

GENEALOGY OF THE CURTISS "SPARROWHAWK" DIRIGIBLE FIGHTERS

by

Willis L. Nye

Three-view drawing by Willis L. Nye

Drawings by Raymond J. Schmitt

FOREWORD

Two years ago the writer had the good fortune to meet AAHS member John Mitchell at the Aviation Writers Association convention in San Francisco held at the Mark Hopkins Hotel. Editor William Larkins had convened a joint local AAHS meeting at the same time. The author inquired of member Mitchell, having served in U. S. Navy Aviation, did he have any data on the parasite fighter F9C-2. He replied in the affirmative. In the interim, member Ray Schmitt, an L.T.A. authority, also exhibited great interest in the parasite fighters used on the U.S.S. AKRON and U.S.S. MACON, and thereby hangs the genesis of this story. Messrs. Nye and Schmitt visited member Mitchell at his home and examined his F9C-2 data. Along with Editor Larkins, Messrs. Mitchell, Schmitt and Nye decided to write the story of the F9C-2 for the Journal as a joint venture.

The Editor felt that this should also include other AAHS members and so invited John Sloan and William Riley to submit their data. Thus this story represents the joint effort of several members as a serious collective effort to present this story in detail. Outside agencies and individuals also contributed their information. Acknowledgement is made to H. B. Miller, Rear Admiral Ret'd USN, who was a commanding officer in charge of the H.T.A. unit aboard the MACON (ZRS-5); and to Mrs. Esther B. Mueller, Air Force Central Museum, who forwarded all the historical documents that were available at that agency. Thus by a coordinated effort this story can be told in great detail for the first time. These airplanes aroused interest throughout the whole world due to their unique function.

Part I - DEVELOPMENT OF THE XF9C-1

THE AIRSHIPS USS AKRON (ZRS-4) AND USS MACON (ZRS-5)

These 6,500,000 cubic foot rigid airships were designed and built for ocean going defense perimeter scouts. Tactically, not unlike the present ZPG-2 and -3W's, their role was one of early warning. They were the handiwork of one of the greatest of airship engineers, Dr. Karl Arnstein, a brilliant scientist, now in his 70's. These airships represented a radical departure in airship design. The basic structural members were made of pressed aluminum alloy instead of built up truss members heretofore comprising rigid airship structural members. While pressed aluminum alloy parts are more efficient than a built-up structural component, the full strength of this kind of construction was not apparent at the time the airships were designed in 1929. According to engineering technicians of today, the airship structure could be engin-

eered with the samo materials to bo approximately 200% stronger. Ironie as it may seem, todays H.T.A, craft owe much to the research made by an airship company in quality control of pressed aluminum alloy parts and the metallurgical studies made at the time, long after the AKRON and the MACON were destroyed,

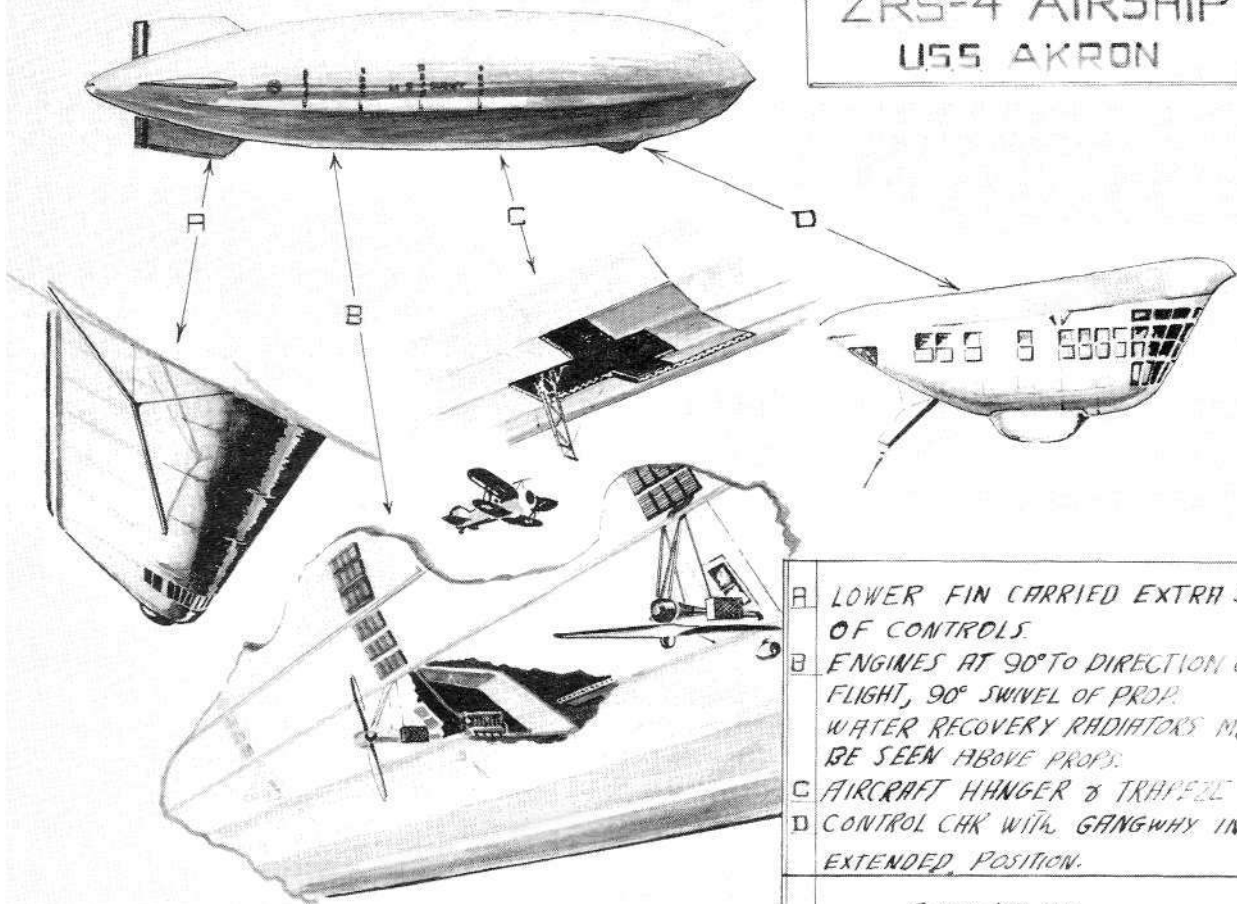
The ZRS-4 and ZRS-5 were to be the forerunners of an air fleet numbering possibly 100 airships. According to certain naval strategists of that date, airships operating from both coasts and our overseas possessions would comprise an early warning defense line extending half way across both oceans. The question naturally arises would the Japanese Navy have undertaken a sneak attack on Pearl Harbor with their chances of 100 to 1 against them from being detected. At this late date, it can only be left to casual speculation.

Although L.T.A. units suffered many technical and operational setbacks, clear thinking high naval officers, including Admiral William A. Moffett, then Chief of the Bureau of Aeronautics, realized the importance of the L»T,A. components of the U.S. Navy. Experience has proved beyond a doubt that L.T.A, meets a naval requirement that cannot be performed by any other component of the air Navy. This then was the valiant Admiral's conviction. The political battles of the day included in their reappings the temporary downfall of the big rigid airships. We reflect on this in an age of missilery. Admiral Moffett decided to advance, and this he did, by the combination of L.T.A, and H.T.A, components working together as a team. This brings us to the basic concept of the parasite fighter, not so much as a fighting, defensive element, but as an adjunct to the scouting effectiveness of the big airships, their prime mission.

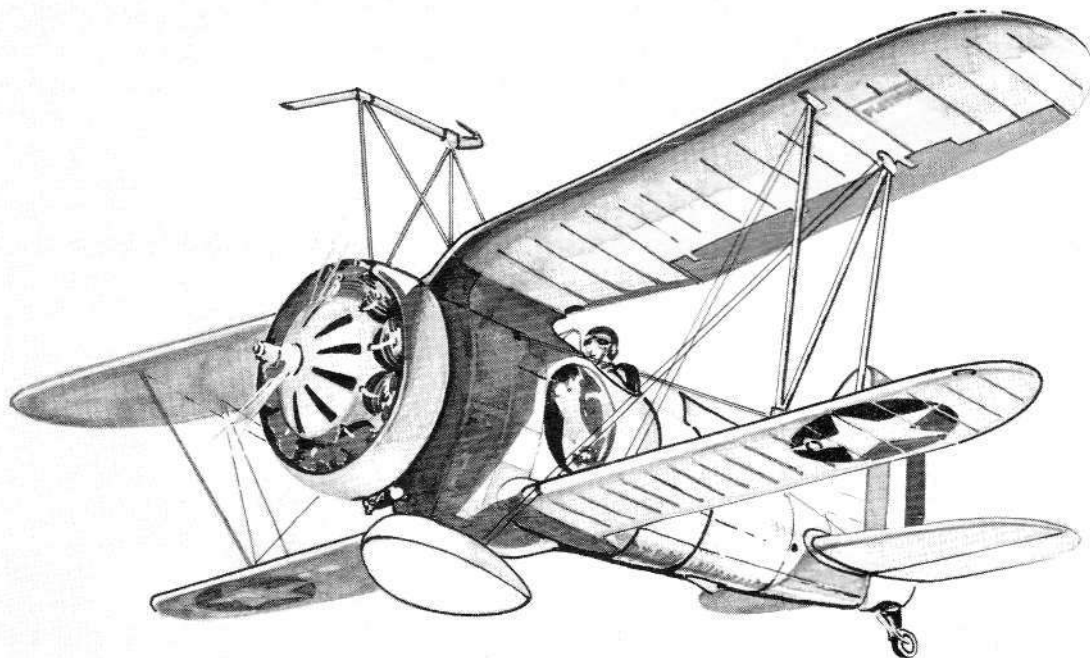
The AKRON and MACON had a helium capacity of 6,500,000 cubic feet. The hull of each was 785 feet in length and 133 feet at the maximum transverse dimension. The height was 146 feet. The helium was contained in ballonets, 12 separate cells. The ballonets wore manufactured from cotton fabric impregnated with latex, over which was applied a film of paraffin wax. The ballonets fitted in bays between the main ring girders with a space left in the lower part of the bays to provide for temperature and altitude expansion of the gas. The ballonets were also provided with automatic pressure relief valves exhausting at the top of the envelope. The vertical and horizontal stabilizer surfaces, 105 feet fore and aft, 40 feet from the root to the tip, were 12 feet thick at the widest point of their airfoil shape. The elevators and upper rudders were approximately 42 by 16 feet and 5 feet thick. The lower fin contained a separate set of flight controls for emergency purposes. The forward control car was subdivided into three sections, i.e., the aft section had the ladder to the interior of the hull and a set of stairs over a trap door exit leading to ground level when opened. The center section of the car was used as a navigation center with the maps and charts for flight operations. The forward compartment contained the flight controls, engine telegraphs, telephones, ballast charts, trim charts, navigation and flight instruments and other accessory equipment.

These airships differed from previous types based on the Zeppelin design in not having a single bottom inverted Vee longitudinal keel. The ZRS-4 and ZRS-5 had three longitudinal keels. One keel was located on the top of the airship structure and the other two were located on the sides of the structure, at an angle of 45 degrees from the bottom. The top keel contained a cat walk. This permitted inspection of the top gas valves in flight. The side keels contained 110 fuel tanks which each held 1,000 pounds of fuel. Eight oil tanks contained 12,000 pounds of lubricating oil. Along the side keels were located the eight engine rooms. Being built within the hull, each room was air conditioned by means of ventilating fans driven by a pulley belt drive.

