

Howard Hughes' Efforts to Preserve the **SPRUCE GOOSE**

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The Beginning—For over 35 years a small guarded plant at the Long Beach Harbor maintained Howard Hughes' Spruce Goose.¹ Few people ever saw the inside of the complex, and many of the employees who worked there never entered the specially constructed hangar to see the aircraft. Secrecy regulations were so stringent that employees could not discuss their work with even their immediate families. After the death of Hughes in 1976 and when the hangar and plant had

to be destroyed in 1980, the Summa Corporation,, its owners, permitted historians to examine the plant records. Through these they found out how the H-4 had been maintained and tested and what daily life inside of the plant walls had been like. Upon entering the hangar they saw the supporting members of an extraordinary structure cantilevered out over the nose of the Flying Boat for 155 feet and front doors designed to open up to a span of 342 feet for launch. Importantly, they met the engineers who created the unique complex, men who knew Hughes and worked with him on the tasks he loved and held vital. The engineering solutions reached then to ensure the security and preservation of the wooden plane may have been overshadowed by more recent breakthroughs; yet, the difficult assignments Hughes gave his engineers and their fulfillment were landmarks in their time. This article treats with the Hughes Long Beach plant and the men who stood behind its design and function.

The study also contributes to what is known of Mr. Hughes. A biographer once noted that Hughes never had a plan for his life and that it was a good demonstration of the proposition that most human lives are never planned but merely ricochet from one thing to another.² Hughes did have diverse interests; further, at least two popular biographies have stressed his other work or his latter and less productive

Sections of the first hangar, designed with Ronney tubular structures and canvas siding, were simply lifted off when the plane was launched.
(Port of Long Beach Photo)



years.³ Hughes' devotion to flight began early and outlived all of his creative obsessions. An account of how he managed to preserve the Flying Boat and the recollections his engineers had about him make a convincing case for a life continuously dedicated to aviation advancement.

Hughes made his first flight in an amphibian aircraft, learned to fly while a teenager, and by 1934 had his own plane and personal mechanic, Glenn Odekirk. Odekirk told him he would never be satisfied until he built his own plane from scratch, and with this in mind the two found a hangar at the Glendale Airport and called it the Hughes Aircraft Company. Hiring two young aeronautical engineers just out of the California Institute of Technology where Hughes had taken classes, the company began design on the H-1, a single-engine racer. Hughes flew this plane to break all landplane speed records. The company then modified a Lockheed Model 14, and Hughes flew it to break the round-the-world speed record in 1938.⁴ At the same time, Hughes tested a Sikorsky amphibian doing personal research on water takeoffs and landings. When the military became interested, he installed larger engines at their request; and since he tested every plane he ever built or modified, he took the Sikorsky to Lake Mead in Nevada for final tests. The nose-heavy plane crashed while landing and sank in water over 200 feet deep killing two passengers. Hughes had the craft raised, put into flying condition, and stored in a locked hangar.⁵ It never flew again, but it had served as a valuable experience in flying boats. The Hughes Aircraft Company moved to Culver City where Glenn Odekirk found a good tract of land in 1941. There Hughes manufactured thousands of machine gun chutes, but the first firm contract for a government plane did not come in until 1942 when the company, then a division of Hughes Tool Co., agreed to build three giant flying boats.⁶

Behind this contract lay the fact that German submarines were sinking allied merchant shipping and troop carriers at such a rate that avoiding these losses appeared to be one of the war's prime problems. Henry J. Kaiser, a major shipbuilder, commented publicly that he guessed he would have to put wings on his boats. Glenn Odekirk heard this, contacted Kaiser, and also advised Hughes that the plant had about 200 engineers who had been working on a wooden plane but had finished the project. Hughes and Kaiser reached an agreement whereby Hughes would design the aircraft while Kaiser would build it at one of his shipyards. The two signed a contract with essentially this agreement on November 16, 1942, with the U.S. Government's Defense Plant Corporation. It authorized construction of three flying boats for test purposes. The flying boats were to be built with no more than \$18,000,000 of the government's money and to be delivered in two years, but design went slowly. In 1943 when the first of the production models, the HK-1, was to have been delivered, Hughes Aircraft had just begun work on the hull of the wooden prototype. The United States was winning the war, had minimized the Nazi U-boat threat, and the need for a cargo plane receded. Kaiser saw no future for the mass production of flying boats and withdrew from the contract in 1944. Hughes completed the plane, redesignated the H-4, at his own expense.⁷

Searching for a Site—It is not entirely clear when the problem of finding a site for assembly and launch fell to the



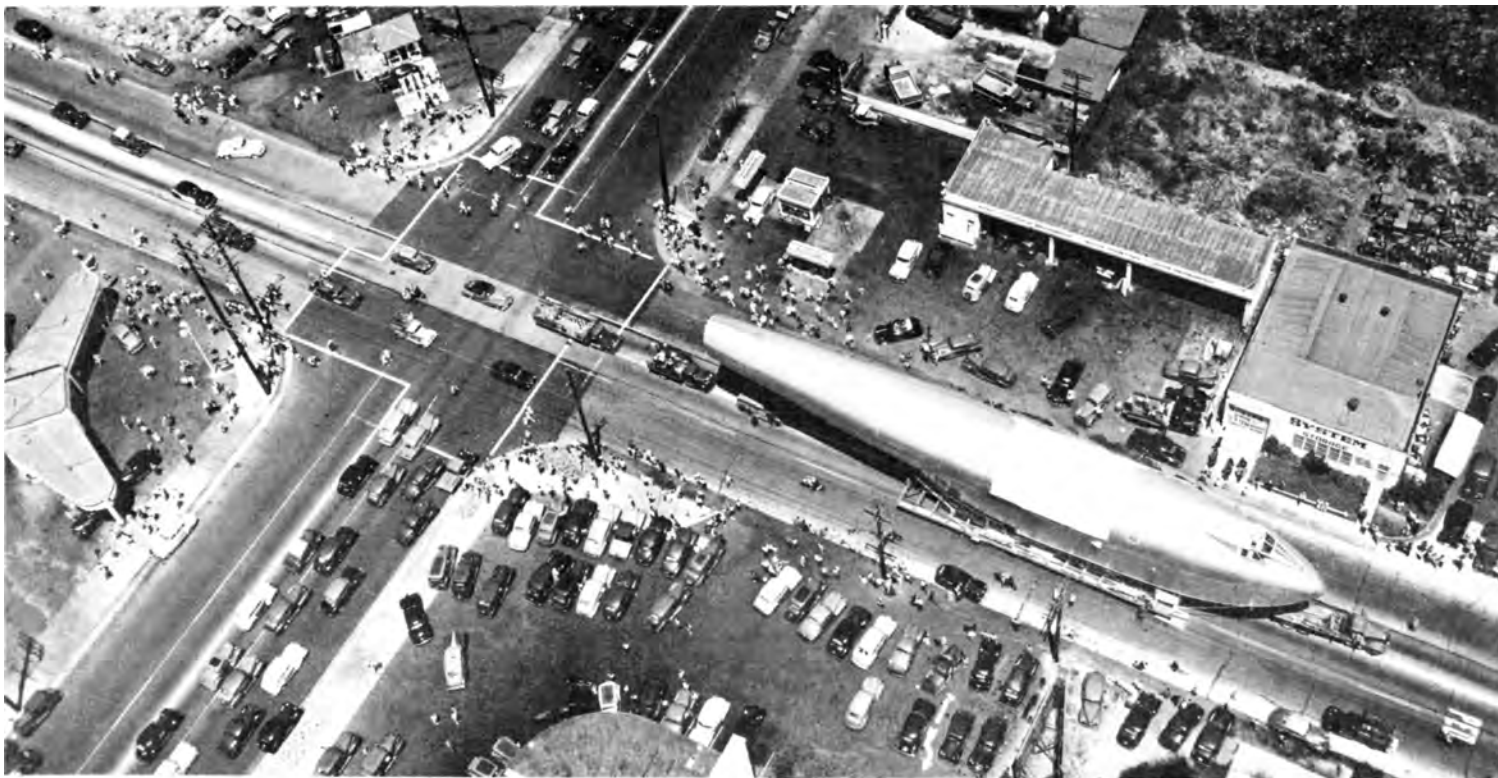
View of the hangar site before the beginning of operations by Atkinson Company, February 5, 1946. Harold Tegart, Hughes Aircraft Co. Collection)

