangar's trussed ceiling, causing an estimated $5M in damage to the wings, hull, and engines.[23]. Despite his advisors' suggestion that he scrap the H-4 entirely, Hughes oversaw its restoration to original flying condition and the addition of a special graving dock cradle; however, records indicate all research and testing activity ceased after the 1953 flood, ending its period of significance. The historic record does not provide a concise reason for the cessation of research and testing activity; however, the end of the seaplane era, advance of the jet age and Hughes' focus on other projects, including communications satellites and space technology, are a few possible reasons. With restoration work complete, the H-4 *Hercules* entered an era of maintenance and flight-readiness. Hughes would spend $1M per year to store his Flying Boat in its specially designed hangar and graving dock in optimum conditions of temperature and humidity, amid the tightest of security, for the rest of his life.

By the early-1970s, although Hughes paid for the upkeep of the H-4 *Hercules*, the US government still owned the seaplane and the General Services Administration (GSA) wanted to give it to the National Air and Space Museum (NASM). There was no room at NASM nor did the museum have the desire to take on the gigantic Flying Boat; however, it was very interested in the Hughes H-1 *Racer*. In 1974, reaching a compromise after an appraisal of the H-4 *Hercules*, Hughes agreed to deed his *Racer* to NASM along with $700,000 to the GSA in exchange for full title to the Flying Boat. Upon Howard Hughes' death on April 5, 1976, a clause in the GSA agreement required ownership of the Flying Boat to transfer from Hughes' Summa Corporation (formerly the Hughes Tool Company) to a non-profit organization. Otherwise, the agreement stipulated, Summa was to cut the seaplane into nine pieces for distribution to museums across the United States, including the NASM, which only wanted a 51-foot wing section.[24]

[22] Huit, ASME Historic Landmark designation, 2-4.
[23] "Giant Hughes Plane Crushed by Sea of Mud," *Daily News (Los Angeles)*, 21 September 1953.
[24] *Spruce Goose Acquired by NASM, Torch (Smithsonian Institution: Washington, D.C. March 1975),* 3.

The termination of the Pier E Terminal Island lease by the Port of Long Beach in the late 1970s created an urgency to find a new home for the Hughes Flying Boat. Determined to preserve the seaplane's historic integrity and its place of significance in aviation history, a group of individuals formed the "Committee to Save the Hughes Flying Boat" (the Committee) and gained national attention for the craft's plight. Working closely with the California State Historic Preservation Office, the Committee submitted a nomination in July 1980 for the listing of the H-4 *Hercules* in the National Register of Historic Places. They also sent a proposal to the US Navy Department for use of the H-4 as a flying test bed for electronic equipment and estimated 12 months of preparation to bring the H-4 *Hercules* to full flight readiness. Members of the original flight and construction crews inspected the aircraft's condition that year, reporting its general appearance as complete and near original.[25]

Jack Real, a friend and colleague of Hughes from his time working on the Lockheed *Constellation*, spent considerable time behind the scenes searching coast-to-coast for a non-profit willing to adopt the Flying Boat. When initial efforts to raise funds for a new home near the *Queen Mary* in Long Beach failed, Summa began planning the disassembly and dissemination of the H-4 per the GSA agreement. At the last minute, leading members of the non-profit Aero Club of Southern California (ACSC) approached the Wrather Corporation, an entertainment-related company, with a plan. In July 1980, Summa signed a letter of intent with ACSC and Wrather, which outlined the donation of the Hughes Flying Boat to the ACSC by Summa. The ACSC then leased the seaplane to the Wrather Corporation for exhibit in a new *Spruce Goose* Museum near the *Queen Mary* (see Figure 31).

On October 29, 1980, the Hughes Flying Boat emerged from its disassembled hangar into daylight for the first time since 1947. The seaplane traveled 300 yards down the back channel from Pier E's Berth 120 to Berth 118 to rest under a tarp on the pier while the Wrather Corporation constructed its new home, a gigantic geodesic dome on Pier J adjacent to the Queen Mary. The move cost $1M and required 200 workers and the use of the Port's famous floating crane vessel, "Herman the German," to lift the 150-ton seaplane.[26] Will Lummus, Hughes' cousin and Summa representative, formally presented the Flying Boat to the ACSC on October 31, and one month later, with the seaplane waylaid in its third setting, the National Park Service listed the H-4 *Hercules* as a property of national significance to American aviation history for its association with Howard Hughes and its scientific contribution to avionics engineering.[27]

Under the Dome

The H-4 *Hercules* met Herman the German again, 15 months later, when the giant crane lifted the seaplane from Berth 118 onto a barge to travel the 4.5 miles out of the back channel, into the harbor, and around the corner to Pier J. There, it was winched tail-first into the nearly completed dome where it would undergo the transformation from Howard Hughes' Flying Boat to the Spruce Goose tourist attraction. Sections of its Duramold skin and two exit doors on the port side of the Flight Deck were removed and replaced with Plexiglas to create a large viewing window reachable from an external platform built up against the plane. An access platform was constructed inside the Cargo Deck. Still in its 1953 cradle, the seaplane was positioned to "float" above a reflecting pool while cut-aways of the plane's engines were displayed alongside a Sherman tank as part of the interpretation. A ten-minute light show turned the white seaplane into a kaleidoscope of colors at regularly scheduled intervals. It took over a year to finish the dome and the display. The Spruce Goose opened

[25] Barton, 226-227; Weinman, 64.
[26] "The Goose is Loose," *San Bernadino Sun*, 31 October 1980; *Palm Springs Desert Sun*, no. 63, 23 October 1980.
[27] Barton, 229; Hughes Flying Boat (H-4 *Hercules*) National Register Nomination, November 26, 1980; Withdrawn October 13, 1992; includes supporting documentation and letters of support.

to the world for the first time on May 14, 1983, with actor Jimmy Stewart christening the tourist attraction under what was then being called the world's largest clear-span aluminum dome.[28]

The Spruce Goose attraction remained popular for many years, but not profitable enough for the Disney Corporation, which became the owner of seaplane when it purchased the assets of the Wrather Corporation in 1988. In May 1990 the company terminated the lease of the seaplane from the ACSC. The H-4 *Hercules* found itself in peril once more. Again, Hughes' friend and colleague, Jack Real, stepped up to bridge a solution to the Flying Boat's plight. Will Lummis had appointed Real to manage Hughes Aircraft Company, which included the helicopter division based in Culver City, California. As president of Hughes Helicopters, Real oversaw the development of the Hughes AH-64 *Apache* attack helicopter and later, when Hughes Helicopters sold to McDonnell Douglas, he continued as president of the latter company. Real's involvement with Hughes and McDonnell Douglas led to an association with Delford M. Smith, who owned Evergreen International Aviation (EIA), a global aviation services company based in McMinnville, Oregon.[29] EIA consisted of seven synergistic companies, including Evergreen Helicopters, which purchased several McDonnell Douglas Model 500 helicopters from Jack Real in 1983. A short time later, Real began service on EIA's board of directors. Undoubtedly Real was aware that Del Smith's son, Michael King Smith, a USAF captain and F-15 pilot, shared his father's love of aircraft and had begun collecting vintage aircraft for a small museum he established at the company's headquarters in 1991 as the Evergreen Museum. A plan to save the Spruce Goose began to emerge.

In response to the lease termination notice from Disney, the ACSC issued a request for proposals to adopt the Flying Boat. Responding to the request, Michael Smith's Evergreen Museum collaborated with Del Smith and EIA to prepare a proposal, which was among eight promising presentations considered by Will Lummus and the ACSC board of directors. Of these, in July 1992, the Evergreen proposal emerged as the most favorable. According to Real, the Smiths' plan stood out because of Evergreen's proven logistical capabilities, but also due to the placement of the H-4 *Hercules* as the centerpiece of a new aviation museum to be constructed specifically for the seaplane as a tribute to Howard Hughes' contributions to aviation history.[30]

A New Home in Oregon

Beginning a new chapter in its history, the Flying Boat was in good hands. Jack Real joined the seaplane as Evergreen Museum's president and George Kruska, who had worked on the H-4 in 1946-47, led the crews who spent several months carefully disassembling and preparing the seaplane for the long trek to Oregon. Moving the Flying Boat to Oregon involved partial disassembly of the dome and complete disassembly of the seaplane. The disassembly project began on August 10, 1992, and proceeded in the following order: propellers, engines, tail cone, pontoons, wing fairings and tips, elevators, rudder, ailerons, vertical stabilizer, horizontal stabilizers, and wings (see Figure 32).[31]

Six weeks later, with the plane in 38 separate pieces, disassembly crews crated the propellers, engines, and smaller parts, shipping them from California to Oregon via Interstate 5. The moving crew made a large opening in the dome while the disassembly crew shrink wrapped the remaining gigantic pieces for the journey on ocean-going barges (see Figure 33). The Flying Boat departed California's Long Beach Harbor on September

[28] "Thousands Visit Goose," *Palm Springs Desert Sun*, no. 244, 16 May 1983.
[29] Jack Real and Bill Yenne, *The Asylum of Howard Hughes, (*Xlibris Corp.: Bloomington, Indiana, 2003), 255-265.
[30] Ibid.; Bill Yenne, *The Evergreen Story*, (Evergreen International Aviation: McMinnville, Oregon, 2008) 263-270; Huit, *Dream to Fly* interview with Jack Real, October 21, 2003; Huit, Research notes and documentation as historian of Evergreen International Aviation, 1999-2007. The Evergreen Museum's Articles of Incorporation, list the organization as a Public Benefit, tax exempt 501 (c)(3) corporation with the State of Oregon as of November 15, 1991.
[31] Delford M. and Michael King Smith, Evergreen AirVenture Museum proposal, May 15, 1992; The Museum updated the articles with an official name change to Evergreen AirVenture Museum in early 1994. Huit, Research Notes and *Dream to Fly* Interviews with restoration volunteer Paul Payne, Jack Real, former ACSC president, Bill Schoneberger, and Delford M. Smith, 1999-2003.

21, 1992, and after traveling 980 nautical miles, the control surfaces, horizontal stabilizers, wings, vertical tail, and fuselage arrived in Portland, Oregon. Thousands of people celebrated the arrival at Tom McCall Waterfront Park with Portland Mayor Bud Clark proclaiming October 22, 1992, as "*Spruce Goose* Day".

The water levels of the Willamette River delayed the Flying Boat's trip from Portland to McMinnville. The water was either too high for passage under bridges or too low for migration from the river to land. The large pieces remained in storage for several months at the Port of Vancouver. Once the river stabilized, moving crews began the slow and final trek of the Flying Boat's journey to its new home. Along the way, the fuselage and wings set records as the longest and tallest loads to pass through Oregon City's historic Willamette Falls Locks.

Meanwhile, preparations began for the final seven-and-a-half-mile trek over a Model-T-width country road from the Willamette River at Dayton to McMinnville. Heavy moving equipment assisted the sections of the Flying Boat in the transition from river to land at Weston Bar, southwest of Dayton, through a quagmire of mud. Once landed and moving, the caravan stretched more than 1,500 feet down the concrete country road. Traveling the final one-mile stretch, the Flying Boat arrived at the Evergreen International Aviation campus on February 27, 1993 (see Figure 34).[32]

Between 1993 and 2001, the massive parts of the H-4 underwent restoration at the hands of volunteers while the Evergreen team designed a new hangar-like structure specifically for the Flying Boat and other historic aircraft. Restoration focused on the seaplane's exterior. Volunteers began by removing the old layers of paint. The first two layers were white from the seaplane's repainting under Hughes' direction in 1952 and again in preparation for exhibit in the dome at Long Beach – along with a layer of fire-retardant coating.

While the restoration work got underway, the design and construction of the H-4's new home stalled with the tragic untimely death of its founder, Captain Michael King Smith, from a car accident in 1995. Planning resumed in 1998 and construction began in the fall of 1999. The first of a planned multi-structure campus, situated on the north side of the busy Highway 18 Bypass to the Oregon Coast, the Evergreen Aviation Building was designed as a giant airplane hangar. Facing south toward the historic McMinnville Municipal Airport, it was built of concrete, glass and steel with local wood and river stone elements and rose to ten stories with a footprint of 121,000 square feet – a dimension driven, obviously, by the dimensions of its main attraction.[33]

The volunteer restoration team continued work on the Flying Boat's Duramold surfaces during 2000-2001, including the fuselage, wings, vertical stabilizer, and pontoons. The paint removal exposed inspection stamps, signatures of men and women who worked on the original construction, and evidence that the Duramold had passed wind shear tests (see Figure 35). The volunteer crew prepared the surfaces for priming while museum staff worked closely with paint professionals at Sherwin Williams® to return the seaplane to its original flight color. Dedicated to a high level of authenticity, the team referred to swatches of the old paint carefully removed from the seaplane to develop a color very near to that used by Hughes in 1946-1947. The paint crew used airless sprayers to apply approximately 500 gallons of Preprite Pro-Block White Primer (#B79 W10). Again, using the airless sprayers, they followed the primer with a topcoat consisting of one part Silver Brite Aluminum (#B59 S11) and five parts Wood Classics Polyurethane Satin Clear (#6403-15941), using about 700 gallons, resulting in as close a match as possible to the original color and sheen.[34]

[32] Ibid., Paul Payne, Jack Real and Delford M. Smith.
[33] Ibid., Paul Payne; Huit, Research notes and documentation, 1999-2006.
[34] Huit, Research notes and documentation, 1999-2006; *Dream to Fly Interviews*, Paul Payne, restoration volunteer Ross Phillippi and restoration manager Michael Wright.

In the fall of 2000, preparations got underway for the final 800-foot move of the Flying Boat's gigantic pieces from the temporary restoration area to the new hangar. On September 16, 2000, moving crews transferred the freshly restored fuselage, wings and tail to the new building (see Figure 36). Preparing for the arrival of the fuselage, the reassembly crew positioned the wings on the right and left, just as they had in 1946. Upon its arrival, carried in its special cradle, the crew lowered the fuselage in to a seven-foot pit at the building's center south side. With the Flying Boat's large pieces positioned for reassembly, construction crews closed in the back portion of the hangar and reassembly of the Flying Boat commenced. It took a little over a year to reassemble the H-4.

