The Eyes of the Fleet

by Francis J. Allen

The date is sometime during the 1920s. The place is the Pacific Ocean. The situation is a state of war existing between Japan and the United States. The two battle fleets are at sea with the American fleet going about the task of securing its lines of communications to advanced Naval bases in the Philippines. The traditional cruiser scouting force is very limited in numbers but this does not mean that the eyes of the fleet are blind. The cruisers will support the battle line in the upcoming surface action. The scouting for the fleet has been taken over by the lighter-than-air carrier. These airships, moving in two waves of five ships each from their base at Pearl Harbor, with their airplanes stationed on their flanks and out ahead will keep the battle fleet well appraised of the enemy's intentions. As far-fetched as that short narrative may sound to those of us in this day and age, it was not so easy to dismiss this notion during the 1920s and the 1930s. It is in light of the above that the American airship program should be seen because if the world had developed as it looked as it might the airships *Akron* and *Macon* would have been the prototypes of a generation of scouting airships instead of the last of their kind.

The promise which was the genius of the rigid airships *Akron* and *Macon,* ZRS-4 and -5, was the ability of the airship to cruise over very long distances and to remain aloft for long periods of time. This promise had been shown in practical terms by the German Naval Zeppelins of World War I. This ability was not used to the full by the European powers who had introduced the technology. This was due in part to the lack of helium as a lifting gas and to the fact that the airplane had been developed to the point that the airship's range and endurance was of less importance, considering the operating ranges necessary for making war in Europe.

The U.S. Navy on the other hand viewed the world from a different point of view. For the American Navy in the post-World War I world the rigid airship was judged the most practical means of providing very long-range reconnaissance. The combination of limited federal monies, treaty limitations, large reserves of nonflammable helium and two large oceans to patrol led to the development of the airship in America.

The Navy saw in the *Akron* and the *Macon,* with their ability to carry heavier-than-air (HTA) aircraft, the ultimate expression of the scouting vessel. An *Akron-type* airship, "Flying at a cruising speed of 60 mph, with one of its hook-on airplanes stationed 60 miles out on each beam, the airship . . . [could] . . . sweep . . . 180 miles and during [a] 12-hour [patrol]. . . could cover approximately 129,000 square miles.

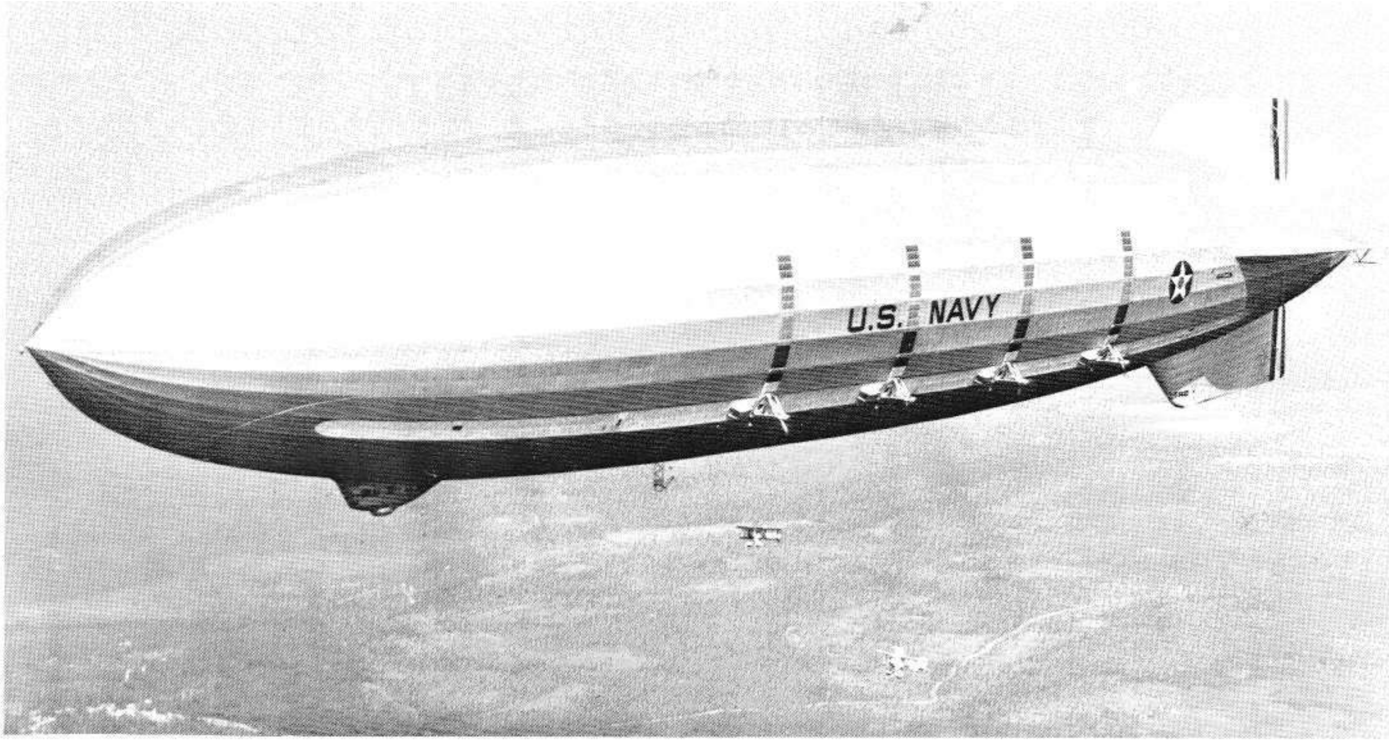
This ability was to be used to free the limited number of cruisers to reinforce the fleet's battle line.

An Early Development History—It was during the 1920s that all of the necessary factors came together for the building of the *Akron* and the *Macon.* During this time with the return from Europe of Commander Garland Fulton and his appointment as head of the Lighter-Than-Air Design Section of the Bureau of Aeronautics, the Navy took the first steps which would lead to the ZRS-4 and ZRS-5. The Navy was already getting its feet wet in the area of LTA technology with the use of ZR-l, the *Shenandoah,* and LZ-126, the *Los Angeles.* These airships could not be considered as the military airships envisioned by the Navy; however, they were used as training ships and as a means to study the necessary elements of cooperation with the surface fleet.

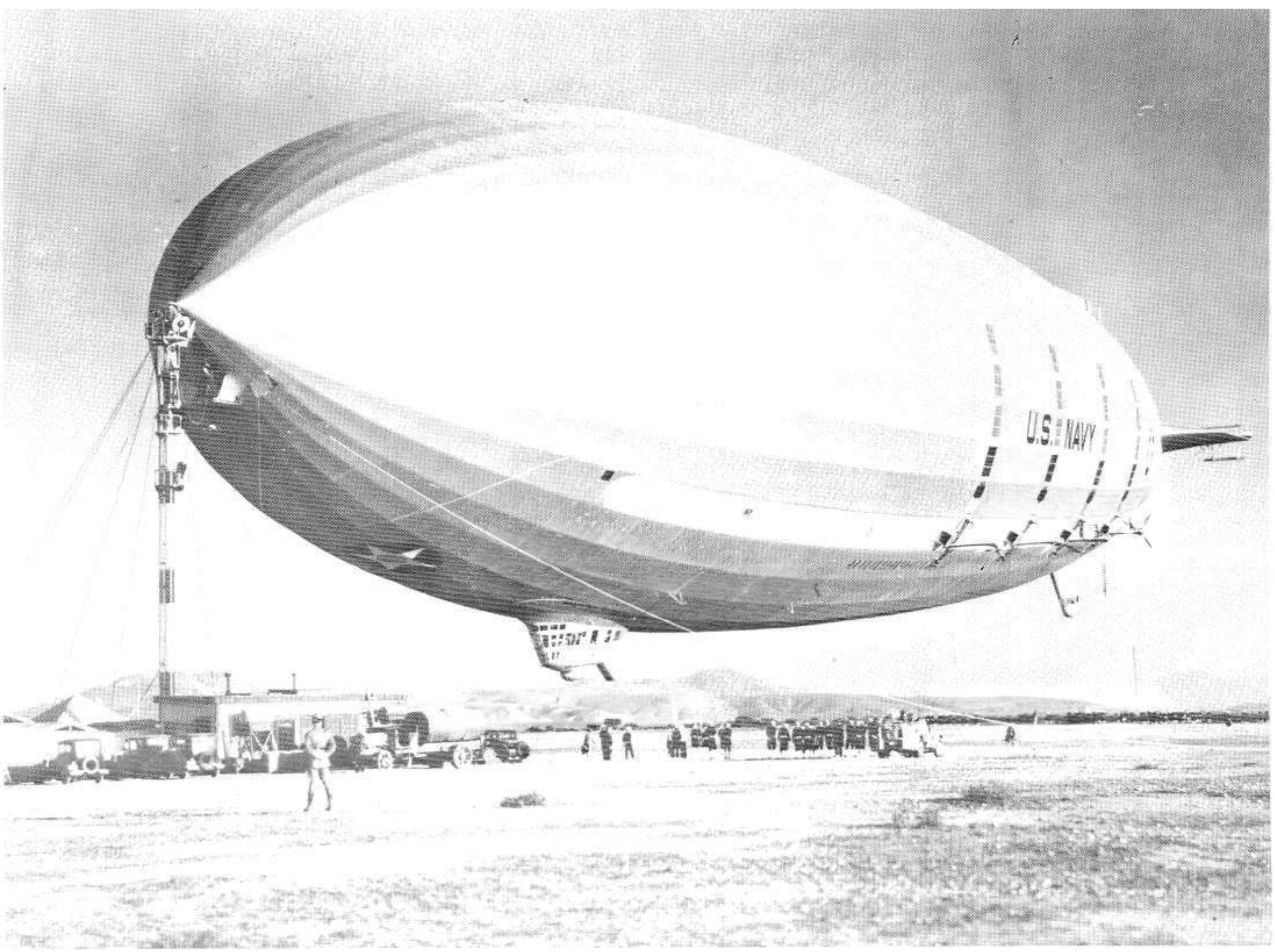
Several times during the 1920s the U.S. Navy tried to obtain funds from the Congress to start construction of a true scouting airship. All of these attempts failed. It was not until 1928 that Mr. William C. Young, the sales manager for the Goodyear-Zeppelin Company, was able to secure funds for airship construction. By then the Goodyear-Zeppelin Company had already submitted to the Bureau of Aeronautics three project studies. All three projects had a gas capacity of 6,500,500 cubic feet. Where they differed was in their internal arrangement of structure and equipment. The U.S. Navy chose the first project study and on October 6, 1928, a contract was signed with Goodyear-Zeppelin for two airships. The first was to be delivered within 30 months and at a price tag of $5,375,000, while the second airship was to come 15 months later and cost $2,450,000. These were in time to be named *Akron* and *Macon.*