ZRS-4 AIRSHIP USS AKRON



R. J. Schmitt '52'



In cold weather, outside air could be drawn over the engine exhaust manifolds for warmth and to initially cool the engine exhaust gases before they flowed through the water recovery system. The exhaust gases were cooled 80% at this point. For cooling in warm weather, the system was reversible. This ventilation system was located above each engine room.

The engines were 580 H.P. Maybach, type VL-2, 12 cylinders, 60 degrees vee type, water cooled. These engines revved to 1600 R.P.M. at full throttle. The reduction gears at the propellers allowed a propeller speed of 985 R.P.M. These engines were mounted transversely so that the crankshaft of the engines pointed 90 degrees to the direction of flight. Outriggers carried the power shaft to 90 degrees bevel gears, and then transmitted the power to the propellers. The propellers could be swivelled through a 90 degree arc so that with reversible engines, thrust was available fore, aft, up and down.

Along the envelope of the airship at the sides were carried water recovery system components comprising four sets of radiators for cooling and then to condense the moisture present in the engine exhaust. This water was then piped to water ballast tanks. This was done to the extent of 140% of the fuel weight used in ideal humid conditions.

The structure of these airships represented 83 tons whereas the gross weight at take-off was 202 tons at cruising trim. The structure was such, as well as the rest of the construction, that in the second bay, aft of the control car, an airplane hangar was provided measuring 75 feet fore and aft, and 60 feet in width. While it was sufficiently large to carry five airplanes of the F9C-2 type, only four were ever carried during flight operations. The hangar was comprised of two transverse girders that closed in the space between the crew's quarters on opposite sides of the airship forward of a longitudinal girder down from the forward engine rooms. These girders supported a fore and aft structural 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. From the edge of the "T" opening in the hull, the crew could guide the planes after they were taken aboard by means of poles and hand holes on the lower wings. This was done by crew members working close to the edge of the opening without the wearing of a parachute. The particular configuration of the three keels made the use of an airship hangar possible.

The 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 airplane 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 hangar. It is worthy to note that although hundreds of hook-on and hook-off operations were performed, no mishap occurred where a plane or pilot suffered major damage or catastrophe.

This brief resume of the great rigid airships of the U. P. Navy has been presented to emphasize how the idea of the parasite fighter evolved. By the combination of a long range airship and four parasite fighters, it was possible to scout hundreds of

miles of ocean area that normally would have required several task forces of surface craft. This is the basic reason for the combination of L.T.A. and H.T.A. for naval operations. The protective effect of four tiny fighters was to say the most of negligible value, particularly as they were definitely limited on range and performance. The planes would scout on a zig-zag course parallel to the course of the airship and thus enhance its scouting performance. Remember that this was in the days before search radar. The economy of airship scouting is obvious compared to surface craft.

THE ORIGIN OF THE PARASITE FIGHTERS - The term parasite "fighters" is somewhat a misnomer because these airplanes were not effective fighters to say the least due to the limitations on weight, engine H.P. and size. Previous experiments had been conducted with several types of airplanes by the U.S. Navy and the U.S. Army. The first successful hook-on by the U.S. Army was made by a Sperry Messenger Biplane on the semi-rigid airship D-3. Certain glider experiments were performed by Lt. Ralph Barnaby, USN, in conjunction with the U.S.S. LOS ANGELES (ZRS-3. (See drawing). Then there followed the successful hook-on and hook-off by Vought UO-1 type biplanes of the Navy to a trapeze installed on the LOS ANGELES. Other airplanes such as the Fleet 2 (N2Y-1) were used in hook-on experiments with the LOS ANGELES. All of these early experiments were performed with a hook-on device of experimental nature, but which did pave the way for the final hook-on configuration. Two Waco XJW-1's were assigned to the MACON for training additional flight personnel for the fighter planes. As related further on in this article, after the selected squadron of pilots mastered the intricacies of airship carrier flight operations, they were reluctant that the F9C-2 airplanes be piloted by personnel inexperienced in those operations, hence the purchase by the Navy of the modified Waco biplanes.

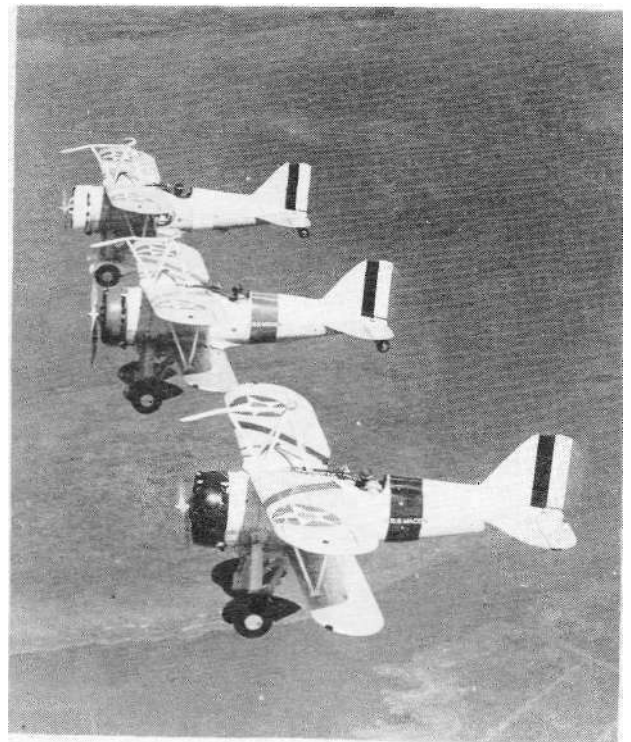
HOW THE XF9C-1 WAS DEVELOPED - When the Bureau of Aeronautics decided to develop the parasite fighter as a weapon to improve the scouting capabilities of the ZRS-4 and ZRS-5, three prominent H.T.A. manufacturers were invited to present their planes for this type of function in a design competition. Those were the Fokker XFA-1, the Berliner-Joyce XFJ-1 and XFJ-2, and the Curtiss XF9C-1. The first three airplanes failed to merit acceptance for production and were eliminated for one reason or another. Neither of these airplanes were ever fitted with hook-on devices as far as is known. Thus they failed before they became acceptable for actual hook-on tests. The Curtiss XF9C-1 was eventually declared the acceptable airplane primarily because of its small size and low weight which is believed to have been the deciding factors in approval for L.T.A. use.

It was not, as may have been assumed, originally intended solely as an airship fighter, but was also designed with features that would make it usable as a carrier fighter of small dimensions. These small dimensions would make it possible to carry more fighters of this type than the current fighters in use at that time that did not have folding wings. When the airplane did not prove acceptable to comply with the entire requirements of a carrier fighter, it was assigned as a type acceptable to airship carrier operations. Although it did not meet current Navy fighter requirements, it was at the time of the development, the finest airplane built for airship carrier functions,

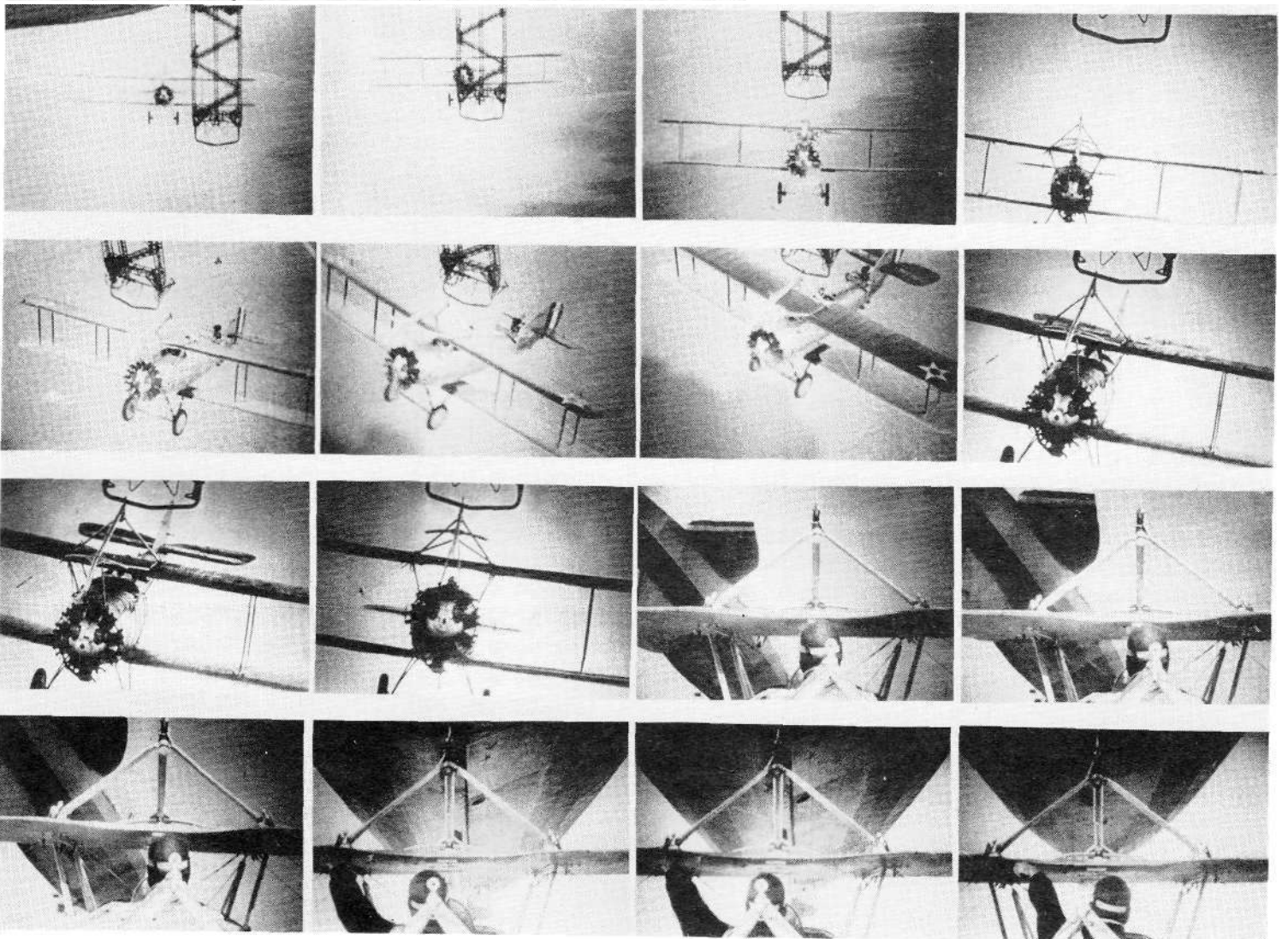
The experimental test article was built by the Curtiss Aeroplane and Motor Corporation, Buffalo, N.Y. The plane designation was omitted at the time of the manufacture, and for flight purposes, it bore the Bureau of Air Commerce number 968M. Secret flight tests were initially performed at Michel Field, N.Y. It was then flown to N.A.S. Anacostia, D.C., for initial Navy flight tests.



Top Left: LT H. B. Miller USN, flying F9C-2 #9058 near Moffett Field, California. Official Navy Photograph.
 Top Right: The "red-white-blue" trio of F9C-2's from the U.S.S. MAGOH. Photo taken 6 July 1933, Official U.S. Navy Negative Number 441941.



Below: A series of experimental photos taken by photographing a film action picture projecting on a ground glass screen with a 35mm still camera. These are from the excellent U. S. Navy action picture film 165-2722D "Lighter Than Air History - Rigid Airships". The scenes show a Vought VC-1 hooking on and off the U.S.S. LOS ANGELES. Note the bottom row which shows the pilot manually releasing the plane from the trapeze by pulling a lever with his left hand. Official U.S. Navy Photos.



