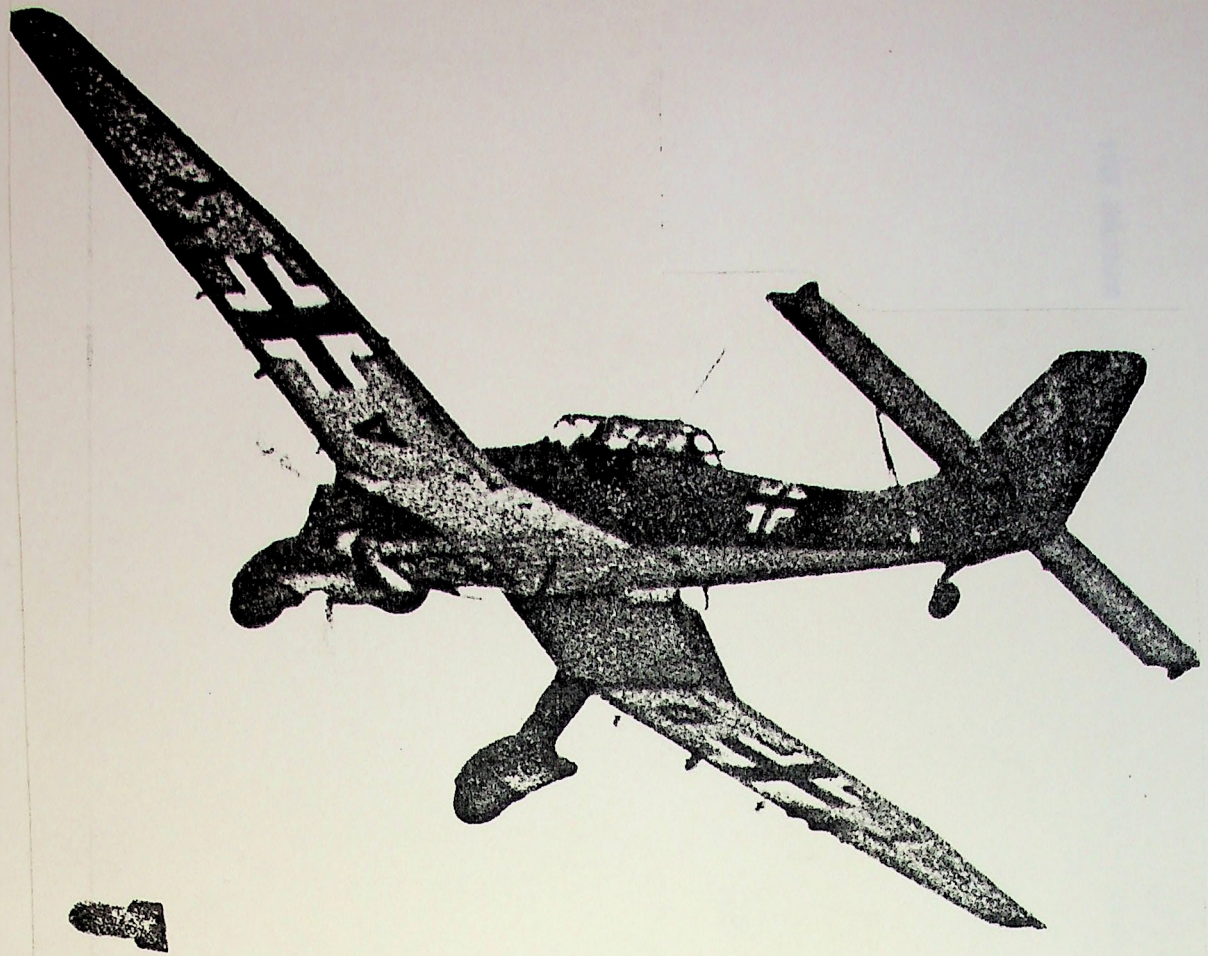

THE DESIGN AND DEVELOPMENT OF AIRCRAFT, 1930 - 1945

SEAN O'CONNELL

APRIL 13TH 1985

INTRODUCTION

When World War I ended the world was very different from that in 1914. Europe was bankrupt, England was no longer the financial centre of the world - the balance of financial power now lay with the United States - which was the one country which had made a huge profit from the war. Despite the upheavals and revolutions in Europe it was a time of hope, with American financial aid rebuilding the war-weakened European Economy.

In Aviation, the aeroplane, though only invented in the first decade of the 20th Century, had within it's infancy been exploited as a military vehicle. At first it had been used in a recoinnasance role, and only later in the war as developments allowed the firing of machine guns 'through' the propellor that the 'Fighter' became widespread. The aeroplane was also developed as a bomber, though with only limited success.

Production of aircraft on the part of the Allies was so great at the end of the war, that they had a surplus of 'planes to such an extent they were being sold off at as low as 10% of their original production price. With the return to peace-time conditions, aviators returned to their pre-war past-times and continued to use aircraft for pleasure purposes. Development of new aircraft was, however, slow as the Allied powers had sufficient planes, and in their opinion technology had probably developed far enough. The English general's attitude to the

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'plane was still that the aeroplanes major role was as support to the infantry and as a 'feeler' of the field and conditions ahead of the troops.

This attitude, as well as the selling off of surplus machines placed a great strain on private plane manufacturers of this time, many of whom had to close down - as they simply could not compete. Aeroplane development did continue, however, if in a roundabout way. Because of the popularity of barnstorming, air exhibitions and the races that were often a feature of these exhibitions, private companies developed their own planes to compete in these races - the incentives being advertising and hopefully, sales. Famous races of the time in which 'privately' designed aircraft races were the Thompson Trophy, the most famous international race being undoubtedly the Schneider Trophy.

In the international competition, winning was frequently a question of national prestige. The fact that Governments were financing their national team reflects the increasing reliance on home manufactured aircraft and indicates the growing nationalism during the late twenties.

All this time there was still a reluctance on America and Britain's part to develop aircraft for military use. However, aircraft development was given a boost in America in 1927 when the nation's air-mail sector's went up for tender. It was

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obvious that any company considering the project seriously would attempt to improve it's planes, or design better new ones. At this stage the plane manufacturers were also the carriers. Boeing was a typical company of the time and tendered successfully for the contract with an improved aircraft - the Model 40.

It may be ironic, but the financial Disaster in Wall Street may have been the greatest possible spur to aeroplane development. Up to this point, Europe had been rebuilding with American aid. When America's economy encountered difficulties, this aid was withdrawn. This may be a somewhat simplistic view, but the end result was that every country now concentrated on helping herself, to the exclusion of others - totally isolating herself. This was the situation in 1930, the world's major economies struggling with themselves, the widespread sense of hope that had been felt all over the world disappearing rapidly under the pressure of a recession.

AIRCRAFT DESIGN FROM 1930

In 1930, British and American design progress was not really co-ordinated or planned, mainly as a result of de-militarisation and financial stringency, and as a result design in these countries was somewhat behind Germany. However, design was continuing to some extent due to such international races as The Schneider Trophy, The MacRobertson England-Australia. From England and America's point of view, these events turned out to be a 'godsend' as many of the outstanding aircraft designed for these races, or derivatives of them went on to distinguish themselves in the war '39-45. This will be discussed later.

To chart the development of aircraft from 1930-1945, and to best appreciate these developments it would be worthwhile to describe first, a typical plane flying in 1930.

A very typical plane of the time was the De Havilland Gypsy Moth. This plane was very popular, exported worldwide and demand for it was such that production was around one a day. It was of wood and fabric construction. The fuselage was a plywood box built around four spruce langerous stiffened by horizontal and vertical cross-members screwed to the plywood. The occupants sat in tandem. The engine protruded greatly from the cowling, needing an oil tank, 1½ gallons of oil being carried in the engine sump. Wing construction comprised 1 section spruce bevs, with built up ribs and rounded wing tips of flattened aluminium tube, the wings being fabric covered.

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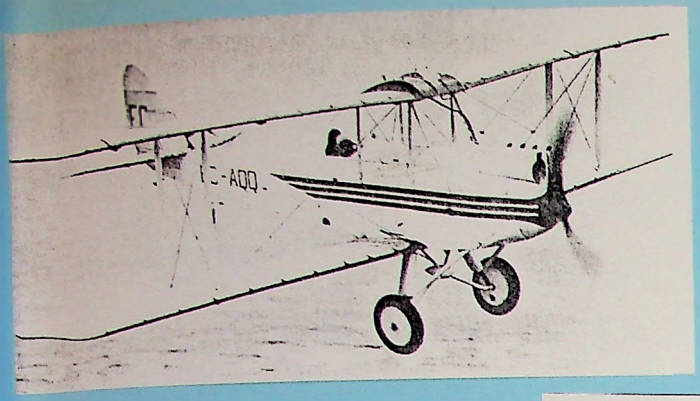
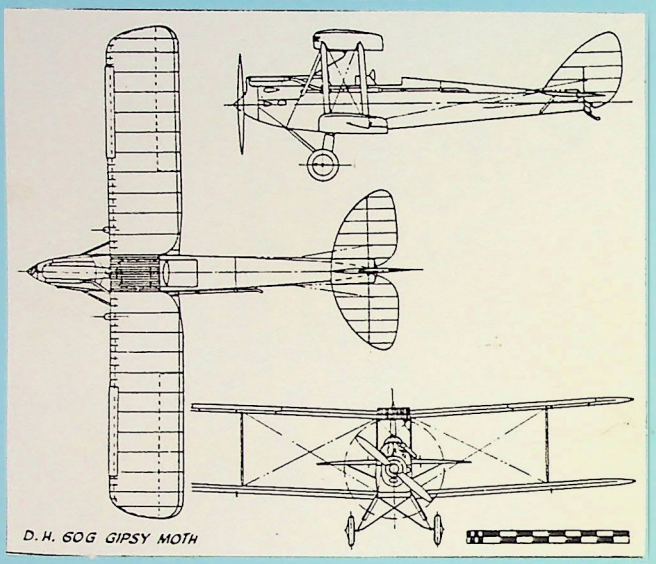
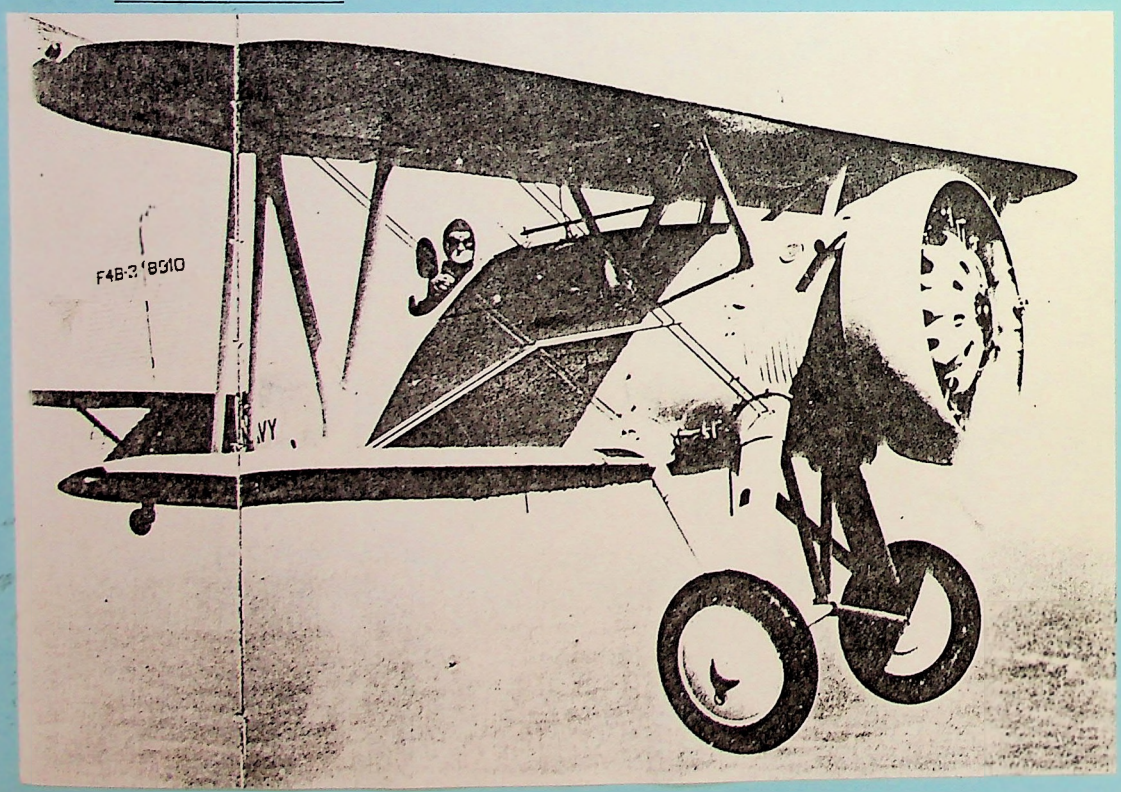


Gypsy Moth.



Boeing F4B.



A more innovative design in 1930 was the Ju 52, and if a design can mirror the political thinking of a country the Junkers Ju 52 does this quite well. This German plane operated in the late twenties and early thirties as a passenger plane but this was never it's intended purpose as any Spanish town bombed during the Spanish Civil war will tell. It had been designed in 1926 by Rohrbach as a stressed-skin monoplane with no bracing struts. As a design it was not typical of 1930, most other planes being the fabric covered wooden bi-plane. It does however serve as an example of design policy in Germany at that time.