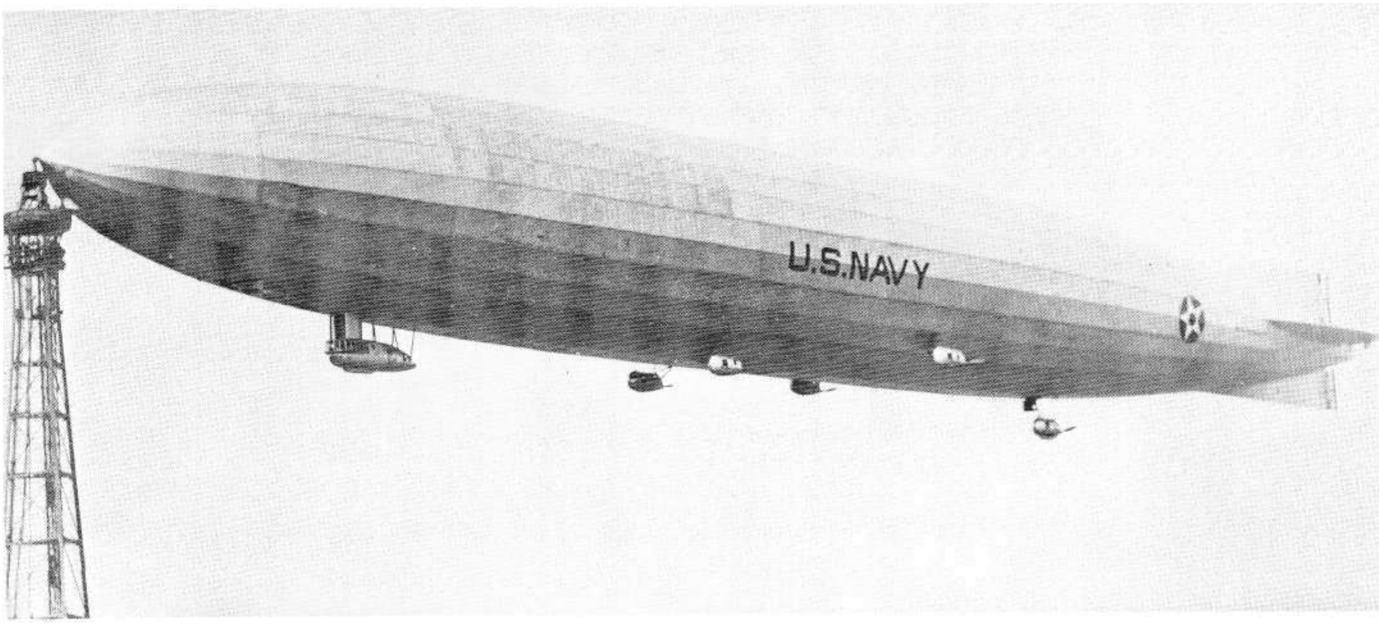
The *Akron* was first officially shown to the public at her christening on August 8, 1931, with Mrs. Herbert Hoover naming her ZRS-4 *Akron,* for the city of Akron, Ohio. This ceremony was attended to with a great deal of hokum. It was unfortunately the inflated expectations that the public held that were not to be justified by the *Akron's* performance. This was not the fault of the airship but the fault of the publicists who credited this aircraft with such titles as "Battleship of the air," "Cruiser of the clouds" and "Leviathan of the skies." The *Akron,* as she rode at her mooring mast, was in reality a prototype airship and nothing more. The *Akron* was commissioned on October 27, 1931, and put to her first test in June of 1932 during the fleet exercises. These were con-

USS *Macon,* ZRS-5 in flight with two Curtiss F9C aircraft from its HTA unit. (National Archives Photo No. 80-G-463096)



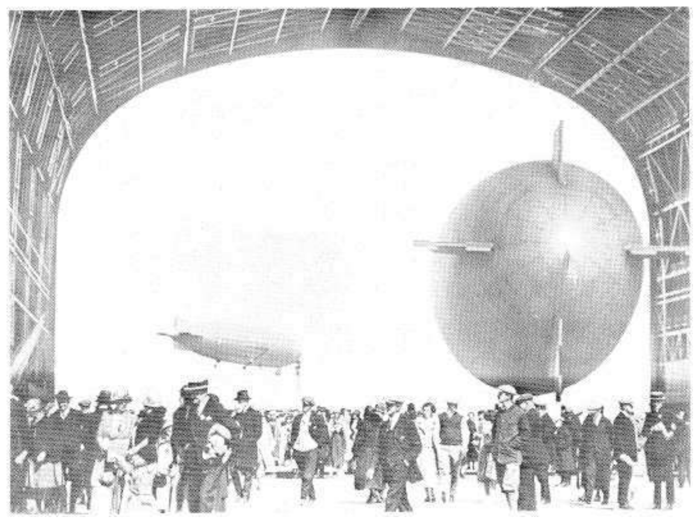
USS Macon secured to the mooring mast at Kearney Mesa near San Diego, Calif., Feb. 8, 1934. (National Archives Photo No. 80-G-463264)





USS *Shenandoah,* ZR-1 at the mooring mast at Lakehurst Naval Air Station, New Jersey, May 31,1924. (National Archives Photo No, 80-G-459498)

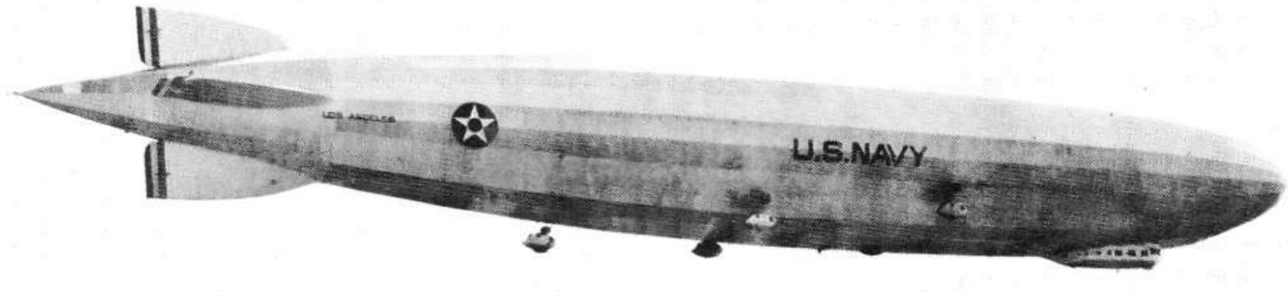
Wreckage of the USS *Shenandoah.* (National Archives Photo No. 80-G-182696)



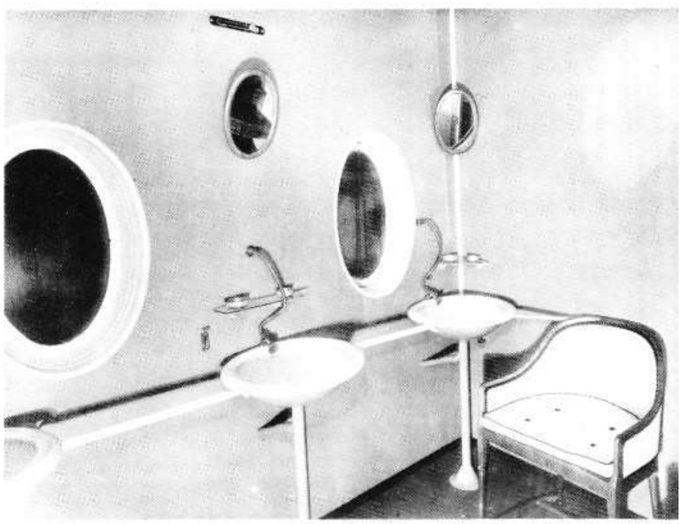
USS *Shenandoah,* ZR-1 at mooring mast viewed from inside hangar looking out on May 31,1924. (National Archives Photo No. 80-G-459504)

ducted on the West Coast and the fleet problems were more complex than had been her workout with the Scouting Fleet held in January of that year on the East Coast. In particular the *Akron* was to be "attacked" by float planes launched from the cruisers of the force that the airship was to be shadowing. Although the ability of the float planes to damage or to even destroy ZRS-4 was rated out of all proportion, the performance of the *Akrons* crew was also not all that could have been hoped for. This poor performance was the result of too much barnstorming and flag-waving, and not enough crew training and practice, which could have been had only by operating and exercising at sea. The *Akron's* HTA unit was also not on board and this simply added to her problems in functioning as a scouting airship. Likewise the talk about the ease with which the airship was destroyed by dive-bombing and machine-gun fire were really wishful thinking based upon the memories of the flaming Zeppelins falling from the skies over World War I Europe.

