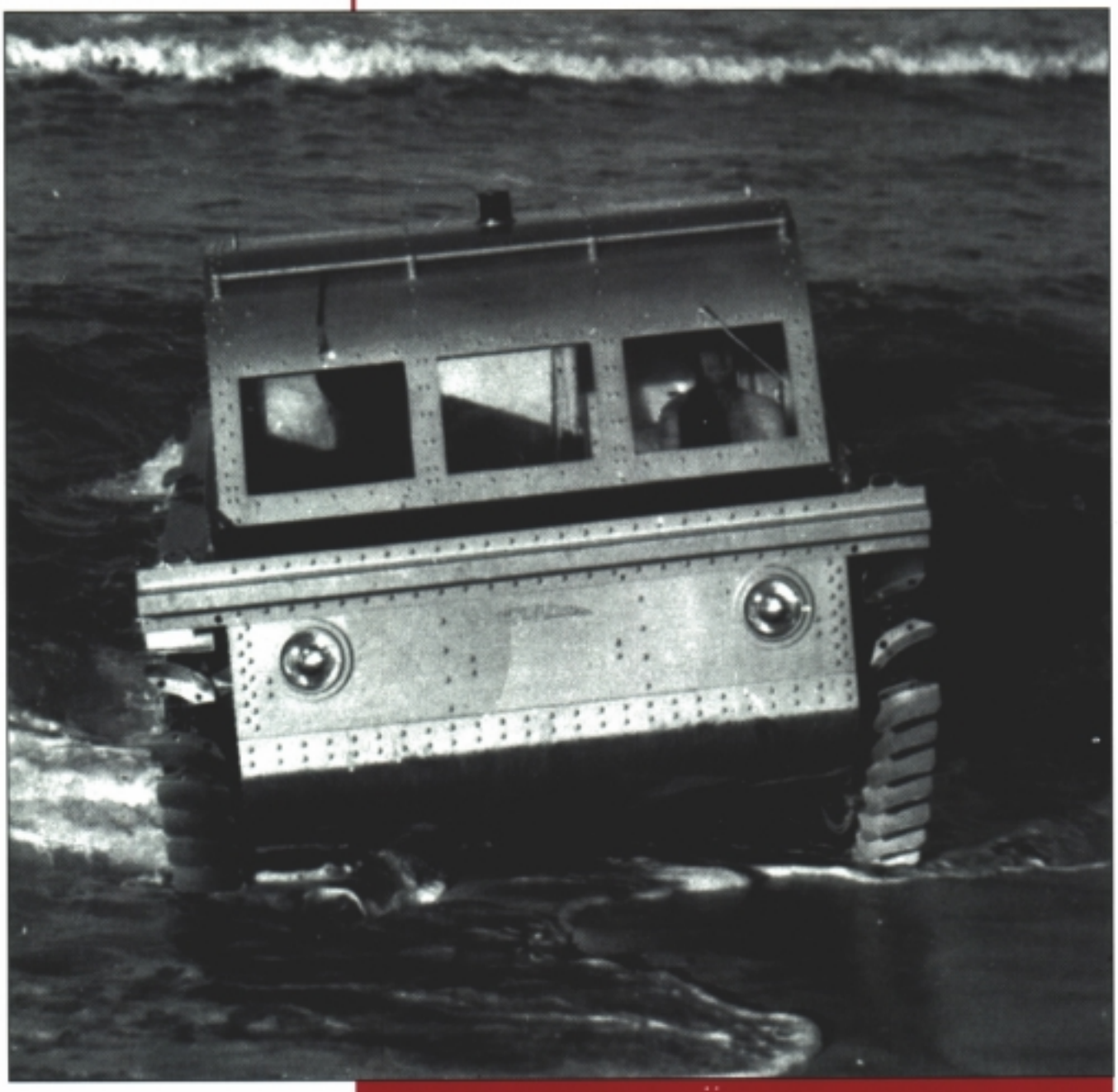
The Alligator Amphibian

A Historic Mechanical Engineering Landmark
May 21, 1997
United States Marine Corps Air-Ground Museum
Quantico, Virginia