One of the first all-metal fuselage bi-planes was the Boeing F4B-1, first flown in 1928, but still being re-designed and flown as the F4B-3 in 1930. Begun as a private venture it was accepted by the US Forces as a fighter, and represented in terms of technology, the limits the US Forces would trust. In design the plane was nothing new, it just embodied all Boeing's previous experience in aerodynamics, structure and power plant. The strength of the new metal structure is easily seen in the number of struts between winds, the total number now being only six, each oval in section to reduce wind-resistance. Originally the plane used a 450h.p. Pratt and Whitney R-1340 Wasp but this was changed to a Standard Wasp, with a slight reduction in speed. The Wasp was the usual aircraft

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engine in the US at the time, and had been introduced by Pratt and Whitney in 1926 as a replacement for the World War 1 "Liberty" engine. It was a revolutionary engine then, being of the 'new' radial type. This new type did not need a radiator or any of the old plumbing lines used in the old engine. It was also 200lbs. lighter, with increased output which to companies like Boeing who in 1926 were involved in Mail freight and limited passenger carriage was a great advantage meaning that they could either carry an 'old' load further, or an extra 200 libs. the same distance.

In 1930 however American engine development was not as advanced as in England, where Rolls Royce were manufacturing the best engines of the day. For example the V12 engine used in R.J. Mitchell's Supermarine S6B seaplane which won the Schneider trophy outright for Britain in 1931, was of 30% greater capacity than the 1921 Curtiss V-12 which turned out 393h.p., yet gave a remarkable 2,600h.p. - an increase of 600% It was the only Government-sponsored development for each years Schneider race that allowed engine development to progress at all.

The main factors influencing engine design at the time were

1. Weight 2. Frontal Area 3. Heat dispersion.
4. Propellor Technology.

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1. Weight

In the mid-20's weight had been recognised as a problem and the first engine to make a successful weight reduction was the 1926 Curtiss V-12 - a cast aluminium engine. Fiat also produced a similar engine with 'new' magnesium alloys which pointed the way for technology in the early thirties.

2. Frontal Area

Reduced frontal area on engines was a necessity, for aerodynamic reasons more than any pure mechanical improvement. Racing aeroplanes of the period are the best example of how this problem was tackled - bulges on the nose of the aeroplane - to clear the cylinder heads, usually one on each side where a U-12 engine was used, or 3 in the case of the Supermarine S6B.

3. Heat Dispersion

Internal combustion engines are not very efficient. Only a relatively small amount of the energy released on burning the fuel/air mixture was used to push down on the piston. The rest had to be dissipated as heat. In air cooled engines this is done by supplying the hot parts of the engine (cylinder and cylinder head) with fins to increase surface area in contact with the air as it rushed past - thus cooling the engine.

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On a water cooled engine, water circulation around the head and cylinder carried the heat to a radiator where the heat is then dispersed.

Early water-cooled engines had overheating problems which were solved by the Curtiss "wet-sleeve" concept. However, as more power was coaxed off racing engines, the increased heat production had also to be got rid of. At first "Lamblin" radiators were used similar to those used in cars. However this system was not aerodynamically sound and was replaced by thin copper panels shaped over the wing surfaces. These provided a large surface area and were used on all racing planes competing in the Schneider until the end in 1931. Pictures of the most highly developed of this type of aircraft - the Macchi Mc79 of 1934 (which produced over 2,500h.p.) show all the wing surfaces, the float struts and the whole top of the floats covered in the fluted copper radiators.

4. Propellor Technology

Most propellors up to 1930 had been wooden - carved from a block of laminated hardwoods, with the leading edge covered with brass sheeting for protection.

However, as engines became more powerful, larger propellors became necessary. This development was not without problems. For a given rate of revolution, increasing the diameter of

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a propellor increases the speed at which it's tip passes through the air. With the larger propellors, what happened was that their tip speeds approached the speed of sound. When this happens normal aerodynamic principles break down, and the propellor becomes inefficient.

One solution to this problem was to make metal propellors. Because of the strength of the duralumin, propellors could have much thinner sections than previously. This meant that the propellor was much more efficient especially at near sound speeds.

Another solution was the variable pitch propellor. It had long been recognised that at least two pitches were needed in propellors - fine for take-off, and coarse for high speed running. The first type became available in 1932 - the Ratier propellor. It was a simple crude device which wouldn't work without a bicycle pump!! It's operation involved pumping up a football bladder in the propellor spinner with a bicycle pump just before take-off. On the ground this forced the propellor into a fine pitch. After take-off however increasing air-pressure forced a flap against the valve releasing air in the bladder allowing the propellor to change to coarse pitch for high-speed flight.

It was however, an interim solution before the development of hydraulically adjustable, fully variable propellors which became available in 1934-35.

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AIRCRAFT DESIGN IN THE MID-THIRTIES

One plane which "suffered" because of the lack of adjustable pitch propellors was the Boeing Model 200 Monomail, designed as a replacement for the Model 40. In America, Boeing had taken advantage of the 'tendered' Mail Routes with the Model 40, carrying mail and another profitable load - passengers. The Model 200 marked the beginning of the new era in aviation - low-winged monoplane of all-metal construction, with retractable undercarriage and very clean lines. The only carry-on from the bi-planes was the open-cockpit.

Although speculative, the aerodynamics and lines of this plane could have had a very great effect on later designs, especially some of the fighters in World War II. At a glance the similarities between it and Germany's fastest propellor driven fighter - the FW-190 are amazing,,the Mitsubishi 'Zero' was also very similar. First flown in May 1930 the Model 200 had been developed to carry 750 lbs. of mail and 8 passengers. By August of that year however, the cramped seating of the passengers, coupled with the non-availability of variable pitch propellors caused Boeing to produce only two of these aircraft.

Boeing were, however, convinced of the profits to be made transporting passengers and this led to the design of the first 'true' passenger plane - the Model 247 (1933). This

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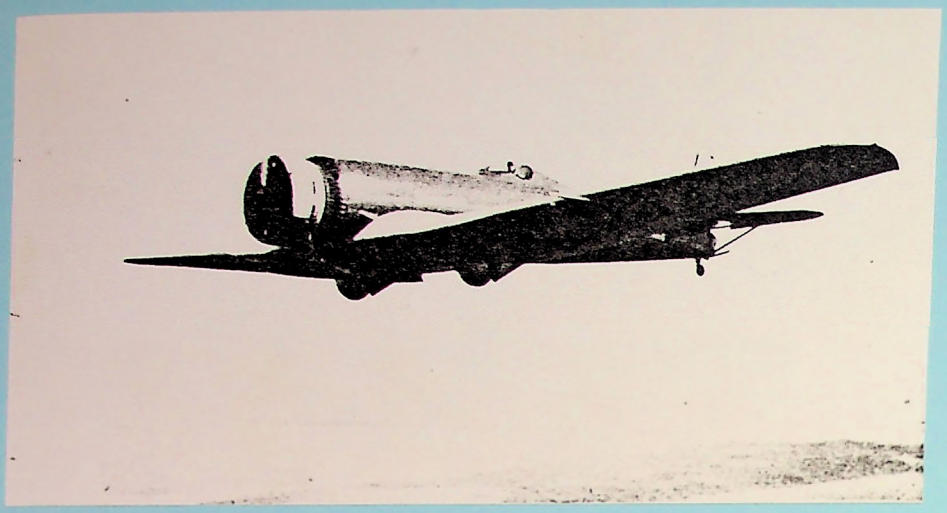
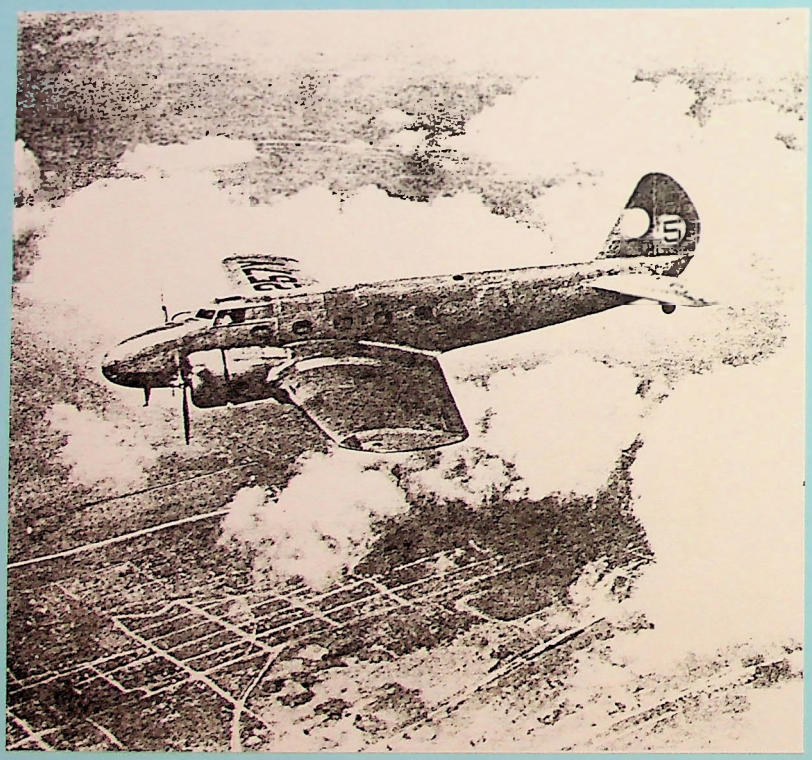


MONOMAIL 200



BOEING 247D

was a low-winged, all-metal stressed-skin monoplane. It was innovative in that it could climb with one engine stopped, and had enclosed accommodation for both pilot and passengers. Yet again it suffered from the disadvantage of not having a variable pitch propellor, but it was still 60m.p.h. faster than it's nearest competitor, and overcame the propellor problem with the introduction of the Hamilton-Standard controllable pitch propellors. Production ceased circa 1936.

Meanwhile Aviation contests were continuing unabated. The Schneider trophy finished in 1931 with the Supermarine S6B winning outright, the plane going on as further developments eventually leading to the Spitfire. One of the strangest designs for the premier American event - The Thompson Trophy was a plane by the Granville brothers. First they got the fastest engine they could lay their hands on - a Pratt and Whitney 535h.p. Racing Wasp, fixed it on to the shortest fuselage they dared (to cut down on drag), added just enough wing area to keep it up in the air, and placed the pilot as far aft as possible to counter the weight of the engine. The result was a very fast plane, named the "Gee-Bee" but very difficult to fly and therefore dangerous. It won the 1931 Thompson Trophy, but killed the pilot later on.

A second version - the Gee Bee R-1 set the world landplane record - 296m.p.h. but crashed later killing the pilot. A

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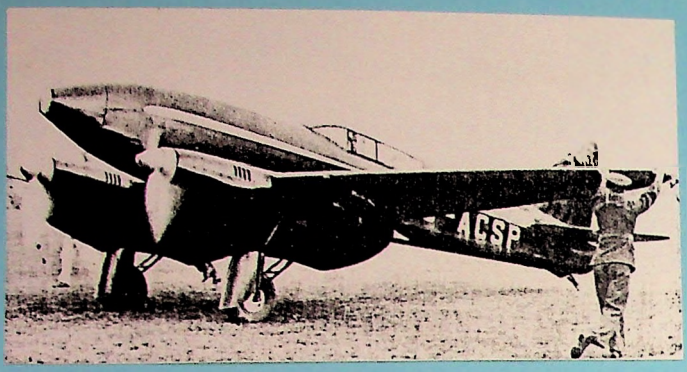
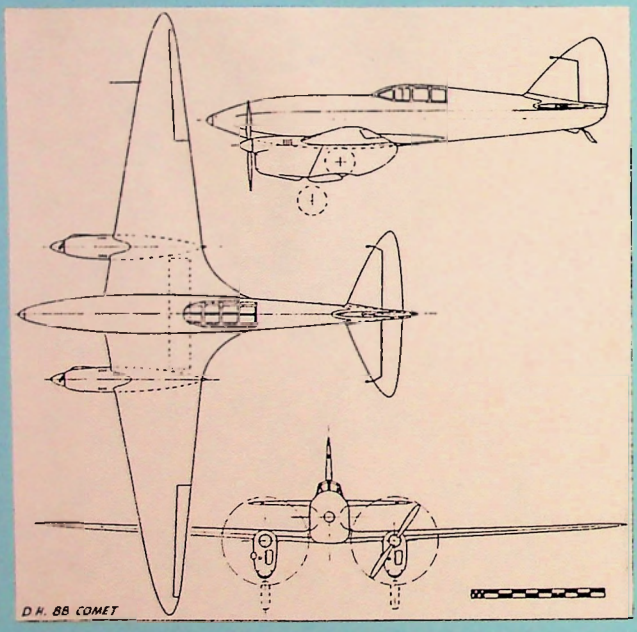
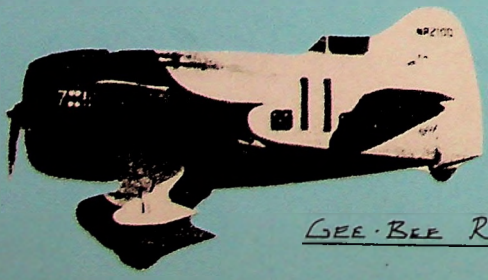


De Havilland Comet





Gee·Bee R·1

A larger 2-seater was built for the MacRobertson race (England to Australia), but crashed in Bucharest flying from New York to Mexico, it crashed into a river and the pilot was drowned. The Company went broke in 1934 after Zantford Granville was killed flying one of his planes. Not what you might term a successful designer.

The winner of the 1934 MacRoberston race was the De Havilland Comet, an important design for British Aviation, with variable pitch propellor, manually retractable undercarriage, thin wing, split trailing edge flaps. It was however, of wooden construction, yet it went on to form the basis for the most successful fighter/bomber of the war - the D.H. Mosquito.

When one looks at the beautiful shapes of the D.H. Comet and Supermarine S6B the improvements in aerodynamics in the early thirties can be easily seen. In fact developments in aerodynamics were far ahead of engine development. A good example is the Boeing XB-15. In 1934 the US Army raised a tender for a truly long-range aircraft capable of the defence of the USA from bases within the mainland, and capable of striking at targets well out into, or even across the Atlantic and Pacific oceans. The Boeing solution was the XB-15, the largest and heaviest aircraft in the world at the time. Despite it's many innovations - 4 engines, flight engineer, and clean aerodynamic shape it was seriously underpowered - i.e. no engines could be found to fly it.