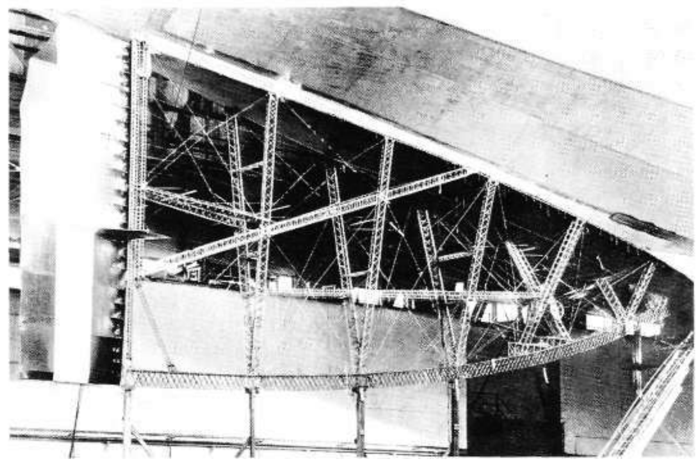
If the first part of the *Akron's* service life was undistinguished, the second half of her operational life was to be in marked contrast to those first years. Under the command of Commander Alger Dresel (June 22, 1932, to January 3, 1933) and Commander Frank McChord (January 3, 1933, to April 4, 1933) the *Akron* was more completely prepared to take her proper place with the fleet. For one thing under Commander Dresel the *Akron's* HTA unit was brought up to strength with the arrival of the Curtiss F9C-2s. During this same period Lieutenant Donald M. Mackey devised a system of prenavigation. Using this method of navigating an F9C-2 pilot could move beyond the limits of having to maintain visual contact with his mother ship. It was first tried with the *Akron* in November of 1932. "The planes were sent out on a course which diverged from the airship's track at 60 degrees, with instructions to maintain a speed exactly twice the speed of the airship. On this course the planes generated a relative motion to the airship track which was equal to the airship's speed; no matter how far they flew on, they would maintain a constant 90-degree bearing on the airship. Wind was of no concern so long as both aircraft were at the same altitude, because they were moving within the same medium. At any point along their divergent course of 60 degrees the planes could execute a 120-degree turn which converged with the airship's track at 60 degrees. On this homeward leg they would return to the airship in the same amount of time flown on the outbound



USS Los *Angeles,* ZR-3 flying over Lakehurst Naval Air Station in the 1920s. (National Archives Photo No. 80-G-461090)



Passenger washroom aboard USS Los *Angeles,* ZR-3. (National Archives Photo No. 80-G-460565)



Framework of lower fin and rudder of the USS Los *Angeles* showing auxiliary control station. (National Archives Photo No. 80-G-460578)

leg.

"Reflection on the airplane's position over this 60-60 course will show that its motion relative to the airship's track is zero. As far as relative motion is concerned the plane is simply sliding back and forth over a course 90 degrees to the airship's position."

"The 60-60 system had the disadvantage of committing the airship and F9Cs to a fixed speed and course until their rendezvous. But it was nevertheless a breakthrough." The first employment of this system did not come until it was used by the *Macon's* HTA unit in Exercise G off China Point.

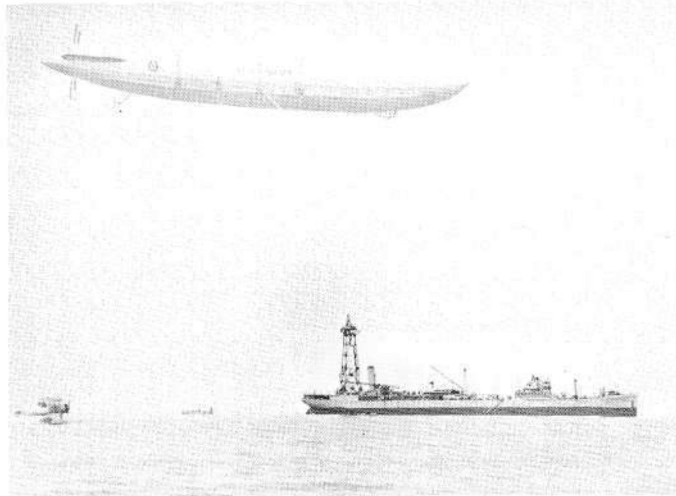
During the second period of the *Akron's* operational life it made a number of other contributions to the development of her sister ship, the *Macon.* Among these was the installation of an experimental three-bladed, steel propeller on the No. 3 engine. The experimental propeller would later become the standard propeller for the *Macon.* Also a Navy-designed water recovery unit, the Mark IV, was tried on the *Akron's* No. 7 engine. These water recovery units became standard on all of the *Akron's* engines and led to improvements being incorporated into the *Macon's* systems then under development. Yet another area of improvement was the modifications made to the trapeze. The modified system eliminated the third pole, its system of steadying arms and the need for steadying points on the plane's wings. In their place a saddle and fork; the former was a padded yoke which was lowered over the airplane's aft fuselage to arrest oscillation and swaying, the latter a pair of prongs at the end of the trapeze which were lowered after a plane landed thus centering its skyhook on the yoke were substituted. The modification of the trapeze saved 300 pounds.

In spite of all of the improvements that had been made to the ZRS-4, the *Akron* was lost on April 4, 1933, off Little Egg Inlet during a severe thunderstorm.

As the *Akron* faded from the mind of the American public another airship was ready to take her place. It was her sister ship ZRS-5, the *Macon.* ZRS-5 was christened by the wife of Admiral Moffett, in honor of the city of Macon, Georgia, on March 11, 1933. She was flown for the first time on April 21, 1933, just days after the loss of the *Akron.* On June 23, 1933, the *Macon* was accepted by the U.S. Navy. The airship was then stationed on the West Coast of the United States at the U.S. Naval Air Station, Sunnyvale, California, later renamed Moffett Field. It was from the West Coast that the *Macon* was to operate during the course of her service life. During the remainder of 1933, ZRS-5 worked with the fleet twice. She demonstrated that, if used in the role of tactical reconnaissance, an airship was of little value. It was also shown that if it were used as a 1914-18 Zeppelin, an airship in the 1930s was very likely to be shot down. Three times during the course of the exercises the *Macon* was attacked and destroyed. Yet with all of these shortcomings there was still hope among the believers that solutions could be found. These solutions, however, were not to come in time to vindicate the airship as embodied in the *Macon.*

The first half of 1934 saw the *Macon* go on trial six times. The results in any one or all of these trials were inconclusive. However, unlike the trials conducted by the Navy with the *Akron,* the official position of the authorities in the fleet was that the performance of the *Macon* was still wanting. It was "... judged that she failed to demonstrate the airship's military usefulness."

''When the *Akron* flew off to her exercises with the Scouting Fleet she was materially deficient." Her crew was not trained, but in her favor the role she was called upon to play was that of a strategic recon aircraft which was more suited to her capabilities. The problem confronted by the *Macon* was different. She was in good material condition. Her crew was trained. Her HTA unit was complete. "The *Macon's* dilemma was that the fleet exercises of 1934 were framed with the purpose of developing the offensive qualities of carrier aviation and gave no consideration to the uses of an airship." The *Macon* was destroyed nine times during the first half of 1934. She had received the bloody nose that the *Akron* should have gotten. Destroying the *Macon* during fleet exercises did not in itself prove the vulnerability of the airship as during these same exercises the carriers were also sunk or out of action and the airplanes were shot down by the enemy. A better "real world" picture might have developed if the *Akron* and the *Macon* had been able to operate together or even against each other. Their failure and successes would have appeared in a more realistic light. In the second half of 1934 things began to look a little brighter for the *Macon.* On July 11, 1934, Lt. Cdr. Herbert V. Wiley took command of ZRS-5. There followed a period when the operations of the airship were perfected. It was around this time that an RDF device, developed by Dr. Gerhard Fisher, was installed in the bumper bag beneath the control car. The combination of a 500-kc homing set with a 4,000-kc radio receiver for use in the *Sparrowhawks* answered most of the radio and navigational problems that had plagued the airship's parasite aircraft program from the beginning.