THE ALLIGATOR

ASME International

HISTORIC MECHANICAL ENGINEERING LANDMARK

ALLIGATOR AMPHIBIAN

1940

THIS VEHICLE, ORIGINALLY DESIGNED FOR CIVIL RESCUE WORK IN FLOODED AREAS AND TRAVEL IN SWAMPY REGIONS, WAS DEVELOPED BY DONALD ROEBLING IN 1935. IT WAS MODIFIED FOR USE AS A SHIP-TO-SHORE TRANSPORT FOR MEN AND SUPPLIES DURING WORLD WAR II. THE PADDLE-TREAD PROPULSION SYSTEM MADE IT A TRUE AMPHIBIAN, THE PREDECESSOR OF ALL TRACKED LANDING VEHICLES. THIS EXAMPLE IS BELIEVED TO BE "ALLIGATOR THREE," PROTOTYPE OF OVER 15,000 VARIOUS TYPES AND MODELS. AFTER THE WAR, DEVELOPMENT OF THE HELICOPTER PRECLUDED FURTHER CIVILIAN APPLICATIONS.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS - 1997

Donald Roebling

INTRODUCTION:

The "Alligator" amphibian tractor is the progenitor of all amphibian assault vehicles used since 1941. It was a pioneer venture both in its design and the materials used in its construction.

In 1935, Donald Roebling, a grandson of Colonel Washington Roebling, designer of the Brooklyn Bridge, built an amphibian tractor to rescue victims of Florida's devastating hurricanes.

Nicknamed the "Alligator," the aluminum tractor was being marketed as a vehicle for oil exploration when it came to the attention of the United States Marine Corps. War with Japan was looming and the Marine Corps was searching for a vehicle that could cross the coral reefs encircling many of the Pacific Islands.

Encouraged by the Marine Corps, Roebling further developed the Alligator into the model being honored here. By the time of America's entry into World War II, an all-steel version had been adopted as the Landing Vehicle, Tracked, or LVT-1.

HISTORY AND DEVELOPMENT

The story of the development of the Roebling amphibian tractor starts with the devastating hurricanes of 1926, 1928, and 1932 that hit southern Florida. Donald Roebling's father, financier John A. Roebling, had witnessed the loss of life and damage caused by these storms in the swampy areas of the Okeechobee region.

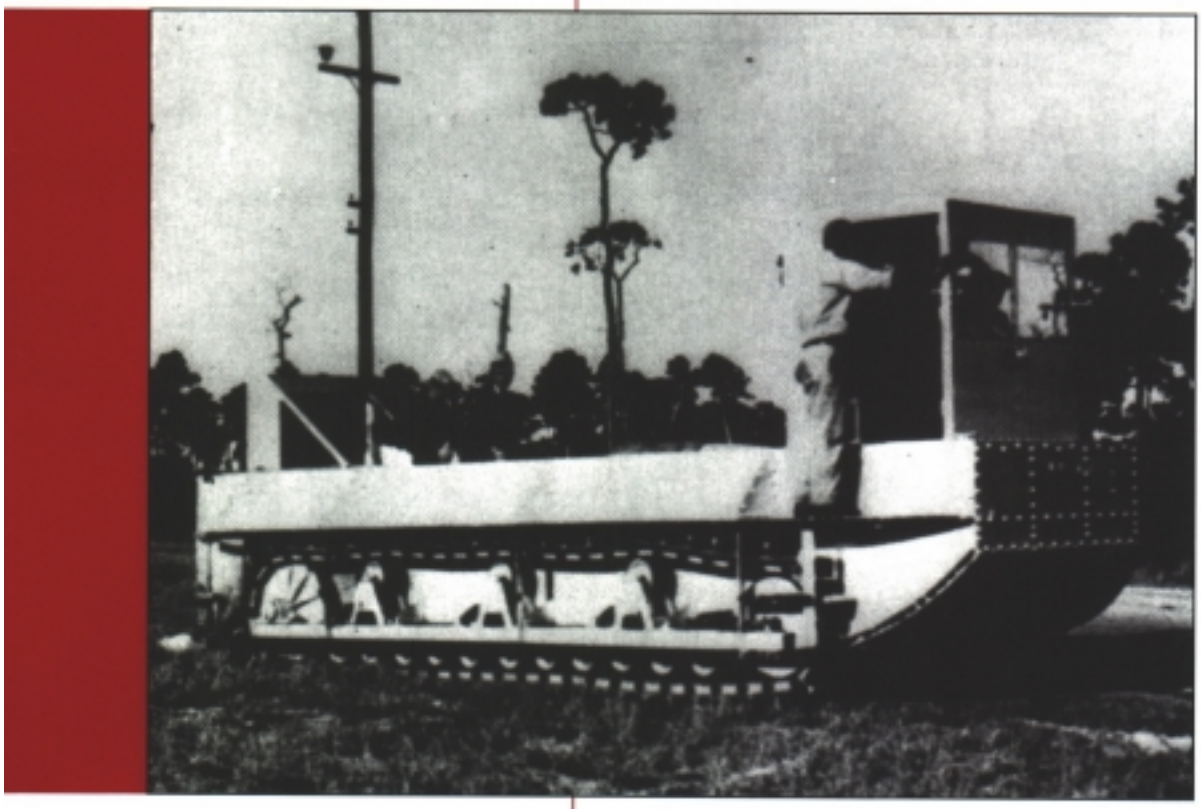
John Roebling was aware he could not do anything about the hurricanes, but perhaps he could help the victims, many of whom became trapped in impenetrable swampy regions. He wanted to build a rescue vehicle that in his words, "would bridge the gap between where a boat grounded and a car flooded out."