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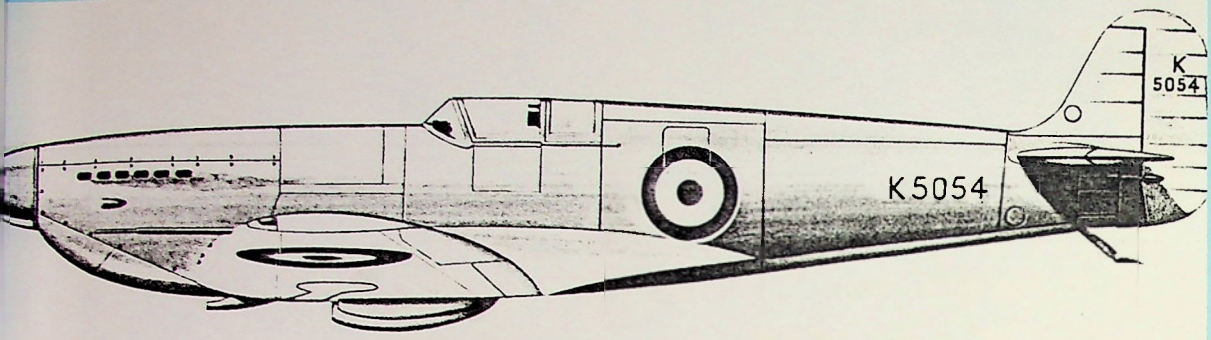
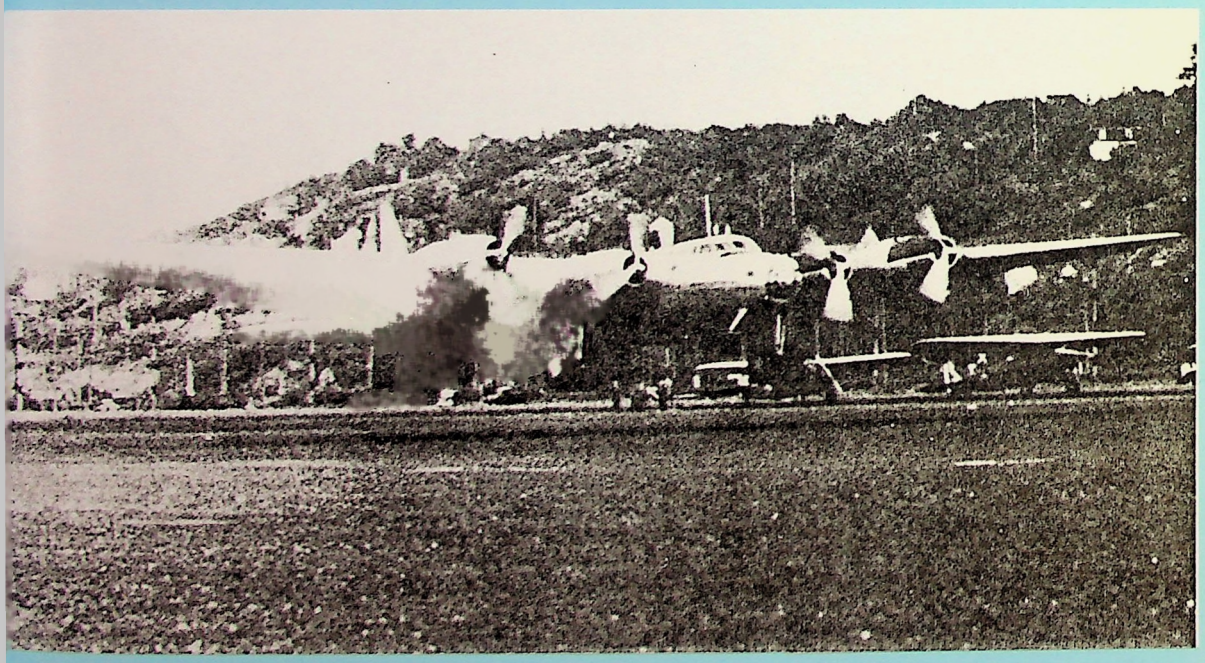


Supermarine Spitfire prototype
Developed from the Supermarine S6B racing seaplane which won the Schneider Trophy for Britain in 1931, the Spitfire was the most famous fighter of the Second World War. It was the only Allied fighter to remain in production throughout the war

SPITFIRE PROTOTYPE



BOEING XB-15

However, when most people think of aerodynamics in the thirties - the Douglas DC-3 comes to mind. The Douglas Commercial (DC) planes first came to prominence with the performance of the DC-2 in the MacRobertson trophy. The DC-2 flown in the race belonged to KLM airlines. Along the route, they delivered mail, carried passengers, even stayed overnight at Albany, Australia and managed to finish second behind a purpose built racer - the De Havilland Comet. That a commercial aircraft should finish second caused worldwide interest and astonishment, and heralded a new era in flight. The predecessor of the famous DC-2 and legendary DC-3 was the DC-1, first flown in July 1933. On August 2nd, 1932, Jack Freye of Transcontinental and Western Air (TWA), solicited bids for "ten or more tri-motor planes". Specifications:- the plane must be an all-metal monoplane with a maximum gross weight of 14,200 pounds, a fuel capacity for a cruising range of 1,080 miles at 145 miles per hour, with the capacity to haul 12 passengers plus a crew of two. The letter ended "Approximately how long would it take to turn out the first plane for service tests?"

TWA was a financially desperate airline, and this was the reason for their raising the tenders. In 1931 one of their Fokker F-10's had crashed, killing the coach of the Notre Dame football team - Knute Rockue - a national figure. Condemnation of air transport and TWA in particular followed, so TWA realised that if this new plane failed, they would go bankrupt. When Douglas received the tender, the team of

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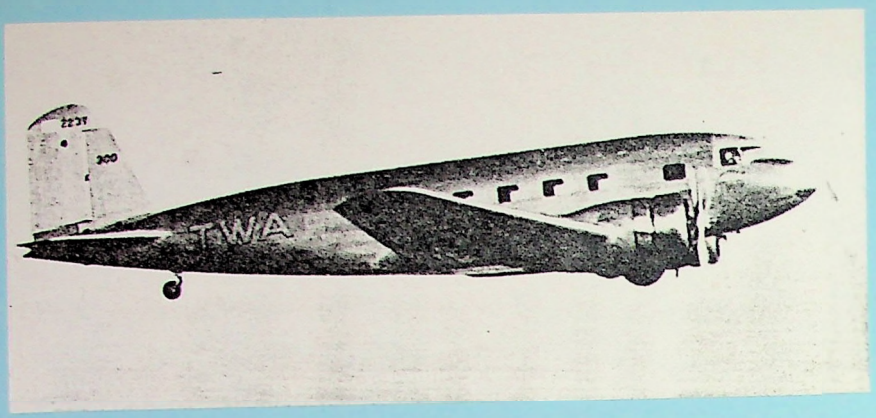
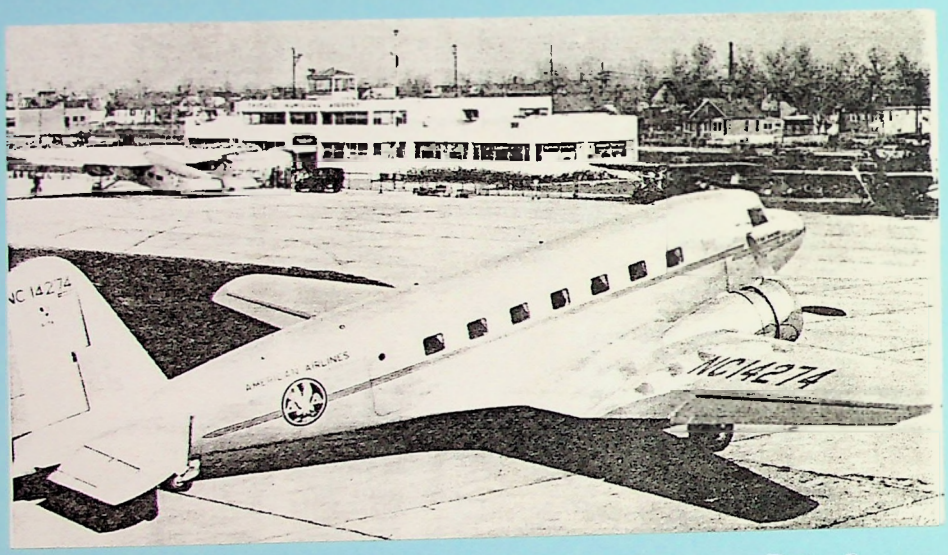
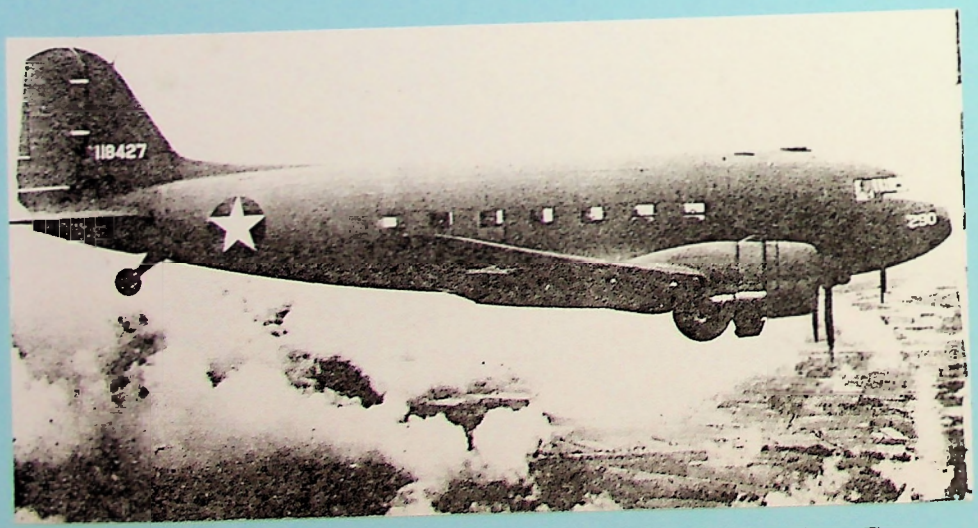


DC-1



DC-2



DC-3

engineers and production men worked round the clock for 10 days coming up with a new design. 2 weeks after Douglas had received Freye's letter the Douglas design team presented their design proposal - A plane with newer more powerful engines, innovative metal propellors, retractable landing gear that folded into the engine nacelles for better streamlining. Several unique features were however, that the plane be a low-wing monoplane with semi-monocoque fuselage and powered by 2 engines instead of 3. They also proposed a "honeycomb" wing construction (similar to what Barnes Wallis later designed in the Vickers Wellington around), and the partial stressing of wings and fuselage with aluminium skin.

The TWA group were impressed. This was not only a new plane, but a new concept of aircraft as well. Acceptance was recommended, but the company's chief Technical adviser the famous Charles Lindbergh intervened and stated that while he recommended acceptance, it first had to satisfy one new clause - it had to be capable of taking off with a full load, from any point on the TWA route using only one engine. The Douglas engineers agreed. The first plane - The DC-1 was ready on 22 June 1933 and first flew on July 1 1933. The plane was powered by two Wright Cyclone 710h.p., nine cylinder, air cooled radial engines using three bladed variable pitch Hamilton propellors. Inside the cabin were two rows of six seats in tandem with a broad aisle in between, also included was a small galley for preparing meals, and

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another passenger 'first' - a lavatory! The plane was also soundproofed and fully heated. In the cabin the new innovation of the Sperry Automatic Pilot was introduced.

On the 4 September the one-engine take-off test took place at Winslow, Arizona - highest point along the TWA route. (At higher altitudes, because the air is thinner engines have to work harder to get the aircraft airborne). The test was a complete success - on one engine the plane flew 240 miles to to Albuquerque, New Mexico arriving 15 minutes before a Ford Trimotor which had left Winslow before the DC-1!! TWA immediately accepted the DC-1 and placed an order for another 25, but these must carry 14 passengers.

Because of this new specification, these 25 DC-2 planes were designated and delivery began within a few months. As stated the DC-2 distinguished itself of the MacRobertson Trophy, and led to the Douglas Company being inundated with orders from all over the US and the World. With the new luxury afforded to passengers Airline executives began to think about sleeper planes for the coast to coast journey. This concept was first introduced by American Airlines using Curtiss Condor bi-plane aircraft, in 1934. However it wasn't fast enough. Airline operators wanted a bigger, faster airplane that could leave New York at sundown, make the coast-to-coast flight overnight and arrive in California the next morning.

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The Douglas company was alert to the demands of his customers, but knew that the DC-2 was not big enough to carry enough passengers each trip to make a substantial profit. William Littlewood, chief of American Airlines developed a new set of specifications calling for the increase of passengers from 14 to 21. Again, Douglas engineers realised that this new plane would need a new designation - the DC-3.

The DC-3 first flew on December 17, 1935 and was to revolutionise passenger travel, and the attitude of the public to flight and travel. The DC-3 was produced in several models. A 21-passenger day plane, a 14 passenger luxury "Skysleeper", and the ultimate in luxury a 14 passenger "Skylounge" were available. The first quantity order was placed by C.R. Smith, president of American Airlines who later said ("It was the first airplane.....that could make money just by hauling passengers". The impact the DC-3 had on the public can be gauged that by the end of 1936 a million passengers had boarded the DC-3 for their first time. In the next 3 years that figure would rise to two million. In a presentation to Donald Douglas President Roosevelt said "This airplane by reason of it's high speed, economy, and quiet passenger comfort has been generally adopted by transport lines throughout the U.S. It's merit has been further recognized by it's adoption abroad, and it's influence on foreign design is already apparent".

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The Russians blatantly copied the DC-3 and called it the Li-2 after it's "inventor" Lissanou.

