THE GRUMMAN CORPORATION, THE FIRST TWELVE YEARS: THE RISE OF A NAVAL AIRCRAFT MANUFACTURER, 1930-1941

by

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Introduction

The Grumman Aircraft Engineering Corporation played a vital role in supplying the United States' Navy with aircraft during the Second World War. The company supplied three of the most numerous types purchased by the Navy from 1940-1945 and over one-half of all carrier aircraft used by the American Navy during World War 11.[1]

Table 1.1

Top Four Naval Aircraft
In Number Built During World War I1

1) Vought F4U Corsair*	12,581
2) Grumman F6F Hellcat	12,275
3) Grumman TBF Avenger**	9,837
4)Grumman F4F Wildcat***	7,898

*7,829 built by Chance Vought, 4,017 by Goodyear, and 735 by Brewster.
**7,522 (TBMs) built by Eastern Aircraft Division of General Motors, the rest by Grumman.
***5,927 built by Eastern Aircraft Division of General Motors, the rest by Grumman.

This corporation had been in business for just over a decade prior to the United States' entry into the war, but in that time it had risen from a small "auto garage" plant to a company housing nearly 700,000 square feet of work space, and it had also become one of the Navy's prime suppliers.

The 1930s were supposed to be a rough period for small companies in the aircraft industry. The large holding companies' control of the industry was being solidified by the Depression, yet Grumman was able to show continued growth throughout the period. How did this small corporation break into the industry during a period of decline? How was it able to become a military supplier when it seemed as if the market was sewn up? How did the company

hold onto the position as a leading naval aircraft manufacturer and continue to grow up to the Second World War and beyond? The ingredients to Grumman's prosperity were numerous, but there were a few that stood out.

The first component was it's management, led by President Roy Grumman and Vice-President and General Manager Leon Swirbul. This administration planned carefully and systematically in order to obtain a production contract and establish the company as a viable aircraft manufacturer. Management made many important decisions which guided the future of Grumman Aircraft, such as what type of airframes to manufacture and what market to enter. Management also made some sound financial moves during the decade that aided the expansion of the Grumman Aircraft Engineering Corporation.

Another feature responsible for Grumman's growth was it's excellent engineering staff which kept the company's airframes on the leading edge of the developments in naval avaiation throughout the decade. The young firm was engineer heavy, having a number of young, yet experienced draftsmen who worked together in pairs or teams. This allowed two or more minds to solve difficulties that arose. The engineering staff was not dominated by a single individual, but there were some exceptional men in this group. Roy Grumman assisted in the drafting process, and he was responsible for two patented features used on several of the company's airframes. His philosophy of strength and simplicity in aircraft construction was instilled in the entire staff. Chief Engineer William Schwendler was another catalyst to the effectiveness of the designs issued from the corporation. He was not only responsible for a great share of the blueprints drawn up, but his supervision of the entire department kept it moving forward. The engineers' designs led to a number of

"firsts" in naval aviation, and helped the company break some records in the number of planes contracted. The engineers were assisted by the National Advisory Committee for Aeronautics (NACA), which in the 1930s was a government organization researching aircraft design, primarily for military use. Grumman would use several of it's airfoils and cowlings. Grumman's engineers, through their own and the government's work, were able to utilize the development resulting from the technological revolution taking place in the aircraft industry during the 1920s and early 1930s.

Complimentary to the draftsmen was a skilled group of craftsmen in the experimental construction crew. Standing out in this group was it's leader, Julie Holpit. He had an uncanny ability to visualize the two-dimensiional blueprints as they would be in 3-D, enabling him to spot design errors or problematic areas. The speed and quality of the entire experimental team's work was a fruitful alliance with the acomplishments of the engineers, being greatly responsible for the high percentage of Grumman prototypes leading to production contracts.

Another key ingredient to the good fortune of Grumman Aircraft was it's association with the United States Navy. There was no written agreement, nor was there likely a known verbal command, in the Navy's Bureau of Aeronautics to give the company preferential treatment; however the Navy seemed to be quite congenial to helping the Long Island manufacturer get established. One reason for this was the Navy's desire for another aircraft supplier free from entanglement in conflicting markets. The naval background of Grumman's personnel was yet another link.

Another compliment to the firm's rise during the decade was the growth of carrier avaiation. The company emerged just after the in-

troduction of the Lexington and Saratoga, the first real fleet carriers of the United States Navy (the Langley being considered an experimental vessel). By December 1941, five more fleet carriers were operational and many times this number were on order. With this growth came the need for more aircraft built specifically for carrier operations, the predominant area the corporation worked in. Naval aircraft expenditures dipped downward with the Depression, but grew at a moderate rate from 1934 to 1940. Grumman would also expand at a steady gait.

There were numerous other ingredients for Grumman's successful first decade. It's geographical position in the industrial northeast was valuable for obtaining necessary materials such as aluminum and for shipping the company's finished goods to the United States Navy's ports, or exporting them to Europe or South America. The location also allowed the firm an abundant source of metal workers and machine operators laid off in the aircraft industry or other industries because of the Depression. This aided Grumman in obtaining the best personnel for it's production lines. The company's decreasing costs per pound of airframe also helped it gain contracts. The lack of preparedness by the Allied Navies in Europe, at least in the area of aviation, also contributed to the firm gaining orders after the war broke out in 1939. Similarly the United States rearmament program just prior to it's entrance to the war pushed it's sales upward. In comparison to the entire industry, Grumman's growth was not phenomenal except during the first four years. The rest of the decade stayed relatively steady to the industry's pace.

It was during the war that Grumman Aircraft climbed in the ranks of the aeronautical industry. The number of aircraft built from it's designs was much, much greater. The reason for it's

success in this period came from it's accomplishments in the 1930s. Examination in detail of the Grumman story will explain how this was done.

Grumman's Formative Years, 1929-1933

Though the Grumman Aircraft Engineering Corporation was established in December 1929, four years passed before it's first aircraft production contract was completed. Nevertheless the corporation's annual earnings increased during this period, so Grumman defied the odds of a small firm surviving in the aircraft industry of the early 1930s. The company's first four years coincides with the financial decline from the initial stages to the depth of the Depression. Small aircraft manufacturers with low capital reserves struggled to survive, and a large proportion failed. The industry was dominated by holding companies. The United Aircraft & Transport Corporation and the Curtiss-wright Corporation, the two most powerful aircraft oligopolies, obtained 71% of the Navy's aircraft business, close to 80% of the Army's purchases, and approximately 94% of the United States' commercial sales from 1927 to 1933.[2] There was a widely held assumption by small manufacturers that the Manufacturers' Aircraft Association, a World War 1 pool made up primarily of big corporation controlled the industry and the government's procurement decisions thereby sewing up the military market so new contenders could not compete. Grumman had limited capital and was not part of a holding company or the Manufacturers Aircraft Association, yet when most small companies were just trying to elude bankruptcy, it was able to advance and establish itself as a notable naval aircraft manufacturer.

What were the reasons behind the young business' financial achievements from 1930 to 1933? It's leaders' decision to produce fighters and amphibians for the United States Navy was one component, as was the planning on how to earn working capital while

getting established in the naval market. Complimentary to the company's decisions was the Navy's need for carrier aircraft and it's desire for another supplier that could devote most of it's attention to naval needs. The manufacturer's engineers would be very crucial to the inital success, for their designs would form the foundation of a positive reputation for Grumman aircraft soon to be held by many in the Bureau of Aeronautics down to naval pilots. The firm's utilization of the latest aeronautical technology provided Grumman prototypes with respectable performance and figures that enabled the firm to gain contracts.

The origins of Grumman Aircraft Engineering Corporation came in 1928 when the New York investment firm Hayden, Stone and Company, a part of the Curtiss-Wright Corporation, bought out Loening Aircraft Company, a Long Island naval and commercial aircraft manufacturer. Loening was absorbed by Keystone Aircraft, a subsidiary of Curtiss-Wright. A group of Loening workers led by factory manager LeRoy Grumman and Leon Swirbul however, did not want to join the Keystone work force in Bristol, Pennsylvania. They persuaded most of what they viewed as the elite of Loening's workers to become part of a new company being formed by emphasizing the facts that the merger called for relocation and the acceptance of demotions in position.

Grover and A.P. Loening, the brothers who headed Loening Aircraft, approved of the formation of a new corporation, but the agreements in the Keystone merger limited them to being investors. The capital they provided was a large percentage of the inital investments (See Appendix 1). Grover Loening was a respected individal in the industry, being an officer in aeronautical organizations and a consultant to the government on aviation affairs during the 1930s. His association with industry's elite did not hurt

the corporation's chance of gaining contracts, for he at least once, and likely on many more occasions referred potential buyers to Grumman Aircraft. The rest of the investors were part of the new management.

The background of the leaders of Grumman's management revealed the engineering experience of each individual. It also showed their knowledge of naval aircraft, influencing the decision of what to build and who to build it for. Roy Grumman, the president and second largest investor in the new firm, graduated from Cornell in 1916 at the age of twenty with a degree in mechanical engineering. He then worked for a short time for the New York Telephone Company. When the United States entered World War 1 in April 1917, Roy enlisted in the Navy and became a Machinists Mate, 2nd Class. He was then sent to Columbia University to study engine operations on submarine chasers, but while there he applied for avaiation duty. His request to become a pilot was turned down because of his flat feet, but he was sent to Massachusetts Institute of Technology (M.I.T.) to study aircraft inspection. In a few weeks he realized that a mistake had been made and that he was actually in ground school for flight training, but he kept quiet. After learning elementary flying at Miami's Naval Air Station, he was sent to Pensacola in July 1918 to complete his flight instruction. Graduating on 7 September 1918 as a naval avaiator, Ensign Grumman stayed at Pensacola to serve as a bombing squadron's flight instructor. Once this tour was completed, Roy applied for the Naval Course in aeronautical engineering taught at M.I.T. He studied under Edward P. Warner, later head of the C.A.B. Upon completion of this course, Roy rose to Lieutenant, junior grade and was sent to the Naval Aircraft Factory in Philadelphia as a project engineer and test pilot. He served as the production super-

visor,and flew the test flights, on Navy-built Loening fighter while at the NAF, catching the eye of Grover Loening who soon offered him a job. On 30 September 1920 the twenty-five year old Lieutenant resigned from the Navy to serve as General Manager and Test Pilot for Loening Aircraft. While working here from 1920 to 1929, his major contribution came with the Loening amphibian which he helped design and fly. Roy was largely responsible for the perfection of it's landing gear, an area that would be important to the beginning of his company. Grumman felt his background played an important part in his decision to run his own corporation. Later he stated, "My World War 1 experience as a Naval Aviator enabled me to gain knowledge and experience with aircraft that in 1929, I formed Grumman Aircraft Engineering Corporation..."[3] Roy Grumman had an abundance of practical experience designing and flying naval aircraft when he became president of the new firm.

Leon "Jake" Swirbul, the extroverted Vice-President and General Manager of the new corporation, had been a civilian aircraft inspector for the United States Army Corps before joining Loening in the mid-1920s. Although he led an active social life, this did not keep him from maintaining a rigorous work schedule. He saw to it that the assembly line ran smoothly, roaming the shop floor and conversing with employees to learn if they were encountering any difficulties in their assigned tasks. His door was always open, and workers were encouraged to come and discuss their likes and dislikes, and needs or desires. His amiable personality made everyone feel comfortable in his presence. Swirbul's social abilities placed him in charge of entertaining many of the visitors (such as military personnel and federal or foreign government dignitaries). Historian David Anderson stated that Swirbul's visibility was so high it seem-

ed as if he, not Grumman was the real mover and shaker in the company.[4] Although Swirbul was important, Grumann had a greater influence on the company.

Chief Engineer William T. Schwendler earned a degree in aeronautical engineering from New York University in 1924, and already had practical experience having worked part-time for Chance Vought, another naval aircraft manufacturer which became a subsidiary of U.A. & T. He was hired by Loening as an engineer the same year. He was a firm believer in stout construction of aircraft, and passed this philosophy on to the rest of the design crew at Grumman. His doubling of strength in the vital areas of an aircraft became known as the "Schwendler factor."[5] He would be greatly responsible for the numerous piston-engineered fighters which were produced on Grumman's drafting boards, and the reputation they would gain for their rugged airframes.

Rounding out the corporation's officers was Edmund Poor, formerly an assistant treasurer at Loening who would head this division at Grumman. Poor's assistant was Clint Towl, who had studied engineering at Cornell for two years before learning the brokerage business in New York. Each invested in the company. Joseph Stamm did not invest, but was made company secretary and purchasing agent. Historian Charles Bright called this group a "closely knit association of fliers from the twenties, the management of Grumman has aptly been called inbred."[6] The majority of the administration had a real grasp of aeronautical engineering, giving the company a group that studied the initial design critically and stated their opinions. This knowledge also allowed them to relate to the needs of the engineers and production crews.

During the last months at Loening the new management made the

key decision to enter the naval market. This choice proved to be advantageous, but may have been questioned in 1920. In that year commercial airframe production stood at approximately $33 million, three times higher that military airframe building. Commercial production seemed to be the lucrative market for the future, while those in the military market could expect fierce competition for it's limited funds. Sales to the military had dropped from $16 million in 1928 to just over $10 million in 1929. The Great Depression caused a drastic change in the industry's sales. Military sales remained fairly constant in the first years due to the five year plans in motion, however by 1932 commercial purchases fell to only $2.5 million.[7] This downturn could not have been anticipated by management, so why did the company choose to enter the military market?

Financial considerations played a major part in the decision to construct military aircraft. Simply put, the young corporation did not have the capital to absorb the losses of experimental work necessary in the production of airframes. In commercial manufacturing the company had to pay all the expenses of experiementation, hoping to gain the money back in eventual sales. If no contracts were obtained, it could not make up the loss and still have the capital to continue the experimentation process on another design. One or two designs moving through the research stages without gaining a contract could prove financially devastating. In contrast the military bought experimental models, and while this did not always totally reimburse the manufacturer for all it's costs, it provided a substantial remuneration. In it's formative years, Grumman Aircraft could accept the minimal losses of the design phase in research airframes not acquired by the military, or the deficit incurred in

building experimental aircraft purchased by the military; but it could ill afford the total losses of experimentation.

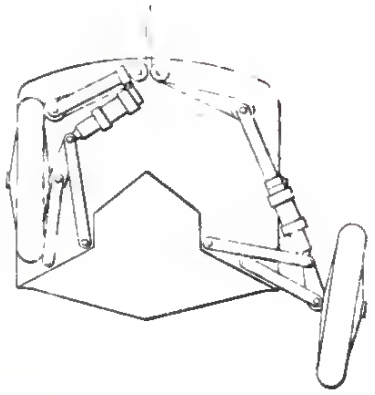
The naval market was also chosen because of the past experience of the management and engineers. These men had all worked with the naval establishment while at Loening and knew it would be much easier to obtain contracts from the Navy who knew them personally and also knew the quality of their work. They also realized the benefits brought by Roy Grumman's acquaintance with those in the high circles of naval avaiation. Edward P. Warner, Roy Grumman's aeronautical engineering instructor at M.I.T. was the first Assistant Secretary of the Navy for Aeronautics. He held this position when Grumman's management was making it's decision (but during most of the 1930s he held the position of Vice- President of U.A. & T.). His successor, David Ingalls, was a former naval pilot contemporary to Roy Grumman. Both had been Lieutenants (j.g.) in the Fall of 1918. The naval aviation community was small up to the Second World War, therefore Roy Grumman knew personally from his days as a pilot, instructor, an engineer at the NAF, and as General Manager of Loening, many of these men who rose into the Bureau of Aeronautics, and was acquainted with others at least by name and reputation. His experience was a key factor in choosing to build for the Navy.

Management knew that gaining a production contract would be competitive with Boeing, Chance Vought, Douglas, Curtiss, and others already firmly established as naval aircraft manufacturers, so they planned a systematic order to obtain a plane contract.[8] They first hoped to establish a name and some working capital by designing a float for the Navy. They also took on other work, such as the repair of aircraft, to gain funding for their aircraft

projects. The third step was to design an airplane for the Navy. Then they hoped to gain a production contract.

The first step was tackled during the last months with Loening when Roy Grumman and Bill Schwendler designed a float, utilizing Roy's newly patented retractable undercarriage, better suited to military performance. The hull would be stronger yet lighter, and the wheels would retract far enough to be flush with the hull for more aerodynamic and hydrodynamic cleanliness. The landing mechanism moved in a slightly deviated parallelogram rather than along a protracted arc swinging on a single hinge like that used on the Loening amphibian (See Diagram A.1 & A.2).

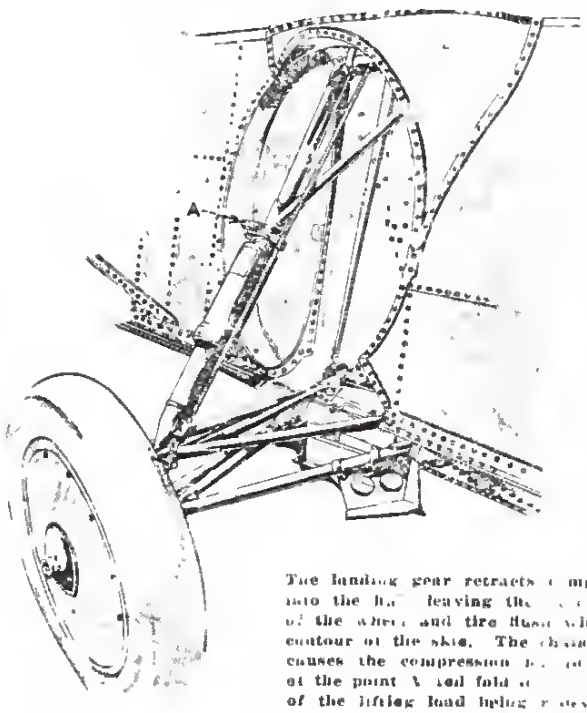
Diagram A.1:



Drawing from Grumman's retractable landing gear patent. The shock absorber strut has the hinge offset, so that under compression the eccentricity tends to keep strut from buckling. In retracting, cables turn the sheave or wheel attached to the upper end of the shock absorber member. The upper end turns inward, "dressing" the strut.

Source:
Richard M. Mack, "Retractable Landing Gears," Aviation, February 1933, vol. 32, p.36.

Diagram A.2:



The landing gear retracts completely into the hull, leaving the lower half of the wheel and tire flush with the contour of the skin. The chain drive causes the compression leg to hinge at the point A and fold as much of the lifting load being carried by the tension of the shock cord is relieved. The Aerol strut has a travel of 4 in.

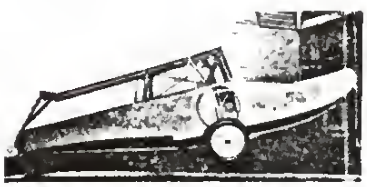
Source:
Grumman Utility," Aviation, December 1934, vol. 33, p. 393.

The engineer's blueprints for the float also included a monocoque design which obtained it's strength through stressed-skin

rather than a heavy framework. Monocoque construction reduced the weight of the design without reducing it's strength. Aluminum ring-shaped frames connected by lateral aluminum ribs, all covered by a heat or chemically hardened alloy outer covering was the basis of monocoque construction. It was just making it's entrance in naval airframe building, and it played an important part in the technological revolution that took place in the 1920s and 1930s in the aircraft industry. Grumman's use of the monocoque design showed that the company was up to date on the latest techniques used in aircraft construction while working on it's first project. The navy Department's Bureau of Aeronautics was skeptical about the strength of Grumman's monocoque float design, but granted the firm a contract for two experimental floats for $33,700.[9] The float was named the Model A (See Photo 1.1).

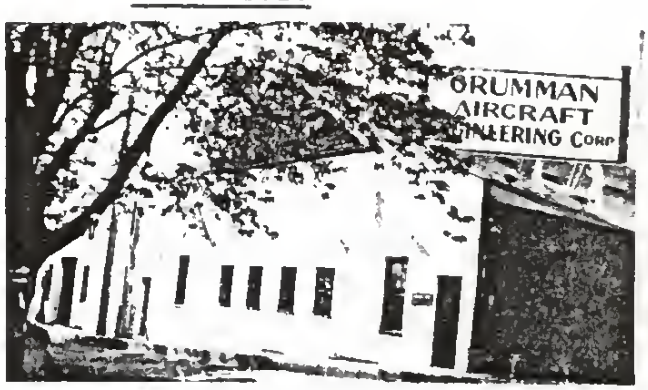
Swirbul found a small shop for Grumman Aircraft in Baldwin (Long Island), New York which had previously been home to an automotive showroom and garage (See Photo 1.2). "Clint" Towl was placed in charge of cleaning and preparing than plant for opening. Grumman and Schwendler were nearly finished with the Model A design when the business opened on 2 January 1930.

Photo 1.1:



MODEL "A" FLOAT, first development of the Grumman organization. Designed for the U. S Navy, because of the lack of amphibians at that time, and used on standard scout planes. Weight of entire installation, including retracting mechanism, was 700 lbs.

Photo 1.2:



Source: Grumman Advertisement, Aero Digest, vol. 36, no. 1 (1/1/40). p. 50.

The reasons Grumman built a float are easily distinguished. It required a low amount of capital, yet it could bring in enough to keep the small manufacturer functioning while aircraft designs were drafted. It was also a good way to earn a favorable reputation in naval circles, for the engineers believed they could easily build a better float than the heavy wood-framed types in use by the service.

To fulfill the second item on management's plan to gain a major order, Grumman looked for repair work on Loening amphibians. It was hoped such work would keep the shop busy and pay the operating expenses of the manufacturer. This was not successful in generating a large volume of business.

Grumman quickly took it's third step in the management's plan to become an established aircraft manufacturer. On 26 February 1930, Roy and Jake met with Commander Webster, Chief of Designs in the Bureau of Aeronautics, with the company's proposal for a high-performance two-seat fighter using Roy's patented landing gear. A couple weeks later informal proposals and drawings were sent to Commander Webster. These were informally approved by Webster on 29 March, and were followed by specific designs and data. This was the beginning of the XFF-1, X for experimental, F for fighter, F for Grumman (G had already been taken by Great Lakes). Informal discussion would be undertaken on each successive design, but there is little record of the contents of such meetings.

The XFF-1, as the Navy designated Grumman's first plane, and all it's successors went through the procurement process, which can be briefly described. Typically the Navy's Bureau of Aeronautics informed the industry that it was going to hold a design competition for a certain type of airplane. Those manufacturers

interested drafted blueprints, submitting these along with the projected performance of the design. From these the Bureau's Chief of Designs and his staff recommended to the Bureau's Chief which designs to choose. The number of designs picked to compete for production varied, depending on the funding available, i.e., how much Congress had appropriated, the quality of the designs submitted, and the degree of importance the type of airframe had in the Navy. The Navy usually picked at least two. The manufacturers chosen built experimental models to take part in a flying competition. After numerous tests conducted under the Navy's control were completed, the results were assessed by the Bureau of Aeronautics whose Chief decided which plane should go into mass production. The manufacturer and the Navy Department then made a negotiated contract on the number and the price of the airframes. The Secretary of the Navy had the power to override any of the decisions made, for each needed his approval. The Navy paid for the procured aircraft on a cash-on-delivery (COD) basis.

The XFF-1 did not originate in this manner, for it did not enter a design or flying competition. It's merits were based on the comparison to existing aircraft. This was not the only case where the Navy would test only the manufacturer's product, nor was it collusive behavior. It was an indication however, that Grumman was considered a viable manufacturer, and was given the benefit of the doubt on it's ability to design promising airframes.

The decision to build carrier fighters and amphibians was also important to the successful emergence of Grumman Aircraft. Roy Grumman influenced these choices. It was no coincidence that these were both the types he had worked on at the Naval Aircraft Factory and with Loening. There were other reasons why management

chose to construct carrier fighters. They realized that carrier aviation would be growing in the future with the successful operations of the Lexington and Saratoga, and with more carriers in the pipeline. Each carrier operated ninety plus aircraft, with additional squadrons training at various Naval Air Stations while the carrier was at sea. With about a four to five year average service life for naval aircraft during the 1930s, each carrier squadron would change it's compliment of aircraft two or thre times during the decade. Thus a carrier utilizing two air groups during the year would need aproximately 600 aircraft during a decade.

Grumman officials may also have realized that with carrier aviation still in it's infancy, no manufacturer would have a great edge in experience or a lock on certain types of carrier aircraft. The two companies building carrier fighters at this time, Boeing and Curtiss, were both adapting land planes to use aboard the floating airstrips. The new company likely felt it could provide a fighter better suited to naval needs by designing it with this in mind. It's management may also have learned through E.P. Warner or another source that Boeing's long-term development plans were in larger transport and bombers, leaving a vacancy that Grumman could fill. Although these are specualtions, each is a reasonable possibility. There is no denying that Grumman's entry coincides with Boeing's withdrawal in building this type, but there is no certainty of a connection.

After construction of the experimental Model A floats were completed in the Spring of 1931, they were tested by the Navy at Anacostia. The catapult launch was the severest test of the float, but it passed easily. The Navy learned that despite the Model A's weight, which was less than any float in service, even those with-

out wheeled landing gear, it was as strong if not stronger than any other. The Navy received it's first lesson that Grumman engineers understood the strain that naval aircraft had to withstand, and built accordingly. The Navy ordered six of the Model As at a unit price of $9,380.[10] The Navy Department was impressed with the landing gear implemented on the Model A. It asked Roy when he visited Washington, D.C. one week after the float contract was signed if his undercarriage could be used on the Navy's current fighter, the Boeing F4B-4. He emphatically stated "No!", noting the fuselage was much too slender for his gear. Roy did not want to see his patent on any other fighter design but his own.[11]

Loening amphibian repair and the contract for the floats was not enough to keep the shop force busy and was not bringing in enough working capital, so engineers drafted plans for aluminum truck bodies for Ted Lyon of Motor Haulage Trucking. Twenty-five truck bodies and a number of chassisless trailers were built during the Fall of 1931 (After World War II when aeronautical work was in short supply, Grumman diversified into aluminum canoes and fiberglass boats until it recovered it's market in military aircraft).

Grumman added to it's engineering corps during the first year, allowing a greater amount of design work to be undertaken. Tom Rae and Charley Niles joined the work force in the last half of 1930. Rae was a former associate, having been employed at Loening while studying engineering at New York University. In January 1931 Charles Tilgner was hired. He had a good background with a Master's Degree in civil engineering from Princeton, and experience with two aircraft manufacturers, one of which was

Loening. These three all worked on the modification of the float, allowing Roy and Bill Schwendler to work on the first plane. Additional draftsmen allowed the engineering staff to work in teams on the projects undertaken. This decreased the mental errors made, for others could catch the mistakes early. Grumman and Schwendler dominated the staff during this period when engineering was so crucial to the establishment of the company as part of the industry.