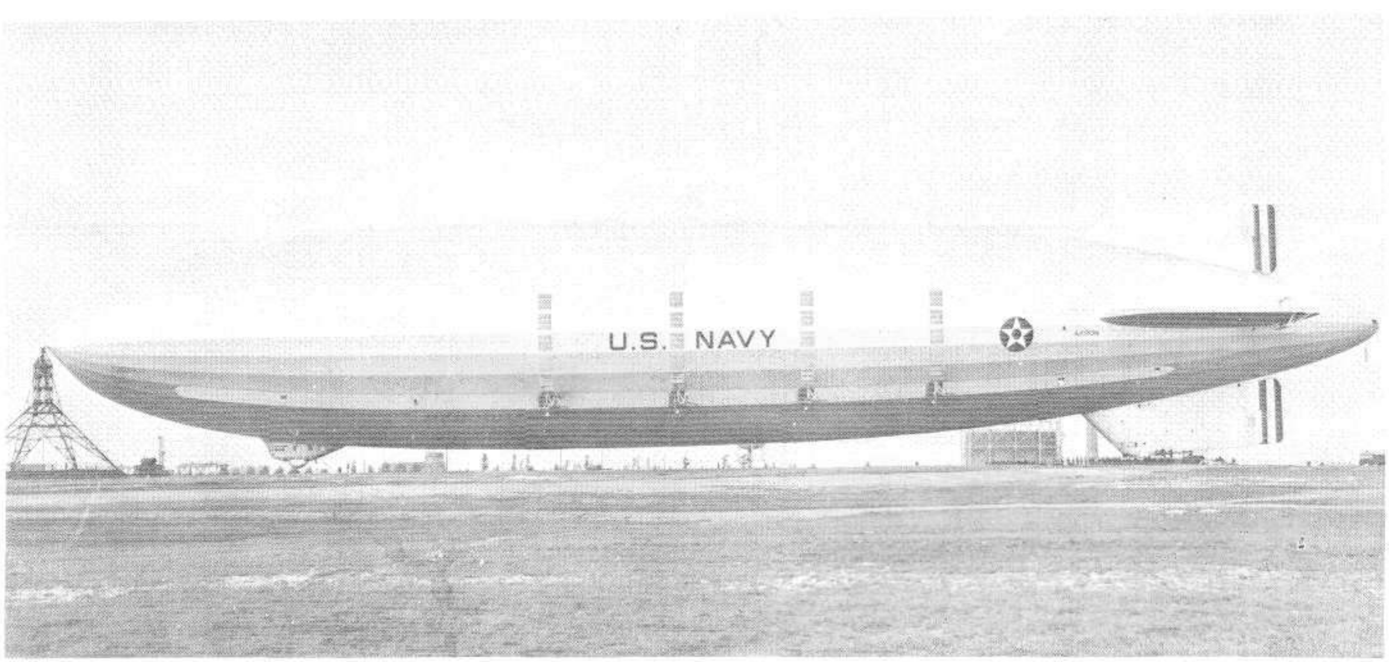
USS *Akron* maneuvering to secure to USS *Patoka* for the first time. (National Archives Photo No. 80-G-1009368)

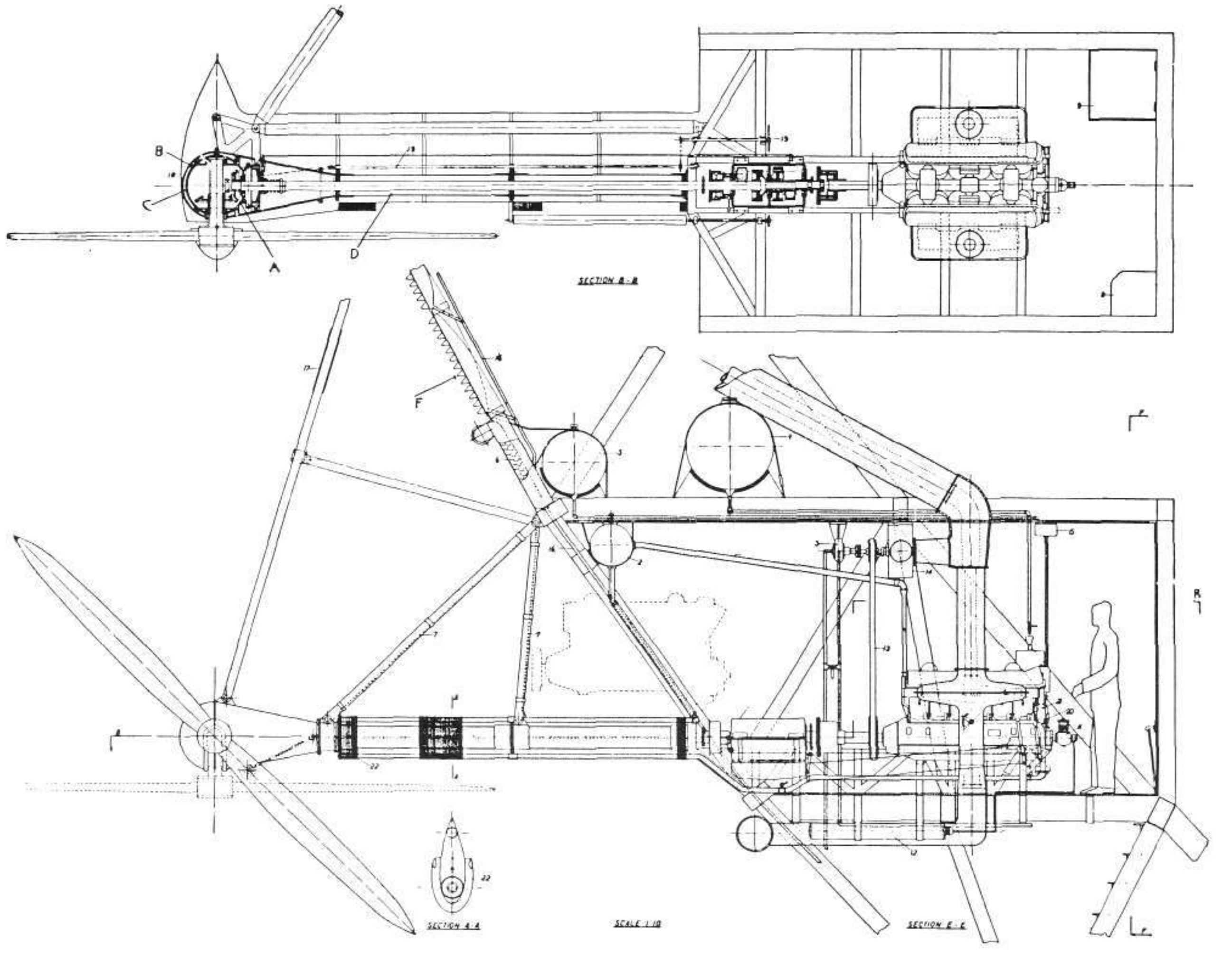
Another gain in performance was achieved by the removal of the landing gear from the F9C-2s. Once the aircraft were aboard the airship the F9Cs no longer needed their landing gear. The weight saved and the space that became available was put to good use with the installation of a 30-gallon belly fuel tank on each of the aircraft. With the additional fuel tank the capacity of the F9C-2 was increased by 50 percent.

The *Macon* was ready for work and in October of 1934 she took part in Exercise Z. She received good marks for her performance.

With the coming of 1935 it looked as if the rigid airship might finally be placed in a situation where her virtues could be used to their maximum effect. In Fleet Problem XVI, the

Broadside view of USS *Akron,* secured to the mooring mast at Lakehurst Naval Air Station, Nov. 2, 1931. (National Archives Photo No. 80-G-462255)





One of the eight powerplants and swiveling propellers of the *Akron* and *Macon*. (Author's Collection)

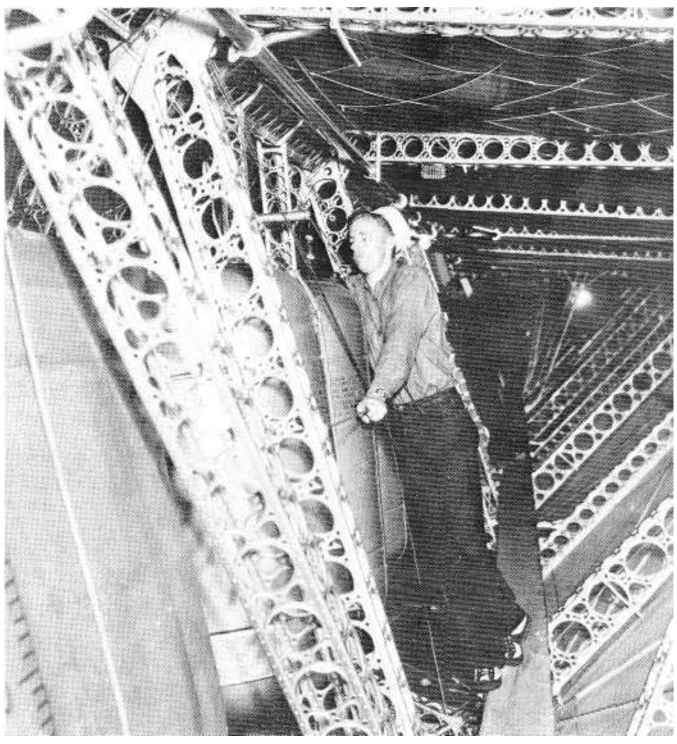
Directly reversible engines were installed in separate engine rooms inside the hull and connected through rigid driveshafts and bevel gears to the propellers. Thus, the propellers could be used for forward and reverse drive and, by tilting their axis through 90 degrees, also for vertical thrust. The swiveling device was mounted in an inner spherical case inside an outer case which was rigidly attached to the hull by a braced outrigger. The inner case could be turned through a quarter of a circle by a worm drive by a rod extending into the engine room, and carried the propeller with it. A locking clutch engaging the inner housing held the propeller shaft in any position. The line-shaft could be disengaged from the engine to slow down the propeller before changing direction of thrust. A proposed system of water recovery to counterbalance the loss of weight from liquid fuel consumption included an exhaust-gas pre-cooler. Longitudinally ribbed condensers extended up the side of the ship, and water separated below the condensers.

spring exercise which was to take place west of Hawaii, the *Macon* and her HTA unit were to be used in the role for which they were designed. This, however, was not to be, because on February 12, 1935, the *Macon* was lost in a crash into the sea off Point Sur, California. The cause of the crash was determined to have been the loss of the upper fin and the confusion that resulted. Of the 83 crewmen aboard at that time only two were lost.

