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Part 12
VF DESIGN BRANCH

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on 1/29/55

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A fairly complete history of flight design although without documentation. Begins with establishment of class desks in 1932, and carries through 1945, showing the development of the branch with emphasis on personnel. Fairly good information on relating branch to other units and on how the branch works. The development of plane design is taken up divided according to type. (See title page for details)

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MEMORANDUM

From: Director of Piloted Aircraft Division
To: Director of Technical Data Division

Subj: History of VF Design Branch - Forwarding of.

Ref: (a) DCNO (Air) and BuAer Administrative Circular No. 58-44 Serial 140812 dated 12 August 1944.
(b) Engineering Division Memorandum 49-44, Aer-E-26-JAB dated 31 August 1944.

Encl: (A) Original and one copy of History of VF Design Branch of the Engineering Division, Bureau of Aeronautics 1932 - 1945.

1. Enclosure (A) is forwarded in accordance with References (a) and (b).

[Signature]
Capt. USN

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Bureau of Aeronautics
Department of the Navy

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HISTORY OF VF DESIGN BRANCH

of the Engineering Division, Bureau of Aeronautics

1932-1945

Lt.(jg) Patricia L. Offield
VF Design Branch
1 February 1946

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The growth of the Fighter Desk both as to size and scope of its duties, closely paralleled the development and use of the fighter plane itself by the Navy. In the early years and just preceding the present war, the Navy's fighter planes had not yet assumed their proper place as the Navy's foremost aircraft and offensive and defensive weapon of the Fleet. Hence, until the entry of the United States into the war, both the Navy's fighter plane complement and the cognizant Engineering class desk were small. It was not until the true value of the Navy's fighter aircraft was recognized and the needs of the Fleet for such type planes became so great that VF Design Branch assumed its present important role in organizing and coordinating nearly every phase concerning the Navy's fighting planes.

ORGANIZATION AND PERSONNEL

Before VF Design Branch was first established as a Class Desk in 1932, the work of that office, together with that of the other airplane types, was handled by two officers in the office of H/A Design which formed a part of the Material Division of the Bureau of Aeronautics. At the close of 1931, "H/A Design" became known as the Airplane Design Section of the Material Division, having under it several design assistants, including all the various technical classification (canceled) (changed to

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This new section first appeared on the BuAer Correspondence Designation List on November 10, 1931. The duties, responsibilities and authority of this section were set forth in Material Division Memo. dated 3 March 1932, to which was attached an organization chart for the entire section. The duties of the Head of the Section and his two assistants, one a design assistant and the other for handling new design, were specifically outlined. This organization served only as a temporary measure, however, until the "Class" desks were incorporated under the Airplane Design Section. Material Division Order No. 7 of 15 July 1932 established the Class Desks under the Airplane Design Section, and the various technical sections, formerly a part of the Airplane Design Section, were placed under a Technical Section, separate in organization from the Airplane Design Section. Under this new set up, the Navy's fighter aircraft became the cognizance of Class Desk "A".

The duties of Class Desk "AF were in general as follows:

New Design - Competitions, drafting and detail negotiations.
Contract changes in connection with new designs.
Mock up boards and changes, initiating of, reports on.
Flight tests and trial board changes.
Airplane specifications and requisitions.
Checking of general and process specifications.
Checking technical orders and notes.
Checking strength and safety matters, including flight restrictions.
Trouble Report Action.
Services Changes, etc.

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A Design Section Memorandum of 16 July 1932 assigned high speed and fighter aircraft to Class Desk A, but put VF(2), a fighter-bomber classification, under Class Desk B, along with the dive bomber aircraft. On 17 October 1933, a further change was made in the organization of the Class Desks, and Class Desk A was given, in addition to fighter planes, the VR and Airship Unit planes. This set-up remained unchanged until altered by Design Section Memo of 5 June 1935 which added to Class Desk A the special assignment of handling the SF-1 and FF-1 airplanes. The Class Desks at this date were carried under the heading of the Airplane Design Section of the Engineering Branch of BuAer. On 1 July 1937, two additional Class Desks, E and F were established, and to Class Desk A fell all the fighter types together with VBF, Airship Unit Planes, and the special assignment of SF-1.

The duties and authority of Class Desk A, along with the other Class Desks, were modified by Engineering Branch Memorandum of 29 July 1937 which established the separate office of Airplane New Design whose function it was to take care of new aircraft design, drafting, design approval, and specifications, thus removing these functions from the Class Desks. There were several reassignments of Class Desk airplane cognizance during the following several years, and on 27 April 1939 the Head of Class Desk A, Lt. Comdr. R. E. Farnsworth, proposed a further regrouping of airplane types in order to clarify the lines of cognizance of the six Class Desks. Class Desk A finally adopted the title it is now known by, i.e. VF Design, on 5 February 1941, when an Engineering Branch Memorandum proposed that the airplane class designation be used on the forthcoming new BuAer route sheet.

Until 1941 when additional personnel were assigned to the Fighter Desk to take care of its growing affairs, the work of the office had been handled by one officer. All the Class Desk officers occupied one room since the volume of work of each Class Desk was not large enough to warrant occupying separate rooms. The Class Desks were first located in Room 2241 of the main Navy Building and remained there until 1935.
when their office was changed first to Room 2245, then to Room 2837, and later in 1939 to Room 2833. In January of 1942 the Engineering Branch was moved to Building "W" and the Class Desks were made into separate sections due to the increase in amount of work brought on by the present war. VF Design first occupied Room 2W57, and later moved to 2W60, 2W62, 2W64, where it remained as of December 1945.

As to personnel who comprised the Fighter Desk, Lt. Cdr. J. R. Allen (CG), USN became the first Head of Class Desk A in 1932. He also assumed the duty of General Assistant of the Airplane Design Section under whose general leadership fell the four Class Desks. In August 1935 Lt. Cdr. J. E. Ostrander, Jr., became Class Desk A officer and remained in that position until the following year when he was succeeded by Lt. Cdr. A. M. Pride. It was at this time also, July 1936, that Lt. J. B. Pearson, Jr., who was later to take charge of the fighter desk activities, first became a part of the Class Desk organization. Lt. Pearson became head of the newly created Class Desk E, VR, WJ, WN, Coast Guard Contracts. Class Desk A had a new officer in charge in June of 1937 when Lt. Cdr. R.E. Farnsworth took over the duties as its head, which position he held for two years until the fall 1939. The fifth Head of the Fighter Desk was Lt. Cdr. R. S. Hatcher, who in the fall of 1939, was transferred from Class Desk E. In July 1940, Lt. Cdr. J. B. Pearson, Jr., who had previously headed Class Desk E, was brought in to take charge of the growing activities of the Fighter Desk. During the time he held this position, he saw, due to the entrance of the United States into the war, the office rise to the level of a branch, and its personnel increase from one officer to 12 officers and 2 civilian stenographers. The "one man" Fighter Desk continued until January 1941 when Ens. G.N. Eisenhart was assigned to assist Comdr. Pearson. On 24 June of that same year, the office received an additional officer, Lt. Andrew McB. Jackson, Jr. Between these two officers the work of the Fighter Desk was divided, Lt. Jackson taking the work concerning the following fighters: F3F-1, -2; F4F-3, -4, -7; F2A-2, -3; F6F-1, -2, -3; XF7F-1, and Ens. Eisenhart the development work of the F4U-1, -4.
-2, -2; F3A-1, FG-1, XPL4C-1, -2, -3; Design 322 (the new Vought proposal with the X-Wasp engine), Design 315 (the Zimmerman design) and the Vultee design. In the following year there were two additional officers assigned, one on 9 June 1942 when Ens. J.G. Gavin, Jr., reported to the Fighter Desk, and the other on 29 September 1942 when Lt. Cdr. T. D. Tyra came on board to take over the growing Corsair section of the Branch. In 1943 six additional officers were assigned. Two of these, Lt. J.F. Sutherland who came in to replace Lt. Eisenhart, and Lt. A. D. Pollock who replaced Lt. Cdr. Jackson, were aviators recently in from the Pacific who brought with them the latest ideas as to what the Fleet needed in the way of planes and equipment. Lt. Cdr. W.E. Sweeney who had just completed the Navy's post-graduate aeronautical engineering course at the California Institute of Technology, reported to VF Design Branch to become project officer for the Grumman fighters and later in 1944 to become Assistant Head of the Branch. In the fall of 1943 Ens. L.W. Cabot was assigned, and one Wave officer, Ens. Patricia D. Offield making the total personnel of VF Design at the end of 1943, nine officers and two civilian secretaries. In the following year nine additional officers were assigned, and three Wave Yeomen, bringing the office complement up to 18 officers, 3 Wave Yeomen, and two civilian secretaries this brought the total number of personnel up to 23, which was maintained until the summer 1946. Lt. Cdr. R. C. Merrick who had been a fighter squadron commander, was brought in from the Fleet to become Project Officer of the Corsairs as replacement for Cdr. T. D. Tyra, who became Head of the Fighter Branch in March 1944. Shortly thereafter Lt. Cdr. J.H. Anderson was also brought in from the Pacific to take charge of the Goodyear fighter development and production program. In the fall of 1945 Lt. Cdr. H.H. Epes, Jr., was brought in to supervise this Goodyear fighter development. Lt. Col. J.D. Harshberger, USMC, night fighter squadron commander, was assigned to VF Design Branch to supervise the night fighter development and to carry on liaison work with the Marine Corps. He held that position until November 1944 when Lt. Col. E.H. Vaughan replaced him. At the time Col. Vaughan returned to inactive duty after the end of the War, Major Ross S. Mickey, USMC, reported in to replace him and
carry on the work as Project Officer for the F7F. The high speed fighter research project was given its first impetus under the direction of Comdr. E.W. Conlon, Head of the Aeronautical Engineering Department of the University of Michigan, who was transferred from the Structures Branch to VF Design Branch to take over this special project. When the Ryan FR-l, Fireball, became ready for production Lt. Cdr. R.W. Mahle was ordered into the Branch to be the Ryan Project Officer, as replacement for Lt. Cdr. A.D. Pollock who was ordered to the Navy's post-graduate aeronautical engineering course at the California Institute of Technology. Several junior officers were also ordered in to take care of the engineering details on the various production and experimental fighters. They were: Lt. (jg) L.C. Josephs III, Ens. R.M. Head, and Ens. C. H. Rose.

On 31 October 1945 Cdr. Tyra was detached as Head of VF Design Branch, and Cdr. A. B. Metsger was brought in as his relief to take over the supervision of fighter aircraft during the post war period.

Eventually the duties, responsibilities, and authority of the Class Desks became more firmly established, and by the time they were given branch status, in 1941, it was fairly well determined. The following is a general outline of the work handled by VF Design Branch:

The Head of VF Design Branch acts as special assistant to the Director of Engineering for all matters pertaining to fighter aircraft, both as to the planes already in service and those under contract. This Branch is the control center for anything concerning fighter aircraft, and coordinates the work of the various technical branches with a view toward improving its present planes and toward creating new and improved types for future service.

All design and engineering correspondence concerning the Navy's fighter aircraft clears through VF Design Branch for approval or for correction or modification. The Branch acts as the liaison agency between Bureau and contractor, Bureau and Trial Board, and Bureau and Service activities, for all design and engineering matters for its airplanes. It is one of the principal duties of VF Design to coordinate the activities of the Branches of the Engineering Division with those of other Divisions in connection with models of fighter aircraft which are of an unusual nature, particularly regarding the design follow-up in cases of special urgency.
and at the beginning of contracts for new airplanes or modifications to them.

General supervisory control over detailed specifications is exercised by the Branch. It also maintains design control of, and sets up, with the concurrence of Maintenance Division, the provision of government-furnished material for Service Changes. The Branch exercises control of design contract changes and takes appropriate action thereon after approval by the Inter-Bureau Contract Change Committee. Accurate records of such changes, date of their approval, and date they are to go into effect in the production line is maintained by this office.

In the matter of weight control of the various fighter types, constant attention is given to any items which may be proposed to incorporate on the airplane, and a vigorous effort is exerted to prevent any items which add weight from being introduced on the fighter whose usefulness does not compensate for the increased load.

Close liaison with Military Requirements Division is maintained by the Branch in order to have a thorough understanding of present and forthcoming combat requirements. Any broad directives of Military Requirements concerning the military characteristics to be incorporated in fighter planes is carried out in detail by the Fighter Branch.

The officers attached to the Branch keep informed on all foreign and domestic developments in power plant, structural and armament matters, and in the aerodynamic and military features of each new design, in order that their fighter types may keep abreast of, and if possible surpass, those of foreign countries. In order that the Navy's fighters may be able to meet future fleet
requirements, combat and intelligence reports are reviewed and analyzed by the officers of the Branch, and an evaluation is made of the effectiveness of our own aircraft and of that of the enemy. By such a study, new design features may be more readily determined in advance. When after it has been fully determined what will be needed in the way of new types of fighters, conferences are held with other Branches and with Military Requirements Division so as to formulate the specifications that will be necessary for a prospective model. Generally, VF Design Branch will initiate the action required by sending out letters to the various contractors, requesting that they submit designs in accordance with certain general specifications. Although the detail designing is the duty of the contractor, engineering and performance are the items of primary concern of the Fighter Branch, and it is constantly reviewing new proposals and designs, and making suggestions and recommendations for Changes or modifications thereon, in an effort to have developed the best fighter possible for Fleet needs. The Branch frequently carries on preliminary informal contract negotiation, and in the case of procurement of experimental quantities, VF Design initiates the procurement directive.

Thus, from the very beginning, the Branch exercises supervision over the preparation of the detail specification, makes arrangements for mock-up board inspections and conducts mock-up board meetings and acts as recorder. From then until the first plane is built, is flown, tested, and is put on a production basis, the Fighter Desk keeps close track of; and supervises, the development of the new model. Even after it has been put into service, the Class Desk follows its performance and serviceability with the Fleet, makes arrangements for correcting

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with N-5°, Preferred, NC° and N-5-0°C Preferred plane, it is essential that the equipment, once installed and operating to extremes of flight altitude and speed be capable of test and control which guarantee the accuracy of the equipment. It is essential that the equipment should be tested under all conditions which may be encountered by the plane throughout its operation. All test reports on equipment are checked through the design bureau which makes

In the event that proper corrective action results from the various recommendations made.

It is the duty of the pilot to make certain that the tests are properly interpreted and that a modification is incorporated in the plane to be used. It is the duty of the pilot to make certain that the plane is to be used. It is the duty of the pilot to make certain that the modifications are actually made before such plane is used in production.

A test report for an aircraft's plant of at N-5°, Preferred plane, it is essential that the equipment, once installed and operating to extremes of flight altitude and speed be capable of test and control which guarantee the accuracy of the equipment. It is essential that the equipment should be tested under all conditions which may be encountered by the plane throughout its operation. All test reports on equipment are checked through the design bureau which makes.

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progress of such tests as are set up may be closely followed.

So active has the interest of the Fighter Desk been on all points concerning any item or situation of the Navy's fighter airplanes, that the story of the Fighter Desk becomes also the history and development of the fighter planes.

**FIGHTER DEVELOPMENT PRIOR TO 7 DECEMBER 1941**

The early development of the Navy's fighter planes suffered greatly from the inadequate funds that were allocated for experimental purposes during the decade just preceding the present war. The value to the Fleet of fighter aircraft was frequently questioned, and with a general lack of enthusiasm and interest to push the fighter program, it was permitted to remain in a virtually stagnant condition and with little advance made in new designs. Although the Navy had in 1932 three carriers, the Lexington, Saratoga and Langley, there was much uncertainty as to just how practical it would ever be for planes to operate satisfactorily from carriers. With only a program for fleet maneuvers and training in mind, the Navy's fighter plane purchases were not impressive. In July 1931, the Navy had only 216 planes on order, 958 useful planes on hand, 83 fighters delivered and 35 new fighters purchased. However, even under the handicap of limited funds, the flight test section at Anacostia, D.C., carried out extensive performance trials of 42 different types of planes built under contract for the Navy, nine of which were fighter planes. The following year, 1932, the Navy fighter purchases amounted to 45 F4B-4 under Contract 21737, dated August 5, 1931, and six F9C-2, purchased under Contract 24021 dated 12 October 1931. It was into this picture that Lt, Cdr. Allen stepped when he assumed the duties of the newly established Class Desk A in 1932.
Active interest in naval aviation had been started only five years before with the passage of the Navy Five Year Aviation Program Act of 1926, under which money was appropriated for the procurement of some 1600 airplanes during the ensuing five year period, so as to enable the Navy to maintain 1000 serviceable aircraft. By the passage of this act, the Navy was authorized to solicit new designs by means of design competitions and to procure experimental equipment. In accordance with the provisions of this Act of 1926, the Fighter Desk, in cooperation with the other Branches of the Material Division (later the Engineering Division), made arrangements for design competitions for fighter aircraft. Requests for new designs were made yearly. From such competitions the Navy obtained a number of good designs for which contracts were let.

During the early part of the 1930's there was an effort made to determine the exact part the fighter planes were to play in the Fleet. It was felt that by thus determining their role, a better understanding could be reached as to the requirements necessary for a really useful fighter plane for the Navy. In setting up the requirements to be met by the various contractors in submitting prospective designs for fighter planes, there were various problems to be considered, such as, whether or not the planes were to be employed for offensive or defensive purposes, whether or not they were to be used solely against enemy aircraft or also against enemy surface craft and ground installations, and whether or not the fighters should be purely fighters or should also carry bombs. With the addition of carriers to the ships of the fleet, there arose the major problem of adapting the planes for use aboard carriers. Thus the matter of size and weight became prime considerations. The planes had to be sufficiently small in size in order for the carrier to be able to carry a maximum number, and light in weight so they could take off in a space of limited length. Although adapted for carrier use with all the encumbrances brought on thereby, the planes were expected to
maintain their customary high performance and maneuverability. In addition there had to be increased engine power to take off in a small amount of space, and to ensure high performance, and this in turn signified a larger and heavier power plant. For carrier landings, the landing speed had to be low, the plane also had to be stronger, and at the same time there must be no appreciable change in weight. Thus there had to be incorporated into the fighter airplanes factors which were constantly operating at cross purposes to one another.

In 1934, Lt. Cdr. Allen found it necessary to investigate ways and means to reduce the weight, for even then the trend of a constantly increasing gross weight was becoming apparent, and the fighters were becoming more and more overloaded. Lt. Cdr. Ostrander at that time made the following note: "Planes are getting heavier due to increases in useful load, not in bare weight of the plane, except enough to carry increasing useful load." There were numerous suggestions for jettisoning the flotation gear, radio, life saving equipment, and many other items which today are considered essential equipment for a combat plane.

As new equipment is developed, the range and performance are increased, and the engine size becomes larger, the problem of weight is one that is always present. It is interesting to note, however, that the average gross weight in 1934 was around 4000 pounds, and in 1944 about 12000 pounds. For a given military load, the larger airplane with a greater percentage of gross weight devoted to power plant has the higher performance. This basic fact, combined with the trend for the military load to increase, has resulted in a growth in size of airplane necessary to achieve the desired increase in performance.

The tendency of airplane design to anticipate a suitable and equally as progressive engine type was a matter that required then, as today, close coordination between engine
and plane design, and this coordination was one of the Fighter Desk's most important jobs. Examination of the development of several series of fighters will show succeeding engine changes within the same airframe.

Until 1933 when the XFT-1 and XF7B-1 projects were initiated, and 1936 when the XF2A-1 was first produced, the biplane had been considered the only suitable design for fighter aircraft because of its generally greater maneuverability. As of October 1935, no low wing monoplane had been approved by BuAer. The bi-plane was still considered to be the most practical for Navy needs. The Navy was possibly given a suggestion on this point, however, when Northrup refused to enter the VF Design competition in 1935, and said in its letter of refusal that "since Northrup is interested only in a low wing monoplane type, the company would not participate." Although there was some interest in this matter, the XFT-2, a low wing monoplane design, was not yet approved as an accepted service type.

During the time when Lt. Cdr. Ostrander was head of Class Desk A, the Navy was still undecided as to just what type of fighter aircraft would best suit the needs of the Navy. During the year 1935, the matter of procuring single or two seater fighters for the fleet became a main point of discussion. The two seater FF-1 had been in use only a short time but it appeared to be less satisfactory than the single seat F2F's and F3F's. VF Squadron 5B at that time was the only squadron employing two seater fighters. (Ref: Conf. ltr CO VF 5B, A4-3/VF/VF5B/CV(35-35), dated 22 May 1935.)

Lt. Cdr. Walter S. Diehl, later head of the Aerodynamics and Hydrodynamics Branch of the Engineering Division, made the following comment in connection with the unclassified (changed to classified) by authority of

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with this controversy over the relative advantages and disadvantages of the single or two seater fighter. "Starting with the same power plant and the same wing loading, a single-seater should obviously be faster than a two-seater, but the margin is not great. This margin may perhaps be increased by using a special power plant or it may be reduced by the operation of certain single-seater requirements such as angles of vision, provision for bombs, etc. From a design standpoint, the two-seater is definitely easier to balance and streamline. The present fighters are handicapped by a neglect due partially to this fact." This comment was dated 23 June 1936.

In discussing the value of fighting airplanes to the Fleet, it was felt that, in order of their importance, the requirements for VF aircraft should be:

(1) speed  (2) climb  (3) maneuverability  (4) ceiling  (5) fire superiority, and that in order to attain this, the single seat fighter could best be adapted. It was believed that the ceiling requirement was of minor importance because fighters probably would not go to such altitude as, for example, 20,000 feet, to break up an attack. It was further pointed out that in order to go over a 20,000 foot service ceiling, there would have to be a light wing loading, but that this condition would undoubtedly make it questionable that such an airplane could stand a sustained high speed dive combined with the extreme difficulty of obtaining hits after such a dive. "The day of the aerial duel purely as such between fighting aircraft has long since been over. Our fighter aircraft will not go into action on a large scale except in support of our own aircraft thrust at enemy surface targets or in thwarting such thrusts by the enemy." (Ref.: Conf. letter ComAircraft, Battle Force, A4-3/11-Mn/FF2-3 (8366), dated 4 April 1936.)
The above referenced letter, signed by Rear Admiral H. V. Butler, concluded that speed was the most essential characteristic of the single seat fighter and that the single seat fighter, not a two seater, was a necessary part of a carrier complement. He further concluded as follows: "Provision for carrying bombs involves a secondary mission of the single seat fighter and is acceptable from the standpoint of necessary added weight but must not reduce speed. Since it is possible to provide for the installation of bombs for special operations without reducing top speed, the inclusion of such provision in the basic design is recommended." He felt that fighters should not be placed on carriers unless they can be built with certain speed superiority and satisfactory armament, and that if these attributes can be assured, fighters should continue to form an important part of carrier complements.

During this period when Lt. Cdr. Pride headed Class Desk A, the matter of firepower of the fighters was considered of great importance. However, even at this period, the firepower of the Navy's fighter aircraft continued to be unsatisfactory and inferior to that of foreign fighter planes. The fighters in service in the middle 1930's lacked both speed superiority and the necessary offensive armament. The F4B-4 and FF-1 were too slow and possessed inadequate armament. To date the .50 caliber long range firing guns had not been satisfactorily developed. The F2F-1 and F3F-1 did possess some margin of speed superiority over many other types, but not enough. The F3F, the Fleet's latest fighter type, was armed with one .50 caliber gun but it had not yet proved totally adequate.

Regarding fighter armament, Lt. Cdr. M. F. Schoeffel summed up the situation as follows:

"At present we are in a position similar to that of the year 1898. Our present guns can shoot much farther than they can hit.....BuOrd has initiated studies in an
effort to develop a sighting or firing control apparatus which will permit hitting at longer ranges. There exists in Europe a considerable number of designs of 20mm (.80 cal.) aircraft guns. The BuOrd conducted one firing test of the Oerlikon gun against a metal aircraft structure. The holes made by the explosive projectiles were not impressive. For several months the Army has been conducting firing tests on stressed metal structures, using guns from .30 cal. to 3". There is no indication that foreign nations have any better gunsights than we do."

There was also much consideration being given to the problem of the fighters carrying bombs. Many felt that bombs would seriously compromise the possibilities of attaining maximum speed superiority which was necessary if the fighter was to be used essentially to attack other aircraft.

Rear Admiral H. V. Butler was convinced that fighter aircraft should not be built unless, (1) satisfactory speed superiority could be assured (a 10% edge over all enemy planes, except fighter-bombers, and 5% superiority without bombs), (2) satisfactory offensive armament is installed (this was defined as greater effective range, more accurate fire and a greater volume of fire.)

The results of months of discussion was that the fighter aircraft was to be used as a purely offensive weapon and should be designed as such, and that they should not be placed on carriers unless they had both speed and fire superiority. A fighter plane was defined as "An aircraft capable of forcing an engagement with other aircraft, armed with efficient offensive weapons to destroy other aircraft, and designed for the purpose of attacking other aircraft." (Ref: Comairbatfor, ltr. A4-3/11-Mn/FF2-3 (8366) dated 4 April 1936).
It was concluded that with speed and fire superiority, the single seater fighter and not the two seater VF aircraft was a necessary part of a carrier's complement. Using the above definition of a fighter, the Navy had not had for years a fighter plane which conformed to the basic requirements of fighters. Even the latest fighter types in mid 1936, the F2F and F3F, lacked a sufficient margin of speed. The F2F had a maximum speed of 231 mph, armed with two .30 cal. guns but no bombs. The F3F had one .50 cal. gun and one .30 cal. gun and could carry two 100 pound bombs. Even without bombs, the F3F was 6 mph slower than the F2F, and 12 mph slower with the bomb load. In comparing the speed of the Navy's latest fighter, the F3F, with other classes of planes in the Navy, the percentage of speed superiority of the fighter was none too great, being only 8% or 9%.

Attached to this report is a copy of the first endorsement to the above referenced letter which gives an excellent picture of the confused situation in 1936 when Lt. Cdr. Pride was attempting, along with other interested parties, to coordinate the factors involved so that a satisfactory fighter could be procured for the fleet.