While the reassembly crew attached the wings and vertical tail to the fuselage, the restoration crew worked on the enormous, Duramold-framed control surfaces (4,414 square feet in total), including the ailerons, elevators, rudder, the geodesic portion of the horizontal stabilizer, the trim and servo tabs, and the flap hangers. They spent hundreds of hours securing Poly-Fiber synthetic aircraft fabric to the control surfaces with thousands of hand tied knots (see Figure 38).

Just before the opening of the newly named Evergreen Aviation Museum, the reassembly crew attached the Flying Boat's eight Pratt and Whitney R-4360 engines, reassembled the 32 propellers creating eight units and attached them to each of the eight engines. Next came reassembly of the horizontal stabilizers to the H-4's tail section. Over the next several months, visitors witnessed the assembly of the pontoons, control surfaces and wing tips. During a ceremony commemorating the 60th anniversary of the attack on Pearl Harbor, December 7, 2001, the crew completed the reassembly process by attaching the tail cone (see Figures 37 and 39-40).[35]

Resting in its graving dock cradle as part of a timeline of aviation history, the Hughes Flying Boat joined a replica Wright Flyer (Early Flight) and biplanes like the de Havilland DH-4M-1 (First World War) on its port side; a Douglas DC-3 *Skytrain* (Golden Age of Flight) near its tail; a North American SNJ-4 *Texan* trainer (Second World War), a McDonnell Douglas F-4C *Phantom II* (Jet Age), Raytheon-Beechcraft *Starship* (Executive Travel) and a Christen *Eagle* II (Sport Aviation) on its starboard side.

The H-4 *Hercules* and the National Register of Historic Places

In 1980, as the H-4 *Hercules* rested under a tarp on Pier E's Berth 118, waiting for the dome on Pier J to be constructed, the National Park Service finalized its listing in the National Register of Historic Places. It was listed as nationally significant for its association with Howard Hughes under Criterion B, and under Criterion C for its role as a research and testing platform furthering the advancement of aviation technology. No period of significance was indicated, as that was not required on the form in the 1980s. In 2004, the National Park Service informed the California and Oregon State Historic Preservation Offices that the H-4 *Hercules* had been automatically delisted on October 13, 1992, because it was moved from California to Oregon without prior approval from the Keeper of the National Register of Historic Places. This decision was made under the general presumption that moving a listed property removes it from its historical associations, unless the new setting is appropriate under the National Register criteria, which is determined by the National Park Service.

It has already been shown in the narrative above that the H-4 *Hercules* retains excellent integrity of design, materials, workmanship, feeling, and association under Criterion B for its association with Howard Hughes and Criterion C for its service as a research platform for avionic and mechanical engineering innovations and the far-reaching contributions the H-4 science has made to the field of aviation and aerospace in this country. Following the guidance in the National Register Bulletin *Guidelines for Evaluating and Documenting Historic Aviation Properties*, this nomination need not make the case for integrity of location as the H-4 is a moveable object. Additionally, the H-4 need not be considered under Criterion Consideration B for Moved Properties. However, a robust discussion on integrity of

[35] Huit, Research notes and documentation, 1999-2001.

setting is warranted for the obvious reason the H-4 has been moved numerous times – its last one triggering the delisting that this nomination is aimed at reversing.

H-4 *Hercules* and Integrity of Setting

The H-4 *Hercules* Flying Boat has been set in five locations in its life, and moved four times since it left the Culver City hangar in which it was built. It has been moved twice since it was listed on the National Register of Historic Places in November 1980; the second move, from California to Oregon, triggered its delisting in 1992. The locations and years and National Register status are noted below.

- Culver City hangar (1943-1947)
- Berth 120, Pier E (1947-1980) *Nomination prepared while here.*
- Berth 118, Pier E (1980-1982, 15 mos.) *Listed while here.*
- Pier J Dome (1982-1992) *Delisted when removed from here.*
- Evergreen Museum (1992-present)

Determining integrity of setting for the H-4's location at the Evergreen Aviation Museum in McMinnville, Oregon will depend on why the seaplane is eligible, its period of significance, and whether it can convey its historical associations as well in the Evergreen Museum as it could in its last listed location, the geodesic dome on Pier J at the Port of Long Beach. Importantly, this determination needs to be made through the lens of the National Register bulletin, *Guidelines for Evaluating and Documenting Historic Aviation Properties,* which presents the National Register policy that historic aviation properties are generally not eligible for listing due to issues of setting, collection, and redundancy of mission.

Setting

If the H-4 *Hercules* was significant under Criterion C as an example of a flying boat, or under Criterion A for the event of its only flight over San Pedro Bay in 1947, then a setting near water would be necessary to tell that story. The setting of a harbor, a bay, a pier, a port, would be important. But that is not why the H-4 Flying Boat is significant.

Since its listing in 1980, it has been significant for two things: its association with its designer, aviator Howard Hughes (Criterion B) and its use as a research and testing platform for advancing mechanically engineered systems that contributed to the technology found in large airplanes around the world after WWII (Criterion C). This nomination has further refined the H-4's significance by determining its period of significance, which was not done in the original 1980 nomination. The period of significance, 1947-1953, is important in determining how and why the current setting is appropriate to the eligibility of the Hughes Flying Boat.

The Flying Boat's association with Howard Hughes is reflected by its very existence: the design, material, feeling, association, and workmanship, without regard to its setting. But for the day he flew the H-4 in San Pedro Bay, the man's relationship to, and engagement with, his Flying Boat took place within the walls of the Culver City hangar where it was built, and the Pier E hangar at Long Beach. It continued when the Hercules was parked on a pier for 15 months and it continued under the dome at Pier J. And it continues in the Evergreen Aviation Building in Oregon.

Similarly, the H-4's significance as a research and testing platform did not depend in any way on its relationship to its harbor setting. Short of the one day in November 1947, the seaplane did not see the light of day during its period of significance. No further tests or flights were conducted on the water. All the research and testing and building and experimenting – all the applied technology for which the H-4 is significant occurred with the plane on a cradle in drydock, inside a hangar.

Today it rests in the cradle Hughes designed for it in 1953, drydocked under a massive truss system, in a giant hangar. The Evergreen Aviation Building is an appropriate setting, not because it is across the street from an airport. It is appropriate because, as a hangar filled with other aircraft, it helps the H-4 convey the associations for which it is listed; as mentioned before, the Hercules may be a flying boat, but all the technological

advancements and research conducted on that seaplane were for advancing the design of aircraft, not ships or other nautical vehicles.

It is worth mentioning here that its current setting is far more appropriate than its last setting, enclosed in an aluminum geodesic dome with colored lights, weird music, movie theater, and a hotdog counter, where it remained listed in the National Register.

Part of a Collection

The H-4 *Hercules* is not in a museum because it is an example of a particular aircraft, as is the case with most air museum airplanes. It is not simply an artifact acquired by a museum to add to its collection. It is the reason for the collection. It is the reason for the building. It is the only one of its kind, anywhere. It is not an example; it is a unique specimen significant for reasons far outweighing its serendipitous landing in McMinnville, Oregon. It is far more a tourist attraction than a museum object. It is so big it literally creates its own setting around itself and has since it was built. The Evergreen Aviation Building was constructed specifically for the seaplane; literally finished around the reconstructed seaplane. Just as the hangar in Culver City was. Just like the hangar on Pier E was, just like the dome on Pier J was.

Redundancy of Mission

The *Guidelines for Evaluating and Documenting Historic Aviation Properties* notes that the National Register generally excludes museum objects from being listed because “National Register status for museum objects is redundant since the objectives of recognition and preservation are inherent in the museum mission,” using the Smithsonian National Air and Space Museum as an example. It is important to know that the Evergreen Aviation Museum is not the Smithsonian. In the 24 years since the Spruce Goose’s arrival there, the museum has had three owners and two bankruptcies. With an airplane the size of the H-4, there is no backup plan. It takes a tremendous amount of resources to house and maintain a structure as big as the H-4. Contrary to what most people think, its extraordinary dimensions do not protect it, they actually make it more vulnerable: to disassembly and dispersal; to disassembly and storage. National Register listing in this case would add a layer of intention to any future discussions of the H-4’s disposition.

Conclusion:

As detailed above, the H-4 *Hercules* is of national significance under Criteria B and C. The Flying Boat survives as a one-of-a-kind historic resource that contributed significantly to mechanically engineered applications used in commercial and military aviation, and space exploration. Engineering genius Howard Hughes designed the H-4 *Hercules* as a seaplane in response to the sinking of commercial ships by German U-Boats at the height of the Second World War. Hughes carried out his responsibilities, fulfilling his revised wartime contract to construct one prototype seaplane. When challenged through a Congressional investigation, Hughes took the seaplane to Long Beach Harbor and flew the craft for less than 30 seconds.

At the time of its completion and test flight on November 2, 1947, the H-4 *Hercules* was the largest aircraft ever constructed. In 1968, the fuselage of Lockheed’s C-5 *Galaxy* (247 feet, 1 inch) surpassed the H-4 (218 feet, 8 inches) in length. The Flying Boat’s wingspan (319 feet, 11 inches) held the record for width until the successful 2019 flight of the twin-fuselage Stratolaunch (385 feet). Yet, with its footprint of a bit more than an acre-and-a-half, the Hughes Flying Boat still holds the record of the largest wooden aircraft in the world.

The flight and size of the seaplane had been the sole focus of the H-4’s significance for years. However, Howard Hughes’ extraordinary advancements in mechanically engineered systems, which took place during the years 1947 to 1953, are of greater importance. For it was during this time, sequestered in a specially built graving dock hanger away from any contact with the sea, that the H-4 served as a research and testing platform for applications used today in both air and spacecraft. Howard Hughes said he intended to use the H-

4 as a test bed to 'advance the art of aviation' and he clearly accomplished this goal. The H-4 *Hercules* is an exceptional – and only surviving – example of an aviation research and testing lab used by Howard Hughes.

After Hughes' death in 1976, the H-4 *Hercules* narrowly avoided the scrapyard not once, but twice. The H-4 *Hercules* left Long Beach, California in pieces; however, a new home in McMinnville, Oregon saved the seaplane from distribution of those pieces around the United States, which would have permanently destroyed its historic integrity as a contributing resource to advancements in aviation. After its arrival in McMinnville, the H-4 underwent exterior restoration and reassembly. The aircraft retains a high degree of historic integrity. It resides in a setting appropriate to an aircraft. Its design, workmanship, and materials reflect the period of significance when it was used as an aviation research platform. The Duramold material gives the Flying Boat a distinctive look, feel and smell that sets it apart from other aircraft. Its mechanically engineered systems, including the redundant fire suppression system, multiple hydraulic components, modified fuel and oil systems, and the enhanced instrumentation and console layout all remain true to the period of significance. The combination of these elements, clearly maintain the feeling and association with Hughes and the engineering research for which the H-4 *Hercules* is most significant.

Howard Hughes said he wanted to be remembered for one thing: his contribution to aviation. The H-4 *Hercules* deserves to be listed in the National Register of Historic Places for its connections to Howard Hughes and in recognition of its significant contributions to the aerospace industry.

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Previous documentation on file (NPS):

____preliminary determination of individual listing (36 CFR 67 has been requested)
__x__previously listed in the National Register
____previously determined eligible by the National Register
____designated a National Historic Landmark
____recorded by Historic American Buildings Survey #_____
____recorded by Historic American Engineering Record # _____
____recorded by Historic American Landscape Survey # _____

Primary location of additional data:

____State Historic Preservation Office
____Other State agency
____Federal agency
____Local government
____University
__x__Other
Name of repository: Evergreen Aviation and Space Museum

Historic Resources Survey Number (if assigned): N/A

Hughes Flying Boat (H-4 Hercules) | Yamhill Co., OR
Name of Property | County and State

10. Geographical Data

Acreage of Property approximately 1.5
(Do not include previously listed resource acreage; enter "Less than one" if the acreage is .99 or less)

Latitude/Longitude Coordinates
Datum if other than WGS84:
(enter coordinates to 6 decimal places)

1	45.204401°	-123.145369°		3			
	Latitude	Longitude			Latitude	Longitude	
2				4			
	Latitude	Longitude			Latitude	Longitude	

Verbal Boundary Description (Describe the boundaries of the property.)

The boundary of the nominated property includes the entire volume of the H-4 *Hercules* contained within the length, width, and entire breadth of the seaplane.

Boundary Justification (Explain why the boundaries were selected.)

The selected boundary isolates the H-4 *Hercules* from adjacent areas that are not directly associated with the history of the resource. The boundary does not include its surroundings or structure that houses it.

11. Form Prepared By

name/title Katherine Huit, Heritage Consultant date 11/14/2023
organization Willoheart Enterprises telephone (503) 434-9853
street & number 7020 SW Lebold Road email katherine.huit@willoheart.com
city or town McMinnville state OR zip code 97128

Additional Documentation

Submit the following items with the completed form:

- **Regional Location Map**
- **Local Location Map**
- **Tax Lot Map**
- **Site Plan**
- **Floor Plans (As Applicable)**
- **Photo Location Map** (Include for historic districts and properties having large acreage or numerous resources. Key all photographs to this map and insert immediately after the photo log and before the list of figures).

Hughes Flying Boat (H-4 Hercules) | Yamhill Co., OR
Name of Property | County and State

Photographs:

Submit clear and descriptive photographs. The size of each image must be 3000x2000 pixels, at 300 ppi (pixels per inch) or larger. Key all photographs to the sketch map. Each photograph must be numbered and that number must correspond to the photograph number on the photo log. For simplicity, the name of the photographer, photo date, etc. may be listed once on the photograph log and doesn't need to be labeled on every photograph.

Photo Log

Name of Property: Hughes Flying Boat (H-4 Hercules)

City or Vicinity: McMinnville

County: Yamhill **State:** OR

Photographer: Katherine Huit

Date Photographed: March 15, 2023

Description of Photograph(s) and number, include description of view indicating direction of camera:

Photo 1 of 18 Northward "Runway" Approach toward Aviation Building on the Evergreen Aviation and Space Museum Campus.

Photo 2 of 18 Westward looking view from the Aviation Building's East Mezzanine Toward the Port Side of the H-4 Hercules. Note the Cargo Deck Access Platform.