The initial prototype airplane was fabricated in the latter months of 1930. The prototype was considerably different in general appearance than the final production article acceptable to the Navy Board of Inspection and Survey. The airplane as originally built was equipped with a tail hook for landing operations aboard carriers. The initial airplane procured by the Navy was assigned Serial No, A8731, the civilian registration number being dropped. It was officially designated as XF9C-1. The XF9C-1 was flight tested by naval test pilots. The notable features that differentiated from the final procured articles were the balanced rudder, high pressure tires, small hard rubber tail wheel, full faired cantilever landing gear, location of the landing hook and the position of the upper wing. This airplane after certain recommended modifications found to be necessary for naval aviation operations, was designated the XF9C-2. The landing gear remained the same as the prototype article, the position of the upper wing was unchanged, the location of the landing hook was not changed, but certain other minor improvements were made in the structure and engine installation. Under the designation XF9C-1 a tripod type braced and faired landing gear with low pressure tires was installed and experimentally tested and found to be satisfactory. However, this was not installed on the XF9C-2 until a later date so we see this airplane with two different landing gear configurations in the various photographs.

It is interesting to note that a number of modifications were tested on airplane Serial No. 9056, the first that was designated F9C-2. The major modification being in the type of landing gear configuration. In this instance the landing gear was slimmed down to reduce drag and a system of swaged brace wires being installed to reduce drag by the elimination of the tripod strut members previously unstable and mentioned earlier in this article. This type landing gear did not prove to be practicable and only increased the high speed about two miles per hour so the idea was abandoned and the conventional tripod type landing gear installed. This airplane seemed to be the experimental test plane of the entire group of planes and new innovations were invariably tried out on this airplane. It is with this streamlined landing gear that most of the advertisements of the time appeared in the magazines of the times. 9056, while being the experimental airplane, was finally brought to the final configuration for operational purposes and did not vary from the rest of the airplanes.

INITIAL TRIALS OF THE CURTISS SPARROWHAWK - Navy Report NASA-91, dated July 1, 1931 issued by the flight test section, Naval Air Station Anacostia, D.C., was issued under the authority of the President of the Board of Inspection and Survey, U.S. Navy. As stated in this report, the Curtiss single place carrier fighter, Model XF9C-1, as tested, first to determine whether the contract guarantees had been compiled with, and second the suitability of this airplane as a service type for carrier operations. The complete flight performance tests were conducted on the XF9C-1 carrying the normal fighter useful load in compliance with the design specifications. The fixed machine guns were fired in the air at high speed and on the ground. This was necessary in connection with a number of ordnance changes. The emergency flotation gear was ground tested. The carrier arresting tests were conducted by the Experimental Division, Naval Air Station, Hampton Roads, Virginia,

CONCLUSIONS OF THE FLIGHT TESTS - The Curtiss XF9C-1 carrying the normal useful load required as a carrier fighter complied with all revised contract guarantees with the exception of the weight empty, where the overweight was six pounds over design specifications. "The Curtiss XF9C-1 carrying items of useful load specified for the normal fighter loading was found under all service load conditions' to be in all respects to be a satisfactory military carrier fighter airplane in correct flying

balance, controllable and stable in the air and on the ground, and suitable for the purpose intended, except as noted hereinafter. The Board recommends that the XF9C-1 with the necessary modifications incorporated as listed under RECOMMENDATIONS, be accepted as an experimental type, but considers that its suitability as a service type is dependent on the practicability of correcting the four major items of design as listed," End of report.

This report was signed by Lt. R. A. Ofstie, Lt. T. P. Jeter, Lt. F. M. Irapnell, and Mr» E. W. Rounds, civilian. It may be interesting to note that these three officers in later years held high ranking posts in the U.S. Navy and participated in World War II.

CONDITION OF XF9C-1 DURING TRIALS - The XF9C-1 was tested as a carrier fighter carrying the useful normal load. The full load weight of the XF9C-1, at the start of each flight test, was 2502 pounds. This included 666 pounds of useful load. The location of the C, of G. for this condition was 29.4% of the M.A.C.

The Wright radial aircooled engine, model R975-C was installed. This engine was equipped with a supercharger having a gear ratio of 10.15:1. The compression ratio was 6:1, The engine developed 421 H.P. at 2310 R.P.M. at sea level, A two blade metal propeller, Design 4651, diameter 96 inches, and the blades set at an angle of 18,1 degrees at a radius of 42 inches, was used during the performance tests. With this blade setting the engine actually turned 2325 R.P.M. at full throttle in level flight at sea-level at a speed of 176.5 m.p.h. This engine was equipped with a carburetor air intake heater and an air maze filter. The heater was set in the cold air position during the performance tests. An engine oil cooler was provided with an automatic by-pass and shutter control interconnected with the main nose shutters of the engine crankcase section. Standard engine accessories wore installed such as a Stromberg NAR9 carburetor and dual Scintilla VAG9-DF magnetos. Domestic aviation fuel was charged with 5 c.c. of ethyl fluid per gallon and symbol 3100 lubricating oil was used during the flight tests,

SUMMARY OF INITIAL FLIGHT TESTS

Full Load Weight in Pounds	2502
Useful Load in Pounds	666
Weight Empty	1836
Percent of Useful Load	26.6
Maximum Timed Speed in M.P.H.	176.5
Stalling Speed in M.P.H.	60.0
Landing Speed in M.P.H, (Three Point)	63.0
Initial Rate of Climb in Feet	2150
Climb in 10 Minutes in Feet	13300
Service Ceiling in Feet	22600
Wing Loading in Pounds Sq. Ft.	14.5
Power Loading in Pounds per H.P.	5.9
Time in Minutes to 24,000 Feet	53
Maximum Rate of Climb Per Minute	1760
Air Speed in M.P.H. at 16,000 Feet	152
Air Speed in M.P.H. at 10,000 Feet	160
Engine R.P.M. at 16,000 Feet	2200
Engine R.P.M. at 10,000 Feet	2250

GENERAL COMMENT ON THE INITIAL FLIGHT TESTS - The XF9C-1 was flown to Anacostia on March 27, 1931. The airplane was weighed and then fitted with instruments for recording the accelerations in flight and air speed. Diving tests were first undertaken by the Curtiss civilian test pilot. On April 3, 1931, the airplane was demonstrated by the Curtiss test pilot. These tests being satisfactory, the airplane was accepted for test by naval test pilots,, As with any aircraft engine, during a demonstration flight an engine valve cam follower on No. 8 cylinder exhaust side seized in the guide. The anti-drag wires were found to be slack in the upper left hand wing. However, no damage was revealed after a detailed inspection of the structure.

The performance tests of the XF9C-1 as a carrier fighter were completed at Anacostia on May 18, 1931. The ordnance tests were then undertaken during which certain installation features that necessitated redesign or modification of certain components were noted.

CARRIER ARRESTING GEAR TESTS - On June 10th 1931, the airplane was flown to Hampton Roads, for arresting gear tests. These tests were performed with the following results. The first landing into the arresting gear resulted in the airplane nosing up on the propeller at the end of the landing run due to a premature application of the brakes and the excessive tail rise produced by an incorrect location of the landing hook. The consequent damage was a bent propeller and a dented engine anti-drag ring. The damage was repaired and the location of the landing hook investigated. It was found that a rise of 34 inches was to be expected under average landing conditions. Because 41 inches of tail rise, it is necessary to place the thrust line of the propeller parallel with the carrier deck and approximately 62 inches to cause the propeller to touch the deck, it was concluded that further tests were possible without direct modification at this time. However, the unfavorable location of the landing hook was to be taken into consideration during the remainder of the tests. As a further precaution, the plate installed on the rudder pedals to comprise - smooth bridge across the rudder and brake pedals, facilitating the use of the brakes during field landings, was to be removed. This removal left the original installation which provides an offset on the brake pedals adjacent, to the rudder pedals making it difficult to apply the brakes except by deliberate shifting of the feet outboard to rest fully on the brake pedals. The rest of the tests were carried on without any damage resulting thereof.

These tests are carried on a portion of the landing field, fitted with arresting devices similar to those on a carrier. These tests consist of twelve landings into the arresting gear. Eleven take-offs at full throttle are made from the deck using release fittings. One landing is made on the platform using the brakes in lieu of the arresting gear.

The objective of the arresting gear tests was to determine if the XF9C-1 was suitable for carrier duty. Certain changes were mandatory before this could be accomplished:

- (a) The hook attachment fitting should be moved one frame space aft to reduce the inherent present excessive tail rise.
- (b) The engine exhaust pipes on each side of the engine should be relocated to remove some of the objectionable obstructions to forward vision during landing operations through the anti-drag ring,
- (c) The clearance between the fuselage tail fairings and the rudder should be increased to one inch to prevent the possibility of interference,
- (d) The propeller tips should have 9 inches deck clearance when the thrust line is horizontal.

- (e) The brake pedals should have a pronounced offset to prevent inadvertent use of the brakes during arresting gear operations.
- (f) The sensitivity of the brakes should be reduced by making them take affect at a smaller range of movement of the brake pedals,
- (g) The landing hook bumper should be extended two inches forward relative to the hook point.
- (h) The size of the tail wheel, the fairing to shed the arresting wires, swivelling action, and shock absorption regardless of the angle of train are acceptable.
- (i) Considerable improvement in vision for carrier operation is necessary as well as straightway flight, without sacrifice of combat vision, could be affected by raising the upper wing approximately four inches, The wing roots should be faired.
- (k) Vision in the XF9C-1 for formation flying is satisfactory.

As a fitting conclusion to the General Comment by the Board of Inspection and Survey, the XF9C-1 airplane carrying the items of useful load as given in the following table, was found under all service load conditions to be in all respects a satisfactory experimental military carrier fighter in correct flying trim, controllable and stable in the air and on the ground, suitable for the purpose intended, except as noted under the recommended modifications.

Thus it can be ascertained that the Experimental Divisions of two naval air testing stations found the XF9C-1 to be a potentially good airplane for carrier use. That it was not assigned to carrier duty was probably due to conditions beyond control of the flight personnel,

CONTRACTUAL GUARANTEES VERSUS PERFORMANCE TESTS - An airplane manufacturer has to submit performance guarantees upon award of a contract to develop and experimental military or naval aircraft. In the case of the Curtiss XF9C-1 these were as follows:

	Actual	Revised Guarantee
Weight Empty in Pounds	1836	1830
Full Speed at Rated R. P. M. (M.P.H.)	176,5	170,0
Minimum Speed (M.P.H.)	60	66
Climb in 10 minutes in Feet	13800	13800
Service Ceiling in Feet	22600	22300

The above guarantees were presented by the manufacturer with the understanding that the engine furnished by the Government would develop 400 H. P. at sea level at 2300 R.P.M. with a dry weight of 560 pounds. However, the engine developed 421 H.P. at 2310 R.P.M. and the weight was 572 pounds dry,

GENERAL COMMENT BY THE FLIGHT TEST PERSONNEL AT ANASCOSTIA - After the contractual guarantees had been complied with, and while the airplane was considered to be a potentially good carrier fighter considering its size and the engine power, the flight test personnel still would not recommend the airplane as delivered because they objected to certain structural features that would have to be modified in order to enjoy unqualified acceptance for carrier operations. The primary features that were recommended to be changed: (1) The location of the upper wing is such as to seriously interfere with vision in normal flight straight ahead. Direct vision over the nose is obscured except during high speed flight. (2) The wing and power loadings are so high that the performance of the airplane is somewhat inferior to existing fighter types in service aboard carriers, (3) The cone of vision for the gun sight is obstructed by the engine and the anti-drag rings (4) The landing angle is such that it is impossible to make a three point landing at minimum speed and still maintain satisfactory aileron control.

It is interesting to note that the flight test personnel disregarded other factors such as initial low cost, fuel economy, light weight, small dimensions with rigid wings, all metal construction, etc. They rated the airplane simply on performance and gunnery. Naturally some of the primary fighter characteristics had to be side tracked in order to produce a small fighter. The manufacturer combined in the XF9C-1 an airplane of small dimensions and light weight, relatively low engine power and still attained moderately good performance and flight characteristics. In relation to the engine power, the overall gross weight was higher than is desirable, but in general, the airplane performed favorably when compared with other airplanes equipped with a supercharged engine.