Adm. J. M. Reeves, then Commander-in-Chief of the Fleet concluded as follows:

"If after actual demonstration these speed differentials in favor of the fighter can reasonably be depended upon, without sacrificing cruising radius and endurance, then the Commander-in-Chief unreservedly and emphatically recommends that additional single seat fighters be procured for the fleet....The Fleet must have airplanes that can fight other airplanes....The Commander-in-Chief is convinced that the sounder policy is to build single seat 500 pound bombers instead of fighters," thus using carrier space to a powerful offensive two-purpose plane, the dive bomber. "The net result will be that the Fleet Commander will have many more planes to fight other planes than he would have if pure fighters were provided in the numbers to which they necessarily must be limited."
The Navy was still groping to make up its mind regarding the fighter aircraft which still was a new and untried weapon of war. The position of fighters was still on the decline and appeared to reach its lowest point in May 1936. Of all the types of Naval Aircraft, the most backward development was the fighter plane. Its position in relation to the Fleet's activities during an actual war still remained unclarified, and the types of fighters the Navy had available for service use did not measure up to expectations and caused many to question their value to the Fleet.

Although the fighter development was retarded due to curtailment of funds during the depression and to a lack of definite fighter policy, Lt. Cdr. Pride was able to see that 1936 was also a turning point, for it became necessary to pursue two courses of action either abandon the fighter entirely, or come to some definite decisions as to the design of fighter airplanes and their mission with the Fleet, and to begin the development of some really useful fighter types. In a memorandum attached to the original letter from ComAirBatFor of 4 April 1936, Capt. F. R. McCrany, then Asst. Chief of BuAer, said, "I am firmly convinced that the fighter, as we know it today, has no military value, and the only excuse for continuing to build them is to keep up with the Joneses, an acknowledgment that we follow and do not lead.

"My recommendation is that we stop, immediately, building fighters as squadrons and that we concentrate our efforts along this line in building experimental fighters as an effort to get something that will have some military value as an aerial offense."

As a result of this intense discussion on the Navy's fighters, the Navy in 1937 work began on its experimental plane program for 1938 with renewed vigor, and out of this program came the fighter types that were destined to play an important role at the beginning of the present war.
It was at that time, thought that the new engines of the higher horsepower than the R-1830 engines would not give any increase in speed over the XF4F. Therefore, it was believed necessary to go into a two-engine, single seat fighter development in order to get desirable performance with speed in excess of 300 mph. In connection with this plan for a twin engined fighter, Pratt and Whitney was approached for engines permitting high altitude performance. There were discussions over the two-stage supercharger and the turbo supercharger. By May of 1937, the turbo supercharger had made considerable progress and was available for experimental aircraft demonstration, Pratt and Whitney suggested that the principal benefit to be derived from the use of a turbo would be that the engine performance between sea level and critical altitude (20,000 ft. or higher) would be along the line of constant horsepower; accordingly, high speed and climb from sea level would be considerably greater than could be obtained when operating with conventional internal supercharging at constant manifold pressure resulting in a sea level power considerably lower than the normal power at altitude.

A few months before Lt. Comdr. Pride was transferred from Class Desk A, a second letter went out to the various manufacturers requesting competitive designs and proposals for a two engine, single seat fighter. This was first inaugurated by Conf. ltr. Aer-E-16-EP-0F dated 31 August 1935 and the second request for twin engine design proposals was made by Conf. ltr. Aer-Pr3-Cw/BA, VF, dated 18 March 1937. Fourteen designs were submitted by six manufacturers: Lockheed, Curtiss, Grumman, Seversky, Vought, Brewster. However, since no twin engine fighter of less than 310 mph at 10,000 ft. offered sufficient advantages over the single engine types, then under construction, no design warranted an award. Although the proposal made by Lockheed did exceed this figure, it had disadvantages in cut, size, poor maneuverability and indifferent lateral vision.
Consideration was given to the problem as to whether or not a twin engined fighter could be landed aboard a carrier. Up to 1937 no such type had ever been landed aboard either an American or British carrier. This brought with it lively interest in the tricycle landing gear and a desire to make test landings of a twin engined fighter. Lockheed had submitted, under the design competition opened by letter Aer-E-21-EQ, VF, dated 18 June 1937, a proposal to equip a plane with arresting gear, and non-retractable tricycle landing gear. Capt. S. M. Kraus, recommended that test landings of a twin engined fighter be made at an early date.

There were numerous conferences held to discuss and compare the relative merits of the single engined fighter, and the twin engined fighter. The Lockheed twin engined proposal caused the Navy to realize that something must be decided on this. Even in those days, discussion prevailed of whether future designs should be based on a liquid cooled or air cooled power plant. The memorandum quoted below was a result of orders from the Chief of BuAer to investigate the possibility of making something out of the Lockheed design. The following memorandum, dated 29 October 1937, and signed by Rear Admiral E. M. Pace, Jr., gives an excellent picture and thorough survey of the fighter possibilities with various power plant combinations as they stood as of that date. Comdr. F. M. Pennoyer, commented on 1 November of that year on this letter that..."if carefully studied in light of tactical considerations (the memorandum) should bring the Bureau to a very close unanimity of opinion and provide a very sound basis for our VF experimental program." He recommended an early conference and decision on the VF experimental program. This letter is quoted substantially as follows:

"For the last two and one-half months the drafting room has been studying the subject with a view to determining the best performance which can be expected by incorporating turbo-supercharging and accepting a higher stalling speed, including
the effect of these same factors on single-engined fighter design, in order to provide a background for decision as to the course which the Bureau should take in experimental VF procurement. Sufficient studies have now been made to require further discussion.

"During this period the practicability of two-stage mechanical supercharging to 20,000 feet has become evident, and also the probability of raising the output of the Allison engine to 1150 horsepower. On the other hand, it has become clear that the R-1535 engine must be considered as capable of only 750 horsepower instead of the 800 horsepower with which the Bureau's original two-engined Design 144 was powered, and much more information is at hand regarding actual turbo-supercharged installations.

"The drafting room has developed two basic designs each of twin-engined and single-engined fighters, and then from the most promising design of each type has worked out a more refined re-design. The effects of variations in power plant supercharging and arrangement were investigated. These designs were conventional in that no untried features were incorporated, but an effort was made to take advantage of every detail now available which could improve performance. At the same time, certain innovations were investigated, but nothing was found which, with reasonable assurance of success, would materially improve performance over what can apparently be obtained by continuing along the lines which have already given maximum performance both here and abroad.

"The usual items required in shipboard fighters were carried. Sufficient fuel was provided for a range of 1000 statute miles at economical speed, and the armament consisted of two 20 mm guns (alternate 50 caliber) plus two .30 caliber machine guns and 200 lbs. of 6 to 10 lb. AA bombs internally mounted. The range at economical speed is the same as in the latest type carrier aircraft. The armament is that recommended by the Joint Bureau of Ordnance and Bureau of Aeronautics Board, and is also in compliance with the Chief of Naval Operations' directive concerning anti-aircraft bombs. Stalling speeds were held at 70 miles per hour with power off for single-engined
designs and to the same figure with power for twin-engined designs.

"These studies indicate that radial engines come much closer to providing rather the speed which can be obtained with Allison engines, in twin-engined designs than in single-engined ones. When the same type of superchargers are used in twin-engined design for both radial and Allison engines, regardless of what that type may be, the reduction in speed at rated altitude for the R-1830 is about 10 miles less than can be obtained with the Allisons and the weight and size of the airplane is slightly less than with the Allison. For the heavier R-2180 engine, the speed reduction is only about 5 miles, but the gross weight of the airplane goes up over 1000 lbs. A considerable reduction in gross weight and size can be made by use of the R-1535 engines, but with a speed reduction of about 20 miles. The Allison is much more definitely superior in single-engined designs. On about the same gross weight, the best that can apparently be obtained with single radial engines of maximum size (R-2180) is at least 25 miles less than with the Allison. This reduction would be even greater with smaller radial engines.

"The highest speeds can of course be obtained with turbo-supercharging. This is primarily because rated power can be maintained to a higher altitude with turbo-superchargers than with any other supercharges now available. Although as high as 385 miles should be capable of attainment in twin-engined designs, not over 355 miles can be expected from a single-engined fighter. In its present stage of development, turbo-supercharging is, however, not recommended for experimental procurement which may lead to a production order. Not only can turbo-supercharged installations be definitely expected to give trouble with heat dissipation, operation, maintenance, and unforeseen weight increases, but it is extremely doubtful if a practicable installation can be made in the limited space available in airplanes of this size and class for Naval use.

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All over
"The reduction in top speed which can be expected by using mechanical two-stage supercharging at 20,000 feet is fortunately only about 9 or 10 miles for twin-engined designs and 13 or 14 miles for single-engined ones. The reduction due to a lower critical altitude is partially compensated for by reduced weight. The use of single-stage supercharging good for only about 10,000 feet would cause a further reduction of at least 30 miles for the twin-engined aircraft and 35 to 40 miles for the single-engined. The desirability of high altitude supercharging when high speed is desired is very evident.

"Inasmuch as VF aircraft cannot always choose the altitude at which they must operate, the speeds attainable at altitudes other than the critical altitude become of very great interest. For twin-engined designs, there is a spread of only about 25 miles between the speeds of all combinations at all altitudes from sea level up to critical. The 1830 and 2180 both show more speed at lower altitudes with both types of mechanical supercharging than does the turbo-supercharged Allison, and the 1535 is only from 6 to 12 miles below it. At altitudes above the critical the speed of designs with different power plants but same supercharging do not maintain the spread of the critical altitude, but tend to come closer together although not markedly so. In the single-engined designs, the Allison engine is markedly superior to the radial up to its rated altitude regardless of the type of supercharging which is utilized, and a two-stage mechanically supercharged Allison shows almost the same speed at the turbo-supercharged critical altitude as does the fastest turbo-supercharged radial, and shows an enormous increase on all engines supercharged to lower altitudes when operated in excess of their critica. Moreover, increased engine size in present radial single-engined fighters interferes so much with vision that the Allison engine appears to become almost necessary for future single-engined design."
"For a single-engined fighter, the present Allison engine mechanically supercharged to 20,000 feet appears outstanding. Rated at 1150 horsepower, which is not yet an accomplished fact but appears possible, it should be possible to obtain a speed up to about 338 miles an hour on a gross weight of less than 7000 lbs. Other speeds for such a design should be about 280 at sea level, 307 at 10,000 feet and 324 at 25,000.

"For twin-engined fighters, weight and size become critical. The 2180 engines involve designs with maximum weights, running from about 11,000 lbs. to nearly 12,200 lbs. depending on the type of supercharging which is used. All twin-engined combinations which were studied have higher speeds than any of the Allison single-engined designs at all altitude up to their criticales, but it is necessary to supercharge to 20,000 feet to maintain this differential at altitudes above 13,000 to 17,000 feet. It is apparently too much to expect to get speeds at 20,000 feet in excess of about 355 miles on a gross weight of less than 10,000 lbs. The increase in speed at all altitudes which can be obtained by letting the weight run up an additional 500 lbs. is, however, sufficient to be taken into consideration. The choice appears to lie between the following, all mechanically supercharged to 20,000 feet:

<table>
<thead>
<tr>
<th>Design</th>
<th>Weight</th>
<th>L.L.</th>
<th>10,000</th>
<th>20,000</th>
<th>25,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Allison</td>
<td>6864</td>
<td>280</td>
<td>307</td>
<td>238.7</td>
<td>324</td>
</tr>
<tr>
<td>Twin R-1535</td>
<td>8870</td>
<td>294</td>
<td>322</td>
<td>355</td>
<td>339</td>
</tr>
<tr>
<td>Twin R-1830</td>
<td>10,500</td>
<td>303</td>
<td>332</td>
<td>366</td>
<td>349</td>
</tr>
</tbody>
</table>

There is little difference in rate of climb or ceiling for any of these three designs, the former being over 2000 feet per minute at sea level and the latter around 34,000 feet. The R-1535 twin can be had on about the same span as the single Allison (about 40 feet), but its take-off distance in a 25-knot wind is about 10 percent more, whereas the R-1830 twin should have about the same take-off run as the R-1535 twin with only

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Declassified under NND 913043
about a 2-1/2 or 3 foot increase in span.

"The major premise of these studies is a practicable attempt to meet the threat of highly supercharged fast shore-based bombers. From this point of view, the twin radial of about 10,500 lbs. appears adequate, the twin radial of about 9,000 lbs. probably adequate, and the single Allison extremely doubtful. Speed at low altitudes appears to make the single Allison definitely deficient for all-around fighting.

"An argument for obtaining the Allison single-engined airplane as well as a twin radial is that it would provide a standby in case the twin radial proved undesirable. It is believed, however, that the adoption of a liquid cooled engine in the Naval Service with all its complications of supply and cooling added to the high altitude problem makes this design more of an experiment than a twin radial, with almost a certainty of not obtaining the desired performance. A more important consideration is the fact that the cooling system added to the supercharging system and pilot's and gun arrangements make such a tight installation in the small space available in a single-engined shipboard design, that it actually constitutes a more serious design problem than does a twin-engined design. The need for a powerful in-line air-cooled engine is clear. In this connection, the Bell scheme of locating an Allison engine in the fuselage below and behind the pilot has been studied, and cannot be expected to give any material increase in performance over the conventional location when the latter is refined as much as appears possible, as the entrance lines can be determined in both cases by the dimensions of the spinner.

"It is felt that the specifications for experimental procurement should call for one airplane only, and that to be around twin radial engines of about 9,000 lbs. This amounts to re-advertising the original twin-engined design
competition, adjusting it to a higher stalling speed and 20,000 ft. mechanical supercharging in order to obtain the desired performance, limiting the weight to keep the airplane within a reasonable advance in operating technique, and eliminating the Allison engine because its slightly superior performance does not appear to be worth the material increase in weight and complication. If a high performance single-engined design is also desired, it appears that the disadvantages of the Allison engine must be accepted in return for the performance and vision which only it can give in this case. It should be realized that there is less chance of design success with this airplane than with the twin radial, although the latter brings in a bolder step in tactics and operation.

"The question of the effect of making any of these designs two-seaters may arise. This cannot be answered accurately without further studies. The inherent speed differential between VF and VSB designs appears to be of the order of at least 15 miles an hour. Since the speed attainable with single-engined single-seat fighters is believed to be deficient, the provision of an extra man would appear to take this type out of the primary VF class. The weight and size of twin-engined fighters is so high that it seems undesirable to handicap the Bureau's first attempt in this class by further increasing them. It is felt that twin-engined carrier aircraft must eventually be seriously considered. In spite of its complications, the single-seat fighter provides what is probably the easiest approach, but only because its size and weight can be kept below that of other types.

"The studies on which this memorandum is based are necessarily incomplete, involving many assumptions and approximations, and the results can be regarded only as indications. They bring out very definitely the extremely limited capacity of the Bureau's drafting room. Only one design study can be undertaken at one time. There are many subjects other than VF aircraft which should be studied, but the needs of
the Service are so varied that many subjects must remain untouched. The addition of one competent and experienced airplane design draftsman would nearly double the Bureau's capacity to undertake such work, and would greatly increase the opportunity to study the effect and practicability of innovations. In addition to the need for high-powered in-line air-cooled engines, the studies also being out the need for reliable trouble-free high altitude supercharging of maximum efficiency, and the need for the highest possible power in radial engines with reduced frontal area and weight for shipboard aircraft.

It was recommended that a modified Lockheed "12" be procured for tests to determine the acceptability of the landing characteristics of twin-engined monoplanes aboard carriers. Rear Admiral Pace commented as follows: "In the course of these tests it is probable that many other features of this type of airplane, such as handling, stowing, etc., will develop service opinion along the general question of satisfactoriness of twin-engined monoplanes as carrier airplanes.

"Until the result of the above have been obtained, it is recommended that the question of going to the trade for further designs be deferred. Aircraft manufacturers claim that the preparation of designs for competition involve considerable expenditures for engineering, sometimes running to as much as $10,000. It seems undesirable to ask the industry to go to this expense, in the face of the very recent unproductive competition, until we can be reasonably confident that the competition will bring forth designs of sufficient merit and attractiveness to us to warrant making awards for actual construction".

Office Desk A, along with the rest of the Navy realized that it could not get what they needed with the 65 mph without power stall limitation for two engined carrier planes. Because of the propeller spooling effect without power,
the inherent two-engined advantage was lost. The whole problem now came to a point that a decision had to be made as to whether or not to abandon a twin-engined plane entirely, or to do some preliminary experimental work with a then existing Lockheed plane with tail hook attached, or to take a chance at what might be a reasonable landing technique and start new design competitions around a Bureau Design No. 144, with a turbo supercharger and a 65 mph stall with power. The Material Division was in favor of proceeding with a two-engined design, using the 1535 engine and the Plans Division also recommended proceeding with a single Allison engined plane with a two stage supercharger.

Capt. A. C. Read made further comments by saying, "I dislike the idea of returning to the liquid cooled system. We got rid of it once, together with its never-ending series of troubles. There are developments on the horizon in the air-cooled field which gives promise of equaling the Allison performance."

It was generally felt, that while the liquid cooled engine was far from desirable, that if a high speed single engined fighter could be obtained only by use of such a type of engine, that this step should be undertaken soon so that the possibilities of the single engine fighter development could be thoroughly explored. At the same time it was also realized that this development might have reached a point where further gains in performance would not be obtained until engines of higher horsepower and smaller frontal area were available.

In a memorandum dated November 16, 1937, Plans Division recommended the following:

(1) procurement and testing as soon as possible an Allison engine mechanically supercharged.

(2) Initiate a design competition for a single engine VF based on the use of this engine.
(3) Test the Lockheed carrier test project with high priority.

(4) Initiate a design competition for a two-engine VF of a weight less than 9000 pounds, using R-1535 engines mechanically supercharged.

Armament provisions were as follows: two cannons of at least 20 mm caliber with alternate provision for two .50 caliber machine guns; and two .30 caliber machine guns; provision for two hundred pounds of AA bombs. Further provisions were for a stalling speed of 70 mph with power and full load, highest possible speed, take off distance 200 feet with 25 knot wind, folding wings.

Impetus was further given to the procurement of a twin-engined fighter by a confidential memorandum emanating from the Plans Division, Aer-PL-3-ESN, VF, dated 16 November 1937, in which it was recommended that a thorough test of the practicability of operating twin-engined airplanes on carriers be pushed with highest priority.

On 27 December 1937 a conference was held in the Engineering Division to discuss certain details of the procurement of 27 or 54 monoplane fighters. Class Desk A was represented at this conference by Lt. Comdr. Farnsworth.

At this time the Bureau was considering procuring some 27 or 54 fighters, Model F4F-2 or F2A-1, based on their prototypes. These fighters, however, did not comply with the requirements of having a fuel capacity sufficient for 1000 miles at economical speed with 50% overload tankage, nor with the armament requirements for two 20 mm cannon in the wings with alternate provision for two .50 caliber machine guns, and two .30 caliber machine guns in fuselage. Nor did the XF4F-2 and XF2A-1 have provision for 200 pounds of anti-aircraft bombs, wing folding with
cockpit control, dive brake flaps or propeller brake. Any increase in or addition of, the above items merely meant a decrease in the planes' performance. The conference concluded that there should be special static test structures to be built concurrently with the first production airplane and delivered to the NAF, the results of such tests could be known in time to incorporate them in the production airplanes. Procurement of two experimental single seat planes would be delayed awaiting results of tests.

Lt. Comdr. Farnsworth, on January 24, 1938, wrote a confidential memo- randum to the Head of the Procurement Division requesting that letters be sent out requesting designs and proposals from various airplane manufactures because the Bureau was interested in procuring two experimental airplanes of the single seat fighter class, one having a single engine, and the other two engines. Type specification for the single engine type was to be Type Specification SD-112-13, and the General Specification SD-24-D. The two engine airplane, was to conform with Type Specification SD-112-14 and General Specification SD-24-D. The proposals were to reach the Bureau not later than 11 April 1938, and the letter requesting bids was sent out 1 February 1938, by confidential letter Aer-PR-BA, VF.

On account of this active interest, on 1 February 1938, another request was made for designs and informal proposals for (1) a single engine fighter designed around the Allison mechanically supercharged engine, and (2) a twin engine fighter weighing less than 9000 pounds. The letter of 1 February 1938 set up the competition and bids were opened on 11 April 1938. At this time five airplane companies submitted ten designs, and in addition, both Grumman and Curtiss submitted two designs and an alternate in the twin engine field. The following companies participated: Vought, Brewster, Grumman, Bell, and Curtiss.

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One of Vought's proposals, called the Vought B proposal, introduced the gull wing and laid the foundation for the development of the present Corsair fighter. This Vought design was considered an experimental project that would need exhaustive wind tunnel and engine tests because of its unconventional design and also because of the then existing status of the 2800 engine. However, in view of the fact that the Vought design could, if the necessity arose, incorporate the R-2600 engine as an alternate, the plane appeared to show considerable promise. Thus, out of this competition came the XF4U-1, the Vought "B" proposal. As outlined in the proposal, the weight would be 6584 pounds. It is interesting to note that the F4U-1 of 1944 has a gross weight of 12,700 pounds, yet in spite of the doubling of the weight, there has been an increase of 80 mph speed over the 356 mph originally calculated. The Pratt and Whitney R-2800 two stage engine was finally incorporated in the plane to give it its added performance.

The other design favorably acted on by Glass Desk A in conjunction with the other offices of the Bureau of Aeronautics was the proposal submitted by Grumman for a twin engine fighter which became the XF5F-1 (Specification SD-112-14). This twin engined monoplane was powered by two Pratt and Whitney R-1535-96 engines capable of developing a total of 1500 horsepower at 9500 ft. With the addition of two-stage equipment it was expected that the engines would develop this horsepower at 17500 ft.

In this design competition, there was a third design award to Bell. The contractor's proposal was similar to an Army project nearing completion. It was felt, however, that with the expected advance in the rating of the Allison engine, that this plane would give the Navy a more modern airplane with outstanding

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See over
performance. With the expected rating of 1150 horsepower at 15,000 feet, it was felt that an attractive design could be developed around the liquid cooled engine. A contract was therefore let for the XFL-1 airplane. As 1938 drew to a close it was very strongly felt that the Navy needed this Bell fighter in order to round out its fighter program and have one light weight fighter. This, however, depended on the outcome of the Allison engine rating (V-1710), for if 1150 horsepower could be attained then a VMax of 347 mph at 12,000 feet could be reached.

The weight of the fighters showed a marked increase in this competition. Existing Navy fighters weighed around 4,000 pounds, for example the F3F-1 weighed 4100 pounds, the F3F-2, 4400 pounds, the XF2A-1, 4800 pounds, and the XF4F-2, 5100 pounds. The new designs jumped to weights around 9000 pounds.

During the two years when Lt. Comdr. Farnsworth was in charge of the Fighter Desk, the situation of the Navy's fighting airplanes took a turn for the better, and those two years marked the beginning of the trend toward a modern type of fighter both in plane and engine design, and laid the foundations for the development of today's high performance fighters.

Shortly before he left Class Desk A, Lt. Comdr. Farnsworth received a letter from Chance Vought, dated 28 March 1939, offering to submit data on a new type of fighter that had been designed and developed by Mr. C. H. Zimmerman. Mr. Zimmerman who was a project engineer for Vought–Sikorsky Aircraft, had developed an unusual type of plane based on the "flying wing". Although it was a very radical design, it was presented to the Navy at a time when the Navy was extremely anxious to investigate almost any type of new experimental design that would give it a fighter plane of unusual and
high performance. So unusual was its predicted performance (an estimated
VMax of 500 mph and a landing speed of zero mph), that by September of 1939
a model of Vought "V-173", which was to become the XP5U-1, was ready for tunnel
tests conducted by NACA. The Navy awaited the recommendations of the NACA before
deciding on developing the V-173 any further. The flying wing received
favorable comment. In their letter of 29 June 1939, the Committee said, "It
is the committee's opinion that the proposed design seems to have valuable
estimated characteristics which, if borne out full scale, should make it of
considerable importance for military purposes. The design, however, is
too experimental in nature to make any very definite statements regarding its
hoped-for performance and characteristics." So unconventional was the design
and so questionable were its possibilities, that there ensued a tremendous
controversy and a great deal of unfavorable comment. It was planned that the
final version should have two R-1830 engines. It was built under detail speci-
ification SD-271, of September 26, 1939.

This Zimmerman design was known by several designations. The wind
tunnel and early flying model was known as the V-173, a development of which
became the VS-315, the military version, and this later was designated the
XP5U-1.

The Vought-Zimmerman project was a design of very low aspect ratio
of 1.0 and a promise of a VMax of 465 to 500 mph, and a low speed approaching
hovering flight. This "flying wing", or, as it later became known, the "flying
flap-jack", had its start some years previously in the early development of the
original V-171 design.

Classification (censored) (changed to
classified)

NavAir 25-45

on 6/29/55 488
(Date) (Signature) (Rank)
Bureau of Aeronautics

Declassified under NND 913043
The following excerpts are quoted from Report No. 4124, dated 18 November 1938, giving the early history and general characteristics of this unconventional type of aircraft which was later developed into the XP5U-1.

"In the spring of 1931 a group of engineers at the research laboratory, operated at Langley Field by the National Advisory Committee for Aeronautics, undertook to design a private owner's aircraft. The undertaking was inspired by Fred E. Weick, now Chief Engineer of the Engineering Research Corporation. In the group was a young engineer, Charles H. Zimmerman, who had certain fairly definite ideas as to the requirements which would have to be met by an aircraft before it would be widely accepted as a private means of transportation. He was assigned the task of drawing up a set of specifications for the group to work toward. He did so, paying slight attention to known limitations of existing craft and keeping in mind characteristics which seemed to him to be actually required."

"The complete set of specifications was lengthy and included many items of secondary importance as well as four main points which were substantially as follows:

"1. The craft must be fast enough to show a genuine time saving over other means of transportation.