Spurred by this challenge from his father, Donald Roebling used his engineering talents to design and develop such a vehicle. He started work on an amphibian tractor in early 1933 and a prototype was completed two years later.

In 1937, US Navy Rear Admiral Edward C. Kalbfus, who at that time commanded all of the battleships in the US Pacific Fleet, showed an October 4 Life magazine article on Roebling's amphibian tractor to Major General Louis McCarty Little, then Commanding General of the Fleet Marine Force.

General Little, alert to the need for an amphibian vehicle for the ship-to-shore movement of troops and supplies, forwarded the article to the Commandant of the Marine Corps. The article was then passed on to Brigadier General Frederick L. Bradman, president of the Marine Corps Equipment Board at the Marine Corps' base in Quantico, Virginia.

Prior to this, efforts to produce an amphibian tractor by both the American designer Walter Christie in the 1920s and the British firm of Vickers-Armstrong in the 1930s proved unsuccessful. The Marine Corps, in fact, had not even been able to develop a practical boat that could land Marines on a hostile shore, despite much experimentation.



The first model of the Roebling Amphibian Tractor. Parts from this vehicle were incorporated into subsequent model...

In March 1938, Major John Kaluf, Secretary of the Equipment Board, was dispatched to Clearwater, Florida, with orders to investigate the military potential of the Roebling Alligator. Major Kaluf returned a generally favorable report and about 400 feet of 16mm movie film of the Alligator in action. Two months later, the Commandant of the Marine Corps requested that a "pilot model" be purchased for "further tests under service conditions."

This request was turned down by the Navy's Bureau of Construction and Repair due to limited funds. However, the Marine Corps' interest in Roebling's design continued and Kaluf made a second trip to Clearwater in January 1939.

Roebling, at that time, was in the process of making a number of modifications to his second Alligator model. In the fall of that year, the new president of the Equipment Board, Brigadier General E.P. Moses, and Kaluf's replacement as secretary, Major E.E. Linsert,

The "Alligator 2" being loaded for transport to a test site.

made a visit to Clearwater that would become a turning point in the development of the Alligator.

During this visit, General Moses persuaded Roebling to design a new tractor more suitable to the Corps' needs. Roebling agreed and he and his staff worked on the design of this new vehicle during the last quarter of 1939. The design of the vehicle was completed in January 1940. Because the Marine Corps lacked the funding to underwrite this design effort, Roebling came up with the $18,000 to build the new tractor, the Alligator 3. Construction was completed in May 1940.

This new version incorporated a number of improvements in response to experience gained with earlier models of the Alligator. With the political and military situation in Europe and Asia worsening, military appropriations from Congress were authorized and the Navy Department's Bureau of Ships was able to fund a $20,000 contract with Roebling for construction of a military test vehicle.