Why Were They Built?—It was for the work of scouting that the *Akron* and the *Macon* were designed and built and it was its HTA unit which was to enable the airships to be used as scouts. Unique to the design of ZRS-4 and -5 was the internal hangar for four airplanes and into which was built the T-shaped hangar door located in the lower portion of the hull between frames numbered 125 and 147.5. In addition to the internal hangar and T-shaped hangar door both ZRS-4 and -5 were equipped with a trapeze device to enable the HTA unit aircraft to be launched and recovered from the airship. The trapeze was positioned on the bottom of the airship's hull, just in front of the T-shaped hangar door. A monorail system was proposed for placement on the outside bottom of the hull. It was to have been a type of flight deck to accommodate several airplanes equipped with skyhooks, freeing the hangar area for more detailed maintenance. Although the idea was sound it was not installed on either of the airships. Instead of the monorail system a small fixed auxiliary trapeze was fitted at frame numbered 102.5.

As for the airplane which would be the eyes of the airship, none was available at the time of the design of the *Akron* and the *Macon.* The best that could be done at that time was for the BuAer's plane division to give over to the HTA unit all experimental airplanes which fit the general size of the hangar door. In the end it was the Curtiss XF9C-1 that was chosen for production. It was not the ideal craft but it was the best that was available. The aircraft were fitted with a skyhook, which was used to engage the trapeze. Both of these devices were perfected, along with the necessary procedures to

Entering one of the engine rooms of the USS *Akron.*
(National Archives Photo No. 80-G-462605)



Crew member inspects fuel system of USS *Akron.*
(National Archives Photo No. 80G-462606)

use them, in trials conducted with LZ-126, the *Los Angeles,* during the 1920s. In the actual procedure, "... used in taking the airplanes aboard was for the airship to take off, gain cruising altitude and speed, so that the dynamic lift of the airship would compensate for the additional weight of the airplanes when taken aboard. Then as the airship reached the area where its scouting mission was to be accomplished, the aircraft were left off. Thus the buoyancy of the airship was not measurably affected to any great degree. During an airship hook-on operation the airship cruised at maximum speed; the parasite fighter approaching it at an airspeed just above stalling speed for the engaging operation. After being engaged to the trapeze, the parasite fighter was drawn up within the hull into the airship."

While the hangar was large enough to hold five airplanes of the F9C-2 type, only four were carried during flight operations. "The hangar was composed of two transverse girders that closed in the space between the crew's quarters. . . . These girders supported a fore and aft structure configuration containing rails in an 'X' disposition. These rails held the rollers, fittings and trapeze from which the airplanes were suspended when drawn up into the hull of the airship. The floor of the hangar was made so that a handling crew could get to any part of it."

As for the HTA craft which were to be carried by the *Akron* and the *Macon* much thought and a little luck effected their development. The first successful hook-on was done by the U.S. Army and not by the Navy, using a Sperry *Messenger* biplane and the semi-rigid airship D-3. There were glider experiments flown off of the *Los Angeles* ZRS-3. These were followed by launchings and recoveries by a Navy Vought OU-1 from the trapeze which had been installed on the *Los Angeles* for the glider trials. By the time the airships *Akron* and *Macon* arrived on stage a great deal of background work had been done which enabled these airships' HTA units to move into new areas of work. The Curtiss XF9C-1 was the chosen aircraft. It was the lesser of all evils that had been in the competition for the Navy contract. In the end the production Curtiss F9C-2 biplane was a reasonably adequate airplane for use aboard an airship. Its small size, a strong selling point for those people working with the development of the airship, made for a restricted working space for the *Sparrowhawk's* pilot when he was called upon to be observer, navigator and radio operator all at the same time. It was, however, the best that was available and so the Navy made do with it. The *Macon,* in addition, had two modified Waco XJW-ls assigned to it for the purpose of training additional flight personnel.

The Airship; How It Looked—By the early 1930s the airship was still the long-distance champion. At a time when the average distance covered in a single flight of a regularly scheduled airliner was around 300 statute miles, an airship could easily handle 1,500 statute miles. It was this long-distance running for which the airship was designed. With this in mind and with the lessons taught by the loss of the *Shenandoah* at hand the Goodyear-Zeppelin Corp., the Aluminum Co. of America and the Navy's Bureau of Aeronautics, in drawing up the specifications, were to apply a strict standard of safety to both the design of the airships and to the materials which were to be used in their construction. Several of these materials should be mentioned because of the large percentage of the total weight of structural materials that they comprised. The aluminum alloy that was chosen was the Aluminum Co. of America's 17SRT. This alloy was derived from Alcoa alloy 17ST. For sheets ranging in thickness from .023 inch to .065 inch the physical properties were the following:

	17ST	17SRT
Minimum tensile strength	5,500 lbs/in^2	5,500 lbs/in^2
Minimum yield point	3,000 lbs/in^2	4,200 lbs/in^2
Minimum elongation % in *2"*	18%	12-10%
Minimum bend diameter	4	3

With the bulk of the girders used for the airship falling between .025 inch, .032 inch, .036 inch and .057 inch, a great deal of strength was gained by using the alloy 17SRT. To complement the gain obtained with the use of the aluminum alloy, structural strength was obtained from the production girders, test articles of which failed at 40-42,000 psi.

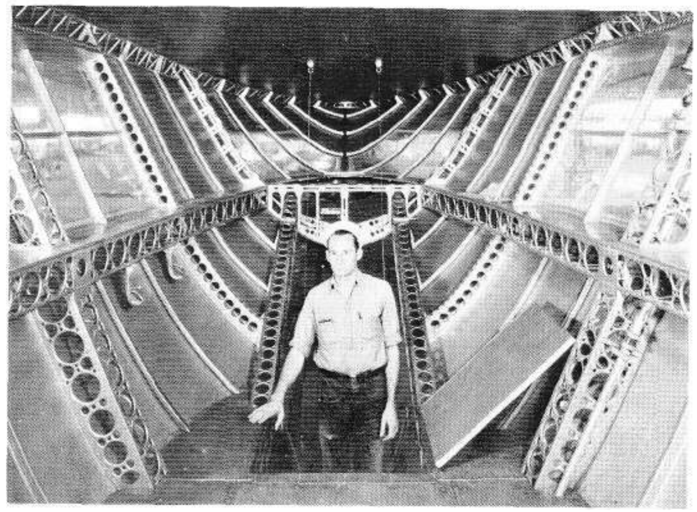
Miles upon miles of wire was used in the airship. The requirements were made very rigid (220-240,000 psi tensile strength). The end wires were formed by bending a loop in the wire. This section was then wrapped with a brass serving wire, and then soldered together.

Cotton cloth, with an estimated life span of seven years, was used for the airship's external covering.

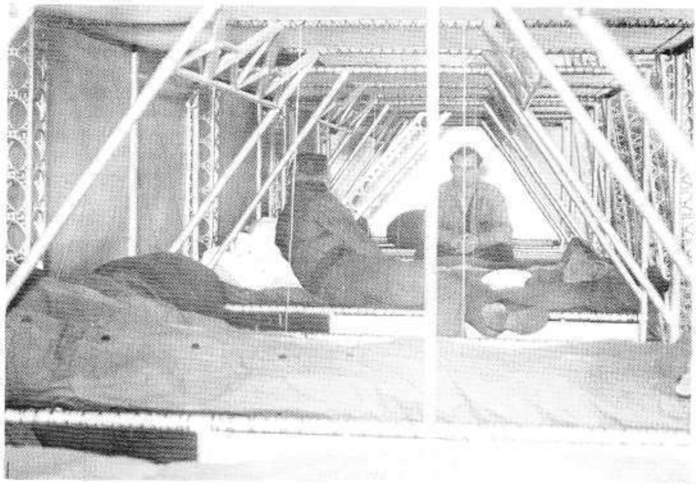
Protection against corrosion was obtained for the 17SRT by means of a chromate coating and one coat of varnish. The wires were galvanized before the last drawing operation. Other steel parts were cadmium or zinc plated.