"2. It must be capable of operating from small plots of ground or from roof tops.

"3. It must be relatively independent of weather conditions. In order to meet this requirement it must be able to descend slowly through clouds and fog along a practically vertical path, to stop in the air, and to rise again substantially vertically should an obstacle be sighted.

"4. It must be safe with no inherent tendency to become uncontrollable as a result of an error in technique or judgment on the part of the pilot.

"The requirements as originally written threatened to stymie the project as none of the group could conceive of such a craft. The limitations were accordingly
revised and softened so that known types of aircraft could be considered."

"To make a long story short the activities of the group culminated in the construction of the Weick W-1, an aircraft embodying several features desirable in a private owner's airplane and one which did much to bring forth the practical advantages of the tricycle landing gear.

"Zimmerman was not satisfied with the decision to build a craft having the limitations inherent in the conventional airplane and withdrew from the group to continue studies of other possibilities. One of the interesting things which had been unearthed during preliminary studies by the group was the rather remarkable tendency for square flat plates to remain unstalled to relatively high angles of attack. This had led to a research into the aerodynamic characteristics of wings with a series of ratios of span to mean chord ranging from six down to one-half. This study (reported in NACA Technical Report No. 431) revealed that airfoils having a ratio of span to mean chord of 1.27 attained very high angles of attack before stalling and had very good characteristics from the standpoint of attaining steep gliding angles and slow speeds. In contrast to a conventional Clark Y wing which stalled at about 15 degrees with a lift coefficient of about 1.4 a Clark Y wing with a ratio of span to mean chord of 1.27 stalled at 45 degrees with a lift coefficient of 1.8.

"A craft utilizing such an airfoil could be made with very little parasite drag because the power plant could be housed within the airfoil, the cabin would be largely within the airfoil, and it appeared that the conventional tail surfaces could be replaced by trailing edge flaps and vertical fin and rudder surfaces on the aft portion of the airfoil. Structural problems would be simplified by the relatively great depth and short span."
"Study was accordingly started of a design of this type intended to have a good top speed and the ability to land in small fields. As the study progressed it developed that the craft could easily land in fields from which it could not take off. In an effort to improve the take-off the design was altered by the addition of a second motor. Further study led to the interesting conclusion that if the propellers were increased in diameter they could be made to exert a static thrust exceeding the weight of the aircraft. Furthermore, practically all of the airfoil body and the stabilizing and control surfaces would be in the propeller blast so that the airstream upon which such surfaces depend for their functions would never be absent. Thus the craft designed to fly supported by an airfoil surface appeared to be also capable of flight as a helicopter supported by lifting airfoils. The interest in a craft which could meet the original requirements of speed, independence of airports, independence of weather, and safety was immediately revived in full force.

"The next question was whether the craft could pass from the condition of flight as a helicopter to that of flight as a fixed wing aircraft without at some intermediate condition encountering instability, stalling, or lack of control. A method of analysis of the airflow about the craft was worked out on the basis of fundamental considerations of force and energy. This method, although necessarily imperfect, provided a tool by which the probable behavior of the craft in the intermediate condition could be roughly predicted. It became evident from such studies that because of the effect of the slipstream the angle of the airflow about the airfoil would never be great enough to cause stalling even if the craft were moving forward fairly rapidly while at a large angle to the direction of motion. The ability of the low aspect ratio airfoil to remain installed up to relatively large angles was found to be an essential feature of the design. This characteristic could not be achieved with an airfoil of conventional planform. The craft as proposed, however,
appeared to be capable of controlled flight at all speeds from zero to the maximum attainable with the craft flying in the manner of a conventional airplane.

"At this point an interesting and valuable by-product of the general design became apparent. The size of the propeller made it necessary that their axes be near the wing tips. Considerations of balance of torque and gyroscopic couples made necessary the rotation of the propellers in opposite directions. An additional stipulation that the propellers rotate so that the outer blades move downward would result in partial cancellation of the wing tip vortices by the twist of the slipstreams. This meant that the chief disadvantage of the low aspect ratio airfoil, i.e., large tip losses at slow speeds, would be partially overcome and some of the advantage of a conventional airfoil realised merely by utilising features included in the design for other reasons.

"Having more or less accidentally hit upon a design which seemed inherently capable of speeds higher than those possible with conventional aircraft with equivalent power and useful load and with the additional features of independence of airports, independence of weather, and safety the next problem was to determine how to overcome certain defects which were quite obvious. First was the question of how to place the pilot and passengers. If seated normally in the high speed condition they would be resting on their backs with their feet above them when hovering. The pilot would be very poorly placed to see where he was going at slow speeds and in helicopter descents. The use of a rotatable dabin or of rotatable seats was seriously considered. This was ruled out as impracticable because of complications and weight. Finally it was decided to place pilot and passengers in a prone position when in the cruising flight attitude.

- 37 -
This results in their being in a standing position when at very slow speeds and hovering. Such an arrangement gives a nearly ideal range of vision at all times. It can be made very comfortable. It will give relative freedom from airsickness. There are small but real gains in aerodynamic efficiency, structural simplicity, weight saving, and economy of construction over any other arrangement. Against these advantages were balanced the equally real disadvantages of unconventionality and the necessity of a great deal of development work to evolve a couch and system of controls which will insure comfort and efficiency of the pilot. It was felt that the first of these objections will vanish rapidly as people actually experience the comfort and convenience of the prone position; that the second is a serious but by no means unsolvable engineering problem.

"The second very grave practical difficulty was that of the behavior of the craft in the event of engine failure. Obviously if one propeller stopped suddenly when the craft was hovering or going forward slowly a very violent maneuver would immediately start and the craft would be out of control until the other motor could also be stopped and the craft had picked up sufficient speed to resume controlled flight in the manner of a conventional airplane. The craft would thus be dependent upon uninterrupted operation of both motors for safety at slow speeds, a thoroughly undesirable condition. Study of the problem indicated the feasibility of connecting the propellers together by gearing and shafting so that they would always rotate at equal speeds. This would eliminate the possibility of a violent maneuver due to unbalanced thrust of the propellers but would still leave the craft unduly subject to engine failure since the good engine would be forced to drag the one which had failed. It was then decided that overrunning clutches must be incorporated between the engines and the
propeller drive system so that failure of either engine would leave the full power of the other engine available to drive the propellers. The craft would then be assured of two-engine reliability and the possibility of sudden and complete failure of the power plant made so remote as to warrant dismissing it as a serious practical threat to the safety and utility of the craft.

"Means of overcoming the foregoing major problems being apparent the next step was to determine whether a craft of this type would actually behave as promised by the paper studies. There were several possibilities. A model could be placed in a wind tunnel and studies made of the aerodynamic characteristics. A free-flying model could be built and flown. A full scale aircraft could be built and flown. The first of these was ruled out because it would still leave determination of the actual behavior to computations of doubtful reliability. The second was adopted because by use of a free-flying model it could be definitely established whether the craft would or would not behave as the studies indicated without the expense and danger to human life involved in construction and testing of a full scale craft.

"There followed a considerable and rather discouraging period during which were constructed four unsuccessful rubber powered models and two unsuccessful gasoline powered models, one large enough to carry a human pilot. Finally a fifth rubber powered model flew well enough to demonstrate that such a craft would behave substantially as the studies indicated. It was not, however, capable of demonstrating stability and controllability except in a very limited way.

"It now appeared that the time had come to make a serious effort to develop the craft. Zimmerman did not have the private resources to carry on such a
development. The NACA is a research organization and for very good practical reasons has always refrained from development work other than that intimately connected with research projects. It was therefore decided to take the project to an aircraft manufacturer. The United Aircraft Corporation had established a reputation for pioneering by its developments in radial engines, in controllable and automatic propellers, in large flying boats. Zimmerman's design met with a favorable reception by the engineers of United. He therefore resigned his position with the NACA to take over the development of his design under the auspices of the United Aircraft Corporation.

"Since the rubber powered model had not been capable of definitely demonstrating stability and controllability characteristics it was decided to build a more elaborate electrically powered model with a complete set of controls. This model would show definitely whether the craft was capable of controlled flight. At the same time it would avoid the expense and possible danger to human life of an experimental full scale craft. Furthermore it would permit studies which would greatly reduce the likelihood of the necessity of extensive alterations to the full scale craft after construction. This model has been built and flown. Although there is much to be learned it has been definitely proven that the craft is controllable in flight in the doubtful regions of hovering and slow speed. It now appears that the time has arrived to start construction of a full scale prototype, the model work being continued and extended as rapidly as possible to solve the many problems still remaining before they are encountered on the full scale job ....."
Since this new proposal of Chance Vought offered the Navy the prospect of obtaining a fighting airplane capable of speeds in excess of 500 mph, the Navy was most anxious to look into its possibilities and begin converting the original design into one for a military plane. Preliminary studies had to be made before the Bureau could even consider the possibility of letting a contract for a model of such radical design.

By confidential letter of 7 April 1939, the Chief of BuAer forwarded to NACA various reports for the purpose of making a study of the adaptability of such a "flying wing" for military purposes. According to NACA confidential letter dated 29 June 1939, it was the Committee's opinion, "that the proposed design seems to have valuable estimated characteristics which, if borne out full scale, should make it of considerable importance for military purposes. The design, however, is too experimental in nature to make any very definite statements regarding its hoped-for performance and characteristics."

It was believed, along with the rather favorable recommendations of NACA, that the Zimmerman type of design warranted sufficient interest for experimental purposes to proceed with model tests. So unconventional was the design and so questionable were its possibilities, that there ensued tremendous controversy and discussion over it.

A full scale flying model was made of this Vought-Sikorsky V-173 airplane, and by October 1939, the 32" span model was being tested in NACA's free flight wind tunnel.

The trend of the fighters in 1939 showed a continual increase in high speed, gross weight, dimensions, engine power and operating altitude. The emphasis had been on the maximum attainable speed at the highest possible altitude. For example, the increase in speed since the F2F-1 had been about 120 mph. This was made possible by
increased power and relatively decreased frontal area of engines and cleaner airframe design. The major gains in performance were due to more powerful engines, and this necessitated larger airplanes. Although the Navy was getting an increase in high speed, the fighting planes as a consequence had to make some sacrifice in maneuverability. This condition of the fighter planes in the fall of 1939 brought on an attempt to find a small light fighter, which would not only be capable of high speeds, but which would be sufficiently small, light and compact to be able to effect changes of altitude more rapidly than could a large, heavy plane. Such a light weight plane, having a light wing loading, would be able to turn on a shorter radius and have a lower stalling speed, than one with heavy wing loading. Thus, it was felt that the addition of such a plane would be a good complement in maneuverability to the Navy's fighter squadrons. Another factor in favor of procuring a small fighter for the Navy was the fact that a greater number of them could be placed on a carrier without having to incorporate any heavy wing folding mechanism.

There were several small fighter possibilities studied:
1. Conventional monoplane of small dimensions.
2. Biplane alternative:
   a. Conventional
   b. Tricycle landing gear and 75 mph landing speed.
   c. Pusher with new NACA laminar flow wing section.

In July of 1939 about the time when Lt. Comdr. Hatcher came into Class Desk A from Clask Desk E, the current developments in design of fighter Classification (corrected) (changed to unclassified) by authority of Doc 12935

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Department of the Navy

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aircraft were along monoplane lines in order to attain the maximum practicable performance, particularly in speed and rate of climb. The resulting monoplane fighter tended to be large in plane form and size, and was comparatively poor in maneuverability. Accordingly, by confidential letter of 31 July 1939, Aer-E-10-WG, VF, an opinion was requested of NACA as to the practicability of obtaining marked improvement in maneuverability without appreciable sacrifice of performance, by the use of a biplane wing arrangement. This swing back to biplane fighters can also be noticed in the request to use a portion of the funds to be appropriated for 1941 for a biplane fighter.

Preliminary tests in NACA's free flight tunnel were begun on 16 October 1939 and completed by December of that year. In reply to the Navy's query, NACA replied, in confidential letter of 14 December 1939, that further tests and development work would be required before a final design could be decided upon. However, it was agreed (see NACA Conf. letter dated 19 August 1939) that there were certain inherent advantages in the maneuverability of a multiplane as compared to a monoplane.

In this letter, the Committee further stated, that "an indication of the influence of reduced span on maneuverability has been obtained by considering flight data obtained in tests of a monoplane fighter (the P-29), and the fact that the maximum rate of roll of an airplane would be expected to vary inversely as the span....On the basis of past experience, it is believed that there is a much better chance of obtaining good flying qualities (i.e. stability and control), particularly at and near the stall, with a multiplane....Another consideration affecting the choice between a monoplane and a biplane is that low-drag laminar-flow
airfoils can be used in case of a monoplane. The use of these airfoils should make possible increased high-speed performance." The Committee believed it desirable that BuAer consider multiplane designs, particularly for very small, high-speed fighter types.

There was a concerted effort at the end of 1939 to develop a type of fighting plane that the Navy would require, depending on the type of mission with the Fleet: (1) whether or not the fighter would attack enemy fighters or bombers, (2) whether or not a fighter could be developed with excellent maneuverability yet sufficient speed to overtake and attack enemy bombing planes approaching our Fleet, (3) whether or not a fighter with great enough range could be designed to accompany our bombers as a protective escort.

Although monoplanes of other types had been in service in the Fleet for some time, the F2A-1 was the first monoplane fighter available for evaluation under service conditions. The Fleet was requested to make in January of 1940 a service evaluation of the F2A-1 with regard to its effectiveness against other aircraft, particularly other fighters.

The European war had begun in the fall of the year before, and for the first time the Navy hoped for a comparison between our own and foreign types of fighters in combat abroad.

Under the Naval Expansion Act of 1940 new fighter plane designs were solicited. In July 1940, the Engineering and Plans Divisions of BuAer got together regarding experimental fighter aircraft procurement. In a joint memorandum dated 27 July 1940, Aer-2-VM, VF, the following summary of the situation of VF experimental planes at the beginning of the European War was unclassified) by authority of
NavAer 2545

on 1/29/59
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made: "The entire range of design studies includes twin-engined aircraft, aircraft with two propellers driven from a single power plant, mid-wing, low wing, and biplane designs, engines behind and below the pilot as in the Bell type, counter-rotating propellers, propeller 6 gear shifts, and all liquid cooled and air cooled engines sufficiently advanced to be considered in connection with a fighter to be built in the near future, and in addition, variations of the F4F-3 have been studied."

In the spring of 1940 steps were initiated to procure 27 F4F-3's for fighting plane complements of the Yorktown and Enterprise, but it was not until November of 1940 that they were delivered.

Although twin engined fighters had current interest as a shore based type, studies had not been made for its application to carriers, nor could tricycle landing gear be considered for single engined planes. There was an attempt to put tricycle landing gear on the XFL-1, but it appeared best to use a P-39 fuselage, modify it, and redesign the remainder of the plane. As of July 1940 the Allison engines were still unavailable. Folding wings were now specified on all fighter orders.

Also under close observation at this period was the Vultee Army design, a fighter powered with a liquid cooled Pratt and Whitney X-1800 engine, having a twin-boom tail, equipped with a supercharged cabin, NACA laminar flow wings, and counter-rotating pusher propellers. The contractor had made a study of a Navy carrier version with a weight of 11,000 pounds and an estimated top speed of 470-500 mph at 20,000 feet.

The employment by the British of their fighter types against the enemy during the early months of the war, centered the attention of the Fighter Desk
on successful British fighter types. Accordingly, Curtiss Design No. 201-C was drawn up, based in general on characteristics of the British Spitfire, which was at that time the best solution to the development of fighters with increased performance and heavy weight. This Navy model, the XFL4C-1, designed by Curtiss in accordance with preliminary detail Specification SD-284, dated 30 December 1940, had a weight of about 10,000 pounds and a wing span about equal to that of the XF4U-1, but with a greatly improved take-off. Its liquid cooled engine was its least attractive feature. At a conference held 12 December 1940 on the proposed new fighter, design 201-C, it was decided that the study of a proposed modification of a set of P-40 wings to incorporate full span flaps and plug type ailerons was to be undertaken with high priority, in spite of the congested engineering schedules of Curtiss, with a view to possible incorporation in design 201-C at a later date.

The Grumman XF4F-4 was the Navy's most promising fighter and considered by many at that time to be the best all around fighter in the world. The contractor was to study a redesign of the F4F around a 2-stage R-2600 engine or around the two speed R-2600 engine, which was not subject to the uncertainty of the two stage version, and ensure its attaining a top speed of 350 mph.

Classification (canceled) (changed to unclassified) by authority of

NavAdm. 2545

on 6/29/55

(Date) (Signature) (Rank)

Bureau of Aeronautics
Department of the Navy
FIGHTER PLANE STATUS - 1940-1941

About mid-July 1940 when Lt. Cdr. J. B. Pearson, Jr., was brought in to take charge of the fighter desk, it had been decided between Engineering Division and Plans Division that the following should be the lines of action followed in regard to the new fighter development:

1. Design and construct a high performance, Lycoming powered (X-1800, liquid cooled), full strength, full range fighter in the 395-400 mph class. (i.e. XFL4C-1)

2. Redesign the F4F-4 to provide full strength with armor, tank protection, increased armament and reduced take-off.

3. Continue with the XF5U-1 development.

4. Take up the Vultee proposal if the Army development should prove favorable.

5. Withhold action on twin engined and redesigned heavy aircooled fighters for the present.

A program for testing the Navy's fighters, both those in production and in service, in combat condition was underway at Anacostia.

By 9 October 1940, the XF2A-2 (Contract 65802) had completed all tests with the combat overload contemplated for F2A-3 airplanes except those involving engine operation in high blower. Operation in this condition developed unstable power characteristics necessitating installation of another blower section by the Wright Corporation. This having been completed, the airplane was ready for completion of the overload tests. After completion of these tests at Anacostia, the airplane in November went to Langley Field for full scale wind tunnel clean-up tests. By the end of the year the F2A-1 airplanes were at the contractor's plant ready for modification to the F2A-2 type.
The overload flight tests for the XF4F-3 (Contract 63072) were completed and showed that the airplane would handle a gross load of approximately 7500 pounds satisfactorily except that the take off in the overload condition would be about 235 feet in a 25 knot wind.

At the close of 1940, Class Desk A's experimental projects stood as follows:

The XF5F-1 (Contract 61586), the Grumman twin motored fighter, was flying at the Grumman plant for correction of various minor deficiencies. Trouble had been experienced by the engine's developing high oil temperatures. Difficulty had also been experienced with the landing gear housing doors. Pending preliminary demonstration tests at Anacostia, the contractor was thinking of a development of the type with 1830 two stage engines, tricycle landing gear and more adequate armor protection, and an increased range.

Vought's XF4U-1 (Contract 61544) was flying with the production type R-2800-4 engine installed. A preliminary flight test had been made and the plane was at the contractor's plant awaiting a decision on possible production quantity.

Bell's XFL-1 was awaiting a rebuilt engine from the aircraft factory, and would probably not be flying again until after the first of the year.

The buried engine fighter, Northrup model XXX (Contract 74996) was awaiting a decision as to a design around the R-1830 or R-2800 engine.

The Zimmerman flying model had undergone tunnel tests and the results were not all that had been expected. Lack of stability and controllability had yet to be overcome.

Such models as were in service such as the F2F-1 and F2A-1 were proving troublesome in dives and restrictions were sent out as to diving.
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conditions and speed. Trials of the first production F2A-2 were being held at Anacostia. To date 13 airplanes had been delivered, and a delivery rate of 9 per week was set up.

Some 21 FLF-3 planes were delivered in December 1940, and the first two planes were undergoing tests at Anacostia and NAF, respectively. Beginning February 1941, forty planes of this model were to be produced a month. Engine cooling troubles had been experienced, and the contractor was studying a cowl flap arrangement to be used in conjunction with the propeller spinner in an effort to eliminate this trouble.

A set of folding wings for the XF4F-4 were being built and ready for flight test in the middle of December. The change of the F4F-3 from fixed to folding wings would be inaugurated on the 82nd plane, this change making it the F4F-4. This F4F-4 was thus the first production fighter with folded wing.

The following fighters were in service with the Fleet: F4B-3, F4B-4, FF-2, and F3F-1. In addition to these, the Navy had at the close of 1940 the following five new types of fighters in operation: F2A-2, F3F-1, F3F-2, and F4F-3. No new types were made operational until the following year when in March the F4F-3A was placed in service, and in August the F2A-3 joined operational units. Only about 500 of these seven models had been produced during the period from April 1936 to the entry of the United States into the war in 1941.

It was becoming obvious early in 1941 that in the event the United States should become actively engaged in the present war, the Navy's part would be centered in the Pacific where the island areas were many hundreds of miles apart, and as a consequence, the Navy would require long range operational fighters.

This subject was discussed in a confidential letter to BuAer from CNO, Op-12A-4-drc (SC) VF, Doc. 27447, Serial 018512, dated 1 March 1941. It pointed out that from available information "it appears practicable to incorporate in single..."
seat fighters now in production sufficient internal tankage to increase the maximum range at economical speed to 1400 miles, and maximum endurance to 10.7 hours.

The following is quoted from the second paragraph of the same letter: "It is the opinion of the Chief of Naval Operations that the production of sufficient standard type fighters to complete the necessary replacements of carrier aircraft should receive the highest priority. However, the advantages of giving some single seat fighters longer range, which will increase their effectiveness for off-shore operations in defense of shipping, and also will permit their transfer in flight over greater distances of open water, are considered to justify such complications as may be involved. The increased take off run and other effects of the greater weight of such airplanes will render them better fitted for operations from shore bases than for operations from carriers. It is requested, therefore, that an investigation be made to determine the most expeditious means for improving the endurance of fighting airplanes on order for Marine Squadrons, and that projects be instituted to accomplish this objective at the earliest practicable date." The letter further requested that an airplane be developed for longer endurance.

In response to this letter, Grumman was requested to increase the range of the F4F's, and it was hoped to get tanks to permit service installations in Marine F4F's without delay in production.

VP Design Branch requested, by confidential letter Aer-E-11-LMH, Serial C-68219, dated 13 January 1943, that Grumman make an estimate of the cost and time to modify two F4F-3 airplanes, utilizing planes with two-stage engines and non-folding wings, being constructed under Contract 75736, for special long range use. The intent of this alteration was to provide a total of 685 gallons of fuel, and related oil tankage, two cameras, automatic pilot, oxygen and radio equipment.
This request was followed by another letter from the Fighter Desk on 29 January, requesting that steps be taken for this conversion at high priority. The long range photographic version of the F4F-3 was an extremely important requirement of the fleet. This was known as the F4F-7. A third letter pointed out that "the contractor should make every effort to build an organization which can handle them (such special projects) promptly...because the contractor must anticipate an increasing number of extremely urgent special projects similar to the proposed long range F4F-3 airplanes." (Ref.: Conf. 1r., Ser. C-563, Aer-E-11-LH, C-68219, dated 10 February 1941.)

By confidential letter Aer-Pr-RA, VP of 21 December 1940, a request was made of the contractors to submit designs in accordance with specification SD-112-18. Eight companies submitted 15 designs which were opened for inspection 24 March 1941. Grumman entered a twin-engined design, suggesting it as a possible night fighter. This Grumman design #51 incorporated two 2600 engines, and appeared to be the outstanding design submitted. An award was given, for what was to become the F7F-1, three years later.

**FIGHTER PLANE STATUS - AROUND 7 DECEMBER 1941**

In May 1941, six months before December 7, the Bureau contracted for the Grumman F6F with R-2600 engines. VF Design was also concerned with such experimental developments as the XFL4C, with a Lycoming engine, and the step by step development of the Northrup buried engine pusher and Zimmerman "flying wing" or Zimmer-skinner, as it was sometimes called. The F4U was being further developed and provisions were being made for increases in range for both the F4F and F4U. The F4F-7 with long range for photographic reconnaissance was another special project. NAF, Philadelphia had under study a pressure cabin F2A which was intended, but never was, to be incorporated in the F4U. To date the Fighter

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Declassified under NND 913043
Desk had not been able to get any attractive development around the XFL-1 due to the low powered Allison engine.

In spite of the efforts of the fighter desk to get the Navy supplied with up-to-date fighter planes and in an adequate number, the Navy faced a shortage of this type of aircraft at the end of 1941. Only about 500 additional fighters had been produced for the Navy during the two years preceding the attack on Pearl Harbor in December 1941. The following table represents the fighters in operation on December 7, together with the dates they went into operational units:

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<tr>
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<tr>
<td>F3F-1</td>
<td>April</td>
<td>1936</td>
<td>39 planes</td>
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<tr>
<td>F3F-2</td>
<td>December</td>
<td>1937</td>
<td>54 planes</td>
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<td>F3F-3</td>
<td>February</td>
<td>1939</td>
<td>22 planes</td>
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<td>F2A-2</td>
<td>October</td>
<td>1940</td>
<td>49 planes</td>
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<td>F4F-3</td>
<td>December</td>
<td>1940</td>
<td>176 planes</td>
</tr>
<tr>
<td>F4F-3A</td>
<td>March</td>
<td>1941</td>
<td>61 planes</td>
</tr>
<tr>
<td>F2A-3</td>
<td>August</td>
<td>1941</td>
<td>107 planes</td>
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Due to this shortage of up-to-date combat fighters, the Fleet was confronted by a critical situation only a few months before the Japanese attacked Pearl Harbor on 7 December 1941. In a confidential letter, A4-1(1), 50-Re/FT2-3 (A-69), dated 22 October 1941 from Commander Aircraft, Battle Force (Adm. A. W. Fitch) regarding the status and requirements of the fighter type airplanes available in the Battle Force Pool, it is interesting to note that in the vital Hawaiian area, only an allowance of 86 fighter aircraft was made, and that only 12 were required to complete that required number. Delivery of fighters to that command had apparently ceased, and a redistribution of aircraft had to be resorted to.