Grumman's engineers worked dilligently to create a fighter design having high performance, ruggedness, maintainability, and a number of other contradictory factors. Aircraft carrier landing and takeoff requirements were the first necessity to meet. American carrier tactics mandated a takeoff run of two hundred feet. TheNavy used the deck-load strike to get the most aircrafts in the air in the shortest time; therefore the lead airplanes had only one fourth of the deck to get airborne. When landing, carrier aircraft needed unobstructed visibility to snag an arresting wire stretched over the aft end of the flight deck. Carrier planes had "beefed-up" landing gear and increased overall structural strength compared to their land counterparts to absorb the punishment of controlled stall landings and the jerk of the cable stopping the craft. The carrier was operating independent of the battle fleet, since it was vulnerable during an engagement. Operating alone, the vessel needed the greatest number of planes possible to protect itself, the battle line, and still attack the enemy. The Navy, therefore desired small airframes that would take up the least amount of space on the carrier deck and hangar. The Navy regarded speed as extremely important, and was willing to sacrifice it only as a last resort. Faster planes could outfight ones more manuver-

able, being able to choose when to engage in combat and when to flee. A high rate of climb and maneuverability were other performance characteristics desired.[12]

In three days after receiving a formal request for a bid on the fighter from the Navy on 6 March 1931, Grumman submitted it's new fighter bid quotation. This was unusually fast, indicating the company had a pipeline in building this aircraft. The firm guaranteed a fighter with 190 m.p.h. capability at sea level, a landing speed below 66 m.p.h., and a climb rate of 12,000 feet in ten minutes. It was to be powered by the new 575 h.p. Wright Cyclone and a variable-pitch propeller (a prop whose bit could be adjusted from the cockpit). This was one of the first uses of a variable-pitch propeller, and a ten-year jump in front of the British naval aircraft.[13] Grumman increased the air flow around this engine by using the new engine ring (early cowlings) designed by the National Advisory Committee on Aeronautics (NACA). The internal structure of the wing was also NACA's design. It had two aluminum spars supporting the leading and trailing edges of the wing, these being connected by ribs which were braced in an elongated "N" fashion. The fabric covered wings were a staggered biplane (the leading edge of the top wing ahead of the leading edge of the bottom wing with an unequal span (top wing lower than the bottom). The fuselage was to be a metal monocoque structure housing the patented landing gear, a first for naval fighters, necessitating a deep belly giving the impression the plane was pregnant. Another first was the "coupe top", or canopy over the tandem cockpit. The engineers' use of the latest technology can easily be seen in the XFF-1 design.[14]

At the time of the design, there was disagreement in the

Navy's aeronautical establishment on the use of two-seat fighters. This was by no means a new discussion for such an argument had occurred since the inception of the fighter. Some naval officers supported the two-seater, believing the performance lost by the additional seat was made up through increased armament with the rear gun and improved navigation. Others felt better speed, climb, and maneuverability were most important, and to compromise by unnecessary characteristic was a mistake.[15]

Despite the dispute, the Navy's Bureau of Aeronautics under Admiral William Moffet's leadership ordered the XFF-1 on 2 April 1931, likely due to it's promised speed. Designs were sent to Julie Holpit, head of Grumman's experimental shop, who supervised the construction of a wooden mock-up. Each part was made of wood and fitted together to insure the blueprints represented a workable , three dimensional airframe. When the design was proven tenable, the experimental shop began building the actual aluminum-framed model. The Bureau of Aeronautics asked the company to design it's own rear-seat gun guidance system and submit it to Commander Webster, for the Navy was experiencing difficulties in finding a competent design.

Design teams were also working on the modification of the Model A float which became known as the Model B. During the Spring the Navy ordered two experimental "B" floats at an average unit cost of $12,960.[16] These were constructed quickly, and then handed over to the Navy for evaulation. Following these tests, the Navy awarded Grumman a production contract for fifteen Model B floats at a unit price of $5,6255.[17] These floats were used on the Vought O2U-3 Corsairs (See Photo 1.3). Management's plan was running smoothly.

Photo 1.3:

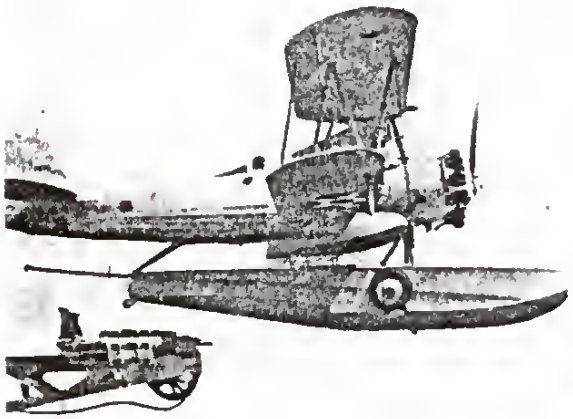
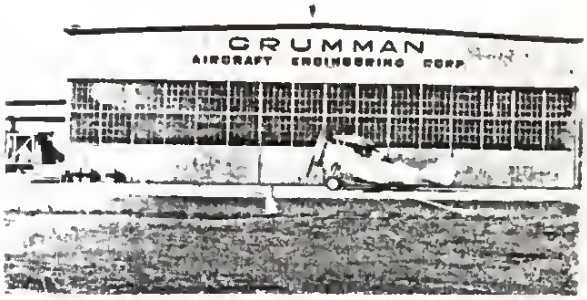


Photo 1.4:

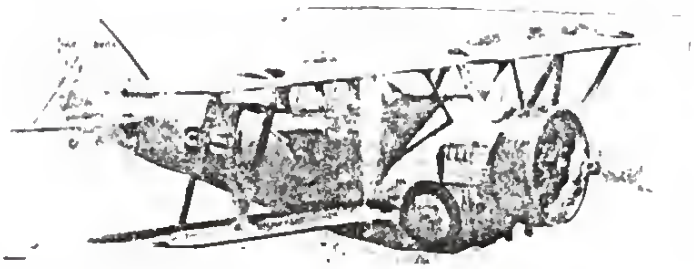
plant at Valley Stream



Source: Aero Digest, vol. 36, no.1, January 1940, pp. 49, 50.

With the float and experimental plane contracts, more space was needed at the factory. On 4 November 1931 the corporation moved into an old Naval Reserve Hangar at the Curtiss Airport in Valley Stream, Long Island (See Photo 1.4). After settled in, production began on the Model B floats and the XFF-1 was completed (See Photo 1.5).

Photo 1.5:



Source: Aviation, vol. 36, no. 4 (April 1937).

On 20 December the XFF-1 began the first phase of testing that service aircraft must endure, i.e., the contractor's demonstration. At this time test pilots could not be an employee of the manufacturer, so civilian pilot William McAvoy's services were obtained for this flight. After checking the ground handling charac-

teristics of the XFF-1 during taxiing, McAvoy took off, but he soon made a premature landing. An untightened oil cap had come off and oil covered the windscreen. McAvoy soon returned to the air to complete the flight test. He appraised the plane as a fine machine, being stable yet responding well to controls.[18] McAvoy reached 195 m.p.h. at sea level, and later naval testing showed a speed of 201 m.p.h. Aviation historian Bill Gunston stated that this speed was "faster than any aircraft in the Navy or, so far as I can discover, any Air Force at that time."[19]

The XFF-1's speed certainly outclassed the United States Navy's prime fighter. The Boeing F4B-4 attained a maximum speed of only 195 m.p.h. at 15,000 feet, and 169 m.p.h. at sea level, significantly lower than Grumman's new plane.[20] It's 120 gallon fuel tank provided a range of 800 miles, comparable to other fighters. The United States Navy would continue to procure fighters with this range throughout the decade, revealing that it did not anticipate the long-range fighter escorts needed in the vast Pacific. This shows that fleet defense would continue to be the naval pursuit's main task, and that the Navy expected dueling carriers to engage each other at smaller distances than actually occurred in World War II. Time to climb to 10,000 feet was approximately ten minutes, somewhat below Grumman's guarantee and the performance of current naval aircraft. A 23,600 feet service ceiling was recorded, also slightly below standards of the day. Despite these limitations, the overall performance of the XFF-1 was better than most single-seat fighters. It's deficiencies started Grumman considering a single-seat pursuit.

The Navy then began it's testing, a phase that took some time (one year for the XFF-1). Aircraft were put through numerous tests

at Anacostia. Pilots reports were written and critical inspections were made, listing any recommendations for changes or modifications, after each flight. The data from these reports was evaluated by the officials in the Navy Department before making the decision whether to purchase production units. [21] Grumman anxiously waited the verdict.

During the Spring of 1932, the engineering department worked on the modification of the XFF-1 into a scout (XSF-1) and an amphibian design joining the fuselage of the FF-1 with the Model B float (XJF-1). Grumman and Schwendler headed these tasks. Roy enjoyed drafting more than his presidential duties, helping to give the impression that Swirbul did most of the wheeling and dealing.

By June the Model B floats, practically the only production order worked on during the year, had long been completed. This left the shop force without much work, but the experimental team soon became busy, for on 9 June 1932 the Navy exercised their option for the scout version of the FF-1. The SF-1 was to have an increased range over the FF-1, but would lose some of it's armament. The SF-1 was Grumman's only experimental order in fiscal year 1932.

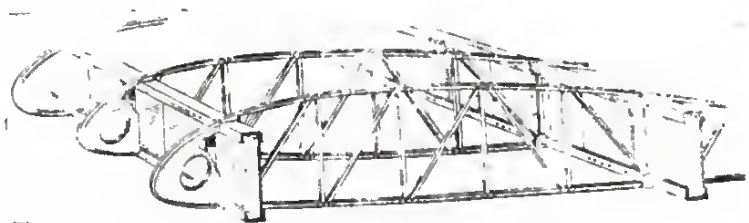
Despite these contracts, the financial picture was not good during the Summer of 1932. With no production orders, Grumman laid off it's workers for two weeks. When they returned the engineering staff worked on the single-seat fighter started after the XFF-1's deficiencies were revealed.

Work was also continued on the amphibian's blueprints. Jack Neady, a former engineer at Loening who had moved to Bristol during the Keystone merger, joined Grumman. His specialty was

hydrodynamics, so he had been made chief draftsman of the XJF-1 project. In August 1932 the Navy ordered an experimental amphibian, needing an aircraft for target towing; aerial survey; aerial photography; rescue; and various other functions which could take-off on land, sea, or a carrier's deck. Grumman's design looked promising.

One can see the company's previous designs in the XJF-1. Grumman engineers used similar features to assist in the production of each successive design. The fuselage, engine ring, and cockpit were similar to the XFF-1. The wings were a stagger biplane connected with "N" type struts, but this time of equal span. The fabric-covered wings internal construction consisted of dual spars with "N" type braced ribs (See Diagram A.3). The fuselage and float were mated with external skin making them look like one structure. Grumman increased the top heaviness of it's engineering corps when Richard Hutton joined the work force. He had worked in Loening's shop after graduating from high school, joining Grumman's shop force at Baldwin while taking night courses in drafting and engineering at Pratt Institute in New York. He moved

Diagram A.3:



The wing structure. Extruded channels of 17ST form the spar f[illegible] web brac[illegible] consists of plates riveted alternately along th[illegible] and rear spar faces. Stainless steel shot-welded ribs are by Fleetwings. In[illegible] Drag bracing, not shown, is of orthoux tie-rod desig

Source: "Grumman Utility," Aviation, Dec. 1934, p. 302.

up in position when he completed this course. Historian David Anderson called Hutton "th brilliant young designer of so many of Grumman's aircraft..."[22] His major contribution came with the Hellcat nearly a decade later, however his and Neady's hiring before gaining a production contract shows the company's dedication to the team design concept.

The XSF-1 flew for the first time on 20 August 1932. The manufacturer's flight showed a top speed of 207 m.p.h. with it's 700 h.p. Wright Cyclone. It's range was 1,100 miles, 300 miles better than the XFF-1. The Navy took over the tests with the delivery of the plane to Anacostia.

While keeping abreast of the Navy's testing of the XSF-1, the experimental shop worked on the amphibian and the engineering department completed it's draft of the single-seat fighter. On 2 November the Bureau of Aeronautics asked for a XF2F-1. The biplane fignter was smaller than the XFF-1, yet it housed a more powerful engine (Pratt & Whitney 625 h.p. XR-1535-44) giving it increased performance. Better aerodynamic efficiency was gained through the use of NACA's new cowling which surrounded the engine. This was the first use of a two-row radial engine in a fighter, allowing a smaller fuselage design. This was also the first single-seat naval fighter with an enclosed cockpit. The XF2F-1 incorporated Grumman's patented undercarriage, which created another fat-bellied, metal-skin, monocoque fuselage. A fabric-covered NACA airfoil in a staggered, unequal span structure extended outward from the airframe's body.

Grumman moved into it's third factory in it's third year of existence in November 1932. The plant was located in Farmingdale, again on Long Long Island. Originally built for a trucking firm,

Photo 1.6:

Source: Aero Digest, Jan. 1940, p. 51.

it had just previously been home to American Airplane and Engine Company. Adjacent to the plant was a larger grass airfield.

Good news came quickly after the move to Farmingdale. In the middle of December the first production order arrived from the Navy Department for twenty-seven FF-1s. The average price per plane was $19,000.[23] This was the beginning of management's last step to establish a permanent foothold as a naval aircraft supplier, for once a production contract was completed, it was believed the Navy's confidence in the new firm would be confirmed.

The contract caused the shop force to expand rapidly from the previous forty-two workers. Experienced and skilled craftsmen were obtained since most aircraft corporations were decreasing their work force due to the financial pinch caused by the Depression. These men were hired to perform the numerous tasks required to construct an airframe. Benchhands prefabricated various parts, their work being apportioned by a dispatcher. Sheet metal workers cut, formed, and hardened metal by heat or chemical solution. Men operated drill presses, grinders, lathes, milling machines, saws, punch presses, and routing machines, while others were assigned as welders, riveters, bucker uppers, coverers (those working with fabric), armorers, electricians, etc. Assemblers constructed different sections such as wings, fuselage, fin and rudder, and stabilizers; and then joined them into one airframe.

Early in 1933 the Bureau of Aeronautics ordered twenty-seven

machine gun mountings to be placed into the FF-1. The engineers made the gun and chair swivel together with manpower guiding the system. Each gun mount was priced at $150.[25] Grumman's simplicity of design had come through when other turret designs failed. The engineers again proved their ability.

While the assembly line began producing the FF-1, Holpit's experimental team completed the amphibious XJF-1 "Duck". It conducted it's manufacturing test flight on 4 May piloted by Paul Hovgard. The 700 h.p. Pratt & Whitney provided enough power to reach 165 m.p.h. It's overall flight characteristics were viewed as acceptable, so the Navy took charge of testing after delivery to Anacostia.

In the Spring of 1933 FF-1s began rolling off the assembly line, with deliveries to Fighter Squadron VF-5V of the U.S.S. Lexington beginning on 21 June. Approximately five were delivered each month until the order was completed in November. The performance of the production aircraft had been increased with the use of a 755 h.p. Wright Cyclone and a larger propeller. Speed rose to 220 m.p.h. at 7,000 feet, and 10,000 feet could now be reached in seven minutes. A ten-gallon increase in fuel capacity extended it's range to 860 miles.[26] Naval aviation historian Theodore Roscoe thought highly of this plane, stating; "Perhaps the best carrier plane produced in the first half of the 1930s was the stubby little Grumman 'Fi Fi' (as the FF-1 was affectionately called by the pilots)."[27] Although the fighter performed it's tasks admirably it was the two-seat pursuit used in the interwar period. The Navy realized, through the application of the FF-1's successors from Grumman, that single-seat fighters could establish air superiority, desired in naval theory on fleet air defense, better than the two-seater.

While the FF-1 production was in full swing, Julie Holpit supervised the construction of the latest fighter, the XF2F-1. It recorded it's first flight on 18 October 1933 with Jimmy Collins at the controls. He noted that it was fast, maneuverable, rugged, and a little touchy during takeoffs and landings. This initial test and the subsequent naval tests showed the maximum speed to be 220 m.p.h., yet it still had a slow landing speed of 66 m.p.h. It registered an initial rate of climb of 3000 feet per minute, dropping off to 2,200 feet after losing it's forward momentum. The XF2F-1 ascended to a ceiling of 29,000 feet. With it's combination of speed, climb, maneuverability, and small size, the XF2F-1 seemed perfect for carrier duty during this period.[28]

Although production of the FF-1 ended in November, the assembly line was not idle for the Navy ordered thirty-four SF-1s on 4 December. The corporation originally priced the contract at just under $800,000, however a Navy "Fair Price Audit" reduced this sum considerably. The cost of each plane was lowered from $19,000 to $16,000. The total price now equalled $687,260, saving the Navy Department $82,000.[29] Thirty-four $150 flexible gun mounts were also ordered.[30] Now that Grumman was gaining working capital, it was not going to be given as free a hand to set slightly "inflated" prices. Although it appears that the Navy Department gave the company slightly preferential treatment during it's first years, allowing it to make a profit on experimental orders when other manufacturers could not, this was only to allow the firm to function until an economy of scale could allow profits to be made, i.e. until production had grown large enough to make financial gain possible. The Navy could not afford to allow any manufacturer to make a high profit on a contract, for accusations

of profiteering and scandal had led to a Congressional hearing (Delaney Hearings) which was currently investigating the practices of the aircraft industry. Bad press would not help the growth of naval aviation.

During the first few years of Grumman's existence there was active opposition to the Manufacturers Aircraft Association, a cross-licensing agreement formed in July 1917 under pressure from the government which desired mass production utilizing all the latest aeronautical developments. The government saw the pool as the best arrangement to meet the needs of World War I. It aided in the concentration of the industry by allowing the selected companies of the patent pool to use all the latest developments, thus giving them better chances to gain orders than those outside the pool. Those uninvolved called for it's dissolution after the war, but it continued to function. The Hoover administration expressed the virtue of laissez-faire capitalism, however it did not oppose voluntary cooperation among businesses and the government. The companies connected with the "Air Trust", primarily the subsidiaries of United Aircraft & Transport and the Curtiss-Wright Corporation, had grown substantially, and the government supported big business. Such growth was viewed as economically beneficial to the country. If the companies of the Air Trust could provide better airplanes, then this would reduce foreign imports. These companies also utilized lobbyists to aid in obtaining contracts.

The Depression, combined with accusations of profiteering and claims that United States military aircraft were inferior to foreign airplanes, caused the government to listen more closely to the opposition of the Manufacturers Aircraft Association. From 1933 to 1935 three Congressional investigations looked at the

practices of the aircraft industry. The most important from the naval standpoint was the House of Representative's Naval Affairs subcommittee on Aeronautics hearings concerning naval aircraft manufacturers. Congressman John Delaney of New York presided, hence the investigation has been called the Delaney Hearings. The Senate's inquiry of the munitions industry included a section examining the aircraft industry. North Dakota Senator Gerald P. Nye chaired the comittee which came to conclusions similar to the Delaney Hearings. The third hearing concerning aeronautical practices was held by the House Committee on Patents, which investigated the Manufacturers Aircraft Association.

Among the most vocal of the independent aircraft enterpreneurs to oppose the Air Trust was James Martin, president of the Martin Aircraft Factory (not to be confused with Glenn Martin, whose company was part of the MAA). He believed the pool "made it impossible for an [independent] inventer...to get his device into operation... [or the MAA] managed that it's adoption is arranged for their benefit..."[31] Martin claimed eight to twenty-two patents on all modern aircraft, yet he never received any form of royalty. He maintained his aircraft designs were greatly superior to others, yet he was unable to gain contracts because of the Air Trust. He designed a fighter capable of 212 m.p.h. for the Navy, but Jerome Hunsaker, a Curtiss Company "air-trust agent" held a commanding position in the Navy service and had prevented tests in our [U.S./NACA's] laboratories of my design." Curtiss received the contract with a plane 60 m.p.h. slower.[32] Martin also claimed to be able to build a bomber with a range of nine thousand miles (without it's bomb load), compared to the one thousand mile range of contemporary United States Army Air Corps bombers. Such a

preposterous figure illuminates one reason why Martin could not obtain orders. Martin blamed the Air Trust, claiming General Pratt, Chief of the procurement section of the Air Corps in Dayton, Ohio told him, "You cannot get a contract. The Air Corps' policy is to keep all the business in the Curtiss-Wright Company, and their associates, the Manufacturers Aircraft Association interests, and it would be futile and a waste of time to try to get any contracts."[33]

Martin regarded the National Advisory Committee for Aeronautics as a "tool of the Air Trust," with men such as Dr. Ames of John Hopkins (chairman of NACA), E.P. Warner, and others involved in both organizations. He called NACA a "bribe committee." Roy Knabenshue, an expert on lighter-than-air aircraft, agreed with Martin believing NACA was an instrument utilized by the large aircraft manufacturers to get ahold of new concepts and innovations made by independent inventors. He believed NACA's cowling was a copy of his invention devised to be used in front of blimps for reducing wind resistance.[34]

Former Brigadier General Billy Mitchell of the United States Army Air Corps also considered the Air Trust as a menace. He believed it lessened the competitive atmosphere of the industry, resulting ultimately in the degrading of America's military capabilities. He felt aircraft would play a major role in a future war; however with the practices of the MAA the United States was not getting the best possible aircraft.

LeRoy Grumman's testimony during the Delaney Hearings presented an alternative view toward the relationship of the Manufacturers Aircraft Association and the inability of non-members to gain contracts or patents. Prior to the congressional inquiry, Roy

stated he did not even know the Air Trust existed, which seems incredible. Taken on face value, his ignorance stemmed from the high degree of engineering work he undertook and the lack of publicity of the MAA. Grumman noted that even though his company was not part of a large holding company, it was able to obtain business from the government. It also had no problem gaining patents, such as the retractable landing gear.[35] Roy did not attribute any reason for his company's success in receiving good treatment from the Navy and NACA. Again his acquaintance with E.P. Warner aided the company's relations with both governmental divisions, since Warner was involved in both areas. The small size of the naval air service community assured the Bureau of Aeronautics was conscious of the ability of Grumman's personnel, and was no stranger to it's president.

The growth of carrier aviation was also responsible for the Navy's conduct, for a manufacturer that worked primarily in this area was needed. The carrier Ranger was nearing completion in 1933, and would be commissioned the following year. During the Summer OF 1933 The National Industrial Recovery Act authorized the construction of two more carriers which became the Yorktown and Enterprise (CV Nos. 5 and 6).

Another reason for Grumman's success with the Navy was it's willingness to work within the Navy's guidelines. It took the Navy's stance om many of the issues of the procurement process and did not make waves when it disagreed. One of the concerns raised, primarily by those who could not break into the military market, was competitive bidding. Billy Mitchelll opposed negotiated contracts in military aircraft procurement, which were the rule rather than the exception. He believed aeronautical equipment

should be bought after three competitions--in design, flying, and price--rather than the current system which used only the first two. Mitchell also suggested the government consider building more of it's own aircraft since it could do so cheaper than private manufacturers. To prove his point, he pointed out the Naval Aircraft Factory in Philadelphia had constructed airframes for 15-20% less than builders in the private sector. Rear Admiral Ernest J. King, Chief of the Bureau of Aeronautics (replacement for Admiral William Moffet after his death in the crash of the rigid airship Akron in 1933) disputed this view, believing it cost the government more to build aircraft at the Naval Aircraft Factory, giving the XT2N-1 as an example. This single-engine experimental trainer cost $71,080 (comparable to Grumman's combat aircraft), but this price did not include price depreciation, maintenance, engineering and office salaries which the private sector prorated into it's cost.[36]

Unlike General Mitchell, Roy opposed competitive bidding for production contracts on a design already accepted. He adopted the Navy's position, believing it wasted too much time and further delayed the drawn out procurement process. The lengthening of procurement would provide airframes that were more obsolescent upon delivery. Grumman believed a negotiated contract could be made in less time, and would provide the military service with superior construction. His feelings were exemplified in his reply to Congressman W.D. McFarlane of Texas who asked if another manufacturer could do as good a job building a Grumman design. Roy stated, "Not with our airplane....I think the person who develops the airplane is best qualified to build it."[37] He expanded on this thought, believing that if a design was manufactured by another company,

they might try to cut costs and cheapen the quality of the plane. They might also find problems in the design, yet still build them into the aircraft since they were not responsible for the original blueprint. Grumman believed pride was a strong motivator for manufacturers, and should not be taken away by allowing another firm to build it's airframes. Grumman also realized that such a policy could have been harmful to his company which had a number of designs but had yet to gain many production contracts.

Aircraft Manufacturers were interested in cost-plus contracts, of which there were two types, that insured profits. One type was cost plus a percentage of profit, in which the contractor's costs were paid along with a percentage of the total costs. The government was especially leery of this type, for it was to the advantage of the manufacturer to drive up costs in any way in order to make a greater profit. These efforts to drive up costs would likely take the form of delays, which would create more obselete aircraft reaching the services. The second type was a cost-plus-fee contract. The government paid the costs plus a pre-determined bonus negotiated between the manufacturer and the service. Although Grumman supported the idea of cost-plus contracts, he was not strongly opposed to fixed-fee ordering. The Navy's Bureau of Aeronautics favored fixed-fee contracts and was opposed to any change. It could not afford an increase in costs for appropriations were declining. With accusations of profiteering by it's suppliers, the Navy could ill afford more negative publicity for it's aircraft procuring process. To initiate the use of cost-plus contracts would be throwing fuel on a nearly uncontrollable fire. Negotiated fixed price contracts continued to be issued throughout the 1930s.38

The growth Grumman Aircraft experienced in it's first four years was remarkable. Personnel expanded from twenty-three in 1930 to two hundred and seven in 1933.[39] Financially,Grumman made steady annual progress, with a good leap upward in 1933 when it completed the FF-1 production order. Annual sales grew from $109,000 in 1930 to $684,100 in 1933. Annual gross income rose from $109,000 in 1930 to $683,000 in 1933.[40] During the same four year period naval aircraft expenditures were cut in half and aircraft industry production fell from $48,530,715 in 1931 to $33,347,122 in 1933.[41] (See Table 1.2 and Table 1.3 for total financial picture; see also Appendix 3).

Table 1.2: Grumman's Finances

YEAR	Sales	Annual Gross Income	Annual Net Profits	Aircraft Industry Production	Grumman's % of industry production
1930	$109,000	$109,000	$ 5,476	$ - - -	- -
1931	$256,971	$146,000	$ 4,456	$48,539,715	0.3%
1932	$250,333	$276,000	$ 44,871	$34,861,158	0.8%
1933	$862,600	$847,000	$133,676	$33,357,122	2.6%

Table 1.3: Grumman's Sales to Navy Expenditures

YEAR	Sales	% U.S. Navy	Naval Aircraft Expenditures	% Grumman
1930	$109,000	31%	$14,245,000	0.2%
1931	$256,971	80%	$12,199,000	1.0%
1932	$250,333	89%	$ 8,715,000	2.8%
1933	$862,600	100%	$ 7,203,000	12.0%

Sources used to compile Table 1.2 and 1.3:
Delaney Hearings, pp. 466, 632-633. Threulsen, The Grumman Story, p. 89. E. E. Feudenthal, "The Aviation Business in the 1930s," p. 105. "Naval Aircraft Expenditures 1920-1939," Congression Record, pp. 727-728.