German construction practice was followed. This meant that the frames were numbered according to their distance either forward or aft of the rudder post; the rudder post was called frame zero. Between each of the main frames were positioned three intermediate rings. These were numbered with respect to their adjacent main frames. All of the rings, except those at the extreme bow and stern, were joined by girders to the three keels and to the main longitudinal members. These main longitudinals were numbered 1-18, port and starboard, running from the bottom of the airship to the top. Between each pair of main frames was an area referred to as the bay. This was the area which was occupied by a gas cell. The numbers assigned to the bays as well as the respective gas cells were shown in Roman numerals.

The first bay to be erected was Bay V. The bays were built in the following manner: "After the framing [had been] fabricated in jigs on the hangar floor, the main frames were hoisted into cradles 22.5 meters apart and three intermediate rings were positioned at five-meter intervals between them . . . the five rings were joined by the keel girders and longitudinal members. Then each rectangular space between the framing and longitudinals was cross-braced with six lengths of hard steel wire called sheer-wiring." After Bay V was completed, rigged and tested. Bays VI and VII, which enclosed the airplane hangar, were erected. This work continued until Bay X was completed. After that, construction was directed aft. Bay XI, the nose section, and Bay 0, the tail cone, were both constructed on the hangar floor and were then at a later time hoisted into their proper position. The fin structures were produced in the same manner. With that last step completed, work could now begin on the internal layout. Eight engines plus their respective rooms and all of their associated equipment were located along the lower keels. The Maybach, Model VL-II, was used for this class of airship. The Model VL-II was rated at 560 horsepower at 1,600 rpm with a compression ratio of 7:1. The engine was a 12-cylinder, 60-degree



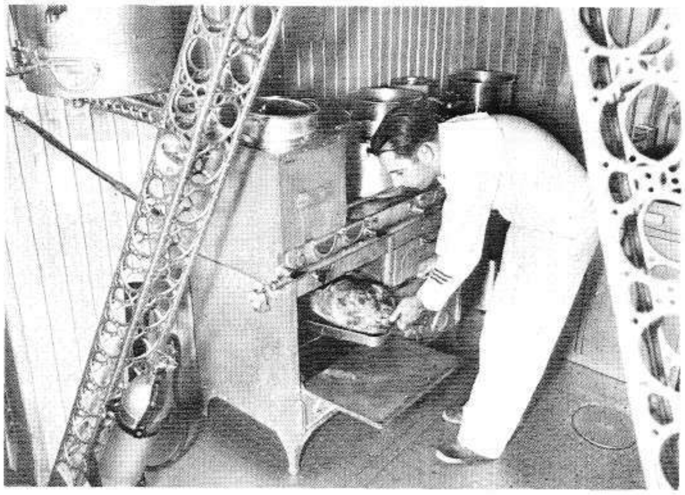
Crew member entering machine gun compartment of USS *Macon,* ZRS-5. (National Archives Photo **No. 80-G-462607)**



Sleeping quarters of USS *Macon.* (National Archives Photo No. 80-G-463025)

V-design, with aluminum pistons, and crankcase. The engines were started by compressed air and they were reversible. The powerplants tipped the scales at 2,600 pounds which was nearly 4.5 pounds per horsepower. Fuel consumption was 0.45 pounds per horsepower.

Since helium was used as the lifting agent, the Maybach engines could be placed in engine rooms located inside the airship's hull. It was believed that this arrangement would reduce the overall drag of the airship. However, the drag which resulted from the bracing struts for the propeller hub eliminated much of the aerodynamic gain resulting from the internal housing of the engines. The engine rooms themselves were " . . . located in main frames which [were] modified structurally in this region to form the rooms and permit removal of the engines." The engine rooms were accessible from the side corridors through doors. There were eight engines which were placed athwartships. Each engine drove a propeller by means of a 16-foot transverse shaft which housed at its outboatd end a short tiltable propeller shaft. The outrigger supporting the propeller shaft permitted it to be swung downward through 90 degrees. That feature, coupled with engine reversibility, produced what could be thought of as the world's largest VTOL aircraft. The engine rooms contained all of the necessary instrumentation for each engine plus a special blower for area and engine ventilation. CO2 fire



Meal preparation in the galley of the USS *Akron.*
(National Archives Photo No. 80-G-462325)

Crew members eating on board the USS *Akron.*
(National Archives Photo No. 80-G-462222)

extinguishers were also provided.

The transmissions for the Maybach engines were built by the Allison Engineering Co. for the Goodyear-Zeppelin Corp. "The general characteristics of the transmission unit may be described as right-angle, bevel-gear drive having spiral teeth; swingable housing; flexible couplings; toothed clutch; propeller shaft, 26 inches long tiltable 90 degrees about the axis of the engine shaft by lockable worm and gear drive on the housing operated from the engine room; time to tilt 90 degrees with engine operating 900 to 1,200 rpm, about 40 seconds." Transmission shaft, approximately four inches in diameter, was enclosed in a tubular housing 8.25 inches outside diameter and 7% inches inside diameter. Combined length of the transmission shaft proper and the inboard extension shaft was approximately 19 feet, 6 inches. The gross weight of the transmission unit, excluding the supporting structure for attaching it to the airship, was 1,600 pounds. The mechanical efficiency of the transmission unit was about 97 percent.

These Allison transmissions were connected to eight 16-foot, 4-inch wooden propellers. The eight propellers were arranged four to a side along the same horizontal line. They were spaced 74 feet apart. Their direction of rotation was staggered so that each propeller turned in the opposite direction to the corresponding propeller on the other side of the airship and also in the opposite direction to the propeller immediately ahead and astern of it.

Engine cooling was effected by means of core-type radiators mounted in the slipstream of the propellers. Although this arrangement produced added aerodynamic drag, no other practical solution could be found at that time.

Another consequence of using helium was the cost of the gas. In order to reduce the amount of money spent on helium, a water recovery system was invented. The recovered water was used to replace the weight lost as the fuel was consumed. This in turn maintained the equilibrium of the airship, avoiding the need to valve the buoyant helium gas. The apparatus as it was installed comprised five panels mounted close to the hull above each engine. Each panel consisted of aluminum tubes connected by heads. All of the parts were made of aluminum with the exception of the lowest sections, which were made of steel or iron in order for these sections to withstand high temperatures. The exhaust gases were drawn upwards and the condensed water was drawn off by way of bypass pipes and circulated to fabric bags or ballast containers throughout the airship. While the percentage of water recovered varied " . . . according to the hydrogen content of the fuel, the air/fuel ratio and atmospheric humidity, a better than 1:1 recovery was normal and satisfactory."

The ballast system which included the above-mentioned water recovery system was made up of 28 storage bags of 4,400 pounds capacity and four bags of 2,200 pounds capacity. Emergency ballast was contained in 12 1,000-pound capacity bags which were located near the bow and stern. The system's plumbing was controlled from the control car. In American Naval practice, keeping 50 tons or so of water from freezing was accomplished by adding alcohol to the water and then to consider the alcohol carried in this way as an emergency supply of fuel.

The normal fuel system consisted of about 126,000 pounds of gasoline in 110 tanks. The cylindrical fuel tanks were located along two side corridors next to the engine rooms. The fuel plumbing system allowed fuel to be accepted at both the bow and near amidships positions. Fuel could be moved at will and shifted as desired. The fuel pipes were made of duralumin, except in the region of the engine rooms where brass was used. Thirty percent of the fuel could be jettisoned quickly if needed. A 1,500-pound-capacity oil tank was located above each engine.

The helium, which was used to lift the airship, was contained in gas cells. For the new airships the Goodyear Tire and Rubber Co., at the instigation of the Bureau of Aeronautics, developed a new gelatin-latex fabric with which to make the gas bags. The total yardage used for the gas cells was around 54,000 square yards, which weighed in at about 22,000 pounds. "Gas valves were located along the upper corridor and they were either full automatic or of a combined automatic and manually operated type, developed by the Goodyear-Zeppelin Corp." The valves were 32 inches in diameter " . . . but the number attached to each cell was such that the bottom pressure . . . never exceeded 0.8 inch of water when the airship was rising at a rate of 4,000 feet per minute." In order to provide for the need to equalize the air pressure inside the airship during the rapid rises and falls, pressure-operated flap doors and the simple device of simply leaving off the sealing strips along certain lower panels of the hull covering were used.

A slack bulkhead of wires was used in the plane of each of the main frames to control the gas cells as they surged under normal operating conditions. Gas cylinders were used to aid in the effort to keep excessive loads off the main frames.

Electrical power aboard the airship was provided by two 8-kilowatt, 110-volt DC generators, each of which was driven by a separate internal combustion engine. For emergency a 24-volt storage battery and a 110V—24-volt reversible dynamometer acted as insurance against a complete failure of the first system. All of the above equipment and its controls we're located in a fireproof generator room which was situated adjacent to the No. 7 engine room. The generators for the radio equipment were located near the radio room in order to reduce the length of the high-voltage conductors. That radio equipment included an intermediate frequency transmitter (300-605 kc) and a high-frequency transmitter (3,000-18,000 kc). Both of these units were manufactured by Westinghouse Electric Mfg. Co. The high-frequency transmitter had a range of about 5,000 nautical miles. The intermediate range transmitter had a range of around 500 nautical miles. The airship carried a trailing wire-type antenna 800 feet in length. This antenna could be used with both radios. The antenna was deployed and retrieved by the use of electrical winches. There was also a fixed-wire receiving antenna, about 100 feet in length, which was installed along the hull, and could also be used as a transmitting antenna when the trailing wire antenna could not be used.