Classification (censored) (changed to unclassified) by authority of

[Signature] 2545  52

[Date] (Signature) (Rank)
Status of VF airplanes:

Hawaiian Area

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San Diego Area

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<td>6</td>
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</tr>
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<td>F2A-3</td>
<td>23</td>
<td>9</td>
<td>14</td>
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<td>F2A-3</td>
<td>27</td>
<td>7</td>
<td>20</td>
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<td>F4F</td>
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<td>22</td>
<td>51</td>
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The letter pointed out that, "VF-3 must be brought up to requirements by 15 November 1941. Unless 17 additional F4F-3's are delivered, it will be necessary to transfer all of the F2A-3's in this area to VF-3 and have VMF-221 operate only 6 F4F-3's, now in VF-3 until January 1942. Attrition may even require that these be sent to the Hawaiian Area during the next two months". The critical nature of the situation was recognized and other alternatives were suggested in order not to disrupt training and delay the operating units in reaching a state of wartime readiness.

Apparently all major activities to which VF airplanes are assigned such as Miami, Corpus Christi, Atlantic Fleet, Pacific Fleet, (including operational training and Marine Units) were short the necessary number of planes to sustain their operating complements, and the training centers were badly in need of additional
fighters. Consideration was given to transferring the Atlantic Fleet fighting squadrons to the more crucial area of the Pacific. Plainly the alleviation of this situation had to come from deliveries of new airplanes. Eighty-eight F2A-3's were held up awaiting propellers and retracting cylinders, the F4F's were held up awaiting wings. Then, too, priority had been accorded to the satisfaction of urgent British requirements. Under the existing directives there appeared no possible relief for the whole situation until the end of the year.

The situation was so critical that, in November 1941, when the Navy was to loan an F4F-3 to the Army in exchange for Army fighter types for testing, it was felt that even the loan of this one plane would seriously affect the Navy's fighter strength, and some advocated cancelling the proposed loan. In spite of this rather desperate feeling, an F4F-3 was loaned to the Army, and in exchange, the Navy borrowed a P-43 for test purposes.

In an attempt to pool resources, consideration was given in December 1941 to the possibility of converting Army pursuit planes, the P-38E, P-47E and XP-62 for use as Navy fighters. The redistribution of Navy fighters, however, did not proceed so rapidly as it was hoped, and as late as February 1942, the twenty-six F4F-3's or F4F-3A's that were expected to arrive at San Diego from the Atlantic Fleet for distribution to Pacific Forces, had not arrived. In addition, there was a shortage of spare engines. Comdr. H. R. Oster, stated that, "Due to the necessity for filling the units there (Hawaii) and providing a minimum number of spares, there will probably be no VF type for the Advanced Carrier Training Group or any Replacement Group until March or April of 1942".

In spite of all the activity that had been shown in new fighter plane development during the several years previous, the Navy was inadequately supplied
with effective fighters, both as to quantity and quality. A picture of the
critical conditions at the time of Pearl Harbor and shortly thereafter, can be
seen from the following quotation from a confidential letter from the Commanding
General, MAW 1, A4-3(3)/jas (GSN 013), dated January 20, 1942:

"VMF's 111 and 121 arrived at San Diego about December 20, 1941, with
thirty-seven F4F airplanes.... These squadrons were then assigned thirty-eight
F2A aircraft of which 17 have been delivered.... The above Marine squadrons commenced
receiving the F2A airplanes on December 26, 1941, and through the greatest effort
on this part, and with the full assistance of the facilities of the NAS here
(San Diego) have been able to place but five of them in all respects ready for
combat.

"It is not considered that the F2A-2 or F2A-3 airplane is suitable for
combat missions either ashore or carrier base.... It has been determined that
the comparative performance of this type above 15,000 feet is strikingly inferior
to that of related types, particularly the F4F-3 and the F4F-3A. Furthermore,
lack of adequate armor protection for the pilot and vital portions of the
structure of the aircraft, lack of self-sealing fuel tanks, and the inability
to secure the above, render the type strictly of non-combat value and suitable
for training purposes only.

"In view of the above, it is quite apparent that the fighter squadrons of
this wing are not in a state of readiness for combat."

The urgency of supplying the fleet units with fighting planes brought
on this attempt to incorporate the lessons of war into an airplane which was
already in service. Whereas combat planes, designed as such, have the combat
loads designed into the airplane from the start, the F2A-1, did not have this

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advantage, and in converting it into a wartime fighter, it was forced to carry additional loads for which it had not been designed. Hence, from its very first flight in combat condition, it was found that there were many items wrong with the airplane: instability, poor diving characteristics, over-balanced ailerons at high speed, light controls, poor landing gear, trouble with catapulting.

It seemed that the conversion of the F2A-1 airplane to the F2A-2, with the addition of combat provisions involved an appreciable rearward movement of the center of gravity so that marginal longitudinal stability might be expected under certain loading conditions. Pilots were warned against high speed dives when the wing guns were installed.

The Navy, however, had never had any illusions on the F2A-3, even though VF-2 did use them to advantage, and had attempted to develop a more suitable combat plane in the F4F-3 and F4F-4, the latter of which had flown for the first time in December 1941.

Lt. Cdr. Pearson who was head of the VF Design Branch during this crucial period, had long been aware of the needs of the fleet, and the branch had in the process of development at high priority several prospective type, the Corsair and Helldiver, which, about a year later, were to become two of the Navy's most successful fighters. It was only the long process of designing, testing and equipping the manufacturer's plant for mass production that delayed getting these new models out and into the fleet.

Five days before the attack on Pearl Harbor, there was a memorandum from the Assistant Chief of BuAer on the matter of aircraft procurement, and requested that 250 additional F6F-1 planes be scheduled for procurement. It remained many months, however, before these planes could be delivered to the fleet to take care of the shortages in the fighter planes. Even as late as the middle of 1942, the
situation regarding the distribution of fighter planes was still critical. A request for nine obsolescent fighter planes similar to F2F or F3F series to be assigned to NAS, Sitka, Alaska for protection of base, for tests of arresting gear, and for pilot training, was turned down because of other requirements of higher priority (Ref. Conf. ltr. Aer-PL-69-MDL, VF, AV-VV, S83-3, NA 32, dated 11 June 1942.)

However, in spite of the Navy's being caught in a state of war, unprepared both as to quantity and quality of fighter planes, the fighter desk went ahead to develop and get into large production status other more suitable combat types.

At the time of the attack on Pearl Harbor, VF Design's fighter program can be outlined as follows:

I. Conventional
   A. Single Engine
      F6F
      (a) 2-stage
      (b) Turbo
      F4U
      (a) 2-stage development
      (b) Turbo
      F4C-1 and -2
      (a) Lycoming (liquid, in line)
      (b) R-3350 2-stage
      (c) R-3350 and turbo supercharger.
   B. Twin engine
      F7F

II. Unconventional
   A. Single engine (proposals)
      Brewster pusher - 3350

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X-Wasp pusher
Northrup Pusher

B.
Twin engine
(Chance-Wought (then Vought-Sikorsky))
Twin pusher (proposal)

C.
Night VF
F4U-2
FTF
Brewster Pusher (proposal)
FIGHTER AIRCRAFT DURING THE WAR PERIOD

The war threw VF Design Branch into an ever increasingly active effort to produce adequate combat aircraft for the Fleet, and by 1942 it was deep into its efforts to produce an ever greater number of fighters to meet the Navy's accelerated carrier construction and conversion program for 1942. By the spring of 1942 the Grumman Wildcat, the F4F-4, was being produced at the rate of about 90 each month, and by July the rate had gone up to 130 per month. On 21 April 1942, the Navy had the following fighters on order with Grumman Aircraft Company: 979 F4F-4, 212 F4F-4B, and 118 F4F-7's.

In addition to replenishing the Fleet with fighters, the Navy had to meet commitments to the British. Hence it became necessary to standardize as much as possible the various aircraft types and parts in order to supply both our needs and those of the British. On 8 January 1942 a conference was held between the British and United States Navy representatives on the matter of the standardization of the F4F planes which were becoming operational at that time. VF Design Branch was represented by Lt. Comdr. A. McB. Jackson of the Fighter Branch. On the 17th of the following month the enforcement of the standardization of various fighter aircraft was placed upon the fighter class desk in Engineering Division. Applications of all standard differences and changes to individual models of aircraft were to clear through VF Design Branch. (Director of Engineering Division Memo, Aer-E-2-EP, VV, Fl, 016881, dated 17 February 1942).

In an attempt to cover up the fighter plane shortage which was glaringly
evident when the United States became involved in the war, and to produce for the Fleet fighters with up-to-date performance and equipment, the Fighter Desk exerted every effort to meet these demands for more and improved fighters by coordinating the engineering work of various Naval activities. Fighter types in service were accordingly improved and modified. In carrying out this work, the VF Design Branch played an important role in coordinating all the various factors such as conducting numerous tests, studying recommended modifications to service fighters and working out with the contractor the method and time of incorporating such changes into the production airplanes. So that no important modification would reach the Fleet before being successfully tested, the Fighter Branch initiated tests at the various Naval test activities.

Early in 1942 a program for 27500 planes was approved, 3008 of which were to be operative VF types and 2588 of which were to be spares, totalling 5596 VF type of aircraft. This program was submitted by confidential letter from the Chief of the Bureau of Aeronautics, Rear Admiral J. H. Towers, Aer-PL-6-XK, AL6-l, VV, serial C-0179, dated 2 January 1942. An increase in the air strength of the Marine Corps was also recommended, and the letter pointed out that, "Marine Corps forces operating in advanced theaters must have adequate air defensive strength within their own organization. The lack of such strength, particularly in fighters, has been a fatal defect in the majority of allied operations, including Crete, Luzon, Amboina and Singapore."

"Due to the fact that the most effective weapon against aircraft is fighter aircraft," the letter continued, "it should be recognized that a force
of this type is the primary means of base defense.... The deficiencies in allied air strength of important strategic bases, such as Manila, Singapore, Hongkong, Rangoon and the Netherlands East Indies, the loss or imminent loss of which may be attributed to a large degree to this deficiency, are well known."

It was urged that Alaskan bases, at that time practically defenseless from seaborne air attack such as was directed at Pearl Harbor, be provided with fighters in sufficient numbers, and the letter further recommended that steps be taken to provide fighter protection to Alaskan air bases. Thus it can be seen that due to the emphasis placed on fighter types, the VF Design Branch would become one of the most active and busy of the class desks, having the responsibility of providing the Fleet with not only improved versions of those types already in service, but with entirely new fighter types adequate to meet the changing needs of the tactics of war.

By confidential letter from the Chief of the Bureau of Aeronautics to Chief of Naval Operations, Aer-PL-71-ER, VF, NTA, Na32, dated 23 February 1942, serial C-2243, a recommendation was made for the increase in fighters as protection of outlying and advanced bases. A total increase of 792 fighters was recommended, plus 490 long range or night fighters, bringing a total of 2,448 fighter airplanes.

The letter went on to say, that since the Navy had accepted the task of protecting various bases in the Pacific and Atlantic, "the air protection which this must include can be furnished only by shore based fighters. The single seat, single engine fighter for this purpose should in most cases be a carrier type in order to provide the proper degree of rapid inter-base
mobility and to provide carrier reinforcement and for replacement squadrons if needed. It is possible that a need may arise for a longer range fighter type which can be used as a night fighter. Such a type may be for a twin engine, two-place fighter, designed for land operations only....It appears that the Marine Corps, because of its inherent mobility, is the logical branch to provide this fighter protection. As Pacific bases are captured or recaptured in the face of opposition from adjacent enemy-held bases, there will be an imperative need for fighter squadrons which can be flown off carriers to base at the new positions. Transportation by AVG type carriers now being procured in large numbers, will provide a greater degree of flexibility in reinforcing outlying bases with fighter aircraft than any organization of the Army Air Corps." In compliance with these broad plans, the Fighter Desk bent its full efforts in expediting fighter aircraft, night fighters, long range fighters, and high performing fighter types. Such principal types are more fully described on the following pages.

Among its three conventional fighter types under consideration in 1942, the F6F, F4U and F14C (see page 57), it was found that the F14C was not progressing so rapidly nor so well as had been expected, and the hopes of both VF Design Branch and the contractor were diminishing. The Lycoming engine which was to be installed in the X14C-1 was not proving satisfactory. Its 300 hp reduction in the military power available at critical altitudes, combined with the gradual increase of the normal gross weight of the airplane, brought about an appreciable lowering of the plane's estimated performance.

Early in March 1943 plans were under study for the design of a fighter Classification (enclosed) (changed to unclassified) by authority of

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around the Lycoming engine which, it was hoped, would give the Navy a fighter in the 450 mph class. Contract 88195, dated 30 June 1941, was signed with Curtiss for one XFL4C-1 airplane with the Lycoming liquid-cooled engine. The first XFL4C-1 mock-up, held 4, 5, 6 November 1941 at the Curtiss Wright Corporation plant in Buffalo, New York, was attended by Lt. Comdr. J. B. Pearson, Jr., Head of VF Design Branch, and a second mock-up was held on 12 February 1942. The failure of the Lycoming type of engine brought an interest in a possible alternative, i.e., the R-3350 two-stage engine with a turbo supercharger. Accordingly, in January 1942 the contract was amended to add one XFL4C-2 airplane, based upon the XFL4C-1, but incorporating the R-3350 two-stage engine and Birmann turbo. The mock-up for the XFL4C-2 was held 19 March 1942. About the same time the XFL4C-2 got underway, authorization was given for two XFL4C-3 airplanes which were also designed around the R-3350 engine, but which would include a pressurised cabin.

Efforts to develop the XFL4C project did not progress as had been hoped, and in 1943 when the Lycoming engine failed to show the expected promise, the XFL4C-1, which was never built, and one XFL4C-3, were cancelled, leaving the turbo-supercharged XFL4C-2 and the second pressure cabin XFL4C-3 airplanes to be given further development. The XFL4C-2, however, was built and eventually delivered to NAMC, Philadelphia, at which time the second XFL4C-3 remaining on the contract was cancelled. The XFL4C-2 since its delivery to NAMC has been used principally for engine installation tests and no further XFL4C models were ever constructed.

The following section of this history will take, one by one, each of the principal service and experimental fighter types under active development during the war, from their inception to the end of the war in 1945.
WILDCATS - FM

The General Motors FM-1 Wildcats which were identical to the Grumman F4F-4 fighters, predominant during the first stages of the war, incorporated improved armament over its Grumman prototype and carried 4 x .50 caliber guns instead of original six. The FM-1 was built in accordance with the detail specification SD-304-1, dated 14 February 1942. The Navy had long needed a small fighter, and with the construction of small carriers the need was even greater. Grumman had been making a study of the small fighter, and a conference was scheduled for 6 July 1942. It was during this period that the Fighter Desk, in cooperation with the representatives from Grumman, and other branches in the Bureau, laid the foundations for a 1000 hp fighter, the XF4F-8, designed for operating from a short platform and capable of maneuverability and a high rate of climb. This new fighter was to be a modified version of the F4F, with some 15-20 mph faster speed than the F4F-4 at altitudes up to 10,000 feet, with an improved rate of climb by about 25%, and with a decreased take-off distance of some 100 feet. It was upon this Grumman fighter that the General Motors Corporation based its small FM-2 fighter. A conference held at the Grumman plane on 30 December 1942 was held for the purpose of expediting the availability of the second XF4F-8 to Eastern Aircraft Division of General Motors, at Linden, New York so that work could begin on the FM-2. At this conference VF Design Branch was represented by Lt. Comdr. Jackson. Tests of the XF4F-8 with both the split type flaps and slotted flaps had indicated that a larger redesigned

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horizontal tail would give more desirable pitching moment characteristics. Accordingly, by letter Aer-E-110-ESR, Serial C-99036, dated 12 April 1943, Grumman was requested to provide a redesigned horizontal tail. Since this experimental model was to be used as a prototype for General Motors' FM-2, a letter was also written in July to them requesting the submission of a cost proposal for the development of a redesigned horizontal stabilizer and elevator for the FM-2. However, because the plane was found to handle more satisfactorily with the original tail and split flaps, the production Wildcats never incorporated the new tail configuration.

For further improved performance of the FM-2, the incorporation of certain items were incorporated such as water injection, canopy, redesigned fuel tanks of greater capacity, reduction of aileron and rudder control forces, change in pilot seat, and rear armor plane, and reduction of aerodynamic drag, were to be studied by General Motors. (Ref: Ltr Aer-E-11-ADP), Serial C-27333, dated 23 November 1943). On 29 December 1943, Lt. Comdr. Pollock, project officer of the FM's, wrote a letter giving indication that even with all of its improvements, the Wildcat was still far below required performance to meet present day combat needs. From recent preliminary reports from service units operating the FM-2 airplanes, the R-1820-45 engine appears to be a desirable power plant for the small fighter. However, a comparative study of the FM-2 airplane, the only small fighter now in production, against Japanese fighters show the performance to be Classification (censored) (changed to unclassified) by authority of Na Ap 2545.

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marginal and below the Jap". The letter pointed out that since the FM-2 would be the only small fighter available for the next year that it should be further improved. Therefore, advance ratings of the R-1820-56 engine, including use of anti-detonate with water and oxygen was requested.

By letter of 22 October 1942, Aer-E-11-ESR, Serial, C-155933, Comdr. Pearson pointed out that the development of the F4F and FM fighter types to meet the future requirements of the Fleet was highly important and necessary. Studies were requested of the contractor for improvement of these airplanes, such as reduction in weight and stalling speed, and of the possibility of incorporating the R-2000 or R-2600 two speed engines. This led to the XF2M-1 design. Although the Bureau desired that the F4F or FM type be kept as modern as practicable, in view of its continued use on small auxiliary carriers, it was not desired to make any changes in the airplanes which would cause any delay in production prior to June 1943.

As a consequence of this general plan, the XF2M design never was shop completed, and was eventually cancelled in the spring of 1945. For small carrier use, the Grumman F3F production was to supersede the FM-2's as a small carrier based fighter during the closing months of the war.
THE CORSAIR:

The Corsair, which was designed to furnish the fleet with a fighter of superiority in speed, range and rate of climb over previous fighter types, was not far enough advanced to take part in the initial operations in the Pacific. In fact, the production version was not in flying status until June of the following year, 1942.

Bids for a fighter of this type, first requested on 1 February 1938, were opened on 11 April of that same year. After careful study of the proposals submitted, the Engineering Division on 8 May recommended procurement of the Vought Design which became the XF4U-1, and on 30 June 1938, contract 61544 was signed. Eight months later, on 8-11 February 1939, the mock-up on the XF4U-1 was held at Chance Vought Aircraft Company, East Hartford, Connecticut, with Lt. Comdr. R. E. Farnsworth representing the VF Design Branch.

The XF4U-1, a single engine monoplane fighter, was powered in 1939 by a Pratt and Whitney R-2800 two-stage engine, rated at 1500 normal horsepower at 17,500 feet. It was designed to give a distinct advance in performance over previous fighter types and was calculated to attain 390 mph in top speed. For armament it carried two .50 caliber and two .30 caliber machine guns. It was a considerably larger fighter than previous types, weighing some 9000 pounds. Later, however, the production version was modified to permit various load increases such as an increase in armament to six .50 caliber guns, an increase in fuel capacity, incorporating self-sealing fuel tanks, and more effective armor. As a result of these and other military changes, a redesign was brought about until the normal fighter condition reached about 12,000
pounds, yet still maintaining a high top speed in excess of 400 mph.

By the fall of 1940, the first flying model was completed, and on 24 October 1940 it was flown to NAS Anacostia for preliminary evaluation.

VF Design Branch was anxious to expedite the production of XF4U-1 and in an attempt to do so, numerous conferences were held. Conferences were also held regarding the necessary changes and modifications that were to be made in the production version.

One of such conferences was held in the Bureau on 23 December 1940. Lt. Comdr. J. B. Pearson, Jr., who had recently assumed the duties as Head of VF Design Branch, represented that office at this meeting. There a decision was reached as to the basis on which Vought would start the production version. At that time it was estimated that deliveries could begin the first part of April 1942. Although an informal production proposal had been informally submitted in November 1940, it was not until 30 June 1941 that the production contract C-82811 was finally signed. The final production contract later became N0a(s) 198.

While the F4U-1 did represent a marked improvement over previous service fighters, there were a great number of undesirable features which needed to be corrected before the plane went into production. Many of these, however, were not remedied until later due to the urgency of getting the plane into production. Thus, in order to expedite the program, certain requirements were waived, such as accepting a two-turn spin instead of the usual ten-spin requirement. When the preliminary demonstration was held on the 24th and 25th of February 1941 at Stratford, Connecticut the plane was able to complete all

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items satisfactorily.

A conference on the development of the F4U-1 was held at Langley Field, Virginia, on 8 May 1941. Lt. Comdr. Pearson from VF Design attended with representatives from Vought-Sikorsky and the NACA. At Anacostia, the following month on 24 June, another F4U conference was held to discuss preliminary recommendations made by the Trial Board on the XF4U-1, specifically as to those items affecting the production airplanes. VF Design was represented by Lt. Comdr. Pearson and Ens. G. N. Eisenhart.

In an attempt to eliminate the "shudder" in the F4U, another conference was held at Langley Field on 6 July 1941. It was decided that the contractor should make a study of larger ailerons and a greatly stiffened control system. In a later conference in the Bureau, on 25 July, it was brought out that a satisfactory aileron arrangement without an undesirable compromise in either stick force, aileron control, or aileron shudder, would most likely not be found. A plan was arrived at whereby a larger aileron was to be incorporated and a series of tests conducted.

Two months after the entrance of the United States in the war, VF Design Branch advised the contractor by confidential letter of 2 February 1942, that the production and delivery of the F4U-1 in adequate numbers to equip fighter squadrons of the Fleet and Marine Corps was the primary and most urgent objective to be accomplished by them. During this very active year of 1942, there was put on flying status two models that soon became the Grumman "Hellcat", and the F4U-1 Vought "Corsair". In June 1942 the first
production F4U flew for the first time and in August of that year was assigned to operational units. On 21 July 1942 the first production F4U-1 was ferried to Anacostia.

By the middle of July 1942, there were various versions of the Corsair under development, i.e. the F4U-1C (with four Mk.2 20 mm cannon instead of six .50 cal.), XF4U-2 (night fighter version, the mock-up of which was held on 10 December 1942), and the XF4U-3 (turbo supercharged version, using a Birmann turbo in conjunction with the R-2800 engine).

One development undertaken on the F4U which involved considerable study, was that of improving the vision. In spite of the "A" priority, the first raised cabin production airplane was not delivered until 1 October 1943 (Approximately the 1440th airplane). The mock-up had been held 26 October 1942 at Stratford, Connecticut. Comdr. Pearson and Lt. Comdr. T. D. Tyra, the Corsair project officer, attended for VF Design Branch.

Because the British carriers could not accommodate the Corsairs built for the U. S. Fleet, a modification was made of the wing tips so that the folded height would be reduced. A conference was held on this problem on 21 June 1943. Lt. Comdr. Tyra and Lt. (jg) B. R. Winborn represented the design desk. Studies had also been made for a torpedo and bomber version of the Corsair, and for making a night fighter version (i.e. the F4U-2), the mock-up on the latter being held 10 December 1941. In the Bureau on 15 February 1943, a conference was held on the night fighter version and Comdr. Pearson, Lt. Comdr. Tyra, Lt. Eisenhart and Lt. (jg) Winborn attended for the Branch.
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By the time the joint Army-Navy Fighter Conference was held at Eglin Field, during the week of 15-27 May 1943, the F4U had developed into a fighter having considerable possibilities and it received a favorable report at the conference. The Corsair was just making its first appearance with the Fleet in combat in the South Pacific (Feb.-Mar. 1943) at this time, and was becoming recognized as a good combat fighter, capable of meeting the enemy on his own terms and even surpassing him in most instances.

The F2A-2 and F2A-3 had been transferred to training, leaving the backbone of the fighter force to be composed of the Corsair (F4U-1, FG-1 and F3A-1), together with the Hellcats and Wildcats. For the first time they were being produced in sufficiently large quantities to make an impressive showing in combat. Improvements were constantly being made in the design and various engineering modifications were being made in production. On the F4U alone some 400 changes had been incorporated in the first year of their operation. This resulted in a plane easier to maintain and a better performing one. In October 1943, glide bombing tests were continuing on the F4U and the contractor was working on an extensive program of clean-up and drag reduction. For longer range and greater power, the planes were being equipped and delivered with drop tanks and water injection. This latter improvement gave the Corsair a 10% increase in engine horsepower for a limited period, making available flash performance when needed, and as a result substantially increased the F4U's margin of performance over enemy aircraft.

Increased and more rapid production was made possible by the manufacture of Corsairs by several different aircraft companies. FG-1 Corsairs were pro-
duced in large quantities by Goodyear Aircraft Company up to the close of the war, while Brewster Aircraft Company manufactured F3A-1's until the middle of 1944.

WF Design Branch as well as the contractors had been giving considerable attention to possible improvements of the F4U-1 to make it show greater performance. Vought submitted by letter of 7 April 1943 a comprehensive study of beneficial changes to the Corsair, and ten days later the Bureau replied, indicating general approval of the contractor's proposal. One means to improve the performance was to install the "C" engine. A conference was held in the Bureau on 22 April 1943 to discuss the engineering and production aspects of the "C" engine installation in both the F4U and F6F. Since Grumman thought the "C" engine too experimental and Vought desired to get started immediately, Vought was given the allocation of the "C" engines, and the new Corsair became the F4U-4 which also had a completely revised cockpit similar to that of the F6F-3. It was scheduled for delivery in September 1944.

Beginning with the 2825th F4U airplane delivered in May 1944, a twin pylon installation, consisting of two stub wing pylons, on either one of which there may be carried either a P-38 type 150 gallon drop tank or a bomb up to 1600 pounds in weight. The outer wing panel tanks were removed and the provisions for the centerline tanks would be available, and this version was designated the F4U-1D. In addition to the twin pylon provisions, the F4U-1D also incorporated a revised cabin and raised tail wheel which considerably aided carrier operations.