The company's ability to expand while funding for naval aircraft dropped and industrial production decreases made it's initial success more spectular.

The two tables reveal Grumman's financial growth and it's reliance on the United States Navy. Only $153,492 of the firm's sales were in the commercial market, on which a 4% profit was made. Compared to the $17 million made in commercial sales by the nine major naval aircraft manufacturers between 1927 and 1933, or just Boeing's $7 million, Grumman's figure was miniscule.[42] This income came from truck production and Loening repair, not from actual airframe production.

Table 1.4:

	United States Navy					
	Production Contracts			Experimental Contracts		
	Sales	Cost	+/-	Sales	Cost	+/-
Grumman Aircraft Engineering Corp.	$234,438	$210,164	+11%	$217,757	$154,763	+40%

Source: Delaney Hearings, Navy Table, p. 502.

Every aircraft sold by Grumman during the first four years went to the Navy. The corporation's sales were 1.2% of the Navy's aircraft expenditures. A 11% profit was made on it's production contracts, and profits made in the experimental area totalled 40%. This was another indication that the Navy was willing to subsidize Grumman while it attempted to get established, for naval air-

craft manufacturer were averaging a 34% loss in experimental contracts.[43] Reflecting the fact that Grumman was just beginning operations, 48% of it's naval contracts (in monetary value) were experimental. No other company came close to having so much at stake in this area. Consolidated was second in line at 15%, and the average was 4.9%. There was past evidence that the military was willing to assist fledgling companies, for Pratt & Whitney, an engine manufacturer, also made high profits in the first few years after it began operation in 1926. Grumman needed profits on it's experimental contracts during these early years to survive, yet the Navy may not have expected the manufacturer to make the percentage it did. It must be noted that there were no major delays or problems in the building and flight testing of the floats or first four experimental aircraft. The Navy may have included a little extra in case setbacks had been encountered, but the engineering and construction efforts proved up to the tasks at hand. When Roy Grumman was asked about the positive profits on experimental contracts, he replied, "I think our company is a little more efficient on experimental work due to our small size."[44] While that may have been part of the explanation, preferential treatment by the Navy also played a part.

One may wonder why the Navy was willing partially to subsidize Grumman Aircraft? Evidence points towards the Navy's desire to be supplied by manufacturers who gave them first priority. The two biggest producers of naval airplanes at this time were the Glenn Martin and Chance Vought Corporation, with $9,895,605 and $6,469,184 in naval sales between 1927 and 1933, respectively. Neither of these two conducted any business with the Army Air Corps during this period, and only Chance Vought made any com-

mercial sales (25%).[45] It was likely no coincidence that Grumman picked as it's major product a type that would not have to compete initially with aircraft from these companies. The void left by the merger of Loening with Keystone, and the increasing need for carrier aircraft also added to the Navy's desire for a manufacturer that built similar types that Loening had built and the types needed by carriers, i.e. fighters and amphibians.

Grumman Aircraft was by no means in a commanding position at the end of it's four years, but it had made some good strides. Expansion had come despite the odds that were faced. These had been surmounted by planning, sound decision making, the use of the most modern engineering concepts without forgetting maritime requirements, and a product complimentary to the needs of the Navy. Grumman now looked to the future, with Rear Admiral Ernest J. King, Chief of the Bureau of Aeronautics (CNO during world war II) specifically including it on a list of three naval airframe manufacturers that he expected to be working with the Navy in coming years.[46]

King of the Biplane Fighters, Grumman Aircraft 1934-38

Part II

Now that Grumman Aircraft had established itself as a capable naval aircraft manufacturer, it hoped to witness corporate growth. It's desires came true, for from 1934 to 1938 it's gross income qaudrupled, with a steady rise each year. The reasons for it's financial prosperity during these five years were similar to that seen in the first four years. The engineer's work from the formative period continued to pay dividends, as did some of their drafting between 1934 to 1938; however there were some disappointments in the engineering department as well. Production became a central concern, so new designs came out at a slower pace than in the period before or following Grumman's reign as the naval biplane fighter King. The price per pound of Grumman aircraft decreased during this period. The growth of carrier aviation and the Navy's slowness to adopt monoplanes also continued to assist the company's rise. Orders placed for Grumman aircraft by purchasers other than the Navy also improved the company's financial standing.

At the beginning of 1934 construction continued on the thirty-four SF-1s and the design of the XF3F. The management stayed well informed on the progress of the Navy's testing of the XJF-1 and the XF2F-1, hoping to obtain production orders in the future. Besides the time spent at the Navy Department and the testing area at Anacostia, Roy had to spend some extra time in Washington during February 1934. He testified at the hearing be-

fore the House of Representatives' subcommittee on aeronautics, which were investigating the practice of aircraft manufacturers, otherwise known as the Delaney Hearings (See Part I).

While Roy was involved with the inquiry, the Navy ordered twenty-seven JF-1 "Ducks", the first order for these utility aircraft. Powered by a 700 h.p. Pratt & Whitney, it had a capacity of four with two in the tandem cockpit and accomodations for two more in the hull, and an "unusually extensive complement of radio and photographic equipment.[47] The latter was complementary to the roles of air search and rescue, reconnaissance, gunnery spotting, and patrolling to be performed by the amphibian. The JF-1's average price was $21,000.[48]

The design work from it's first four years continued to pay off. While the XF2F-1 was being put together tests at Anacostia, Grumman extrolled the virtues of the aircraft to persuade the Navy Department into awarding his company another production order. He noted the small size, performance, and handling capabilities were ideal for carrier operations. The retractable undercarriage, which included the tailwheel assembly and arresting hook, was improved over earlier models.

On 17 March 1934 the diligence paid off, for a production order came for fifty-four F2F-1s, the largest single order for aircraft by the Navy up to this time. Evidently the Navy was aware of the virtues of Grumman's airplane. The total contract came to just under $1 million for airframes, parts, and drawing and information.[49] Grumman now had three assembly lines at the Farmingdale factory throughout most of 1934. Production efforts moved to the forefront of Grumman's activities.

Legislation in 1934 had an impact on naval aircraft

suppliers. The aircraft industry had reached it's low point in 1933 due to the slow commercial sales caused by the Depression and the end of the military's five year plans. The Baker Board looked into the problem, resulting in new five year aircraft procurement plans for the services beginning in 1935. More legislation came in the form of the Vinson-Trammell Act which passed in March 1934. It increased the authorization for aircraft to be purchased by the Navy, more than doubling the previous one thousand plane navy. This expansion was to be completed by 1940. These planes were necessary to fill the decks of the aircraft carriers authorized by the Act, and those already being built. It also limited contractors to 10% profit of it's airframes and engines.

The politics behind the Vinson-Trammel Act were threefold. One purpose was to warn the Japanese the United States did not approve of it's terrorism in Manchuria or it's announcement it no longer adherred to the 5:5:3 tonnage requirements of the Washington and London Naval Treaties (one year advance notification required by treaty). Another reason for the legislation was to aid the economic situation of the United States by providing jobs in the shipbuilding industry. A third purpose was to eliminate profiteering, or the fear of profiteering, recently discussed in the Nye and Delaney inquiries.

On 30 March 1934 Grumman began deliveries of the SF-1 to the United States Navy. Scouting Squadron VS-3B of the Lexington received the aircraft, putting the FF-1s and SF-1s aboard the same carrier. Grumman airplanes now formed more than half of the vessel's air group. Aviation historian Bill Gunston stated, "The serviceability and toughness of these aircraft earned the company a reputation it has jealously guarded."[50] At the end of fiscal

year 1934 (year ending 30 June 1934), Secretary of the Navy Claude Swanson stated that the "past year had witnessed placing in service carrier planes of marked increase in performance."[51] He was in part describing the introduction of the FF-1 and SF-1 to active front line service.

While both of these aircraft performed admirably, each was the last of a breed. The FF-1 was the last two-seat fighter used by the Navy until night-fighters showed up in World War II, and the very last to have an aft machine gun (the large twin-engined P-61 Black Widow night-fighter may be an exception since it had a top turret, however it was usually locked in the forward position to complement it's other guns). The single-seat fighters from Grumman that succeeded it proved to the Navy that they were superior in gaining command of the air over the fleet. The SF-1 was the last of the scout-fighters; for as the carrier turned more to the role of attack and the need for increased range in scouts was needed to offset the dramatic increase in range of shore-based patrol planes, scouting duties were performed by bombers. Douglas' Dauntless' dive bombers were performing this role when the war broke out in the Pacific in 1941.

In October 1934 the Navy accepted the design proposals of the XF3F-1 which had recently been submitted to Commander Royce, the new chief of Designs in the Bureau of Aeronautics for a price of $75,840 (nearly $20,000 cheaper than XF2F-1). Grumman's XF3F-1 fighter prototype was it's third pursuit, and fourth consecutive design purchased by the Navy. It's dimensions had been increased over the F2F to improve it's maneuverability compared to it's ancestor. (See Appendix 2). The F3F was the company's biggest selling product during the 1930s. It was also the last biplane used by

the Navy.

The JF-1 production line was augmented by an order from the Coast Guard for fifteen utility amphibians in July 1934. Special equipment was added along with the 700 h.p. Wright Cyclone; therefore the Coast Guard's Ducks were designated JF-2. On 21 December 1934 one of these JF-2s piloted by Commander E. F. Stone established a new world record for amphibians. He broke Major Alexander de Seversky's (who flew a Seversky amphibian) 9 October 1933 record of 176.76 m.p.h. Stone's new mark was 191.8 m.p.h.[53]

The beginning of 1935 saw the start of deliveries of the F2F-1s to the Navy. Production models reached 231 m.p.h. at 7,500 feet and 205 m.p.h. at sea level. It had an initial rate of climb of 3,000 ft./min., and could reach 10,000 feet in four minutes and forty-two seconds. At 210 m.p.h. cruising speed, the F2F had a range of 750 miles, but at one-quarter throttle it could squeeze out 900 miles. The cockpit enclosure was enlarged and modified on the production order for more pilot comfort. The NACA cowling had been re-designed to provide increased aerodynamic efficiency around the two-row Pratt & Whitney engine. Matt and Robertson, historians of naval fighters, stated that the F2F was "easily serviced," and it's rugged construction allowed "violent maneuvers" without causing "strain on the aircraft. The Navy was concerned with the F2F's tendency to spin and it's directional instability, good qualities for quick maneuvering, but poor for landing and long flights over water where vertigo was a problem. F2Fs were delivered to the U.S.S. Lexington and the newly commissioned U.S.S. Ranger. Ranger's F2F squadrons later were used by the carriers Wasp and Yorktown until replaced by F3Fs in 1939. VF-7 aboard the Lexington would operate F2Fs until June

1940, giving these aircraft a front line service life of five and one nalf years, which was above average for the 1930s.[54]

From the perspecitve of today's aerospace industry 5 1/2 years would be an extremely short life. McDonnell's F-4 Phantom has served for over twenty years as fighter-bomber, yet it still compromises a large percentage of modern air forces and can compete with newer aircraft. Grumman's own F-14 Tomcat has been a carrier fighter for more than a decade, yet it will be the Navy's elite interceptor on into the 1990s. In the 1930s service lives of airframes were much shorter, with naval fighters averaging four years.

The reasons for the changing life-spans of the 1930s to that in the jet age have been the increasing investment in design and testing aircraft and the change in the emphasis on performance. The cost of designing and testing combat aircraft today can only be undertaken by large corporations with huge reserves of capital for the length of the design phase has increased, but more importantly the amount of technical equipment such as radars, computers, and complex missile systems has caused the rise in costs. Such systems have been the major technological advancement in the last two decades, whereas in the 1930s technical development provided improved strength and better performance. Airframe construction was changing from wood frames and canvas coverings to aluminum frames and skins. The Boeing F4B initially had wooden wings, whereas Grumman always used aluminum construction. Roy Grumman noted in 1934 that 90% of the weight of his aircraft was aluminum.[55] Speed and climb spiraled upward at a tremendous rate with improved metallurgy, a better understanding of aerodynamics, and the increasing horsepower of engines.

Grumman received more orders from the Navy for the utility amphibians on 12 February 1935. Eleven JF-1s plus parts were purchased for an average of $20,944.[56] The amphibian's price had not been increased.

By March the XF3F-1 was ready for initial testing. The plane improved the compact cockpit, directional unsteadiness and the proneness to enter an unwanted spin that it's predecessor (the F2F) suffered. It was soon discovered that the XF3F-1 had troubles of it's own. Tragedy struck on 22 March when Jimmy Collins was killed in the crash of the experimental plane while conducting the terminal velocity dive test (diving straight down from a high altitude, reaching the highest speed possible, and then pulling out of the dive). As shown in Warner Brothers' 1930 movie "Wings of the Navy", this test was one of the severest of experimental airframes.[57] The XF3F-1 was supposed to encounter nine "Gs" (the force of gravity) in it's pullout, however the recorder recovered from the wreck showed the stress was actually fourteen Gs.[58] The plane had encountered the problem of high compression, a menace just beginning to be understood by leading aerodynamic theoreticians.

The Bureau of Aeronautics purchased a second experimental model with reinforced fittings and engine mount. It successfully completed tests at Farmingdale, and was delivered to Anacostia in May. A second setback was suffered in the XF3F-1's trials when naval pilot Lee Gelbach was forced to bail out after losing control of the prototype in a spin. After the crash Chief Engineer Bill Schwendler took a model of the design to NACA's new spin tunnel at Langley Field. After numerous tests, the problem was solved by adding a small fin below the fin and rudder. NACA's spin

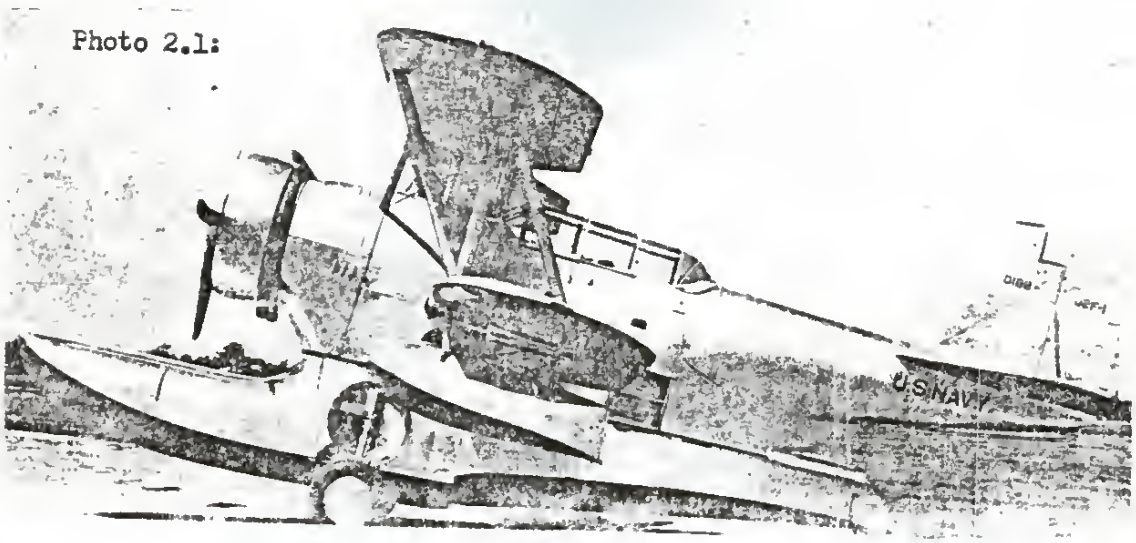
tunnel saved Grumman from losing a contract for the Bureau of Aeronautics were still interested in procuring production F3Fs. Julie Holpit's crew refitted the Gelbach wreck in less than one month, turning it over to the Navy on 20 June so testing could continue.[59]

In late May or early June Grumman entered a flight competition with Chance Vought after these two were awarded contracts for their experimental scout-bombers. Grumman's plane was an improved version of the SF-1, with better aerodynamics and a bigger engine. Holpit and his fellow workers began working on the new bomber, designated XSBF-1, and would have it ready for flight tests in eight months. For the first time Grumman had moved away from the fighter or amphibian area, but the end result was not encouraging.

Grumman received more orders from the Navy in June. On the 29th the Bureau of Aeronautics ordered twenty-nine JF-2 amphibians. These amphibians were basically the JF-1 except they housed a more powerful 830 h.p. Pratt & Whitney, thus causing a slight change in designation. These Ducks averaged $23,337, only a modest increase due to the modifications made.[60] It was simple to see that the Navy was pleased with the capabilities of the Ducks by it's continual purchases. In the last two years it had procured sixty-seven utilities from Grumman (not including the fifteen ordered by the Coast Guard). This was 62.7% more than the Navy had on hand prior to the Vinson-Trammel Act.[61] At the end of fiscal year 1935 the Navy's arsenal consisted of nine hundred and seventy-four service aircraft with four hundred and seventy-two on order.[62] Grumman placed one hundred and eighty-two airframes on these lists, equalling 12.6% of all naval aircraft on hand or on

order.

Photo 2.1:



Grumman's J2F-1 Utility
Source: Jane's All The World's Aircraft, 1938, p. 270c.

August 1935 started out on a bleak note when a hail storm obliterated the glass skylights of the Farmingdale factory, but the despairing problems soon gave way to encouraging news. On 24 August the Navy ordered fifty-four F3F-1s. The F3F-1 won a flight competition against an airframe from Curtiss Aeroplane & Motor of Buffalo, New York. Curtiss' bid was the lowest at $1,067,344, but Grumman's $1,082, 965 bid gained the order with Secretary of the Navy Claude Swanson using his power to award contracts to the lowest responsible bidder. Curtiss dealt with the Air Corps more than the Navy, having obtained nearly twice the amount in sales from the Army from 1927 to 1933. It's planes were adaptations of land planes, so did not put naval need first. In case of war, the Navy realized that the Army's orders would be placed ahead of it's purchases. Another consideration was the Navy's experience with tne BF2C fighters recently built by Curtiss for carrier duty. These fighters only lasted a few months before having to be taken

out of service after suffering numerous accidents caused by faulty retractable landing gear. This made Grumman a more reliable manufacturer. It's prototype also proved to have a better maximum speed and other performance characteristics.

During 1935 the design team led by Chief Engineer Schwendler had been working on yet another new biplane fighter, the XF4F-1. On 15 November Rear Admiral King, Chief of the Bureau of Aeronautics, approved the recommendation for a design competition for a carrier fighter. The contest pitted designs from Brewster de Seversky and Grumman against each other. Grumman was to receive $111,300 for their biplane, but it was scrapped after the company saw it could not compete with Brewster's monoplane.[64]

January 1936 saw the experimental scout-bomber (XSBF-1) ready for the manufacturer's flight test. After passing these, it was taken to Anacostia for naval testing. The XSBF-1 marked the first time Grumman Aircraft was unable to gain a production order. It lost in a competition with the Vindicator, a product of Chance Vought of East Hartsford, Connecticut. Grumman's bid was actually lower than Chance Vought's, being priced at $1,473,722 while Vought's contract read $1,846,308.[65] The Navy opted for the expensive contract for a variety of reasons. Vought had more experience building scouts and bombers than Grumman, which was viewed as a supplier of fighters and utilities, giving Vought an upper hand. This company was one of the Navy's prime aircraft suppliers so it was obligated to keep them busy if it did not want the firm to look elsewhere for business. The Navy liked to spread it's sales around to keep a number of suppliers in business, and Grumman had plenty of orders in 1935 to keep them busy. The Vought design may have had better performance for which the Navy was willing to pay

extra, although Grummanites believed their product at least equalled their competitions.

Photo 2.2: The XSBF-1
Source: "A Decade of Grumman Progress," Aero Digest, Jan. 1940

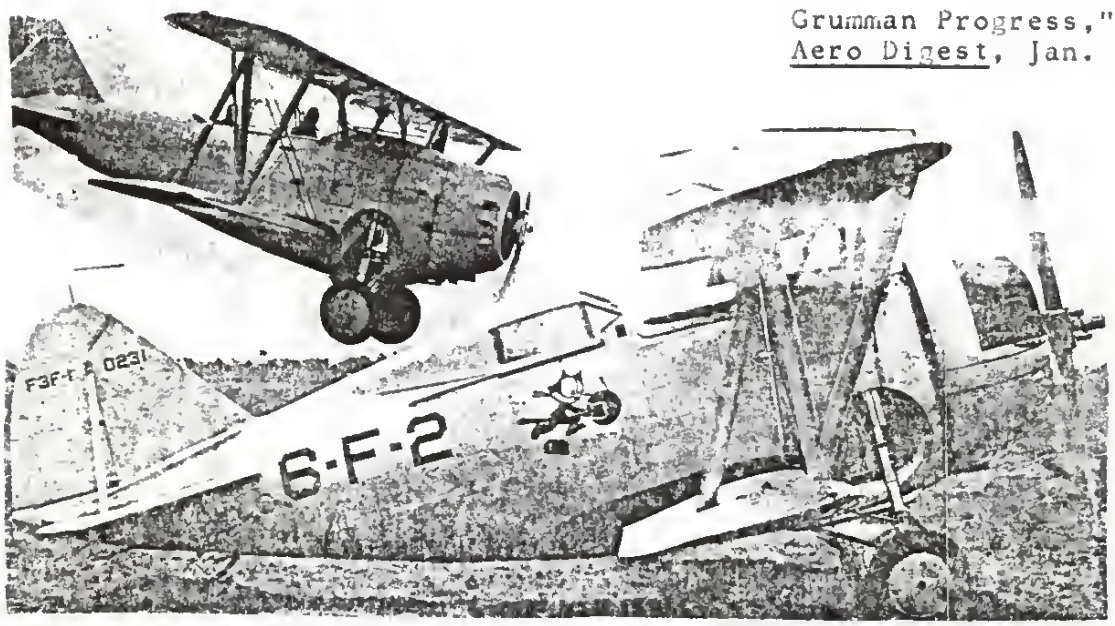


Photo 2.3:
Source: Jane's All the World's Aircraft, 1938, p. 270c.

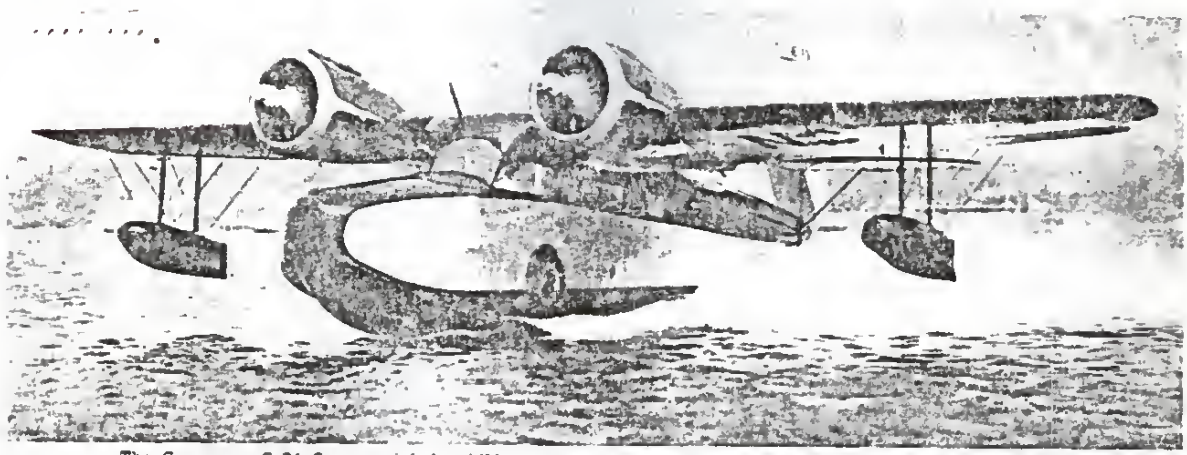
Grumman's production forces were instrumental in placing new aircraft with the naval air fleet and as yet every contract had been completed in less than one year. Grumman delivered it's first production JF-2 to the Navy in April and by the end of Fiscal Year 1936 eleven were operated under naval control. Forty-nine F3F-1s were placed in the Navy's control by 30 June, with the order of fifty-four completed in August.[66] The Navy used the fighters aboard the carriers Ranger and Saratoga.

While the shop force labored on these airframes, the engineers worked on a couple new designs in the corporation's two areas of specialization, amphibians and fighters. The amphibian was the G-21 Goose. It was the largest aircraft built by Grumman

during the 1930s, and the company's first commercial product. Management entered the commercial market now that the company had capital to pay for it's design and indicators showed expansion in the area. The G-21 was the corporation's first monoplane to fly, using NACA's 23012 airfoil design. A pair of 400 h.p. Pratt & Whitney Wasp Juniors were placed in nacelles leading into the high wing. A top speed of 200 m.p.h. and a range of 800 miles was expected from the commercial amphibian. It was designed for eight passengers plus the crew. The Goose was a flying-boat, since it's floating capability came from it's own semi-monocoque hull and not an attached float. The patented Grumman undercarriage retracted from the hull, providing the Goose with it's amphibious capability. Ralston Stalb, chief engineer for the G-21 project, had just recently joined Grumman, but he was no stranger to the company's management. He had been a chief engineer at Loening before it's merger with Keystone, and therefore associated with Roy and his cohorts. Stalb was a naval architect by training. This influence can be seen in the stout construction of the Goose, and it also paralleled the corporation's philosophy on construction (See Photos 2.4,2.5, &2.6 on following page). Roy likely had some input as well, despite the fact that his presidential duties were keeping him from spending much time as an engineer. His knowledge of amphibians and desire to make the first commercial venture a successful one would have overridden some of his unimportant tasks, or allowing Jake to handle more of the administrative duties.

The decision to start the project came after a group of wealthy New York businessmen led by William Lloyd-Smith having been referred to Grumman by Grover Loening, discussed with the

Photo 2.4:

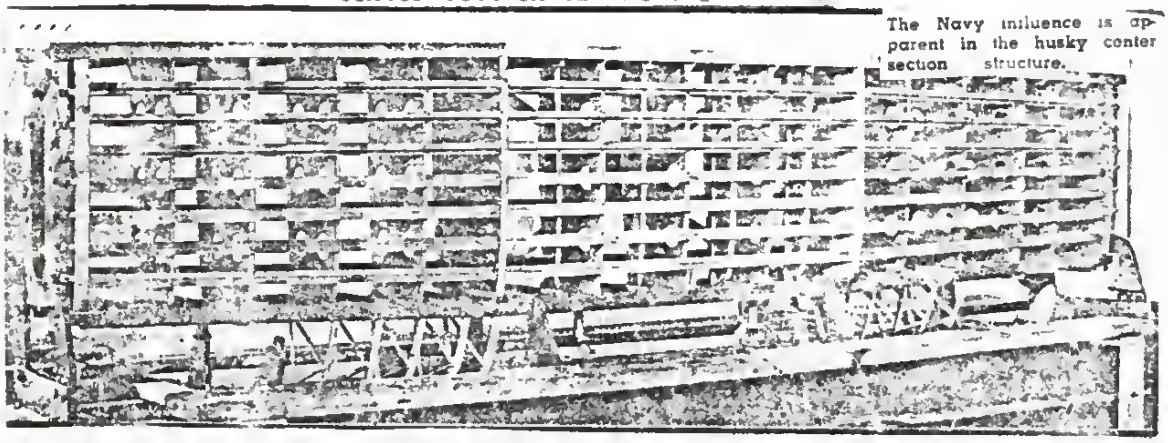


The Grumman G-21 Commercial Amphibian (two 450 h.p. Pratt & Whitney "Wasp-Junior" engines).