Photo 3 of 18 The nose of the H-4 *Hercules* faces south with three of the Pratt and Whitney R-4360 engines showing on the starboard wing, each featuring Hamilton Standard Propellers.

Photo 4 of 18 Looking northwest from the H-4 *Hercules*' nose, note the seaplane's anchor and the two white doors (one is behind the other) next to a Pratt and Whitney R-4360 engine. In 1980, dome exhibitors removed the two doors and Duramold skin from the port side of the Flight Deck, replacing all with plexiglass for viewing from an elevated platform.

Photo 5 of 18 The H-4 *Hercules* interior, looking aft from the Cargo Deck Viewing Cube toward the seaplane's tail. The wings come together at the top of the image and are accessible by the ladder at the left.

Photo 6 of 18 The H-4 *Hercules* interior, Cargo Deck looking forward toward Viewing Cube. Note the 36 red CO2 canisters, which are part of the Fire Suppression System; the hydraulic tubing on the upper right side of the image (the seaplane's port side), and the beach balls, discovered in the Pontoons during restoration.

Photo 7 of 18 The Standby Hydraulic Station, located on the H-4 *Hercules*' Cargo Deck, near the nose. Note the Duramold framework of the nose, with its aged silver-aluminum paint dating to 1946-47 now a patina green.

Photo 8 of 18 The Battery Cutoff Station, located on the H-4 *Hercules*' Cargo Deck aft of the Standby Hydraulic Station, near nose.

Photo 9 of 18 A short, steep flight of steps connects to circular stairs, creating a Companionway between the Cargo and Flight decks of the H-4 *Hercules*. The Companionway is located on the starboard side of the seaplane, in the forward section.

Photo 10 of 18 On the Flight Deck of the H-4 *Hercules*, looking southeast toward the seaplane's port side are Observers' seats and the plexiglass viewing window installed for the dome exhibit circa 1982.

Photo 11 of 18 The 281-gallon Oil Storage Tank, sits just outside the port side leading edge wing access door, aft, on the H-4 *Hercules*' Flight Deck.

Photo 12 of 18 On the Flight Deck, aft center, is a ladder that ascends to the Docking Elevator, which enabled personnel to supervise docking and mooring of the H-4 *Hercules*. Notice the Electrical Distribution Panel to the left of the ladder.

Photo 13 of 18 There is an exit door on the H-4 Hercules' Flight Deck, located on the starboard side between the Auxiliary Power Unit and the Propeller Test Station that is identical to that removed for the plexiglass viewing window on the port side.

Photo 14 of 18 Located on the H-4 Hercules' Flight Deck port side, the Flight Test Oscillograph Station sits forward of the Flight Test Strain Gauge and Temperature Recording Stations.

Photo 15 of 18 The Flight Engineer's Station is aft of the Co-Pilot's position on the starboard side of the H-4 *Hercules*' Flight Deck.

Photo 16 of 18 Located on the port side of the H-4 *Hercules*' Flight Deck, the Assistant Flight Engineer's Station sits in the second row of the Observers Seating.

Photo 17 of 18 Located on the port side of the H-4 *Hercules*' Flight Deck, aft of the Pilot's Position, the Radio Operators Station features a Morse Code Telegraph Key in front of the panel, to the right.

Photo 18 of 18 The Pilot's (located on the port side) and Co-Pilot's (located on the starboard side) positions sit above the H-4 *Hercules*' nose on the Flight Deck.

United States Department of the Interior
National Park Service

National Register of Historic Places Continuation Sheet

Hughes Flying Boat (H-4 Hercules)
Name of Property
Yamhill Co., OR
County and State
N/A
Name of multiple listing (if applicable)

Section number Additional Documentation Page 29

List of Figures

(Resize, compact, and paste images of maps and historic documents in this section. Place captions, with figure numbers above each image. Orient maps so that north is at the top of the page, all document should be inserted with the top toward the top of the page.

Maps and Site Plan

Figure 1 Regional location map showing Portland, Salem and McMinnville, home of the Evergreen Aviation and Space Museum (EASM) and the H-4 *Hercules*. Satellite overlay image, Google Maps

Figure 2 Local location map showing McMinnville, EASM, and McMinnville's Municipal Airport Satellite overlay image, Google Maps

Figure 3 Map showing tax lot location of the EASM. Yamhill County Assessment and Tax Cartography

Figure 4 EASM Campus Site Plan. Satellite Overlay Image, Google Maps

Historic Drawings and Images

Figure 5 HK-1 Flying Boat Three View Drawing, 1942, Hughes Flying Boat Archive, EASM

Figure 6 HK-1 Flying Boat Master Stations Diagram, 1943, Drawn by Godfrey Nystrom, Hughes Flying Boat Archive, EASM

Figure 7 Howard Robard Hughes, Jr. and the H-1 *Racer*, 1935, Unknown Photographer, Library of Congress

Figure 8 Howard Robard Hughes, Jr. and the Hughes D-2 Bomber, 1940, Unknown Photographer, UNLV Photograph Collection

Figure 9 Howard Robard Hughes, Jr. and the Hughes XF-11 Photo Reconnaissance Plane, 1946, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 10 Howard Robard Hughes, Jr. piloting the H-4 *Hercules*, 1947, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 11 HK-1 Flying Boat Construction – Duramold Skin, 1943, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 12 HK-1 Flying Boat Construction – Duramold Formers, 1944, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 13 HK-1 Flying Boat Construction – Fuselage Framework, 1944, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 14 H-4 *Hercules* Construction – Wings, 1946, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 15 H-4 *Hercules* Fuselage Move to Pier E, Long Beach Harbor, 1946, Bill Newman, Photographer, Hughes Flying Boat Archive, EASM

Figure 16 H-4 *Hercules* Fuselage and Wings Assembly at Pier E, Long Beach Harbor, 1946, Bill Newman, Photographer, Hughes Flying Boat Archive, EASM

Figure 17 Launch of the H-4 *Hercules* into Long Beach Harbor, October 31, 1947, Bill Newman, Photographer, Hughes Flying Boat Archive, EASM

Figure 18 H-4 *Hercules* Taxi Test in Long Beach Harbor, 1947, Bill Newman, Photographer, Hughes Flying Boat Archive, EASM

Figure 19 H-4 *Hercules* Taxi Tests and Flight, Long Beach Harbor, 1947, Bill Newman, Photographer, Hughes Flying Boat Archive, EASM

Figure 20 H-4 *Hercules* Flight Log Book Entry, 1947, Hughes Flying Boat Archive, EASM

Figure 21 H-4 *Hercules* Flight Deck Diagram Post-Flight, ca.1948-1952, Flight Operations Manual, Hughes Flying Boat Archive, EASM

Figure 22 H-4 *Hercules* Fuel System Diagram Post-Flight, ca. 1948-1952, Flight Operations Manual, Hughes Flying Boat Archive, EASM

Figure 23a H-4 *Hercules* Fuselage Carbon Dioxide *(*CO2) Distribution System Diagram, Post-Flight, ca. 1948-1952, Flight Operations Manual, Hughes Flying Boat Archive, EASM

Figure 23b H-4 *Hercules* Wings CO2 Distribution System Diagram Post-Flight, ca. 1948-1952, Flight Operations Manual, Hughes Flying Boat Archive, EASM

Figure 24 H-4 *Hercules* Hydraulics System Diagram Post-Flight, ca. 1948-1952, Flight Operations Manual, Hughes Flying Boat Archive, EASM

Figure 25 H-4 *Hercules* Standby Hydraulic System, ca. 1948-1952, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 26 Howard Hughes and H-4 *Hercules* Pilot's Console, October 31, 1947, Bill Newman, Photographer, Hughes Flying Boat Archive, EASM

Figure 27 H-4 *Hercules* Post-Flight Pilot's Console Configuration, ca. 1948-1952, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 28 H-4 *Hercules* Flight Engineer's Station, Flight Configuration, 1947, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 29 H-4 *Hercules* Flight Engineer's Station, Post-Flight Configuration, ca. 1950, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 30 H-4 *Hercules* Flight Engineer's Station, Left Side Panel, Post-Flight Configuration, ca. 1950, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 31 H-4 *Hercules* on exhibit in geodesic dome, 1982-1992, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 32 H-4 *Hercules* - disassembly of the wings, 1992, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 33 H-4 *Hercules* fuselage, Oregon-bound, shrink wrapped, 1992, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 34 H-4 *Hercules* in giant pieces, arrives in McMinnville, February 27 1993, Unknown Photographer, Hughes Flying Boat Archive, EASM

Figure 35 H-4 *Hercules* - inspection stamps, signatures discovered during fuselage restoration, 2000, Katherine Huit, Photographer, Hughes Flying Boat Archive, EASM

Figure 36 H-4 *Hercules* move to Aviation Building, 2001, Katherine Huit, Photographer, Hughes Flying Boat Archive, EASM

Figure 37 H-4 *Hercules* wings, engines and propellers, horizontal and vertical stabilizers assembled, 2001, Katherine Huit, Photographer, Hughes Flying Boat Archive, EASM

Figure 38 H-4 *Hercules* ailerons restored with new fabric, sewn by hand, 2001, Katherine Huit, Photographer, Hughes Flying Boat Archive, EASM

Figure 39 H-4 *Hercules* – After installation of the Control Surfaces, Tail Cone assembly took place on December 7, 2001, Katherine Huit, Photographer, Hughes Flying Boat Archive, EASM

Figure 40 View looking northeast toward the completely reassembled H-4 *Hercules*, September 25, 2002, Katherine Huit, Photographer, Hughes Flying Boat Archive, EASM

Glossary

Aft:	Near, toward, or in the tail of the seaplane.
Aileron:	Movable airfoil at the trailing edge of the seaplane's wings used for turns
Airspeed Indicator:	A gauge that shows the seaplane's speed through the air.
Altimeter:	A gauge that shows the seaplane's altitude above sea level
Elevator:	A primary flight control surface, mounted on the horizontal stabilizer, which controls the up and down motion (pitch) of the seaplane
Flaps:	Mounted on the trailing edge of the wings; deployed downward for takeoff and landing, increased force produced by the wings.

Flap Control Switch:	A switch that controls the seaplane's flaps.
Flight Controls:	The means by which the pilot controlled the direction and attitude of a seaplane in flight. Primary flight controls include Ailerons, Elevators and Rudder. Secondary flight controls include the Flaps. The Flying Boat's controls surfaces are located on the trailing edge of the wings, horizontal and vertical stabilizers.
Formers:	Large wooden frames that serve as the base structure for the seaplane.
Forward:	Near, toward, or in the nose of the seaplane.
Fuel Gauge:	A gauge that shows the amount of fuel in the seaplane's tanks.
Fuselage:	The body of the seaplane; consists of three levels – Flight Deck, Cargo Deck and Bilge.
Graving Dock	A graving dock is a specific type of dry dock that has a tight-fitting entrance gate, which makes it more suitable for larger vessels that need structural repairs. It has a rectangular shape with sides that slope inward, with a bottom made from concrete or masonry. The name "graving" refers to the process of scraping the hull of a ship while the vessel is in the dock.
Gunite	Also known as shotcrete, Gunite is basically pneumatically applied concrete. It is a process that applies concrete through a hose and nozzle under pressure, which removes air pockets, creating a strong product. The Gunite molds used to create the Duramold formers held up well under heat and pressure.
Horizontal Stabilizer:	A fixed horizontal piece of the tail; prevented up and down motion (also called pitch) of the seaplane's nose.
Leading-Edge	The front edge of the seaplane's wings that enters the air first and directs it over and under the wing to create lift.
Manifold Pressure Gauge:	A gauge that showed the pressure of the air delivered to the engine.
Master Switch:	A switch that controls the airplane's electrical power.
Mixture Control:	A lever or knob that controls the mixture of fuel and air in the engine.
Port:	When looking forward, the left side of the seaplane.
Propeller Control:	A lever or knob that controls the pitch of the propeller blades.
Rudder:	Mounted on the trailing edge of the vertical stabilizer; operated by foot pedals, the seaplane's rudder moved its nose to the left or the right (also called yaw) and helped with stability.
Starboard:	When looking forward, the right side of the seaplane.
Stringers:	Small wooden strips attached to formers, creating a series of ribs that provide additional structural support.
Throttle Control:	A lever or knob that controls the engine's power.
Trailing-Edge:	The rear edge of the wings or flaps; follows the airflow and makes up the aft portion of the wing's profile; critical for controlling the lift, drag, and stability of the seaplane.

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Turn and Bank Indicator: A gauge that shows the airplane's bank (angle of turn) and rate of turn.

Vertical Speed Indicator: A gauge that shows the rate of climb or descent.

Vertical Stabilizer: A fixed vertical piece of the tail; provides stability and kept the seaplane's no from swinging side to side (also called yaw).