Numerous buffeting problems associated with drop tanks and other external stores on the F4U had to be ironed out before the F4U's could completely develop

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By the time the joint Army-Navy Fighter Conference was held at Eglin Field, during the week of 15-27 May 1943, the F4U had developed into a fighter having considerable possibilities and it received a favorable report at the conference. The Corsair was just making its first appearance with the Fleet in combat in the South Pacific (Feb.-Mar. 1943) at this time, and was becoming recognized as a good combat fighter, capable of meeting the enemy on his own terms and even surpassing him in most instances. The F2A-2 and F2A-3 had been transferred to training, leaving the backbone of the fighter force to be composed of the Corsair (F4U-1, FG-1 and F3A-1), together with the Hellcats and Wildcats. For the first time they were being produced in sufficiently large quantities to make an impressive showing in combat. Improvements were constantly being made in the design and various engineering modifications were being made in production. On the F4U alone some 400 changes had been incorporated in the first year of their operation.

This resulted in a plane easier to maintain and a better performing one. In October 1943, glide bombing tests were continuing on the F4U and the contractor was working on an extensive program of clean-up and drag reduction. For longer range and greater power, the planes were being equipped and delivered with drop tanks and water injection. This latter improvement gave the Corsair a 10% increase in engine horsepower for a limited period, making available flash performance when needed, and as a result substantially increased the F4U's margin of performance over enemy aircraft.

Increased and more rapid production was made possible by the manufacture of Corsairs by several different aircraft companies. FG-1 Corsairs were pro-
duced in large quantities by Goodyear Aircraft Company up to the close of the war, while Brewster Aircraft Company manufactured F3A-1's until the middle of 1944.

VF Design Branch as well as the contractors had been giving considerable attention to possible improvements of the F4U-1 to make it show greater performance. Vought submitted by letter of 7 April 1943 a comprehensive study of beneficial changes to the Corsair, and ten days later the Bureau replied, indicating general approval of the contractor's proposal. One means to improve the performance was to install the "C" engine. A conference was held in the Bureau on 22 April 1943 to discuss the engineering and production aspects of the "C" engine installation in both the F4U and F6F. Since Grumman thought the "C" engine too experimental and Vought desired to get started immediately, Vought was given the allocation of the "C" engines, and the new Corsair became the F4U-4 which also had a completely revised cockpit similar to that of the F6F-3. It was scheduled for delivery in September 1944.

Beginning with the 2825th F4U airplane delivered in May 1944, a twin pylon installation, consisting of two stub wing pylons, on either one of which there may be carried either a P-38 type 150 gallon drop tank or a bomb up to 1600 pounds in weight. The outer wing panel tanks were removed and the provisions for the centerline tanks would be available, and this version was designated the F4U-1D. In addition to the twin pylon provisions, the F4U-1D also incorporated a revised cabin and raised tail wheel which considerably aided carrier operations.

Numerous buffeting problems associated with drop tanks and other external stores on the F4U had to be ironed out before the F4U's could completely develop
combat potentialities. For the purpose of discussing and establishing remedial measures for the undesirable characteristics, a conference was held 1 August 1945 at Chance Vought, Stratford. Comdr. Tyra and Lt. Comdr. Merrick from the Fighter Desk attended.

The policy of improving the models already in service was vigorously pursued by VF Design and a program was worked out with Chance Vought whereby a number of substantial improvements, including a new engine, a new propeller and improved canopy were made on the original Corsair. This improved version with a new top speed in excess of 450 mph became the F4U-4 and was delivered to operating activities late in 1944. By 1944 the F4U-1 had been employed extensively in combat and was considered as a top fighter. However, with the higher speed versions of the Tojo encountered by the Corsair and other Navy fighters, the need developed for a Navy fighter having a speed edge over the Jap fighters, and accordingly, the F4U-4, the "G" engine version of the Corsair, met the challenge when delivered to Fleet units during the closing months of the war.

On August 1944, a mock-up of the modified F4U-4 cockpit was held at Vought, and Comdr. T. D. Tyra and Lt. Comdr. R. C. Merrick attended from VF Design Branch. This mock-up was in connection with the proposed trial installation of a flat front windshield and bulged canopy. The contractor had been requested to incorporate a bullet-resisting glass panel as an integral part of the windshield to form a "flat-front" windshield and to give increased visibility by the reduction in the size of the retaining metal framework. In October 1944 an F4U-1D which had been fitted with the flat windshield and bulged canopy, successfully passed evaluation by NAS, Patuxent.
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The new windshield and canopy went into the 1001st F4U-4 in April 1945. The F4U-4 version of the Corsair, which also incorporated a redesigned wing folding mechanism and provisions for rocket firing installations, was expected to be some 15 or 20 mph faster than the F4U-1 due to the somewhat higher powers of the "C" engine over the "B" engine. The designation of F4U-4C was given to those Corsairs to be equipped with 20 mm. cannon mounted in the outer wing panels.

In the fall of 1944, studies were made by both VF Design Branch and Chance Vought of the modification of the F4U for use as a carrier night fighter. By September 1944, mock-ups of both the APS-4 surface search radar and the APS-6 night fighter radar were underway at Vought in the F4U-4. The F4U-4(N) became the night fighter equipped with AN/APS-6 night fighter radar gear, to be used primarily against airborne targets, and the F4U-4(E) became the night fighter-bomber aircraft equipped with AN/APS-4 night search radar gear, to be employed against surface targets and for search of surface objectives, although none reached service use during the war. Eventually both the APS-6 and APS-9 were superseded by APS-19.

Early in 1944 a comparison was made by Capt. J. B. Pearson, Head of VF Design Branch regarding the existing status and future possibility of the F4U and F6F series. This comparison is given here in that it offers a fairly good picture of the status of the two main Navy fighters in 1944 during the height

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of the war. The following points of interest were taken from Capt. Pearson's memorandum:

The F4U airplanes were then being delivered in a configuration which gave a top speed of some 431 mph as checked by NAS Patuxent. The F6F airplane with special finish and special hand-tailored cowling was at the same time checked at 410 mph, with the same basic engine ratings as were used on the F4U speed check. The F4U airplane was then being delivered at a full internal weight of 11,962 pounds and the F6F at an equivalent weight of 12,366 pounds, with the rates of climb of the two airplanes calculated roughly in the inverse ratio of these two weights at equivalent engine powers.

The above figures were based upon the R-2800 "B" two-stage engine with water injection. The next model engine in this series was the R-2800 "C" engine. The difference in the basic ratings at critical altitude on those two engines was 1975 hp at 16,900 feet for the B engine and 2100 hp at 21,900 feet for the C engine, the C engine having somewhat higher powers than the B engine throughout the entire altitude range. With these ratings, the F4U-4 which incorporated the "C" engine, was expected to be some 15 to 20 mph faster than the F4U-1 with lower rating of the "B" engine. At the time that commitments had to be made for installation of the C engine in one or both of the big fighters, Grumman was unwilling to make a commitment, feeling that the "C" engine was somewhat of a gamble and that it would require substantial flight testing on the "C" engine prior to committing the entire Grumman production line to the new engine. Vought, on the other hand, had enough
confidence in the "C" engine to make a strong bid for the first "C" engines
off Pratt & Whitney's production line. Under the circumstances, it was a-
greed to allow Vought to have these engines, one of the contributing factors
in the matter being that if minor troubles developed in the "C" engine inci-
dent to the first flight tests, there would be three lines of Corsairs, one
only of which would have the "C" engine installed. It was anticipated that
the F4U-4 with the new engine installed would start production deliveries in
the middle of 1944. In addition to the change in engines, this airplane also
had an improved armor installation and a completely new cockpit arrangement,
the latter of which was patterned after the F6F cockpit which had received
much favorable comment from all pilots.

The F4U with the original low cabin was considered definitely inferior
to the F6F as a carrier plane and hence the choice of the F6F's for the
Fleet at that time was sound. Early experiences of VF-17 on the USS Bunker
Hill with the raised cabin F4U airplane indicated that in that configuration
even if not so good a carrier landing airplane as the F6F, it was not far
behind. The raised tail wheel and bounce eliminators on the main landing
gear which were tested early in 1944, on a small carrier at winds over the
deck as low as 16 knots, made a definite improvement in its carrier landing
characteristics, and it was believed that eventually with development on
the Corsair, then in progress, there would be little to choose between the
carrier landing characteristics of the two airplanes.

As to comparison of the angles of vision between the Hellcat and Corsair,

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there appeared to be little difference in the angle of the pilots vision over the leading edge of the wings, but there was a distinct advantage in favor of the F4U in down vision to the rear, due to the fact that the F4U pilot sat much higher above the wing than the F6F pilot and directly above the trailing edge.

The radius of action, drop tank capacity and bomb carrying adaptability of the two airplanes were about the same except that the F4U-4 would not have a belly position for either tank or bomb. It did have, however, one pylon on each stub wing capable of carrying either a drop tank or up to 1000 pound bomb.

Although the Corsair demonstrated excellent suitability as a carrier fighter on tests aboard the Bunker Hill, there were still a number of refinements which had to be made and checked out by squadrons on carriers.

The maintenance characteristics of the F6F had always been very favorably reported on. The roominess of the airplane and its accessibility were part of the reason for its loss of performance as compared with the F4U types. The maintenance difficulties of the Corsair type were attributed to: (a) lack of spares, (b) certain defects in design which could be corrected and (c) the general compactness of the airplane. Although items (a) and (b) were fairly well cleared up by the end of the war, there would always be a difference between the two airplanes due to the third factor. It was believed that this boiled down to a point of relative convenience rather than to a real difference in ability to keep a percentage of airplanes in the air. It was felt that this
was borne out by the record of VF-17 which was landed in the Solomons with a reasonable number of spares and which consistently kept a very high percentage of airplanes in the air. The airplanes subsequent to those employed by VF-17 were substantially better from a maintenance standpoint.

In spite of the excellent reputation and unusually versatility of the F6F, it appeared, by the spring of 1944 that the F4U-1 airplane had a substantial advantage in performance over the Hellcat as it was then being produced. This performance difference widened beginning in the summer of 1944. Since the two best Japanese fighters, the "Tojo" and "Tony" were in the same range of speed as the F6F airplane at that time, several carrier squadrons of the Corsair type (F4U-4) were forwarded to the forward combat areas.

The following is a brief resume of the development of the Corsair:

1. Link tab ailerons went in about the 300th F4U-1 which changed characteristics from "barely acceptable" to "exceptionally fine".

2. Raised cabin went in about the 1000th airplane, and this change gave improved all around vision.

3. Drop tanks were provided in place of unprotected wing tanks beginning in September 1943.

4. Raised tail wheel went into service in December 1943. This gave marked improvement in ground handling and landing characteristics.

5. Water injection started in airplanes delivered in October 1943. This gave improvement in rate of climb by about 400 fpm and the Vmax by about 20 mph.
6. The F4U-4 which started in production 1 January 1945 had an improved cockpit and armor arrangement in addition to the R-2800-C, two-stage engine. This gave a 25 mph increase in the maximum velocity and some 500 fpm in climb.

7. Bomb rack adapters were made available which permitted the use of a 1000 pound bomb on the drop tank fittings. This could be used in dives from all angles up to 80 degrees.

8. The R-4360 engine went into semi-production in the F2G airplane in December 1944. Only 17 of these airplanes were delivered. This gave very flashy low altitude performance.

9. Flat front windshield and bubble canopy went into the 100st F4U-4 and was delivered in April 1945.

10. FG-3 went in production in October 1945, incorporating "C" engine, a high altitude supercharged airplane. First one with "B" engine flown in August 1945.

11. Scheduled:

   a. 20 mm cannon for March 1946.

   b. Mark 51 bomb racks for March 1946.

   c. Goodyear rotoform canopy which provides 2" additional head clearance and greatly improved optical qualities.

   d. "CE" engine to be used in the F4U-5.

   e. "F" engine to be used in the F4U-5.
f. Twenty-seven FG-3 incorporating "C" engine with Birmann supercharger to be delivered by March 1946.

The FG-1 and F3A-1

In order to increase production of the Corsairs, Brewster Aeronautical Company and Goodyear Aircraft Company were authorized to manufacture fighters based on the Vought design. The Corsairs thus manufactured became known as the F3A-1's and FG-1's respectively. Lt. Comdr. Pearson, Head of WF Design, initiated a conference on 26 September 1941 with representatives from Vought-Sikorsky to make arrangements for starting production of the F3A-1's under Contract C-90615 (later became Noa(s)172). The Goodyear fighters were produced under contract 99529 (later Noa(s)1871).

Further in order to accelerate production by setting up some form of standardization, and to get the planes out to the fleet to take care of their shortages, WF Design Branch arranged in April 1942 for the interchangeability of parts of all the Corsair models: the F4U-1, F3A-1 and FG-1. It thus came about that any change in design or part in one model would also be effective in the other. In an effort to improve the performance of these Corsairs, it was planned that a modified set of outer wing panels should be developed in order to give increased lift and improved stall characteristics and to lower the length of take-off runs. This change was considered desirable in view of the contemplated weight increased. By thus increasing the tip chord and tip thickness, combined with a change in tip section, which would bring about an increase in wing area, it was felt that the Corsair's performance at altitude should be improved. However, the modi-

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fied outer panels proved to be unsatisfactory since the resultant drag proved to be very excessive.

Since the British were to receive a large number of Corsairs, a modification of the wing was made so as to provide hangar deck clearance for these airplanes aboard the British carriers. A set of modified wooden cut-down wing tips were flown and tested and found to result in only minor changes in the flight characteristics of the airplane. A conference on this matter was held on 21 June 1943 at which representatives of Vought, Brewster and Goodyear attended. VF Design was represented by Lt. Comdr. Tyra, and Lt. (jg) B. R. Winborn who were the two Corsair project officers at that time.

These models were essentially identical to the FAU-1 and any changes and modifications which went into the Chance Vought Corsairs was accordingly incorporated in the Goodyear and Brewster models. In mid-1944 the Brewster models went out of production.

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F6F-3 HELLCAT

The Hellcat (F6F-3) was one of the two principal combat fighters of the war. It had its beginning early in 1941. In April 1941 VF Design Branch was negotiating with Grumman Aircraft Engineering Corporation for a development of the F4F series, using a R-2600-10 engine, which plane was to be called the XF6F-1, the forerunner of the XF6F-3. Early in 1941 Contract 88263 was let for two XF6F-1 airplanes and the mock-up was held 12 January 1941. The first experimental model was flown at Bethpage on 8 July 1942. An engine change to the R-2800 engine was made in the second XF6F-1 in order to improve the plane's performance and make it at least comparable to the F4F whose performance estimate was encouraging. There was further experimentation on the first two XF6F-1's and in September 1942, the first XF6F-1 was also converted into an F6F-3 by an engine change, and the original XF6F-3 (the second XF6F-1) airplane was supplied with a two speed R-2800 engine and was accordingly designated the XF6F-4. Grumman was given a free hand in the engineering of the prototype XF6F-1. It had originally been planned to make only minor changes over the F4F series, but it was developed into practically a complete new design.

Various tests were made both at Anacostia and Bethpage on these experimental models. 1080 F6F-1's were procured on production contract C-90071, delivery to begin in September 1942. There was a change-over in production classification (seemedled) (changed to

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in September to the R-2800 engine, and the F6F-1's under contract C-90071 became F6F-3's. No F6F-1's were delivered.

Due to the Fleet's very urgent need for competent fighters at the beginning of the war, an accelerated production program was carried out by Grumman, and by the end of February 1943 that company had delivered 58 planes. By October 1943 all 1080 planes under the first contract were delivered, and Grumman proceeded under new contracts for hundreds of additional airplanes (Contracts No(s) L4105 and No(s) 846, dated 26 November 1942 and 29 December 1943, respectively.)

Some of the first production planes were put immediately into squadrons for service evaluation. In February 1943, VF-9 on the USS Essex squadrons was outfitted with the first F6F-3's. This squadron found the Hellcat's performance and operation excellent and reported only minor troubles which consisted mainly of cracking of engine exhaust. Reports from the Fleet also indicated general satisfaction with the Hellcat and stressed its ruggedness, ease of maintenance and reliable performance.

Because of the urgent need of the Fleet for night fighters, investigations were made into the possible reconversion of some of the existing service models for this purpose. In the spring of 1943, Grumman made a design study of the installation of night fighter equipment on the F6F-3 and by April the study had progressed to a point where the design was nearly complete and showed that the installation was relatively simple. Due to Classification (see 1623) (changed to unclassified) by authority of

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the fact that the full scale wind tunnel tests showed that a low position of the scanner nacelle was the most desirable, the nacelle could be mounted without disturbing the normal wing contour. This allowed the removal or installation of the nacelle in a relatively short time, thus permitting the F6F-3 to be readily converted for employment in night missions. Since the Navy had no fighter specifically designed for night fighter use, the modified Hellcat (F6F-3N) became the most widely employed night fighter. In June 1943 installation of AIA radar equipment had been made in one F6F and was delivered to Quonset Point for test that same month. Installation of AIA in other Hellcats was far behind schedule. The following year, in March 1944, the night fighter version of the F6F-3 was officially designated the F6F-3N and had the following items of difference in comparison with the standard Hellcat version: AIA search radar with nacelle on the right wing, AN/APN-1 radar altimeter, flat front windshield which served also as the gunsight reflector, redesigned instrument panel with red lighting.

The report of the joint Army-Navy Fighter Conference held at Eglin Field, Florida, 15-27 May 1943 reported that the Hellcat had the following desirable characteristics:

1. Good forward and shooting visibility.
2. Good landing and ground handling characteristics.
3. Excellent turning circle with maneuvering flaps.
4. Excellent cockpit arrangement.
5. Extraordinary cooling.

However the following defects were noted:

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1. Excessive rudder forces.
2. Stiff ailerons
3. Excessive trimming required of elevators.
4. Poor visibility to rear.
5. Disappointing speed in level flight.

In July 1943 studies were made of the F6F airplane modified for small carrier use. This airplane was designated the F6F-4 which was the standard F6F-3 airplane with the two speed "C" engine installed, two guns and corresponding ammunition eliminated and with the rear (75) gal fuel tank eliminated, plus other modifications to give increased wing area and span. Although the modified F6F airplanes appeared to possess a greater degree of merit for small operations than the F6F-3, in comparing it with the FM-2, its superiority was questionable. Since the FM-2 was the smaller airplane, allowing more airplanes to be carried aboard a carrier, and was already starting in production, it appeared questionable that the speed advantage and probable lower attrition rate due to wider tread landing gear of the F6F airplane justified the engineering and productive effort required to put them in production.

As early as 1943 Comdr. Pearson had recognized that the F6F could be employed successfully on many different types of missions. Practically all the targets in the Pacific, whether island bases or ships, demanded low altitude attacks, using strafing, dive bombing and glide bombing tactics. Pylons were incorporated so that the F6F could carry torpedoes or bombs should the mission require it. In August 1943 tests were made of the F6F-3...
with two external 1000 pound wing bomb racks and an external belly fuel
tank and was found suitable for service operation. By September all
production F6F's were being equipped to carry a wing bomb up to 1000 pounds.
Early the following year, various tests were conducted to determine the
maximum dive angle for bomb release on the F6F's. At the recommendation
of Patuxent test activities, an improvement was made in the aerodynamic
cleanliness of the bomb racks so they would offer the minimum amount of
drag. At this time comparison was made between the F4U-1 and the F6F-3
with one 1000 pound bomb:

<table>
<thead>
<tr>
<th></th>
<th>F6F-3</th>
<th>F4U-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>400</td>
<td>361</td>
</tr>
<tr>
<td>Gross Weight</td>
<td>14265</td>
<td>13700</td>
</tr>
<tr>
<td>Max. Range - no reserve</td>
<td>1215</td>
<td>1200</td>
</tr>
<tr>
<td>Max. Range-20% fuel reserve</td>
<td>970</td>
<td>960</td>
</tr>
<tr>
<td>Combat Radius-Naut. mi.</td>
<td>360</td>
<td>261</td>
</tr>
</tbody>
</table>

Beginning in September 1943, delivery of Hellcats with the 1000 pound
bomb racks on the right stub wing was commenced.

Although rockets had not yet come into service use, the Head of the
Fighter Branch early realized that by adapting rocket projectiles to the
F6F's that their effectiveness against light surface forces would im-
measurably be increased, and accordingly, numerous preliminary studies
were made, as to the feasibility of their incorporation on fighters should
rockets come into combat use.

A major modification went into the F6F toward the close of 1943. By
confidential letter C24116, dated 16 October 1943, VF Design Branch re-
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quested Grumman to forward to the Bureau an informal cost quotation covering work of modifying windshield and cockpit enclosure. This was brought about because of the restricted vision from the cockpit of the F6F-3 airplanes. It had been found that dust collected between the bullet-proof glass and the windshield glass, decreasing the visibility in the sector ahead of the airplane. In addition, night fighter desired the elimination of all unnecessary surfaces which cut down light transmission. There was also need for more unobstructed rearward vision and VF Design believed that an adoption of the blown canopy effect would give an enlarged degree of vision. In the referenced letter the contractor was requested to make studies of a new day fighter windshield, a new night fighter windshield, a revised sliding canopy, and a revised turtle deck structure. By September, the redesigned windshield with the bullet-proof glass forming the center section and curved plexiglass as the side panels was ready for test by night fighter personnel and Naval test activities. As a result of this request, the newly designed canopy was incorporated in the production.

Reports from the Fleet indicated general satisfaction with the F6F as an all-around carrier aircraft. Although large numbers of F6F's were badly shot up, they still managed to return to their base, and the Hellcats gained a reputation for being able "to take it." It seemed that a much higher percentage of F6F's were maintained in combat commission than other combat fighters.

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1944 saw the Hellcat going into combat with numerous improvements. In January their radius of action was greatly extended by the incorporation of a 150 gallon droppable fuel tank into the Hellcat's operating with the Pacific Fleet. After encountering Japanese fighters with improved armament, and particularly as a result of the Gilberts action, the Fleet felt that it would be desirable to have Hellcats of stronger firepower than the existing 6 x .50 caliber guns could guarantee. Accordingly, studies were made with a view toward replacing the .50 caliber with the 20 mm. cannon. A further improvement was made by increasing performance when water injection was installed in the Hellcats, beginning in March 1944.

In January 1944 Grumman reached its peak production and levelled off at 500 F6F-3's per month. Numerous improvements were being incorporated, and in January Grumman began to equip 60% of its production F6F-3's with water injection engines. A cleaned up version of the F6F-3 with refinements in production, specially fitted cowling, water injection, and a smooth paint finish was found to have a maximum speed of 410 mph at 21,000 feet altitude, and fitted with spring tab ailerons, stick forces were noticeably diminished. This improved F6F-3 became the F6F-5. This version was to include the flat front windshield, red lighting instrument panel, close fitting cowling, spring tab ailerons, increased armor, strengthened tail, smooth finish. On 21 April the last F6F-3 came off the line and the F6F-5 superseded it in production. This new version had approximately 15 mph higher speed than its predecessor as well as increased armor protection.
and increased strength. Along with the FG-3's it was produced under contract No(s) 846 and would include the R-2800-10N engine instead of the R-2800-10.

In August a new Grumman Hellcat version was in the making, and though it had the same configuration as the FG-5, it was some 400 pounds heavier and 20-25 mph faster. It had a four bladed propeller installed, larger "C" two-stage intercoolers, and R-2800-22/29 engines, and AN/ARC-1 radio. Initial production was to have begun in September but by the end of the year it was decided to postpone the production of the FG-6 version indefinitely. Only two such models were built and were being flown and tested at the contractor's plant.

Beginning with 1945 the production and engineering capacity of Grumman was being turned to the development of the FG and FF, and until the end of the war when the FG-5 contract was cancelled, only modifications and improvements were initiated in the existing models. Grumman was working on plans to equip all night fighters with 2 x 20 mm cannon as well as 4 x .50 cal. guns. The following model designations of Hellcats were in service use during 1945:

- FG-3 - standard carrier fighter
- FG-5N, 2N - night fighters
- FG-5P - tri-metrogon photographic plane
- FG-5E - night in truster plane equipped with AN/APS-4.
NIGHT FIGHTERS

The need for a night fighter type aircraft for use by Navy as well as Marine Corps pilots was recognized early in the war in order to stall off night and pre-dawn attacks on fleet units and advance bases by enemy aircraft.

The Marine Corps was particularly desirous of acquiring fighter aircraft equipped with special radar installations for the purpose of night fighting. Accordingly by confidential memorandum from the Director of Aviation, Marine Corps, to the Director of Planning Division, Aer-WR-dst, dated 23 February 1942, it was requested that a design study be made for night fighters.

The matter of finding a suitable aircraft for use as a night fighter was one of the special projects of VF Design Branch, and it immediately took action to develop a suitable fighter for this purpose. The most suitable type of aircraft would be one that would have a twin engine, a tri-cycle landing gear, good forward visibility, adequate armament. The Army A-26A and P-61 were suggested as possible types; however, these planes in production quantities were far away, and it was felt that a Navy fighter, the F4U-1, could be converted into a night fighter, designated the F4U-2, almost as soon as one could be procured from the Army. The Grumman twin engine proposal (XF7F-1) was still in the design stage, and hence could not be counted on to fill the needs of the Marine night fighters at any time in the near future. The Vought F4U-2 would be ready within the year, and was expected to be adequate to outfit the first Marine night fighter squadron.

On 29 May 1942, Comdr. J. B. Pearson, Jr. represented the VF Design Branch at a conference held on the XF4U-2, which appeared to be the first available

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night fighter. This model was to be a development of the F4U into a night fighter, incorporating British night experience and advanced radar. It was to retain all of the features of the F4U-1 in accordance with the mock-up held on 28 January 1942.