Source: Jane's All the World's Aircraft, 1938, p. 271c.

Photo 2.5:

Center Section of the G-21's Wing



Source: "Grumman's Amphibian," Aviation, vol. 36, no. 7 (July 1937), p. 37.

company's management the need for a quicker mode of transportation to travel in the city so they could avoid the delays caused by the congestion of New York traffic. Representatives of air commuters were represented and each were looking for new aircraft. The group hoped Grumman could produce an airplane ideal for short or long business flights. For the first time Grumman Aircraft had to provide all the funding for the development of an aircraft, but they

were almost assured of gaining at least a few orders from the groups of entrepreneurs.[67]

Photo 2.6:
Source:
"Grumman's Amphibian," Aviation, v. 36, July 1937, p. 37.

Another engineering team, under the guidance of Bill Schwendler, worked on the previously mentioned biplane in competition with designs from Brewster and de Seversky. The project was scrapped since the F3F was already meeting the expected performance of the new design and the engineers realized that a biplane design could not operate with Brewster's monoplane (XF2A-1). Not to be outdone, Grumman engineers also began working on a monoplane. This decision was important to Grumman staying on the leading fringe in naval aircraft development. Chief of Bureau of Aeronautics King approved Grumman's new monoplane design (XF4F-2) on 28 July. The XF4F-2 and XF2A-1's engineers both promised a top speed of at least 300 m.p.h. for their respective designs.

Two more engineers were hired by Grumman at this time. Bob Hall joined in a dual role, being a designer and a test pilot. He had worked for Fairchild and Stinson, and was the designer of the speedy but lethal handling Gee Bee racing plane. Hall, loving the exhiliration of flight, test flew all the history-making aircraft up to the jet age.[68] George Titterton also joined Grumman. He

had worked for the Bureau of Aeronautics as a civilian engineer. Titterton had been the Navy's representative at the manufacturing flight of the XFF-1 years before. His understanding of the Navy's bureaucracy would be another asset. These two further supplemented the use of team design.

July 1936 contained another piece in Grumman's naval fighter development. On 25 July the Navy purchased the XF3F-2, a variant in the F3F series. It was powered by a 1000 h.p. wright Cyclone rather than a Pratt & Whitney like the original version. The Bureau of Aeronautics paid $26,300 for data, designs, and the modifications of the last production F3F-1.[69] It was not uncommon for an experimental variant to be made from the last airframe of an earlier contract.

In the summer of 1936 the firm broke new ground with international orders. It's first export came from the Argentine Government which ordered eight Ducks. The Company's other planes were on the export market, but there was not an international demand for carrier fighters. Only a few navies operated aircraft carriers, and those that did produced their own naval aircraft. This situation continued until World War II; however an international deal was made on one of it's fighters early in October 1936 between Grumman and the Canadian Car & Foundry Company, Ltd. of Montreal. These businesses announced that an agreement had been reached giving the Canadian company the rights to build the FF-1. The Canadian Air Force planned to use it as an advanced trainer. Fifteen were built for this purpose, and they were named Goblin 1. One Canadian built FF-1 was delivered to Nicaragua, and another showed up in Japan. Fifty more were delivered to Turkey, which passed them to France where they were purchased by the Spanish

Republican Air Force to take part in the Spanish Civil war which began in 1936.[70] Unfortunately I do not know whether they saw combat, or how they faired if engaged in combat.

Grumman also worked on an aerobatic plane for Gulf Oil Company. Newcomer George Titterton headed the project. The plane had been ordered after Al Williams, a former member of the Navy's racing team and currently stunt flyer and chairman of the aviation department of Gulf Oil, flew the F3F-2 while looking for a replacement for his Curtiss F6C. Intrigued by the responsiveness of the plane, he asked for a modified version to be called the Gulfhawk II. It was completed on 1 December 1936 and delivered to Roosevelt Field, Long Island. The Gulfhawk mated the fuselage of the F3F with the wings of the F2F, and was powered by a 1000 h.p. Wright Cyclone. It was modified for enhancement of aerobatic capability by such methods as giving it a large tail, and by installing oil and gas tanks which had several outlets plus extra pumps which allowed it to fly inverted for one-half hour. It had a speed of 290 m.p.h. at 12,000 feet and a 3,500 ft./min. climb rate. A vivid color scheme was used to increase it's visibility. The airplane was coated in a glossy orange with blue trim with outward radiating white stripes on the upper and lower wing surfaces. For the next twelve years the Gulfhawk II thrilled air show audiences in the United States and Europe. This use aided Grumman's public image. In 1948 it became the property of the Smithsonian Institution and now hangs in the National Air & Space Museum.[71]

After their recent agreement to build FF-1s, the Canadian Car & Foundry sponsored a flight from New York to Montreal using the two-seat fighter. On 13 December Howard F. Klein took-off from Roosevelt Field, Long Island, landing one hour and forty minutes

later at Montreal's St. Hubert Field. This was seventeen minutes faster than Frank Hawk's 1931 record flight time between the two cities. Two days later on his return flight Klein improved his own time by ten minutes, thus on the two trips combined, he averaged an airspeed of 220 m.p.h.[72] Such records also improved the image of the firm, bringing public recognition.

At the time this FF-1 was making a record, the FF-1s and SF-1s were being withdrawn from the carrier fleet and being assigned to the Naval Reserve. This provides a perfect example of the tremendous rate of performance growth and the short service life of aircraft in the 1930s. These aircraft had only been in service two or three years, yet they were already being downgraded to the reserves. Aircraft were being produced that were 50 m.p.h. faster, while others on the drawing boards were nearly 100 m.p.h. quicker. Such fast improvement during the aeronautical revolution caused the FF-1 and SF-1 to have had a design and experimental phase that was nearly as long as it's front line service.

The XF3F-2 endured it's initial testing in January 1937, being sent on for naval testing. Variants of an already proven design did not have to go through the same testing procedure as new models. This airplane endured three months of observation of the mating of the 850 h.p. Wright Cyclone driving a Hamilton Standard controllable-pitch propeller and the Grumman airframe. The Navy was pleased with the results, ordering eighty-one of these naval fighters on 23 March. It was the largest order for airplanes the Navy had ever handed out at one time, the second time the company received this distinction. The average price per plane was $16,536.73 The production F3F-2s could attain a maximum speed of 260 m.p.h., yet the landing speed still hovered around 66 m.p.h.

The new F3Fs could reach an altitude of 32,000 feet, a record service ceiling for pursuits. When cruising at 125 m.p.h. the F3F-2 had a range of 975 miles. With only an $11 increase over the original production version, yet a substantial rise in performance over it's predecessor, the Navy got a good bargain. F3F-2s were used aboard the Enterprise, which would be commissioned in 1938, and in Marine squadrons. The entry of the new carriers and the increase in Marine Corps aviation were the stimulants causing the large order. F3Fs served aboard the Enterprise until May 1941, and with the Marines until after the war broke out between the United States and Japan.

Following the recpetion of the large contract, Grumman prepared to occupy it's fourth home in it's eight year existence. The decision to build a plant was made after finding out that the Farmingdale complex presently being rented was to be sold to de Seversky (later Republic). Construction of the new quarter million dollar factory began the previous autumn on a one hundred and twenty acre parcel of land located in Bethpage, Long Island. The land was purchased at $300 per acre. Funding came from Grumman reserves and short-term loans. Under Clint Towl's supervision construction progressed steadily. By the end of March 1936 the company began moving into the nearly completed structure, which had twice the floor space of the previous site. By 8 April the move was completed.[74]

At the new plant the shop force got quickly to work on their back-log of orders from the Navy. Despite the continual work on airframes, it could not keep up with new orders. In May the Bureau of Aeronautics ordered an additional fifteen Ducks for $571,923, which after the deduction of $114,385 for parts, the amphibians

cost $30,000.[75] An additional fifteen amphibians were ordered in August for the same price.[76] The reason for the increase in price over Ducks sold in previous years was these were a new variant, which had some design modifications.

The G-21 Goose neared the point when it would stop being a financial drain when it made it's first flight on the last day of May with Bud Gillies and Bob Hall at the controls. The flight test progressed without a hitch, so ten ordered units were added to the two already in the production process. On July 16 the first G-21 was delivered to Lloyd-Smith, who paid $60,000. Single orders for the Goose continued to pour in during the rest of 1937, and according to Aero Digest the owner's list of the G-21 became "a veritable 'Blue Book' of important persons in America."[77] America's richest were not the only elite to receive the amphibian for in 1937 financier Ben Smith ordered a G-21 for his friend Lord Beaverbrook, Great Britain's Minister of Aircraft Production. In 1940 Beaverbrook ordered another G-21. In the process Smith became Grumman's underwriter in the company's move to public stock.[78]

The corporation began to feel the need for financial assistance with the country's short lapse back into depression, the need to relieve the shortage of capital caused by the recent venture into the commercial market, and the desire to expand to meet the Navy's needs with the carriers Wasp and Hornet under construction to curb the growth of unfilled orders. It decided to go public with it's stock. Ben Smith aided the company in registering 140,000 shares of common stock with the Securities & Exchange Commission, of which 95,000 were for public consumption, 5000 for Grumman employees, and the final 40,000 reserved for exercise of warrants.[79] In October of the following year the business would

be listed on the New York Curb Exchange board. With the assistance of the public, Grumman would continue to expand in the years prior to America's involvement in World War II.

In 1937 Grumman attempted to improve it's relationship with the Navy by hiring Oscar Olsen as a liason between the Navy Department in Washington, D.C. and the corporation's headquarters in Bethpage. Since Grumman did not have an office in Washington D.C. like many aeronautical manufacturers, Olsen flew there once a week. Tuesday became "Grumman Day" at the Navy Department, with Olsen meeting those with problems or questions concerning the corporation's airframes. These affairs would be transmitted to Bethpage either immediately or in the following day, depending upon the severity of the problem. The Company hoped to "earn the respect and confidence of Navy people" by employing a liason.[80]

On 2 September 1937 the XF4F-2 became airborne for the first time under the guidance of Bob Hall. Despite changing to a monoplane design after Brewster completed it's airframe's blueprints, Grumman's "Wildcat" flew four months before Brewster's "Buffalo." The configuration of the XF4F-2 was different than the well-known warbid that was produced later, it's outline favoring the biplanes. It had a three spar NACA airfoil located on the centerline of the fuselage, where the biplanes had two spars; however these wings, and the tail surfaces, had rounded tips like the biplanes. The "razor back" aft of the cockpit curved down into the rear fuselage rather than curving back up into the fin and rudder as it would in later models. The horizontal tail plane fitted into the rear fuselage, but in later models it would be raised onto the fin and rudder. A spinner was placed on the nose of the propeller (it can barely be seen in Photo 2.7). The airframe was armed with four

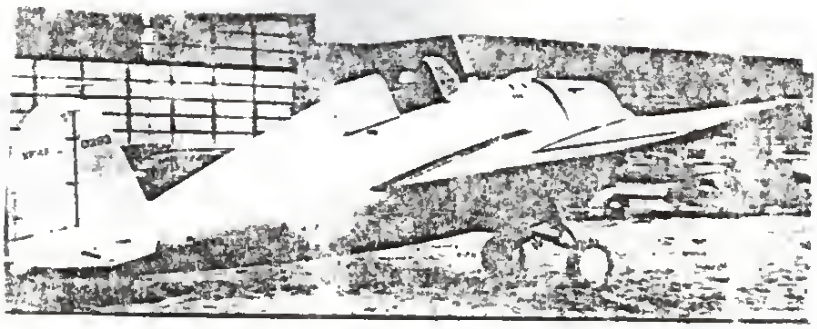


Photo 2.7: The XF4F-2 Source: Aviation.

.50 calibre machine guns, two located in the nose and two in the wing. The 900 h.p. single-state supercharged Pratt & Whitney powered it to a speed of 290 m.p.h., which was less than promised but slightly faster than Brewster's experimental plane. The XF4F-2 had an increased rate of climb compared to the company's biplanes, but it recorded a lower ceiling. After Brewster's monoplane flew for the first time in January 1938, the struggle between the three fighters from de Seversky, Brewster, and Grumman in a flight competition officially began, the winner to receive a production contract.

While the XF4F-2 competed with two rivals at the Navy's testing grounds (See Part 2), Grumman workers continued to build and design new airframes. One such plane was the Gulfhawk III, the second purchase by Al Williams of Gulf Oil Company. This special two-seat biplane was completed and delivered on 6 May 1938. Grumman Aircraft also built one for it's own use, such as quick flights to Washington, D.C. Both of these planes would be taken over by the Army Air Corps to be used as trainers after the war came to America.[81]

Grumman was indirectly influenced by Congress, which passed the Naval Expansion Act of 1938 on 17 May. It provided for an increase in aircraft carrier tonnage to 175,000 tons, and to keep

pace it authorized a 3000-plane navy. According to Secretary of the Navy Claude Swanson, "Demands of the fleet consistently require broader and more inclusive roles for aircraft in the tactical organization. The importance of meeting these demands has resulted in assigning greater precedence to aircraft development."[82] Aviation was gaining status in the Navy.

In June Grumman received it's first production contract from the United States Army. During fiscal year 1938 the Army Air Corps obtained the XOA-9, a military version of the G-21 Goose. The Navy also bought an experimental model, which was designated the XJRF-1, during the same period. The naval version was purchased for $74,000 just slightly higher than the commercial fee.[83] The air corps granted the corporation a contract in June for twenty-six amphibians and spare parts at a price of $1,412,916.[84] Assuming that 20% ($282,583) would be subtracted for spares, the Army's OA-9s averaged $43,474, a reasonable price when compared to the $66,000 of the commercial G-21. The low cost demonstrated the advantages of bulk purchases.

During the flight competition at Anacostia between the three fighter prototypes, Grumman's XF4F-3 encountered more than it's share of problems. It first experienced engine trouble when a crankshaft bearing burnt out. On another occasion the rear fuselage caught fire. The worst came when a second engine failure forced a crash landing. de Severksky's NF-1 also crashed during the tests. Despite Grumman's prototype recording the highest speed, Brewster's entry won by default owing to the trouble experienced by it's competitors. On 11 June 1938 the Navy purchased fifty-four F2A-1s at an average price of $28,302 (a figure that would prove to be to Grumman's advantage in the following year).[85]

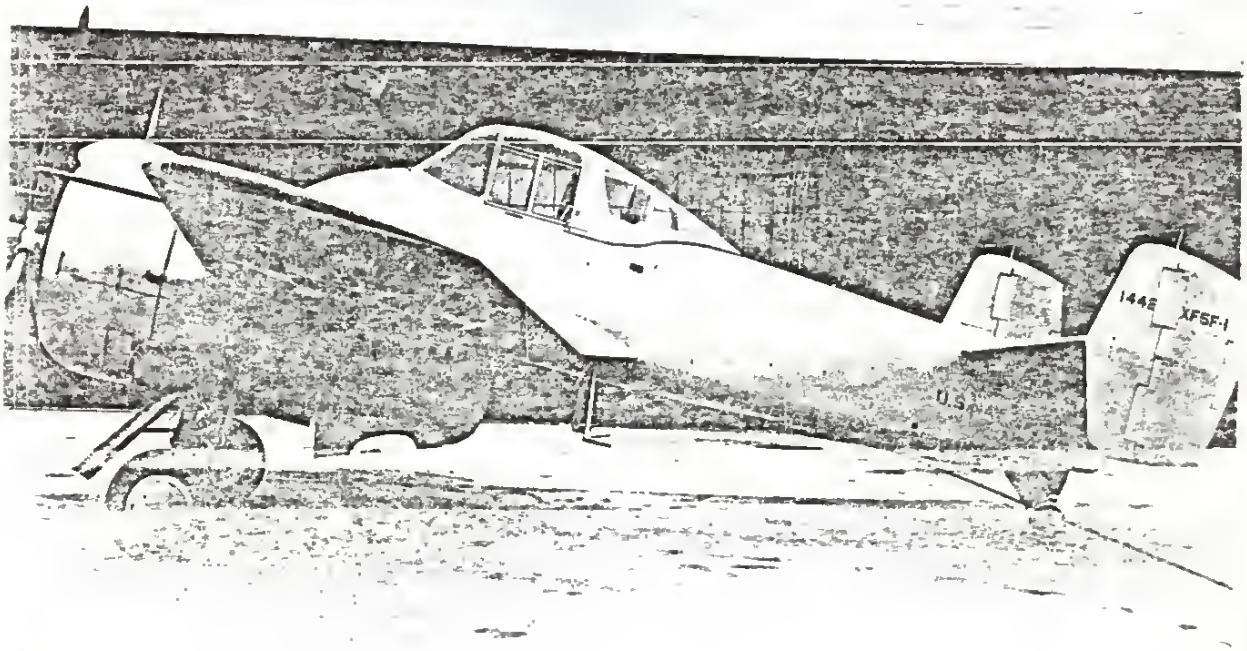
With Boeing's F4B-4 being retired from the fleet in 1938, Grumman fighters constituted the only air superiority weapon on the carriers and with the Marine Corps until the Buffalo began to reach squadron service after the war began in 1939. Grumman Aircraft had been the only manufacturer to receive orders for naval fighters for approximately five years prior to Brewster's order, quite a feat for such a young, small company.

In the first half of 1938 the engineering team had been working on a fighter design to be included in the Bureau of Aeronautic's competition to be held in June. This pursuit contest initiated the Vought F4U Corsair, the reputable aircraft which will be referred to later in the text. It also produced one of Grumman's few failures, the XF5F-1 "Skyrocket." The blueprints of the XF5F-1 showed a radically new outline, it being the first twin-engine design for a carrier fighter. Another unique feature was the fuselage which grew out of the main spar of the wing (See Photo 2.5). The tail unit sported twin fins and rudders mounted at the edges of the horizontal stabilizers. Unlike the Grumman biplanes and the XF4F-2, the Skyrocket had square wings and control surfaces. The large wingspan of forty-two feet was cut in half by upward folding wings. On 30 June the Navy ordered the experimental plane for a total of $248,000; with expenses broken down in the following categories:[86]

Design Data and Drawings	$ 71,000
Wind Tunnel Test Model (full size)	$ 10,000
Tests and Miscellaneous Data	$ 45,000
Airplane (2 engine) less engine and props	$112,000
Final Corrected Information and Drawings	$ 10,000
	$248,000

The Navy ordered two other aircraft from this design competition;

Photo 2.8: The Grumman XF5F-1 Skyrocket



Source: Aviation, vol. 39, no. 11 (November 1940), p. 19.

the previously mentioned Vought XF4U-1 Corsair and the Bell XFL-1. Both were conventional in outline, unlike the Skyrocket.

In the first six months of 1938 a few orders for commercial G-21 had been received. Since the corporation was quite busy and did not have practical experience in marketing commercial aircraft, this task was placed in the hands of Gillies Aviation Corporation of Hicksville, New York. It was owned and operated by Jack Gillies, brother of Grumman test pilot Bud Gillies. This company obtained eight orders for the $66,000 Goose.[87]

In July the Navy took control of the XF3F-3, which was the last production F3F-2 transformed into an experimental plane. The conversion cost $12,750.[88] Without putting the XF3F-3 through the extensive testing procedure, since the airframe had already proved itself and only minor modifications had been made to incorporate a larger engine, the Bureau of Aeronautics ordered twenty-seven of

the single-seat biplane fighters at a unit price of $25,937.[89] Compared to earlier F3Fs, this figure was quite high. Part of the reason for the increase was the result of the low number ordered, but the previous month's loss to Brewster and the price charged for the Buffalo had a greater effect. The high price was unwarranted, and the only real drastic deviation from the cost per pound of Grumman aircraft (which will be shown later in the text). The conservatism of the Navy shown through as it was willing to purchase biplanes after it was conceded monoplanes were superior. This type of thinking aided the Bethpage manufacturer. The following year these F3Fs went aboard the Yorktown, which had been commissioned in 1937.

In September Grumman gained another contract from the United States Navy for it's utility series. Twenty J2F-3s were ordered, still at a unit price of $30,160.[90] Continued procurement of this series showed the Navy was pleased with it's performance.

During the same period an export order for four G-21A amphibians had been received from the Peruvian Air Force. These planes were completed the following Spring. Lt. Commander Humberto Cal-Lino of Peru's Air Flotilla took control of the delivery to his country in April 1939. The export contract totalled approximately $200,000.

After the fifty-four Brewster Buffaloes were ordered in June 1938, Grumman went right to work to modify the XF4F-2. The resulting XF4F-3 brought about the well-known Grumman shape. (See Photo 2.10). To support the rising weight of the design, the wing area was increased by a larger span and squared tips, thus giving the airfoil a "plank-like" appearance. The fin and rudder was squared as well. This squaring improved capability of mass production, the

Photo 2.9:

Four Grumman G-21's which are used by the Peruvian Government

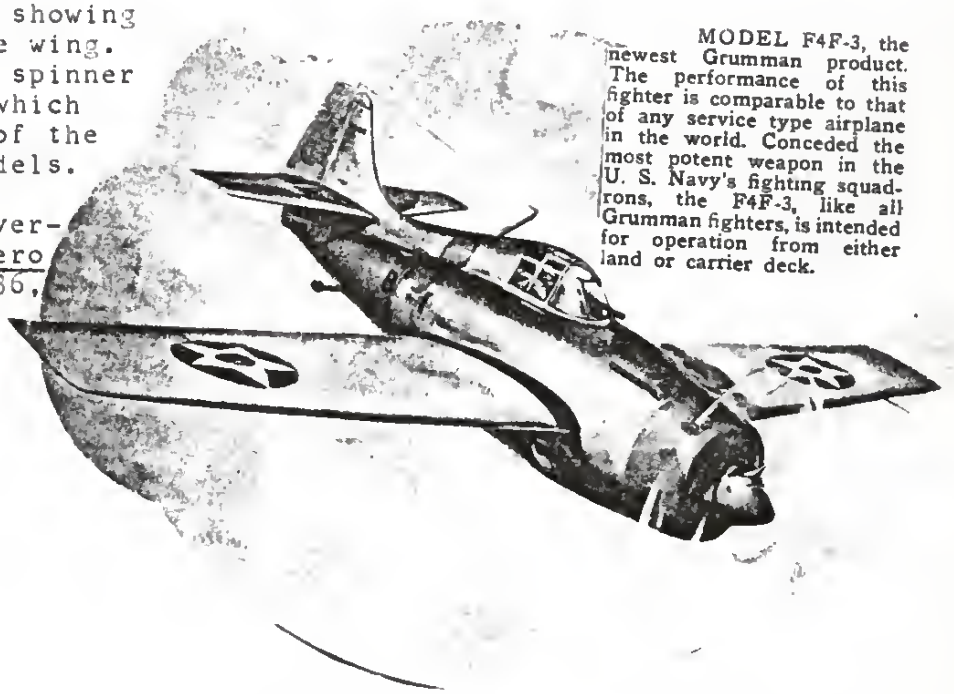
Source: "Decade of Grumman Progrss," Aero Digest, vol. 36, no. 1, p. 52.

first sign the company expected increased orders in the future. The tail-plane was raised onto the rudder, the latter curving gently down to join the fuselage spine. The Pratt & Whitney Twin Wasp (XR-1830-76) engine, with a two-stage, two-speed supercharger, powered the airframe. It was expected to improve the Wildcat's performance at higher altitudes. The Navy ordered the XF4F-3 in

Photo 2.10:

An artist's rendition of the F4F-3, showing the plank-like wing. Also note the spinner on the prop, which was not part of the production models.

Source: An Advertisement in Aero Digest, vol. 36, no. 1, p. 51.



MODEL F4F-3, the newest Grumman product. The performance of this fighter is comparable to that of any service type airplane in the world. Conceded the most potent weapon in the U. S. Navy's fighting squadrons, the F4F-3, like all Grumman fighters, is intended for operation from either land or carrier deck.

October. It was not listed specifically in Aircraft Purchased by the Navy Dept., FY 1939, being one of the numerous orders recorded as "confidential."

Towards the end of 1938 the Bethpage plant sold two sets of a dozen Ducks to the Argentine Navy and the United States Coast Guard.[91] Considering the price paid for the J2Fs sold, each of these contracts brought in approximately $434,300. In 1938 the corporation was branching out with exports to Peru and Argentina, military sales to the Air Corps and the Coast Guard, and commercial sales. Grumman became less dependent on the United States Navy this year.

Although the corporation had not received any orders relating to the rising world tensions over the possibility of war, the outlook for military exports looked promising. This expectation, along with the infusion of public capital, caused the company to expand. It bought 100 acres of land adjacent to their current headquarters at the end of 1938 for $28,500.[92] This allowed space for future plant addition which would soon be added.

Table 2.1:

YEAR	Billings	Income from Sales	% Income from USN
1934	$1,808,400	$1,368,000	88%
1935	$1,640,000	$1,114,000	87%
1936	$1,915,000	$1,719,000	84%
1937	$3,574,533*	-----	---
1938	-----	$4,904,941	---

Source: Threulsen, The Grumman Story, p. 89.
*My own figure, which do not always correspond to Threulsen's.

Table 2.2:

YEAR	U.S. Naval Aircraft Expenditure	% Grumman	Aircraft Industry Production	% Grumman
1934	$12,273,000	10.0%	$ 43,891,925	3.1%
1935	$20,691,000	4.7%	$ 42,506,204	2.6%
1936	$26,561,000	5.4%	$ 78,148,893	2.2%
1937	$20,963,000	---	$115,076,950	---
1938	$27,265,000	7.4%	$150,000,000	3.2%

Source: Freudenthal, The Aviation Business in the 1930s," The History of the American Aircraft Industry, (Cambridge, Mass: The MIT Press, 1968), p. 105.
"Naval Aircraft Expenditures 1920-1939," The Congressional Record, vol. 85, Part 2, 76th Congress,2cd Session, pp. 727-28.
(the percentages are my figures)

Table 2.3:

YEAR	Units Ordered	% from U.S. Navy	Units Delivered	% to USN
1932	30	100%	2	100%
1933	34	100%	29	100%
1934	97	85%	64	88%
1935	97	100%	72	90%
1936	--	----	78+	90%+
1937	124	90%	--	----
1938	112	66%	--	----

Source: "Industry & Finance," Aviation, (Oct. 1937), pp. 63-64. Plus additional sources stating when orders were complete, etc. (--means unknown).