Hughes engineers. According to Rae Hopper, chief engineer for the H-4, the original plan for launching was that they would simply move the plane on its cradle to the ocean near the Culver City plant and slide it into the water. However, as the design work progressed, the concept changed to that of a very large aircraft, larger than any ever constructed. Hopper recalled that they all began to wonder just where they were going to launch it.⁸

The plant facilities engineer, Harold Tegart, was called on to search out a site, and once it was found he was assigned a series of responsible tasks such as arranging for the move, for the launch, and for building a hangar over the large plane. He had come to work for Hughes in 1941 with only two years of engineering study at UCLA having left school due to the Great Depression. After selling floor waxers, he hired on at Hughes for a minor survey job; however, by studying at night he was soon able to plot new plant sites, design buildings, and lay out runways such as the 9,000-foot turf strip at Culver City.⁹ His energy and ingenuity made him the kind of engineer Howard Hughes could call upon at any hour of the day or night to assign specifications for a new project and to ask for unprecedented solutions.

Tegart was a part of the team who worked on the Flying Boat project in Culver City. He contributed to the design of the Cargo Building where the H-4 components were built, a wooden building covering eight acres of land. He was involved in plans to launch the H-4 onto Ballona Creek, and in alternate plans to construct a separate new channel from the plant to the shore. When these plans were abandoned Hughes asked Tegart to search southward where he considered the Manhattan, Hermosa and Redondo Beaches and several berths at the San Pedro Harbor.¹⁰ In January 1944 he came upon a workable site on Terminal Island in the Long Beach Harbor and plotted it out for Mr. Hughes. It consisted of 7.2 acres of shore property at Berths 120 and 121 on Pier E and a controlled water space for testing and launching adjacent to it.¹¹ The acreage lay on the channel leading from the Long Beach Middle Harbor to the Inner Harbor and could be serviced by access roads and bridges that would carry the loads and provide the clearance needed when the plane parts would be moved there.

Negotiations on the lease went forward with Port Manager



Hughes Flying Boat hull being transported by Star Movers from Culver City to the Long Beach plant on June 16, 1946.

(Courtesy Harold Tegart, Hughes Aircraft Co. Collection)

E.J. Amar who pointed out the protection Hughes Aircraft could expect both from the older breakwater at the outer harbor and from the new Navy mole then under construction. Landfill for Pier E had yet to be completed, but Amar argued that the port's contractors could commence work immediately by building up existing submerged dikes. They would then place a hydraulic fill of dredged mud and rock from the harbor floor behind them.¹² With Hughes' approval, Tegart completed negotiations for a two-year lease with an option for three additional years which company executives signed in September 1945. Mr. Hughes did not draft, initial, or sign correspondence, notes or legal instruments concerning the Long Beach plant. In fact, documents there contained only a few scattered references to the things Mr. Hughes had actually said.¹³ According to the men who dealt with him and those interviewed for this research, Hughes kept what he knew in his head and discussed matters openly with his managers and engineers. His instructions at the plant were transmitted verbally to company officers like Rae Hopper and then passed on.

Preparation of the Site, the Move, Assembly, and Flight-

Having found a site, Harold Tegart spent 1945 designing for the final assembly of the Flying Boat scheduled to be carried out there. He first got together a list of all the needed facilities such as housing for the hydraulic, electrical and engineering departments. He indicated protective cover for wood, veneer, paint and tools, and about 36 employees.¹³ A contractor to build the dry docks for the hull and wing floats would come on the property first. A wooden graving dock had been considered adequate with steel sheet pilings around it since the whole thing was intentionally designed as a temporary launch site. However, the dock's susceptibility to maintenance problems caused Tegart to decide on a series of three reinforced concrete dry docks: one for the body of the Flying Boat and two additional for the wing floats. He proposed that

the contractor dewater the area by well points placed around the dock area and hooked to a manifold and pumps to intercept seepage from the ocean. The contractor would excavate for the main dock and the two auxiliary float slips by drag line but leave an embankment between these docks and the ocean for protection during construction. The embankment and well points would be removed after the three gates were installed. Experts from the Navy and from Pan American Airways studied his plans and concurred.¹⁴

Guy F. Atkinson Company contracted for the work and had their equipment, construction sheds and office on the lease January 31, 1946.¹⁵ Weather permitting, the dock was to be ready in 90 days to receive the hull of the Spruce Goose. Harold Tegart recalled driving out to the site that January day, parking his car on the flat land, and walking around. He returned to his car to find the wheels almost out of sight and the auto's body resting on the ground. An Atkinson Co. tractor came over to pull him out, but it too bogged down. Finally, a cable attached to a distant crane pulled him free.¹⁶ In addition to this hazard it was well known that the whole area was subsiding at a rate of an inch a month due to oil and gas removal from underground. Yet, pumping continued, and in 1946 no solution was in sight. Historical photographs illustrate the progression of work on the dry docks showing excavation at its final depth. Above ground and along the horizon stood a virtual forest of oil well derricks, reminders of the ongoing subsidence.¹⁷

Mr. Hughes wanted a 155,400-gallon standby water tank for fire protection on the property before any of the plane's parts arrived. He had built his first wooden plane, a long-range medium bomber called the D-2, in Glendale in the late

1930s. One night while it was still undergoing tests, lightning hit its hangar destroying the plane and a million dollars' worth of research. Thus, fire prevention had high priority at the Long Beach plant.¹⁸ The machine shop and utilities were in and the paving completed so as to make the new plant ready for the plane by the end of August.¹⁹

Hughes Aircraft issued no press releases; nonetheless, on January 14, 1946, the *Long Beach Press-Telegram* had carried a small article which read, "A graving dock from which the huge flying cargo boat of the near future will be launched for their trips to the South Pacific, will be erected at Long Beach." In March, for lack of any recent releases from the then closed-down public relations office at Hughes Aircraft, the *Los Angeles Evening Herald Express* carried a picture of the immense Cargo Building at the Culver City plant where, it reported, crews worked around the clock on the "\$20 million mystery." The *Express* printed that it would cost \$2,000,000 to move the plane down to Long Beach.²⁰

Concurrent with the site work, Tegart went ahead with plans to move the H-4 to Terminal Island. Of the component parts, the hull of the ship was the primary height problem. It was over three stories high in travel, would intercept over 2300 wires, and interrupt the power and communication overhead line facilities of 21 different companies. Tegart assembled representatives of all the companies and hosted a bus trip over the most feasible route, obtained cost estimates, and got the approval of Mr. Hughes. However, orders to proceed with the move did not come for nearly a year. Even with the delay 20 of the companies claimed they could meet the new schedule; but Mr. Heath representing the Edison Company declared they would need a year or more to reassemble their necessary personnel. This was not the kind of a setback Mr. Hughes would accept, and especially when he had his personnel working 24 hours a day on the Flying Boat. Edison Company high tension facilities held up the entire job since their wires had to be lifted before the lower wires could be taken off. Tegart looked into state regulations, found that since all the lines were over public streets he could hire an independent contractor, and reported back to Mr. Heath. With this point of leverage, Edison stepped in to remove their own wires, on time.²¹