Until the plane to be used as a night fighter was ready, plans were made to establish a small aircraft unit at NAS Quonset Point for night fighter development, for testing night fighting equipment and for training a limited number of officers and men who would later be used as instructors in a larger training effort. This night fighter unit was established by confidential letter from DONO, Op-28-E-MB (SC) A-4-3/WV, Do. 4824, serial 038338, dated 18 April 1942, and was placed under the cognizance of the Bureau of Aeronautics. It was first designated as Project Argus, and later became known as Project Affirm.

In mid-1942, the night fighter program for both Marine and Naval aviation was skymied for the lack of suitable aircraft, and it was from the night fighter project set up at Quonset Point that the Navy expected to get its answer to the Fleet's request for adequate night fighter type of aircraft and equipment.

In a conference held at Vought's plant, in Stratford, Connecticut, about 5 June 1942, it was decided to adopt the proposal of Cdr. Pearson to install the AIA equipment in one JRB airplane. It was arranged that the installation should simulate the F4U-2 installation insofar as possible so that tactical tests could be effective. It was further decided that a second JRB should be modified to include a maneuvering pilot. One JRB-2 was assigned for this night fighter devel-
opment, and eventually, in January 1943, the first F4U-2 was delivered for testing and training. All the F4U-2’s produced, some 37 in number, were assigned to that unit to be used for training and testing, and later in actual combat in the first night fighter squadron.

Project Argus was carried out with high priority because of the urgent need for night or low visibility fighters to operate with the fleet. The fleet had requested the development of some method of combatting the Japanese four engine patrols which had been able to keep American task forces in sight, and although shown on the radar screen, had escaped by using a cloud cover. The urgency of this need had been illustrated by the results of the Coral Sea action where Japanese scouts eluded the Navy’s fighters and the existing stage of radar by use of clouds and low flying. There was additional need for night fighters to protect the Fleet against a night aircraft torpedo attack and to reinforce night flying squadrons at advanced island bases.

The need for night fighter squadrons in the European theater was also foreseen, and the air operations there indicated that, as allied day fighter superiority was established, the enemy would be forced to resort to bombing at night, and this would necessitate using fighter aircraft with the proper equipment for attacking these bombers during their night operations.

It was estimated that the Navy would require some 200 night fighters in 1943 and some 250 in 1944. This growing demand made it requisite for the Navy’s Fighter Branch to look into the possibility of procuring from other than Classification (deleted) (changed to unclassified) by authority of

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Navy sources a plane that would fit into its program. The Navy was endeavoring to procure from the Army one of its twin engined fighters in sufficient quantity to outfit eight proposed 12 plane squadrons, plus adequate spares. Investigation was made into the possibility of increasing the P-61 production at Northrup. However, no solution to the Navy's night fighter need could be found from this source as the Army indicated that the entire production would be needed by theAAF. Eventually, in order to organize a squadron specifically outfitted for night flying, one squadron of Marine night fighters was authorized to be commissioned on or before 1 January 1943, but this squadron, instead of being equipped with fighter type aircraft, was to include PV-1's and SBD's. This Marine night fighter squadron VMF(N) 531 was formed at an earlier date in the fall of 1942 by Lt. Col. F. H. Schwable, USMC, who had just returned from studying night fighter tactics in England. This squadron was established to train not only pilots but ground crews for ground radar operations as well. The PV-1 airplane with which they were first trained, was used with AI-MX IV British radar installed as it had already been successfully employed in combat by the British in their Beaufighter. Installation of radar was made at Quonset Point (Project Affirm) with further armament installations made at Norfolk. A unit of VMF(N) 531 left for the South Pacific in the spring of 1943 complete with ground control personnel under the command of Lt. Col. John Harshberger with

Col. Schwable as liaison officer. Upon his return from the Pacific, Col. Harsh-

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berger was assigned to VF Design Branch as its night fighter and Marine liaison Officer.

On 1 April 1943 the Marine formed Corsair night fighter squadron, VMF(N) 532, using F4U-2 Corsair night fighter squadron, Airplanes. Major Ross S. Mickey, who was later, in 1945, to report into VF Design Branch as its night fighter project officer, as relief for Lt. Col. E. H. Vaughan who had succeeded Lt. Col. Harshberger, was commanding officer of this squadron during the time it was in training at Cherry Point. Lt. Col. E. H. Vaughan eventually took it out into combat in the Pacific in December 1943 as a fifteen plane land based night fighter squadron stationed at Tarawa. The carrier-based Navy F4U-2 squadron, composed of six aircraft, was designated as VF(N) 75 and was transferred to the Pacific Theater at the same time as the Marine Squadron VMF(N) 532. The VF Design Branch called for a conference on night fighters on 15 February 1943. At this meeting it was suggested that steps be taken to investigate the suitability of the Mosquito airplane for installation of the AIA radar. On 24 February, a Mosquito bomber airplane was inspected at NAS, Anacostia. Among those present to inspect the plane were Major J. D. Harshberger, USMC, who a year later was to report to the Fighter Branch as its Assistant Head and Night Fighter Project Officer, and Lt. (JG) B. R. Winborn, from the VF Design Branch.

Another night fighter conference of February 15th was held in the Bureau and was attended by Comdr. J. B. Pearson, Jr., Lt. Comdr. T. D. Tyra, Lt. G. N. Eisenhar, and Lt. (JG) B. R. Winborn from the Fighter Desk. Various phases of

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the night fighter program were discussed, and it was agreed that the maneuvering pilot was desired on all night fighters when and if it were proved to be satisfactory. It was further decided to attempt to procure two Mosquitos for trial installation, one for installation of AIA, and the other for an SCR-720 installation which appeared to be the most nearly perfected radar equipment available and which could be procured from the Army. NAF was to be asked to expedite a study of a radar installation in the F4F-8 airplane with particular reference to the use of this airplane as a night fighter on CVE's. Acceleration of the F4U-2 program was recommended, and at the time when the first flight tests of the F4U-2 proved practical, a comparison between the F6F and F4U for night fighter adoption would be made. By the time of this meeting, Quinset Point, where Project Affirm was stationed, had completed thirty hours of flight time in JRB's simulating single seat night fighter operations.

Three months later on 29, 30 April, 1943, a group of officers and civilian technical advisors from the Bureau of Aeronautics visited the DeHaviland Factory in Canada to obtain information regarding the problems which would be involved in installing American night fighter and photographic equipment in Mosquito airplanes. Lt. Comdr. T. D. Tyra was sent from VP Design Branch on this trip. The installation of all desired American equipment, except the AIA, appeared quite practicable; however it was anticipated that complications would undoubtedly arise at a future date in that the Mosquito was designed essentially to British dimensions and standards and this would complicate the furnishing of spare parts.
and the maintenance and servicing of the airplane.

Grumman planes, in the meanwhile were also being made ready for night fighter missions. In September 1943 one F6F-3N was equipped with AIA radar equipment for a night fighter version and made ready for tests at Quonset Point. The Equipment of other night fighters with AIA was far behind schedule.

By September of 1943, progress had been made on the Navy's twin engined fighter, the XF7F-1, and the first XF7F-1 was ready for its scheduled flights at the end of October. After several years effort in endeavoring to develop an adequate night fighter from existing single engine production versions, it appeared that at last the Navy was about ready to obtain a fighter that could be made into one suitable for night operations. Until such time as it was in production however, the standard Navy Corsair and Hellcat, particularly the latter type, would be furnished with radar gear for night flying.

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F7F - Tigercat

The Navy's first twin engined night fighter, the F7F Tigercat, had its inception some six months before the attack on Pearl Harbor. By a letter from Engineering Division to Procurement Division, dated 12 May 1941, a requisition was made for two XF7F-1 twin engined fighter aircraft based on Specification SD-288 dated 12 May 1941. The mock-up, held the following year at Bethpage, Long Island, on Tuesday, 15 September 1942, was attended by Comdr. J. B. Pearson Jr. and Lt. Comdr. A. McB. Mackson, from the Fighter Desk. Contract 88725 covered the procurement of the two XF7F-1 airplanes. The production contract, NOa(s) 1679, calling for 650 F7F's was signed 1 April 1944.

At a conference at the contractor's plant on 29 June 1943, Comdr. Pearson and Lt. Comdr. Sweeney, the Grumman project officer, discussed with the contractors the type of engines that were to be used on the F7F. The contractor had made a preliminary study on various engines for the F7F and had come to the conclusion that the R-2800 two-speed B engine would be preferable to the R-2600 which had been originally considered. The R-2600 was to be installed on the first XF7F regardless of the ultimate decision, but the question as to which engines should go in the second and subsequent airplanes was deferred until completion of studies, then being made by the contractor, of the weight, balance and performance of the XF7F with the R-2800 two-speed, R-2800 two-stage and R-2600 turbo engines. The final conference on the selection of engines for the F7F was held in the Bureau on 6 August 1943, with Lt. Comdrt's. T. D. Tyra and W. E. Sweeney and Lt. A. D. Pollock representing VF Design Branch. Because of the production difficulties experienced by Wright Aeronautical Corp., and after examination of relative performance figures by VF Design Branch and interested technical branches in Engineering Division, a decision was finally reached to replace the R-2600-14 engine with the R-2800-C engine. However, since the R-2800-18 two-stage C engine was not available in time
for installation in the first production planes, it was decided that approximately
the first 200 F7F's would be produced with R-2800-22 two-speed C engines and the
remainder with two-stage engines.

The first XF7F was equipped with an R-2800-27 two-speed "B" engine, and the
second one with an R-2800-22 two-speed C engine, and as soon as an experimental
R-2800-18 two-stage engine could be made available to Grumman, an installation
would be made on one of the two experimental planes. The first airplane was flown
in November 1943. It was found that the two-speed engines enabled the F7F to ex-
ceed at sea level the speed of the F6F-3 by some 50 MPH and the F4U-1 by some
30 MPH, though above 18,000 feet the Corsair and Hellcat showed better performance.

Because of requests from the fleet and Marine Corps, VF Design felt late in
1943 that there was a need to have a second man in the F7F to operate the radar
equipment, and on 31 August 1943 a conference was held in VF Design regarding the
 advisability of initiating a design study of the F7F with a radar operator. It
was decided that interested parties should visit the Grumman plant on 7 September
1943 to look into the matter and reach a definite conclusion. Thus, by letter
dated 20 January 1944, VF Design Branch formally requested Grumman to make a design
study for modifying the F7F to provide a place for a radar operator just aft of the
gas tanks. On 7 March 1944 representatives of the Bureau and Grumman including
Capt. J. G. Pearson Jr. and Comdr. E. W. Sweeney of VF Design, met at the con-
tractors plant for the mock-up of a possible position for a second man. Space was
made available by cutting down the capacity of the reserve fuel tank by 56 gallons
and lengthening the canopy. Because of the reduction of the weight of the gasoline
carried, this modification increased the weight of the F7F-2 over the F7F-1 by an
amount of only around 95 pounds. However, this reduction in gas capacity brought
a loss in combat radius of 100 miles. The Prototype F7F-2, the two-place version,
was made on the third production F7F. This modification was considered satisfactory,
and accordingly, the entire F7F production line became F7F-2's starting in October 1944, for 500 two place night fighters, the 36th and subsequent planes up to the 500th to be F7F-2's.

The F7F met the Marine and Fleet requirements for a night fighter with tricycle landing gear. However, because of this and because of its heavy weight of some 21,500 pounds, a distinct problem was presented in considerations to operate it from a carrier, since the type of barriers installed on aircraft carriers was designed to be used with the conventional type of landing gear. The CV-15 was the first CV-9 class aircraft carrier with the higher capacity arresting gear designed to accommodate operations of planes of the weight of the Tigercat, as the F7F came to be called, and in December 1944 an F7F-1 was successfully landed aboard an Essex class carrier with no trouble or bad landing and take-off characteristics whatsoever. Because of the satisfactory outcome of the carrier suitability tests, the United States became the first country to prove successfully that a heavy tricycle landing gear plane could be operated from a carrier. The success of the F7F brought about a request from the British for two F7F's, and in the spring of 1945 two models were sent to England for testing by the British aboard their carriers, and comparison trials with comparable British aircraft.

An extensive test program on the F7F which was underway during the fall of 1944 disclosed that the principle troubles encountered were:

1. Blast effect of the 20 mm wing guns.
2. Jamming of the .50 cal. guns because of horizontal mounting.
3. Marginal control forces harmonization and stability characteristics.

Because of the difficulties encountered with directional stability, Grumman was requested to design an enlarged vertical fin in an effort to increase the directional stiffness. On 15 January 1945 VF Design Branch initiated a conference to discuss the recommended changes of tail configuration in the F7F to correct the
directional instability. It was decided that the 166th and subsequent planes were to incorporate the new tail design.

The F7F failed to meet the final demonstration dive at Patuxent by failing to reach the required speed by 15 MPH. Longitudinal oscillations were encountered and the pilot feared he could not recover if he continued in the dive since the plane exhibited a tendency to go into an increasingly steeper dive. To correct this, rib spacing on the elevator surface was reduced to half, and this change successfully corrected the oscillations that developed during a dive.

The following designations of the Tigercat were authorized: F7F-1, the single seat version; F7F-2, the two place F7F; F7F-3, the strengthened version of the F7F-2 with an engine change; and all the night fighter versions of these models included an "N" at the end of the designation. By November 1944 Grumman was in production on the F7F-2N's, the F7F-1N program having been completed. This production plan continued until about March 1945 when production was started on the F7F-3, the day fighter version with 80 gallons more fuel and no radar equipment, which was to continue until about August of that year, after which it was planned that night fighters were again to be produced. The F7F-3 had an engine change from the R-2800-22W engine to the R-2800-34W. Both engines were interchangeable but the new engine had improved oil seals, improved supercharger efficiency and a higher critical altitude, and surge trouble which was encountered with the original engine was not present.

Since the Marine Corps was to receive a large number of these planes for night fighter purposes, evaluation tests were conducted by them and by Patuxent Tactical Test personnel at MCAS Eagle Mt. Lake, Texas. The Marines were interested in having a navigator as well as the radar operator and pilot, but since this change would involve a major design involving practically the design of a completely new plane, it was decided not to encumber the F7F program with the large amount of engineering work that would be necessary in making this possible. However,
improved radar equipment was made possible by installation of SCR-720 radar in the
F7F-3, and the fuselage forward of the pilot's cockpit was altered to accommodate
the SCR-720 scanner. This installation was to be incorporated in production when
the night fighter version was again resumed in the fall of 1945. Previous F7F-2N
models were equipped with APS-6. Another feature which was desired was the in-
stallation of the automatic and maneuvering pilot and this was incorporated in the
35th F7F-3N version. Modification of 49 F7F-3's to 3N's was accomplished by the
Navy Lockheed Modification Center at Van Nuys, California, which also modified
58 - 3's to 3P, the photographic version. All F7F-3's except 3P's were equipped
with rocket firing provision, HVAR rocket installation, four on each wing.

On 31 March 1945, VF Design called a conference to discuss and make re-
commendations as to the F7F armament problems. Comdr. T. D. Tyra, Comdr. W. E.
attended for the Branch. As a result of this conference it was decided to have the
contractor expedite the design and incorporation of the external Mk. 51 bomb rack
and pylon, and to have the Mk. 9 rocket launchers in production on the 250th F7F.
A further conference was held on 23 April 1945 to discuss the difficulties that had
been met with the nose gun installation, and the hazards attendant with firing long
bursts and consequent tumbling of bullets. Further studies were to be made and the
20 mm wing installation was to be incorporated as soon as possible. By July 1945
improved cooling and blast tubes on the .50 cal. nose guns had been installed and
a shift had been made from the .50 cal. to 20 mm wing guns.

A month before the end of the war, the first F7F's were being delivered to
the Marine Corps for use as land based day and night fighters, and the first
squadron of F7F-2N (with AN/APS-6 radar) was ready to leave the United States for
operations in the Pacific. However, this plane never got into combat operations with
the enemy and as of V.J. Day, drastic cuts were made in its production. However,

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the F7F along with the F8F became one of the Navy's important postwar night fighters.
P-8 - BEARCAT

Although the Bearcat was never able to get into combat with enemy fighters, it was in operation with the Fleet when the war ended. VF-19 began receiving its first P-8's for training in May 1945, and an accelerated test program had been underway since the first of the year in an attempt to place the P-8 into combat at as early a date as possible.

The P-8 was initially designed as a high performance interceptor fighter principally for use on CVB class carriers. At the time, November 1943, of the Grumman proposal, the need for an interceptor to protect the Fleet was of such high priority, and performance was so important, that small carrier limitations were not allowed to compromise the performance of this fighter. Contract Noa(s) 2419 was signed 27 November 1943 for two experimental XP-8-1 airplanes, and called for one experimental plane with the R-2800-C two-speed engine, and one with an "E" engine. A later contract, Noa(s) 4799, on which the production fighters were procured, was signed 6 October 1944. On this latter contract, 23 additional fighters designated as experimental aircraft were obtained and used for special test purposes. All of the experimental XP-8's were equipped with the "C" engine. The cockpit mock-up was held on 21 December 1943 with Comdr. Sweeney as VF Design's representative. By March 1944 the power plant was ready for inspection, and accordingly, a power plant mock-up was held 8 March 1944 at the Grumman plant in Bethpage, Long Island. Both Captain Pearson and Comdr. Sweeney from VF Design attended.

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The first experimental XF5F began flying 31 August 1944, and preliminary flights and tests indicated that the airplane would have few major troubles and that an early production rate of 100 per month could probably be met by June 1945. However, only 45 were actually delivered by that time.

The F5F was equipped with 4 x .50 cal. guns, although provisions were made on all production airplanes for carrying a 1000 lb. bomb on each wing. Hydraulic gun chargers were incorporated, 4 x Mk. 9 rocket launchers, 150 gal. centerline drop tank, and two wing racks.

An original 2000 fighters were placed on order under NAa(s) 4799, and was later increased to 4000, with a production schedule completely supplanting the F6F production by March 1946.

The need for this lightweight interceptor increased in the early part of 1945 to the extent that it was decided that General Motors (Eastern Aircraft Division) should produce a fighter based on the F5F and that Grumman Aircraft should furnish that company drawings and an airplane. This was similar to the plan that was evolved several years earlier when Eastern Aircraft produced FM's for the Navy, based on the Grumman F4F-8. Accordingly, in March 1945 there were numerous conferences held in VF Design Branch and in the Bureau on the subject. One of these conferences was held on the sixth of March with representatives of Grumman and Eastern Aircraft regarding ways and means to expedite the F5F and the F5M, as the Eastern Aircraft version of the F5F was Classification (censored) (changed to unclassified) by authority of

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to be called. On the 22nd a conference was held to determine which parts of the F3M airplanes should be interchangeable. The 37th airplane was assigned to Eastern Aircraft to further their production of the F3M's. These General Motors versions were never completed due to the end of the war and cancellation of their contract.

The twenty-five experimental planes were sent for test at various Naval activities and the plane was found generally satisfactory. However, on June 1945 VF Design was notified by NAS Patuxent that flight tests with a 150 gallon centerline drop tank showed unsatisfactory directional stability and control at high speeds and that rudder control was inadequate at low speeds. At speeds of 300 knots and above, longitudinal and directional buffeting developed which increased in severity with increase in speed. Accordingly, VF Design Branch requested the contractor to investigate at high priority the directional and flight characteristics of the F3F. A conference was held on 28 July 1945 in VF Design between representatives of Flight Test of Patuxent, Grumman, NACA and VF Design Branch to take up the matter of directional and flight characteristics, directional stability and buffeting. As a result of this conference, tank fins were installed as a temporary means for eliminating the buffeting and directional instability until such time as Grumman completed arrangements for the incorporation of a new tail. In August 1945 at the time of the end of the war, a general program was set up as a means of preventing buffeting of aircraft when carrying external stores. Test activities also reported it un-

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safe and unsatisfactory to fly the F&F with more than 250 pounds unbalance on either wing rack at low speeds. Hence steps were taken to insure simultaneous loading on both wing positions for installation and release of 500 pound bombs, 1000 pound bombs, and Tiny Tim. In order to give this new fighter increased fire power, one XPF was fitted with 4 x 20 mm T-31 guns and in June 1945 the first F&F with that installation was flown. In the following month, the contractor was asked to construct 100 F&F's with 4 x 20 mm guns installed.

In order to advance the performance of the Bearcat, the "E" engine Mock-up Board was convened at Grumman on 6,7, February 1946. Representatives from VF Design were Comdr. W. E. Sweeney, Comdr. T. C. Caldwell, and Lt. Comdr. W. S. Woollen. Early trial installations were projected for March with shift over in production dependent on the availability of the P & W engine, probably June 1947.

Although production of this small, lightweight 9000 pound fast fighter was drastically cut on VJ Day, it remains one of the main postwar Navy fighters.
FR-1 - FIREBALL

The first application of jet propulsion to a Navy fighter first made its appearance in the FR-1, or Fireball, and represented one of the means the Navy undertook to develop a light, fast fighter to outperform improved Japanese fighter aircraft. The FR-1 was a combination jet airplane, powered by a conventional engine as its main power plant and augmented by a jet propulsion unit as an auxiliary booster for exceptional performance when needed for a limited length of time. The balance between the conventional engine and jet unit was such that the conventional engine was adequate for all operation except where maximum performance was required. Except for the jet unit in the aft fuselage, the FR-1 was otherwise conventional in arrangement. By combining a conventional reciprocating engine with a pure jet engine as a booster unit, it was able to fall within the limitations of stalling speed and size permitted aboard the small carriers. Sea level rate of climb in excess of 500 fpm could be obtained in an emergency by employing the jet unit and the take-off distance in a 25 knot wind was estimated to be around 335 feet, but could readily be reduced to around 221 feet when the jet engine was in operation.

Powerful conventional engines are both heavy and large. However, jet propulsion units, though light in weight with respect to the large power output, are somewhat uneconomical in fuel consumption, and in order to take advantage of the first feature and to circumvent the second, it was decided to use the jet propulsion unit in conjunction with a conventional engine. Early in 1943 when this
matter was under discussion, Comdr. J. B. Pearson, who was head of the Fighter Branch, strongly advocated developing at highest priority a fighter combining the beneficial features of both a jet and conventional engine until such time as it was possible to perfect the jet engine for use as the sole propulsion engine in a pure jet fighter. The only favorable design presented the Fighter Branch was the one submitted by Ryan Aeronautical Company of San Diego, Calif. The ultimate successful operation of the jet engine was a matter of conjecture, yet it was certain that the development and use in the near future of jet power plants would be a necessary factor in the design of future fighter planes if they were to maintain constant superiority over those of the enemy and attain increasingly higher speeds and performance.

The XFR-1 was a low winged monoplane, weighing around nine thousand pounds gross weight, and designed specifically to have a take-off and stalling speed adaptable for operating from small carriers. It was planned for the FR to be substituted for the FM-2 aboard the CVE(s). Its tricycle landing gear was a new innovation in carrier fighters.

It was early anticipated that the airplane, the first of its type for Navy use, would probably require continued development during the early stages of the production program, and that it might not be possible to get the plane ready for Fleet use prior to early 1945 even if the test period were relatively free from trouble, which, as it turned out was not the case.

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The availability of the jet power plants would be to a great extent
determine the development of the airplane, though, as it was anticipated, the
engine became available for installation in the first experimental airplane by
the time the XFR-1 was far enough advanced to have it installed. Numerous con-
ferences were held early in 1943 between Ryan engineers and the General Elec-
tric Company and Westinghouse for the purpose of discussing the aspects involved
in installation of the jet unit. On 4 February 1943 a conference was held at
NACA, Langley Field, Va. to discuss the ducting system on the XFR-1 with emphasis
placed on obtaining a system which could be used with either a unit requiring
high velocity air at low pressure or relatively low velocity air at high pressure.
was agreed that the leading edge of the wing was the most efficient place to
introduce air. The same ducting system from the leading edge of the wing back
to the rear of the pilot's cockpit would serve equally as well for both types of
units. At that time consideration was being given to the possibility of installing
the Westinghouse jet unit, depending whether or not the general Electric unit or
Westinghouse unit progressed the more favorably. It was tentatively planned to
install the Westinghouse unit in the third experimental airplane for test purposes.

In the initial stages, the FR progressed rapidly, and on 19-22 March 1943
mock-up for the XFR-1, procured under contract NOa(s) 314, was held at the Ryan
attended for VF Design. Two months later, on the 17th and 18th May 1943, the main
power plant mock-up was held for the Wright Aeronautical Company's engine, the R-1820-56, two-speed, supercharged engine, with a rating of 1350 BHP for take-off. The cooling air provisions for this engine was somewhat unorthodox in that exhaust jet augmentation in conjunction with sliding or rotating cowl flaps were proposed in lieu of the more conventional outward opening cowl flaps. The fuel system was arranged so as to make all fuel available to either the main or jet power plant, or both, simultaneously.

By the fall of 1943 the need for a fast, light weight fighter such as the FR was increasingly evident and the Fighter Branch exhausted every possibility to expedite the development of the Navy's first jet fighter, and the plane's progress was marked. The Navy was anxious to get this plane into combat, and as an incentive and in order to further expedite Ryan's efforts, a contract was negotiated in August of 1943 for an initial production order for 100 planes. A procurement directive for 100 FR-1 fighters had been issued on 12 June 1943, and on 2 December 1943 contract No(s) 1322 was signed for the 100 planes.

An extensive wind tunnel test program was set up for the XFR-1 and numerous conferences were held by officers of VF Design Branch, and NACA and representatives of the contractor. One of these was held 28 June 1943 at Ames Laboratory. At this meeting Lt. (jg) Gavin and Mr. I. H. Driggs presented the Bureau's views in the discussions concerning the various problems that would be caused by the use of the jet units. It was decided that prior to the construction of any production planes, that the XFR-1 should be tested in the 16 foot tunnel at Langley Field, as

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a final check on the engine cowl and engine cooling on the jet unit installation, inlet and vane design, the oil cooler and the jet stacks. Results from other wind tunnel tests indicated that the original horizontal tail was deficient under several conditions of flight. NACA designed a new tail and authorization was given the contractor to proceed with it on the fourth airplane. By working closely with the contractor, VF Design succeeded in getting Ryan to incorporate the newly designed tail available for flight tests early in the career of the first experimental airplane.