Marine Sergeants Clarence H. Raper (right) and Walter L. Gibson pose beside the first amphibian tractor procured by the Marine Corps. It was tested extensively in 1940 under the direction of then Captain Virtor H. Krulak.

This was the first amphibian tractor procured by the government entirely with appropriated funds. It was almost identical to the Alligator 3 but was powered by a 120-horsepower Lincoln-Zephyr engine and had some additional improvements suggested by the Equipment Board.

Completed in October 1940, this fourth model Alligator was shipped first to Quantico and then to the Caribbean for testing. While the tests revealed some deficiencies, the general design was proclaimed a success. The hull of the tractor was changed from aluminum to steel and the first vehicle of an initial order of 100 LVTs rolled off the Food Machinery Corporation's (FMC) assembly lines in July 1941.

Originally employed solely to bring supplies ashore and inland during the early campaigns in the Solomon Islands, amphibian tractors were first used as assault vehicles at Tarawa Atoll in 1943. As the war progressed, design deficiencies became apparent in both the LVT-1 and the LVT-2, leading to the introduction of two more improved models.

Concurrently, a family of armored and armed tracked landing vehicles had emerged and by the war's end, seven different versions had been employed. They were used against the Japanese by the Marine Corps and Army Amphibian Tractor Battalions and also against the Germans by the US Army and the British.

TECHNICAL BACKGROUND

Roebling and his staff completed their first model Alligator in early 1935. It utilized aluminum, a comparatively new and unproven material, in the construction of the hull in order to reduce weight and increase buoyancy. Although aluminum had been in use for the past 40 years, it had not been used to any appreciable extent in the manufacture of vehicles.

The tractor portion had a rudimentary cab for the operator and a large bed in the back. The tractor was propelled on land and in water by paddle-tread tracks, similar to early paddle-wheel steamships, and was powered by a Chrysler 92-horsepower industrial engine.

Roebling's paddle-tread principle was patented in 1938 and he turned his patent over to the government for universal use and without fee during World War II.

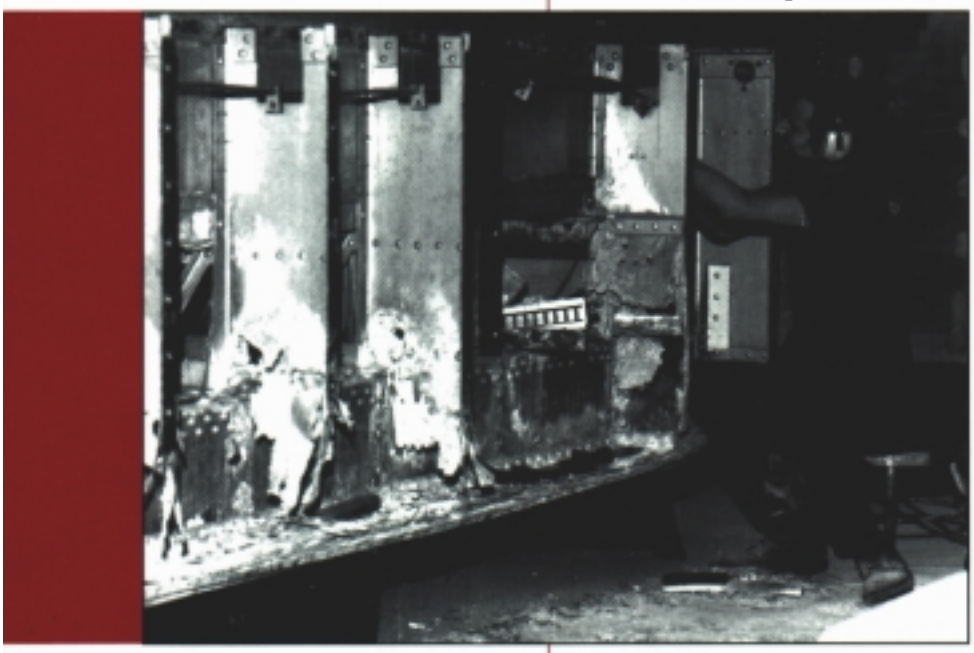
The first model was modified a number of times to improve its performance, especially in the water. In 1937, Roebling redesigned and rebuilt this vehicle so extensively that the result is generally referred to as the second model Alligator. It was 4 feet shorter and incorporated distinctly new tracks, with built-in roller bearings that rode in specially designed steel channels.