UPPER WING ATTACHMENT TO THE FUSELAGE OF THE XF9C-1 - One of the distinguishing features of the airplane design was the attachment of the upper wing to the top of the fuselage. This was done in order to provide better upward vision for the pilot. However, the location of the upper wing actually interfered with forward vision in normal forward flight to a greater degree than the project engineer in charge of the design realized. Based on previous experience with another fighter intended for airship use, it was recommended that the upper wing be raised four inches. This modification would give satisfactory vision except directly ahead. At speeds below 80-90 percent of the maximum high speed, the pilot could not see over the nose because the engine is located in a position relatively high with respect to the eyes of the pilot. By raising the wing four inches on each side of the fuselage the pilot could look under the wing, and is thus partially compensated for the lack of vision directly forward.

XF9C-1 LANDING GEAR - After it was agreed to install a conventional tripod landing gear in place of the cantilever configuration with which the airplane was originally equipped, It was found that the angle of attack of the wing when the airplane is at rest on the ground is less than the angle that would generate maximum lift by the Clark CYH airfoil. In order to overcome this deficiency, the landing gear struts were lengthened in subsequent aircraft to increase the landing angle. In addition, this change in the length of the main strut allowed the engine to be lowered one inch, this lowering of the engine contributed to the improvement of the forward vision by the pilot. The propeller clearance with the deck was not changed. Test flights indicated that the design of the landing gear was good.

Because of the installation of brakes on the landing gear, and the installation of a full swivel tail wheel, the XF9C-1 handled well on the ground and during taxi runs on the airfield. Landings and take-offs were performed in the usual manner,

XF9C-1 HORIZONTAL STABILIZER AND LONGITUDINAL TRIM AND BALANCE - The horizontal stabilizer is fixed and is not adjustable during flight by the pilot or on the ground. Changes in longitudinal trim and balance are compensated for by the installation of a rubber cord bungee on the elevator control, However, flight test personnel did not approve of this installation because it resulted in a slight longitudinal instability. But the bungee was to some extent effective. It was found that at maximum level speed, the load on the bungee was small. If the speed was changed, the joystick moved in such a direction under the variation in the elevator loads as to contribute to longitudinal instability and make the airplane unstable when the controls are free. When the flight controls are fixed the airplane is stable about all three axes of stability

PILOT'S COCKPIT ON THE XF9C-1 - The flight test personnel approved the cockpit layout with a few minor modifications being recommended, among these being an improvement in the pilot's seat adjustment. The windshield was found to be adequate.

ENGINE AND ANTI-DRAG RING AND FORWARD VISION - The Curtiss XF9C-1, as will be noted in the photographs presents a very clean appearance. However, the frontal area of the engine as enclosed by the anti-drag ring militates against the forward vision. Due to the design of the engine cylinders, the location of the engine exhaust pipes, the carburetor air intake scoops, and location of the engine oil cooler, almost the entire area within the anti-drag ring is obscured to forward vision. This, in addition to increasing the head resistance in relation to the wing area, seriously interfered with the forward vision. Thus any lowering of the engine without changing the propeller diameter would be a distinct improvement. Hence this was accomplished on the production airplanes,

ORDNANCE INSTALLATION ON THE CURTISS XF9C-1 - The ordnance tests revealed that modification of the machine gun installation was necessary. When the machine guns were fired in the initial firing test, a stoppage occurred which was caused by the cartridges jamming in the cartridge ejection chute. After the first firing tests were concluded, it was found that the blast tubes had been elongated due to the heat of the nozzle blast and that the engine anti-drag ring was damaged,

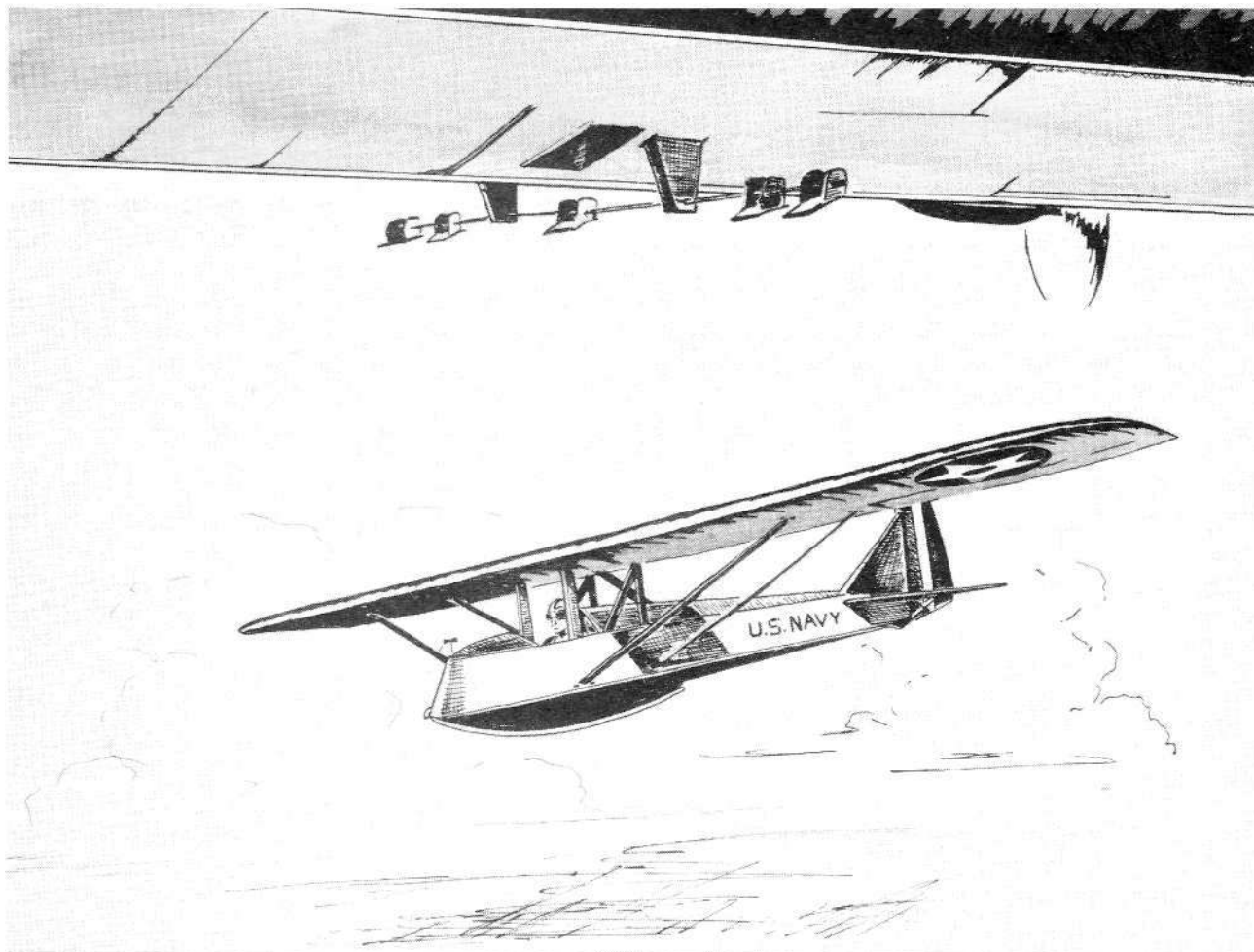
A field modification was made prior to the second firing tests. This modification allowed the individual chutes leading from each gun so that the expended cartridge cases entered the lower chute at a more acute angle. The prototype blast tubes were replaced by longer tubes of elliptical section and the second firing test was then performed. However, it was found that the elliptical cross section blast tubes became circular during firing and this was unsatisfactory. A third set of blast tubes were installed, these being circular in cross section and of heavier material. To facilitate cooling, sixty 1/4" diameter holes were drilled in each tube.

It was found on further firing tests that a strong upward current of air would blow into the ejection chute. This caused the expended cartridge cases to jam. To prevent this, it was necessary to provide a small deflector ahead of the opening of the ejection chute.

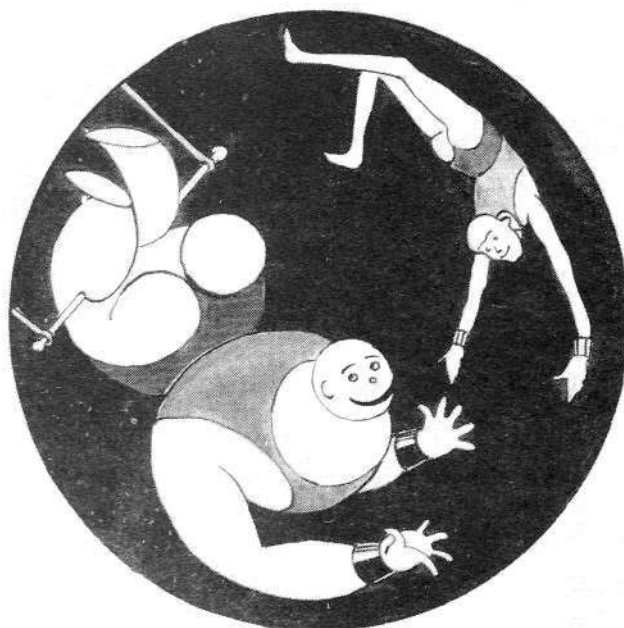
CONDITION OF THE WRIGHT R-975-E ENGINE AFTER FLIGHT TESTING - After the Curtiss XF9C-1 returned from the arresting test at Hampton Roads N.A.S., which were performed after the initial flight tests, an inspection of the engine revealed that the key holding the nut in place on the forward end of the impeller shaft had fallen out due to a defective retaining spring. This caused some superficial damage to the impeller and its gear train. The engine had 95 hours of operational time up to the time of this inspection,

RECOMMENDATIONS OF THE NAVAL FLIGHT TEST GROUP - The flight test group at the conclusion of the official test flights of the XF9C-1 made the following recommendations. These were to be incorporated in the Curtiss XF9C-2 airplane when submitted for further tests:

STRUCTURE: (1) Provide clearance for the heels when moving the rudder pedals; 2) Increase the clearance between the fuselage tail fairing and the rudder; 3) Provide an inspection hole for the indicator of the condition of charge for the emergency float gear bottle; 4) Increase the angle of vision through the windshield by a redesign of the windshield frame; 5) Remove the aerodynamic balance from the rudder; 6) Rework the construction of the leading edge and wing tips of the lower wing in order to prevent the deformation and subsequent loss of the airfoil section resulting from normal ground handling.