The Navy's first experimental jet airplane, the XFR-1, was flown for the first time on 24 June 1944, with two flights of approximately 15 and 30 minutes duration. On these first flights, however, the jet units were not installed and the airplane was ballasted suitably in order to ascertain its flight characteristics. The second XFR-1 was flown on 20 September of that same year. This second airplane differed from the first in that the portion of the aileron control system in the fuselage was a push-pull rod type instead of the cable type that had been installed on the first airplane. By incorporating the second type of control system, friction in the aileron system, present in the first XFR-1, was reduced.

The first XFR-1 had been flying successfully for nearly four months when it crashed on a test flight on 13 October 1944 due to undetermined causes. Just a week prior to the crash of the first airplane, the second XFR-1 was flown to NAS Patuxent and arrived there 7 October 1944 for preliminary flight testing by Classification (censored) (changed to unclassified) by authority of

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Patuxent flight personnel. As had been anticipated by many Naval personnel working closely with the project, the combination-jet Fireball, being a distinctly new type of Navy fighter, would require many modifications and improvements before it could be sent out to the Fleet for strenuous combat operations. For three days Flight Test personnel at Patuxent flew and tested the XFR and reported a number of deficiencies, the most important of which were lack of sufficient rudder effectiveness and heavy aileron stick forces. From there it was flown to NAMC, Philadelphia, for carrier suitability trials, where it was found that the nose wheel oleo action needed to be revised to prevent bottoming and that the the c.g. appeared to be located too close to the main wheels. The thirteen arrested landings indicated that the propeller clearance was unsatisfactory, and VF Design initiated action to correct this by having incorporated a longer nose strut and new tire. Investigations were also made of relocating the arresting hook. At a conference held at NAMC on 10 November 1944 with representatives from Ryan, SEU, Delco (manufacturers of the shock strut) and Firestone (tires), and BuAer, an expeditious program was set up to improve the carrier landing characteristics of the Fireball. The program agreed upon was as follows:

(1) Relocation of the arresting hook
(2) Longer nose wheel oleo.
(3) Improved oleo metering pin.
(4) Higher capacity tire.
(5) Relocation of catapulting hooks.

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As the availability of new and improved jet engines appeared eminent, consideration was given to using them in the FR. In November 1944 the following program was proposed as experimental power plant installations in the FR:

Main engine:

(1) R-1820-74W — A Wright engine which was a slightly revised 1820 engine with 100 hp increase in rating.
(2) TG-100 — A General Electric gas turbine power plant putting 80% of its power into the propeller shaft and 20% into jet exhaust. It had a very high power/weight ratio.

Jet booster installations:

(1) 19B (Westinghouse) — a axial flow jet unit.
(2) 19XB (Westinghouse) — an improved 19B unit.
(3) I-20 (General Electric) — an improved I-16 unit.
(4) 24C (Westinghouse) — a new axial flow unit as yet in the design stage.

Until these jet units could be investigated, the main propulsion was given a conventional engine of increased rpm, and the combat planes were to have the advantage of this improved R-1820-72WA engine.

In November, also, definite plans were being formulated for commissioning an FR squadron. Cominich confidential dispatch 141427 of November 1944 directed Classification (canceled) (changed to unclassified) by authority of

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that the operating complement of VF-66 be filled with FR-1 fighters. This assignment of FR's was for the purpose of expediting service tests and for combat evaluation. By confidential Aviation Planning Directive 105-FS-44, dated 24 November 1944, CVEG-66 was assigned to the USS Salerno Bay, a Sangamon class carrier. However, plans for replacing the FM-2 aboard CVE's and for forming this squadron did not go on as quickly as had been hoped and by April 1945 VF-66 had received only four FR-1's with which to train.

VF Design Branch and the Navy had hoped that 1945 would see the Navy employ its jet fighter against the enemy, but instead, a vigorous testing program was initiated and a great many modifications had to be designed and incorporated by the contractor in order to meet Navy standards. Hopes were dimmed that the FR might get into combat before the war's end.

In January 1945 the second production plane was delivered to NAS, Patuxent for flight testing. Although the test program was being expedited by all concerned, it was already behind schedule by the crash of the first experimental plane in the fall of the year before, and so many new changes had to be in the production airplanes that the production program, too, lagged.

While the XFR was on the east coast, arrangements were made to take it aboard the USS Charger for carrier trials, and on 3 January 1945 it was successfully landed and flown off the carrier. Shortly thereafter, on the 15th, a conference was held in Engineering Division to discuss the changes that would be required as a result of these carrier trials. Comdr. T. D. Tyrmand

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Lt. Comdr. A. D. Pollock, the FR project officer, attended for the Fighter Branch. It was reported that the catapulting operations were carried on without incident and that the new forward position of the catapult hooks were satisfactory. The arrested landings were satisfactory with the three inch longer nose wheel strut, and in spite of predictions to the contrary, the tricycle landing gear caused no trouble.

Since the FR appeared to be a promising carrier fighter, VF Design was extremely anxious to get these modifications incorporated in the production planes so it could be a serviceable combat fighter. Accordingly, on 17 January 1945, the Fighter Desk wrote a letter to the contractor urging prompt incorporation of the following changes:

1. New long nose wheel strut and improved tire, relocated catapult hooks and possible shift of the C.g. location.
2. Modification to assure satisfactory engine cooling.
3. Modification to provide satisfactory rudder, particularly as regards rudder effectiveness and force.
4. Early demonstration, including the incorporation of modifications to assure spin recovery.

Naval test activities viewed the Fireball with a critical eye, almost amounting to suspicion, and no defect went by unnoticed. When Patuxent, in one of its reports, strongly asserted that it considered it the poorest of fighter airplanes recently tested as regards stability and control, VF Design Classification (censored) (changed to unclassified) by authority of

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Branch decided that the best and quickest way to correct the deficiencies, and get a really good combat semi-jet airplane out to the Fleet as soon as possible, was to assign a larger number of the production FR-1 airplanes to test activities for experimental purposes. The first thirteen airplanes were so assigned, and the fourteenth was to incorporate most of the recommended changes. Also, as a result of the deficiencies reported by Flight Test, it was necessary to assign an early FR-1 to NACA, Ames Aeronautical Laboratory, Moffett Field, for testing in their tunnel.

New troubles were encountered in March 1945 when the Fireball was grounded on account of a flap failure during a high speed pull-out at the contractor's plant. The plane was restricted to 400 mph indicated until such time as a temporary fix could be incorporated in all planes. In addition, two incidents occurred in which the access door to the entrance air duct to the jet engine blew off in flight, partially jamming the elevator control cables.

By the end of March the preliminary demonstration was completed and the plane had been demonstrated at higher velocities and higher g's than either the F4U or F6F restrictions permitted. At 20,000 feet, 345 knots indicated that 6 g's were demonstrated, while the F4U at the same altitude had been flown 325 knots and 4 g's. Seven and one half g pull-outs were successfully made and it was expected that the plane could be demonstrated to complete limits of the buffet boundary which was substantially higher than the F4U or F6F.

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Patuxent's preliminary report of its service acceptance trials, dated 19 March 1945, indicated that the FR-1 was unacceptable for service use as a fighter type airplane for the following major reasons:

1. Longitudinal static stability was negative in the landing condition and rated power climb.
2. Lateral stability was negative in the landing condition.
3. Take-off characteristics were unsatisfactory due to the aft location of c.g. relative to the main landing gear.
4. Directional stability was marginally weak.
5. Aileron forces were excessively high and aileron effectiveness was below Navy requirements.
6. Poor workmanship.
7. Lack of rigidity in the flap mechanism.

Upon receipt of the report from Patuxent another extensive program was immediately organized to correct the deficiencies. That program included the following:

1. Wind tunnel for full scale test of a revised flap installation.
   New flaps gave improvement in both longitudinal and lateral stability.
2. A trial installation of increased dihedral in the outer wing panels to improve lateral stability.

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1. Wind tunnel for full scale test of a revised flap installation. New flaps gave improvement in both longitudinal and lateral stability.
2. A trial installation of increased dihedral in the outer wing panels to improve lateral stability.
(3) A trial installation of a elevator spring such as was used on F4U-1's to increase longitudinal stability.

(4) Heavier engine and heavier propeller to be installed by August 1945 to improve the c. g. location and consequently, longitudinal stability.

The next definite set-back to the FR program occurred on 9 April 1945 when the third XFR-1 crashed. This was due to a structural failure and was brought about by the method of riveting employed. Fears were expressed that there might be a fundamental weakness to the whole airplane, making it entirely unacceptable for combat purposes. In order to allay any concern, officers of VF Design Branch flew to Ryan for a conference during which a very rigid experimental program was set up in order to correct, in a minimum length of time, the deficiencies that had been noted by Naval test activities. An increased number of planes were assigned to test for this program, thereby further delaying the readiness date for the first FR-1 squadron.

The situation had become so critical that from 6-8 April 1945, the Director of Engineering Division, Capt. T. L. Lonnquest, together with Comdr. Tyra from VF Design Branch and several officers from the various technical branches of Engineering Division, visited Ryan Aircraft to ascertain what had been accomplished and what could be done to correct the defects of workmanship as well as

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the deficiencies found in the general handling, controllability and stability characteristics of their fighter. The purpose of the conference was to examine the corrective measures proposed by the contractor and to affix definite dates on which the corrections would be made and evaluated satisfactorily.

Remedies under consideration were as follows: For lateral stability, it was proposed to substitute a single slotted flap for the double, and to increase the dihedral. It was expected that the single slotted flap would also improve the wave-off characteristics on carrier approaches. For improving longitudinal stability, there were three possible programs, one in which the tilted mount was the fundamental factor, another in which the extended engine mount, with or without tilt, was the main factor, and a third possibility was one for the extended fuselage and relocation of the landing gear. For improving the aileron forces, both the flat sided ailerons and spring tab mechanism were to be incorporated. By July an FR with flat sided ailerons, single slotted flaps and an elevator bungee had been tested by Patuxent resulting in greatly improved lateral stability and improved aileron forces, and satisfactory longitudinal stability. During the same period, in order to have completely satisfactory aerodynamic qualities, an increased dihedral for better later stability, an increased dorsal fin, an extended chord rudder for better directional control and stability, spring tab ailerons for better roll, and a tilted forward engine and extended nose were being prototyped and tested.

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By Confidential letter dated 6 April 1945, VF-66 which had been training and evaluating the FR airplanes, reported on characteristics it found in the airplane. While the troubles reported by NAS Patuxent were present and some were noticed only to a minor extent, VF-66 nevertheless found some very desirable characteristics, such as an improved rate of roll and turning over the current standard fighters. However, because of numerous maintenance troubles listed and the uncertainty of the FR's consistent good performance, the endorsement of Confairwestcoast, dated 13 April 1945, expressed an unfavorable reaction to the airplane as a whole. The following is quoted from the endorsement: "In view of recent difficulties encountered with maintenance and because of failures in flight, some question has arisen as to the suitability of this plane for service use. This command is of the opinion that every effort should be made to overcome the difficulties encountered both in production and in operation as the jet principal of aircraft propulsion is unquestionably a 'must' for incorporation in future designs."

Although the Navy and the contractor exerted every effort to expedite the incorporation of improvements and engineering modifications in the FR, it was nevertheless apparent by the middle of 1945 that their efforts were inadequate to the urgency of getting these jet fighters into combat use during the present war.

Studies were made for taking advantage of the new jet engines being developed for improving the FR. In order to obtain added performance, the main Wright
engine was changed to the R-1820-77W with the addition of a higher activity factor propeller, and the airplane with these improvements was designated the FR-2. The FR-3 was the designation given to the plane utilizing the General Electric I-20 jet unit in the aft engine instead of the original I-16. In the XF2R-1 the main conventional engine was to be replaced by a General Electric TG-100 gas turbine engine, driving a conventional propeller. This latter change brought about a 30 inch increase in length in the nose section by a redesign of the fuselage forward of the front spar below the cockpit floor. By employment of the TG-100 marked increase in performance was expected. By letter of 16 August 1945 Ryan submitted an engineering proposal for a FR with a 24C turbo jet engine with expected performance of 480 Vmax at 14,500 feet, rate of climb 7300 fpm, at sea level. A new wing utilizing a new airfoil section, would be included in model FR-4.

With the surrender of Japan, the Ryan picture changed perceptibly. Contract NOa(s) 1322 was cut back from 700 airplanes to 194, to be delivered at the rate of 10 per month through the first quarter of 1946, and five per month thereafter, until delivery of all planes under the contract was made. The FR-2, FR-3 versions were cancelled, and Ryan was working on a modification of the FR-1 to be powered by an R-1820-77W and 24C jet unit and on other beneficial changes. This airplane will be prototyped by two airplanes which have been authorized for test work and which will be designated the XFR-4. It is expected that these airplanes will fly Classification (canceled) (changed to

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sometime during the latter part of 1945 or early 1946, and if these prove satisfactory, the remainder of the airplanes to be delivered under contract NOa(s) 1322 will be of this new configuration.

Modification of the FR-1 design to incorporate a Westinghouse 24-C turbojet engine and a General Electric TG-100 gas turbine as the forward power plant was made in the fall of 1945, and the FR with these modifications was officially designated the XF2R-2 in December 1945. This change took place under contract NOa(s) 1322 which called for 66 production FR-1 airplanes. In addition, two XF2R-2 planes were authorized to be included under this contract. Besides the change in power plants, the XF2R-2 was also designed to have increased fuel capacity and redesigned wings. With these new modifications the improved Fireball was estimated vastly increased speed and rate of climb. It is expected that Ryan's engineering work will be sufficiently advanced for the mock-up to be held sometime around the middle of February, 1946. It is estimated that the first airplane will be ready for flight late in 1946. It is anticipated that cabin pressurization, pilot ejection, and after burning will be incorporated in these airplanes.

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XF5U-1

Besides the numerous modifications to the regular service fighters during the war, there were several new types under development of an experimental nature. They were all calculated to give increased performance. They were the XF5U-1, the XF38-1, the XF15C-1 and the XPD-1.

From point of age, the XF5U-1 is the oldest, having been started sometime before the beginning of the war. Its early conception has already been described in detail on preceding pages. Early wind tunnel tests have been encouraging, and by December 1941, there were indications that Vought's VS-315 design offered promise of being a successful military version, capable of attaining the speeds which had been predicted for it, around 500 mph. Comdr. L. C. Stevens, long a champion of this Zimmerman model, was very much in favor of pushing this development in view of the fact that it might turn out to be one of the most outstanding of future fighter types. At that time it appeared to be almost the only hope the Navy had of building a fighter in the 500 mph class. On 27 July 1942, Comdr. Stevens said, "We have been on this job two or three years now, and it still looks good -- but only in case it is pushed by placing an actual contract now. Conventional pilot's position is planned and will be arranged for. This may not be the "airplane of the future", but I know of no unconventional types with more solid and well founded promise." In addition, many believed that the development work on power plant remote drive and two speed reduction gear
unit might be utilized for other aircraft should the XF5U ever turn out unsatisfactorily.

Because the XF5U was the only fighter design in sight that offered such attractive performance when compared with the airplanes at that time, formal authorization to proceed with the project was given on 17 September 1942. Early progress of the design was delayed somewhat by the uncertainty of the engine development. An original R-1830 engine was to be used, but at the time of consideration was in an experimental status! R-2000 engine which was ultimately incorporated, was under development early in 1942 and offered the best promise of early development. At the time the authorization was granted in September, the contractor estimated that the airplane could be delivered by June 1945. This date was finally extended by some eight months.

Preliminary flight tests of the originally flying model, the V-173, from which the XF5U was developed, were carried out successfully in December 1942, and on 7 June of the following year the XF5U mock-up was held at the contractor's plant at Stratford. Both Comdr. Pearson and Lt. Comdr. Tyra attended from the VF Design Branch.

By 1944, however, the original high hopes for this airplane had diminished, and it was realized that it could not be developed into a service type for use in the current war, and that other service types were proving to be highly successful in combating enemy resistance in the Pacific. It was believed, how-

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ever, that it still had sufficient promise to warrant continuing its development, especially since it had become such a costly project. The airplane had several revolutionary features of design which VF engineers were desirous of testing, such as a circular wing, no fuselage, buried engines and special control surfaces, which of necessity required long and painstaking development. It was expected that these unusual features would permit the airplane to perform very well at high speeds and in addition to perform well in low speeds as a helicopter. Until the recent developments in 1945 of turbo-jet powered aircraft, the performance of the XF5U looked very attractive. In spite of the fact that the project had been very slow in developing, the revolutionary features inherent in the design were considered sufficient to justify the continuation of the project.

In June 1945 careful study was made by VF Design Branch of the XF5U project to determine an advisable course to follow regarding whether the project should be continued, cancelled, or modified. Since the estimated delivery dates for various items showed considerable delay over the delivery dates as set down in the original contract, and the original sum would be exceeded by several million dollars, a review was given the contract and VF carefully considered the usefulness of the XF5U program together with the advisability of fulfilling the contract or portions thereof, not only from the point of the military usefulness of the airplane but also of the aeronautical information that might be gained.

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by continuing the program through demonstration and flight test of the first airplane. Such information would provide an index upon which the first airplane would fly. This and other factors together with the nearness of the date on which the first airplane would fly had caused the Bureau to arrive at the following plan:

(a) The first airplane would be completed and flight tested at a site to be chosen by the Bureau, the scope of the flight testing would be reviewed in detail and revised so as to provide a program which will primarily furnish an evaluation of flight and aerodynamic portentialities and characteristics of the flying wing configuration.

(b) Contractor's demonstrations and static test requirements would be reduced in magnitude.

(c) Further construction work on the second airplane and its components would be reduced to the lowest possible priority.

After initial flights, consideration would then be given to cancellation of the entire portion of the contract.

As it neared completion in 1945, and ready for initial flight tests, Chance Vought proposed that the first flights be conducted in a dry lake in the Mojave Desert. Accordingly, arrangements were made by VF Design with the Army Air Forces, for initial flights at Muroc Dry Lake, California, and by the end of 1945 it was expected that the flight would take place sometime during the first part of 1946.
In a letter dated 6 December 1941 to the Chief Engineering of Boeing Aircraft, Lt. Comdr. Pearson expressed to him the sentiment of the Bureau as reflected in the current designs:

"The armament requirement is for four 20 mm. cannon with space provision for 200 rounds per gun, of which 165 rounds is normal load. The ammunition for these guns must be protected from 30 calibre fire through a cone of 15° from forward and 30° from aft. Space provision should be provided if practical for two additional 20 mm. cannons with the same armor and ammunition arrangements.

"Higher altitudes are definitely desired and the turbo is accepted for experimental fighters. The Navy leans toward the Birmann type, however, due to its improved efficiency as compared to the G. E. type. I believe that the best compromise for selection of propeller diameter and blade size is that which will give best efficiency at maximum speed, for a critical altitude of approximately 30,000 feet. Both the Wright and Pratt-Whitney Companies have designs for a two speed propeller gear in some versions of their new engines. I think that this gearing will be available for new airplane design which is starting now.

"Present thought on armor is for 30 calibre protection from forward with space provision for 50 calibers protection from aft through the cones as described in the above paragraph on ammunition."
"The X-Wasp and equivalent large right air-cooled engine (both developing around 3000 horsepower) may be considered.

"I believe that you will find that the landing speed will not be critical if you maintain a take off run of approximately 200 to 225 feet, which later figure is considered an absolute maximum.

"Consideration should be given to the installation of about 250 pounds of night fighter radar equipment. The only part that has to be located in any specific part of the airplane is an 18" hemisphere which must be unobstructed from forward. This weighs of the order of 30 pounds.

"Although it will not be a specific requirement it is considered desirable to have facilities for installing a 1000 pound bomb externally for dive bombing without any displacement gear. In its place a droppable tank can be installed to make possible ranges above the 1500 mile build-in gasoline requirement.

"Considerations should also be given to a combination of speed arrestors and/or dive brake for use in dive bombing as well as for slowing the airplane down for either night or day attacks on bombers. This correspondence led eventually to the submittal of the proposal for the XF3B-1 in spring of 1943 at which time it was believed that a long range fighter would be desirable in the conduct of the war in the Pacific."
Boeing Aircraft had been studying the possibilities of a design around
the X-Wasp (XR-4360 two stage) engine, and in April submitted such a proposal.
Since the design appeared attractive and the contractor guaranteed quick deli-
very if they would be permitted to proceed on their own without Bureau inter-
ference, authorization was given to proceed, and on 4 May 1943 Contract NOa(s)
742 was signed for three airplanes. The mock-up was held 20-24 September 1943,
and the power plant mock-up 13-15 December 1943. Captain Pearson and Lt.
Sutherland, the project officer, attended from the Fighter Desk.

It was expected that the XF2B would be a sturdy airplane capable of reason-
able maneuverability, heavy fire power and especially long range. Although its
size might be somewhat big for carrier employment, in the air it was expected
to be highly satisfactory as an escort fighter, skip bomber, attack fighter
or rocket carrier. It was designed to have six interchangeable .50 caliber or
20 mm guns with the highest combat radius of any fighter under design. It had
several distinctive features from other Navy fighter aircraft in that it utilized
counter-rotating propellers, and had a bomb bay which could be used to accomodate
extra gas as well as bombs.

The basic airplane was designed to weigh some 17,000 pounds, and at this
weight, the top speed was calculated at 418 mph at 25,000 feet altitude, with a
sea level rate of climb of over 3000 fpm. In the long range fighter configuration,
a 240 gallon leak-proof bomb bay tank and two standard external drop tanks would
be carried, resulting in a radius of action of 890 nautical miles, or a range in
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excess of 2700 miles. With a take-off weight of 17,000 pounds, a deck run of 475 feet with a 25 knot wind would be required. Having gone out 890 miles and dropped its external tanks, the airplane would then have a combat performance in the order of 375 mph at sea level and over 433 mph at 25,000 feet and with a rate of climb of 3660 fpm at sea level.

Production commitments hinged on the development of the two stage R-4360 engine, the dual counter-rotating propellers, and the plane's favorable comparison with other fighter types. A comparison is set forth below:

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<tr>
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<th>XF38</th>
<th>F2G</th>
<th>F4U</th>
<th>XF15G</th>
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<td>535 (with bomb bay tank)</td>
<td>355</td>
<td>340</td>
<td>352 (1 ext. tank)</td>
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<td></td>
<td>890 (2 ext. 350 gal. tanks)</td>
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By the middle of 1944, the airplane was not progressing so quickly as had been anticipated, and the original need had changed for such a plane with Fleet operations in the Pacific. Great speed and maneuverability, rather than long range was becoming of prime importance. The originally estimated flight date for early in the year was delayed and the initial flight did not take place until 27 November 1944 when it was flown for a duration of one hour and three minutes.

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Lt. Comdr. Sutherland, the project officer, flew the first XF6B-1 on 9 January 1945 and found the handling characteristics excellent, the take-off effortless, and that the stability appeared to be positive. The experimental flights were delayed by a crash on 13 February 1945. On 5 April of that same year the plane was flown from Seattle, Washington, to NAS Patuxent River, Maryland for preliminary evaluation. It was found to be an excellent flying airplane, but by this late date the Navy had no need for such a large, long range fighter, and consideration was therefore given to converting it into an attack-torpedo type. Inasmuch as the second and third airplanes were nearly completed and delivered to the Navy, but that no further planes of this type were to be constructed for the Navy. The three XF6B's would probably be used as limited demonstration planes, and for general flying under limited flight conditions. As of January 1946, the contract is being wound up as expeditiously as possible with curtailed demonstration.

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XF15C-1

In this first group of experimental Navy fighters in the early part of the war were two combination-jet fighters, the XF15C and the XFR-1, designed to utilize the jet development in aircraft engines and conformed to the Navy's belief at that time that a pure jet-fighter would not be suitable for carrier based operations. The XFR is discussed under a separate heading inasmuch as it became a production fighter before the close of the war. The second airplane to use jet propulsion was theXF15C-1 which was similar in general arrangement to the FR-1 but larger in that it was planned for use aboard the CV-9 class carriers.

Curtiss Wright Corp. sent into VF Design Branch a proposal for the XF15C-1 on 1 February 1944. It was designed to be an all-purpose, medium range fighter, with the radius comparable to that of the Corsair and Hellcat, and capable of attaining extremely high performance. It was to be a heavily defended plane using 4 or 6 light weight (T-31) 20 mm. cannon, which was the most recent development in aircraft armament. Like the FR, it had a conventional R-2800-E single stage engine as its main power plant, and in addition had an auxiliary jet unit arranged in tandem. The jet unit used in this particular airplane was different from any of the others used by the Navy fighters in that it was a British Helford H-1 unit. It was selected because of its high power and its expected early readiness date. Performance was calculated at about 485 mph at 25000 feet altitude, with a sea level rate of climb in excess of 4890 feet per minute.

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minute.

Because the XF15C promised extremely high performance at all altitudes, from sea level to 35000 feet, the Navy was anxious to procure some flying models for test purposes. A procurement directive for three XF15C airplanes and one static test article was signed 24 February 1944, and on 7 April 1944, contract NOA(s) 3245 was signed.

The mock-up was held the 6, 7, 8 April 1944 at the contractor's plant in Buffalo, New York, and the following month on 1 May the power plant mock-up was held. Three officers from VF Design Branch were on the mock-up board: Comdr. Tyra, Lt. Sutherland and Lt. (jg) Gavin.

On 10 October 1944 a conference was held at NACA, Ames Aeronautical Laboratory in order to solidify the XF15C wing tunnel program and to arrive at a workable program for improving carrier approach and wave-off stability characteristics. Lt. Comdr. Sutherland attended for the Fighter Branch. There were numerous possible modifications discussed, and the following program was finally agreed upon:

1. Incorporate a revised horizontal tail.
2. Tilt the thrust line — a new engine mount with thrust line tilted 5° down was to be built for incorporation in one airplane, provided the results of tests on the model with the revised tail indicated an

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improvement in longitudinal stability characteristics for take-off condition.