Table 2.1, 2.2, and 2.3 list Grumman's finances, orders, and deliveries, and the company's progression compared to naval aircraft expenditures and the industry's production. Grumman Aircraft's income quadrupled from 1934 to 1935, as did it's orders from 1933 to 1937. Despite these increases, the corporation

initially declined in it's percentage of industrial production and it's shares of share naval aircraft expenditures. The reason for the fall in it's percentage of the aircraft industry's production were the greater Air Corps expenditures and the improvement in the commercial market. Between 1934 and 1938 the Army spent $129 million on aircraft compared to $73 million in naval spending.[93] Commercial production, though consistently below that for the military services, was climbing during this period. It reached and surpassed the levels attained before the Depression. The reasons for this climb was the introduction of the modern airliners from Boeing and Douglas. Grumman's sales were almost totally to the Navy and Coast Guard from 1934 to 1936, thus explaining why the company's finances grew, yet reduced in comparison with the rest of the industry. As the company entered other markets in 1937 through 1938 the firm's share of production began to increase. Management's decision to enter these markets proved to be beneficial.

The expansion of carrier aviation was a big stimulus to Grumman's growth. With the addition of three new carriers from 1934 to 1938, the need for carrier aircraft more than doubled. Grumman Aircraft supplied nearly all the fighters for the fleet during this period. This explains why the corporation's percentage of naval aircraft expenditures rose through most of the period. The drop from 1934 to 1935 was the result of the doubling of available funds, not a decrease in purchases from the manufacturer. Grumman had to compete for portions of the funding with manufacturers building larger, more expensive aircraft. For example, in 1937 the Bureau of Aeronautics announced the purchases of nineteen amphibians, fifteen from Grumman and the remaining

four to Sikorsky. Grumman's fifteen single-engined utilities totalled $554,300, while the four Sikorsky twin-engined amphibians cost $827, 839.[94] It's growth in monetary income from the Navy showed the company was supplying an increasing percentage of the number of Navy aircraft.

The engineering success discussed in the text can be shown in looking at the fleet service lives of the various fighters used aboard the carriers during the 1930s. The average service life was four years, yet Grumman's three fighters averaged five years aboard carriers. Only one of the fighters (the F2A) listed on Table 2.4 saw combat in World War II and none saw combat from a carrier. To deduce the aircraft's combat ability, one can only compare performance figures and service lives, and Grumman held high marks in both categories.

Grumman's success in the mid-1930s was partly due to the low cost of it's airframes. It's fighters consistently stayed in the $5 range in cost per pound, with the lone exception (See Table 2.5). Other manufacturer's costs varied more. These airframes were also just modified land planes, whereas Grumman aircraft were built for the naval environment. The Long Island firm's other aircraft sold to the military had lower costs (not including the airframes in the commercial market). The SF-1 and JF-1 were priced at $5.15 and $3.64 per pound, respectively. Production efficiency combined with the good designs and the growing need for carrier fighters made Grumman successful in the mid 1930s.

Table 2.4: U. S. Navy Fighters, Fleet Service Life in the 1930s

Plane	Years of Fleet Service
Curtiss F6C	3
Curtiss F8C	2
Curtiss BFC	6
Curtiss BF2C	1/2
Boeing F3B	4
Boeing F4B	8
Grumman FF-1	3 1/2
Grumman F2F	3
Grumman F3F	6
Grumman F4F	6
Brewster F2A	3
Average:	4 1/2

Table 2.5: Carrier-Fighter Prices of the 1930s

Airplane	Average price per Airplane	Empty Weight of Airplane	Price per Pound
Boeing F4B-2	$ 18,565	2,000 lbs.	$ 9.28
Boeing F4B-3	$ 17,414	2,301 lbs.	$ 7.59
Boeing F4B-4	$ 10,900	2,354 lbs.	$ 4.65
Curtiss BFC-2	$ 14,731	3,037 lbs.	$ 4.85
Curtiss BF2C-1	$ 15,813	3,163 lbs.	$ 5.00
Grumman FF-1	$ 19,000	3,221 lbs.	$ 5.90
Grumman F2F	$ 14,815	2,625 lbs.	$ 5.64
Grumman F3F-1	$ 16,525	2,870 lbs.	$ 5.75
Grumman F3F-2	$ 16,536	3,250 lbs.	$ 5.09
Grumman F3F-3	$ 25,037	3,250 lbs.	$ 7.70
Grumman F4F-3	$ 26,472	5,238 lbs.	$ 5.05
Brewster F2A-1	$ 28,302	4,420 lbs.	$ 6.40

Part III

The Impact of the European War and Tensions in the Pacific on Grumman Aircraft, 1939-1941

The period from January 1939 to December 1941 was a critical period for Grumman Aircraft in many ways. Grumman had established itself as an eminent naval biplane fighter manufacturer, but the age of the biplane was over. Brewster had the jump in monoplane fighters after the Buffalo beat the Wildcat, so the Bethpage manufacturer would have to make up some ground to re-establish it's previous position. The three year period was also important for the planes to see combat in World War II were being designed and tested. The engineering corps played a crucial role at this time, for the success of the firm's airframes depended upon their ability. Grumman's finances or orders were not affected by the tensions in Europe until after the war began. Most of the European countries expected to build all of their aircraft in their own factories. With the outbreak of war, the belligerents turned to the United States for assistance in this area. Their need was responsible for a surge in orders and income at Grumman, as well as the entire industry. Tensions increased in the Pacific as well as Japan became more aggressive. The naval limitation treaties had not been in effect since 1936, yet no significant naval expansion had yet been undertaken. It was not until approximately one and a half years prior to Pearl Harbor that Grumman felt the first indications that the Navy was expanding, and most of the rise in orders came in the final twelve months before the surprise attack. These three years allowed Grumman to expand it's facilities and

design the warbids, thus placing it in a position to be counted on to supply so many aircraft during the Second World War.

The year 1939 began with Julie Holpit and his experimental crew working on the XF4F-3, showing their metal by completing it in four months. After a successful first flight on 12 February, it was turned over to the Navy for evaluation. In the six months spent at Anacostia, the Wildcat attained a maximum speed of 334 m.p.h., an initial rate of climb of 2,800 feet per minute, and a service ceiling of 3,500 feet. Grumman and Navy officials decided to reposition all four guns in the wing, rather than placing two in the nose and two in the wing. The monoplane had ample room in the airfoil for the guns, and this placement did not require synchronized gear to shoot through the propeller. The loss to Brewster proved to be advantageous, for the new design was far superior to the XF4F-2.

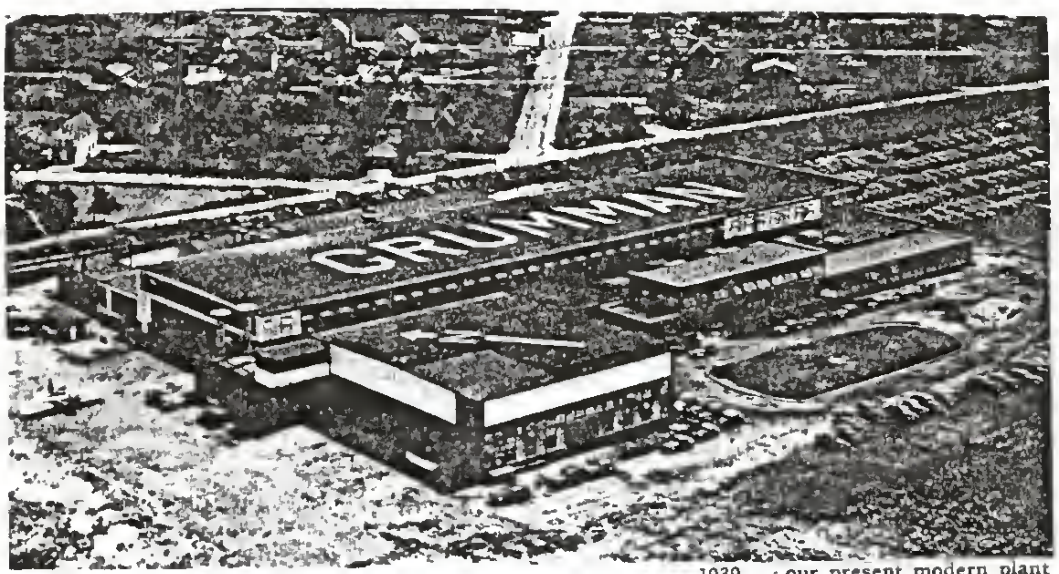
Grumman's commercial Goose was proving to be a fine military vehicle, gaining two contracts in the Spring of 1939. The Navy wanted twenty JRFs, and the Coast Guard asked for ten. The average price per plane was $41,675 on these contracts, considerably less than the commercial price and two thousand less than the Air Corps' order despite the lower number contracted. The Bethpage corporation treated it's best customer well.

During the first four months of 1939 aircraft deliveries brought in $1,755,474 in income, 24% more than the same period in 1938.[95] Part of these deliveries were the final F3F-3s, for the contract was completed in May. These aircraft filled the fighter squadron aboard the Yorktown, which had been commissioned in 1937. Grumman fighters now composed all the carrier fighter squadrons of the United States Navy, showing the dominance it had in gaining

orders for naval pursuits in the mid-1930s.

Management's decision to obtain financial assistance by going public with it's stock in 1937-38 was beginning to be noticable when the company occupied the new addition to it's plant. Construction began at the start of 1939, and added three thousand square feet of floor space. This did not include the new paint spraying room that was completed within a few weeks. The Bethpage factory now contained 48,000 square feet of work space for it's 700 workers, roughly equal to the area taken up by forty-eight F3Fs placed wing tip to wing tip.[96] The financial assistance also allowed the firm to buy the machine tools to be used in the new work area.

Photo 3.1: Grumman's Plant No. 1



1939, - our present modern plant at Bethpage, Long Island, N. Y

Source: Advertisement in
Aero Digest, vol. 36, no. 1, p. 51.

The engineering improvement of the Wildcat paid dividends in August 1939. Brewster's Buffalo entered squadron service in June

with a top speed of 323 m.p.h., a 2,500 feet per minute initial climb rate, and a 34,000 foot ceiling, all of which were below or roughly equal to the XF4F-3 then testing at Anacostia.[97] The Navy did not hesitate very long before granting a contract on 8 August for fifty-four Wildcats. These fighters averaged $426,472 per plane, nearly $2,000 less than a single Buffalo.[98] The Navy paid $1.35 less per pound for the Wildcat, yet it was receiving a better airplane. Grumman was again competing with Brewster to see which company would emerge as the main supplier of naval fighters.

With Hitler's attack on Poland on 1 September 1939, Britain and France declared war on Germany. The navies of both countries needed aircraft and looked to the United States to augment their own industrial output. Among the needs of France was a carrier-based fighter to be used on the Dearn and two Joffre class carriers which had just been laid down. After war broke out, French policy was to concentrate aircraft purchases in the United States, and Grumman Aircraft was included in it's orders. Colonel (Jacques) Jacquin, chairman of the French Purchasing Commission ordered 100 G-36As (Wildcats) from Bethpage. These fighters were to be powered by the Wright Cyclone since the French were already experiencing delays in the delivery of the Pratt & Whitney with the two-stage, two-speed supercharger. The Twin Wasps were in short supply because of the numerous orders, and the time consuming mechanical setbacks it's supercharger encountered. Grumman had to modify the nose of the G-36 for the Wright Cyclone, but within a week one took to the air with the new engine.

France and Britain, realizing they would need the assistance of the American aircraft industry, paid inflated prices for the aircraft provided by United States factories. The reasons for the

exxagerated payment were twofold. It was to insure production of these airframes was completed posthaste. It was also to give these manufacturers capital to expand. With the fall of France the following June, this order (which has been reduced to 81) was transferred to Britain.

While Hitler and Stalin conquered Poland and enjoyed their spoils, the engineering staff at the Bethpage plant worked on several new designs. The Bureau of Aeronautics announced in 1939 a design competition for a torpedo-bomber for the carrier fleet. The Navy wanted a 300 m.p.h. airplane with a scouting range (without ordinance) of 3000 miles, an internal weapons bay, self-sealing fuel tanks, and plate armour. Bob Hall was placed in charge of Grumman's project, which became the TBF Avenger.

The engineers also worked on a second plane to be placed on the commercial market. It was a smaller version of the G-21, taking the name G-44 widgeon. The G-44's plans showed accomodations for four to five passengers, giving businessmen a smaller and cheaper transport.

Draftsmen labored to modify the XF5F for the United States Army Air Corps, which designated it the XP-50. Unlike in the XF5F, the blueprints showed a fuselage stretched forward ahead of the wing and a hydraulically operated tricycle landing gear extending from the tip of it's nose. The two supercharged Wright Cyclones rotated in the opposite direction to avoid the problems of torque. The Air Corps was interested enough to order a prototype on 25 November, despite a high investment.

In the latter part of 1939 the Bureau of Aeronautics asked for a Wildcat with folding wings. The Royal Navy stored all it's carrier planes in the hangar decks, so every square foot saved was

important; thus it was also deeply interested. Grumman wished to avoid folding the wings straight up since this weakened the wing structure. Designers also had to contend with the various hangar deck heights in aircraft carriers. With paper clips and drafting erasers, Roy Grumman developed the idea behind his patented "sto-wing." Mechanically, "the mainplane pivoted about the mainspar as they folded back to lie against the fuselage sides."[99] This system was similar to a bird tucking it's wings back along it's body. The sto-wing reduced the wingspan of a Wildcat from 38 feet to 14 feet four inches, a 62% reduction. One aviation historian called the inclined single-hinge system a "brilliant and simple idea, typical of the company's approach to design."[100] After designing the sto-wing and discussing the system with the Navy, it was ordered on a Wildcat, which was designated XF4F-4, in March 1940. Grumman's ingenuity again brought results that would eventually reap rewards.

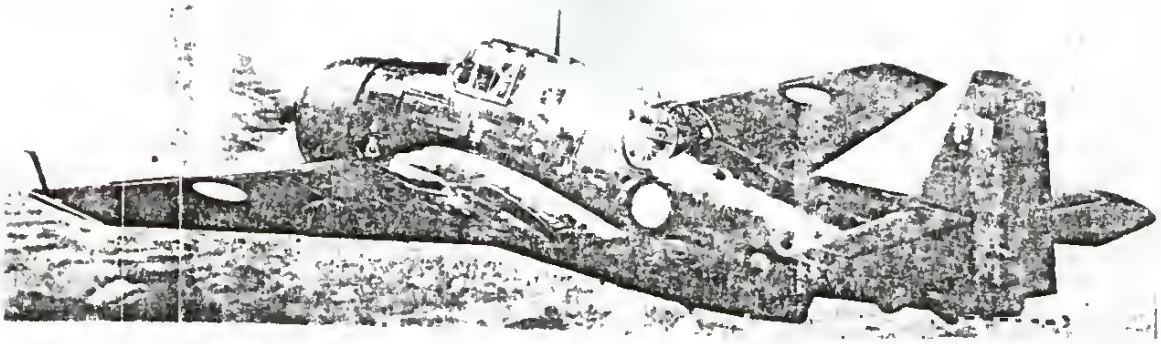
The war in Europe caused a short change in the main benefactors of Grumman's production. The first production model of the F4F-3 made it's first flight in February 1940. The Bethpage manufacturer had planned to provide the U. S. Navy with as many of the F4Fs as possible when it received the initial Wildcat contract, showing it had the best carrier fighter available. But with the war in Europe, France's 1939 G-36 production order took precedence. Wildcats which soon began rolling off the production line were sent to the Europeans. In 1940, Great Britain received the majority of planes coming from Grumman's assembly line. The XF5F-1 twin-engined fighter was completed in March, making it's first flight on 1 April with Bud Gillies controlling the joystick. The experimental plane was then handed over to the Navy for more testing. Several delays were experienced at Anacostia, for the radical

design and it's engines experienced numerous "teething" problems. When functional, it recorded a speed of 358 m.p.h. at sea level, and 380 m.p.h. at 16,500 feet. It had an initial rate of climb of 4000 feet per minute, thus gaining the name "Skyrocket." While under the Navy's control the XF5F-1 was reported to outfly anything it met in the air due to it's speed and climb. Despite it's performance, the Skyrocket had some flaws in it's design. For one, the pilot had an obstructed landing view, a fatal vice for any carrier aircraft, with the placement of the cockpit at the training edge of the wing. The size of the plane and it's radical outline were also considered detriments. The problems encountered during testing brought in more negative views. The anticipated high price was yet another factor keeping the Skyrocket from making progress, but Grumman had other projects to take it's place.

The XTBF-1 moved forward on 8 April when the corporation got the go ahead to build two experimental three-seat torpedo-bombers. The blueprints held all the Navy's desired characteristics of speed, range, and an internal weapons bay. The Avenger was the first plane used by the Navy to hold it's torpedo inside a bomb bay. The drafts also included the sto-wing, reducing it's 54' 2" span to 18' 4" (a 66% decrease). An electrically-driven dorsal turret was to be used, another first for an American single-engine bomber. An outward-retracting undercarriage was utilized, making the Avenger the first Grumman production model not to use Roy's patented landing gear. The outline of the XTBF-1 resembled an enlarged Wildcat, with it's barrel fuselage and square wings and tail.

The first export G-36A lifted off at Bethpage on 11 May, just

Photo 3.2:



Two views of the Grumman Avenger, which served in The U.S. Navy and the Royal Navy during World war 11.

Source: Eric Brown, Wings of the Navy, p. 125.

Photo 3.3:

after Germany's invasion of the west. A few reached France, but the order was transferred to Great Britain after the fall of France on 22 June. Britain received it's first G-36A on 27 June. The Admiralty renamed the fighter the Martlet Mkl. Upon reaching the Royal Navy, the Martlet was it's fastest airplane. Captain Eric Brown of the Royal Navy's Fleet Air Arm, who set a record for the number of deck landings while flying various aircraft, stated; "I will always maintain the Martlet had the best landing characteristics of any naval aircraft that I flew... It offered good forward vision, excellent slow flying characteristics, a robust undercarriage fully capable of absorbing the most punishing vertical velocities and an intelligently positioned arrestor hook that could convert a shaky approach into a safe arrival." The Martlet was "designed specifically for the naval evironment, to such a degree that it was easier to takeoff and land on an aircraft carrier than on a runway..." Brown was also impressed with other aspects that aided the pilot in air combat, such as the all around view

(with even two windows on the floor of the cockpit for limited downward visibility). Seeing the other guy first has always been a vital need for air combatants. The Martlet also had a "good rate of roll" in maneuvering, and provided a stable platform for gunnery. Brown believed the initial rate of climb, which he stated as 3300 feet per minute, "was one of the most sensational aspects of the performance of this little fighter...[T]here was nothing around to touch it." Brown concluded the Martlet was "one of the finest shipboard aeroplanes ever created."[101] Brown's assessment of the Martlet was the summation of two factors. First, he saw the results of the engineers' design for naval environment. He also was affected by the poor performance of British naval aircraft, thus making the Martlet seem even better than it was.

By October 1940 the eighty-one Martlets were completed and delivered to Britain. They entered squadron service the same month, replacing the Sea Gladiators of 804 Squadron.[102] Grumman provided the Royal Navy with a fine aircraft when Britain was hardpressed for fighters to defend their homeland. The heighth of the Battle of Britain had just passed, and planes and pilots were in short supply. The first batch of Martlets would operate from the shore, but later deliveries would be utilized aboard the British carriers.

The United States Navy gained legislation in June 1940 which was important to the surge of naval aircraft orders which took place during the last year before America's involvement in the war. The 11% Expansion Act of 14 June increased aircraft carrier tonnage to 79,500 tons and authorized an increment in naval aircraft from 3,000 to 4,500. The following day the Aviation Expansion Act enlarged the number to 10,000. Yet another bill,

the 70% Expansion Act, was passed on 19 July, increasing the number of planes authorized to 15,000. Congress also appropriated two billion dollars for aviation purposes for fiscal year 1941 (30 June 1940 through 30 June 1941), which was nearly half of the total defense bill. Of the 19,000 planes to be built, 4,000 were to be for the Navy. The Bureau of Aeronautics received $125 million in cash and $375 million in contract authority to purchase the aeronautical equipment for the Navy. The appropriation bill also provided the funds for twenty Essex class carriers. The effects of this legislation would soon be felt by Grumman.[103]

While Grumman's military market looked promising, it also took a step forward in the commercial market with the first flight of the G-44 Widgeon on 28 June. But Gillies and Roy Grumman piloted the successful flight of the amphibian (showing Roy's involvement in all aspects of manufacturing, and his desire to shuck his administrative duties at times). Construction of production models for single buyers began right away. Discussions would soon begin between the Navy and Grumman over the former's use of the G-44.

August 1940 was a big month for the growth of Grumman's business and an indication the U.S. Navy was preparing for war. On 3 August the United States Navy placed an order for ten utility Ducks. Two days later the Navy awarded the "Iron Works" it's biggest contract to date. Two hundred forty-three F4F-3 Wildcats were purchased for $7,260,280, dropping it's average price to $23,861.[104] This looks to be the point at which the Navy made the decision to replace the Buffalo with Wildcats. Only eleven of the initial order for fifty-four Buffaloes had been given to the Navy, the remaining had been sent to Finland. An improved version of the F2A had been ordered but only one hundred and eight were produced.

Grumman was again on top of the United States Navy's fighter list. In six months Grumman's backlog grew to 58%, while Brewster's showed little significant increase.[105]

In the three months of July, August, and September the company shipped $3,779,619 worth of airframes, including sixty-four F4Fs (Martlets). It had not been many years when this would have been a year's production. New sales made in the same period totalled $14,807,000. This figure came from the U.S. Navy purchases and a British order for 100 Martlet Mk IIs with a standard Pratt & Whitney engine. These contracts pushed Grumman's backlog to $20 million.[106]

The great volume of orders in 1940 made plant expansion mandatory. In September 1940 the company purchased a fifty-three acre farm adjacent to it's factory. The new acreage was to be the location for a new "blackout" factory designed and constructed by the Austin Company. The nearly 500,000 square feet structure held a 140 foot center aisle for final assmebly with 800 foot alleys on both sides to build smaller units such as the wing and tail. Flourescent tubes and mazda high-intensity lamps lighted the workshops. A network of overhead conveyor belts was utilized to keep the workers supplied with materials. A twelve hundred seat cafeteria, a locker room, a communication system, air-conditioning, and two thousand space parking lot were also part of the project. The $2,100,000 factory was to be completed in 120 working days. Funding for the plant came from several sources. Grumman was aided by the inflated prices it charged the Allies at war with Germany and Italy. The United States Government's new corporation income tax code, which allowed aircraft manufacturers to depreciate new construction in five years, helped lower the overall cost. The

company mainly made use of the Emergency Plant Facilities program, where the Reconstruction Finance Corporation (RFC) loaned the manufacturer it's building costs in a five year plan. After the five year period, the RFC either took ownership of the plant's title or it sold the factory to the firm. Plant No. 2 was soon completed, and it played a key role in the output of Grumman aircraft throughout the upcoming war.[107]

On Christmas Day 1940, Grumman Aircraft received a "present" in the feat by two of it's airplanes which brought the company some publicity and proved it's product could perform the task it was designed for. On that day two Grumman-made Martlets of Britain's 804 Squadron, piloted by Lt. L.V. Carver and SubLt. A. Parke destroyed a German Junker (Ju 88) twin-engine bomber as it attempted to attack the British Flet at Scapa Flow. The Ju 88 was one of the better performing medium bombers of the Luftwaffe, which made the accomplishments even more spectacular. The distinction of the victory was that it was the first air-to-air "kill" by an American-made airplane during World War II. Grumman workers proudly boast of their plane's tour de force.[108]

December 1940 was another distinctive month for the contracts awarded the Bethpage Corporation. Eight months before the XTBF-1 made it's first flight, the Avenger edged out Vought's design in gaining a production order. The United States Navy procured 286 torpedo bombers for $30 million, by far the largest order ever received by Grumman up to that time. The unit price of the TBFs was $84,688. The largest order was followed by a $6 million purchase of 144 J2F-5 Ducks. The big orders for torpedo bombers and utilities, coupled with the large order for fighters four months earlier showed the Navy was finally anticipating the likelihood of war,

and were preparing for it. With these orders, Grumman's backlog rocketed to $60 million at the beginning of 1941. To combat this rise the corporation began to use the two ten-hour shifts to get production moving at a swifter pace.[109]

Early in 1941 the United States Navy asked for ninety-five F4F-3As (Wildcats using the Wright Cyclone with a single-stage supercharger) as an insurance measure in case the newer Pratt & Whitney failed. The latter was experiencing difficulties with it's two-stage blower. By the end of the year sixty-five F4F-3As were in operation with the Navy and Marine Corps.

In 1941, Greece was anxiously trying to obtain modern fighter planes. It had been attempting to purchase these aircraft from the United States since the fall of France in June 1940. The Royal Hellenic Air Force was totally dependent on foreign manufacturers. Greece tried to go through proper and improper channels to buy Curtiss P-40s, but numerous obstacles were met. For one, U.S. Secretary of State Cordell Hull was initially unwilling to hear the request. Secondly, Britain continually remained opposed, believing it's imports from the U.S. would be impaired by a Greek purchase. Another obstacle was President Roosevelt's unwillingness to consent to aid while campaigning for his third term. On 28 October Italy declared war on Greece, creating a greater demand for the fighters, but the release of planes still met snags. Henry Morgenthau Jr., Secretary of Treasury for the United States, suggested Britain receive the P-40s, and in return send another fighter to the Hellenic peninsula. The British agreed to send the Boultan-Paul Defiant, but Greece was not willing to accept the Defiant in lieu of the Curtiss Warhawk/Tomahwak. The United States had promised to supply the aircraft, so the government continued

pressing for a visible solution. In January 1941 Frank Knox, Secretary of the Navy, recommended that Greece purchase thirty of the F3Fs currently being replaced by more modern fighters aboard the Wasp, but the Hellenic government was unwilling to accept obsolete Grumman biplanes. On 11 February Morgenthau informed Knox that thirty Grumman Wilcats were to be sold instead. Knox was irate, and only a presidential order forced him to relegate the planes intended for the Navy to go to Greece. The Navy was still able to stop the shipment, for the Neturality Acts required Admiral Harold Stark, Chief of Naval Operations (CNO), to approve the items as non-essential to national security. The Navy stated the sale would interfere with the passage of Lend-Lease, so the order was halted. The passage of the latter on 11 March made the delivery of planes possible; however for a short time President Roosevelt hampered the sale by planning to send the planes to Britain since it was now aiding Greece. He felt British pilots would be better prepared to use the modern fighters. Roosevelt reversed his decision just prior to the German invasion on 6 April 1941. The shipment of F4Fs was on it's way the following week, but was held up at Gibraltar as Hitler's two-prong attack rolled down the Hellenic peninsula. Britain took control of the thirty F4Fs, and ordered ten more like them, all of which were designated Martlet IIIs.[110]

At the time the Navy was concerned about the loss of it's Wildcats, it also anxiously waited for the development of the stowing so it could be utilized on carrier aircraft. Grumman, making sure the folding wing would stand up to the stress of flight and landings, took it's time. On 14 April the XF4F-4 left the ground for the first time. The prototype had a hydraulic wing folding

mechanism, but in production models it was folded manually--a task for the carrier deck crew. The sto-wing and other modifications soon incorporated into the Wildcat, such as the inclusion of self-sealing fuel tanks; plate armour and bullet-proof glass for pilot protection; and the increase to six .50 calibre machine guns (added after the British recommendation), and the weight of the F4F increased to nearly 8000 lbs. Thus a slightly slower and more sluggish Wildcat was created, but also one less destructable and one taking up less carrier deck or hangar space.