With it's long tapering fuselage, clad in shiny aluminium, the DC-3 epitomizes for many people the thirties and the new advances in air travel, aerodynamics and streamlining. This is not only because of the impact the plane had in the thirties, but also because it was so robust that it saw action in World War II, the Korean and Vietnamese wars, and over 2,000 are still flying today. In the DC-3 people have a ready reference to that decade (the 30's) and from a design point of view it has a lot in common with the design thinking of the time.

Another plane which evokes the thirties as the streamlined decade is the Boeing 307 Stratoliner. It was designed as a civilian counterpart of the now famous Flying Fortress - it had the same wings, tail, powerplant and landing gear. The fuselage was different however, being of a larger circular diameter. In appearance it was a large teardrop with wings, tail fins attached - an excellent statement of thirties streamlining. It was Boeing's first attempt at a major pressurised airliner, capable of flying at 20,000 ft. - above turbulence - hence it's name Stratoliner.

The Stratoliner's military sister became much more famous - the Boeing B-17 or flying fortress. While the underpowered XB-15 was trying to get off the ground, the B-17 was taking shape on the drawing board. Design started on 18 June 1934 and

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Boeing 307 Stratoliner

Boeing B-17G Flying Fortresses

the plane first flew on 28 July 1935. The plane was a tender for the USAAC requirement issued in May 1934 calling for "a multi-engined bomber capable of carrying 2000lbs. of bombs over a range of 1,020 miles at 200m.p.h. (but preferably of carrying the same bomb load over a range of 2,200 miles at 250m.p.h.)." The USAAC called for delivery of the prototype for service testing within 16 months. This was an incredibly short space of time, and Boeing only managed because they were already working towards such an aircraft. It was hardly surprising, then, that the final solution was in appearance a cross between the XB-15 and the Model 247. This time the 4-engined concept worked very well indeed, and the plane was more than adequately powered.

An indication of how well it performed during tests can be seen by comparing it with the performance of it's nearest rival the Douglas DB-1.

Although the B-17's wingspan was only 8ft. greater than the Douglas's, it could carry a bomb load of 4,800lbs as opposed to 2,532lb, it's top speed was 236m.p.h. as opposed to 220m.p.h. and the B-17's range was substantially farther. The B-17 was powered by 4,750h.p. R-1690E Hornet Radials and carried five .30in. machine guns, while the Douglas was powered by two 850h.p. Wright R-1820-G5 radials, and carried three -30in. guns. The B-17 lost on cost understandably enough - £99,620 against £58,500. However, the USAAC had little hesitation in taking the Boeing, realising it's military potential, considering the increasing world unease.

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The impact of the Douglas DC-3 and Boeing Stratoliner was not lost in England, where it was being realised how lacking the English were in this area. For this reason the D.H 91 Albatross was designed - England's first 4 engined passenger aircraft. It was not of stressed metal construction but of laminated Spruce with plywood skin. This was a very elegant plane, with lovely sleek shark-like lines and in my opinion the most beautiful plane of the thirties. None survive.

Before the 247's and DC-3's the public relied on a much different looking aircraft for long-distance travel - the Flying-boats or sea-planes. Passenger Sea-planes first came to prominence with Dornier Do-X designed by Claude Dornier which way flying by 1930. At the time it was the largest plane in the world, and needed 6 engines to keep it airborne. Inside, it offered the ultimate in passenger comfort, probably because of it's large size more than any brilliant space-saving interior design. Aeroplane designers at this time still believed that safety was proportional to size - the greater the size the safer the plane. This thinking can be seen particularly in Norman Bel Geddes "Airplane no. 4". This hypothetical plane represented to Bel Geddes what a sea-plane would look like in 1940. The plane was huge - it could carry 600 passengers, and shared a similarity with Dorniers Do-X in that its 12 engines were mounted on top of the top wing. It never flew.

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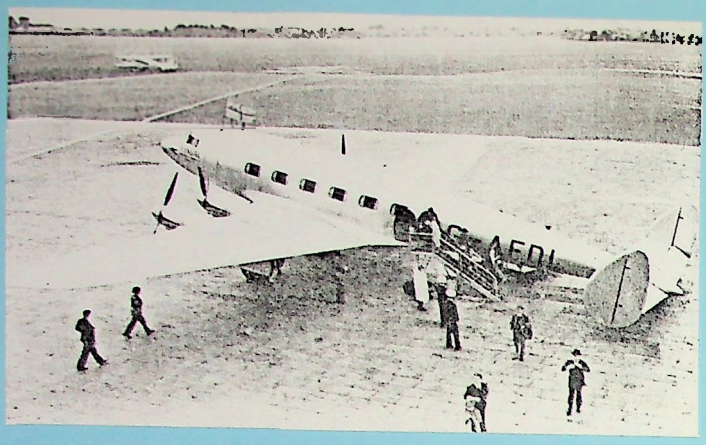
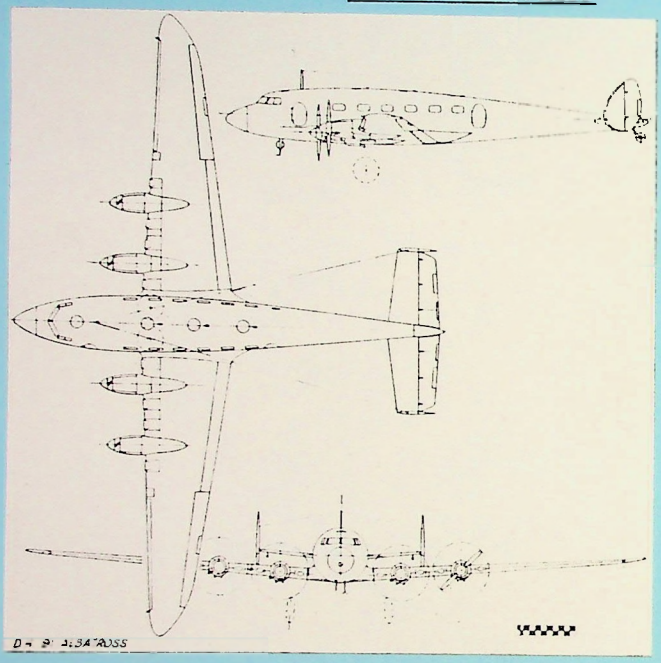
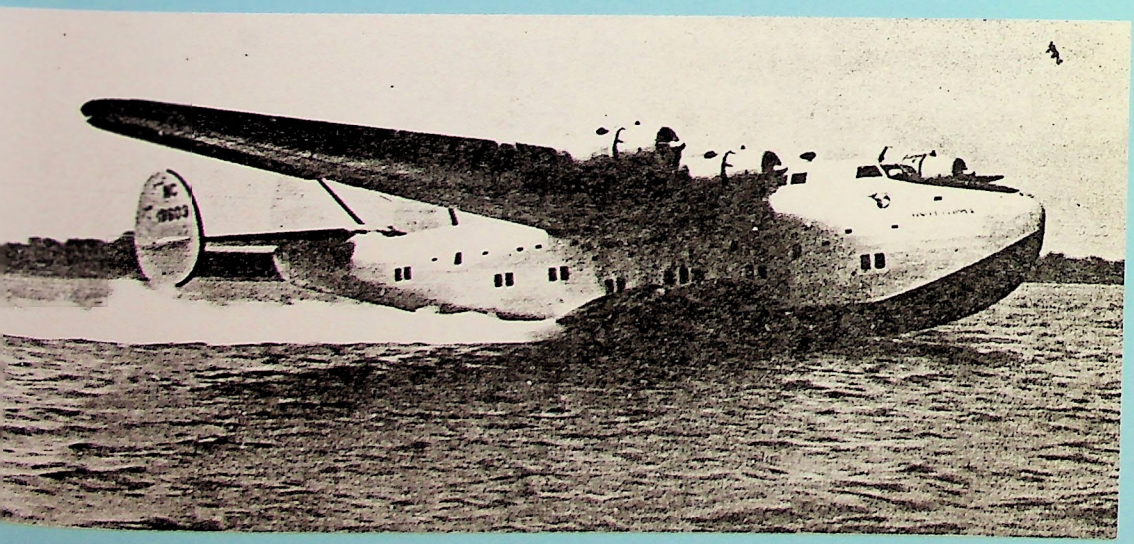


D.H. ALBATROSS





BOEING MODEL 314 'CLIPPER'

Seaplanes as passenger aircraft for intercontinental flights were originally conceived because planes did not have the range to fly non-stop across the Atlantic for example. Sea-planes could skip from port to port along the way, refuelling as they went, and supposedly if the worst came to the worst land on the water and wait for assistance!!

Probably the most famous sea-plane ever was the Boeing Clipper (Model 314), which was the next 'civil' plane the Boeing designed after the Stratoliner Model 307. The Model 314 became known as the 'Clipper' after Pan American's (the purchasing airline) copyrighted prefix for all it's aircraft's names. While the 307 Stratoliner used many features of the B-17 flying fortress, the Clipper borrowed the wings of the underpowered XB-15, and used more powerful engines. The hull of the 314 Clipper was unique in that it was balanced by sponsons rather than by underwing floats. As originally designed, the 314 clipper had only a single vertical tail surface - similar to that of the 307 or B-17, but this did not give sufficient stability, and was replaced by twin endplates, oval in shape. However, these were also unstable so the endplate was restored alongside the twin endplates, giving three endplates a rather unusual looking configuration. The First Model 314 flew on 7 June 1938 and flying Trans-Atlantic and Trans-Pacific routes for Pan American airlines, became the greatest civil sea-plane ever built, operating these routes economically for the first

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time. The 314 Clippers were regular visitors to Foynes on the Shannon Estuary in Co. Limerick, one - the "Bermuda Sky Queen" crashing nearby having run out of fuel.

The improvements in range of land planes were what eventually led to the demise of the sea-plane. Sea-planes which were originally conceived as long range planes - the Boeing XPBB-1 Sea Ranger, and the Short Sunderland spent the second World War operating as coast-guards, while the land-planes carried out the long-distance bombing missions.

"HAWKER" HURRICANE TO SUPERFORTRESS"

With the development of the B-17 in 1934 the U.S. had realised it's requirement for a long-distance bomber as a means of defence. The same thinking was not common in England, where it was not until the collapse of the Disarmament Conference, the same year that serious thought was given to significant rearmament of the air force.

In 1933 the Air Ministry had issued a requirement for a "high performance multi-gun fighter", but there was no sense of urgency attached to the issue. In 1935 two British Ministers - Anthony Eden and Sir John Simon returned from Germany with news that Hitler's rearmament in the air had proceeded much further than the British Government realised. The Government was so alarmed that it ordered quantity production of the Hawker Hurricane and Supermarine Spitfire - before they had even flown. (These two planes were in the process of being designed to satisfy the 1933 Air Ministry requirement).

Bomber development at the time was minimal. This was because it was felt that while fighters were defensive in character bombers were offensive. Therefore fighter development would be seen as defensive rearmament and thus would not trigger an arms-race. The British Government had recommended in 1930 that the RAF's composition be ⅓ fighter and ⅔ bomber, but because of the arms race fears, the bombers were largely neglected.

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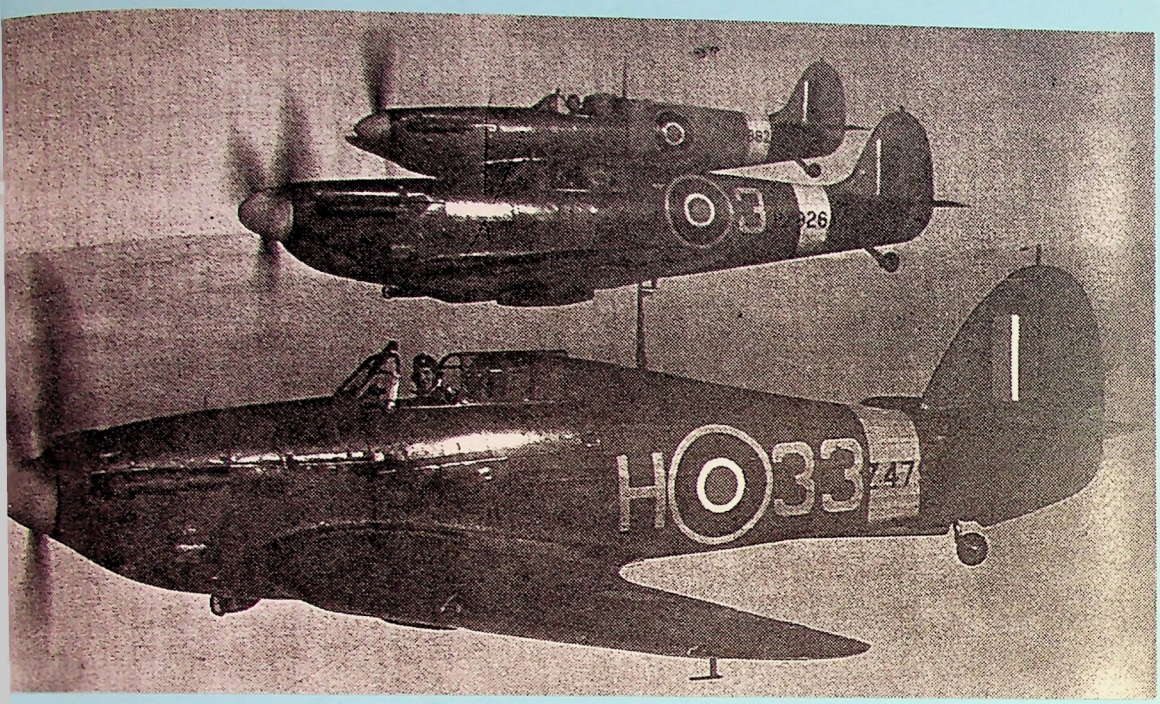

HURRICANE (FOREGROUND) + 2 SPITFIRES

The results of the fighter development were the Hurricane and the Spitfire. The Hurricane was the first to emerge having it's maiden flight on 6 November 1935. The Hawker Hurricane was designed by Sidney Camm and was something of a regression in that the tubular-metal frame was fabric-covered, despite the international trends towards light metal stressed skin monococque. Production models were, however metal skinned. The Hurricane was the first British fighter to exceed 300m.p.h., and along with the Supermarine Spitfire became Britain's most famous fighters of the war.