A lightweight radio compass was also carried aboard the airship.

Communications throughout the airship was by a 20-30-volt manually operated switchboard system. The switchboard was located in the control room. Eighteen gas-tight telephones were located in the airship. Voice tubes supplemented the telephone system in certain parts of the airship interior. In addition to all of this mechanical engine telegraphs transmitted signals from the control room to the engine rooms.

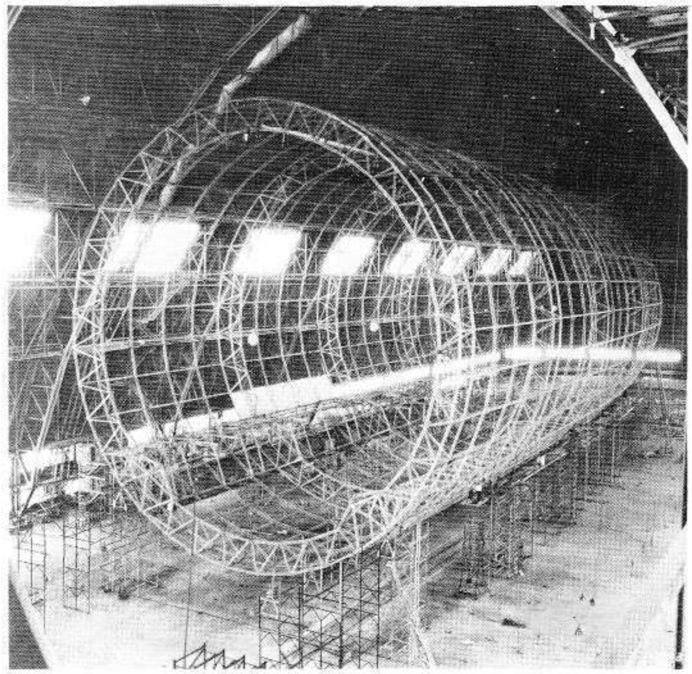
The control room was divided into three sections. The forward third contained the rudder controls which were manually operated through a system which required two turns of the rudder or elevator wheel from hard over to hard over (25 degrees each side of neutral). The long lengths of control cable running from the control room required equalizing devices to take out the slack. Also in the forward third of the control room were the gas and the ballast controls flying instruments and the rest of the apparatus used in the operation of the airship.

The middle section was the navigation compartment.

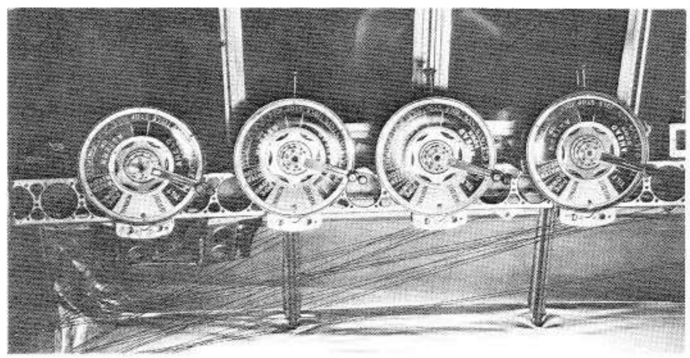
The aft third was used for the location of the access hatches and of the ladders.

An emergency control station was located in the lower fin. Rattan bumpers were placed beneath the control room and underneath the lower fin. The radio room, aerological room, an office space and a photographic laboratory were placed above the control room.

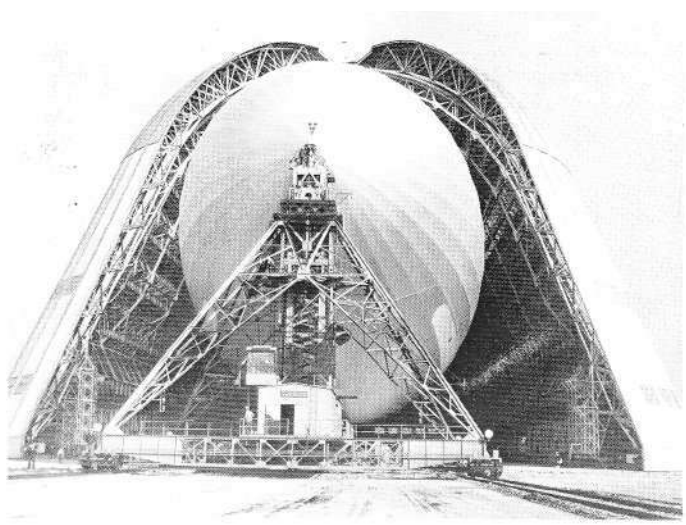
The living accommodations aboard ship were primarily concentrated in Bay VII along either side of the airplane compartment. Crews quarters, mess areas and the officer accommodations were provided for in this area and in the next bay forward.



USS *Macon* under construction at Akron, Ohio, August 15, 1932.
(National Archives Photo No. 80-G-460947)



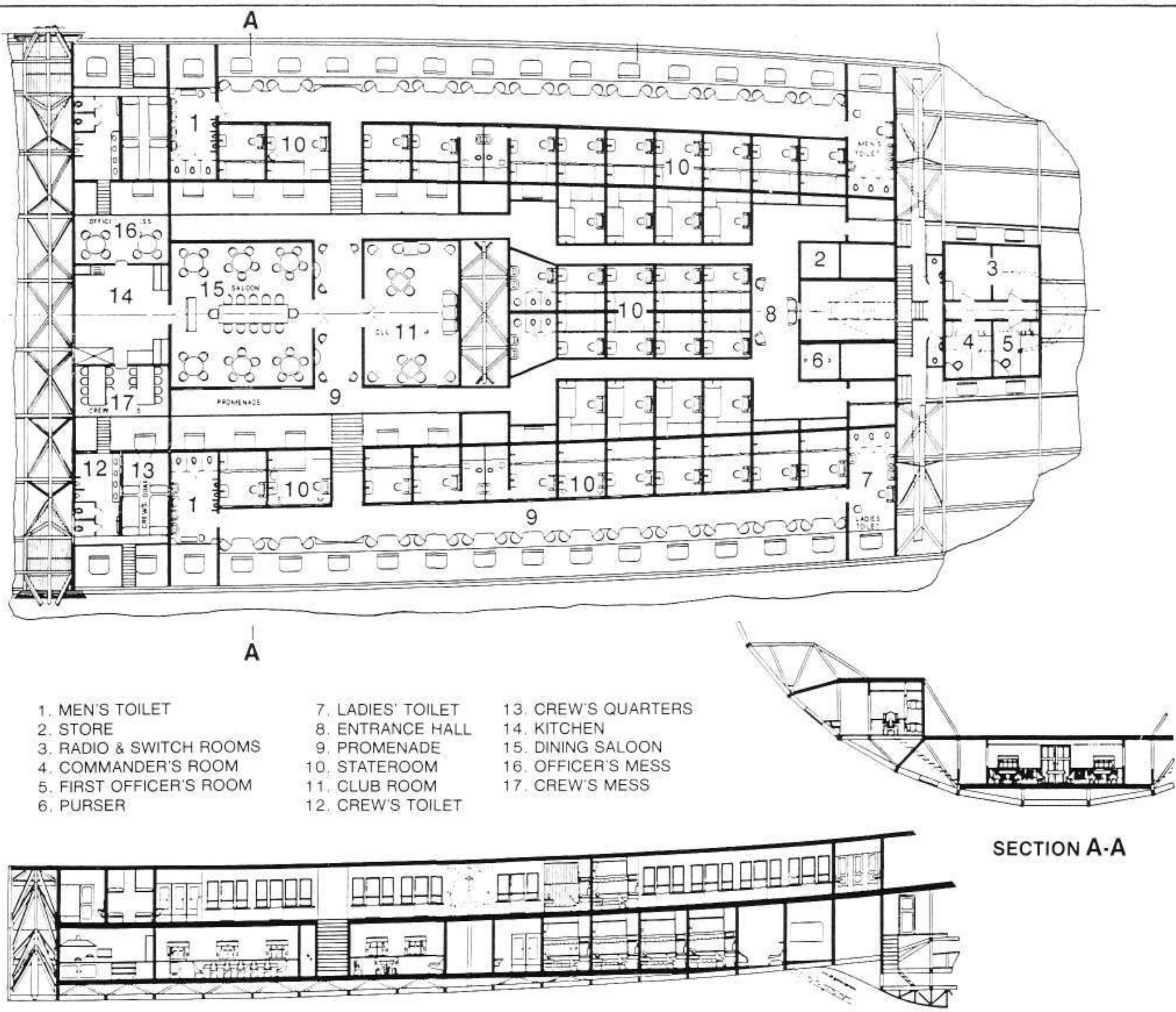
Engine room telegraphs of USS ***Akron,*** **Nov. 11,** 1931.
(National Archives Photo No. 80-G-186730)