The first operational use of the Wildcat with the Pacific Fleet came in May 1941. Lt. Commander Clarence Wade McClusky's Fighting Six (VF-6) aboard the U.S.S. Enterprise was the first squadron to obtain the Wildcat. The air unit exchanged it's F3F-2s

A Group of F4F-4 Wildcats:

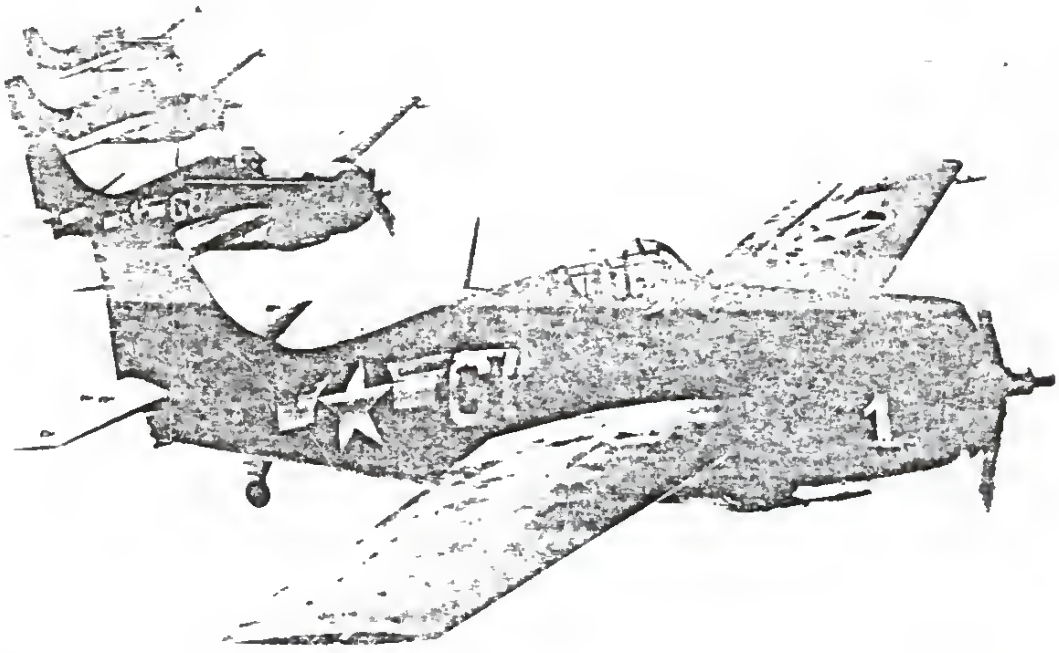


Photo 3.4:

Source: O'Leary, United States Naval Fighters of World War II, p. 38 (USN).

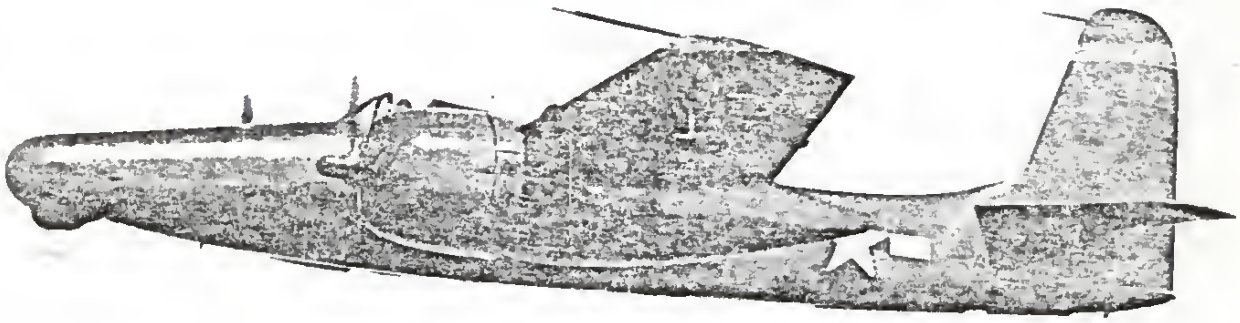
for eighteen F4F-3As. Other carrier fighter squadrons would convert to the Wildcat throughout the year.[111]

Although the twin-engined Skyrocket was discarded by the Navy after 211 test flights, it's sister, the XP-50, was still of interest to the Air Corps. But this changed after it's supercharger blew up and caught fire on it's maiden voyage on 14 May. Bob Hall brought it down to land, but the hydraulic lines had been severed and the back-up system failed to lower the nose gear. Hall bailed out, letting the XP-50 crash in the depths of Long Island Sound. Becuase of this failure, along with the Air Corps' interest in Lockheed's P-38 Lightning and a new twin-engine project by Grumman, the XP-50 was cancelled.

Although it's first twin-engined fighter had been terminated by both services, Grumman had another to take it's place. The G-51 design used a tricycle undercarriage for improved taxiing; a cockpit placed well ahead of the wing for excellent visibility forward; a 5 1/2 foot, square-tipped wing utillizing an upward folding mechanism; and a long slender fuselage with a sharp-edged spine flowing into the tail giving the "Tigercat" it's "sleek" looks. With two 1,800 h.p. Wright engines, Grumman anticipated a maximum speed of 430 m.p.h. On 19 May 1941, just days after the XP-50 crashed, the Air Corps ordered two prototypes which were called XP-65. The Navy also showed interest, ordering two on 30 June, which were designated XF7F-1. While moving through the experimental stage with this design, Grumman came to the conclusion that the requirements desired by the two services were unique enough that both could not be filled. This attitude likely came from pressures by the services to deal exclusively with them. There was at this time an unwritten guideline forming in the air-

craft industry to deal primarily with a single service. Grumman stuck to naval aircraft construction.

Photo 3.5: The F7F Tigercat



Source: O'Leary, p. 140. This is a -3N version housing radar in it's nose. It was used as a night-fighter.

Another important fighter design was on the drawing boards in the first half of 1941. This pursuit had a background of designs dating back to 1938 when the company studied the idea of using a larger engine in the Wildcat. The outline had been formed in January and was given it's "final definition" in Specification SD-286 and Report No. 2421 on 24 February 1941. The F6F Hellcat was officially started.[112]

In June the Navy asked Grumman for an improved Wildcat in case of delays in the Vought F4U Corsair, which came out of the previously mentioned 1938 design competition. Grumman instead showed them the blueprints for the new design, and the Navy ordered two on the last day of the month. The Hellcat first used the Wright Cyclone, but with the delays encountered by the Corsair and Republic's P-47 Thunderbolt, it switched to the Pratt & Whitney Double Wasp engine with it's two-stage, two-speed supercharger, often considered the best radial piston engine ever used. It gave

the first production Hellcats a speed of 375 m.p.h. These F6Fs were flying a year and a half after the experimental order. Only North American's P-51 Mustang could claim a faster development, and this was only by one month. Because of the rising weights being encountered in combat aircraft, Grumman designers put an

Photo 3.6: Grumman's F6F-5 Hellcat

Source for Both Photos: John Taylor, Combat Aircraft of the World, p. 503.

Photo 3.7: F6F-3 Hellcat, the variant joining the fleet in 1942-43.

Grumman F6F-3 Hellcat

immense wing on the Hellcat. It was the largest airfoil to be used on a single-engined fighter during the war with a span of nearly forty-three feet and a wing area of 334 square feet. Two-thirds of the wingspan was eliminated during storage with the installation of the sto-wing. The big powerplant and the large wing gave the XF6F an initial climb rate of nearly 3,000 feet per minute and production versions 3,650 feet per minute. Speed and climb had been seen as being extremely important in combat in Europe before America's involvement. General Manager Swirbul visited England during the Battle of Britain and became informed of what was needed. He later went to the Pacific after Japan attacked the United

States, and naval pilots' supported the earlier information. The knowledge gained in these trips was incorporated into the Hellcat's structure.

In June workers continued to build Wildcats and Martlets as orders came in for more to be made. There were still ninety Martlet Ils to be contructed, all of which would use the sto-wing (the first ten on the contract did not have the folding wing). An additional 150 Martlet Mk lVs (equivalent to F4F-4 except for the use of a Wright eigine) were placed on order by the British. The United States Navy followed with another 436 F4F-4s during the summer. Five of the latter were delivered by the end of the year. The war in Europe was having an effect on Grumman's new sales, but the Navy's preparation for a struggle at sea had a much greater impact in this area.[113]

In the first six months of 1941, Grumman's unfilled orders had risen to $70 million despite working two shifts. Income during this period equalled over $9 million, a 287% increase over the amount earned by 30 June the previous year. Net profit in this period was $747,218. Every business category was skyrocketing, as was the entire industry's production and financial statistics. Grumman's share of the orders placed in the aircraft industry still hovered around 1.0%.[114]

The next five months were a busy period for Grumman. In 1941 sixty-nine Widgeons were sold, thirty-three to individuals. The Coast Guard obtained twenty-five. The remaining eleven G-44s were originally ordered by the government of Portugal, but were commandeered by the United States Army after the Japanese surprise attack. More were sold to the Navy, and also to the British (called Goslings), during the war.[115]

On 1 August 1941 the Avenger made it's first flight. Although the XTBF-1 nearly met the requirements promised, the Avengers produced in quantity did not have the speed or ceiling originally specified. The rising weights of pilot protection, fuel tanks, and more caused the reduction in performance. It was nicknamed "Turkey" by naval pilots who viewed it's ability to fly when it's "wings were clipped," for without power the TBF lost altitude fast. Despite the shortcomings the Avenger performed their tasks admirably, especially when escorted by Grumman or Vought fighters. With the initial flight and the previous production order for TBFs, two of the three major warbirds built by the corporation had flown and were in mass production by the time the United States entered the Second World War. The third had received an experimental order. Thus Grumman, like the industry as a whole, fought the war with pre-war designs.

Table 3.1 shows the financial development of Grumman during the four years prior to the United States entry into World War II. The company was growing at a rate similar to the mid-thirties until the war broke out in Europe. This event caused the corporation's financial statistics to skyrocket. In 1940 it's total income doubled over the previous year's total. By the end of the first half of 1941, gross income already exceeded the 1940 total, assuring a second consecutive doubling of annual gross profits. Net profits grew, too, but not at such a high rate. Unfilled orders made the greatest leap, growing from three and a half million dollars at the end of 1938 to seventy million dollars by 30 June 1941. Compared to the aircraft industry, Grumman's backlog advanced at a similar rate. The affect the war had on the company was analogous to the results of all the manufacturers, i.e., it was

obtaining the same amount of orders as the rest of the industry.

The war in Europe had a major impact on the amount of exports contracts the company received. Table 3.2 shows that these rose from 4% of the planes procured in 1938 to 41% in the year the war began. In the second half of 1940, the United States Navy began to prepare itself for war after Japan took advantage of France's

Table 3.1: Grumman's Finance's 1938-40

YEAR	Grumman's Backlog (end of)	Grumman Backlog vs. Industry	Grumman's Gross Income	Grumman's Net Profits
1938	$ 3,500,000	----	$4,904,946	$ 617,074
1939	$ 6,000,000	1.0%	$4,482,350	$ 892,063
1940	$63,500,000	1.6%	$8,811,294	$1,415,916
1941 1st 6 months	$70,000,000	1.0%	$9,001,013	$747,218

Sources: "Aviation Finance: Current Earnings Report," Aviation, vol. 39 (May 1940), p. 64.
----------, --------, vol. 40 (May 1941), p. 111.
----------, --------, vol. 40 (Oct. 1941), p. 131.

Table 3.2:

YEAR	# planes ordered	% USN	% Military Export	% US Army Air Corps
1938	112	66%	4%	23%
1939	194	38%	41%	1%
1940	651[t]	85%	15%	--
1941*	790	86%	5%	0.2%

t number may be too low, for Threulsen stated 759 Wildcats (p.122) ordered in 1940. Even by adding the 95 F4F-3As which Swanborough and Bowers state as ordered in 1941 (p.206)--which makes our 1941 Wildcat orders roughly the same--the most I get is 592.

*Does not include orders after 12/7/41.
(The graph may exclude some commercial sales the author is unaware of)

helplessness after German conquest by invading and occupying French Indochina. The United States demanded, through the oracle splendor of President Franklin D. Roosevelt, in July 1941 that Japan relinquish it's "protectorship", imposing embargoes on such materials as iron and oil until it did so. It's refusal made war inevitable. Under this backdrop of events, the Navy geared for war. In the last sixteen months before the war began, it awarded Grumman four very large contracts for F4Fs (2 orders), TBFs and J2F-5s. The Navy's preparation for war caused it's return as Grumman Aircraft's main market.

The successfulness of the company during the last three years before Pearl Harbor can be illustrated by the achievement of planes designed and produced during this period. Each of the corporation's planes, except the J2F series, was designed, tested, or in the early stage of production between 1939 and 1941. These planes showed their "metal" in the war.

The amphibians or the J2F series, and the naval versions of the Goose and Widgeon, performed many unglorious tasks during the interwar period. Aviators learned the procedures to aerial search and rescue, air patrol, and personnel and supply transport. The J2F also aided many to learn the art of aerial gunnery by pulling the target sleeve. After the war began these airplanes continued to fulfill the jobs that do not get the notoriety they deserve. Though these roles were often monotonous and certainly unglamorous, they were still important to the total war effort.

Of Grumman's combat aircraft of World War II, only the Wildcat had been produced in quantity by the time Japan attacked the United States. When the war began the F4F was entrenched as the number one fighter for the Navy. Although Harvard's Graduate

School of Business showed that 471 F2A Buffaloes had been accepted to only 430 Grumman wildcats, Richard Threulsen gave a more realistic portrayal of U. S. Navy fighter strength, listing 250 Wildcats to 90 Buffaloes.[116] In terms of front-line carrier service the F4F was certainly top dog. Of the 162 fighters aboard the seven fleet carriers available in December 1941, all but 18 were Wildcats.[117]

The F4F could not equal it's prime adversary, the Japanese Zero (Zeke), in a dogfighting dual; however it could more than hold it's own against an equal or superior number of enemy fighters when operating as a group and utilizing tactics founded upon it's ruggedness and firepower. As one marine pilot involved in the highly contested airspace over Gaudacanal stated, "The Zero could outmaneuver, outclimb, outspeed us. One Zero against one Grumman is not an even fight, but with mutual support two Grummans are worth four or five Zeros." In speaking of the Wildcat's ruggedness, another pilot exaggerated, "A Zero can't take two seconds' fire from a Grumman and a Grumman can sometimes take as high as fifteen minutes' fire from a Zero."[118] In the first six months of the war against Japan, the F4F rolled up a kill ratio of 3:1 (meaning for every three planes shot down by a Wildcat, one wildcat was destroyed in the air by a Japanese pilot). At the end of a year the ratio increased to 5:1, and by the end of the war it was nearly 7:1.[119] The F4F Wildcat performed it's job well.

The Wildcats domestic competitor in the manufacturing arena, the Buffalo, did not fare nearly as well. In it's limited combat it performed disastriously. Even if it's poor U. S. battle record was discounted (for it did serve Finland adequately in the

country's struggle with the Soviet Union), the F2A was a failure with the Navy because it could not survive the carrier environment. As historian John Lundstrom noted, "The Brewster airplane simply lacked the strength for prolonged service at sea."[120] Buffaloes experienced a high number of carrier deck crashes, largely due to an inadequate undercarriage. These mishaps caused naval pilots to lose confidence in the F2A. Brewster's reputation sank farther into the depths when the Corsairs it built during the war suffered wing stress, with several losing their airfoils during aerobatics. The scandalous activities of the company forced it out of business.

Grumman's Avenger also achieved great distinction during the war. Deliveries of the torpedo-bomber began in January 1942. After the TbFs were "devastated" on 4 June at the Battle of Midway (as were the first six Avengers to see combat), the TBF became the only torpedo-bomber used by the American Navy through the rest of the war. It continued to serve various functions with the Navy until 1954.

The Grumman airplane that presented the best performance during the Pacific war was the F6F Hellcat, which was only being built as a prototype when the American battleship fleet was made obsolete on 7 December 1941. After recording it's first production flight in November 1942, it made it's combat debut early in the Fall of 1943. For the next two years it dominated the skies over the vast Pacific. Hellcats virtually won the Battle of the Philipine Sea single-handedly by destroying a large majority of Japan's carrier aircraft and pilots while defending the task force off the Marianas. In two years of aerial combat, F6Fs destroyed 5,155 enemy aircraft, nearly 75% of all Navy and Marine Corps "kills"

made in the entire war. Only 270 Hellcats were lost to enemy aviators, giving the F6F an impressive kill ratio of 19:1.[121] The vaunted Corsair, often considered the best piston-engined naval fighter ever produced, had a 10.5:1 kill ratio.[122] When the Hellcats escorted attack aircraft to the assigned targets, only forty-two of the bombers were lost to enmeny combatants, making the fighter an appreciated chaperone. It was also a mechanic's dream, allowing it to be ready for operations 90 to 95% of the time, the highest mark in the fleet.[123] When the F6F began to be replaced in the air superiority role by the Corsair, which had proved it's ability to operate off carriers while serving with Britain's Royal Navy, it stayed aboard the fleet carriers as an attack aircraft, even though it was not specifically designed for such a role. The Hellcat and the Wildcat provided cheap but effective carrier fighters.

The F7F Tigercat and the F8F Bearcat (a project started after the beginning of the war) were joining the fleet and marine units when the atomic blasts ended the conflict. Neither saw any major combat, though the F7F did serve as a night-fighter for the Marines for several months. Both would see action in Korea a few years later, but by this time they were over-shadowed by the jets. The performance of these planes was superior to the warbirds, and had the war continued in the Pacific they would have upheld the reputation built by their predecessors.

Table 3.3 provides a list of all the carrier-fighters to be used by the Navy during the war. It shows the relative short period utilized for design and experimental work on the company's warbirds, which was a contributing factor to the success of these planes. The quick design phase coupled with the squared features

Table 3.3

Air plane	Design Work Started	Proto-type ordered	First Flight	Produc-tion order	5th Air-plane delivery	Years up to 5th del	Years Front-line Service
F2A	mid 1935	6/23/36	1/--/38	6/11/38	6/--/39	4	2 3/4
F4U	2/--/38	6/11/38	5/29/40	4/02/41	Late 42	4 1/2	12+
F4F-3	mid 1938	10/--/38	2/12/39	8/08/39	8/--/39	2*	6
F6F	5/--/41	6/30/42	12/02/43	- - - -	4/--/44	3	8

* This figure is somewhat misleading for it does not include the work on the XF4F-1 biplane nor the -2 monoplane which lost in a flight competition to the F2A, but this variant had been altered enough to use the starting date listed.

Source: Problems Accelerating Aircraft Production..., Harvard Business School, p. 16: plus my own personal compilation of facts attained throughout the sources listed in the bibliography.

of the corporation's airframes which were easily manufactured, helped Grumman mass porduce the aircraft used during the war.

This integration also allowed the most economical means to make aircraft be utilized. Grumman was very proud of the fact that it had the lower-priced carriers available to the fleet, as Table 3.4 shows. The cost per pound of aircraft produced by the Bethpage

Table 3.4: Prices For World War 11 Carrier-Fighters

Airplane	Price per Airplane	Empty Weight of aircraft	Price/lb. of aircraft
Brewster F2A	$28,302	4,420 lbs.	$6.40
Grumman F4F	$26,472	5,238 lbs.	$5.05
Grumman F6F	$35,000*	9,025 lbs.	$3.88
Vought F4U	$50,000**	8,982 lbs.	$5.57

* As stated in Anderson's Hellcat, p. 23. The 27 Sept. 1943 article in Life entitled "Navy's Newest Fighter," has a lower figure of $24,000.
** Anderson states Hellcat costs 2/3rds of Corsair.

manufacturer was decreasing in the war period. The price of Grumman's aircraft compared to it's competitors was favorable. The comparison between the F2A and the F4F in Table 3.4 was a good

illustration in that it comes from two production orders in roughly the same period for the exact same number of airframes (54). Likewise the F6F and F4U prices were those at the end of the war when both had been built in nearly equal amount. Good designs, and efficient production leading to comparatively low prices, were the key components to the success of the period from 1939 to 1941.

Conclusion

The Grumman Aircraft Engineering Corporation's orders and finances followed a parabolic pattern through it's first twelve years in operation, (See Diagram C.1 and C.2) similar to the production in the periods of peacetime equilibrium and rearmamental instability according to the wave theory presented by Robin Higham in Air Power: A Concise History. Unlike the industry, which reached it's low point in peacetime production in 1933, Grumman was growing rather than declining before this point. Management's planning to stay in business while the engineers produced their initial designs, and it's decision to produce fighters and amphibians for the Navy were vital to this initial success. The Navy's purchase of experimental and production models of each of the first five designs produced by Grumman was also a major reason for it's rise. The reasons for these initial orders were a combination of the quality of engineering and the needs of the Navy with it's expanding carrier force.

From 1934 to 1938 Grumman grew at roughly the same pace as naval aircraft expenditures. It's progression in this period was closely associated with the rise of carrier aviation. Grumman supplied the majority of fighters and single-engine amphibians for the Navy. The firm also associated it's growth by constructing aircraft for export and commercial markets. Production was the most important element of this period, and the firm's consistent fair pricing, with perhaps one exception, and the performance of

Diagram C.1:

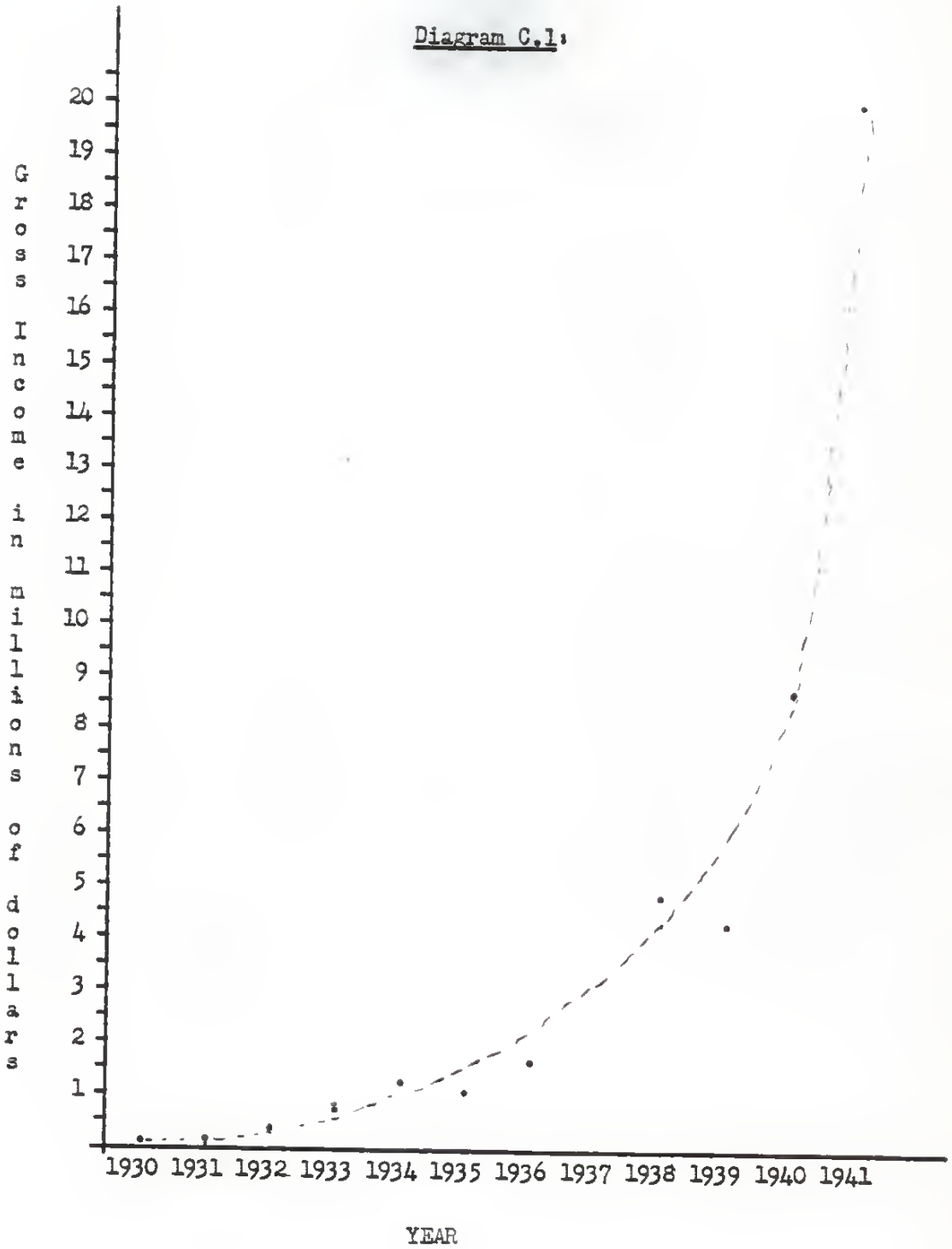

Gross Income in millions of dollars
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941
YEAR

Diagram C.2:

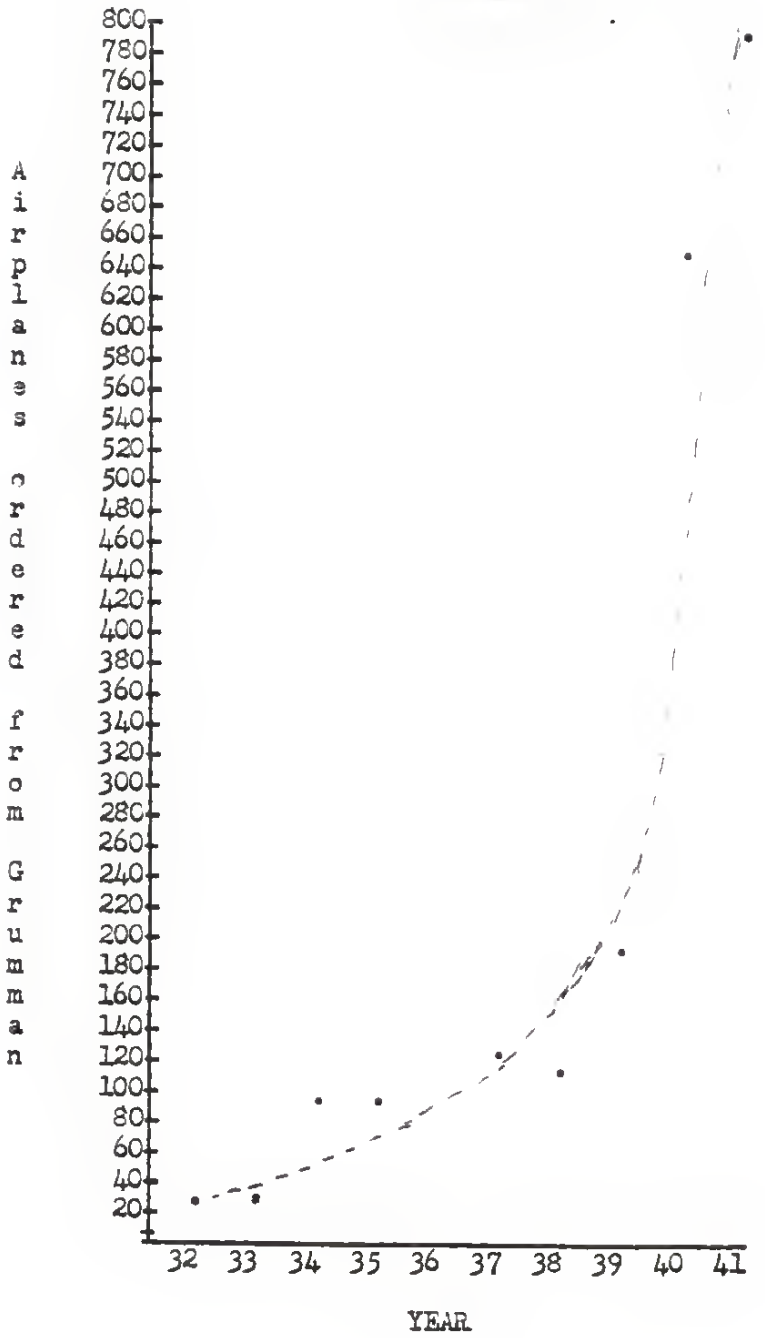

Airplanes ordered from Grumman
800
780
760
740
720
700
680
660
640
620
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
32
33
34
35
36
37
38
39
40
41
YEAR

Table C.3: Aircraft Production, 1940–45

Company	*Production by Number of Units*
North American	41,188
Convair	30,903
Douglas	30,696
Curtiss-Wright	26,154
Lockheed	18,926
Boeing	18,381
Grumman	17,428
Republic	15,603
Bell	13,575
Eastern Aircraft Division, * General Motors	13,449
Martin	8,810
Chance-Vought	7,890
Ford	6,791
Goodyear	3,940

Company	*Production by Airframe Weight (thousands of lbs)*	*Percent of 5-Year Grand Total*
Douglas	306,573	15.3
Convair	291,073	14.6
Boeing	226,447	11.3
North American	210,913	10.5
Lockheed	180,118	9.0
Curtiss-Wright	136,091	6.9
Martin	126,970	6.3
Ford	123,076	6.2
Republic	75,893	3.9
Grumman	73,767	3.7
Bell	53,037	2.7
Eastern *	47,869	2.4
Chance-Vought	28,952	1.4
Goodyear	13,668	0.7
All other plants	101,136	5.1
Grand total—all plants	1,995,613	100.0

SOURCE: W. F. Craven and J. L. Cate, "Men and Planes," as cited in John Bell Rae, *Climb to Greatness: The American Aircraft Industry, 1920–1960* (Cambridge, Mass.: MIT Press, 1968), p. 168

* Eastern Aircraft Division of General Motors built airframes from Grumman's designs, thus the number of planes built from the company's blueprints was even higher.

the aircraft produced allowed it to expand.