Star House Movers made a bid of \$16,970 to move the Flying Boat, but the Hughes people had to plan and coordinate the move in such a manner that from the time the wings and hull left the Culver City plant until they reached Terminal Island there would be no delays except for the planned overnight stop. The wing component parts were 55 feet wide by 160 feet long and were loaded and moved on June 11 and 12. The hull had not been designed to withstand the wracking and twisting of ground travel, so Tegart devised a three-point support for the cradle. The H-4 was moved on June 15 and 16 when there was a full, high tide to support the floating pontoon bridge which crossed the channel between the Long Beach mainland and Terminal Island. After the hull was towed over the bridge and by road to the end of Pier E, it was taken down a ramp into the dry dock. At this level the wings could be mated and attached with a minimum of lift distance. Watertight gates held the harbor water from entering the dock.²² June photographs show the plane assembled with scaffolding built up to the top of the 92-foot-high fin,

around the nose, and by each engine nacelle.²³

During final assembly Howard Hughes called on Tegart to discuss a secure procedure for launching the plane from its drydock into free water and retrieving it back into its drydock. The hull still rested on a steel fabricated cradle, but it had to be modified for the launch and for any accidental flooding of the dock should the drydock gates be damaged or sabotaged. Water entering the drydock would lift the Flying Boat first in the front (putting it into trim) and shift almost all of the weight onto the rearmost bulkhead crushing it and wrecking the plane. Tegart solved this by designing independent steel beams to replace the six rear cradle supports, beams that could be lowered out of the way by hydraulic plungers when the plane was fully afloat.²⁴

Less than a month after the parts arrived on Pier E, on July 7, 1946, Hughes took his newly completed XF-11, an experimental twin-engine photo-reconnaissance plane with counterrotating propellers, on a test flight. During the flight the rear four blades of the right propeller suddenly changed into reverse pitch veering the plane violently to the right. Hughes crash landed into some houses in Beverly Hills and suffered multiple injuries. He hovered near death, then slowly recovered.²⁵ Glenn Odekirk stayed with him at the hospital and recalls the many things he did for Hughes. In particular, Hughes did not want to take the drugs his doctors had prescribed and suggested to Odekirk, "Let's just cut it in half."²⁶ In September of 1946 Hughes was again flying his personal plane, a converted B-23 bomber. He made it clear that no physical problem stemming from the accident would hold up completion or flight of the H-4.

Meanwhile, at the Long Beach plant, assembly and testing continued on the H-4, but flight readiness was still considered a year or two away. Hence, Tegart was told to design a temporary hangar. Hughes Aircraft had previously worked with a company that manufactured Ronney Tubular structures; so the Hughes engineers designed a hangar using their



Flying Boat hull crossing over the channel to Terminal Island on the Navy pontoon bridge, June 16, 1946.

(Courtesy Harold Tegart, Hughes Aircraft Co. Collection)

materials and completed with canvas siding. Rather than design doors to open when the plane was to be taxied out, several sections of the truss and stanchion structure were simply lifted off with a crane. The hangar was shaped to conform to the configuration of the hull, wings, empennage and nose.²⁷ By early 1947 a control tower had been installed on top of the water tank and a regular fleet of boats attended the launch site.²⁸

The Hughes Aircraft Company had close to \$60 million in war plane contracts in 1947; and that summer Senator Owen Brewster, chairman of the Senate Investigating Committee, attempted to discredit the then Democratic administration by claiming that persons close to the administration had taken bribes from the Hughes company. After five days of testimony Howard Hughes abruptly left his California office, walked out to his plane, and flew to Washington. There he impressed the committee and the audience with his intellect, independence and honesty. He placed Brewster on the defensive when he revealed that Brewster had come to Hollywood and said that the hearing would be called off if Hughes, who then owned Trans World Airline (TWA), would agree to a merger of TWA and Pan American Airways so as to form an airline similar to Air France or Lufthansa. At the close of the hearings, Brewster charged that the H-K 1 lumberyard would never fly. Hughes replied that he would leave the country if it did not and further disclosed that he had spent \$7,200,000 of his own money on it. The hearings recessed until November, while Hughes-for-President Clubs sprang up around the country.²⁹ As a result Hughes returned to Culver City with the resolve to get the H-4 into the air before the hearings resumed. He sped up connection of the different systems of the H-4 and announced he would conduct taxi tests during the weekend of November 1 and 2. The plane was really only ready for taxi tests. Bill Berry, the H-4 project director,

recalled that it was four to five months away from flight test capability.³⁰

In regard to launch, Hughes conferred with Engineer Tegart over the fact that there was only six feet clearance between the plywood skin sides of the H-4 and the concrete drydock walls as it moved out. If a gust of crosswind hit the side of the eight-story fin, or swept along the 320-foot-long wings, it could move the hull against the dock wall and crush the hull. Tegart studied articles on marine terminals such as the German seaplane base at Sylte. The Mars Flying Boat offered some insights; however, it weighed only 85,000 pounds while the H-4 weighed about 225,000 pounds and had much greater exposed surfaces. To steady the H-4, Tegart constructed two projecting rock revetment jetties extending out on each side of the main drydock. Winches and cables tied the plane to heavy tractors which moved out on the jetties with the plane and held it absolutely steady as it slid out of the dock and down to the ramp. In order to prevent the tractors from following divergent paths and pull the plane apart, a separate cable was run from a tractor on one side completely through the airplane to the opposite tractor. As the Flying Boat moved out, two side-winch operators gradually took up their lines maintaining a 2000-pound tension. Once the tail of the H-4 was allowed to turn to face into the wind, the towing boats took over and towed it to its offshore anchor mooring.³¹

On November 1, Glenn Odekirk drove Mr. Hughes down to the Long Beach plant for the taxi tests which had been announced in October. Winds prevented taxi tests that day, but on November 2 with the invited press and thousands of spectators on the shore, Hughes made three taxi runs on the

The Hughes H-4 Flying Boat during assembly at Long Beach, June 1946.
(Port of Long Beach Photo)





choppy waters with a number of the press aboard each time. On the final taxi run with only his crew and one newsman, Jim McNamara, aboard, he made the decision to fly the plane briefly. He flew for a distance of about one mile, and the plane reached an altitude of 85 feet. Following the flight the plane was towed into drydock, the hull was placed on the cradle, and the water removed from the dock. The tent and catering services for the press and invited guests were all taken out, and the Long Beach plant went back to tight security.³²

Years of Transition 1947-1953—Following the test flight, Hughes gradually converted the Long Beach plant surrounding the H-4 into a permanent test and maintenance facility. Primarily he wanted a durable structure built over the docked Flying Boat and asked Harold Tegart for a design. Tegart's first drawings called for a structural steel frame, canvas covered. He recently recalled the essence of the frame he designed to build over the plane.

There were two front columns immediately behind the rear edge of the wings on either side which actually supported the whole structure. Sixty feet back of them were two more columns. They were hold-down columns and kept the building from tipping over on its nose. At first I designed pilings for them; but upon test pilings would not resist the uplift, so we put in a big 300,000-pound concrete anchor footing. The building was cantilevered forward of the front columns, out beyond the engines and over the nose of the ship for a total distance of 155 feet. I designed as if there were 180 pounds per linear foot around the perimeter of the hangar.³³

The work was already underway when Mr. Hughes let Tegart know that he did not like the idea of canvas sides and instead wanted a solid hangar with controlled temperature and humidity that would accommodate proper gluings on the birch plane. Hughes specified a wood shop addition to the hangar so that any new wood coming into contact with the older wood surfaces on the plane would not be rejected.³⁴

Fortunately, the Hughes' engineers were used to working with lightweight metals, since they would now have to find a