HOOK ON SQUADRON INSIGNIA -SS-



ENGINE INSTALLATION: 7) Improve the vision between the cylinders of the engine by accomplishing the following: a) Relocate exhaust pipe from No. 8 cylinder between cylinders No. 8 and No. 9; b) Relocate exhaust pipes from cylinders No. 4 and 7 so that these pass between the valve covers; c) Relocate the exhaust pipe from No. 3 cylinder to a position between No. 2 and 3; d) Remove the exhaust pipes between the upper cylinders to improve forward vision; 8) Relocate the fuel wobble pump operating handle in a more convenient position; 9) Improve the mechanical features of the fuel wobble pump drive; 10) Relocate fuel supply from the fuel tank so that at least 98% of the fuel can be burned when the airplane is in a climbing attitude,

MISCELLANEOUS EQUIPMENT: 11) Install the safety belt so that it will lead around the pilot instead of taking a straight position across in front of him; 12) Eliminate excessive friction in the operating mechanism of the emergency flotation gear; 13) Increase the length of the landing hook bumper to prevent damage to the fuselage; 14) Provide a positive method of fastening for the crash pad mounted above the instrument panel; 15) Eliminate interference between the landing hook retrieving handle and arm; 16) Eliminate the radio mast; 17) Provide a positive locking arrangement for holding the landing hook in the "DOWN" position; 18) Provide ejection chutes and ammunition boxes of such a design as to eliminate the possibility of links or cartridge jamming in the cases; 19) Eliminate the updraft in the cartridge ejection chutes; 20) Reinforce the front and rear sides of the two ammunition boxes by means of ribs pressed into them during manufacture; 21) Provide a system of five drain holes in each ammunition box; 22) Provide round machine gun blast tubes extending to the leading edge of the anti-drag ring; 23) Provide an improved air cooling for the machine guns;

STRUCTURAL IMPROVEMENTS: 24) Raise the upper wing 4 inches; 25) Improve the forward vision over the nose and through the gun sight; 26) Move the landing gear hook attachment point one frame aft to reduce the tail rise during an arrested landing; 27) Assure a 9 inch propeller clearance with the deck or ground; 28) Provide a pilot's seat that is adjustable on the ground or in the air; 29) Eliminate aileron flutter occurring during power stalls; 30) Set the horizontal stabilizer at an angle of incidence so that the airplane will balance with normal load at maximum speed with no load on the elevator; 31) Make such changes in the landing gear as are practicable to more nearly approach the maximum wing stall attitude during a three landing; 32) Lower the engine mount to improve visibility forward to assist vision during landing and for gunnery;

ENGINE INSTALLATION: 33) Install a standard reserve fuel system with a fifteen gallon capacity;

MISCELLANEOUS EQUIPMENT: 34) Install the release handle for the emergency flotation gear in the trailing edge of the upper wing; 35) Improve the adjustment for the machine gun alignment; 36) Provide greater accessibility so as to permit adequate adjustment of the gun synchronizers.

It should be noted that these comments by the arrested landing gear and flight test personnel indicate that the Bureau of Aeronautics apparently did not lay down a specific specification for this airplane to be constructed to. It is possible that this airplane was solely conceived by the Curtiss Company on its own initiative and financed by its own funds. These improvements no doubt improved the overall efficiency of this airplane for naval use. It also shows that aircraft manufacturers in producing a new type overlook many minor details that are of great importance to flight operations. In this instance, the conception of the airplane was based on a

performance concept with limited power, and gunnery became a secondary consideration. However, these omissions have not been entirely confined to this airplane type but is a common failing of all aircraft not manufactured to a detailed specification issued by Bureau of Aeronautics,

PART II - DEVELOPMENT OF THE XF9C-2 AND F9C-2

GENERAL DESCRIPTION OF THE CURTISS XF9C-2 - The first airplane of this type was constructed at the Garden City Plant of the Curtiss Aeroplane and Motor Corporation, Buffalo, New York, It was originally designed as a single seater carrier fighter. This airplane was more or less intended to comply with the Bureau of Aeronautics Design No. 96,

WING STRUCTURE— The wing cellule consists of upper and lower wings each having two outer panels joined to a center section structure, with a single pair of interplane struts. The interplane struts are braced with two sets of double flying wires and the usual set of landing wires to comprise a determinate structure. The wires are swaged streamlined section and are adjustable in length. The terminals of the wires are concealed within the wing.

The lower cabane structure functions as an attaching point for the drag wires braces as well as the terminal point of attachment for the landing gear. One set of flying wires runs from the forward end of the lower cabane structure to the upper aft wing spar at the attachment of the interplane struts. The other set of flying wires runs from the aft end of the lower cabane to the upper forward wing spar at the interplane strut. The landing wires run from the lower forward wing spar at the interplane strut, to the bulkhead to which is attached the aft upper wing hinge fitting.

Outboard of the interplane struts is installed a flotation bag in each wing. These bags are held in place by means of an aluminum alloy panel to which is attached a release device which jettisons this panel and permits the bag to inflate when the release device is manually actuated. These bags are inflated by carbon-dioxide carried under pressure in a steel bottle stowed in the lower fuselage cabane.

The ailerons are located on the upper wing only and are of the Frise type. The clearance ahead of the leading edge of the aileron is designed to act as a slot, the action of which is to increase the lift coefficient of the wing and to augment the lift of the wing at stalling angles, thus making aileron control effective at low speeds.

The wings, including the ailerons, are constructed of aluminum alloy tubes and shapes, with single steel tie rod drag bracing. The wing structure is fabric covered. Torque tubes for aileron operation are contained in the upper wing for aileron operations. The leading edges of the upper and lower wing structures are covered with sheet aluminum alloy back to the aft edge of the forward wing spars. The interplane struts are of streamline steel tubing.

TAIL SURFACES STRUCTURE - The horizontal and vertical stabilizers are constructed as an integral part of the fuselage. These are of aluminum alloy construction with a covering of smooth sheet attached by rivets. The elevators are of aluminum alloy framework covered with fabric. The front spar of the elevators is continuous but is detachable at the centreline of the fuselage for disassembly. The balanced rudder

is of aluminum alloy construction and is covered with smooth sheet covering attached by rivets,

ENGINE INSTALLATION - A Wright R-975-C, radial, air-cooled, nine cylinder supercharged engine rated at 400 H. P. at 2400 r.p.m. was installed. A carburetor air intake heater was also installed. A throttle stop holds the engine to the rated power at sea level. A pressure fire extinguisher, manually controlled by the pilot is also installed,

THE ENGINE STARTING SYSTEM - This consists of a hand operated turning gear of the inertia type mounted to an integral booster magneto and an engine fuel primer. The starter trip is controlled by the pilot. A fuel shut-off cock is provided in the fuel primer line near the fuel primer pump.

COOLING SYSTEM - The nose cowling of the engine is provided with an adjustable shutter device. This makes it possible for the pilot to control by manual operation the cooling of the engine crankcase.

FUEL SYSTEM - The fuel system consists of a main fuel tank, fuel quantity gauges, fuel supply lines, and the appropriate fittings. The fuel tank is made of welded sheet aluminum and has a capacity of 60 gallons. Fuel supply lines are made of copper tubing with Titeflex connections at the engine end of the lines. A hydrostatic fuel quantity gauge is installed,

LUBRICATION SYSTEM - The lubrication system consists of an engine oil tank, oil supply lines, and a quantity gauge. The oil tank, of welded aluminum construction, is located forward of the firewall of the fuselage. The tank has a capacity of five gallons, plus 1.5 gallons expansion space. All oil supply lines are made of copper tubing except a short section of Titeflex at the engine end of each supply line. An oil temperature regulator is provided. An oil pressure gauge and temperature indicators for the inlet and outlet oil supply are provided. Provision is made for straining the service oil and oil returning from the engine.

INSTRUMENTATION - The following flight instruments are provided: Inclinator, aneroid altimeter, airspeed indicator, turn and bank indicator, clock mount socket, magnetic compass. The following engine instruments are provided; Tachometer, oil pressure gauge, oil thermometer, fuel pressure gauge, fuel quantity gauge,

SURFACE CONTROLS - The surface controls are operated by a joy stick and pedal controls for the rudder which are adjustable. A bungee is installed on the elevator control to compensate for a fixed stabilizer during minor variations in longitudinal trim. The ailerons are operated by a torque tube. The ailerons are of the differential type and one aileron can still be operated in event of damage to the other.

ELECTRICAL EQUIPMENT - Standard navigation lights are provided. Cockpit instrument lights are installed, A small storage battery is also carried which is charged by means of an engine-driven generator. The instrument panel is lighted by indirect methods. All electrical wiring is carried in light gauge aluminum electrical conduit,

FURNISHINGS - The pilot seat is removable but not adjustable. It is hinged to provide access to the radio equipment located aft of the pilot's cockpit.

A unit type optical gun sight is provided to pass through the windshield. This type of sight can be bore sighted by visual methods.

GENERAL - The Curtiss F9C-2 is a direct descendant of the Curtiss XF9C-2, Plane Serial No. A-9056. The XF9C-2 design functioned as the prototype and test article for the rest of the airship fighters produced for the U. S. Navy. This airplane, although designated as the "X" model during flight testing, was finally modified into the F9C-2 fighter and functioned with the rest of the airship fighters. This fighter was a versatile airplane. While it was never intended as a carrier fighter, the airship fighter unit on the U.S.S. Macon landed these fighters on carriers when the occasion arose. They were flown with and without the landing hook attached. Essentially there was no basic difference between the Curtiss XF9C-2 and the F9C-2, except that the former was the test article and bore the "X" designation. The three view of the F9C-2 shows the airplane as it was used in airship fighter duties.

FLIGHT TESTS OF THE XF9C-2 - This airplane was received by air at the N.A.S. Anacostia, D. C., on May 3rd 1932. Minor engine adjustments were accomplished prior to the weighing operation which was performed May 9th and 10th. The airplane was demonstrated in flight tests on May 10th, 1932 by the Curtiss test pilot, but nothing more than routine flight maneuvers were accomplished. Spins and dives were exhibited by the Curtiss test pilot at the Naval Proving Grounds, Dahlgren, Virginia, on May 13th. The overall performance tests were then performed from May 15th to May 31st, 1932. Gunnery and ordnance tests were undertaken on June 9th to 15th and the radio tests were made on June 10th and 11th, 1932,

On June 14th, 1932 the F9C-2 was flown to the N.A.S., Hampton Roads, Virginia, for arresting gear tests. Although the airplane was officially designated to be an airship fighter, these tests were performed to determine how the airplane would function when landing on a carrier at sea. After the arresting gear tests were performed, the airplane was flown to Anacostia, on June 20th, 1932. Following further adjustments, the airplane was flown to Lakehurst, for hook-on tests to be performed in conjunction with the Akron, On June 29th, 1932, 9 hook-ons were performed by Lt. Harrigan, U.S.N., in 1.35 hours of flight time. Lt. Young, U.S.N., performed 13 hook-ons for a duration of 1.50 hours. The airplane after completing these tests satisfactorily was then flown to N.A.S. Anacostia, D.C. on this date for further flight tests. Radio tests were then continued and were finally completed on July 11th, 1932.

THE OBJECT OF THE AIRSHIP HOOK-ON TRIALS. - The F9C-2 was tested to determine first, if the contractor's guarantees had been complied, and second, the suitability of this airplane as an airship fighter. During these tests the airplane carried the normal useful fighter load. The maximum speed was determined without the airship hook-on device attached. This was in accordance with paragraph 104a of SD-169-2, Detail Specification of the Curtiss F9C-2, dated January 1st, 1932.

CONDITION OF THE AIRPLANE DURING THE TRIALS - The F9C-2 weighed 2770 pounds at the start of the flight tests, which included 661 pounds of useful load. The center of gravity was located at 29.8 percent of the mean aerodynamic chord.

A Wright model SR-975-E3 engine, having a compression ratio of 6/1 and a supercharger drive ratio of 10,15/1, was installed for the flight tests. This engine developed 438 H.P. at 2200 R.P.M., at sea level, at standard temperature and density. Standard engine accessories were installed. The magnetos were double, being type Scintilla VAG-9DF of a 12-volt ignition system, Stromberg carburetor Model NAR-9 was installed on the engine. The thrust was obtained from a two blade Hamilton Standard aluminum alloy propeller, Design No. 5678, diameter 8'6", with the blades set at an angle of 19.7 degrees at a radius of 42 inches during the trials.

The carburetor air intake heater was installed during the trials which was set at the "COLD" position. The fuel was domestic aviation gasoline charged with 5»5 c.c. of ethyl fluid which attained an octane rating of 87. Symbol 3100 lubricating oil was used during the flight trials.