The Spitfire first flew 5 months after the Hurricane, in March 1936. It was designed by Reginald Mitchell and was a direct descendant of the S6B which won the Schneider Trophy outright for Britain in 1931. Unlike the Hurricane it was the state-of-the-art aeroplane of it's time, employing all-metal stressed-skin monocoque structure and was the smallest practicable airframe that could be designed about the pilot, the chosen power plant and the specified armament. The initial model powered by a Rolls Royce Merlin engine had a top speed of 346m.p.h. Flown on 14 May 1938 the production model reached RAF squadrons by that August - just in time, as the Second World War broke out a year later.

Germany, on the other hand had been developing and modernizing her airforce throughout the thirties. When Poland was invaded in 1939, Germany already had planes of the calibre of the

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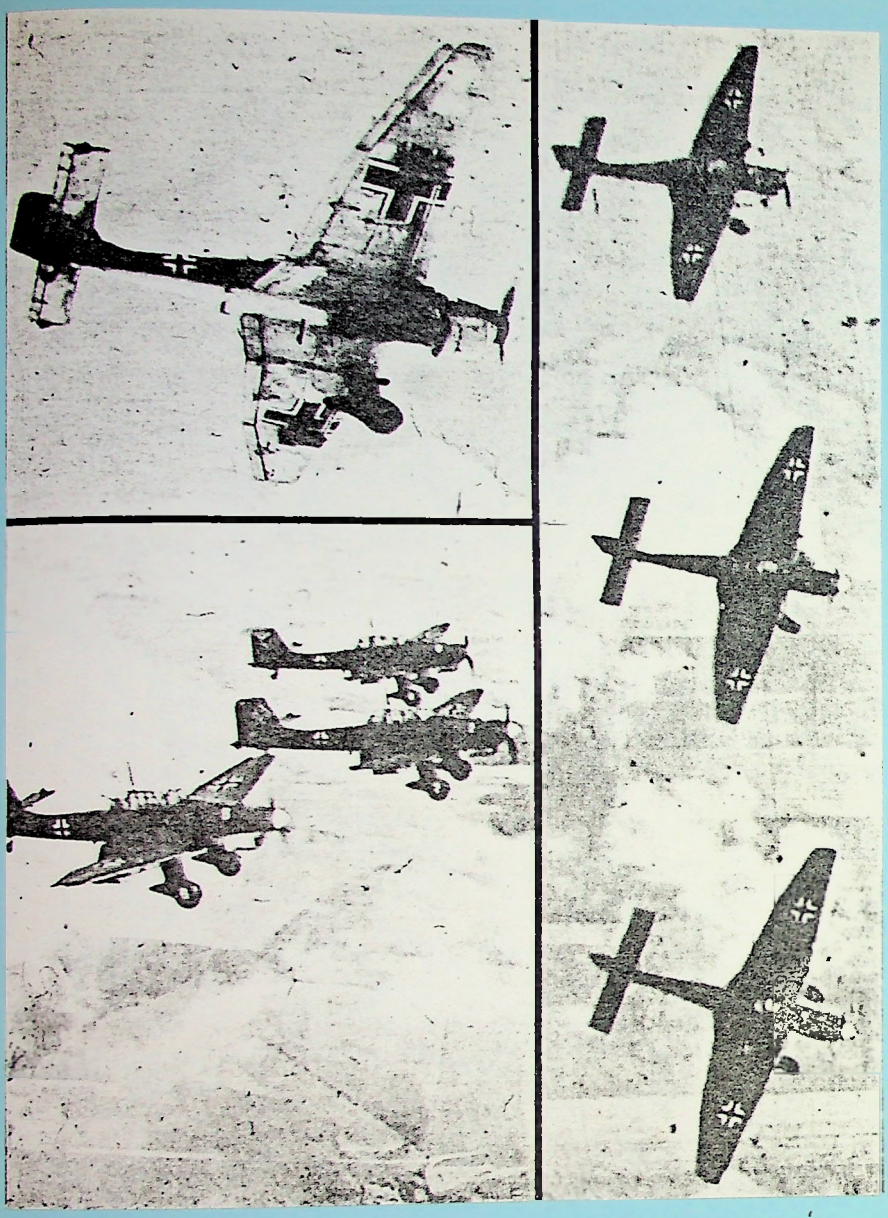
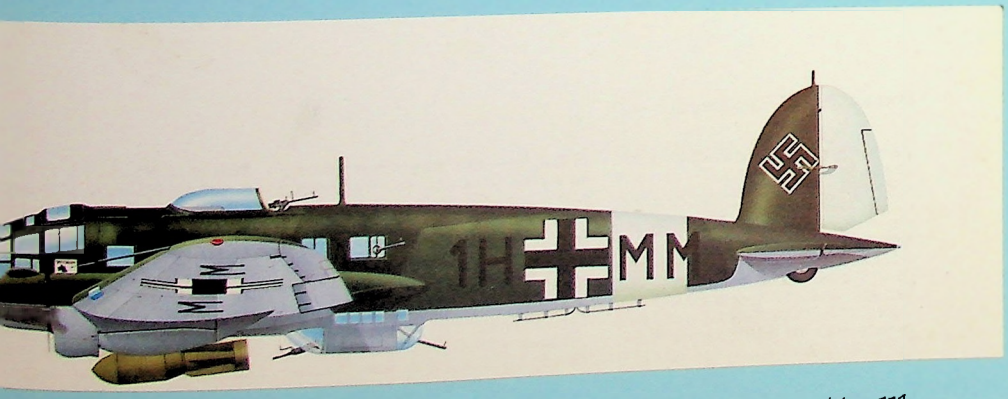


JUNKERS JU 87 'STUKA'



HEINKEL HE 111

Junkers Ju 87, the Messerschmitt BF 109, the Me 110, the Ju 88, the Dornier Do 17, and Heinkel He 111. Many of these planes had seen action in the Spanish Civil War and two in particular - the Ju 87 'Stuka' and He 111 were very successful.

The Ju 87 'Stoka' was a dive bomber which under fighter escort cleared the way for very quick victories in Poland and France. The Germans became interested in dive-bombers as a result of American experiments in 1927. In 1933 the German ace Ernst Udet convinced Hermann Goring to purchase two Curtiss BFC bombers (designated BFC) at the then high price of £11,500 each. The "Stuka" was designed as a German equivalent following tests on the American planes. The "Stuka" was instantly recognizable by the 'W' configuration wings and large air-brakes immediately behind them. The body was of stressed skin construction around a tubular frame. The "Stuka" was innovative in that the bomb was carried under the fuselage on a swinging arm that catapulted the 1,540 lb. bomb away at the bottom of the dive. Bomb aiming was also innovative in that the pilot aimed the bomb through a glass visor situated in the floor. A more sinister element in the "Stukas" design was the attachment of a free-spinning propellor to each undercarriage which was not retractable. Whilst diving and gaining speed, these little propellors gave off a high-pitched scream, like a long drawn-out siren, causing fear and panic amongst those on the ground.

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The main German fighter of this time was the Messerschmitt BF 109 - the German equivalent of the Spitfire. The first prototype flew in late May 1935, and as a design was more evolutionary than revolutionary - it was the first single seat fighter to combine with the low-wing cantilever monoplane configuration a flush-riveted all-metal stressed skin monocoque structure, a retractable undercarriage and enclosed cockpit. This was the first time all these features were combined in one airframe. It's dimensions and technical performance were very similar to the Spitfires (The BF's top speed was 340m.p.h. compared to 346), and were almost equal in combat except from the point of view of manoeuvrability. The BF 109's main strength lay in it's versatility and eleven different versions were produced, and these in greater numbers than any other combat aeroplane in history.

The German's found their answer to the Spitfire in their next fighter aircraft - the Focke Wulf Fw 190, designed by Dipl-Ing Kurt Tank and first flown on June 1 1939. The Fw 190 was the first of Germany's World War II fighter to use an air-cooled radial engine instead of the usual liquid cooled engines. The engine chosen was a BMW 80-ID 14 cylinder 2 row radial air cooled engine, which gave the lane a top speed of 355m.p.h. When introduced to combat in 1941 it caused widespread consternation amongst the RAF as it could out-manoeuvre the Spitfire V on every count apart from turning circle, and it was not until the introduction f the Spitfire IX that something of a balance was achieved.

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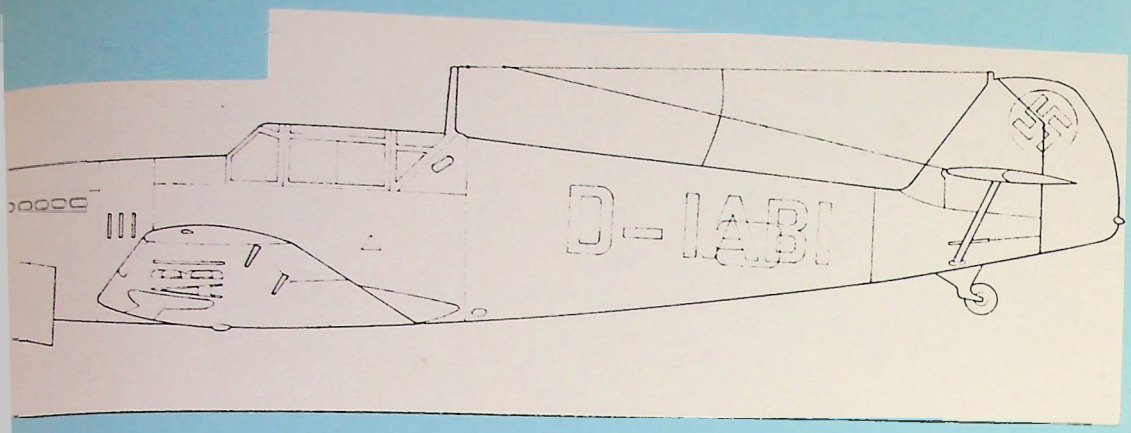
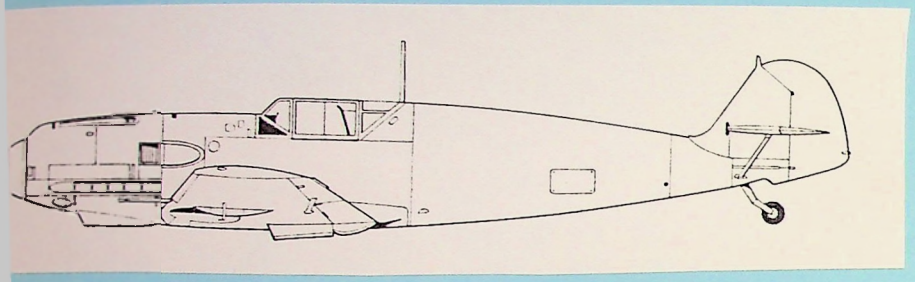
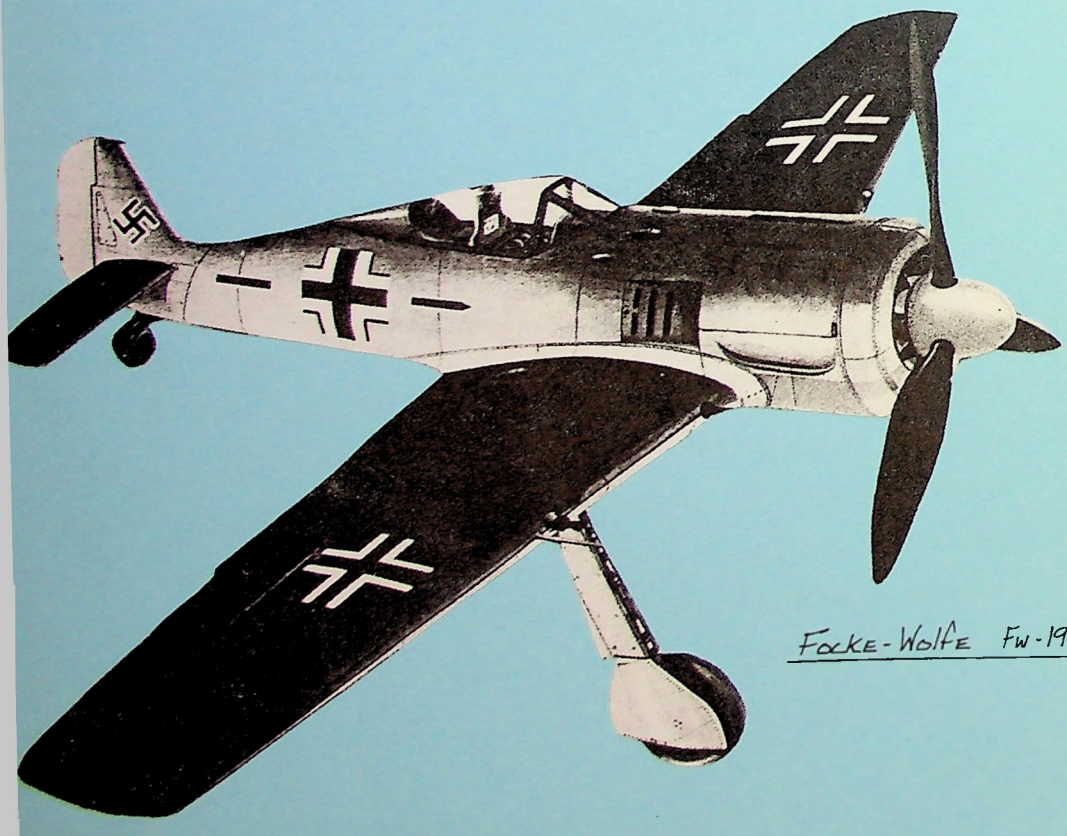


MESSERSCHMITT BF 109 PROTOTYPE



BF 109



FOCKE-WOLFE FW-190

The other major propellor driven single seater fighter of the war was the North American P-51 Mustang which first flew in October 1940. It was an outstanding achievement in that it was translated from outline concept to completed prototype in only 122 days. It was innovatory in that it used a low-drag laminar-flow aerofoil Section. It also had the highest speed of any allied plane (395m.p.h.) except for the Typhoon (404m.p.h.).