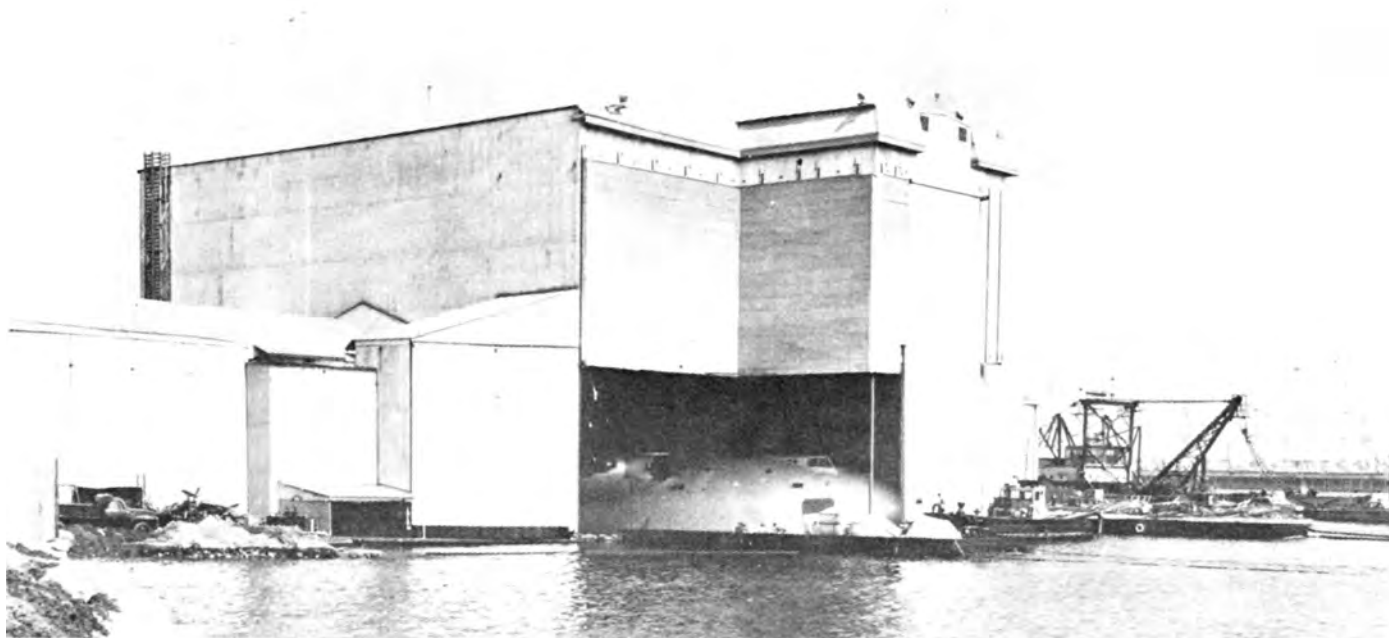
Signed photograph of the single H-4 flight sent to the Port Manager by Howard Hughes.
(Port of Long Beach Photo)

siding material weighing less than 180 pounds per linear foot. Aluminum siding did not come into use until after the war; nonetheless, Engineer William Leas introduced the idea and had John French in the Materials Department run tests on it. French declared it met the requirements, and Leas requisitioned it for the hangar. This was, perhaps, the first application of aluminum siding in the industry.³⁵

The new hangar, like the temporary one, fit around the plane. The main or hull portion was over eight stories high to accommodate the tail fin and rudder when they moved through it on launch. An extended rear enclosure housed the empennage, and a forward extension provided for the nose. Two wingtip portions extended out to the sides giving the building a cruciform shape. Hughes wanted doors at the front that would open quickly in the case of a fire or other disaster, so Tegart considered several solutions: roller doors as were used commonly for dirigible hangars, folding doors, or those that would lift up into the building.³⁶ Ultimately he designed



Harold Tegart designed a permanent cruciform hangar for the Flying Boat. Aluminum siding replaced the canvas panels.
(Elmar Baxter Photo)



a 10,000-pound lift-up aluminum door for the center front, 30 feet wide and 78 feet high and a smaller center door 80 feet high by 45 feet wide. On each side were two door panels 40 feet high and 117 feet long, each having two 90-degree bends. All of these doors were raised by electric motor power and could be stopped in any position to avoid exposure of the H-4 to the sun.³⁷ Six lower panels enclosing the nacelles and pontoon drydocks were lifted off by cranes. After the press of three buttons it took about 30 minutes to open the 342-foot front of the hangar facing the harbor so that the airplane could be launched.

In 1948 Mr. Hughes made it known that he wanted permanent temperature and humidity controls. His chemical engineer, George Shull, visited the new hangar and contacted the usual vendors such as Carrier and Trane for consultation. They said they did not want to do it since it was a huge sheet metal building without insulation. Further, Hughes specified that air temperature had to be 1° or 2° only, thus 75° and not vary beyond 77° or 73°. The humidity had to be held at 55% and not vary beyond 53% or 57% regardless of outside conditions. No air could blow on the ship.³⁸

Shull then asked George Studer, a mechanical engineer who Hughes relied on at Culver City, to speak with Mr. Hughes by phone. After Hughes brought him up to date on the problem Studer replied, "Of course it can be done." Hughes asked, "Can you guarantee it?" Studer answered, "You know my guarantee isn't worth a nickel and besides it will cost a lot of money, perhaps a quarter of a million dollars." Hughes told him to go ahead, and following a year's study Studer introduced several new concepts to air conditioning in large spaces. The secret of his success was that the upper part of the hangar was ignored. He distributed five systems around the hangar which created ideal air by mixing cold air, hot air, and moisture. The mixture was then discharged through low speed piping to 30 nozzles and the "throw" controlled for distance. Each nozzle pointed in a specific direction so that all the air dissipated before it hit the ship. Recorders at 30 stations around the H-4 provided a

Nose of Hughes H-4 taken from earth dike south of the Long Beach plant seven days after the Pier E flood in September 1953.

(Port of Long Beach Photo)

readout of the air temperature and humidity, and spot checks were periodically sent to Mr. Hughes. A large air-conditioning equipment pit at the east side of the hull held the equipment below ground level so that the cables on the tractors that pulled out the plane were not obstructed. The equipment functioned for over 20 years without a failure. Although Studer had only come to Long Beach for the installation, he stayed on until he retired. Looking back on the assignment, Studer observed that on any engineering problem Mr. Hughes laid down the specifications and the engineer had to figure out the solution. Everything was like that, otherwise you didn't work for him.³⁹

Permanency after 1948 called for a mooring for the H-4 southwest of the Hughes lease⁴⁰ and for an administration building, sometimes called the Hughes office. Mr. Hughes, however, had no office. He visited the plant manager in this building, and it was probably his headquarters when he needed an office.⁴¹ A hydraulics and engine shop was built when the decision was made to change from a pneumatic to a hydraulic system on the H-4 and to electrical controls.⁴² Until 1960 change and additions were constant. Bill Berry was director of the plant from 1947 to 1962; Bob Ford held the post for the next 17 years, 1963 to 1980.⁴³

A permanent plant required a long-term lease, so in 1949 Hughes Aircraft made a request for a 25-year contract to take effect in September 1950. They argued that they saw an important place for seaplanes in the United States economy and that testing for these in addition to the value of the H-4 itself justified further expenditures at the site.⁴⁴ Howard Hughes wrote an open letter in 1949 to his employees which included the passage:

". . . I assure you that *nothing* means more to me than the success of the Flying Boat. And if we do finally succeed in designing, building, and flying an airplane twice as large as

anything else in the world, and overcoming the hundreds of serious obstacles which are a part of this tremendous step ahead in the world's progress in aviation, then I believe people will wake up to what we have accomplished."⁴⁵

The Port countered the lease proposal by replying that they had never planned Pier E for seaplane cargo operations. Instead, Pier E was for heavy or bulk type cargo, and they would not sign a lease of over three years with additional yearly extensions not to exceed a total of five.⁴⁶ Hughes had to agree to this lease; nonetheless the H-4 was to remain in its hangar on Pier E for 30 more years.

Land Subsidence—The land was sinking at and near the Port of Long Beach and the changes had been recorded in surveys as early as 1928. Drilling at the Wilmington Oil Field between 1937 and 1947 worsened matters. The Long Beach Oil Development Corporation, under contract to the city of Long Beach, was responsible for pumping oil from under the Long Beach harbor area. Thanks to its efforts, by 1950 its own offices were in a virtual hole surrounded by dikes higher than the peak of its tiled roof. The Edison plant, just north of the Hughes site on Pier E, had sunk 27 feet. To stop the subsidence Long Beach officials finally injected salt water under extremely high pressure into fault blocks underlying the area and thereby restored underground pressures depleted by oil and gas removal.⁴⁸ However, this program did not effectively stop subsidence in the harbor area until 1960.⁴⁹

The Hughes plant kept records of subsidence on their property, and by March 1949 found its land had sunk nearly two and a half feet below the level to which it was filled before the H-4 arrived in 1946. Both the harbor and the plant carried on regular remedial work in the way of rock dikes, sea wall extensions, and sea gate extensions to keep the ocean out of the drydock. Flooding was a constant concern. Meanwhile, the Port of Long Beach continued to expand using some of the money that it earned from selling the oil that the Long Beach Development Corporation removed from under it for the financing. In 1953 the Harbor commissioners went ahead with an ambitious program of dredge and fill which included the extension of Pier E into the ocean southward toward the federal breakwater.⁵⁰ As a part of the extension work Pier E accommodated two lagoons or settling basins and a large lake on its south end. The Pacific Dredging Company pumped material off the ocean bottom and into one of the lagoons, then an outflow pipe system carried the overflow water from the lagoon into a large lake at the south end of Pier E. From there it flowed into the sea between two circular bulkheads.