3. Off-set fin and increased rudder throw.

4. Dihedral — increased dihedral to be incorporated from the outer panels and possibly in production from the center panel.

5. Canopy — redesign the canopy in order to raise the critical Mach number.

6. Leading edge intake ducts — NACA's upper lip design was to be incorporated in all airplanes.

In the spring of 1945 the construction of the plane was progressing, and by March it was possible to complete the first flight by using the main engine only. The Halford unit was late in arriving from England and finally reached Buffalo on 20 March, some time after the XF15C was ready for incorporation of the jet unit.

By the end of April 1945, the first plane with the experimental H-1 unit, was flying at Buffalo with no trouble experienced, although the aileron and rudder forces were somewhat heavy at low speeds and light at 350 mph indicated. On 8 May 1945 the first XF15C crashed after running out of fuel while approaching the field at low altitude. By August the second airplane was flying status with the first production H-1 unit installed.

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In June the contractor proposed incorporating the T-tail on the 2nd and 3rd airplanes. This new arrangement had the advantage of 30% increase in spot aboard a carrier and indicated improvement in various aerodynamic factors during approach and greater stability during high speed flight.

The following changes were finally incorporated and resulted in satisfactory longitudinal stability and control characteristics, acceptable lateral stability characteristics and considerable improvement in directional control characteristics:

1. Incorporation of new horizontal tail with sealed internally balanced elevators.

2. Tilting the thrust axis down 5 degrees.

3. Replacing the double slotted flaps with NACA 27.5% chord single slotted flaps.

4. Incorporating a down spring or blowback tab in the elevator control system.

5. Off-setting the fin 2 degrees and using a larger dorsal fin than originally incorporated in the airplane.

The second airplane was tested at NATC Patuxent during October, November, and December 1945. While the performance created a favorable impression, the stability characteristics were so poor that the future of the airplane must await tests on the T-tail.

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Capt. Pearson of VF Design Branch recognized early in the war the trend toward the development of some type of jet propelled airplane and he was anxious that the Navy should also have a part in this development.

Although the first all jet Navy plane the XFD-1 was under development in 1942, there was only meager jet-propulsion information and experience available in this country.

England had gone further in the way of getting a useable jet engine, and in order to survey their progress, a group from Engineering Division, which included Capt. Pearson, went to England. It was felt that the scope of English jet development surpassed that of the United States by about 10 to 1. As a result of the visit of this Naval group, it was recommended that (a) larger effort be directed toward jet development, (b) the commitment for Allis-Chalmers to manufacture the Halford H-1 unit in America be carried out at high priority, (c) further liaison be arranged between organizations in America and Great Britain on these problems, in order that full advantage might be taken of the extensive work which had been accomplished in England up to that time, (d) that a representative be attached to the office of the Naval Air Attache, London, whose full time efforts could be applied toward following and reporting on jet development, (e) a joint Army-Navy-NACA working committee be organized to study the whole field of gas turbine applications to aircraft.

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and assist in guiding the development of these machines in the United States.

In spite of these recommendations the relative scale of effort remains at the time of writing greatly in favor of the British.

**NAVY JET DEVELOPMENTS:**

The idea of a twin engined all jet fighter had its conception in the Bureau in December 1942, and by January of the following year, an attractive proposal was received from McDonnell Aircraft Company, for building such a fighter for the Navy. A letter of Intent No(s) 161 was signed 7 January 1943 for three small conventional airplanes powered by two Westinghouse 19B turbo-jet engines. The mock-up held 31 May 1943 at the contractor's plant in St. Louis, Missouri, was attended by Comdr. Pearson and Lt. (jg) Gavin from VF Design. By 10 July the Westinghouse jet propulsion unit, the 19A, had successfully passed the 100 hour endurance test and the manufacturers were already working on an improved version, the 19B unit. In regard to these units, the following is quoted from a confidential memorandum, Aer-E-441, REB, FL1-4(1) QM (193), dated 10 July 1943:

"It appears that Westinghouse has done an outstanding job in the development of their engine. Unaided by any British experience in this field (because of the United States Army's secrecy restrictions) they have designed a unit which appears to be fundamentally superior from almost every standpoint to the British development. Moreover, they accomplished this in a relatively..."
short time. The original conception is less than two years old. The Bureau awarded a letter of Intent for a study contract only 17 months ago. The contract for the construction of the unit was let 9 months ago. The first unit was completed 4 months ago. The time required to develop this engine to the point of passing a satisfactory type test compares favorably with the development time of any experimental engine known to the Bureau. This was signed by Capt. S. P. Spangler, Head of PP Design Branch.

On 30 August 1943 contract NOa(s) 161 was signed for three experimental airplanes. The XFD-1 was designed as a 8200 pound twin-engine, jet propelled carrier-based interceptor airplane, powered by 19" Westinghouse axial flow turbo jet units, and using four .50 caliber guns for armament. This plane became the first pure jet fighter undertaken by the Navy.

Progress of the XFD-1 was rapid, but the Westinghouse 19B development had slowed up and by October 1944 only one jet engine had arrived at McDonnell for incorporation in the plane. Until 4 January 1945 when the second engine arrived, the contractor used the single engine for taxi tests. A series of engine difficulties delayed the first flight which eventually took place 26 January 1945. Two successful flights were made that day, totalling 49 minutes in the air.

By April 1945 the first airplane had made nine flights, making a total of 5 hours in the air. During this time a second engine failure was encountered apparently due to foreign materials entering the forward bearing through the oil system. With this exception, the engine operation was free from trouble. The
contractor's preliminary evaluation was nearly complete and the results indicated that the airplane was stable directionally laterally and longitudinally in the landing condition. In the high speed condition, a slight deterioration of stick-free longitudinal stability was noted and investigated. In addition, aileron forces appeared somewhat great. However, none of these appeared to be difficulties that could not be overcome.

XFD-1

The following unsatisfactory characteristics of the XFD-1 were discovered in the course of flight tests and corrections were made in later production models:

(1) Excessive aileron system friction.
(2) A fuel system difficulty suspected to be vapor lock.
(3) Slight directional oscillation at high speed.
(4) Possible deterioration of stick-free longitudinal stability at high speed.

The success of its first all-jet fighter, caused the Navy in February 1945 to authorize the procurement of 100 FD-1 airplanes. (See BuAer Con.
Procurement Directive C-06000 dated 27 February 1945) The FD-1 thus became the first pure jet fighter of the Navy to be the subject of a production order.

NOa(s) 6242 was signed 12 Mar.1945 for 100 production fighters. It was planned that 20 of these 100 FD-1's should go to test activities, 6-8 to technical training, and the remainder to form and support one squadron for evaluating the plane.

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24 Planes would be the number comprising one squadron. (See CNO confidential letter of 15 March 1945, serial 064631). The FD-1 was a development of the XFD-1, incorporating engines with advanced ratings and additional internal fuel capacity, and windshield modification, improved fuel system, gunsight and instrument arrangement.

On 22 and 23 June 1945, Lt. Gavin, the project officer, and Lt. Comdr. Sutherland visited McDonnell to investigate the progress of the flight program of the XFD-1, and the overall capability of the contractor to handle the various problems concerned in the transition from an experimental flying model to a satisfactory prototype fighter. It was found that McDonnell had done well on its tests and the second XFD-1 which was just in flying status had the revised horizontal stabilizer incidence which should eliminate or improve the undesirable longitudinal characteristics at high speed.

Two mishaps occurred to the first two experimental planes, one on 24 August 1945 when the second XFD-1 made a belly landing and the second on 1 November 1945 when the first XFD-1 crashed to complete destruction.

Due to VJ Day cutbacks, the FD-1 production was reduced from 100 to 30 planes. It was, however, contemplated to continue with the production and development of the FD's (Later named the Phantom), and to give them a thorough service evaluation by the Fleet, since this was the first all-jet Navy fighter to go into production and the first one to attain a speed in excess of 500 mph.

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NEW JET TYPES

Toward the end of 1944 Allied aircraft in Europe had encountered swift jet propelled German aircraft, namely, the Me 262 and Me 163. The realization that mass production jet aircraft was an actual fact, coupled by the belief of many that the Fleet would soon encounter comparable Japanese jet aircraft, led the VF Design Branch on 26 September 1944 to initiate requests for proposals from the various aircraft manufacturers for pure jet fighter designs that would give outstanding performance by taking advantage of the relatively large increase in performance made possible by the development of turbo-jet engines.

Although the XFD-1 was nearing completion, a need was felt for additional pure jet fighters designed around the new and improved jet engines. Three possible designs were accepted. These included the 9,000 pound XF6U-1 designed by Chance Vought around a single 24" Westinghouse engine with an estimated top speed of 541 mph, the 12,000 pound XFJ-1 of North American, built around the General Electric TG-180 engine with an estimated top speed of 544 mph; and the 12,000 pound McDonnell XF2D-1, built around two 24" Westinghouse engines with an estimated top speed of 572 mph.

The development of these three projects was urgent and given highest priority, and effort was made to get the first of these models built and in flight status early in 1946. Even after the end of the war, these projects were still being expedited, as they represented the Navy's principal advanced fighter types.

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Author: NND 913043
The following is a resume of the three latest jet fighter types:

XFJ-1 — A North American fighter designed around the TG-180 jet power plant. This airplane had the earliest estimated first flight of any of the three new jet designs. On 20 December 1944 a procurement directive was issued for three XFJ-1 model aircraft, and on 1 January 1945 the Letter of Intent NOa(s) 5311 was signed. The program advanced rapidly, and on 26-28 February 1945 the mock-up was held at the North American plant in Inglewood, California. Comdr. Tyra and Lt. Comdr. Sutherland, the project officer, were the VF Design members on the mock-up board.

On 1 May 1945 VF Design requested that the Bureau take action to procure production FJ-1 airplanes — an initial order of 100 in order to provide the Navy at an early date of an outstanding jet propelled fighter in quantity, and to provide a jet fighter in the Navy's fighter program which would be independent of the development of Westinghouse's 24C jet engine which might not be available until the second half of 1946. Two TG-180 engines were allocated from General Electric for the XFJ program with tentative delivery 30 October and 15 November.

In the original conception of the XFJ, the contractor proposed an airplane with a normal fighter gross weight of 11,300 pounds. This weight was considered to be higher than desirable and as a result of the discussion with the Fighter Branch and during the preparation of the detailed specification and contract, the contractor agreed to guarantee a normal fighter gross weight of 10,830 pounds with a c.g. location of 25.3% MAC.
From the beginning of its construction, the XFJ showed a constant increase in weight. Due to the natural tendency of a plane to increase in weight, the Design Branch warned the contractor that such an early weight increase was most desirable and might bring the plane to critical stage in its performance characteristics as a result of its overweight. The original calculated performance of a Vmax S/L 535, and 547/20,000, with a R/C 5410 fpm, was altered somewhat by the increase in October 1946 to a gross weight of 12,150 pounds, an overweight of 1320 pounds. With this latter weight the SL Vmax fell to around 535 mph, and R/C to 4780 fpm. However, its critical low speed performance, especially the critical take-off rate of climb condition was a matter of serious consideration in that the success of the whole future of the airplane depended upon the correction of the serious effects brought on by an overweight condition.

XF2D-1 - This newest McDonnell fighter is powered by two Westinghouse 24C turbo-jet engines and is similar in layout to the XFD-1. The gross weight is calculated to be approximately 12,400 pounds, with 4x20mm cannon for armament, for armament, and a combat radius of some 300 nautical miles. In general appearance it looks like the XFD-1 but it larger, with higher thrust engines, and consequently designed for greater performance.

Authorization to build three experimental XF2D models was given by Contract NOa(s) 6130 which was signed 2 March 1945. The mock-up was held 24, 25, 26 April 1945 at the contractor's plant in St. Louis, with Lt. J. G. Gavin as VF Design Branch representative.
XP6U-1 An all jet single engine fighter, powered by a 24C Westinghouse
turbo-jet unit. It is designed for small carrier operations, carries 4 x 20 mm.
T-31 guns in the nose, and incorporates tri-cycle landing gear, and uses
Metallite, sandwich-type construction.

Authorization to build three experimental XP6U fighters was granted by
Contract NOa(s) 5312 which was signed 29 December 1944. The mock-up was held
at the Chance Vought plant in Connecticut on 9, 10, 11 January. Comdr. Tyra
and Lt. Comdr. R. C. Merrick were VF Design Branch's representatives.
HIGH SPEED RESEARCH

With speeds far in excess of 500 mph anticipated for the Navy's post war carrier fighters, it became apparent that there was insufficient information available to make a rational design of an airplane to meet operating conditions in the speed ranges which were under consideration at the close of the war. Prior to this time, the operating speeds of airplanes in service were sufficiently low that major difficulties due to compressibility effects were not encountered. These effects began to become more important at speeds of approximately 3/4 the speed of sound and are believed to reach their maximum intensity at about the speed of sound itself. For airplanes in service, compressibility effects were largely evident in severe buffeting during high speed dives, with a partial or complete loss of control of the airplane. The solution, as far as service airplanes is concerned, was to keep them flying within safe limits and not to permit the airplane to enter into the compressibility range. However, the pure jet airplanes which are currently under development, are expected to have their level flight top speed limited by the drag increase associated with compressibility, and in diving or gliding flight can readily get into the speed range where extreme difficulties may be anticipated. The effects of compressibility can, in some measure, be alleviated by the use of thinner airfoil sections, by the use of sweepback in the wing plan form, and by special control devices. However, the information which is available as to the shifting
loads, the magnitude of improvement that can be obtained by various corrective measures, and the control devices required, is still very meager. Further, wind tunnel tests are not completely reliable in this transonic range, and the compressibility corrections to the tunnels themselves are not too well established. As a result of this definite need for specific information, VF Design undertook, in collaboration with the NACA, the development of a pure research airplane. This airplane, which is being built by the Douglas Aircraft Company, the D-558, was authorized in June 1945, and is being constructed sufficiently strong structurally to be able to withstand the most severe buffeting anticipated. It will also have provisions for installing various wing, tail and nose configurations and will be completely instrumented for measuring structural loads, control system loads and effectiveness, airflow characteristics and other high speed phenomena. It is anticipated that the first airplane which will be flying in June 1946, will be able to reach speeds in level flight of approximately 9/10 the speed of sound, and that the phase II airplane, which is expected to be forthcoming during the next year, will carry the airplane at least to, and probably above, the speed of sound.

Early in 1944 work was started in VF Design Branch on this project, and on 16 March 1944 a joint conference was held with representatives of the AAF, BuAer and NACA, at Langley Field, Va., to discuss the advisability of initiating such a research program. The NACA proposed a program of high speed aerodynamic flight

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research that would be advantageous to the Navy in conducting tests to investigate such basic problems as (1) air loads (b) stability and control (c) flutter (d) design of ducts and power plant installations. At the March conference it was agreed that the research necessary for the development of guided missiles and jet propelled aircraft required the procurement of a special high speed research airplane. Douglas Aircraft Company forwarded an informal submittal of data on its Model D-558 aircraft, and after lengthy discussions between officials of the Bureau, NACA and Douglas, NACA recommended acceptance of the proposal submitted by the Douglas Aircraft Company to construct special high speed airplanes which were calculated to reach a Mach number of 0.9 in level flight using a single turbo-jet propulsion unit, and which would reach a Mach number of 1.0 or higher in level flight using a smaller turbo-jet unit and a rocket boost. As a result of further conferences with representatives of NACA and Douglas, the original configuration was modified in various ways to comply with the requirements of NACA. In procuring these Douglas models of high speed research airplanes it was felt by all that this project would offer an opportunity for large advance in aerodynamic knowledge in the transonic region of flight.

In considering the construction of such high speed research plane, it was felt that the horizontal speed of this airplane must be greater than the maximum permissible diving speeds of present fighter aircraft. In collaboration with the High Speed Research Staff of the National Advisory Committee for Aeronautics, the

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Fighter Branch and Bureau made studies of a purely research airplane which would have sufficient thrust to drive it well above the normal critical speed and would be designed to withstand abnormally high loads. It was planned that it would carry a pilot, recording instruments and only enough fuel for very short flights. Evaluation was made of NACA and Bureau (& Douglas) studies in order to arrive at a configuration satisfactory to all parties.

It was planned to incorporate the data obtained from the research airplane in the design of a service fighter which, it was hoped, would exceed in performance any other fighter under contemplation.

Douglas Aircraft Company had been asked to submit estimates of cost and delivery for the design, construction and demonstration of the following:

(a) Six high performance research airplanes, plus one static test article.
(b) Three high performance VF type airplanes, plus one static test article developed from (a).

The purpose of this test airplane is to obtain aerodynamic characteristics of the airplane in level flight at speeds approaching a Mach number of 1. The project was to be considered in three parts, the first of which is outlined as follows:

Phase I — The design and construction of six test airplanes powered with General Electric TG-180 jet engines and equipped with special instrumentation to

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be furnished by the NACA. These airplanes will also be fitted with several alternate airfoils, intended to be used for test only and are to be uncompromised by combat equipment. These airplanes will be used to explore high speed flight characteristics to approximately a Mach number of .9, which is believed to be the maximum speed attainable with the TG-180 power plant.

Phases II and III are as yet unsolidified, and no definite outline of the plans for those phases can therefore be given, although it appears fairly certain that Phase II will include a sweepback configuration.

The mock-up was held at the contractor's plant in El Segundo, California, on the 2, 3, 4 July 1945. Commanders Tyra and Conlon attended from VF Design. The letter of Intent for Contract NOa(s) 6950 was signed 22 June 1945.
FIGHTER DEVELOPMENTS

Several technical and tactical developments occurred during the war which resulted in considerable and immediate changes in the conception and design of fighters. The fitting of droppable fuel tanks in early 1942 greatly extended the radius of action of the fighters as well as their endurance on defensive patrols. As the Hellcats and Corsairs began to appear in large numbers in Fleet operations, a definite edge in aerial combat superiority became evident. By early 1944 this edge had become so pronounced that a considerable number of fighter airplanes in the Fleet could afford to be used for other than pure fighter work. They were used first for diversionary straffing coordinated with dive bombing and torpedo attacks. The external supports used for carrying the droppable fuel tanks were also used for the carrying of bombs. This gave the fighter striking power sufficient to make it an important offensive weapon. With the decline of Japanese fighter opposition, the multi-purpose use of the fighter became more common. Further, the introduction of airborne rocket projectiles increased the tactical versatility of fighter airplanes and made them very useful in attacking enemy shipping, damaging ground installations, and supporting amphibious operations. In the last months of the war, all fighters were delivered to the Fleet with provisions for carrying both bombs and rockets.

Early study of the use of fighters for the above purposes was made by VF Design Branch and early in 1943 Lt. Comdr. T. D. Tyra, Assistant Head of the Branch, pointed out in his memorandum of 16 January 1943 that the fighter could be successfully adapted to carry such additional loads as bombs and torpedoes. The following excerpts are from this memorandum:
"From time to time the possibility of carrying bombs on fighter type airplanes has been considered, and in the past provision has been made for installing 2 100 pound bombs on each airplane. The general consensus of service opinion has been that these bombs are not sufficiently effective against surface targets to be worth the penalty in weight and drag which provisions for these bombs entails. It has also been thought that a fighter should not habitually carry bombs because these bombs would interfere with the fighting ability of the airplane. This consideration appears sound.

"However, within the past year a somewhat different conception has been growing as to the possible use of bombs or torpedoes on fighter aircraft. According to this viewpoint, bombs will not be carried when the airplane is employed as a fighter. However, it is recognized that there are many tactical situations in which it would be desirable to have more heavy bombing and torpedo planes than are normally available. For these specific operations, it is considered that fighter planes may be used to a good advantage as high speed, high performance carriers of heavy missiles. The structural problems involved are largely simplified by the fact that all our modern fighters are being equipped to carry and drop an external gasoline tank of approximately the same weight as a 1000 pound bomb."

It was pointed out the various uses made by foreign fighters such as the FW 190 and the Me109's and the British Firebrand, Whirlwinds, and the U. S. Army also used bombs on their P-40's and P-38's.

Another advancement during the war was the development of suitable airborne radar equipment. This was coupled with the gradual retirement of the Japanese from aggressive daylight operations. These factors led automatically to the development of the night fighter. At first this was accomplished merely by

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installing radar equipment on the standard day fighters, namely the Corsair and Hellcat. This configuration met with immediate success as it provided a means for disrupting Japanese night attacks and preventing enemy night raiders from attaining their objectives. However, the success of these stop-gap night fighters diminished as the Japanese became prepared for them and took suitable counter-action. The answer to this diminished success was the development of more effective radar equipment, which, due to its size and complication, required the use of a radar operator in addition to the pilot. This necessitated the used of a larger airplane to carry the crew and equipment and still maintain the required high performance and radius of action. To achieve the desired result in a short period of time, the original conception of the F7F was modified, first, to provide an additional seat for the radar operator, and second to incorporate a radar set of greatly improved characteristics.

In the power plant field, the major development which took place was the introduction of the jet engine which offered new possibilities in high speed performance. The disadvantages of high fuel consumption and poor take-off characteristics normally associated with the use of jet engines were minimized, and the Naval use of the additional performance inherent in jet engines assured, by the development of the combination airplane. At the sacrifice of some top speed, the endurance of the airplane using a conventional engine as its main power plant and the jet engine as a booster unit to give flash performance, is vastly increased over the pure jet type. In this type of configuration, the conventional reciprocating engine supplies the power required at low speeds for good take-off and landing characteristics and permits economical cruising operations, whereas, the jet engine is used as a unit to obtain the maximum in high speed and rate of climb.
Another major development during the war was the progressively increasing use of catapulting in launching airplanes from carriers rather than using the usual method of flying the airplanes off. At first, catapulting was used primarily aboard the small carriers. The slow speed of these carriers, plus the heavy loads carried by the airplanes, brought about the widespread use of catapulting as a habitual means of launching. Catapulting also came into general use for launching airplanes at night as it was found that not only were operations thereby expedited, but greater safety for the pilots resulted. This development of catapulting technique has enabled the Navy to take advantage of pure jet propulsion airplanes without being handicapped by the excessively long take-off run which they require.

By the end of the war, the fighter aircraft which, in the years just preceding the outbreak of hostilities had been under such heated controversy as to their place and mission with the Fleet, had proved to be the Number One service aircraft, capable of being employed for many different purposes as well as for purely fighter-interceptor tactics.

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Bureau of Aeronautics
Department of the Navy

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MEMORANDUM

1 June 1944

From: VF Design Branch
To: Technical Data Branch

Subj: BuAer War Aviation History.

Ref: (a) Engineering Division Memo 8-44 dated 17 Feb 1944.

1. In compliance with reference (a), VF Design Branch submits the following:

By the middle of 1943 it became evident that the Japanese were depending more and more on night attacks on our convoys and task forces. In the resulting development of various night fighter planes, it was decided to make the F7F-1 a night fighter by installing radar search equipment.

The first night fighter squadron to reach the Pacific was a squadron of PV's with night fighter equipment operated by Marine personnel, who had learned the science of night interception from the British. Both the British and their own experience indicated that it was most desirable to have at least two men in a night fighter. They felt that it was at best inefficient to have the pilot flying the plane in combat and operating the radar at the same time. They found that the best way to make a kill was for the radar operator to direct the pilot to such a position that a visual contact with the enemy could be made by the pilot, who could then go into combat in the conventional manner. The second man had the further advantage of being able to assist the pilot in navigation work during the long night patrols. Therefore, it was decided to change the F7F to a two-place night fighter, the F7F-2.

The F7F-2 mock-up was held in March 1944 at the Grumman Aircraft Engineering Company. The first prototype is being built from the third production F7F-1 airplane, and should be complete in July 1944. From the 36th production F7F on, Grumman will be building the two-place F7F-2's.

Adding a second place to the F7F was accomplished by merely reducing the size of the main fuel cell and extending the cockpit canopy a little further aft. This change increased the weight only slightly and it is estimated that there will be only a negligible decrease in the performance. At the present time a self-sealing fuel cell is being designed to fit in the place of the second man, so that by removing the night fighter equipment and installing the extra tank, the plane may be converted to a long range day fighter.

Other features are the same as the basic F7F. Namely a twin engine, high
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performance fighter plane with R-2800-22 Pratt and Whitney air cooled radial two-speed super charged engines, a top speed of 425 m.p.h. at 20,000 ft., a 3800 ft/min. rate of climb, folding wings and an arresting hook for carrier operations, tricycle landing gear, 4 - 50 cal. guns in the nose, and 4 -20 mm. guns in the wings, provisions for bombs and droppable fuel tanks.

T. D. Tyrus
Commander, USN
MEMORANDUM

From: VF Design Branch
To: Technical Data Branch

Subj: BuAer War History.

Ref: (a) Engrg. Division Memo. 8-44 dated 17 February 1944.

1. In compliance with reference (a), VF Design Branch submits the following:

The XF15C is similar to the Ryan XR-1 but is designed for greater radius of action. It is not intended to be operated on CVE's but only on combat carriers.

In order to conform to the Navy's idea that a purely jet plane would not be suitable for carrier based operations, the XF15C-1 will have, besides the one Halford H-1 jet propulsion unit, one Pratt & Whitney R-2800-E single stage engine. This combination furnishes the XF15C-1 with the necessary power requirements for carrier type aircraft.

This is a medium range, all purpose fighter with extremely high performance at all high altitudes, from sea level to 35,000 feet, and with the radius of action of the Corsair and Hellcat types. It ably combines both high speed and endurance and has a predicted top speed of almost 500 mph. The armament is comprised of 4 or 6 - 20 mm. guns, 200 rounds each. The mock-up of the XF15C-1 was held 6 April 1944 in Buffalo, New York, and the letter of intent is dated 7 April 1944.

T. D. Tyra
Comrd, USN

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Chief of Bureau of Aeronautics
Department of the Navy

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