USS Macon leaving hangar prior to flight from Sunnyvale Naval Air Station, **Calif.,** March 20,1934. ' (National Archives Photo No. 80-G-405497)

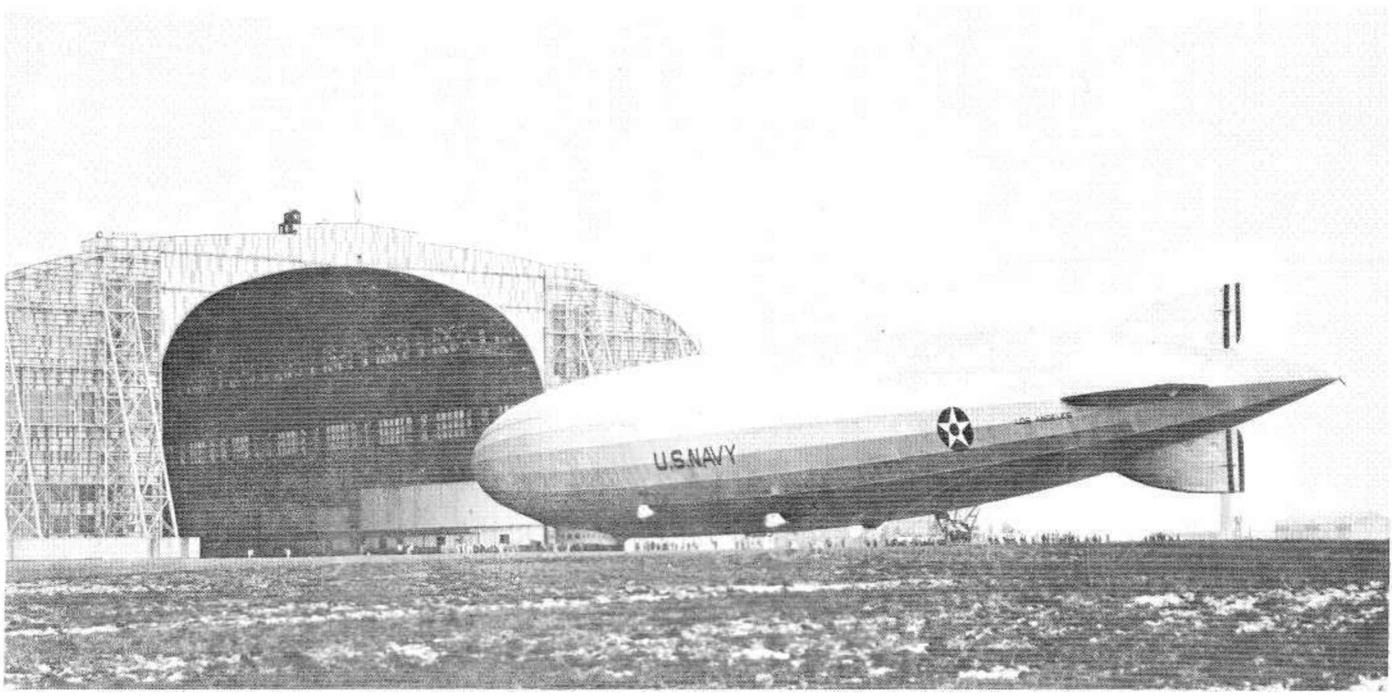
Propane gas supplemented by an auxiliary electrical apparatus was used for cooling and heating water in the galley.

Heat in the living areas was taken care of by the use of warm air ducted from the forward engine rooms through a large aluminum pipe running under the floors of the living



Proposed arrangement of passenger accommodations inside the hull of helium-inflated airship. (Author's Collection)

USS Los *Angeles* and hangar at Lakehurst Naval Air Station, New Jersey. (National Archives Photo No. 80-G-460963)



spaces and also to the control car. Louvers in the floors above certain sections of that pipe acted as heaters.

The airplane compartment was a specially arranged space, one frame space long by 58 feet wide by about 16 feet high. There was a T-shaped hatch 32 feet wide by about 40 feet long used for the launching and recovery of the airship's internally stowed airplane component. The hatch was closed by a part folding, part sliding door. There was also an overhead framing system to carry the tracks of the airplane stowage system. The airplanes were suspended, one at each of the four corners and one in the center, from these overhead tracks.

Mooring and mechanical handling of the airship on the ground was taken care of by the provision of the normal horizontal steel spindle with pendant mooring cone at the bow and a strong-point near the forward end of the lower fin on which the airship might rest.

Conclusion—It well might be said that it was the gap between the promise and the performance which caused the death of the airship in the service of the U.S. Navy. Compounding the problems faced by the rigid airship while in service was the fact that the influence that could be heard in favor of the airship was small if compared with the voices raised in favor of the other aspects of naval aviation. In the struggle for a fair share of the budget, the airship faction lost out time and time again. Had the *Macon* survived for another four years or so the final chapter might well have been very different. The *Macon* was never tested in the area in which her ability lay, the area of the long-range patrol.

The loss of the *Macon* ended the era of the rigid airship in the U.S. Navy with many questions about its capabilities and abilities left unanswered.

GENERAL **DESIGN CHARACTERISTICS***

General **Dimensions**

Total gas volume, 100% inflation, c.f.	6,850,000
Nominal gas volume, cells 95% full, with helium of standard purity, lifting 0.062 lbs. per c.f.	6,500,000
Total air volume of hull, c.f.	7,401,260
Overall length, ft.	785
Maximum diameter of hull, ft.	132.9
Overall width (propellers at vertical), ft.	137.5
Overall height from ground, ft.	146.5
Aspect ratio of hull (length : diameter)	5.91 : 1

Hull Structure

Materials of structure	Duralumin 1 7-SRT
Number of main keels	3
Number of main frames	12
Normal spacing of main frames, ft.	74
Number of intermediate frames	33
Normal spacing of intermediate frames, ft.	16.4
Number of sides to polygons of athwartships framing	36
Number of longitudinal girders	36

Fin Structure

Axial length of fin and movable surface, ft.	119.76
Length of fin, leading edge root to hinges, ft.	104.99
Span of fin at rudder pintles, ft.	41.4
Total span, horizontal fins, across hinges, ft.	144.33
Span of fin balancing surfaces, ft.	14.6
Chord (width) of fin balancing surfaces, ft.	3.6
Area of vertical tail surfaces, sq. ft.	7,200
Area of horizontal tail surfaces, sq. ft.	7,100
Maximum thickness of fin at junction with hull, ft.	11.48
Total weight of each upper three fin structures, lbs.	2,700

Fuel, Oil, and Ballast

Maximum fuel capacity, lbs.	126,000
Number of fuel tanks	110
Normal fuel load, lbs.	110,000
Maximum oil capacity, lbs.	12,000
Number of oil storage tanks	8
Normal oil carried, lbs.	2,400
Maximum ballast capacity, lbs.	223,000
Normal ballast carried upon unmooring, lbs.	20,000
Number of 4,400-lb. bags for storage ballast	28
Number of 2,200-lb. bags for storage ballast	4
Number of 1,000-lb., quick-release bags for emergency ballast	12

Gas Cells

Material	5.3-ounce cotton cloth impregnated with a gelatin-latex compound
Number of gas cells	12
Volume of largest cell, c.f.	900,000
Total cell material, sq. yds.	54,000
Total weight of gas cells, lbs.	22,000
Normal number of gas valves per cell	3
Diameter of all gas valves, inches	32

Outer Cover

Material	2.8 ounce, 65-lb. strength, cotton cloth
Treatment	four coats of clear dope, two with aluminum pigment
Weight of material per sq. yd. after treatment, ounces	5.5
Total material, sq. yds.	33,000
Total weight of outer cover after treatment, lbs.	11,300

Powerplant

Engine	Maybach VL-II, 12-cylinder, 60° V-type, 560hp at 1,600rpm
Dryweight of one engine, lbs.	2,600
Ratio: pounds per horsepower	4.5
Number of engines	8
Total horsepower	4,480
Maximum engine rpm	1,600
Maximum propeller rpm	925
Diameter of propeller arc, feet	16.33
Maximum upward thrust (propellers rotated), lbs.	6,000
Maximum downward thrust, lbs.	8,000
Generators (2)	Westinghouse 8-KW, 110-volt, DC
Prime movers (2)	Universal Lighting Co. 4-cylinder, 30 hp gasoline fueled

Complement and Crew

Complement	16 officers, 75 enlisted men
Flight crew	10 officers, 50 enlisted men
Airplane pilots...	4
Airplane mechanics	15

Performance

Total lift, based on nominal gas volume and helium at standard value, lifting 0.062 lbs. per c.f., lbs.	403,000
Deadweight of structure, lbs.	242,356
Useful lift, including crew, fuel, oil, ballast, and military load, lbs.	160,644
Maximum speed, knots	75.6
Standard speed, knots	65.0
Cruising speed, knots	55.0

ENDURANCE AND RANGE WITH NORMAL MILITARY LOAD
AND 110,000 LBS. OF FUEL

Speed in **Knots**	**Hours**	Range in Nautical **Miles**	Radius in **Nautical Miles**
70	68	4,760	2,380
65	75	4,855	2,427
55	108	5,940	2,970
46	158	7,268	3,268

* Taken from *The Airships Akron and Macon*

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