At about 3:00 A.M. on the morning of September 18, 1953, the flow was somehow interrupted, and the water, rather than flowing out to sea, flowed into the Hughes Aircraft Company plant. The on-duty fireman recorded in his log book, "Dirt fill broke between the hangar and the electric shop and flooded docks and yard, also engineering building. Telephones out of order. Lt. Gray, security, left in his own car to give alarm."⁵¹ Mud, silt, and sea water rushed downward through the H-4 complex. The engineering building filled to a depth of two-and-a-half feet, and the furniture, walls, written records, drawings, and office machines were saturated with mud. In the hangar silt and water filled the air-conditioning pit, flooded the main drydock and one tip float dock. The Flying Boat floated off its cradle, and tipped. It

suffered skin breaks and bruises, sustained structural damage, and damage to the control surfaces of the wings and tail. The impact damaged one of the engines and parts of the plane's hydraulic and electrical systems.⁵²

One person the alarm reached that night was Noah Dietrich, executive vice president of Hughes Tool Company and often described as Mr. Hughes' business manager. He was happy to learn that the Flying Boat was wrecked. He later wrote, "... my heart danced. At last a way to escape the crushing expense of the flying whale."⁵³ Dietrich's joy, however, was short-lived, as Hughes ordered the plane repaired. On Monday the Long Beach morning newspaper, the *Independent*, reported, "Hughes 'Goose' Wrecked; Damage Totals \$5 Million."⁵⁴

In the days following the flood, secrecy regulations at the plant made it difficult to assess the damage and decide how extensive it really was. Charles Vickers, the new Port Manager, on hearing of the disaster, put the Hughes' Facilities Engineer, Joe Hall, in touch with the officials of the Pacific Dredging Company and the Gridley Construction Company who were in charge of the dredge and fill. However, these officials were denied entry to the Hughes plant by Plant Director William Berry "because of circumstances beyond his control."⁵⁵ The following Wednesday Hughes Tool Company hired Ben Jarvis, a civil engineer, to make an independent survey of the plant. Jarvis complained that he and two Hughes employees were kept waiting at the gate and that the Harbor Department inspectors, who might have spotted the failure in the dredging and filling system, were denied admittance. He observed that virtually all of the muck had been removed by plant employees, much of the inundated machinery was being cleaned, the files were clean and even the documents had been spread out to dry. The city of Long Beach also hired an engineer to make a survey of the damage, Kenneth Q. Volk. Volk was denied entrance to the plant to inspect the damage and not allowed to talk to Hughes employees or to look at the Hughes photographs of the scene. Under these restraints Volk estimated the cost of repairs at less than \$77,000. Six months later the Hughes Tool Company sued the city of Long Beach for \$12 million for damage suffered by the Flying Boat and installations at the plant.⁵⁶

Volk's investigation determined that a section of dike 150 feet south of the Hughes fence had also settled. Kenneth Volk wondered if these events might have been related by something other than chance. Suspecting an earthquake, he sent an inquiry to Charles Richter, the famous seismologist then at the California Institute of Technology. Richter replied that on the morning of September 18 at 2:17:55 there was an earthquake with an intensity of 2.2 on the Richter Scale and the epicenter was about three miles south and east of Pier E. Since the dikes that settled were constructed on top of hydraulic fill, it was pointed out that earthquakes of relatively low intensity could cause settlement. Upon hearing this, Volk reminded the Hughes plant officials that they had drawn up plans in January 1953 to raise the walls of its graving dock and pontoon docks and to put fill material in place. If these plans had been carried out in May, as scheduled, there would have been no damage to the Flying Boat.⁵⁷

In March 1954 Hughes did raise the dock walls and the floor of the hangar, even though the Flying Boat, the cradle,

and the launching mechanism on which it rested had already been raised six feet. Two crews worked around the clock on the H-4 with observers posted at 15 stations around the H-4 to make sure that it was elevated without damage. The observers could ask the foreman at any time to stop the move if they felt the plane was in danger. The forward fingers separating the docks, the bridges, and the sea walls were all elevated by six feet, and the many associated systems had to be adjusted to the new elevation. Workmen then anchored the Flying Boat securely in its drydocks to prevent any unforeseen liftoffs. As for the air-conditioning pit, it was filled with decomposed granite and never used again.⁵⁸

Since the Hughes Tool Company continued in its \$12 million claim against the city of Long Beach in 1956, the city attorney informed Hughes that their lease on Pier E would be terminated in April of that year. Hughes hired a local attorney, Jonah Jones, to represent them, and he appeared before the Harbor commissioners to negotiate a settlement. This tactic apparently failed.⁵⁹

The documents available at this time do not reveal the means by which settlement was reached. Noah Dietrich in his book on Hughes put forth his own recollections of the matter. They followed upon his characteristically negative treatment of his former employer and read as follows.

His counterattack showed Howard Hughes at his most devious. He knew that Long Beach had been embroiled for years in a controversy with the State of California over the tideland oil pools that lay beneath the harbor. Hundreds of millions of dollars in royalties were involved in the lengthy dispute. At last a formula was devised to make a division of the funds between Long Beach and the state. The solution seemed to please everyone, and the legislation was about to go through the Senate and Assembly in Sacramento.

Howard summoned his two high-paid lobbyists. "Get up to Sacramento and kick Long Beach in the ass on that tideland oil settlement," he ordered.

The lobbyists started working their wiles. They had used Hughes' money to pay campaign bills for many of the assemblymen and senators. The underpaid legislators were beholden to Hughes, and overnight the tidelands bill began to grind to a halt.

The Long Beach interests panicked. After years of trying, they had finally arrived within reaching distance of those oil millions. Now a petulant millionaire was throwing a wrench in the legislative process.

Truce was called, and Long Beach granted a 10-year lease to Howard Hughes for his *Hercules*. In return, Hughes dropped his \$12,000,000 suit against the city and settled for half a million.⁶⁰

There is no evidence, other than Dietrich's assertion, that any of this happened.

In August 1956, negotiations on a new 10-year lease progressed under the guidance of Jonah Jones. All of the representatives of the parties concerned with the Hughes plant flood and its aftermath met in October in the Harbor commissioners' board room to effect a complete settlement. Hughes Aircraft paid \$67,299 in back rent to the harbor and accepted \$600,000 to cover the cost of repairing the Flying Boat and the Long Beach plant after the flood. All of the parties agreed not to involve the federal government, the legal owner of the Flying Boat, in further litigation.⁶¹ The

new 10-year lease, in response to Mr. Hughes' desire for secrecy, set forth the following compromise on entry.

Lessor and its authorized representatives shall have free access to the demised premises for purposes of inspection, surveying, or any purpose deemed necessary by Lessor in connection with its operation of the Port of Long Beach. Such right shall be exercised so as to interfere with Lessee's operations as little as possible and shall not include access to the interior of the buildings of Lessee.⁶²

The language was still tight enough to keep out curiosity seekers. Members of the Board of Harbor Commissioners discovered this when they came to test it and were refused a glimpse of the Spruce Goose.

The Plant—Between 1946 and 1962 the H-4 hangar complex operated as a regular aircraft plant employing as many as 300 people. Testing the large airplane required basic facilities such as shops, test laboratories, and security. Inside the hangar the H-4 had a hydraulic system for tilting the airplane, a pumping system for removing water from the docks, and a system for inflating emergency trim air bags for changing the attitude of the Flying Boat when it was floating in the hangar. Since the plane was almost entirely made of laminated birch, shops for working and gluing wood were required as well as a sewing shop for the parts of the plane covered with fabric.