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Hughes Flying Boat (H-4 Hercules)
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Figure 1

Regional Location Map, Latitude/Longitude Coordinates: 45.204401°, -123.145369°, Google Earth

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Name of Property
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Figure 2

Local Location Map, Latitude/Longitude Coordinates: 45.204401°, -123.145369°, Google Earth

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Hughes Flying Boat (H-4 Hercules)	Name of Property
Yamhill Co., OR	County and State
N/A	Name of multiple listing (if applicable)

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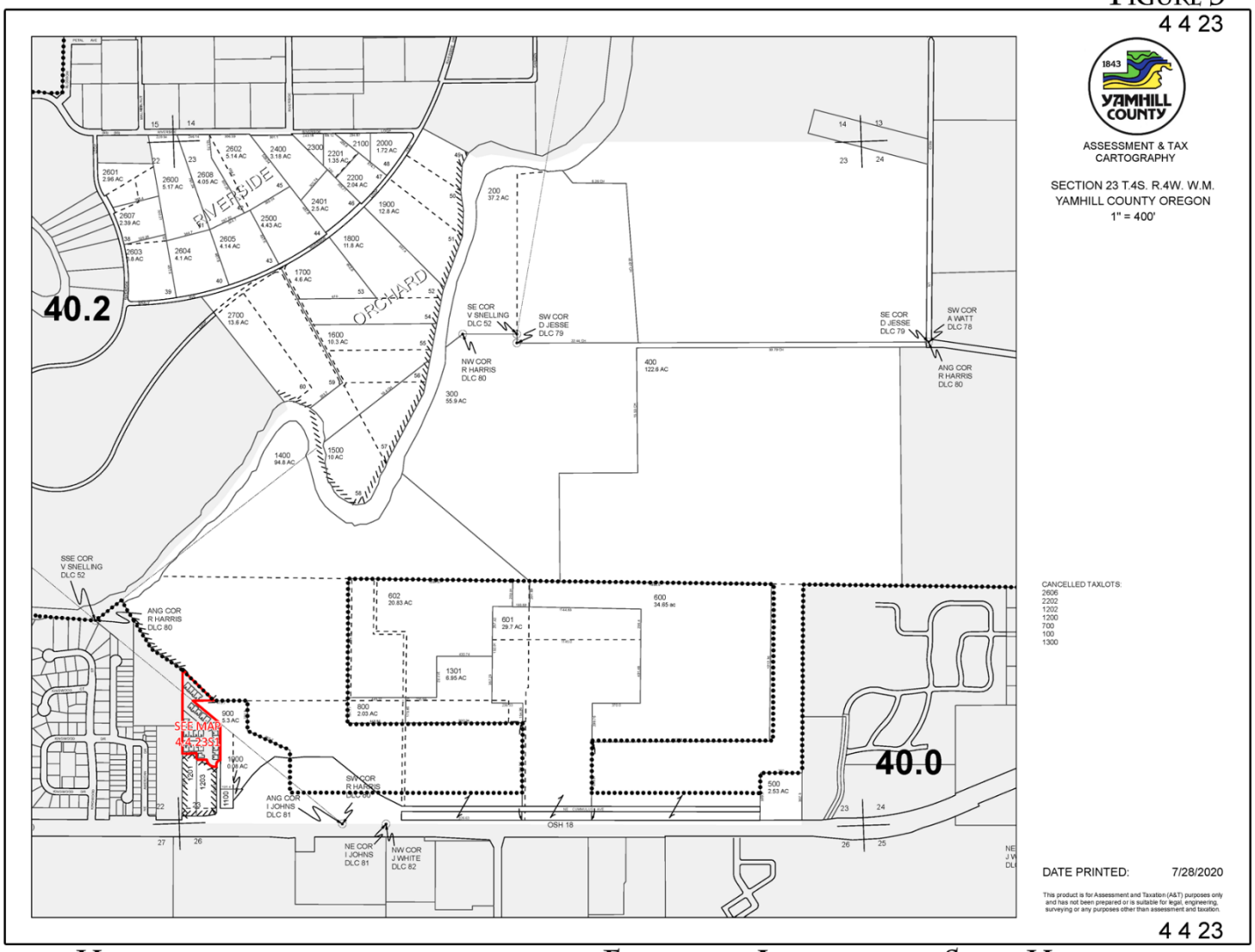
FIGURE 3



MAP SHOWING TAX LOT LOCATION OF THE EVERGREEN AVIATION AND SPACE MUSEUM
YAMHILL COUNTY ASSESSMENT AND TAX CARTOGRAPHY

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FIGURE 4

EVERGREEN AVIATION AND SPACE MUSEUM CAMPUS SITE PLAN
SATELLITE OVERLAY IMAGE, GOOGLE MAPS

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Hughes Flying Boat (H-4 Hercules)	Name of Property
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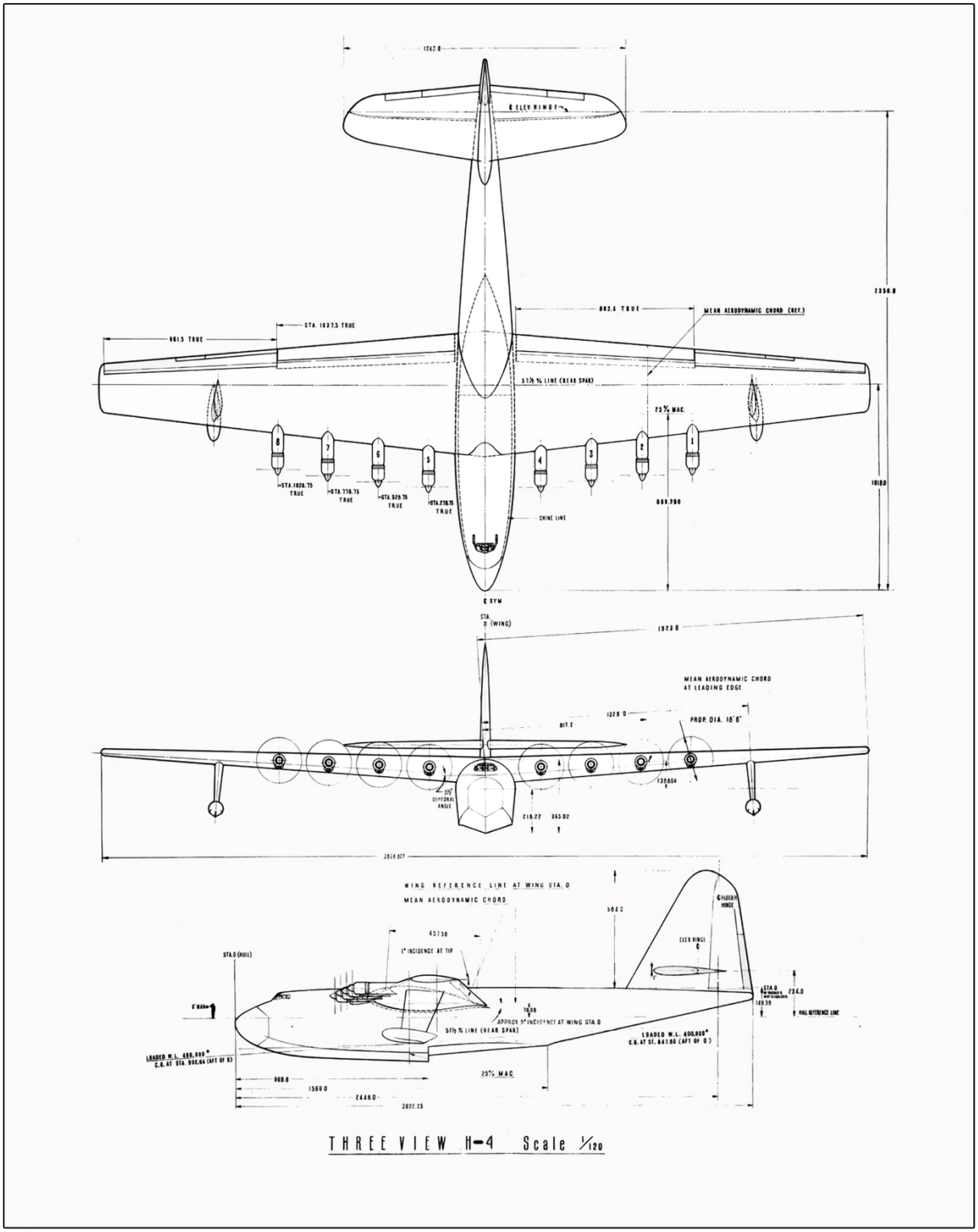
FIGURE 5



THREE VIEW DRAWING OF THE HK-1 FLYING BOAT, CIRCA 1942
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)	Name of Property
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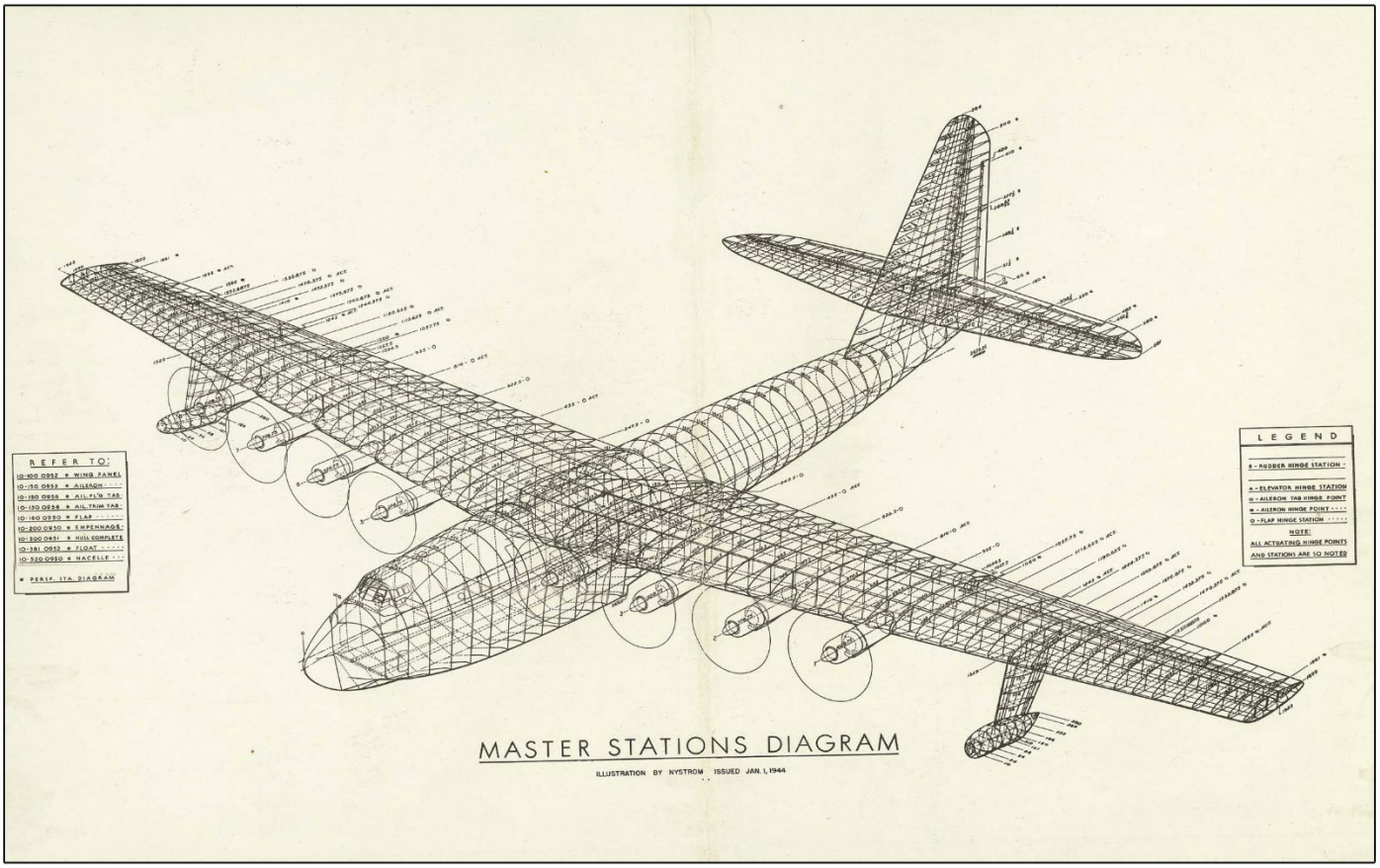
FIGURE 6



MASTER STATIONS DIAGRAM OF THE HK-1 FLYING BOAT
ENGINEERING ILLUSRATION DRAWN BY GODFREY NYSTROM, SEPTEMBER 11, 1943
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)	Name of Property
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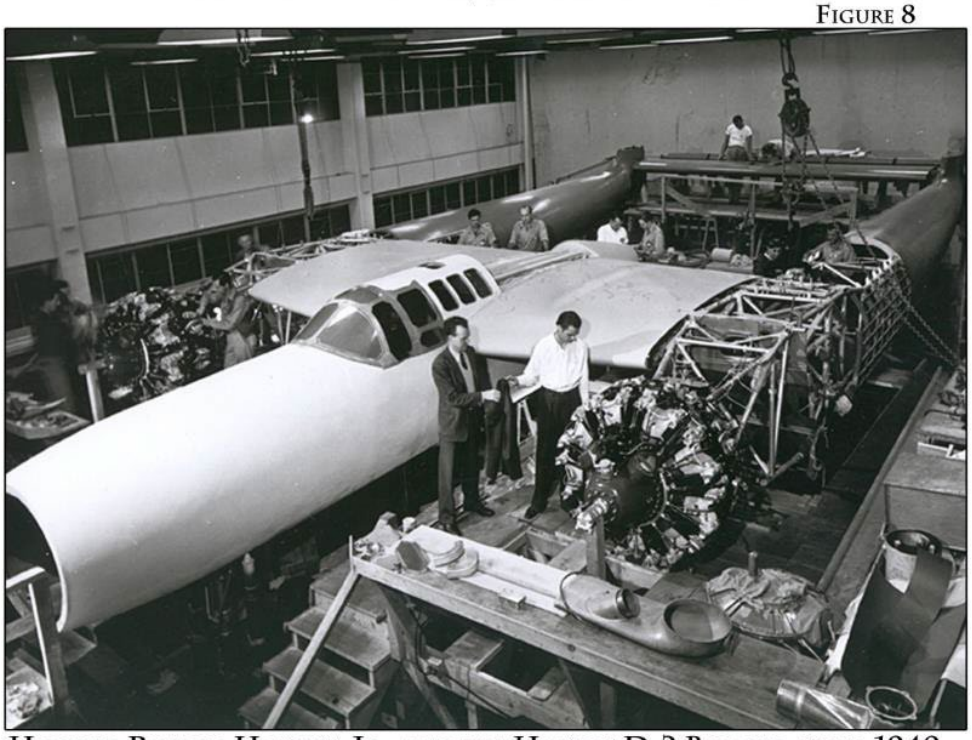
FIGURE 7

HOWARD ROBARD HUGHES, JR., AND THE HUGHES H-1 RACER, CIRCA 1935.
UNKNOWN PHOTOGRAPHER, LIBRARY OF CONGRESS IMAGE

FIGURE 8



HOWARD ROBARD HUGHES, JR., AND THE HUGHES D-2 BOMBER, CIRCA 1940.
UNKNOWN PHOTOGRAPHER, UNLV PHOTOGRAPH COLLECTION

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FIGURE 9

HOWARD ROBARD HUGHES, JR., AND THE XF-11 PHOTO RECONNAISSANCE PLANE, 1946.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 10