SUMMARY OF THE FLIGHT TESTS OF THE F9C-2

Full load weight in pounds.	2770
Useful load weight in pounds.	681
Weight empty in pounds,	2089
Percent useful load.	24.6
Maximum timed speed in M.P.H.	176.5
Stalling speed in M.P.H.	63.0
Initial rate of climb in ft/min.	1700
Climb in 10 minutes in feet.	11300
Service ceiling in feet,	19200
Wing loading in lbs/sq. ft.	16.0
Power loading in lbs/h.p.	6.4
Speed at 4000 feet in M.P.H.	176.0
Speed at 8000 feet in M.P.H.	170.0
Speed at 12000 feet in M.P.H.	162.0
Speed at 16000 feet in M.P.H.	118.0

EARLY DEMONSTRATION PRIOR TO THE U. S. NAVAL FLIGHT TESTS - According to the Inspector of Naval Aircraft, at the Curtiss plant in Buffalo, in a letter to the Chief of the Bureau of Aeronautics, May 6th, 1932, the F9C-2 was demonstrated before the I.N.A. at Buffalo, N.Y. The airplane was taken up for a flight of one hour. This demonstration flight also included a terminal velocity dive to an indicated airspeed of 240 knots per hour at 9,000 feet. The pull-out revealed that a 9.8 G was experienced by the Curtiss test pilot. The guns were checked for operation but were not fired.

On May 10th, 1932 the F9C-2 was demonstrated by the Curtiss test pilot at Anacostia. The flight included all known aerobatic maneuvers except the outside loop. On May 13th, 1932, the F9C-2 was again demonstrated in aerobatics and terminal velocity dives at the Naval Proving Ground, Dahlgren, Virginia. Two tail spins of ten turns each, one to the right and one to the left were performed. Recovery from the right spin was made in three-quarters of a turn, whereas the left spin required approximately one full turn. On the same day four test dives were performed in compliance with the naval aircraft contract performance guarantees. The following table shows the results:

	<u>1</u>	<u>2</u>	<u>3</u>	<u>h</u>
Altitude at start of dive in feet	14000	15000	14000	15000
Altitude of start of pull-out in feet	8000	9000	6500	6500
Altitude lost in pull-out in feet	1000	1000	1200	1200
Speed in m.p.h. at start of pull-out	265	265	265	275
R.P.M. at start of pull-out		2600	2750	2750
Maximum acceleration in pull-out (G)	9.5	7.5	7.8	8.5
Estimated joystick force in pounds	20	10	10	—

From records made on the instruments installed by the NACA, it was concluded that the terminal velocity of the F9C-2 ranged between 289 and 295 m.p.h. in standard air and temperature. The maximum G accelerations ranged from 8.5 to 10. Substantially, the F9C-2 complied with the terms of the airplane procurement contract and was in all respects proved to be a satisfactory airship fighter airplane in correct flying balance, controllable and stable in the air and on the ground. However, before the Naval Survey and Review Board approved the airplane there were some exceptions to be made, but in general, these exceptions to some extent were of minor nature. What justifies this is that no changes were made to the airplane during the contractor's test flights or the test flights performed by naval personnel.

REVISION OF THE CONTRACTOR'S PERFORMANCE GUARANTEES - After the naval test flights revision was made in compliance with the authority of the Bureau of Aeronautics to the contractor's guarantees. This applied to the performance, the weight, and to the engine power.

The empty weight of the F9C-2 as constructed by the Curtiss Aeroplane and Motor Corporation was given as 2090 on airplane Serial No. A-9056. The empty weight as determined by Anacostia, was given as 2089 pounds. However, due to a change in the weight and rating of the Wright engine which was supplied as a government furnished item, the weight was revised to 2147 pounds, A comparison is given in the following:

	Actual	Naval Guarantee	
		Original	Revised
Full speed at rated R.P.M. at sea level	176.5	178	176.5
Minimum speed without power at sea level	63.0	66.0	66.0
Climb in 10 minutes from sea level in feet	11300	11800	11000
Service ceiling with full load in feet	19200	21400	19000

These guarantees were made with the understanding that the engine would develop 420 H.P. at sea level, would be supplied with fuel at 87 octane rating, and would weigh when dry, 590 pounds. Not more than 15 pounds for weight of residual oil and lubricants would be used. The engine on this airplane actually weighed 596 pounds. Dynamometer tests were performed on the engine used to power the plane in the tests. These tests revealed that the engine actually developed 434 H.P. at 2200 R.P.M..

COMPARISON WITH OTHER SIMILAR TYPES - The F9C-2 is a development of the XF9C-1 and the XF9C-2. It differs from the latter in the substitution of a split axle tripod type landing gear with low pressure tires and the installation of the airship hook-on device. The following will show a comparison.

	F9C-2	XF9C-1
Full load weight in pounds	2770	2502
Useful load in pounds	681	666
Weight empty in pounds	2089	1836
Percent useful load	24.6	26.5
Wing loading in lbs/ sq. ft.	16.0	14.5
Power loading in lbs/hp	6.4	5.9
Maximum speed in m.p.h.	176.5	176.5
Stalling speed in m.p.h.	63	60
Initial rate of climb ft/min.	1700	2150
Climb in 10 minutes in feet	11300	13800
Service ceiling in feet	19200	22600

Note that the weight of the airplane loaded and empty tended to grow with the development as a military type. Note that the performance of both of these aircraft was below the comparable fighters of this era. But other fighting aircraft were of greater weight and larger in size, hence, the small size and small weight, though paid for in reduced performance, made this airplane an acceptable airship fighter type.

FAILURES DURING FLIGHT TESTS - No major failures were evident either with the airplane or the engine installation during the flight tests. However, a minor failure occurred when the horizontal members of the tail wheel assembly collapsed on two occasions during the tests. This required that the assembly be replaced. On the second failure of this assembly, this failure caused the rudder to jam and to become inoperative.

FLYING CHARACTERISTICS - Considering the wing and power loadings, the F9C-2 exhibited satisfactory flying characteristics. The increased weight over the XF9C-1 consequently decreased the performance to a noticeable degree with a resultant loss in maneuverability at altitude.

When the airship hook-on device is attached, the airplane experiences directional instability. This made approaches to the trapeze on the U.S.S. Akron difficult. The instability affected the accuracy of machine - gun fire. This was corrected in the production airplanes by adding an 8 inch Wide section to the vertical stabilizer and a three inch sheet metal strip to the rudder.

Compared to the XF9C-1, slight changes in the aileron balance and the slot farm had reduced but not entirely eliminated the aileron "kick" at stalling speeds. However, the aileron effectivity was noticeably increased,

GROUND HANDLING CHARACTERISTICS - Taxi tests revealed that the F9C-2 handled good. However, on rough terrain, the tail wheel assembly seemed to be subjected to undue severe shocks when the hard rubber small diameter tail wheel was installed.

The rework of the rudder pedals to the hanging type proved satisfactory over those of the prototype airplane and provided an improved rudder and brake control during taxi operations. However, the rudder pedals were not adjustable which would have been desirable.

CHANGES IN THE STRUCTURE - The changes noted in Part I of this article were incorporated in the F9C-2 except the engine exhaust collector ring. Changes were made between the XF9C-1 and the XF9C-2, the latter airplane being more nearly similar to the F9C-2. The following changes were to be made in the production airplanes at the request of the naval Board of Inspection and Survey. The XF9C-2 differed from the XF9C-1 in the following features: 1) The upper wing was raised 4 inches to improve vision; 2) The rudder balance was removed and the equivalent area added to the vertical stabilizer; 3) The horizontal stabilizer was set at a minus 3 degrees; 4) The bungee on the elevator control was changed to a steel coil spring in place of rubber shock cord; 5) The height of the landing gear was increased 6 inches to provide a greater landing angle; 6) A single strut tripod type landing gear was installed; 7) Low pressure 7.5" x 10" tires were installed; 8) The tail wheel was made steerable within the range permitted by the rudder movement; 9) The height of the tail wheel assembly was reduced 1.5 inches to improve landing characteristics; 10) The wing panels were strengthened to increase the stiffness in a terminal velocity dive pull-out; 11) The aileron slot was modified to decrease aileron kick at

stalling angles of attack; 12) The airship hook-on and hook-off device was installed with manual controls; 13) The fuselage was strengthened to carry the raised gull upper wing loads; 14) The rudder area was increased by the addition of a 3 inch strip to the trailing edge.

ENGINE INSTALLATION - In this respect the engine installation of the XF9C-2 differed from the XF9C-1 in the following: 1) The propeller diameter was increased to 8 feet 6 inches; 2) The Wright R-975-E engine was installed in place of a Wright R-975-C. The prototype engine had side exhaust ports instead of front ports; 3) The radius of the Model E engine was 3/4 quarters inch less, making the anti-drag ring smaller and improving the vision; 4) The Model E engine was lowered one and a half inches on the mount; 5) The fuel wobble pump handle was changed to the conventional type; 6) The fire extinguisher was located forward of the instrument panel; 7) The engine was completely shielded to improve radio reception; 8) The engine oil cooler was mounted aft of the top engine cylinder; 9) Rubber hose connections were used at the engine oil cooler; 10) Engine controls were improved in operability; 11) The fuel valve, strainer, and fuel pump were relocated to improve accessibility and maintenance.

The actual changes existing between the XF9C-2 and the F9C-2 include the following: 1) A Wright Model R-975-E3 was installed in place of the R975-E. The rated R.P.M. of the latter was 2200 as against 2300 for the earlier types; 2) An Eclipse type Series VII hand electric engine starter was installed instead of the Series VI hand inertia type; 3) Installation was made of the necessary electrical wiring for a plug-in device for starting the engine.

FIXED EQUIPMENT - The fixed equipment of the XF9C-1 and the XF9C-2 was practically the same as used in the F9C-2.

COMMENTS ON THE GUNNERY INSTALLATION ON THE F9C-2 - It is evident from the comment on the gunnery installation of the XF9C-1 that major improvement would be desirable to improve the accessibility of the gun installation as well as the accuracy of firing. The best that can be said is that due to the type of airplane and the size, it would normally not meet the gunnery requirements of the naval fighters of this era. In the production model airplane the guns could only be boresighted between the limits of 85% and 90% of the maximum speed. An additional modification would seem to have been in order at the rear machine gun mounting posts in order to permit satisfactory adjustment at 100% maximum speed. The major deficiencies in these respects were the interference between the blast tubes and the cylinder heads and a lack of clearance under the rear end of the machine gun mounts.

To illustrate, the centerline of the telescopic sight G-3 clears the engine oil cooler by 2-1/8 inches instead of the 3 inches normally required. During firing, a large amount of smoke and gas floods the pilot's cockpit. Some of this gas seeps in behind the firewall. Therefore, the firewall was sealed as tight as possible. Flight maneuvers performed during firing caused the cartridge feed failure because the ammunition belts fouled. The fore and aft size of the cartridge boxes was found to be greater at the bottom than at the top, thus permitting excessive clearance for the cartridges during feeding. The original ammunition box was of fragile metal construction to save weights. All of these deficiencies were later corrected in the production airplanes.

RADIO EQUIPMENT TESTS - A type XF and XH radio installation was made in the F9C-2 airplane and tested. The installation of this equipment by the manufacturer after supply by the government was satisfactory in general. The naval radio engineers,

RUDDER MOVEMENT 35° RIGHT AND LEFT
 RUDDER AREA 6 SQ. FT.
 ELEVATOR AREA 11 SQ. FT.
 HORIZONTAL STABILIZER 6 SQ. FT.
 VERTICAL STABILIZER AREA 9 SQ. FT.

NAVIGATION LIGHT
 COCKPIT PROVIDED WITH OXYGEN EQUIPMENT

FUSELAGE FILLET

WALKWAY
 HAND GRIP
 RIB SPACING VARIED

LOWER WING AREA 68.3 SQ. FT.
 UPPER WING AREA 104.5 SQ. FT.
 AILERON AREA 19 SQ. FT.