Management personnel explained that a prototype airplane required a much larger crew to operate and maintain it than did a similar production airplane because of the many engineering discrepancies or "bugs" that became apparent after testing had begun. Problems had to be expected with the hydraulic and pneumatic systems since their valves, actuators, and other components were subject to leakage and lack of compatibility with each other. The electrical systems also had compatibility problems, and the miles of electrical circuits could have been incorrectly connected. Control cables and linkages for the throttles, cowl flaps, landing flaps, propeller pitch, and flight control surfaces needed frequent adjustment until optimum settings were found. Engineers, mechanics, and inspectors had roles comparable to those in any regular aircraft plant.

The fully developed plant simply evolved as the operation changed from temporary to permanent. Men came down from the Culver City plant expecting to stay six months and then return, instead they stayed until they retired. Robert J. Ford, assistant project engineer, was a case in point. He was at the site in the summer of 1946, helped get the H-4 assembled, but stayed until 1979. Richard Grey hired in at the plant in 1946 as a security guard. He was told the job was temporary, about six months, but he worked there 34 years.⁶³

Plant engineering and maintenance, fire, and security were among the first departments formed. Engineering and maintenance usually employed about 40 people: painters, riggers, crane operators, welders, electricians, boiler and air-conditioning personnel, and boat handlers. The man in charge of the boats was a diver and did the necessary diving to check on the underwater equipment and on the condition of the sea gates. With the exception of the engineers, most of the personnel were shop type people, and some of the woodworkers were older Europeans. Women worked at the plant both in the sewing shop and in secretarial positions. A flight



crew readied the engines and other equipment and would have been operators on the plane if it had flown. Periodically, high-frequency sound waves were used in an inspection procedure to detect flaws in the glued joints of the airplane. Scaffolding had to be built both inside and outside of the plane at specific locations for the test. For this and other tests, a test group was formed to catalogue and inspect the instruments. As time went on, the Flying Boat was not only tested as a prototype but also served as a laboratory for pure research.⁶⁴

Longtime employees assured the writer that no fire ever broke out at the plant. Hughes wanted the best fire detection and firefighting equipment available and went far beyond the National Fire Protection Association recommendations for a 42,640-square-foot hangar. The association recommended nine extinguisher units. Hughes had 373 units in addition to hoses capable of delivering 4000 gallons of water per minute, carbon dioxide carts, foam, and two pumps in a location to use sea water in an emergency.⁶⁵ The fire department hired men for three shifts, seven days a week.

Security employed as many as 28 to 30 guards: three shifts with four men each who worked but five days a week. After 1950 a closed-circuit TV at the main gate enabled the man there to observe the dock side of the hangar. On a typical shift one man was at the gate, two others held posts, and a fourth patrolled. Mr. Hughes was never paged on the loud-speaker. Security also prevailed inside the plant, and only those with passes could enter the H-4 hangar. Some employees worked there for years and never saw the Flying Boat. An entry in the fireman log tells us how one watchman stood by the starboard hangar crane door checking employee passes into the hangar and was relieved by a man on the next shift. Perhaps the most poignant statement on secrecy found in the course of this study was one made by Bob Ford who said that he never talked about his work, even to his wife, for over a period of some 35 years.⁶⁶

The fully developed Long Beach plant on Pier E in foreground. Piers D, C, B and the Los Angeles River channel lie to the east.
(Port of Long Beach Photo)

The plant managers seldom asked Mr. Hughes for permission for anyone to enter the hangar. Hughes had remarked that if the person was important enough to see the airplane, he would show it to him himself. Hughes did not want the Coast Guard, city firemen, police, city officials, or Harbor Board members on the site and certainly not in the hangar. No interference with work was permitted and no time could be taken away from people's jobs. For example, Noah Dietrich, business manager for Hughes, never visited the plant. Senator Claude Pepper's visit was one of the rare exceptions to the rule.⁶⁷

The main jobs were maintenance and testing on the H-4; however, the plant did build three helicopters in a small area, predecessors of the Model 300. By building them in Long Beach they could be kept out of sight. The plant also built two air cushion water vehicles and called one of them a hydro-streak.⁶⁸

In 1951 when it still appeared likely that Mr. Hughes would test fly the plane again, the launching and docking procedures were revised adding a new phone system, revising the tip float dock pumps, and providing a new procedure to follow in the event of electrical power failure during launch. That year Plant Director Bill Berry advised his personnel:

"At the present time, it is the intention to return the Hughes Flying Boat to the hangar daily, after taxi or flight operations where it will remain afloat.

"The removable doors on the hangar will not be installed and the air conditioning of the hangar and airplane will not be resumed unless conditions are such that the airplane will not be taken out for a period of several days."⁶⁹

In those early years the 75-foot hull door in the hangar and the composite panels were checked every two weeks by fully



In 1980 the hangar doors had not been raised in 20 years. Demolition crew cut the doors off in order to remove the flying boat. The Navy's crane, Herman the German, moved the Flying Boat out of its hangar in early 1981. Howard Hughes at work. (Port of Long Beach Photos)

opening and closing them. Both the 75-foot overhead door and the composite side panels could be stopped at any point to avoid exposure of the airplane to the sun. One memo warned that "From the end of the port jetty the airplane between engine No. 3 and engine No. 6 would be visible," thus creating a break in the secrecy barrier.⁷⁰ The fifties were an active decade, but the last reference to a planned launch found in the search of the plant records was June 30, 1960. Director Bob Ford observed that the doors were never opened after 1962. Still, even after it became doubtful as to whether the H-4 would be flown again, Hughes maintained it so that the pure research experiments could continue.

Mr. Hughes—Howard Hughes was a frequent visitor at the hangar in the early years, coming in weekly. According to Engineer Studer he was concerned about the condition of the plane since he had been told that no one could meet the maintenance requirements he had set up. As the years passed the visits became monthly rather than weekly and after 1962 ceased altogether. George Studer recalled that it was not Mr. Hughes' habit to talk to his engineers on the job. Rather, Hughes made many of his visits to the plant at night. Then he would call the engineer by phone or have him come to his so-called office at the Samuel Goldwyn Studios to talk over the problem. Engineer Tegart recalled one of those meetings when Hughes wanted to discuss the launch of the Flying Boat. A guard instructed him to drive around to the back of the building, go up some stairs, and knock lightly on a specified door. If there was no response he was to wait one minute by the clock and repeat the procedure. Mr. Hughes opened the door to a large sparsely furnished room with a long table

suitable for laying out drawings. The couch where Hughes slept was visible in an adjoining room, and while Tegart was there a boy arrived with a sandwich and a quart of milk which Hughes ate and drank as they conferred. Tegart was seeing Hughes as had so many who worked with or for him: intense and concentrating on immediate matters to the exclusion of any unnecessary attention to his personal needs.

Among the company records at Long Beach there is indeed little documentation of the Hughes visits. Interdepartmental correspondence is to be seen that passed between Mr. Berry and Mr. Hopper with the subjects "Jobs Requiring Decision by Mr. Hughes" or "Items to be Discussed with Mr. Hughes." These memos tell us that some meetings were held at the plant during the day with management personnel.⁷¹ Employees recall the night visits. Hughes came into the plant, but often a companion would remain in the car.