The war years of 1939 to 1941 were a great stimulus to the growth of the corporation. Orders leaped upward in 1939 and skyrocketed in 1940, and gross income followed suit, although it lagged behind the orders by one year. The quick, yet skillful engineering work on the warbirds was a major factor in the success of this period, for it allowes the new designs to play a major role in the upcoming war. The cheap costs compared to it's competitors was an added bonus to the Navy. The expansion that came in the beginning of 1939 with the aid of public finance, and the building of a new plant in 1940 funded by European orders and the Reconstruction Finance Corporation were important in supplying aircraft early in the war. The expansion from 1939 to 1941 in men, machines, and work space placed the company in a position to be able to obtain the orders during World War 11.

Appendix 1: Investments and Stock

Table A-1: ORIGINAL INVESTMENT

Investor	Shares		Money for Shares		Total Money
	Preferred	Common	Preferred	Common	
A. P. Loening	100	100	$10,000	$2,500	$12,500
Grover Loening	200	200	20,000	5,000	$25,000
Leroy Grumman	- -	675	- - -	16,875	$16,875 + $75*
Leon Swirbul	- -	325	- - -	8,125	$ 8,125
E. W. Poor	100	100	10,000	2,500	$12,500
F. C. Towl	50	50	5,000	1,250	$ 6,250
Sub-total	450	1,450	$45,000	$36,250	$81,250[t] + $75
3 March 1930 Investment					
Bill Schwendler	- -	125	- - -	$3,125	$ 3,125
E. W. Poor	- -	20	- - -	500	$ 500
Ed Weick	- -	40	- - -	1,000	$ 1,000
Julie Holpit	- -	40	- - -	1,000	$ 1,000
Total	- -	1,675	$45,000	$41,875	$86,875 + $75

Source: Richard Threulsen, The Grumman Story, pp. 32, 41.

*Adds the three incorporation shares purchased by Grumman.

[t] Threulsen lists as $77,250, of which available funds equalled only $58,825 (In Guggenheim Medalists initial capital stated as $67,000). When giving final total Threulsen lists $86,750, with $64,325 actually available, only slightly less than my addition.

18 December 1930 "Agreement and Consent of Stockholders and Subscribers to Modification and Partial Cancellation of Certain Subscription Agreements" caused a reduction in the par value of preferred stock by 50%, but left common stock alone.

January 1933: Montauk Research Corporation formed to keep the patents and property of Grumman Aircraft Engineering Corporation under control of those who had already invested. Each of the nine stockholders was given ths same number of shares as he owned in the company. Each share given a par value of one dollar.

Summer 1937: Grumman announced it would go public with its stock, registering 140,000 shares of common stock with the Securities Exchange Commission, of which 95,000 went to the public, 5000 to Grumman employees, and 40,000 was held back for exercise of warrants.

Appendix 2: The Airplanes

FF-1, -2:

Dimensions: Span: 34' 6" Length: 24' 6" Height: 11' 1"

Speed: Landing: 65 m.p.h.

Maximum : 201 m.p.h. (575 h.p.), 220 m.p.h. (775 h.p.); -2, 207 m.p.h.

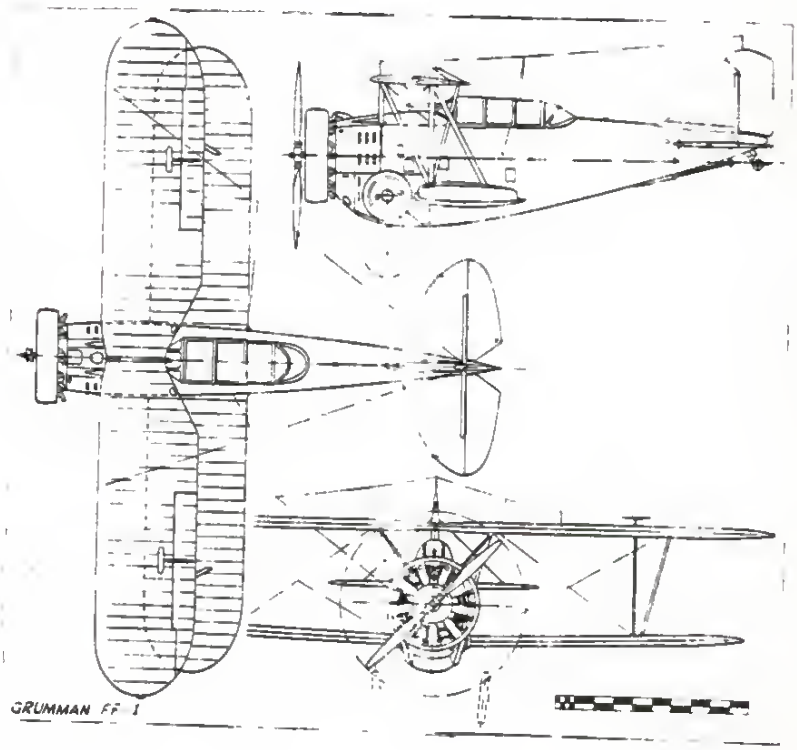
Cruising : 191-200 m.p.h.

Climb: avg. : 1,000

initial : 1,724-1,800 feet per minute (depending on engine)

Service ceiling: 21,000-25,000 feet (depending upon engine)

Range/fuel cpty: 800 miles/120 gal. (575 h.p.), 647 miles/120 gal. (775 h.p.)



Line sketchings of the FF-1

Source: Swanborough and Bowers, United States Navy Aircraft Since 1911, p. 196.

F2F

Dimensions; Span: 28' 6" Length: 21' 5" Height: 9' 1"
Wing area: 230 sq. ft.

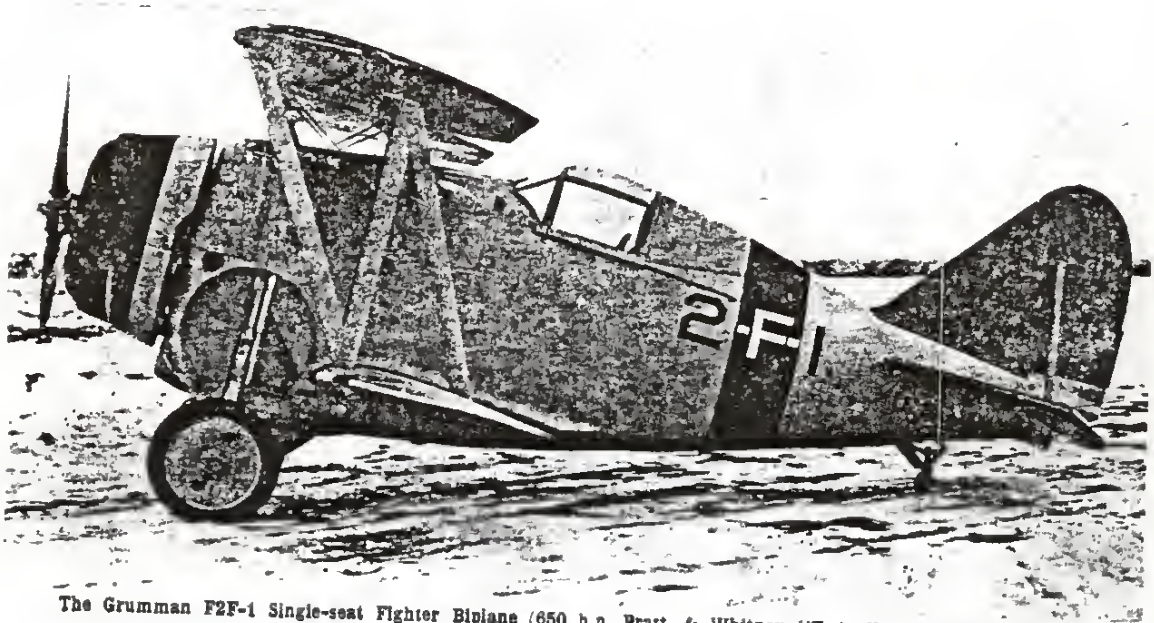
Speed; Max: 237 m.p.h. (P&W), 257 m.p.h. (Wright)
Cruising: 215 m.p.h.
Landing : 66 m.p.h.

Climb Rate;
Average: 2,500 ft./min.
Initial: 2,700 ft./min.
ceiling: 27,500 ft.

Powerplant: Pratt & Whitney R-1535-72, Wright "Cyclone" R-1820-F53
650 h.p. 750 h.p.
Weight: 3,847 lbs (gross load)

Range/Fuel capacity: 750-985 miles/110 gallons

Armament: Two Browning .30 in. machine guns in the nose.



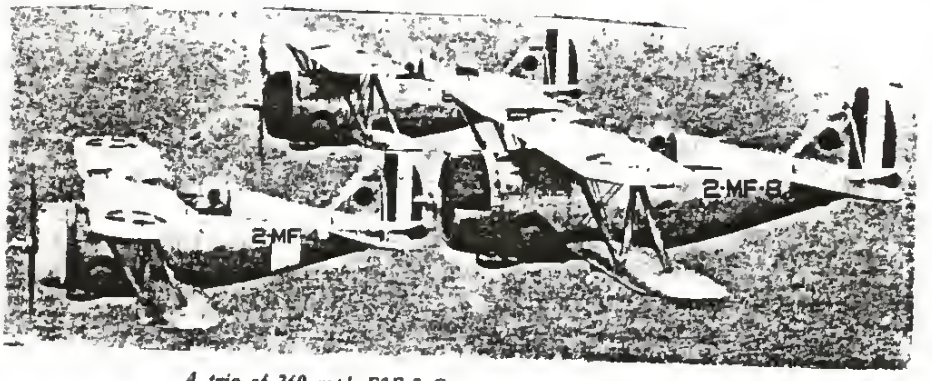
The Grumman F2F-1 Single-seat Fighter Biplane (650 h.p. Pratt & Whitney "Twin-Wasp Junior" engine).

F3F

Dimensions;
Span : 32' Length: 23' 2" Height: 9' 4"
Wing area : 260 sq. ft.

	F3F-1	F3F-2	F3F-3
Speed;			
Maximum	240 m.p.h.	260 m.p.h.	264 m.p.h.
Cruising	215 m.p.h.	241 m.p.h.	242 m.p.h.
Landing	66 m.p.h.	66 m.p.h.	66 m.p.h.
Climb Rate;			
Average			
Initial	2,700 ft/min		2,750 ft/min.
Ceiling	29,000 ft.	32,000 ft.	33,300 ft.
Powerplant	650 h.p. P&W Twin Wasp Jr.	750 h.p. Wright Cyclone	950 h.p. Wright Cyclone
Weight/max	4,100 lbs.	4,620 lbs.	4,795 lbs.
Range/fuel	720 miles/ 110 gal.	975 miles/ 130 gal.	980 miles/ 130 gal.
Armament	one .30 and one .50 in. Brownings		
Price			
Experiment:	$75,840	$26,300	$12,750 *
Production: per unit	$16,525	$16,536	$25,037 **

* This was the modification of the last F3F-2 into the XF3F-3, which also shows why the Navy did not run extensive tests.
**The increase in price was partly due to the smaller number of aircraft ordered.



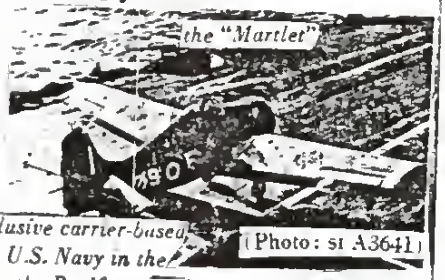
A trio of 260 mph F3F-2 Grummans in formation flight

F4F Wildcat (Martlet):

Dimensions; Span: 38' Length: 28' 9" Height: 11' 10"
Wing area: 260 sq. ft.

	F4F-3	F4F-3A	F4F-4
Speed; Maximum Cruising Landing	331 m.p.h.	312 m.p.h.	318 m.p.h.
Climb Rate; Average Initial			
Ceiling	37,500 ft.	34,300 ft.	34,900 ft.
Powerplant	1200 h.p. P&W 2 stage 2 speed twin wasp	1200 h.p. single stage 2 speed Wright Cyc.	same as F4F-3
Weight/max	7,065 lbs.	6,876 lbs.	7,964 lbs.
Range/fuel	860 miles/ 160 gallons	825 miles/ 160 gallons	770 miles/ 160 gallons
Armament	(4) .50 MG	(4) .50 MG	(6) .50 MG
Price: per unit:	(1) $26,472 (2) $23,861		

A good view of the Wildcat's (Martlet's) "plank-like" wing.



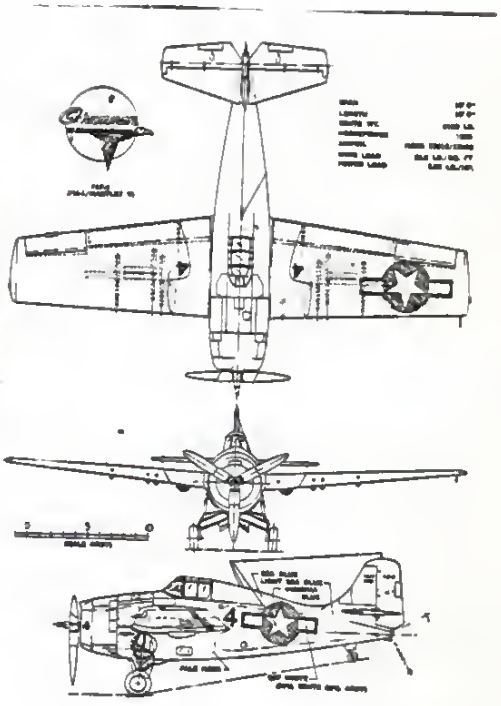
Wildcats were the exclusive carrier-based fighter aircraft for the U.S. Navy in the first years of the war in the Pacific. (Photo: SI A3641)


(Photo: NASM)

A good look at the Grumman fighter's fuselage.

Aircraft of the

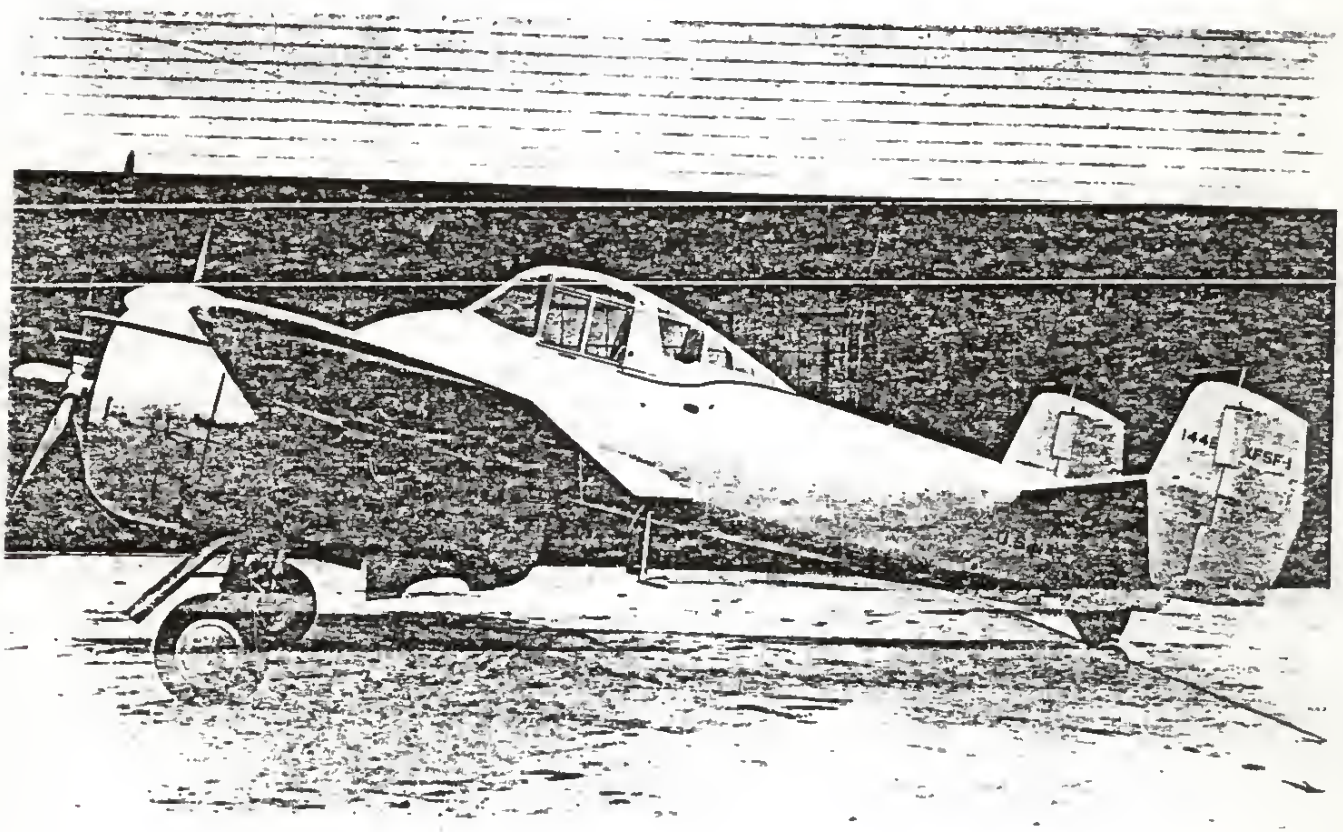
Picture Source: Mikesh, Robert, "National Air and Space Museum," Smithsonian Inst.



F5F Skyrocket (XP-50):

	XF5F-1	XP-50*
Span	42 feet	42 feet
Length		32 feet
Height		12 feet
Max. speed	380 m.p.h. at 16,500 feet	424 m.p.h.
Cruising speed		317 m.p.h.
Initial rate of climb	4000 ft./min.	similar to F5F
Ceiling	33,000 feet	40,000 feet
Powerplant	Two 1,200 h.p. Wright Cyclones R-1820-40	Two 1,200 h.p. Wright Cyclones R-1820-67/69
Weight/max.		10,558 lbs
Range/fuel		585 miles/217 gal

* Proposed specifications since the XP-50 crashed during its initial flight before statistics could be gained.

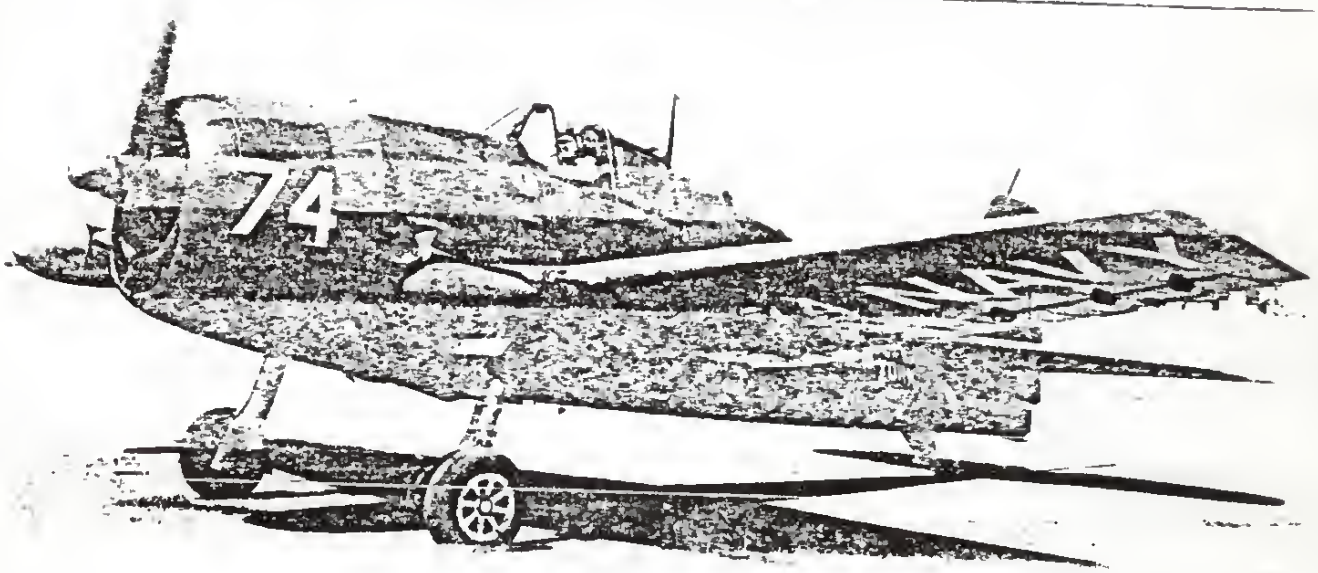


F6F Hellcat:

Dimensions;
Span : 42' 10" Length: 33' 10" Height: 14' 5"
Wing area: 334 square feet

	XF6F	F6F-3	F6F-5
Speed			
Maximum	375 m.p.h.	391 m.p.h.	410 m.p.h.
Cruising	200 m.p.h.	200 m.p.h.	200 m.p.h.
Landing	82 m.p.h.	82 m.p.h.	82 m.p.h.
Climb rate			
Initial	2,980 ft./min.	3,650 ft./min.	similar to -3
Average	2,350 ft./min	3,100 ft./min.	3,150 ft./min.
Ceiling	35,500 feet	39,400 feet	38,800 feet
Powerplant	Originally 1,600 h.p. Wright R-2600 replaced by P & W 2000 h.p. in XF6F-3	Pratt & Whitney's 2000 h.p. (R-2800-10 or 10W)	Pratt & Whitney's 2000 h.p. (R-2800-10W)
Weight/max.	11,629 lbs.	13,221 lbs.	12,598 lbs.
Range/fuel	1,500 miles 250 gallons	1,850 miles 250 gallons	1,900 miles 250 gallons
Price	Price had originally been approximately $50,000 per plane, however price cut to $35,000, and even to about $24,000		

Sources: Anderton, Hellcat
O'Leary, Naval Fighters of World War II in Action

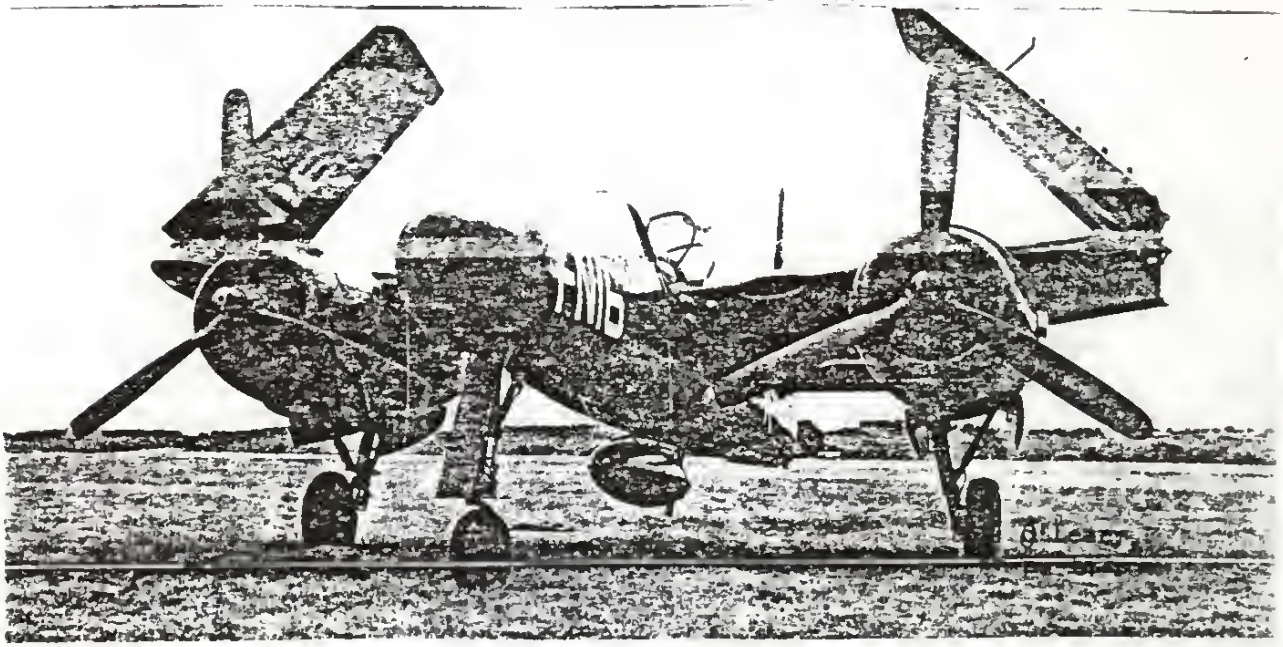


F7F:

Dimensions;
Span : 51' 6" Length: 45' 6½" Height: 13' 9"/ 14' 7"
Wing area : 455 sq. ft.