This new design eliminated the need for idler and bogie wheels (a special undercarriage used to provide traction on uneven surfaces) as were used on most tractor and tank designs. The result of these

changes was an increase in maneuverability and water speed. Roebling then used the parts from his two earlier prototypes to build the Alligator 3.

This version also incorporated several improvements, both in response to engineering design and military requirements. This vehicle, which is on exhibit in the Marine Corps Air-Ground Museum at Quantico, originally was powered by a 95-horsepower Mercury engine. After World War II, this power plant was replaced with a 1952 Pontiac Silver Streak 102- horsepower 6-cylinder engine.

This last engine was restored by a summer college intern working in the Marine Corps Museum's restoration shops in 1989 and placed on exhibit alongside the tractor. Its treads also are a postwar improvement and were mounted on the tractor by Roebling in 1946 or 1947.



Museum specialist Ronald Gay removing corroded metal from, the Alligator 3 hull during its restoration.

The Alligator 3 had been displayed outdoors at the Marine Corps Reserve Center in Tampa, Florida since the mid-1960s. It was shipped to the Marine Corps Air-Ground Museum in 1984 and was completely restored by the museum staff before being placed on exhibit.

GENERAL SPECIFICATIONS

Manufacturer:	Donald Roebling Clearwater, Florida
Engine:	Mercury 95-horsepower, 8-cylinder, water-cooled gasoline engine
Transmission:	2 forward speeds, 1 reverse
Dimensions:	Length 20 feet (60 m) Height 8 feet (2.4 m) Width 8 feet (2.4 m)
Weight:	8,000 pounds (3,600 kg)
Maximum Speed:	Land, 25 mph (40 km) Water, 10 mph (16 km)
Crew:	1 driver and assistant
Payload:	7,000 pounds (3,150 kg)

TECHNICAL DESCRIPTION OF THE ORIGINAL ALLIGRTOR 3

The driver's cab is 6 feet 4 inches wide (193 cm), 5 feet 6 inches high (167 cm) and 5 feet 6 inches long (167 cm). It has seats for three people including the driver. Windows in front are fixed and made of l/2-inch (1.27 cm) Plexiglas. Side windows are made of 3/8-inch (.95 cm) Plexiglas and slide back to open. The door in back, when closed, made the cab water tight.

The passenger or cargo compartment is 9 feet long (274 cm), 6 feet 4 inches wide (193 cm) and 3 feet 7 inches deep (109 cm). It will accommodate 7,000 pounds (3,150 kg) of cargo and is water tight with respect to the rest of the hull. There is a l2-inch deep (30.5 cm) space between the compartment floor and the bottom plate that contains the gas tanks, the wiring and rods between the motor and the cab, and the structural framing of the hull.

The motor compartment is 5 feet 6 inches long (167 cm), 4 feet 5 inches high (135 cm), and 6 feet 4 inches wide (193 cm). It contains the motor, transmissions, gear reductions, and the cooling system, all controlled from the driver's cab.

HULL: Composed of duralumin, fabricated by riveting, except for the floor plates, which are screwed down to permit removal for servicing.

MOTOR: A Mercury V-8 engine giving 95 horsepower at 3,600 rpm. Power is delivered to the treads through a standard Ford clutch to 1:1 spiral bevel gears, driving a shaft at right angles to the motor on either end of which is mounted a Ford clutch and a three-speed transmission.

These in turn deliver through a double universal to 7:1 herringbone reduction gears and through the hull to the drive sprockets. On the inside ends of the drive shafts are mounted hydraulic brakes and drums of the Packard 8 type. All bearings are anti-friction. Gear cases are cast aluminum. The engine room deck with the cooling system mounted beneath may be removed as a unit to permit removal of the engine assembly.

CONTROLS: Clutches, brakes, gear shifts and throttle are rod controlled. The clutch pedal operated by the driver's left foot is for fore and aft movement without steering effect. Two vertical hand

levers between the driver's knees control the steering clutches. When pulled beyond the clutch disengagement, these hand levers apply the brakes on their respective sides.