FUEL FILLER

ALL WING PANELS WERE ATTACHED
 TO CENTER SECTION BY BOLTED
 FITTINGS

CARBON-DIOXIDE INFLATION FOR
 FLOTATION BAG CARRIED IN COM-
 PARTMENT IN UPPER WING ON
 EACH WING TIP

ANTI-DRAW RING CUT AWAY TO
 CLEAR MACHINE GUN BLAST
 MACHINE GUN BLAST TUBE
 STEEL TUBE AIRSHIP HOOK-ON
 AND HOOK-OFF PYLON

TWO 30-CALIBER MACHINE GUNS
 SYNCHRONIZED TO FIRE THROUGH
 THE PROPELLER. 600 ROUNDS
 FOR EACH GUN.

STREAMLINE STEEL STRUT
 PITOT HEAD
 HAMILTON-STANDARD FIXED
 GROUND ADJUSTABLE ALUMINUM
 ALLOY PROPELLER
 GUARD TO DIVERT CAR-
 RIER DECK LANDING WIRES

WRIGHT RADIAL AIR COOLED
 ENGINE R-975 E-3 AT 2200
 R.P.M. SUPERCHARGER DRIVE
 RATIO 10:15 TO 1

7.5 X 10 SEMI-BALLOON TIRES
 CABLE ACTUATED BRAKES

RUDDER-CABLE OPERATED
 ELEVATOR-CABLE OPERATED
 35° UP - 25° DOWN
 FIXED HORIZONTAL STABILIZER
 -2.5° INCIDENCE

RADIO ANTENNA
 ADJUSTABLE SEAT
 G-3 TELESCOPIC GUN SIGHT

ALL METAL GULL WING
 CENTER SECTION
 HOISTING LUG

FABRIC COVERED METAL FRAME
 FRISSE TORQUE TUBE OPERATED
 DIFFERENTIALLY CONTROLLED
 AILERONS - 3 HINGES
 AERODYNAMIC BALANCE
 35° UP - 20° DOWN
 NAVIGATION LIGHTS

RIB STITCHING
 CLARK CYH AIRFOIL

ENGINE OIL COOLER

PROPELLER DIAMETER 8'-6"
 BLADE ANGLE 19.7° AT 42' RADIUS
 FLOTATION GEAR RELEASE
 CONTROL

METAL FRAME WING STRUCTURE
 FABRIC COVERING

RADIO ANTENNA
 RADIO MAST
 DIHEDRAL ON UPPER WING 2°

0° WING INCIDENCE
 GAP 45"

FLYING, LANDING, AND DRAG
 WIRES ALL DOUBLE AND OF
 SWAGED SECTION
 HAND GRIP

0° WING INCIDENCE
 AILERON BELL CRANK FAIRING

P & W TYPE MANUALLY CON-
 TROLLABLE SHUTTERS

(AIRPLANE SHOWN IN THE
 TAKE OFF ATTITUDE)

CURTISS AEROPLANE & MOTOR COMPANY

BUFFALO, N. Y.

U.S. NAVY

AIRSHIP FIGHTER F9C-2

COLORATION	
WINGS	YELLOW
TAIL SURFACES	BLUE
FUSELAGE	GRAY
LANDING GEAR	GRAY
WHEELS	GRAY
TIRES	BLACK
PROPELLER	ALUMINUM
HOOK-ON STRUCTURE	GRAY

MANUAL RELEASE MECHANISM
 AIRSHIP HOOK-ON AND HOOK-OFF
 STRUCTURAL DEVICE

RADIO ANTENNA MAST
 ENGINE OIL COOLER
 ANTI-DRAW RING
 MACHINE GUN BLAST TUBE

COWLING BULGED TO PERMIT
 AIR EJECTION FROM ENGINE
 ACCESSORY COMPARTMENT
 SHORT ENGINE EXHAUST PIPES
 OIL TANK FORWARD OF FIREWALL
 (5 GALLONS)
 FUEL TANK BEHIND FIREWALL
 (63 GALLONS)

FLOTATION BAG COMPARTMENT 5'-2"
 SEMI-OLEO SHOCK STRUT
 FIXED WHEEL FAIRING

LANDING GEAR WAS REMOVED FOR
 AIRSHIP FLIGHT OPERATIONS TO
 INCREASE THE RANGE OF FLIGHT.
 AN AUXILIARY FUEL TANK WAS IN-
 STALLED TO ACHIEVE THIS.
 FLOTATION BAG CO2 BOTTLE MOUNTED IN LOWER CABANE

0 1 2 3 4 5 6 7 8 9 10 (SCALE)

20'-2"

STAGGER
 25"

RADIO ANTENNA

ALL METAL SEMI-MONOCOQUE
 FUSELAGE STRUCTURE

ALL METAL VERTICAL AND HORIZONTAL
 TAIL SURFACES

8" VERTICAL STABILIZER ADDITION

3" METAL PLATE ADDED TO TRAILING
 EDGE OF RUDDER

HOLE FOR TAIL LIFTING BAR

STEERABLE TAIL WHEEL
 PNEUMATIC TIRE

9'-2"

FILLET
 CARRIER HOOK
 FAIRING FOR CARRIER HOOK
 LANDING ANGLE 13°
 FITTING (TIE DOWN)
 STEP
 LOWER WING FILLET

however, noted that the transmitter control box was located so far to the rear in the cockpit that it made proper use of the telegraph transmission key difficult due to elbow interference. In the production airplanes the transmitter and receiver control boxes were moved to a comparable position on the left side of the fuselage to provide proper operational clearance for the telegraph key. This change, however, was made contingent upon the contemplated change in the dirigible hook-on release device.

The F9C-2 was dived at speeds exceeding 200 m.p.h, and the antenna installation was found to be satisfactory up to and including this airspeed.

ITEMS OF USEFUL LOAD - During the weighing operation the following items of useful load were installed: trigger for machine gun control unit, bowden cable, two impulse tube assemblies, two trunnion bolts, two rear machine gun mounting post assemblies, two synchronizer generator units, type G-3 open sight, very pistol cartridge holder, safety bolt, oxygen tubing and clips, electrical generator, generator control box, pilot and parachute, fuel (43 gallons), lubricating oil (3.5 gallons), open gun sight, unit sight, mounting brackets for gun sight, very pistol cartridge holder, very pistol and holster, very pistol ammunition (12 rounds), life jacket, safety belt, life preserver, oxygen cylinder, oxygen regulator, oxygen supply lines and clips, first aid kit, life raft, generator, generator control box. All of these items of useful load added to a total of 679 pounds.

THE ARRESTING GEAR TESTS - While the F9C-2 was deemed to be suitable for carrier duty, it was not cleared for this assignment until certain modifications would be made on the production airplanes. The flight personnel who conducted the arresting gear tests performed 11 landings into the arresting gear. Seven full throttle take-offs were made from the deck using the release fitting.

The carrier tests revealed that with the present wheels installed with the tires deflected, as may readily occur in a free flight landing, permitted the axle center to travel 2 inches below the athwartship deck wires, rigged with an 8 inch clearance at the center of the span. In addition, under these conditions, and with the fuselage horizontal, the propeller clearance with the deck was only 6 inches. Obviously, this condition is worsened when a landing is made off center, because the height of the wire at the yielding elements is approximately 12 inches. The request was made that large diameter wheels be installed. However, the personnel of the airship fighters eliminated this situation by making a special deflector plate on the wheel fairings which ran fore and aft and so deflected the wires when landing on a carrier deck.

The second testing of the F9C-2 was routine and performed at the Experimental Division, N.A.S. Hampton Roads, Virginia. These tests while routine, still found the F9C-2 to be deficient in vision for extensive carrier operations. Tests were made with the anti-drag ring removed and modified.

The same annoyance to the pilot of the F9C-2 in viewing the instruments when the pilot's seat was in the "UP" position. The recommendation of the test pilots was to enlarge the cockpit coaming or to relocate the instrument panel.

The landing hook bumper pad constituted another source of annoyance to the test pilots. The extension of the bumper pad one and a half inches forward and the relocation of the retrieving tang on the landing hook was made in a form of a recommendation to prevent damage to the underside of the fuselage shell plating.

Likewise the arresting gear tests revealed that the tail wheel bracket was not faired properly to prevent fouling of the arresting gear wires. The existing flat surface on the front and on the shoulders of the bracket were to be rounded to a specific curvature,

FINAL REPORT OF THE ARRESTING GEAR TESTS - Lt. J.R. Tate, Lt. J.F. Wegfarth, and Lt. E.P. Moore, U.S. Navy, conducted the arresting tests, AH agree that the F9C-2 was not suitable for carrier duty until the "recommended changes have been incorporated and vision for carrier landings has been improved," It should be noted that while some of the F9C-2 airplanes did make landings on the carriers, these were strictly on an unofficial assignment status and not recommended by the personnel of the Naval Board of Inspection and Survey,

TESTS OF THE AIRSHIP HOOK-ON DEVICE ON THE F9C-2 - The three flight officers who recommended against the F9C-2 for carrier duty unless a host of changes were made, were replaced when the Bureau convened a Sub-Board of Inspection and Survey for the purpose of conducting airship hook-on trials and the performance of the hook-on device. These tests were started on June 28, 1932, the airplane being flown to Lakehurst from Anacostia for this purpose. The Curtiss F9C-2 was tested to determine the operation of the airship hook-on device and the overall suitability as a service type airship fighter. It should be noted that no norms existed to determine the suitability of the F9C-2 as an airship fighter. In short, if the airplane performed good for this specific assignment it would be recommended for this function in place of carrier duty. No difficulty was experienced in the hook-on and hook-off releases from the U.S.S. Akron made by two pilots experienced in this kind of operation.

COMMENT ON THE ACTUAL AIRSHIP FIGHTER TESTS - A full load drop test was made after the arrival of the airplane but the releasing mechanism of the airship hook-on device did not function satisfactorily. The airplane in this instance was attached to the U.S.S. Akron and was carried aloft for the drop test. It should be noted that the hook-on device was experimental at the time, and its operation uncertain. There were several type of hook-on mechanisms tried out experimentally,

Specifically the trouble with the hook-on device centered around the bent end of the hook tripping cable which straightened within the fitting when tension was applied at the releasing lever without causing any movement of the releasing cam. The release cam lever was extended 3 inches and a temporary tripping cable was led over a sheave to a point forward of the windshield where it was secured to a short length of elastic cord to prevent accidental tripping with the plane on the trapeze, A toggle was secured in this cable in a location convenient to the pilot.

Two full load drop tests were made upon completion of this temporary installation. The cam tripping gear functioned satisfactorily during these tests and during subsequent hook-on trials. The cam actuating spring was of insufficient strength to overcome the weight of the additional lever arm. This in addition to the drag of the tripping cable and the toggle at cruising speed, caused the cam to drop below the locked positions. However, near the stalling speed necessary to hook-on the airship, this tendency lessened and a sharp jerk on the cable caused the cam to return to the locked position.

During the approaches of the F9C-2 to the trapeze of the U.S.S. Akron, all of which were conducted at airspeeds close to the stalling speed of the airplane, excessive right rudder was necessary, In this stage of the approach to the airship a slight change of the rudder angle caused an unusual amount of yaw. This was counteracted by raising the left wing.

No other difficulty of control was experienced during airship hook-on tests. The spring balance tension device to assist in longitudinal trim was not highly thought of by the test pilots. It was their consensus that a pair of trim tabs on the elevators would function better.

During the airship tests, it was found to be difficult to adjust the pilot's seat. This seat was secured within the cockpit by means of two spring loaded pins. It was found necessary to disengage these pins to gain access to the baggage compartment. Thus it was recommended that an alternate method of securing the seat be employed. This was a safety precaution to prevent the seat from falling out in inverted flight,

A flight control locking system is provided for all moveable control surfaces. This control surface locking system is not considered essential to the operation of an airship fighter. However, it is a desirable feature when the airplane is staked out in the open and as such was recommended.