These fighters were the best and most influential in terms of aircraft development and design in their respective countries during the war. They were not the only fighters each country possessed but any propellor driven fighters which were built afterwards all possessed or tried to emulate the qualities of these planes - e.g. Hawker Typhoon, Rebublic P-47 Thunderbolt, Grumman Hellcat, Me 262.

When the Second World War started the British bomber force consisted of the Vickers Wellington, Armstrong Whitworth Whitley, and Handley Page Hamden. The Vickers Wellington was notable in that it used the Geodactic lattice structure invented by Barnes Wallis. This structure divided the stresses equally throughout the fuselage, which meant that the plane could absorb enormous structural damage and still stay airborne. While the Wellington was a medium 2-engined bomber, the Hampden and Whitley were both heavy bombers, designed to carry a bomb raid deep into enemy territory.

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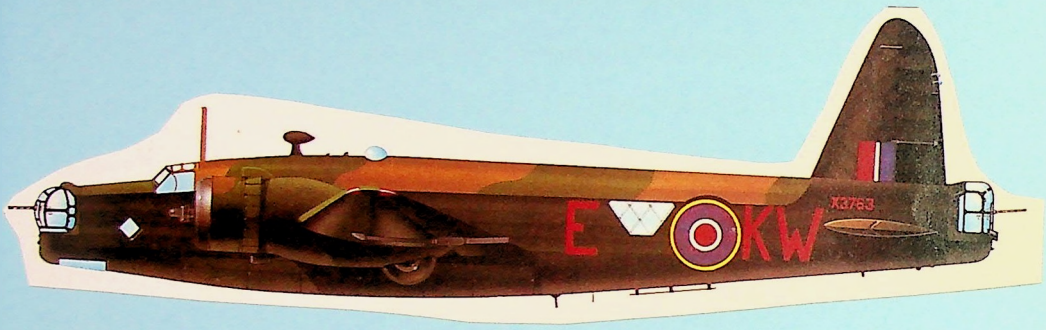
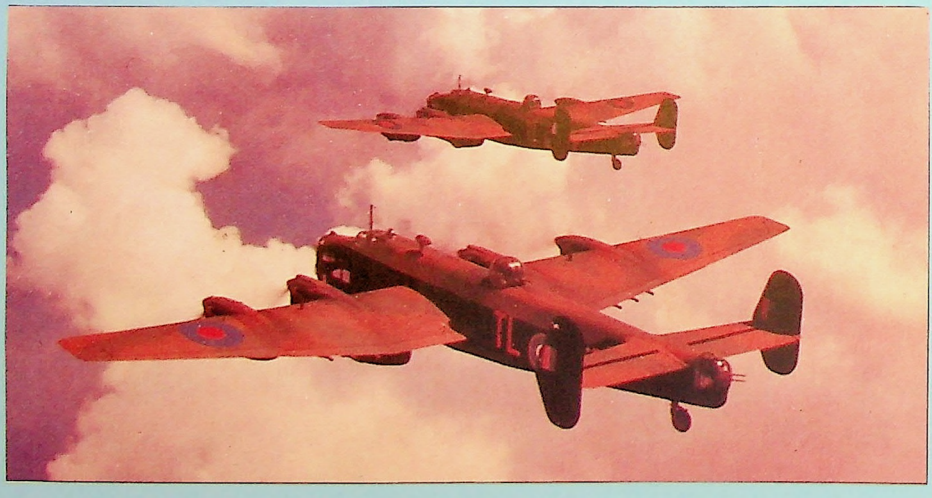
Armstrong Whitworth Whitley



Vickers Wellington



Handley - Page Halifax

Germany's planes, on the other hand were medium bombers - the Heinkel He III, the Dornier Do 17 and Junkers Ju 88. These were faster and more agile than the British bombers, designed to fly daylight raids well ahead of their armies, as when designed there was no fighter opposition capable of catching them.

The Heinkel He III was similar to the Ju 52 already mentioned, in that Siegfried and Walter Hunther designed it in 1934 as a dual purpose commercial transport/bomber. In appearance it was very similar to the Boeing 307 Stratoliner, having the same 'teardrop' fuselage and fully glazed asymmetric nose. The fully glazed asymmetric nose was a common feature of all German medium bombers.

The main strong point of the German planes like the BF 109 was their versatility the Ju 88 for example, of which more were built than any other German bomber (15,000 in all) was modified about twenty times, seeing roles as a medium-bomber, fighter/bombers, night fighters, reconnaisance aircraft, anti-tank attack machines. It was probably most successful as a night-fighter.

This was possibly a fault, overall, however. While the Germans were content to modify and adapt existing planes, some of which were 6 or 7 years old when the war began, the allies concentrated on developing entirely new aircraft,

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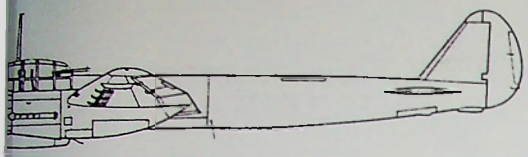
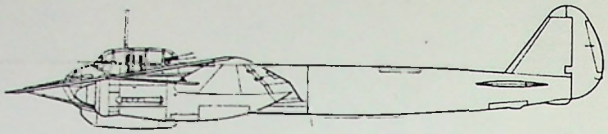


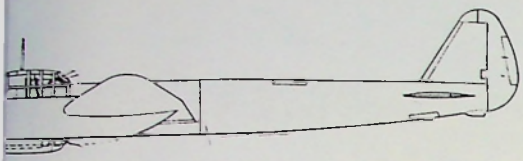
JUNKERS Ju 88 A-5

The A-5 was similar to the A-1, which made its debut in September 1939, but had its wing-span increased to 65 ft 10⅜ in. and a larger bomb load (6,614 lb) which reduced its maximum speed to 273 mph

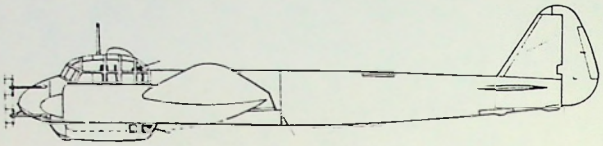


JUNKERS Ju 88 A-6

Generally similar to the A-5, the A-6 carried as standard a balloon-cable fender and destroying gear. This was so unwieldly, however, that it was soon withdrawn from service

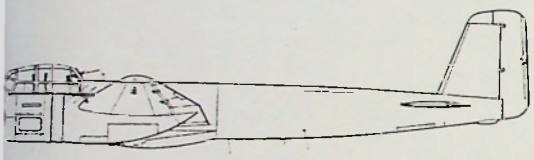


JUNKERS Ju 88 C-4

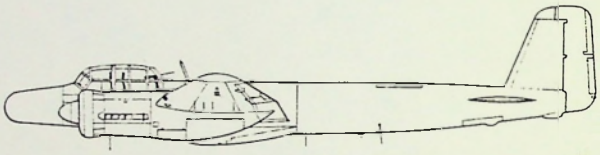


JUNKERS Ju 88 C-6b

The C-series were all primarily fighters, developed parallel with the A-series of bombers

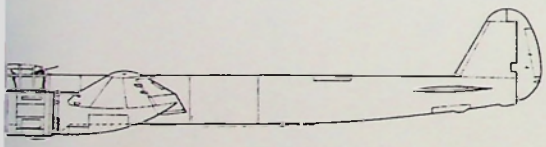


JUNKERS Ju 88 G-4



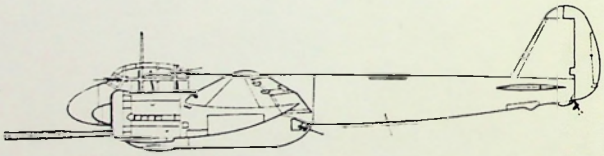
JUNKERS Ju 88 G-7c

The G-series of Ju 88s were specialised night-fighters



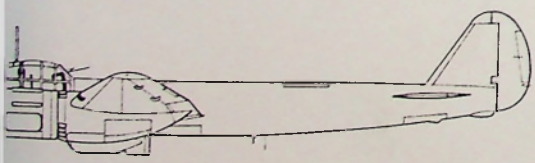
JUNKERS Ju 88 H-1

The H-1, characterised by an elongated fuselage to house extra fuel tanks, was a long-range photo reconnaissance aircraft

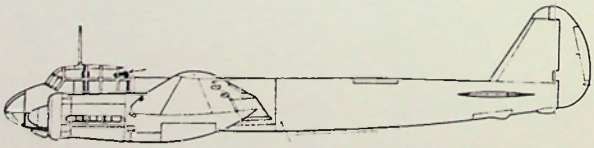


JUNKERS Ju 88 P-1

The P-1 was an anti-tank ground attack machine, used mainly on the Russian front and armed with a single forward-firing 75-mm BK 7·5 long-barrel cannon, in addition to rearward-firing twin MG 81 machine-guns fitted in a gun fairing which could be jettisoned if necessary



JUNKERS Ju 88 S-1



JUNKERS Ju 88 S-3

By 1943 the A-series were too slow for unescorted daylight operations, so development went ahead on the S-series, in which the bomb-load was reduced to 1,760 lb, and the upper nose guns and ventral gondola removed in order to increase speed. The glazed nose reverted to a shape similar to the early prototypes. The S-1 was the initial production model of the series, with 1,700 hp BMW 801G engines with GM-1 power boost, and only one rearward-firing 13-mm MG 131. The S-3 was powered by 1,750 hp Jumo 213E-1 engines

VARIATIONS OF JU 88'S PRODUCED

AVRO LANCASTERS 1940

and through a concerted mass production effort ensuring that these aeroplanes were produced in sufficient numbers, made a definite impact on the war. Examples of these planes are the P-51 Mustang, The Auro Lancaster, The De Havilland Mosquito, The Boeing Superfortress, the Consolidated B-24 Liberator, and the Northrop P-61 Black Widow. Any development by the Germans was only in relation to Jet aircraft, but this was substantial and will be discussed later.

The Allies could therefore bring new aircraft specially designed for a particular purpose into the war. This was not only a design feat but a production feat as well. The Allied production effort was based on the "throwaway" or "disposable" ethic. If a product was expended in the war theatre it had served it's purpose. A new product would then replace it.

The German ideal placed more emphasis on the quality and durability of the product. However, a plane destroyed is a plane destroyed irrespective of the quality of construction, and it must still be replaced. It can be seen therefore how the Allies were in a better position to replacing planes as that was how their production effort was geared.

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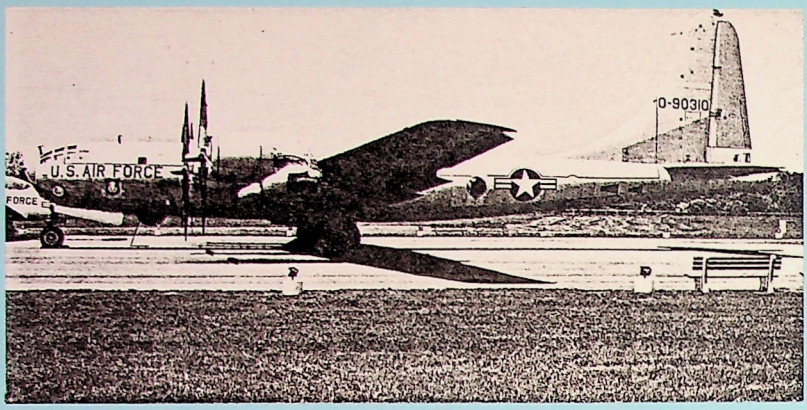
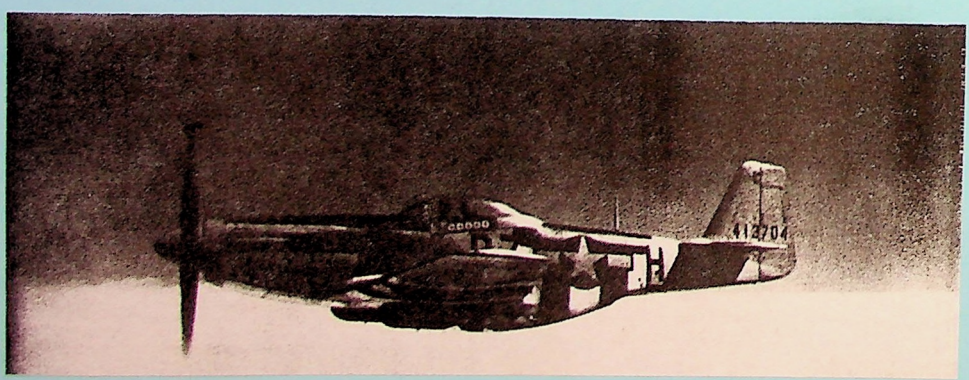


Boeing B-29 'Superfortress'

A B-17G just off the Production Line



North American P-51 Mustang

The best example of the American production effort, and excellent aircraft design during the war was the Boeing B-29 "Superfortress". On the 5 February 1940 the USAAC issued a requirement for a "Hemisphere Defense Weapon", capable of flying 5,333 miles at a speed of 400m.p.h. with 2,000 lbs. of bombs to be dropped at the midpoint. Boeing tendered successfully and two XB-29 prototypes were ordered on 24 August 1940. Although the prototype did not fly until 21 September 1942, the urgency of the USAAC was such that over 1,500 planes were already ordered, the US Army having brought the following companies into a major co-production programme. Bell (Marietta, Georgia), North American (Kansas City) and the fisher Body Division of General Motors (Cleveland, Ohio).