The throttle may be operated by the driver's right foot or by hand. Two gear-shifts are mounted on the dash. The instrument panel contains a tachometer, compass, ammeter, thermometer, oil pressure gauge, and switches for ignition, solenoid operated choke, starter, and headlights.

FUEL SUPPLY: Two 40-gallon (1521) stainless steel are tanks mounted under the passenger compartment.

COOLING: The radiator is mounted against the rear underside of the motor compartment deck and is filled from outside. 6 inch by 9 inch aluminum blowers operate in a stainless steel water-tight duct as air is taken in at the back and discharged from the sides.

CHAINS: The Alligator derives its propulsion from special 4-inch Tee shaped curved duralumin cleats bolted to Link-Belt roller chains. The drive sprocket teeth are cut to fit these rollers.

The pitch of the chain is 3.265 inches (8.293 cm). It is of double width and has a tensile strength of 80,000 pounds (36,000 kg). The chains are kept parallel to the machine by a steel channel that takes the side thrust in turning. The tension of the chains is obtained by moving the front idler sprockets forward with hydraulic jacks pumped from the driver's cab. The jacks are supported on coil springs to absorb shock.

CLEATS: The cleats are of Alcoa 24ST extruded in a Tee section with a stem 4 inches high (10 cm) and a top 4 inches wide (10 cm), bent to a 12 inch radius (30 cm) and having four bolt holes.

The Alligator is designed to travel on land between 15 and 25 mph (24 and 40 km) and in water between 8 and ten mph (12.8 and 16 km). Its patented paddle-tread design enables travel on both land and in water without change of propulsion.

SIGNIFICANCE AND CONTRIBUTIONS

"The development of the amphibian tractor, or LVT, which began in the middle 1930s provided the solution and was one of the most important modern technical contributions to ship-to-shore operations. Without these landing vehicles, our amphibious offensive in the Pacific would have been *impossible."*

General Holland M. Smith
US Marine Corps, 1949

By the end of World War II, over 15,000 amphibian tractors, in seven different configurations, were produced. Although Germany and Japan had a limited experience with amphibious vehicles during the war, the United States became the first country to produce a practical amphibian tractor.

Used extensively by US forces in the Pacific theater, the amphibian tractor played a vital role in the island hopping strategy employed by the US Marines Corps. Used also in the European theater by the US Army, the amphibian tractor played a crucial part in the amphibious assault of Normandy during the D-day invasion.

The amphibian tractor was also used decisively in the Korean War during the successful landing at Inchon and continued its service on land throughout the Vietnam War.

Today, an upgraded, modernized version called the LVTP-7Al Assault Amphibian Vehicle (AAV) provides the US Marine Corps with the ability to conduct amphibious operations.

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THE ASME HISTORY AND HERITAGE PROGRAM

The ASME History and Heritage Program began in September 1971. To implement and achieve its goals, ASME formed the History and Heritage Committee, initially composed of mechanical engineers, historians of technology, and the curator (Emeritus) of mechanical and civil engineering at the Smithsonian Institution. The committee provides a public service by examining, noting, recording and acknowledging mechanical engineering achievements of particular significance. The History and Heritage Committee is part of the ASME Council on Public Affairs and Board on Public Information.

Since the ASME History and Heritage Recognition Program began, 181 Historic Mechanical Engineering Landmarks, 6 Mechanical Engineering sites, and 6 Mechanical Engineering Heritage Collections have been designated.

The ASME History and Heritage Program illuminates our technological heritage and encourages the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians, and travelers and helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

For further information, please write to Public Information, ASME International, 345 East 47th Street, New York, NY 10017-2302; call 212-705-7740; fax 212-705-8676.

ACKNOWLEDGEMENTS

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MARINE CORPS AIR-GROUND MUSEUM

The Marine Corps Air-Ground Museum is located at the Marine Corps Combat Development Command, Quantico, Virginia. Marine sentries assist visitors arriving at the base; visitors are issued vehicle passes and are given directions to the museum or research site. There is no admission charge. Free Parking is available.

The Marine Corps Air-Ground Museum is open to the public from April 1 through November 15. The Hours are 10:00am to 5:00pm, Tuesday through Saturday. Sunday hours are from 12:00pm to 5:00pm. The Museum is closed on Mondays and Easter Sunday.