The instruments in the upper part of the instrument panel cannot be read from the normal position of the pilot's eyes on account of the shape of the forward part of the cockpit coaming and attached padding.

Severe pounding of the tail wheel assembly is noticeable when taxiing over sandy ground. An additional shock absorber capacity is desirable on the tail wheel.

The sleeve about the guard tube, approximately 8 inches from the throat of the airship landing hook tended to stop the trapeze bar from latching properly in the hook. An additional amount of throttle control is necessary to complete each airship hook-on after this sleeve is connected to the bar.

An exhaust collector ring was recommended as a desirable accessory. During the airship tests, the engine was not started with the airplane on the trapeze. Access to the fuel and oil tank fillers is satisfactory when the airplane is attached to the trapeze.

RECOMMENDATIONS FOR MODIFICATIONS - The following recommendations are similar to those previously described for the XF9C-1, some of which have been corrected in the XF9C-2. These recommendations were submitted by the airship hook-on test pilots and were intended to make the airplane improved in overall performance and handling. Some of the recommendations were unreported previously: 1) Directional stability should be improved at stalling speeds; 2) The tail wheel shock absorber should have more capacity; 3) Improvement is to be made in the pilot's seat adjustment in the air; 4) Install additional attachment to the securing of the pilot's seat; 5) Provide an exhaust collector ring; 6) Install the type of airship hook-on device which has a system of links and bellcranks to provide the best tripping leverage; 7) Investigate the strength of the hook-on device locking spring and increase this sufficiently to maintain the cam in the fully locked position with the hook tripping installation mounted; 8) Remove or fair in all sleeves and obstructions along the upper surface of the guard tube; 9) Replace the auxiliary hook control levers by a system similar to that installed on the XF9C-1; 10) Modify the shape and padding of the forward section of the cockpit coaming to make the upper instruments visible from the normal position of the pilot's eyes; 11) Investigate the strength of the radio antenna brackets on the upper wings. Substitute wing tip terminals similar to those attached on the XF9C-1. Test the airplane at terminal velocity with the antenna installed.

THE REPORT OF THE BOARD OF INSPECTION AND SURVEY - After the flight tests, arresting gear tests, radio tests, and airship hook-on tests, this board found that the Curtiss F9C-2 complied with all performance guarantees.

This airplane carrying these items of normal useful load specified for an airship fighter, under all service load conditions, was found to be in all respects a satisfactory military airship fighter airplane in correct flying balance, controllable and stable in the air, and on the ground, and suitable for the service intended except as previously noted.

The Board recommended that the Curtiss F9C-2, with the prescribed modifications incorporated as listed under all previous recommendations, be accepted as a service type for airship operations.

The Board of Inspection and Survey consisted of the following! Lt. Commander G. F. Bogan, U.S.N., Lt. T. P. Jeter, U.S.N., Lt. J. F. Bolger, U.S.N., Lt. E. W. Litch, U.S.N., Lt. D. S. Cornwell, U.S.N., Lt. E. B. Pirie, U.S.N., Lt. F. M. Trapnell, U.S.N., Mr. E. W. Rounds, U.S.N..

It should be noted that other than directional stability when the airship device was hooked on, the Curtiss F9C-2 was accepted with actually few minor changes to the basic structure. This indicates that the basic aerodynamic design was correct. The recommendations could be easily corrected during production of the remainder of the airplanes.

THE AIRSHIP HOOK-ON DEVICE - This structure was subject to considerable experimentation before a satisfactory configuration was obtained. Each of these devices had a cable operated release gear, operable by the pilot of the airplane. Considering that the device was strictly experimental in nature, no serious accidents occurred through the use of the hook-on device. The hook-on device in conjunction with the trapeze on the airship functioned in an efficient manner.

F9C-2 FUSELAGE - This fuselage was of the semi-monocoque all metal type made of aluminum alloy. The structure consisted of transverse open bulkheads, short longerons, stringers, skin, all fabricated from 17ST aluminum alloy. The main bulkheads to which the wings and fuselage are attached are of heavy gauge box construction. The rest of the bulkheads are of .051" J-section. The flange is 7/16" and of various depths commensurate with the strength requirements. The longerons are hat sections, .051" x 1" x 1" with 0.5" flanges. The upper longeron is located between bulkheads 2 and 6 and the lower longerons between bulkheads 2 and 3. The stringers are .032" J-section 7/8" deep, and 7/16" flat flange, and 3/8" curved flange.

The skin of the fuselage varies in thickness. Between bulkheads 2 and 5 it is .025" thick, .020" between bulkheads 5 and 12, except for a short section on the underbody between bulkheads 5 and 8. The skin on the pilots headrest and streamline and fin is .016" thick.

The manufacturer static tested the fuselage by means of sand bags to the high angle of attack conditions to 80 percent of the design load. From a stress analysis it was revealed that under this kind of static testing that the fuselage as constructed revealed that no part of the structure was stressed beyond the elastic limit of the aluminum alloy.

HOOK-ON OPERATIONS - It is remarkable that with the hazardous operation of these parasite fighters that no serious accident occurred. All hook-on operations were directed from the platform inside the bottom of the hangar on the U.S.S. Akron and U.S.S. Macon. After the airplanes were retrieved and hoisted into the hangar, the "T" shaped opening into the hangar was closed by one sliding panel and two trap type doors.

During the whole operation of this trapeze and hangar operations, including hundreds of day and night operations no serious accident occurred despite the lack of a railing around the hangar opening for the handling crewmen. Night hook-ons were made with the assistance of a single light that was located on the trapeze.

An interesting sidelight on these operations and one that is the subject of the drawing occurred during a night operational hook-on by Lt. Simpler on the U.S.S. Macon when he requested permission to come aboard. For reasons known only by the captain of the airship at the time, the normal routine forward speed for landing was refused. The pilot was instructed to make a normal hook-on regardless, much to the perplexity of the pilot's and hangar plane handling crewmen. All hands braced for the inevitable impact when the F9C-2 hooked-on. Rather tense moments developed as the F9C-2 approached the trapeze. The pilot had to fly the airplane at a power stalled attitude.

The hook-on occurred, the hook engaged with a resounding crash which shook the airframe, the nose of the F9C-2 dipped, and the plane hung with the engine shut off. Immediately it was ascertained that all that was holding the airplane was one bolt. The other bolt had sheared and there the plane hung. The bolt that had sheared was one nearest to the hook. Should the strain on the hook bolt become too great, the Sparrowhawk would fall tail first. It was not possible to move the trapeze. Quickly a looped rope was passed down to the pilot, who carefully slipped it over his head and under his arms and was drawn up into the hangar. He saluted the officer of the day and retired to his quarters. The airplane was then carefully lifted aboard and the hook lashed as good as possible for the night. The next morning the airship cruised over the Pacific Ocean. Another pilot volunteered to board the airplane, The plane and pilot were finally released and much to the relief of all the crewmen made a safe landing ashore,

THE TRAPEZE ON THE AIRSHIPS U.S.S. AKRON AND MACON - The final hook system was developed from a three point cable attachment used on the U.S.S. Los Angeles, to a simplified single point attachment as used on the larger naval airships.

The landing hook mechanism was quite an innovation, having been made to swing forward and upward at a 45 degree angle, while the main trapeze structure was sprung to take the impact loads much as the present day shock absorption gear on the deck of a carrier. The initial impact was lessened by the airship cruising at 75 knots while taking on the parasite fighters. The one new and noticeable innovation as used on the U.S.S. Macon was the addition of an extra arm structure at 90 degrees pointing aft. This was let down to hold the airplane steady while it was being hoisted into the hangar.

TABLE No. 1 Comparison of the XF9C-1 With Other Existing Fighters in Navy Use at This Time

	XF9C-1	XFJ-1	XFJ-2	F4B-1	F4B-2	XF5 ⁽¹⁾	Boeing 218
Full load, weight in pounds	2502	2797	2843	2725	2797	2849	2707
Use Load in pounds	666	751	743	800	739	772	743
Weight empty in pounds	1836	2046	2100	1925	2058	2077	1964
Percent useful load	26.6	26.8	26.2	29.4	26.4	27.1	27.4
Wing Area	172.9	178.6	178.6	227.5	227.5	157.3	227.5
Maximum Span	25.5	28.0	28.0	30.0	30.0	30.6	30.0
Overall Length in feet	20.3	20.3	20.6	20.1	20.1	21.0	20.4
Overall Height in feet	7.1	8.3	8.6	9.3	9.3	9.4	9.2
Engine Type	R-975-C	R-1340-C	R-1340-D	R-1340-B	R-1340-D	R-1340-D	R-1340-D
Critical Altitude in feet	S.L.	6000	6000	S.L.	6000	6000	6000
Rated H.P. at Critical Altitude	400	450	500	500	500	500	500
Maximum Speed at " " /MPH	176.5	172.0	193.0	165.5	186.0	183.0	193.0
R.P.M. at Maximum Speed	2325	2100	2200	2100	2200	2200	2200
Minimum Speed in M.P.H.	60	65	65	57	57	66	58
Rate of Climb at Critical							
Altitude, Feet per Minute	2150	1860	1700	2110	2040	1850	2300
Climb in 10 Minutes in Feet*	13800	15100	14300	14350	16300	16100	17400
Service Ceiling in Feet	22600	23800	24700	26400	26900	27100	29000
Power Loading, Lbs per H.P.**	5.9	6.2	5.4	5.3	5.3	5.42	5.24
Wing Loading, Lbs per sq. ft.	14.5	15.7	15.8	12.4	12.3	18.1	11.9
Normal Fuel Load in pounds	258	300	300	300	300	300	300
Endurance Full Speed***	1.16	1.25	1.08	1.08	1.08	1.08	1.08
Range Full Speed In Miles***	204	216	208	179	198	198	208

(1) Editor's Note: Believed to be Boeing XF5B-1.

* Assuming constant rate of climb below critical altitude.

** Based on actual power.

*** Based on fuel consumption of .53 pounds per B.H.P. and actual power.

TABLE No. 2 Official Navy Photographs

For those interested in obtaining 8" x 10" single-weight, glossy photographs the following list of negative numbers is presented. Copies are sold for \$0.55 each from the Naval Photographic Laboratory, Anacostia, D.C. Make checks payable to the Treasurer of the United States.

<u>Negative Number</u>	<u>Aircraft</u>	<u>Description</u>
30552	XF9C-1	3/4 rear, photo taken 4-27-31
30553	XF9C-1	Rear, " " "
30554	XF9C-1	3/4 front, " " "
30555	XF9C-1	Front, " " "
30556	XF9C-1	Side, " " "
31464	F9C-2	Front, photo taken 5-16-32
31465	F9C-2	3/4 front, " " "
31466	F9C-2	Side, " " "
31267	F9C-2	3/4 rear, " " "
31468	F9C-2	Rear, " " "
416335	F9C-2	1/4 Rear, hooking on MACON
432805	F9C-2	Hooking on MACON
441979	F9C-2	1/4 Front right, hooking on MACON
441981	F9C-2	Three in flight formation, 1/4 front up, line abreast. Photo taken 7-6-33.
644470	F9C-2	Left side, ground, #9056. MACON insignia.

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2. "U.S.S. Akron", Aero Digest, December 1931.
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12. Flying Fleets, S. Paul Johnson, Silver Burdett Co., 1941.
13. National Aeronautical Collections, Smithsonian Institution, 9th Edition, 1956.

Editors Note: Certain statements and conclusions differ between this article and the following one. Each is presented as the evaluation of the author stated and should be accepted as such. Further comments and/or disagreements are invited for the Correspondence section of the Journal.