HOWARD ROBARD HUGHES, JR., PILOTING THE H-4 HERCULES, NOVEMBER 2, 1947.
UNKNOWN PHOTOGRAPHER
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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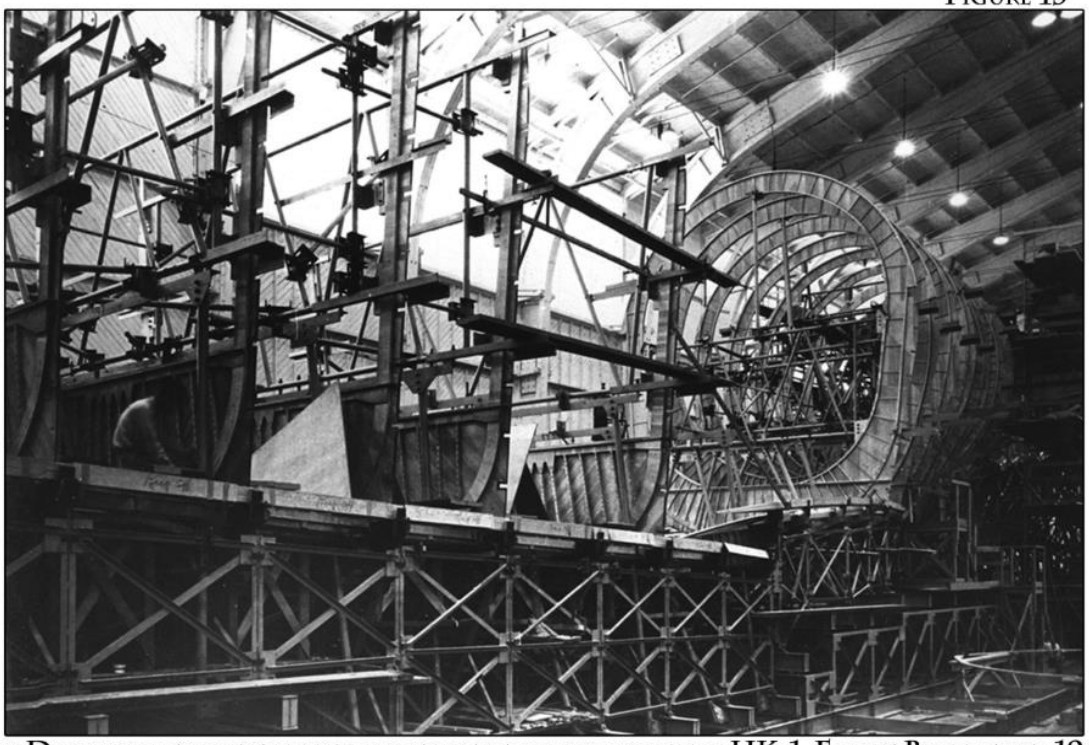
FIGURE 11

HUGHES' CARPENTERS CREATED DURAMOLD SHEETS (WOOD VENEER PLIES WITH GLUE) FOR SKIN
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 12

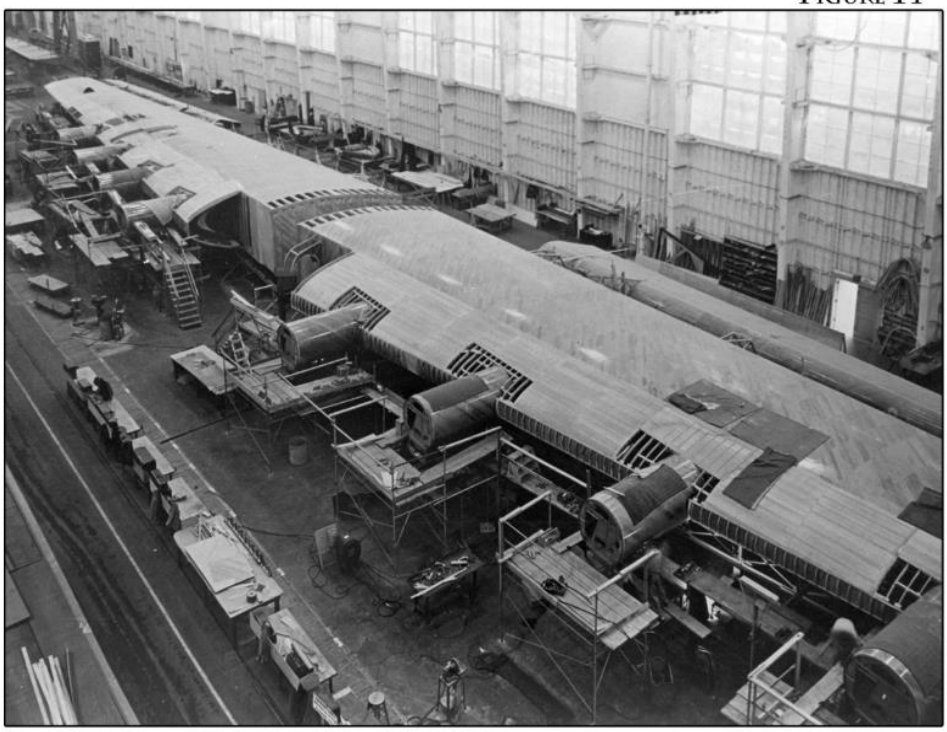
CARPENTERS CREATED DURAMOLD FORMERS IN VARIOUS THICKNESSES FOR THE HK-1'S FRAME, CIRCA 1944.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 13



THE DURAMOLD FORMS CREATE THE FUSELAGE FRAMEWORK OF THE HK-1 FLYING BOAT, CIRCA 1944.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 14



THE NEARLY-COMPLETE WINGS FOR THE H-4 *HERCULES* ARE MADE OF DURAMOLD, CIRCA 1945.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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FIGURE 15

THE H-4 *HERCULES* FUSELAGE MOVING FROM HUGHES AIRCRAFT IN CULVER CITY TO PIER E, LONG BEACH HARBOR, FOR ASSEMBLY, JUNE 1946.
BILL NEWMAN, PHOTOGRAPHER
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 16

ASSEMBLY OF THE H-4 *HERCULES*, PIER E, LONG BEACH HARBOR, CIRCA 1946-1947.
BILL NEWMAN, PHOTOGRAPHER
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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FIGURE 17

LAUNCH OF THE H-4 *HERCULES* INTO LONG BEACH HARBOR, OCTOBER 31, 1947
BILL NEWMAN, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 18

H-4 *HERCULES* TAXI TEST IN LONG BEACH HARBOR, NOVEMBER 2, 1947.
BILL NEWMAN, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE

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FIGURE 19

H-4 *HERCULES* FLIGHT OVER LONG BEACH HARBOR, NOVEMBER 2, 1947.
BILL NEWMAN, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 20

FLIGHT LOG

DATE	NATURE OF FLIGHT	No. of Pass.	TIME OF FLIGHT Up	TIME OF FLIGHT Down	TIME IN AIR Hours	TIME IN AIR Min.	Miles Flown	REPAIRS — ADJUSTMENTS — REMARKS	SIGNATURE	LICENSE NUMBER
11/2/47	FIRST TAXI RUNS				APPROX. 30 SEC.			AFTER SEVERAL TAXI. RUNS SHIP LIFTED ABOUT 25 FT. IN THE AIR.	H. C. Smith	68036-41
TOTALS FORWARD										
TOTALS TO DATE										

THE ONLY ENTRY IN THE HUGHES FLYING BOAT FLIGHT LOG BOOK, NOVEMBER 2, 1947.
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)	Name of Property
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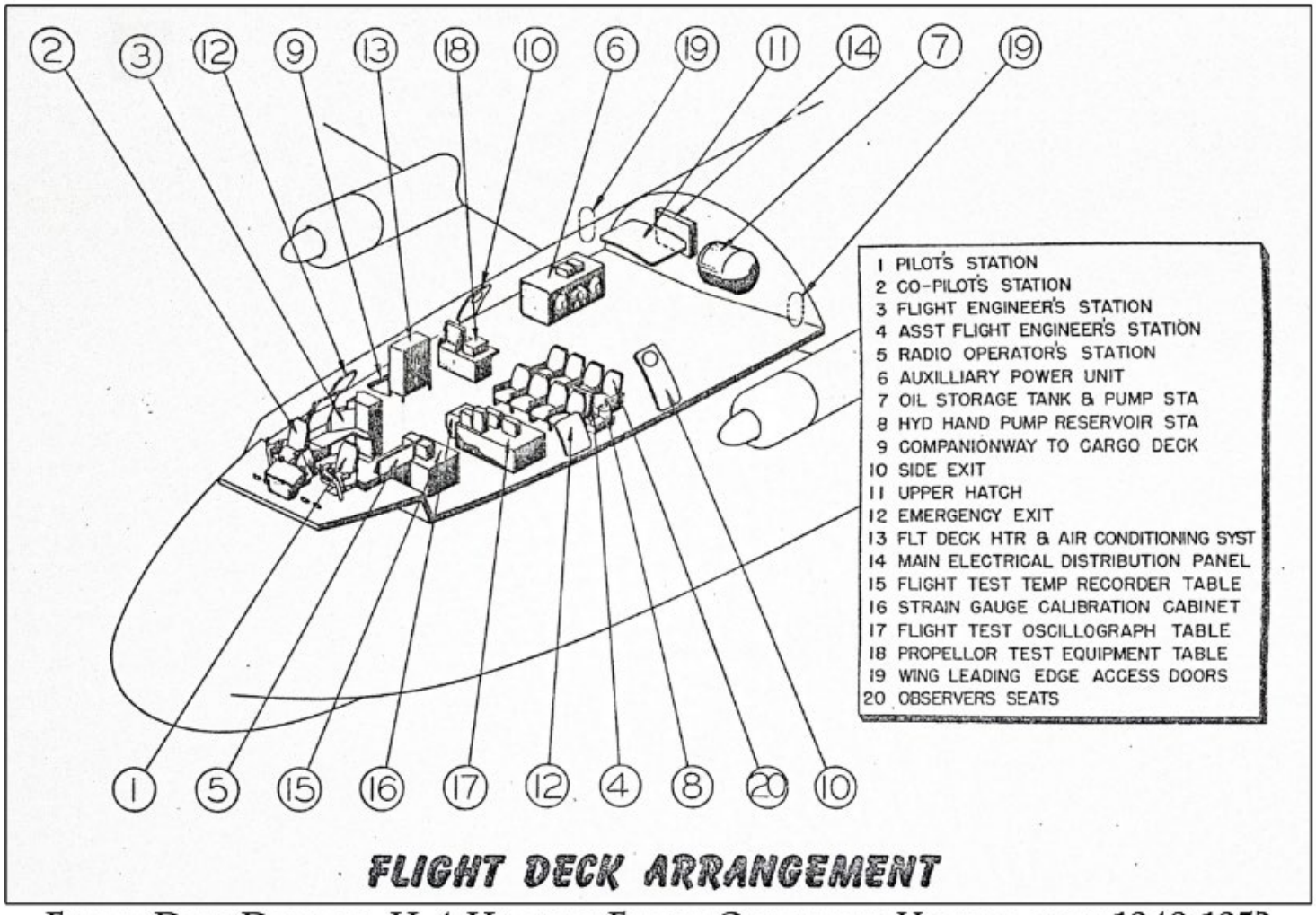
FIGURE 21



FLIGHT DECK DIAGRAM, H-4 *HERCULES* FLIGHT OPERATIONS MANUAL, CIRCA 1948-1952.
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)
Name of Property
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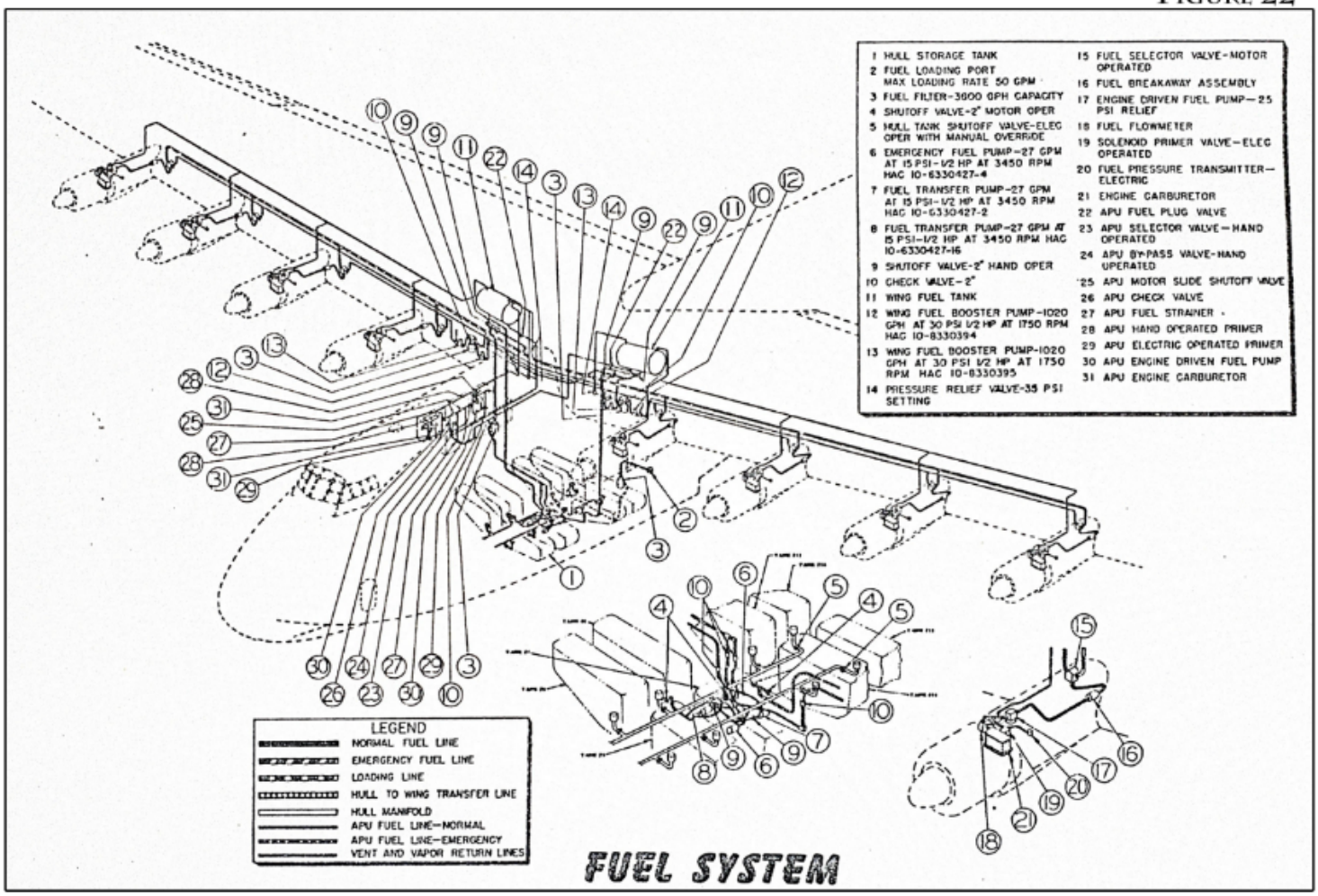
FIGURE 22