Construction of three prototypes for initial flight-testing was pushed ahead with all speed at the No. 1 plant Seattle, and then the parts were moved by truck to Boeing field for assembly and flight tests. Once tests were completed, the prototype was sent to Wichita where 14 pre-production YP- 29's were built, followed by the first production Models. Bell was also able to start production on time, and the third factory began production when the US Navy's facility at Renton on Lake Washington was exchanged for the US Army's factory at Kansas City. Fisher Body became a major producer of sub-assemblies, the Martin company at Omaha, Nebraska, taking over production from it. One of the most impressive parts of the whole B-29 programme was the extent and smooth-running of the huge sub-contracted effort involved in

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B-29's OVER JAPAN 1945

the manufacture. Thousands of companies - large and small, were involved in the manufacture of single items or major portions of the airframe and it's equipment. All these components had to be brought together in the right order and quantities at the four assembly facilities. How complicated this was, can be gauged by looking at the accompanying map, showing the assembly points relative to one another. There were problems inevitably. These were mainly with the auxillary components, so special modification plants were set up in Marietta and Omaha to iron out these problems without upsetting the production lines. Support problems and bad weather for outside assembly made things difficult, but during a hectic six weeks, during March and April 1944 known as "The Battle of Kansas" the B-29's were made operational.

The first operation was flown on the 5 June of that year to Bangkok from Indian bases. The B-29 went on to wipe out Japans cities, transportation systems and factories, and it was the B-29 which dropped the first atomic bombs on 6 and 9 August 1945.

Outside the magnificent production effort, the B-29 was an innovative design, and extremely advanced aircraft for it's time, a fact emphasized by it's sleek lines. It was the first aeroplane to have remotely controlled armament located in four barbettes above and below the fuselage, to supplement

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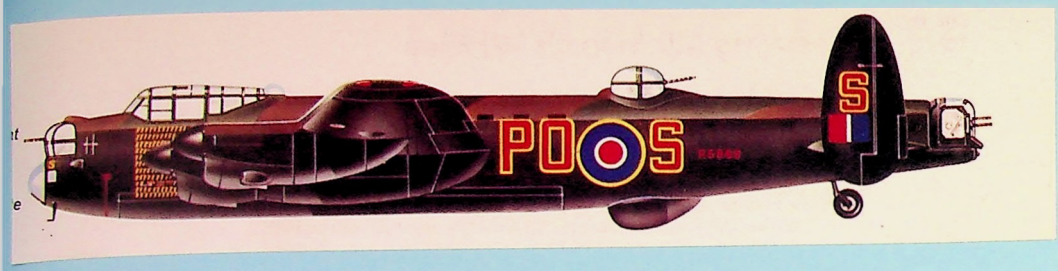
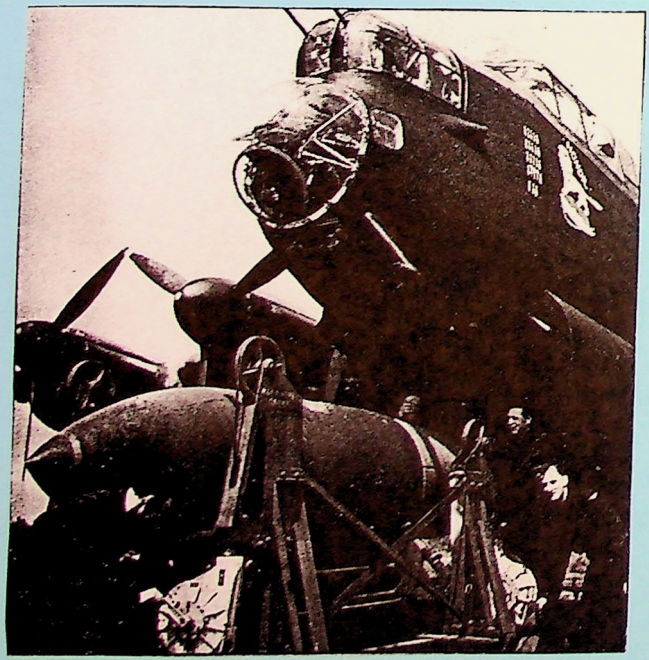


LANCASTER B-MK 1

MODIFIED LANCASTER WITH 'TALLBOY' BOMB



LOADING A 'TALLBOY'

the manned tail turret. Although remotely controlled the four turrets had an override system if the gun sighter had a good target. It was also the war-production aircraft to introduce cabin pressurisation because of the great altitudes the plane flew at 31,800ft. With a maximum speed of 358m.p.h. it was still 70m.p.h. faster than the Consolidated B-24 Liberator it's fastest heavy bomber rival.

The finest British Bomber was undoubtedly the Auro Lancaster which first flew on 9 January 1941. Like the B-29 the Lancaster was the result of a concerted production effort, in fact production was so great that at one stage a shortage of Merlin engines was threatened. This was countered by licence production by Packard in the USA of the Merlin.

A strange aspect of the Lancaster design evolution went hand-in-hand with the development of bombs. Early Lancasters carried their bomb loads in normal flush-fitting bomb-bays, but as bombs got larger it became necessary, in order to be able to close the bomb doors to make the bays deeper so that they protruded slightly below the fuselage line. Eventually with developments such as the "Dam-Busher" bomb, the "Grand Slam", and the "Tallboy" the bomb doors were omitted altogether. In all 7,377 Lancasters were produced.

The De Havilland Mosquito was however the finest example of British design and development during the war. Strangely enough, it nearly didn't fly. This was due to the operational

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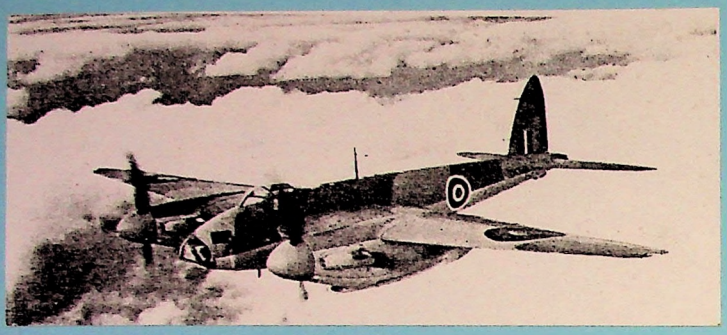
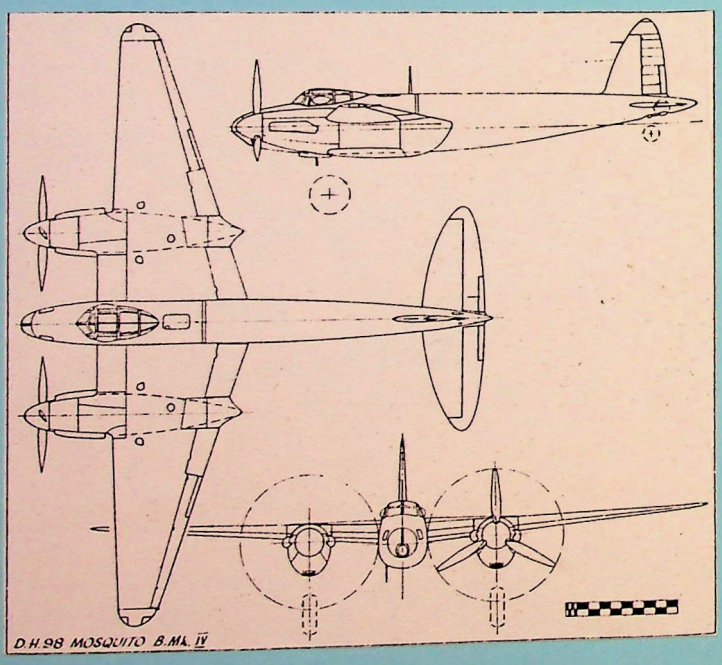


D.H. MOSQUITO



concept that lay behind it. It was conceived as an unarmed bomber, capable of out-flying all contemporary fighters. This was totally contrary to thinking at the time and official scepticism was great. However, design was allowed to ahead. Design itself seemed retrograde in that a wooden structure was used, when wood use in aircraft had long been discarded. Although designed as a bomber, it was realised that it had potential as a fighter, so space was allowed under the cockpit for cannon.

Manufacture was also novel in that the plane was manufactured in two halves the dividing line running from tail to nose. Once all parts and assemblies were included the halves were glued together in a special jig. This proved successful in the European climate, but in Tropical conditions, humidity and wood-boring insects often caused the aircraft to split open. This led to special pre-treating of wood and different glues being used in Australian factories where Mosquitos were manufactured under licence. Both fighter and bomber versions were very successful, 7,781 Mosquitos being built, 4,650 being fighter versions. The bomber version having a maximum speed of 380m.p.h. was the fastest bomber of the war.

These 3 planes - the B-29, The Lancaster, and Mosquito represent the finest design and development of aircraft during the war. The B-29 went on after the war eventually leading to the B-50 which first flew in 1947, the Lancaster was developed from the

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Auro Manchester during the war, and the Mosquito represents excellence in design from 'scratch'.

The development of Jet aircraft was somewhat seperate and is discussed in the next chapter.

JET AIRCRAFT DEVELOPMENT

Although combat by jet propelled aircraft was limited to the final year of World War II, the knowledge that jet reaction was potentially the most efficient of all aircraft propulsion systems had existed for some 15 years beforehand. The greatest advances in jet-engines had taken place in Germany, through the efforts of F.W. Sander and Fritz Van Opel with solid-fuel rocket power, Paul Schmidt with pulse jets and Dr. Hans Van Ohain with the gas turbine, all of whom had achieved limited jet reaction-powered flight or were just about to do so when war broke out in September 1939. In the U.K. work was progressing due to Frank Whittle with little financial support, but elsewhere in the world there was little or no interest.

Germany was the first to fly an air-breaking jet aircraft - the Heinkel He 178 which flew for the first time on 27 August 1939, under control of Flugkapitan Erich Warsitz. The He 178 was a shoulder wing aircraft with wooden wings, but with a semi-monocoque metal fuselage. The engine (1X500kg thrust Heinkel He S 3B centrifugal-flow turgo-jet) drew it's air through an inlet in the nose and exhausted through a long jet-pipe which extended to the extreme tail. On it's maiden flight it crash-landed due to a bird being sucked into the engine causing it to flame out. The He 178 was an extremely clean design with fully retractable and faired-in undercarriage, bubble cockpit giving excellent

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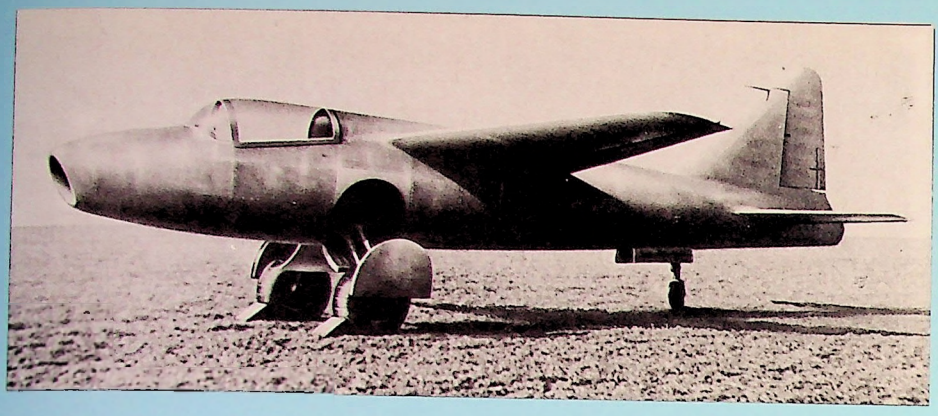
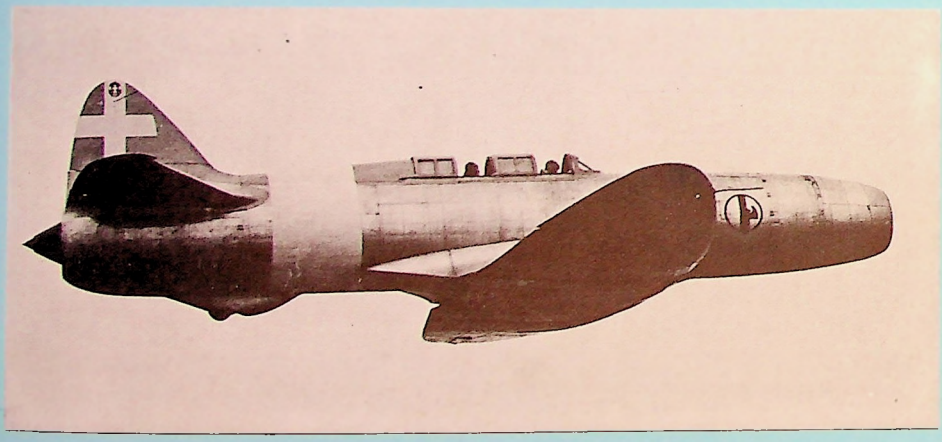


HEINKEL HE 178



CAPRONI - CAMPINI N-1

GLOSTER E.28/39

GLOSTER METEOR

all-round visibility. Maximum speed was 360m.p.h. (at sea level) 14m.p.h. greater than the maximum speed of the prototype Spitfire.

Surprisingly, the Italians were the next country to fly a jet. It was however more of a freak than the end result of dedicated research and development. The Caproni-Campini - NI as it was known first flew on 28 August 1940 but with top speed of only 233m.p.h. and no further development being carried out, the project was abandoned.

The first turob-jet aircraft designed from the beginning as a fighter was the Heinkel He 280 which made it's first flight on 2 August 1941,(19 months before the first successful British jet aircraft - The Gloster Meteor). It was powered by two centrifugal-flow He S 8 engines, specially designed by Van Ohain, each generating 1,534lb. of thrust, giving a colossal maximum short-burst speed of 559m.p.h. It was also in the He 280 that the first ever bale out using an ejector seat was made, when Argus Test Pilot Schenk ejected when his controls locked due to icing up. Although production of the He 280 was planned, recurring structural and fuel system problems led to the design being abandoned in favour of the Messerschmitt 262.