New instructions by Mr. Hughes were what kept the plant active. By 1962 he was no longer visiting the plant, and there were no new instructions. The belief grew at management levels that the people at Long Beach were just marking time. That year the decision was made to cut 130 people from the work force, leaving about 35 permanent employees at the plant. The hydraulic and electrical systems on the Spruce Goose were still cycled, and the engines were turned over by electric motors while hot oil circulated through them. During the 1960s the air conditioning was cut back, and in 1970 the entire air and humidity control systems were disconnected.⁷²

Pressure to Leave—At the same time that testing on the Spruce Goose was winding down, the Port of Long Beach was implementing a master plan of development. Some of the changes at Pier E were underway even before the 1956 lease negotiations. These included construction of bulkheads and wharfs and the creation of 130 acres of filled land at the south end.⁷³ The Richfield Oil Corporation took out a 35-year lease on Berth 118, began to build the largest bulk oil terminal on the West Coast, and in 1961 applied to the Port to lease Berths 120 and 121, the H-4 hangar site, when the Hughes lease expired in 1966.⁷⁴ In January 1966 Jonah Jones, the Hughes Long Beach attorney, requested a 20-year extension of their lease. He wanted the Harbor Board to consider amending the lease so that Hughes could install water and land facilities to conduct studies in oceanography. This was the only mention of oceanography among the documents; however, we might speculate that with the virtual end of tests on the Flying Boat and the end of Mr. Hughes' visits, the plant was considering other options. Port Manager Charles Vickers recommended approval of a 10-year lease extension, but some of the commissioners wanted to deny the lease altogether. Commissioner Ridings noted that the property seemed very inactive. Commissioner Craig objected that he had not been permitted to enter the property even though he felt the 1956 lease specifically provided that the lessor could do so.⁷⁵ The H-4 complex was already paying more per square foot than its neighbors, but when Hughes Tool agreed to pay even more, \$36,054 a year, the Port drew up another 10-year lease. Three years were firm. After that the lessee had to make an annual extension request.

During these negotiations Mr. Hughes was confined to his Bel Air home. As mentioned above, he had not visited the plant since 1962, but then he probably had not visited his other enterprises either. His biographers Barlett and Steele

claim that he started out for Boston on July 16, 1966, and that "It was the first time Hughes had been outside in four-and-a-half years."⁷⁶ Yet, in all of the negotiations to save the lease site, it was undoubtedly Mr. Hughes who determined that the H-4 remain in place.

Pressure to vacate Berths 120 and 121 built quickly after 1971; hence, lease extensions became more and more difficult to obtain. The Long Beach Plant Director, Robert J. Ford, got orders to search for a new hangar site. He considered Navy yards up and down the coast, but nothing seemed to work out.⁷⁷ Harbor Department plans in 1972 called for a deep-water terminal capable of accommodating super tankers at dockside. The main entrance channel for that terminal was to be immediately adjacent to the Hughes leasehold and had already been deepened to handle the tankers. Notice was served Hughes Tool Company to vacate the lease by March 1973. To complicate matters the General Services Administration gave notice that the Spruce Goose would be sold at auction in January 1973; thus, the Hughes lease on the plane itself would terminate. Vice President Rae Hopper argued that unless his company could make some arrangements to continue in possession of the plane, it would not be in a position to move someone else's property. Because of the embarrassing position which this posed for Hughes, Hopper proposed that the rent be raised to \$100,000 a year and that Hughes be awarded a firm two-year extension. The Port agreed.⁷⁸ In 1975 the plant got an extension to June 1978; however, in April 1976 Howard Hughes died, so the Port of Long Beach would not have his wishes to deal with in further lease agreements.⁷⁹ After his death and due to corporate rearrangements, the Long Beach plant fell under the Hughes Helicopter Division, Summa Corporation.

In May of 1978 the Port reaffirmed its intent to construct a marine petroleum tanker terminal on the Hughes leasehold. Atlantic Richfield Company (ARCO) and Shell Oil Company had joint rights to a pipeline from Pier E to refineries inland, and ARCO stood ready to construct the terminal at Berths 120 and 121. The Port advised Summa to demolish its existing structures with "all possible dispatch" and to pay a holdover monthly rent while doing so. That arrangement expired in September 1980. Much effort was put forth between 1978 and 1980 to save the Spruce Goose; but no voice was raised to save the H-4 hangar even though it had been recognized as a significant historical structure in 1978.

Ultimately Summa Corporation agreed to remove the hangar and other surface installations at its expense and to pay the Port \$50,000 in lieu of removing the drydocks and building foundations.⁸⁰ By 1980 Wrather Brothers, Inc., had agreed to erect a Hughes Flying Boat Exhibit Center. Attention turned to the center's design and to the ARCO Terminal relocation schedule. Demolition crews entered the plant in November 1980 to cut off the hangar doors. They had not been raised by the power system for 20 years, so it was considered inoperable. After the Spruce Goose had been towed out of its berth and lifted onto a barge by the Navy's German crane, crews demolished the remainder of the hangar and the other buildings in the complex.

Conclusions—May 14, 1983, the Spruce Goose went on display under a geodesic dome next to the QUEEN MARY mooring. Curiously enough, Howard Hughes had envisioned a scene something like it in 1938. He was speaking to a crowd in New York City at the completion of his record-breaking world flight and said that he looked forward to "the day when you will lean out of a New York skyscraper window and see a ship, a great ship, perhaps not as large as the QUEEN MARY, but larger than some of the ships that are plying the Atlantic today . . . just a few feet above the surface, gliding between two rows of buoys marking one of the landing paths across New York Harbor."⁸¹

Today, people need only to look out of a skyscraper in Long Beach, California, to see where his great Flying Boat rests next to the QUEEN MARY.

The original hangar with its unprecedented moisture and air-conditioning system, door openings, and launching procedure along with the Long Beach plant are now a part of the Port's history. Yet, the little plant will go down in aviation history as Howard Hughes grows as an historic figure. Hughes held a personal interest in the Long Beach plant, visited it regularly, and his personnel there waited for his judgment on even the smallest matters. Hughes respected the engineer types who worked for him there and listened to them. Mr. George Bromley who spent many years at Long Beach spoke for them when he observed, "Everything Hughes did had great purpose. His dealings man to man were always extremely fine, extremely fair."⁸² The Flying Boat, the tight

The Hughes H-4 as it was towed toward the Wrather geodesic dome in 1983.
(Elmar Baxter Photo)



security, the seclusion and intimacy of working conditions all made the plant unique. From the onset the decisions that governed the plant's life were unprecedented. For example, as Bob Ford pointed out, they built the hangar over the plane.