FUEL SYSTEM DIAGRAM, H-4 *HERCULES* FLIGHT OPERATIONS MANUAL, CIRCA 1948-1952.
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)	Name of Property
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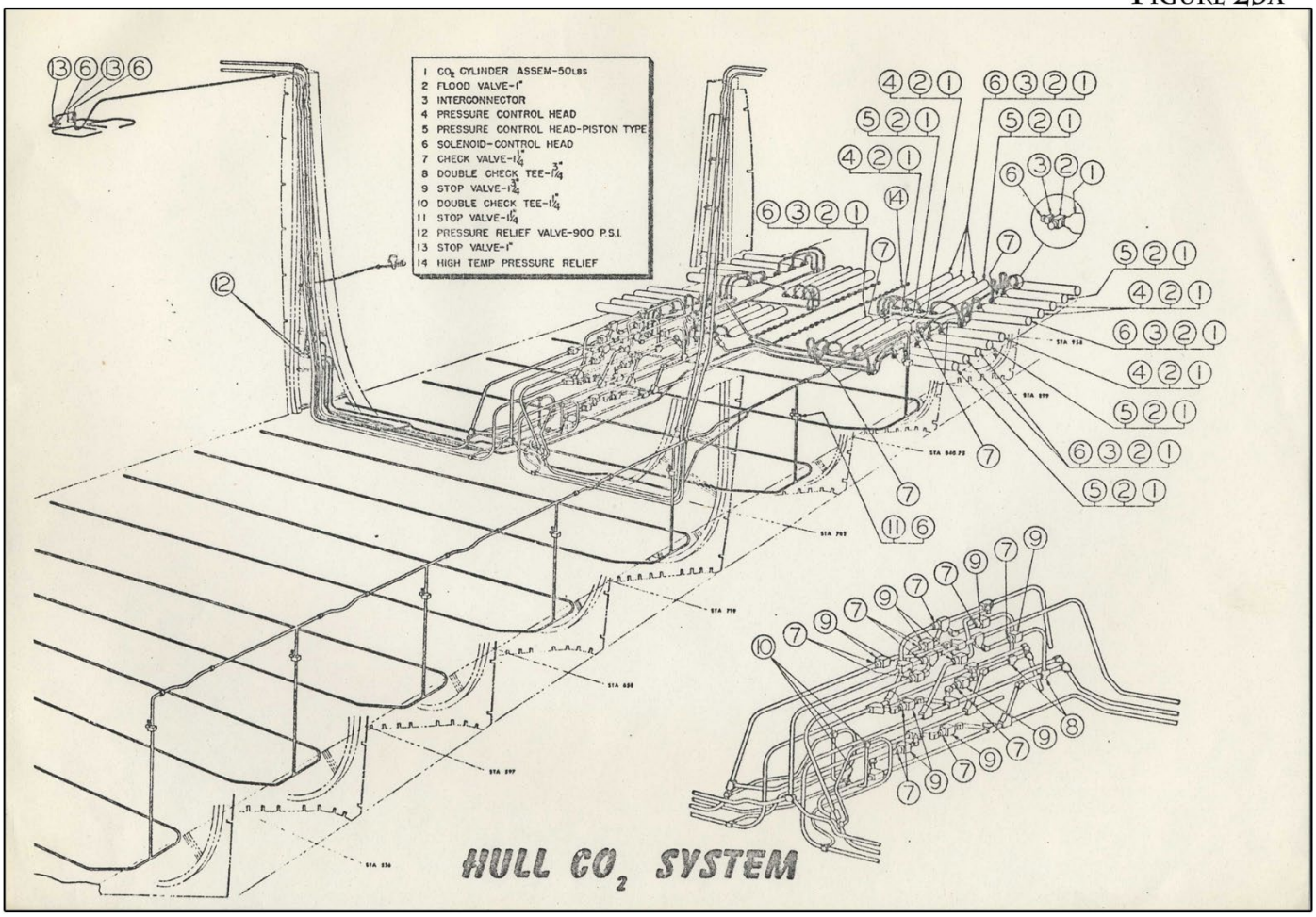
FIGURE 23A



THE H-4 *HERCULES* FUSELAGE / HULL CARBON DIOXIDE (CO2) DISTRIBUTION SYSTEM DIAGRAM.
H-4 *HERCULES* FLIGHT OPERATIONS MANUA, CIRCA 1948-1952
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM-

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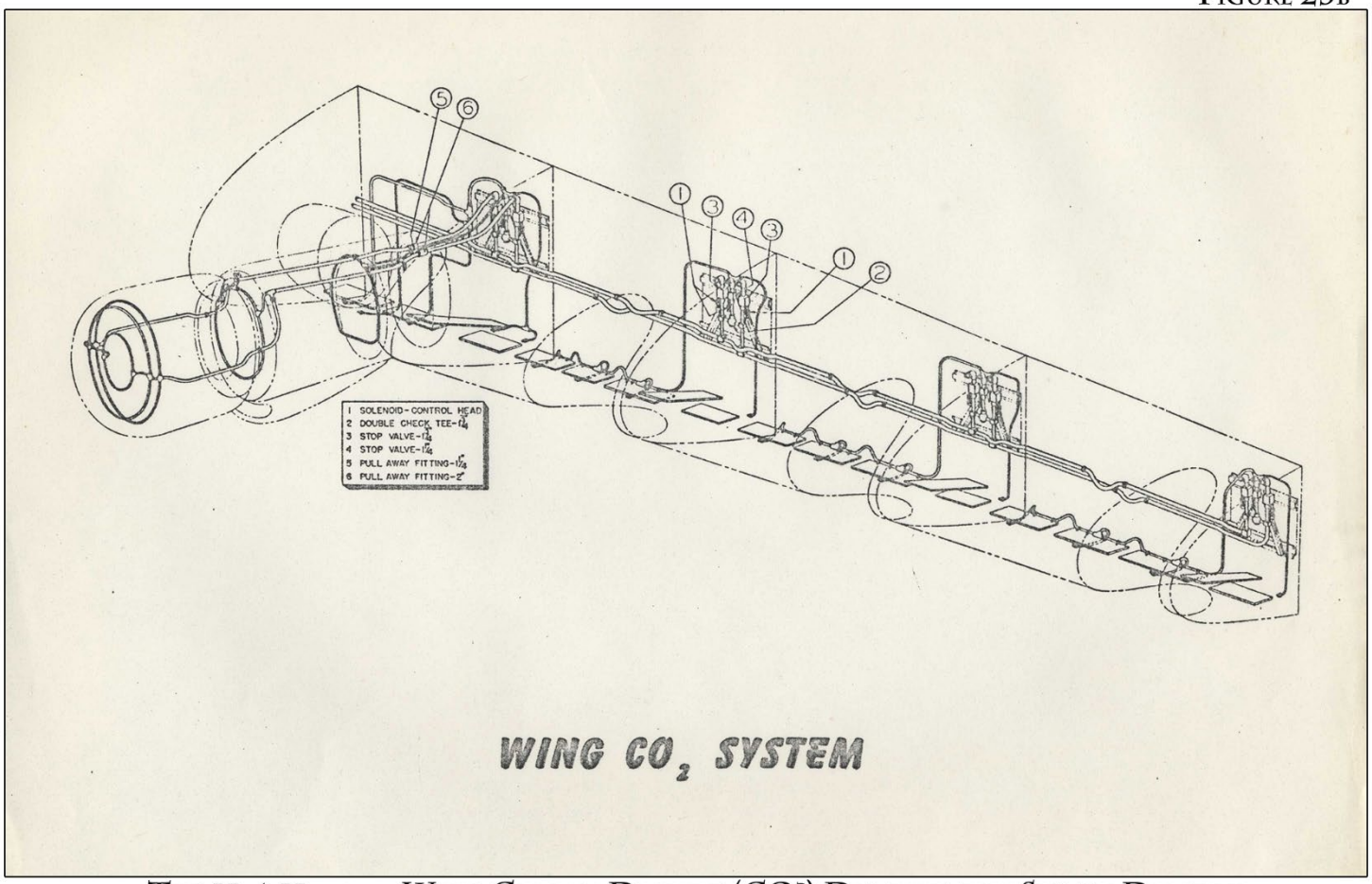
FIGURE 23B



THE H-4 *HERCULES* WING CARBON DIOXIDE (CO_2) DISTRIBUTION SYSTEM DIAGRAM.
H-4 *HERCULES* FLIGHT OPERATIONS MANUA, CIRCA 1948-1952
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM-

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Hughes Flying Boat (H-4 Hercules)	Name of Property
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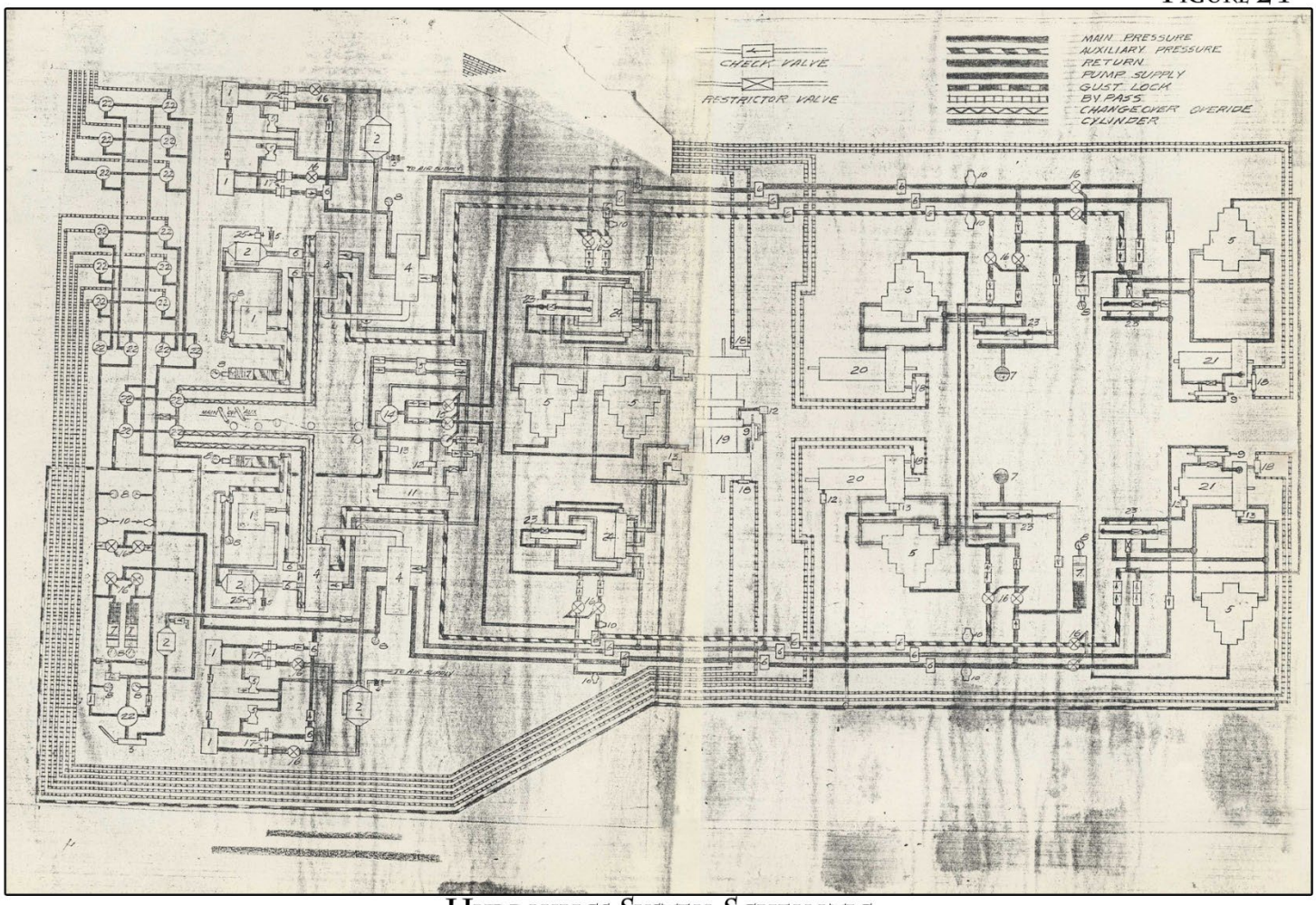
FIGURE 24