Without doubt the most famous jet fighter of World War II was the Messerschmitt Me 262. The Me 262 launched the new era of aerial warfare, and it's performance was so good that

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it could have regained mastery of the skies for the Luftwaffe at the end of the war, but for misuse and lack of pilot training.

Initial design for the Me 262 began in October 1938, but it was not until May 1940 that a definitive configuration was reached, when increased engine weight caused the Messerschmitt team to sweep back the wings to compensate for the planes centre of gravity being brought forward. This was rather fortunate, as at the time the aerodynamic advantages of swept wings in jet aircraft were not known, so it was a stroke of luck that the Me 262 became the world's first swept-wing fighter.

The first prototype the Me 262 V1 flew on 18 April 1941 with a Jumo 210 G piston engine this being retained for the initial flight with turbojets on 25 March 1942. The first flight on turbojets alone took place on 18 July 1942 (Me 262 V3) and Luftwaffe accepted the aircraft in April 1944 with the first production aircraft arriving in June of that year.

In flight, the Me 262 handled superbly, and was a vast improvement over the Luftwaffe's main fighter - The Messerschmitt BF 1096. The Me 262 was powered by 2 Jumo 004B turbojet engines, giving a maximum speed of 541m.p.h. The engines, although an extraordinary achievement for the time using technically difficult axial compressors were very dangerous during landing/take-off.

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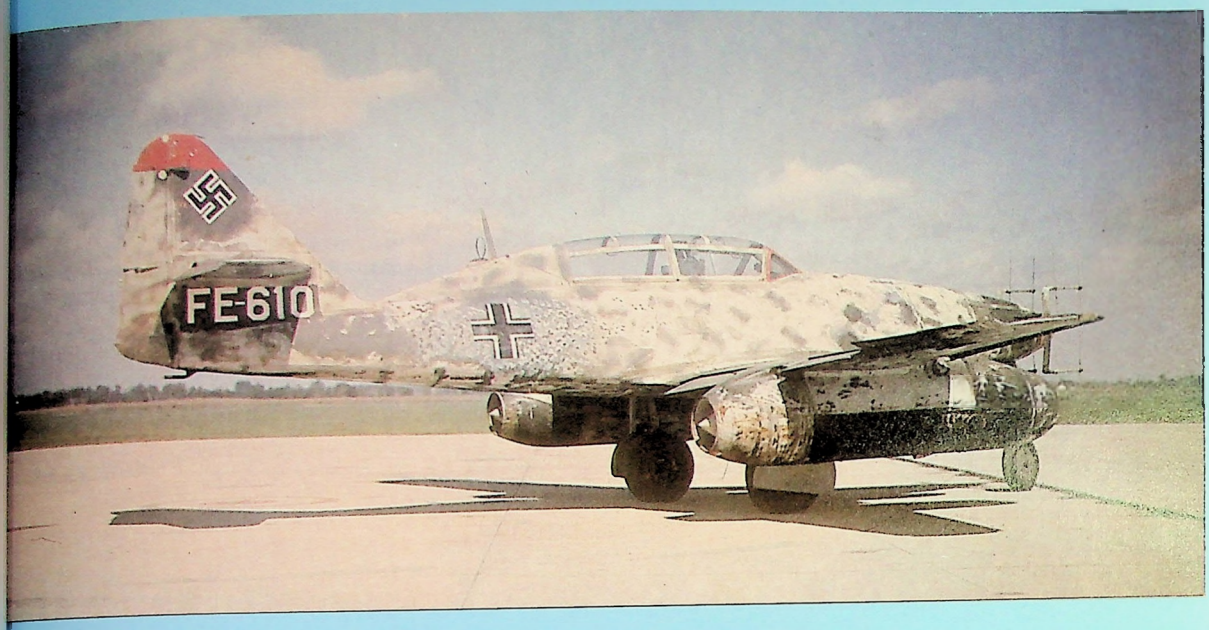
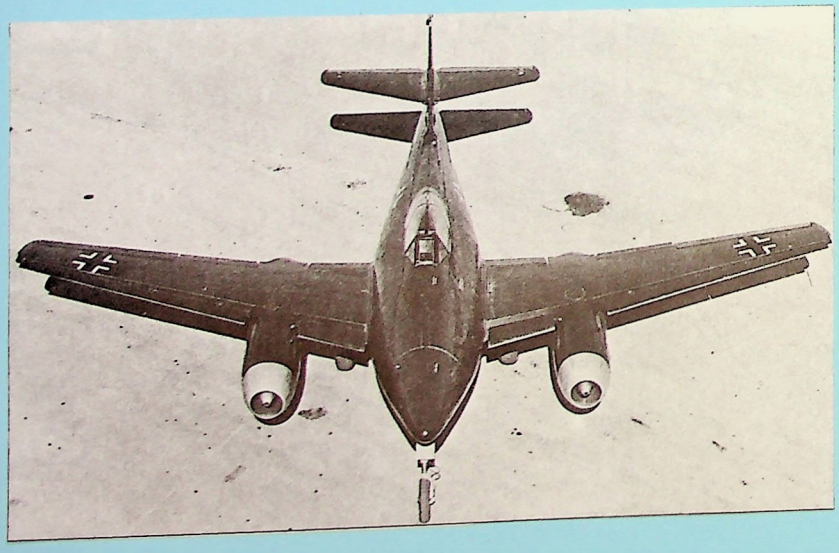


MESSERSCHMITT ME 262



The trottles had to be eased very gently or the aeroplane was likely to "flame out" and crash. It was around it's own airfield that the Me 262 was most vulnerable, and out of the 500 Me 262's that reached combat, 100 were shot down (at least 21 of these while circling their own bases) and 240 were lost due to accidents.

In Britain the first jet to fly was the Gloster E. 28/39 on 15 May 1941 some 20 months after the Heinkel He- 178 first flew in Germany. It was a research aircraft designed purely to test the Whittle W.1 reverse flow gas turbine. It was similar in some respects to the He 178, having a nose inlet tail exhaust.

The result of the Gloster E. 28/39 experiment was the Gloster Meteor which first flew on 5 March 1943 and began operations in July 1944. Development had been hindered by engine manufacture, the initial engines manufactured (Rover W. 2B) by the Rover company proving very unsatisfactory, and it was not until the introduction of Rolls Royce W. 2B/37 Derwent engines that the plane finally saw service.

In comparison with the Me 262 the Gloster Meteor did not fare well. It was not as easy a plane to fly in full flight as the Me 262, and as it's speed increased, it became more difficult to control, to the point where the controls became 'solid'. Aerodynamically, the Meteor was not as advanced as the Me 262, lacking the swept wings and clean

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lines of the German plane. In appearance, the Meteor was very similar to the Mosquito, and this is perhaps more than coincidence. If one compares their dimensions, the similarity can be seen

	METEOR	MOSQUITO
SPAN	43ft.*	54ft. 2in.
LENGTH	41ft. 3in.	40ft. 10 in.
HEIGHT	13 ft.	15ft. 3 in.

* The Meteors span had originally been greater but was cut down to improve roll characteristics.

It is a personal view, but considering the success of the Mosquito as a fighter/bomber, in terms of speed and handling, it may have appeared sensible to design the Meteor as a sort of jet powered Mosquito.

The Meteor was sufficiently successful to continue service in the RAF for 16 years after the war ended.

Although these jets were probably the most important in terms of jet aircraft evolution and how they would develop, the Allies only found out how far advanced the Germans were in jet aircraft design until after the war.

It seemed that in Germany despite technical difficulties, material shortages and just losing the war, aircraft designers used to vie with one another to draw the most futuristic shapes and if possible fly them.

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One of the most advanced planes produced in numbers was the Arado Ar 234 a high wing jet powered by 4 Jumo 004B engines (as used in the Me 262). Designed as a reconnaissance plane and featuring a pressurised cockpit the plane first saw service in September 1944. By the end of 1944 over 1,000 photo-reconnaissance sorties had been flown giving superb results, of locations as far afield as England and Italy. Many believe that if the Arado Ar 234 had seen service say 10 months earlier and been able to plot the build-up to D-Day (June 1944) the course of the war could have been changed.

One of the most visually striking German designs was the Horten Ho IX, a "flying wing" with no tail or projections of any kind except the neatly faired in cockpit. An indication of how much ahead of it's time this plane was can be seen when comparing it to the RAF Vulcan bomber which only left operational service in 1982.

The most technically and aerodynamically advanced plane was the Junkers Ju 287 bomber. Because of lack of parts the interim prototype was lashed together using the fuselage of a Heinkel He 177, a Ju 388 fail unit, Ju 352 mainwheels and the nosewheels of captured B-24 Liberators. Technically the plane was advanced in that two of the engines (Junkers Jumo 109-004B turbojets) were mounted on the fuselage itself, rather than on the wings, such as on many of today's jetliners.

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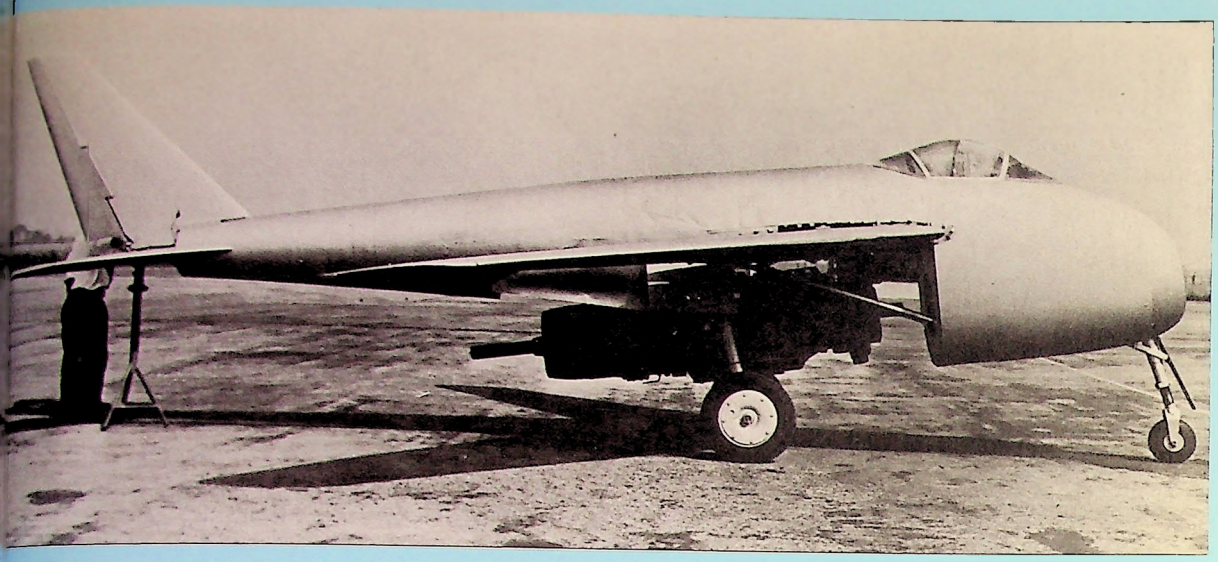
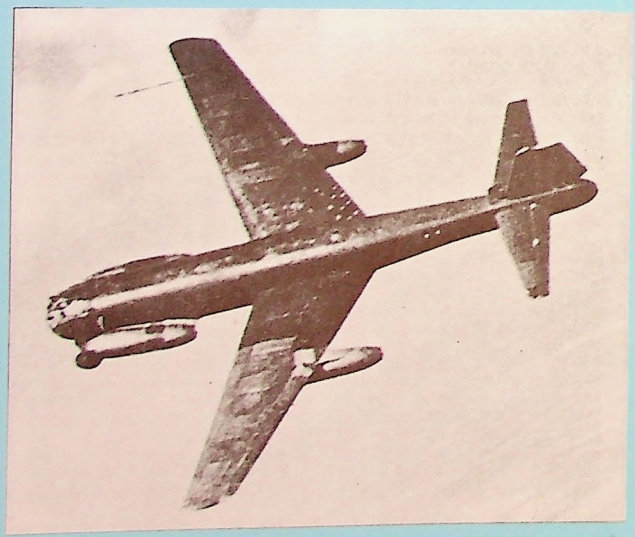


MESSERSCHMITT P-1011



JUNKERS JU 287

Probably most advanced was the wing configuration, their being swept forward rather than back. This was an attempt to overcome the problems of compressability, and the same solution is being applied today, 40 years later to the German X-29A. Many other German designs were very far ahead of their time - the Messerschmitt P-1011 employed variable sweep wings which only became common after the mid sixties with the General Dynamics F-III, the Grumman F-14 Tomcat (1970) and the Panavia Tornado (1974). Other advanced planes were the Heinkel He 162 with interchangeable wings - forward or back swept, the Me 263 a rocket launched plane which attacked bombers under power, and then glided back to base when it's fuel had been used up.

The development of these planes was swamped by the Allied advance and they all arrived much too late in the war to have any great affect. However, had they arrived sooner the outcome of the war could have been very different. Any immediate developments in jet aircraft after the war were largely due to the great advances the Germans had made during the war.

THE DESIGN AND DEVELOPMENT OF AIRCRAFT 1930-1945

CONCLUSION

This essay charts the design and development of aircraft from 1930 to 1945. Those fifteen years have probably seen more aircraft development than any other period in aviation history. The transgression from fabric-covered wooden structured bi-planes to stressed-metal monocoque jets with forward swept wings is appreciably a very great one. The aircraft listed were all milestones of design for various reasons during this period of development.

Some better-known planes have not been mentioned (e.g. Mitsubishi Zero, Short Stirling, Gloster Gladiator) and some lesser known aircraft have - e.g. Dornier Dx, Boeing F4B-1). This is because, that in terms of design and development their impact was much less than that of some of the lesser known aircraft.

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