NOTES

1. The subject aircraft had the following designations: Hughes-Kaiser 1 (H-K 1) and the Hughes 4 (H-4). The source of the epitaph, *Spruce Goose*, is unknown and Mr. Hughes disliked hearing his birch airplane referred to as that. The Hughes Long Beach plant correspondence referred to the plane as the H-4 or the Flying Boat. While under construction at the Culver City plant it was nicknamed the *Hercules*.
2. John Keats, *Howard Hughes* (New York: Pyramid, 1970), Introduction p. IX.
3. See Donald L. Barlett and James B. Steele, *Empire, The Life, Legend and Madness of Howard Hughes* (New York: WW. Norton and Co., 1979) and Noah Dietrich and Bob Thomas, *Howard, the Amazing Mr. Hughes* (Greenwich, NY.: Fawcett Publications, 1972).
4. Keats, pp. 1, 65, 114-119; Interview, Glenn Odekirk, December 12, 1983.
5. Keats, pp. 166-168.
6. Keats, pp. 158-159.
7. D.D. Hatfield, *Howard Hughes H-4 Hercules* (Inglewood, CA: Northrop Institute of Technology, 1972), pp. 1-4; Interview, Odekirk.
8. Interview, Rae Hopper, September 15, 1980.
9. Interview, Harold Tegart, November 3, 1983.
10. Hatfield, p. 21; Interview, Tegart; Harold Tegart, "Historical Sketch H-4 Flying Boat," Tegart Papers, Tegart Engineering, Sunland, Ca. (hereafter "Tegart Sketch").
11. Vicinity Maps 901, Summa Corporation Files (SCF). All Summa files used in this research were seen at the Long Beach plant in 1980. They are now housed at Wrather Port Properties, Ltd., Historical Archives, Long Beach Harbor. See also Hughes Drawing (HD) F-5014, SCF.
12. Letters, E.J. Amar to Hughes Aircraft Company, November 25 and December 8, 1944, Hughes Tool Company 1944-1947, Central Files, Port of Long Beach (PLB).
13. Lease, City of Long Beach and Hughes Aircraft Co., September 4, 1945, Hughes 1944-1947, PLB; Letters, Tegart to Nolan, January 17, 1945, and Ground Improvements, SCF.
14. Tegart Sketch; Building Permit K1879, Long Beach Planning and Building Departments (LBP).
15. Conference held January 28, 1946, at Guy F. Atkinson Co. office, SCF; Letter, John Stearns to E.J. Amar, January 22, 1946, and HD 0028 in Hughes 1944-1947, PLB.
16. Interview, Tegart.
17. Tegart Papers; Photograph Collection, Chief Engineering Office, PLB.
18. Keats, pp. 158-159.
19. Long Beach Harbor Site Developments Progress Reports February 11, 1946, through March 25, 1946, Tegart Papers; Building Permit K2620 and K2484 LBP 20. March 12, 1946.
21. Tegart Sketch; Interview, Tegart.
22. Tegart, Typescript, December 19, 1983.
23. Photo Series 11479, Engineering Vault, PLB.
24. Tegart, Typescript, December 19, 1983.
25. Keats, pp. 186-187.
26. Interview, Odekirk.
27. Photographs, Tegart Papers and Interview, Tegart.
28. Interview, Bill Berry, September 23, 1980.
29. Lois J. Weinman, *Los Angeles-Long Beach Harbor Areas*. (Los Angeles: U.S. Army Corps of Engineers, LAD, 1978), p. 120.
30. Interview, Berry.
31. Interview, Tegart; "Cradle for a Giant Graving Dock for Hughes H-4," *Business Week*, June 16, 1945, p. 45; Scrapbook, Beaching and Servicing Seaplanes, Tegart Papers; Drawing HD F 0139, SCF.
32. Interview, George Bromley, September 12, 1980.
33. Interview, Tegart.
34. Interview, George Bromley.
35. Interview, William Leas, September 15, 1980.
36. Building Permits L 9089, L 9092, L 9090, L.B. Planning; Interview, Tegart, September 12, 1980.
37. Permit M 2653, L.B. Planning; Drawing F 0446 and plot plan Drawing F 0253. For empenage enclosure see Drawing F 0445 and plot plan Drawing F 0253, in R. Hatheway and L. Roberts, "Documentation Report, Howard Hughes H-4 Aircraft Hangar Facility," Prepared for the Port of Long Beach, October 1980. Vol. IV.
38. Letters: Stearns to Long Beach Harbor, September 28, 1949; Maddy to Hughes, October 3, 1949; Tegart to Shoemaker, March 3, 1950; Maddy to Hughes, March 8, 1950, in Hughes 1950-1953, Central Files, PLB. See also Drawings F 0439 and C 0428 in Hatheway and Roberts Vol. IV and Permit 5043, L.B. Planning.
39. Interview, George Studer, October 1, 1980.
40. Letters, Maddy to Hughes Co., March 23, 1949, and Tegart to Long Beach Harbor, March 18, 1949, Hughes 1948-1949, Central Files, PLB.
41. Letter, Maddy to Hughes, November 15, 1949; Interview, Bill Berry, and Bob Ford, September 17, 1980.
42. Inter Departmental Communication (IDC), Leas to Berry, April 15, 1952, "Harbor Facilities Structures," April 15, 1952, SCF.
43. Interview, William Leas.

44. IDC, Shoemaker to Board of Harbor Commissioners, May 9, 1949, Hughes 1948-1949, Central Files, PLB.
45. Howard Hughes, typescript, N.D. Misc. SCF.
46. Lease, 1950, Hughes 1950-1953, Central Files, PLB.
47. Long Beach Department of Oil Properties, "Elevation Changes in the City of Long Beach, August 1973-February 1974" May 28, 1974, p. 5.
48. Walter A. Tompkins, *Little Giant of Signal Hill: An Adventure in American Enterprise* (Englewood Cliffs: Prentice-Hall, 1964), pp. 131-132.
49. Long Beach, "Elevation Changes," p. 6.
50. Letter, John R. Jannarone to Long Beach Board of Harbor Commissioners, November 21, 1951, Pier E, Chief Engineer's Office, PLB.
51. Fireman's Log No. 11, pp. 105-106, SCF.
52. "Claim," December 4, 1953, Leases, SCF.
53. Dietrich and Thomas, p. 213.
54. *Independent*, September 21, 1953. An annotated clipping in the Summa Corp. file, Chief Engineer's Office, PLB.
55. Letter, J.G. Hall to H. Butler, October 12, 1953, untitled file, SCF.
56. Letter, R.R. Shoemaker to E.J. Amar, January 7, 1954, Summa Corp., Chief Engineer's Office, PLB; Letter, C.L. Robingson to Howard Hall, September 2, 24, 1953, Insurance Buildings and Equipment, SCF; Volk, "Report," Central Files PLB.
57. Volk, "Report."
58. "Invitation to Bid . . ." December 11, 1953, Subsidence, Johnson Western, SCF; Interview, Chuck Jucker, September 15, 1980; IDC, W. Leas, March 15, 1954, Raise Docking Cradle Six Feet, SCF.
59. Letter, Wahlfred Jacobson to Hughes Aircraft Co., February 21, 1956, Hughes 1956-1957, Central Files, PLB.
60. Dietrich and Thomas, p. 214.
61. Letter, Jacobson to Board of Harbor Commissioners, October 18, 1956, Hughes 1956-1957, Central Files, PLB: "Release and Indemnity Agreement" October 9, 1956, Leases, SCF.
62. Lease between City of Long Beach and Hughes Tool Company, October 15, 1956, Leases, SCF.
63. Interviews, Bob Ford 1980 and Richard Grey, September 12, 1980.
64. Interviews: Berry, September 23, 1980, and Studer, October 1, 1980.
65. IDC, Pausic to Leas, April 23, 1954, Harbor Facilities, SCF; "Control and Maintenance Technical Equipment," approved Berry, July 11, 1955; Letters: Holahan to Marsh and Co., December 6, 1962, and Jagasz to Ford, 30 November 1962 in Insurance, Buildings SCF; Interview, Bromley.
66. Interviews: Juker, September 15, 1980; Grey, September 12, 1980; Berry, September 23, 1980, and Ford, September 17, 1980.
67. Interview, Bromley.
68. Interview, Berry.
69. IDC, March 12, 1951, Harbor Facilities Structures, SCF.
70. IDC, Berry to Hopper, 18 March 1953, Harbor Facilities, SCF.
71. Interview, Studer and files cited in text, SCF.
72. Interview, Berry; "Soderberg: Man Who Keeps Spruce Goose," *L.A. Times*, April 21, 1983.
73. *Long Beach Independent*, March 23, 1955, June 7, 1955, and July 10 1960.
74. *Independent Telegram*, June 7, 1959; Letters, Vickers to Richfield Oil, November 4, 1960, and Durham to Hoffmaster, November 10, 1961, Hughes 1960, Central Files, PLB.
75. Harbor Board "Hughes Tool Company Application," January 27, 1966, Leases SCF.
76. *Empire*, p. 275.
77. See Site Exploration file, SCF; Interview, Ford.
78. *L.B. Independent*, August 22, 1972; Letter, Hopper to Board, 10 August 1972; Memo, Thorley to Board, August 17 and 21, 1972; Lease Amendment 1972, Hughes 1958-1977, Central Files, PLB. Summa Corporation did manage to retain the *Spruce Goose* until 1980.
79. Lease Amendment, 1975, Hughes 1958-1977, Central Files, PLB.
80. Environmental Resources Group, "Draft EIR on ARCO Marine Tanker Terminal Relocation to Berths 120-121" (1979) p. I-2, and McJunkin to Daryl B. Crown, March 7, 1980, Summa, Chief Engineer's Office, PLB.
81. Keats, p. 159.

ABOUT THE AUTHOR

Lois Roberts was born in Los Angeles in 1920 and has been involved in the world of flying since 1949 when her husband got a *Navion* dealership at Van Nuys Airport and subsequently moved his fixed base operation to Guayaquil. She received her doctorate in history from UCLA in 1970 and since that time has taught California, United States and Latin American history at California State University Long Beach and at CSU Northridge. In 1976 the United States Corps of Engineers asked her to make a historical survey of the Los Angeles and Long Beach Harbors. This was followed by other contract work such as a study of the Channel Islands for the U.S. National Park Service and of the *Spruce Goose* hangar for the Port of Long Beach. She is currently teaching, writing and taking flying lessons at Flight Works, Van Nuys, where she owns a Mooney 201 with her flier husband.