HYDRAULICS SYSTEM SCHEMATIC

H-4 *HERCULES* FLIGHT OPERATIONS MANUAL, CIRCA 1948-1952.
HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)
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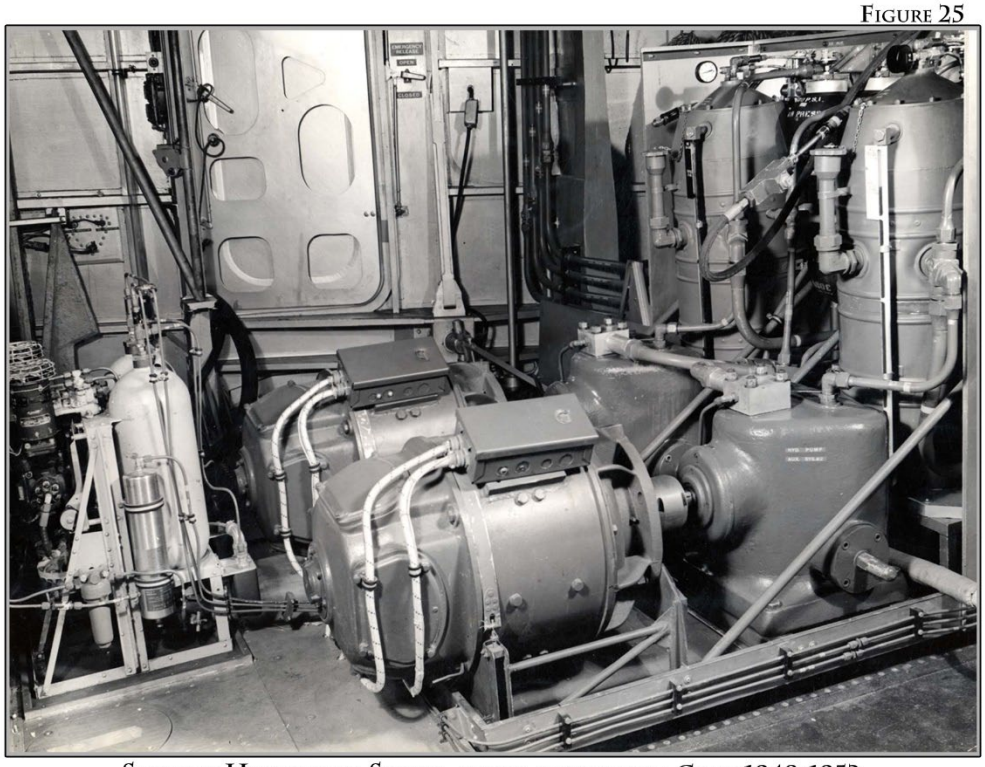
FIGURE 25



STANDBY HYDRAULICS SYSTEM, ADDED POST-FLIGHT, CIRCA 1948-1952.
UNKNOWN PHOTOGRAPHER. HUGHES FLYING BOAT ARCHIVE. EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 26

HOWARD HUGHES AT THE H-4 *HERCULES* PILOT'S CONSOLE, OCTOBER 31, 1947.
BILL NEWMAN, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)
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FIGURE 27

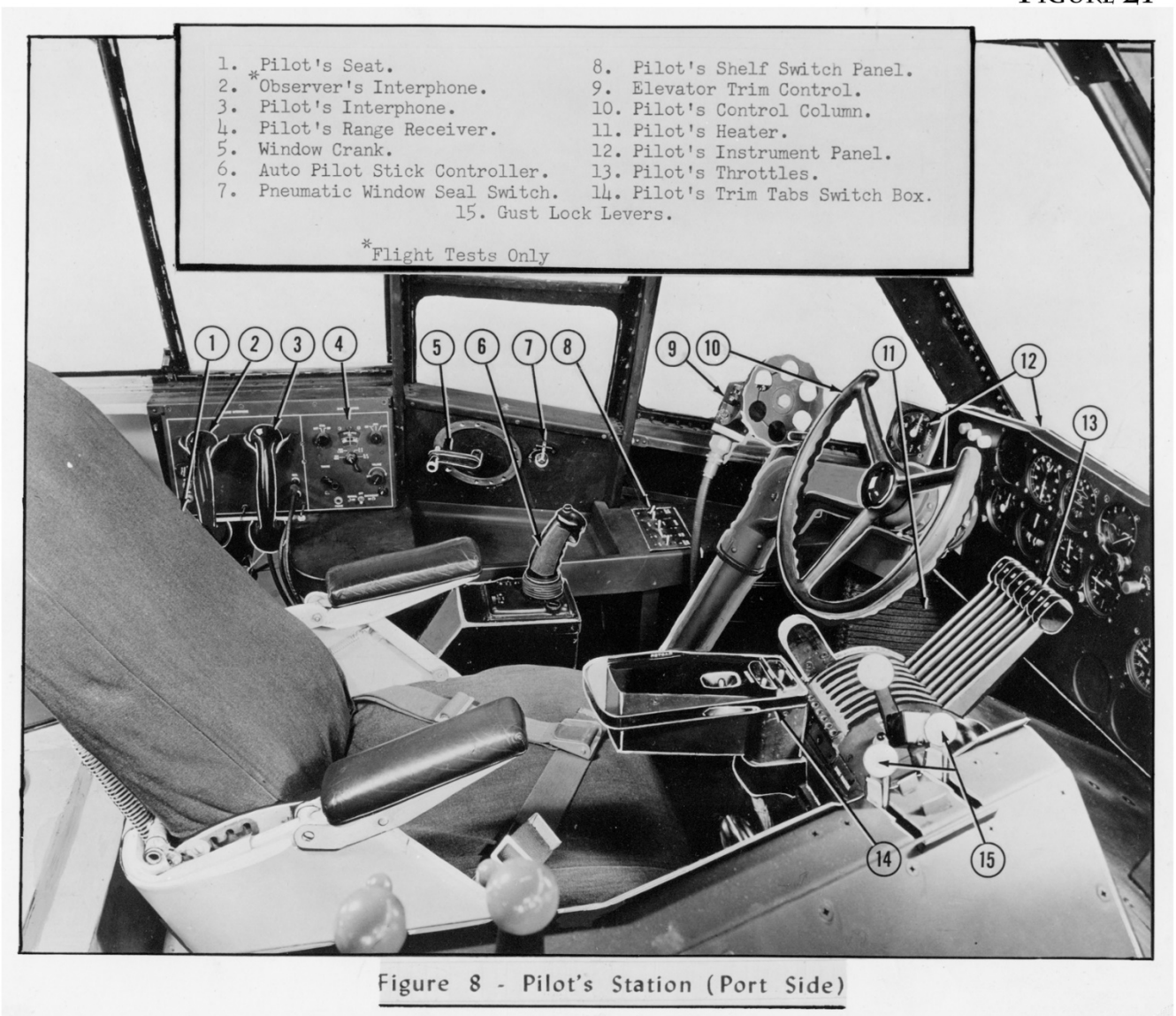
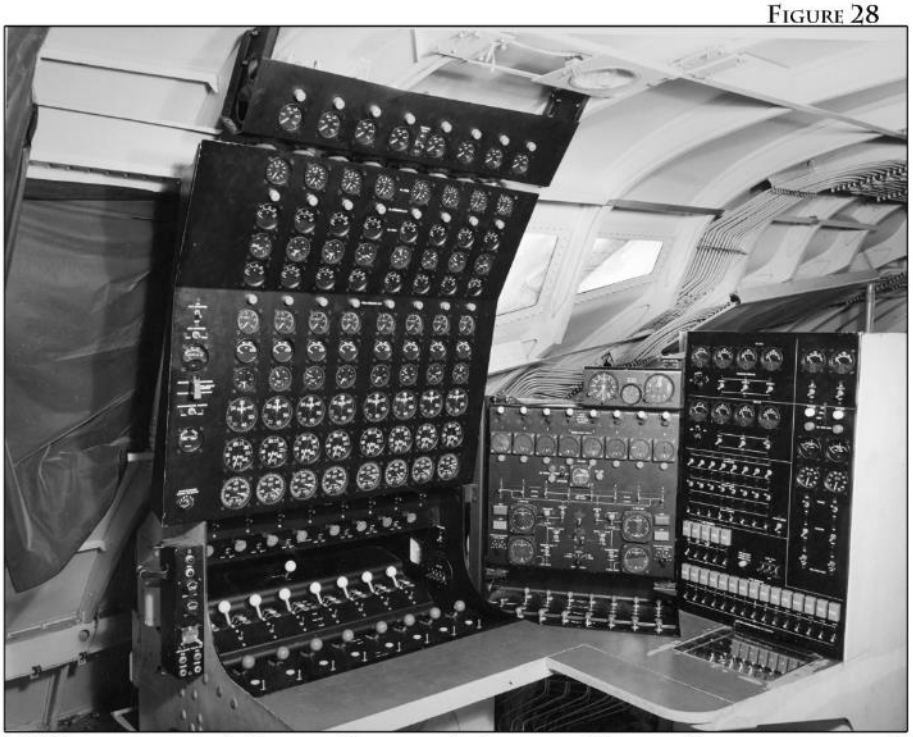


Figure 8 - Pilot's Station (Port Side)

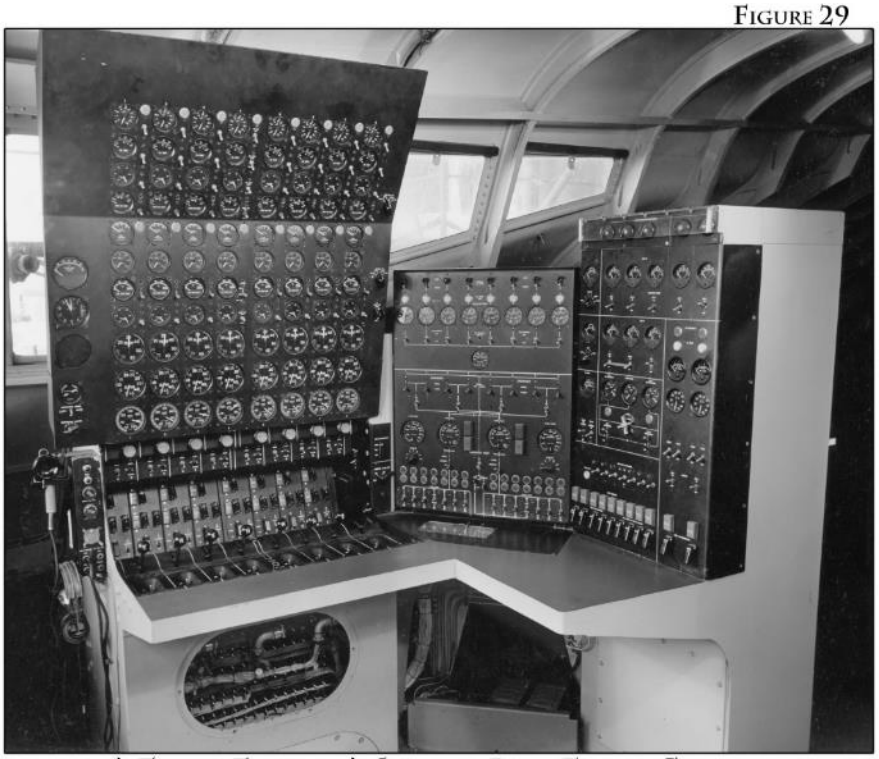
H-4 *HERCULES* PILOT'S CONSOLE, POST-FLIGHT CONFIGURATION, CIRCA 1948-1952.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 28



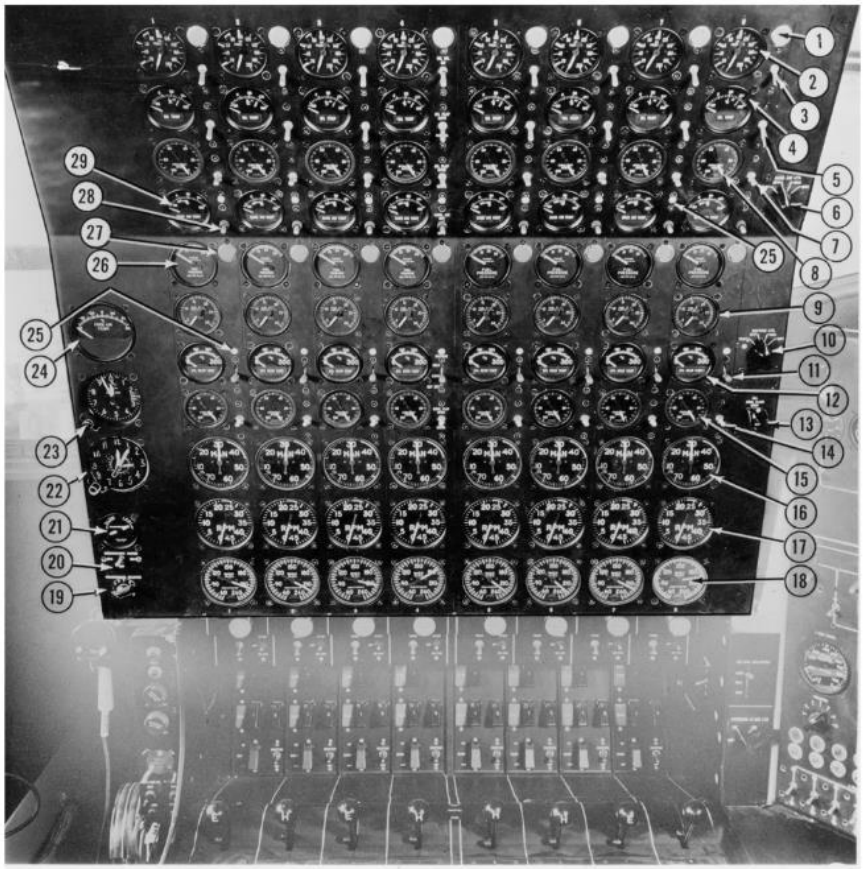
H-4 *HERCULES* PILOT'S FLIGHT ENGINEER'S STATION, FLIGHT CONFIGURATION, 1947.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 29



H-4 *HERCULES* PILOT'S FLIGHT ENGINEER'S STATION, POST-FLIGHT CONFIGURATION, CIRCA 1950.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 30



1. Low Oil Pressure Light
2. Oil Pressure Indicator
3. Oil Dilution Switch
4. Oil Temperature Indicator
5. Oil Flap Control Selector
6. Carb. Air Lamp Control Switch
7. Oil Flaps Control Switch
8. Oil Flaps Position Indicator
9. Fuel Flow Indicator
10. Mixture Lamp Control Switch
11. Mixture Control Switch
12. Cylinder Head Temperature Indicator
13. Cowl Flap Master Switch
14. Cowl Flap Control Switch
15. Cowl Flap Position Indicator
16. Manifold Pressure Indicator
17. Tachometer
18. Torque Indicator
19. Synchroscope Selector Switch
20. Synchroscope Master Selector Switch
21. Synchroscope
22. Clock
23. Altimeter
24. Outside Air Temperature Indicator
25. Neon Position Indicator Lamp
26. Fuel Pressure Indicator
27. Low Fuel Pressure Light
28. Carburetor Heat Control Switch
29. Carburetor Air Temperature Indicator