	XF7F-1	F7F-2N*	F7F-3
Speed;			
Maximum	430 m.p.h.	445 m.p.h.	460 m.p.h.
Cruising	180 m.p.h.	190 m.p.h.	190 m.p.h.
Landing	approx. 70 knots		
Climb rate;			
Average			
Initial	4,200 ft./min.	5,200 ft./min.	6,000 ft. min.
Ceiling	42,000 feet	41,000 feet	40,000 feet
Powerplant	Two 1,800 h.p. Wright Cyclones XR-2600-14	Two 2,100 h.p. Pratt & Whitneys R-2800-22W	Two 2,100 h.p. Pratt & Whitneys R-2800-34W
Weight/max.	20,107 lbs.	21,690 lbs.	21,906 lbs.
Range/fuel	1,160 miles 406 gallons	1,800 miles	1,900 miles
Armament	Four 20 mm in wing root and Four .50 in. in the nose	Four 20 mm and rocket capable	

Source: O'Leary, United States Naval Fighter of World War II in Action, (Poole, Dorset: Blanford Press, 1980), p. 144.



JF, J2F;

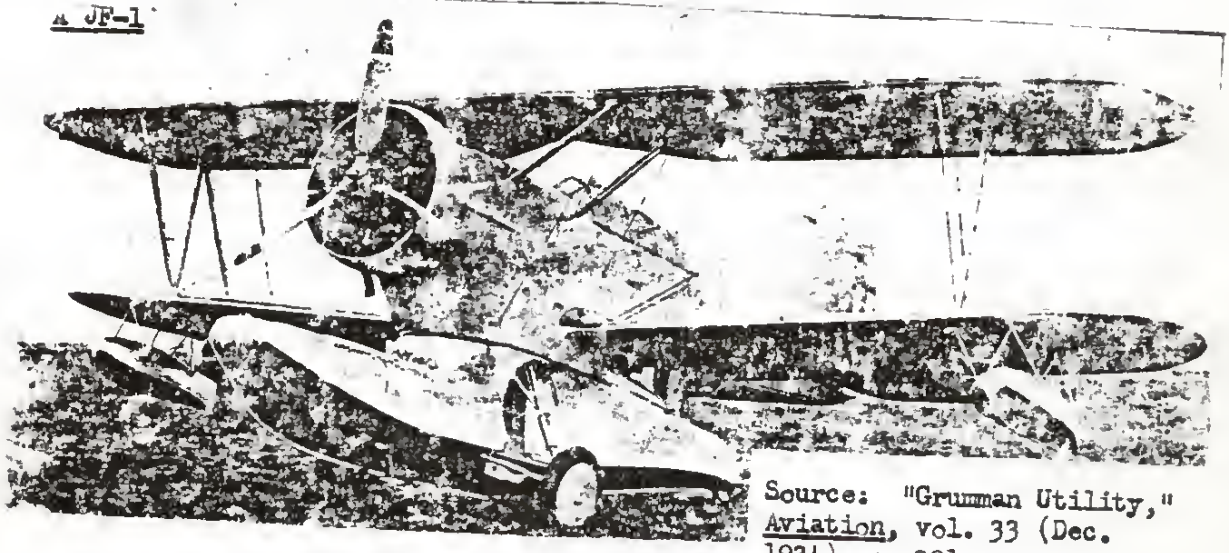
Dimensions;
Span : 39' Length: 33' / 34' Height: 12' 8" / 15' 1"
Wing area : 409 sq. ft.

	JF-2	J2F-5
Speed;		
Maximum	185 m.p.h.	188 m.p.h.
Cruising	155 m.p.h.	150 m.p.h.
Landing	65 m.p.h.	65 m.p.h.
Climb rate	1,600 ft./min.	1,500 ft./min.
Ceiling		27,000 feet
Powerplant	775 h.p. Wright Cyclone	850 h.p. Wright Cyclone R-1820-50
Weight/max.	5,760 lbs	6,711 lbs
Range/Fuel	620 miles/ 150 gallons	780 miles/ 190 gallons
Price	$ 20,944 in contract for 11	$ 33,193 in contract for 144

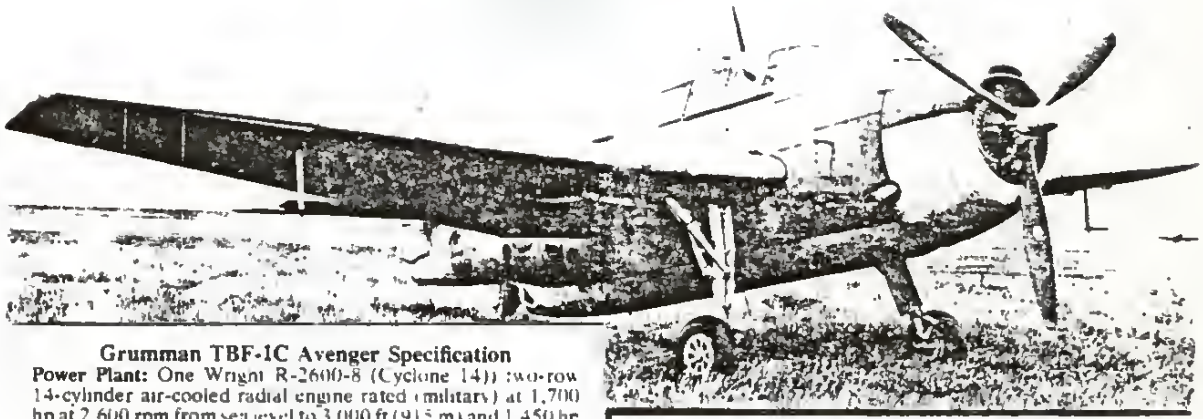
Sources: "American Planes & Engines for 1938," Aviation, vol. 37 (February 1938), pp. 35-66. (Used for JF-2)

Swanborough & Bowers, United States Navy Aircraft Since 1911, 2cd ed., (Annapolis: U.S. Naval Institute Press, 1968), p. 204.

JF-1



Source: "Grumman Utility," Aviation, vol. 33 (Dec. 1934), p. 391.



Grumman TBF-1C Avenger Specification

Power Plant: One Wright R-2600-8 (Cyclone 14)) two-row 14-cylinder air-cooled radial engine rated (military) at 1,700 hp at 2,600 rpm from sea level to 3,000 ft (915 m) and 1,450 hp at 2,600 rpm between 7,800 ft (2,375 m) and 12,000 ft (3 660 m), or (normal) 1,500 hp at 2,400 rpm from sea level to 5,600 ft (1 770 m) and 1,350 hp at 2,400 rpm between 8,900 ft (2 715 m) and 13,000 ft (3 960 m). Three-bladed Hamilton Standard constant-speed propeller of 13 ft (3.96 m) diameter Standard internal fuel capacity of 335 US gal (1 269 l) comprising 147 US gal (557 l) main tank with 94 US gal (356 l) port and starboard. Provision for two 58 US gal (220 l) underwing tanks and (ferry) 275 US gal (1 042 l) jettisonable weapons bay tank

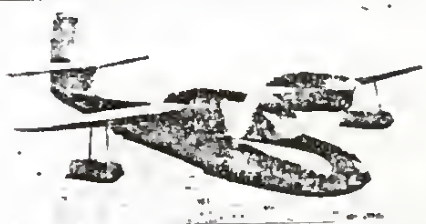
Performance: (At 16,412 lb (7 444 kg): Max speed, 249 mph (401 km/h) at sea level, 257 mph (414 km h) at 12,000 ft (3 660 m); range cruise, 153 mph, (246 km hr), time to 10,000 ft (3 050 m), 13 min, to 20,000 ft (6 095 m), 41-6 min, service ceiling, 21,400 ft (6 525 m); max range (internal fuel), 1,105 mls (1 778 km), (with two drop tanks), 1,390 mls (2 236 km.) ferry range (with weapons bay and underwing tanks), 2,685 mls (4 320 km)

Weights: Empty equipped 10,555 lb (4 788 kg); loaded (one Mk 13-2 torpedo), 16,412 lb (7 444 kg), (four 500-lb-226,8-kg bombs), 16,426 lb (7 450 kg), (Mk 13-2 torpedo and underwing tanks), 17 364 lb (7 876 kg)

Dimensions: Span, 54 ft 2 in (16,51 m), folded), 19 ft 0 in (5.79 m); length, 40 ft 9 in (12.42 m), height (tail down), 13 ft 9 in (4.19 m); wing area, 490 sq ft (45.52 m²); wheel track, 10 ft 10 in (3.50 m)

Armament: (Defensive), Two fixed forward-firing 0·5-in (12.7-mm) machine guns with 600 rpg, one 0·5-in (12.7-mm) machine gun with 400 rounds in power-operated dorsal turret and one 0·3-in (7.62-mm) machine gun with 500 rounds firing aft from ventral position (Offensive): One Mk 13-2 torpedo, one 1,000-lb (453.6-kg) bomb or four 500-lb (226.8-kg) bombs.

GRUMMAN Model No. G-44 (Widgeon) :



SPECIFICATIONS: Span 40 ft., overall length 31 ft., overall height 9 ft., landing gear tread 90 in., wing loading 18.75 lb. per sq. ft., power loading 11.25 lb. per hp., weight empty 3,075, gross weight 4,500, powered by two Ranger engines with a total rating of 400 hp at sea level, fuel capacity 108 gallons, normal range 775 miles, fuel consumption at cruising speed 20 gallons per hour, wing area (including ailerons) 240 sq. ft., aileron area (total) 14.6 sq. ft., stabilizer area 17.3 sq. ft., rudder area 14 sq. ft., stabilizer area 25.8 sq. ft., total elevator area 19.6 sq. ft. Seats five.

PERFORMANCE: Cruising speed 150 miles per hour at an altitude of 7,000 ft., stalling speed 61 miles per hour, climb at sea level 870 ft. per minute, service ceiling 15,000 ft.

Grumman Airc. Engineering Corp. G-21

Weight

Airplane Gross Weight	7500 lbs.
Airplane Empty Weight	5320 lbs.
Useful Load	2180 lbs.
Maximum Oil Capacity (15 Gals.)	112 lbs.
Maximum Fuel Capacity (220 Gals.)	1320 lbs.

Performance (7500 lbs.)

Maximum Speed at 5000 ft.	205 M.P.H.
Maximum Speed at Sea Level	195 M.P.H.
Cruising Speed at 9600 ft. (300 H.P.)	193 M.P.H.
Cruising Speed at 5000 ft. (300 H.P.)	184 M.P.H.
Cruising Speed at Sea Level (300 H.P.)	175 M.P.H.
Maximum Rate of Climb at Sea Level	1490 Ft. per Min
Climb to 5000 ft.	4.4 Min
Climb to 9600 ft.	9 Min.
Service Ceiling	24,000 Ft.
Absolute Ceiling	25,800 Ft.
Absolute Ceiling with One Engine (7500 lbs.)	14,000 Ft.
Take-off Run at Sea Level	796 Ft.
Take-off Time at Sea Level	11 Secs.
Take-off Time at Sea Level (Calm, glassy)	18 Secs.
Landing Speed at Sea Level (Flaps Down)	80 M.P.H.
Fuel Consumption with 300 H.P.	52 Gals. per Hr.

Range	*M.P.H.*	*Power*	*160 gals.*	*220 gals.*
9,600 Ft.	193	75%	506	795
5,000 Ft.	184	75%	480	755
5,000 Ft.	150	46%	740	1150
Sea Level	175	75%	460	720

Appendix 3:

YEAR	Planes ord	Planes del	% USN. col. 1	% USN col. 2	Income from annual sales/ deliveries	Net Profits	Naval Aircraft Spending X 1000	% Grumman	Aircraft Industry Prod X 1000000	% Grumman	# employees end yr or given	# in management
30			---	--	$ 109,000	$ 5,476	$14,245	0.2%	- ---	---	1/1/30 21	
31	1		100%	--	$ 146,000	$ 4,456	$12,199	1.0%	$ 48.5	0.3%	42	
32	30	2	100%	100%	$ 276,000	$ 44,871	$ 8,715	2.8%	$ 34.9	0.8%	69	
33	34	29	100%	100%	$ 847,000	$ 133,676	$ 7,203	12.0%	$ 33.4	2.6%	207	
34	97	64	85%	88%	$ 1,368,000	$ ---	$12,273	10.0%	$ 43.9	3.1%	-- --	
35	97	72	100%	90%	$ 1,114,000	$ ---	$20,691	4.7%	$ 42.5	2.6%	--	18
36	--	78+	--	90%	$ 1,719,000	$ 337,930	$26,561	5.4%	$ 78.1	2.2%	--	
37	124	--	90%	--	$ - - - -	$ 139,062	$20,963		$115.1	---	4/8/37 362	
38	112	--	66%	--	$ 4,904,946	$ 617,074	$27,265	7.4%	$150.0	3.2%	700	
39	194	--	38%	--	$ 4,482,350	$ 892,063	$24,238		$225.0	1.9%		
40	651+	262	85%	--	$ 8,811,294	$1,415,964	$24,000		backlog $4,030.0	t 1.6%	1,964	
41	790+	475+	86%	--	$20,000,000*	- - - -	- - -	---		t 1.0%	7,000	22

*Uses the assumption that Grumman's sales income would at least be double that of 6/30/41.

t--Based on comparative backlog, so since Air Corps receiving more orders, could skew amount of Grumman's production to industry downward.

Sources: Aviation Magazine, vol. 29-39; Threulsen, The Grumman Story, pp. 17, 64, 79, 89, 130-32; Freudenthal,"The Aviation Business in the 1930s," The History of the American Aircraft Industry, p. 105; Delaney Hearings, pp. 466, 502-503, 632-33. Problems of Accelerating Aircraft Production. . ., Harvard Graduate School of Business Administration.

Appendix 4

Aircraft Prices

U. S. Naval Fighters of the 1930s and World War II

Plane	Prototype ordered	Prototype Price	Production price	initial contract (# in year)	Cost per lb.
Boeing F4B-3	(5/10/30)	$ 50,000	$17,414	30 in 1931	$ 7.59
Boeing F4B-4	(6/30/31)	$ 82,152	$10,900	38 in 1932	$ 4.65
Grumman FF-1	(4/ 2/31)	$ 73,975	$19,000	27 in 1932	$ 5.90
Curtiss BFC-2	(4/16/32)	(2 at) $104,712	$14,731	28 in 1932	$ 4.85
Curtiss BF2C	(		$15,813	27 in 1934	$ 5.00
Grumman F2F	(11/ 2/32)	$	$14,815	54 in 1934	$ 5.64
Grumman F3F-1	(10/ /34)	$ 75,840	$16,525	54 in 1935	$ 5.75
-2	(7/25/36)	$ 26,300*	$16,536	81 in 1937	$ 5.09
-3	(	$ 12,750*	$25,037	27 in 1938	$ 7.70
Brewster F2A			$28,302	54 in 1938	$ 6.40
Grumman F4F-3	(10/--/38)		$26,472	54 in 1939	$ 5.05
Grumman F6F	(6/30/41)		$35,000	12,000	$ 5.88
Vought F4U	(6/11/38)		$50,000	12,000	$ 5.57

*Modification of production airframe

When comparing prices, one should look at the number purchased and the year. For example, the original F2A and F4F production sales match very well, since both are for the same number of airframes and were purchased in nearly the same time period. The F6F and F4U are also a good comparison. These two show that Grumman's warbirds were cheaper to buy. The lower costs of Curtiss' and Boeing's fighters in 1932 show that there were other reasons besides cost that allowed Grumman to take-over the carrier fighter market in the mid-1930s.

Footnotes

[1]Barrett Tillman, Avenger at War, (New York: Charles Scribner's Sons, 1979), p. 17.

[2]Elsbeth E. Freudenthal, "The Aviation Business in the 1930's," The History of the American Aircraft Industry, G. R. Simonson; editor, (Cambridge, Massachusetts: The MIT Press, 1968), p. 85.

[3]Reginald Wright Arthur, Contact! Careers of U. S. Naval Aviators Assigned Numbers 1 to 2000, vol. 1, (Washington, D. C.: Naval Aviator Register, 1967), p. 328.

[4]David A. Anderton, Hellcat, (New York: Crown Publishers Inc., 1981), p. 22.

[5]Anderton, Hellcat, p. 4.

[6]Charles D. Bright, The Jet Makers: The Aerospace Industry from 1945 to 1972, (Lawrence: The Regents Press of Kansas, 1978), p. 176. Bright was actually describing the post-war management, which was made up of primarily the same men. Roy Grumman had vacated the presidency and had become Chairman of the Board, and the others advancing up a step.

[7]"What the Factories Are Doing," Aviation, vol. 32, no. 3 (March 1933), p. 76.

[8]Richard Threulsen, The Grumman Story, (New York: Praeger Publishers, 1976), p. 35. The plan stated is quite similar to the one given by this author.

[9]United States House of Representatives, Hearings Before the Subcommittee on Aeronautics Making an Investigation into Certain Phases of the Manufacture of Aircraft and Aeronautical Accessories, and Related Subjects as They Refer to the Navy Department, (Washington, D. C.: USGPO, 1934), p. 407. Head of the committee was New York Congressman John Delaney, thus the inquiry has become known as the Delaney Hearings.

[10]Delaney Hearings, p. 413.

[11]Threulsen, The Grumman Story, p. 41.

[12]Temple N. Joyce, "Airplane Design in Relation to Tactical Requirements," USNIP, vol. 57, no. 341 (July 1931), pp. 981-984. The author was the V.P. of the Berliner-Joyce aircraft manufacturing firm.

John B. Lundstrom, The First Team: Pacific Naval Air Combat from Pearl Harbor to Midway, (Annapolis, Maryland: Naval Institute Press, 1984), p. 12.

Threulsen, The Grumman Story, p. 113.

[13]Bill Gunston, The Plane Makers, (London: New English Library, 1980), p. 46.

[14]C. G. Grey and Leonard Bridgman, Jane's All The World's Aircraft 1938, (Sampson Low Marsten & Company, Ltd., 1938), p. 269c.

John W. R. Taylor, ed., Combat Aircraft of the World, (Ebury Press and Michael Joseph: 1969), p. 499.

[15]Lt. Commander Forrest Sherman, USN, "Fighters," USNIP, vol. 56, no. 331 (September 1930), pp. 831-33. The author became a renowned World War II strategist and later Chief of Naval Operations (CNO).

[16]Delaney Hearings, p. 414.

[17]Delaney Hearings, p. 397.

[18]Threulsen, The Grumman Story, p. 60.

[19]Gunston, The Plane Makers, p. 46. (See explanation on footnote 20).

[20]Delaney Hearings, p. 1,511. According to the hearings, Britain's Hawker Nimrod was the fastest naval fighter in the world in 1933-34, with a speed of 210 m.p.h. By the time the FF-1 reached the service there were several fighters in the world with 200+ m.p.h. capability.

Lt. Harold M. Martin, USN; "Service Aircraft," USNIP, vol. 57, no. 342 (August 1931), p. 1040.

[21]Bureau of Aeronautics (USN), Tests of Service Airplanes," USNIP, vol. 57, no. 343 (September 1931), p. 1,276.

[22]Anderton, Hellcat, p. 17.

[23]Delaney Hearings, pp. 470, 1484.

[24]"Jobs Which Are Required in Constructing Aircraft," Aero Digest, vol. 37, no. 4 (October 1940), pp. 49-51.

[25]Delaney Hearings, p. 286.

[26]Gordon Swanborough and Peter Bowers, United States Navy Aircraft Since 1911, 2cd edition, (Annapolis, Maryland: Naval Institute Press, 1968), p. 196.

[27]Theodore Roscoe, On the Seas and In the Skies: A History of the U. S. Navy's Air Power, (New York: Hawthorn Books, Inc., 1970), p. 239.

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[29]Delaney Hearings, pp. 580, 1484.

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[30]Claude Swanson, Secretary of the Navy, Aircraft Purchased By the Navy Department, FY 1934, Senate Miscellaneous Document no. 6, 74th Congress, 1st Session, (Washington, D. C.: USGPO, 1935), p. 3.

[31]United States House of Representatives, Pooling of Patents: Hearings Before the Committee on Patents, 74th Congress, (Washington, D. C.: USGPO, 1936), p. 62.

[32]Pooling of Patents, pp. 97, 190.

[33]Pooling of Patents, p. 170.

[34]Pooling of Patents, pp. 3-210.

[35]Delaney Hearings, p. 642.

[36]Pooling of Patents, pp. 6-52.

Delaney Hearings, p. 307.

[37]Delaney Hearings, pp. 644-45.

[38]Delaney Hearings, pp. 472-73.

[39]Threulsen, The Grumman Story, pp. 17, 79.

[40]Delaney Hearings, pp. 466, 632-33.

[41]Freudenthal, "The Aviation Business in the 1930s," p. 105.

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[42]Delaney Hearings, p. 503.

[43]Delaney Hearings, p. 502.

[44]Delaney Hearings, pp. 502-3, 644 (quote).

[45]Delaney Hearings, pp. 295, 502-3.

[46]Delaney Hearings, p. 273.

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[47]"Flying Equipment: New Ships for the Navy," Aviation, vol. 33, no. 5. (May 1934), p. 160.

[48]Delaney Hearings, p. 273, 470.

[49]Threulsen, The Grumman Story, pp. 78-9.

[50]Gunston, The Plane Makers, p. 46.

[51]Claude Swanson, Secretary of the Navy, United States Department of the Navy Annual Report, FY 1934, (Washington, D. C.: USGPO, 1936), p. 2.

[52]W. H. Standley, Acting Secretary of the Navy, Aircraft Purchased by the Navy Department, FY 1935, Senate Miscellaneous Document no. 146, 74th Congress, 2cd Session, (Washington, D. C.: USGPO, 1936), p. 2.

[53]"News of the Month: Fastest Amphibian," Aviation, vol. 34, no. 2 (February 1935), p. 65.

[54]Paul R. Matt and Bruce Robertson, United States Navy and Marine Corps Fighters 1918-1962, (Fallbrook, California: Aero Publisher Inc., 1962), pp. 68-9.

Swanborough and Bowers, Navy Aircraft, p. 197.

Taylor, Combat Aircraft, p. 499.

[55]Delaney Hearings, p. 634.

[56]"Production and Export," Aviation, vol. 35, no. 4 (April 1936), p. 79.

[57]"Wings of the Navy," Lloyd Bacon, director, Warner Brothers Pictures, 1939. This movie uses a F2F in showing the testing of an airplane.

[58]Threulsen, The Grumman Story, p. 84.

[59]Matt and Robertson, Navy and Marine Corps Fighters, pp. 69-70.

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[60]"Production and Export," Aviation, vol. 35, no. 4 (April 1936), p. 79.

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[65]"Production and Export," Aviation, vol. 35, no. 4 (April 1936), p. 78.

[66]"Service Aviation," Aviation, vol. 36, no. 4 (April 1937), p.

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[69]Adolphus Andrews, Acting Secretary of the Navy, Aircraft Purchased by the Navy Department, FY 1937, Senate Miscelleneous Document no. 120, 75th Congress, 2cd & 3rd Sessions, (Washington, D. C.: USGPO, 1938), p. 2.

[70]Gunston, The Plane Makers, p. 48.

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[73]Threulsen, The Grumman Story, p. 89.

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[75]"News of the Month: Navy Buys Planes," Aviation, vol. 36, no. 6 (June 1937), p. 67.

[76]"Naval Affairs: Amphibious Contracts," Aviation, vol. 36, no. 9 (September 1937), p. 67.

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[80]Threulsen, The Grumman Story, p. 118.

[81]Threulsen, The Grumman Story, p. 106.

[82]Claude Swanson, Secretary of the Navy, United States Department of the Navy Annual Report, FY 1938, 76th Congress, 1st Session, (Washington, D. C.: USGPO, 1938), p. 1.

[83]William D. Leahy, Acting Secretary of the Navy, Aircraft Purchased by the Navy Department, FY 1938, Senate Miscellaneous Document no. 6, 76th Congress, 1st Session, (Washington, D. C.: USGPO, 1939), p. 3.

[84]"Lets Talk Business," Aviation, vol. 37, no. 7 (July 1938), p. 57.

[85]"Brewster XF2A-1," Aviation, vol. 37 (1938), p. 36.

[86]Leahy, Aircraft Purchased by the Navy Dept., FY 1938, p. 4.

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THE GRUMMAN CORPORATION, THE FIRST TWELVE YEARS: THE RISE OF A NAVAL AIRCRAFT MANUFACTURER, 1930-1941

by

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The Grumman Corporation, the First Twelve Years

Grumman Aircraft Engineering Corporation saw its origins in 1930, and twelve years later it would be the United States best supplier of fighter aircraft. It produced by far the most naval fighters used during the Second World War. This thesis looks at the development of the company, primarily its financial growth, and its relationship to the U. S. Navy. The Navy was the company's main market thoughout most of the period, and both it and the corporation would benefit from their work together.

The first section of the thesis looks at the formative years of Grumman Aircraft, and how it was able to grow despite the odds it faced. These were being a small business unassociated with a holding company and not belonging to the Manufacturers Aircraft Association, thought to be two necessities to gain military orders, and the impact of the Depression on the aircraft industry. A primary reason for the firm's growth was its choice of the United States Navy as its prime market; and the Navy's treatment of the new company, giving it a preferred status while it was getting established.

The second part observes the company's work in the mid-1930s, when it held a monopoly on U. S. naval fighters. It looks at the performance of these airplanes and the short duration lives of military aircraft in this period caused by a technological revolution. This section also shows the upward linear progression of Grumman's business figures. This progression was still related with the Navy.

The third part shows the growth of the business from 1938 to 1941, and the effects the war had on it. The war in Europe caused the linear

progression to begin to curve upward. It also forced the military export market to replace the U. S. Navy as the corporation's prime market. This situation was short-lived, for as the United States began preparing for war the Navy returned as it dominant buyer.

The conclusion discusses the benefits Grumman and the Navy gained from their relationship. It also analyzes the business picture for the entire twelve years. The statistics show the growth moved in a parabolic (wave-like) fashion during the period, and that the United States Navy was responsible for most of the progression. The Navy would be repaid for its investment in World War II.