H-4 *HERCULES* FLIGHT ENGINEER'S LEFT SIDE PANEL, POST-FLIGHT CONVIGURATION, 1950.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION

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FIGURE 31

H-4 *HERCULES* ON EXHIBIT IN THE DOME, , 1982-1992.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 32

H-4 *HERCULES* - DISASSEMBLY OF THE WINGS, 1992.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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FIGURE 33

H-4 *HERCULES* - OREGON-BOUND, SHRINK WRAPPED FUSELAGE LEAVES THE DOME, 1992.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 34

H-4 *HERCULES* - IN GIANT PIECES, ARRIVES IN MCMINNVILLE, OREGON, FEBRUARY 27, 1993.
UNKNOWN PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)	Name of Property
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FIGURE 35

H-4 *HERCULES*-INSPECTION STAMPS, SIGNATURES DISCOVERED DURING FUSELAGE RESTORATION, 2000.
KATHERINE HUIT, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 36

H-4 *HERCULES* - FUSELAGE MOVE TO AVIATION BUILDING FOR REASSEMBLY, 2001.
KATHERINE HUIT, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

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Hughes Flying Boat (H-4 Hercules)
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Name of multiple listing (if applicable)

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FIGURE 37

H-4 *HERCULES* - WITH WINGS, ENGINES AND PROPELLERS, VERTICAL AND HORIZONTAL STABILIZERS ASSEMBLED, 2001.
KATHERINE HUIT, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 38

H-4 *HERCULES* - AILERONS RESTORED WITH NEW FABRIC SEWN ON BY HAND, 2001.
KATHERINE HUIT, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

United States Department of the Interior
National Park Service

National Register of Historic Places Continuation Sheet

Hughes Flying Boat (H-4 Hercules)
Name of Property
Yamhill Co., OR
County and State
N/A
Name of multiple listing (if applicable)

Section number Additional Documentation Page 60

FIGURE 39

H-4 *HERCULES* - AFTER INSTALLATION OF THE CONTROL SURFACES, TAIL CONE ASSEMBLY TOOK PLACE ON DECEMBER 7, 2001.
KATHERINE HUIT, PHOTOGRAPHER, HUGHES FLYING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

FIGURE 40

VIEW LOOKING NORTHEAST TOWARD THE COMPLETELY REASSEEMBLED H-4 *HERCULES*, SEPTEMBER 25, 2002.
KATHERINE HUIT, PHOTOGRAPHER, HUGHES FLYUING BOAT ARCHIVE, EVERGREEN AVIATION AND SPACE MUSEUM

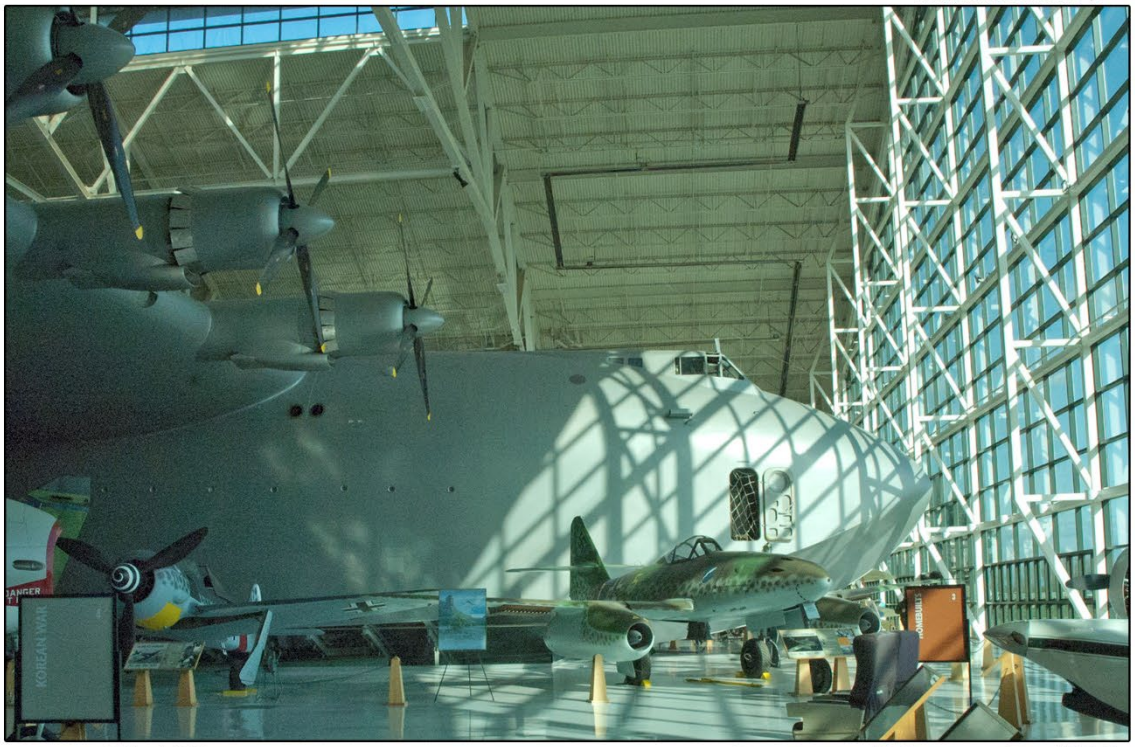
PHOTOGRAPH 1

NORTHWARD "RUNWAY" APPROACH TOWARD THE AVIATION BUILDING ON THE EVERGREEN AVIATION AND SPACE MUSEUM CAMPUS.

PHOTOGRAPH 2

WESTWARD LOOKING VIEW FROM THE AVIATION BUILDING'S EAST MEZZANINE TOWARD THE PORT SIDE OF THE H-4 *HERCULES*. NOTE THE CARGO ACCESS PLATFORM.

PHOTOGRAPH 3



THE NOSE OF THE H-4 *HERCULES* FACES SOUTH WITH THREE OF THE PRATT AND WHITNEY R-4360 ENGINES SHOWING ON THE STARBOARD WING, EACH FEATURING HAMILTON STANDARD PROPELLERS.

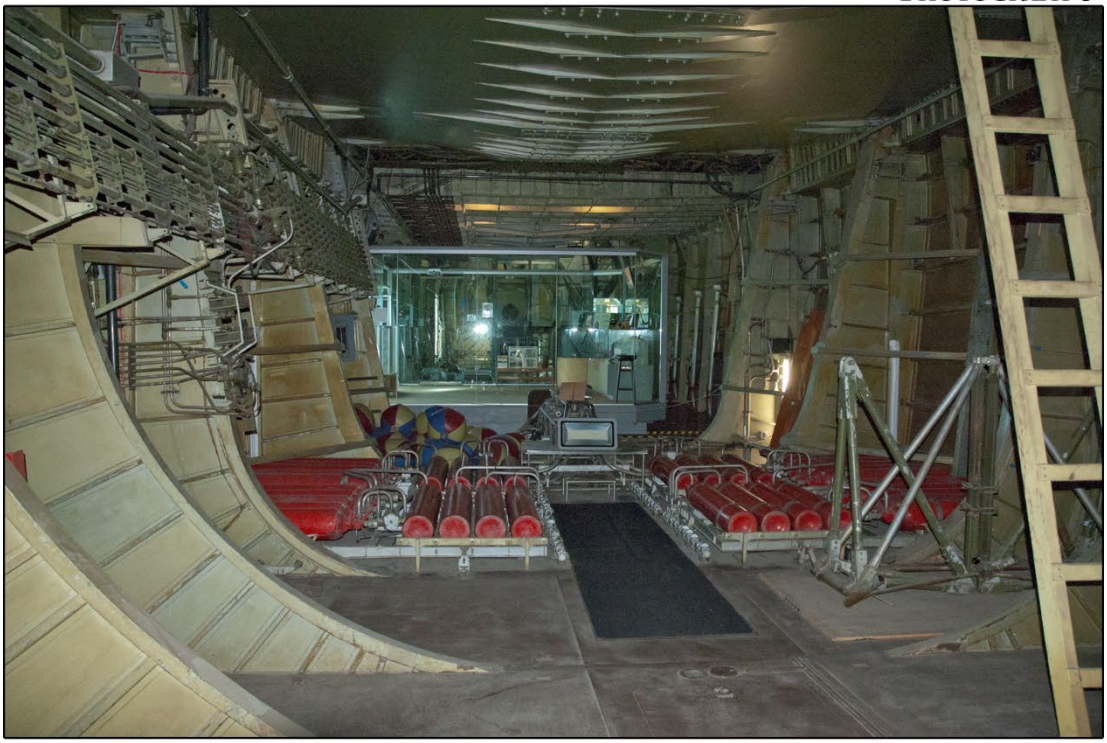
PHOTOGRAPH 4

LOOKING NORTHWEST FROM THE H-4 *HERCULES*' NOSE, NOTE THE SEAPLANE'S ANCHOR AND THE TWO WHITE EXIT DOORS (ONE IS BEHIND THE OTHER) NEXT TO A PRATT AND WHITNEY R-4360 ENGINE. IN 1980, DOME EXHIBITORS REMOVED THE TWO DOORS AND DURAMOLD SKIN FROM THE PORT SIDE OF THE FLIGHT DECK, REPLACING ALL WITH PLEXIGLASS FOR VIEWING FROM AN ELEVATED PLATFORM.

PHOTOGRAPH 5

THE H-4 *HERCULES* CARGO DECK, LOOKING AFT FROM THE VIEWING CUBE TOWARD THE SEAPLANE'S TAIL. THE WINGS COME TOGETHER AT TOP OF THE IMAGE, ACCESSIBLE BY THE LADDER AT THE CENTER, THE RESTORATION CREW DISCOVERED THE BEACH BALLS (LOWER RIGHT) IN THE PONTOONS. NOTE THE RED CO2 CANISTERS, WHICH ARE PART OF THE FIRE SUPPRESSION SYSTEM.

PHOTOGRAPH 6



THE H-4 *HERCULES* INTERIOR, CARGO DECK LOOKING FORWARD TOWARD VIEWING CUBE. NOTE THE 36 RED CO2 PRESSURE TANKS AT THE CENTER, AND THE HYDRAULIC TUBING TRAVELING DOWN ON THE PORT SIDE.

PHOTOGRAPH 7

PHOTOGRAPH 8

THE STANDBY HYDRAULIC STATION, LOCATED ON THE H-4 *HERCULES* CARGO DECK, NEAR THE NOSE. NOTE THE DURAMOLD FRAMEWORK OF THE NOSE, WITH ITS AGED SILVER-ALUMINUM PAINT DATING TO 1946-47 NOW A PATINA GREEN.

THE BATTERY CUTOFF STATION, LOCATED ON THE H-4 *HERCULES* CARGO DECK AFT OF THE STANDBY

PHOTOGRAPH 9

A SHORT, STEEP FLIGHT OF STEPS CONNECTS TO CIRCULAR STAIRS, CREATING A COMPANIONWAY BETWEEN THE CARGO AND FLIGHT DECKS OF THE H-4 *HERCULES*. THE COMPANIONWAY IS LOCATED ON THE STARBOARD SIDE OF THE SEAPLANE, IN THE FORWARD SECTION.

PHOTOGRAPH 10

ON THE FLIGHT DECK OF THE H-4 *HERCULES*, LOOKING SOUTHEAST TOWARD THE SEAPLANE'S PORT SIDE ARE OBSERVERS SEATS AND THE PLEXIGLASS VIEWING WINDOW INSTALLED FOR THE DOME EXHIBIT CIRCA 1982.

PHOTOGRAPH 11

THE 281-GALLON OIL STORAGE TANK, SITS JUST OUTSIDE THE PORT SIDE LEADING EDGE WING ACCESS DOOR, AFT, ON THE H-4 *HERCULES* FLIGHT DECK.

ON THE FLIGHT DECK, AFT CENTER, IS A LADDER THAT ASCENDS TO THE DOCKING ELEVATOR, WHICH ENABLED PERSONNEL TO SUPERVISE DOCKING AND MOORING OF THE H-4 *HERCULES*. NOTICE THE ELECTRICAL DISTRIBUTION PANEL TO THE LEFT OF THE LADDER.

PHOTOGRAPH 12

PHOTOGRAPH 13

THERE IS AN EXIT DOOR ON THE H-4 *HERCULES* FLIGHT DECK, LOCATED ON THE STARBOARD SIDE BETWEEN THE AUXILIARY POWER UNIT AND THE PROPELLER TEST STATION THAT IS IDENTICAL TO THAT REMOVED FOR THE PLEXIGLASS VIEWING WINDOW ON THE PORT SIDE.

LOCATED ON THE H-4 *HERCULES* FLIGHT DECK PORT SIDE, THE FLIGHT TEST OSCILLOGRAPH STATION SITS FORWARD OF THE FLIGHT TEST STRAIN GAUGE AND TEMPERATURE RECORDING STATIONS.

PHOTOGRAPH 14

PHOTOGRAPH 15

THE FLIGHT ENGINEER'S STATION IS AFT OF THE CO-PILOT'S POSITION ON THE STARBOARD SIDE OF THE H-4 *HERCULES'* FLIGHT DECK.

KATHERINE HUIT, PHOTOGRAPHER, MARCH 15, 2023

PHOTOGRAPH 16

THE ASSISTANT FLIGHT ENGINEER'S STATION IS LOCATED ON THE PORT SIDE OF THE H'4 *HERCULES'* FLIGHT DECK, IN THE SECOND ROW OF THE OBSERVERS SEATING.

KATHERINE HUIT, PHOTOGRAPHER, MARCH 15, 2023

PHOTOGRAPH 17

LOCATED ON THE H-4 *HERCULES* FLIGHT DECK, PORT SIDE, AFT OF PILOT'S POSITION, THE RADIO OPERATOR'S STATION FEATURES A MORSE CODE TELEGRAPH KEY IN FRONT OF THE PANEL, TO THE RIGHT.

PHOTOGRAPH 18

THE PILOT'S (LOCATED ON THE PORT SIDE) AND CO-PILOT'S (LOCATED ON THE STARBOARD SIDE) POSITIONS SIT ABOVE THE H-4 *HERCULES* NOSE ON THE FLIGHT DECK.