The World's Fastest
Piston-Engine Airplanes

by Dipl-Ing Robert W. Kempel

Recently I was talking to a test pilot friend, who is qualified in Unlimiteds as well just about anything that flies including jets or prop jobs, and I asked him what would it take to get to 500 miles per hour? He said that's simple; just get yourself down to LAX, buy a commercial airline ticket, get on the plane, and soon after you become airborne you will be at 500 mph or better. No, no I said what I mean is to get an Unlimited propeller-driven airplane to a true airspeed of 500 mph in level flight at an altitude under 7,000 feet. That's entirely different he told me and further qualified his comment by saying that, "that my boy, is very very difficult if not almost impossible. What you will need is an almost unlimited cash supply, the right airplane, the right pilot, a very talented group of the right support people, and a vast amount of good luck. This, however, will not ensure success." Sounds as if I will have to have plenty of the "right stuff" I said. "That's absolutely correct," he said, as we finished our conversation.

This conversation got me interested in the subject of just what were the fastest, officially recognized, propeller-driven airplanes in the World. What made them different from other airplanes, how did they progress technically, and how did they contribute to our understanding of aviation over the years? A good place to start , it seemed, was the post-Great War (WWI) era when the fastest airplane speeds were just pushing the 200 mph mark.

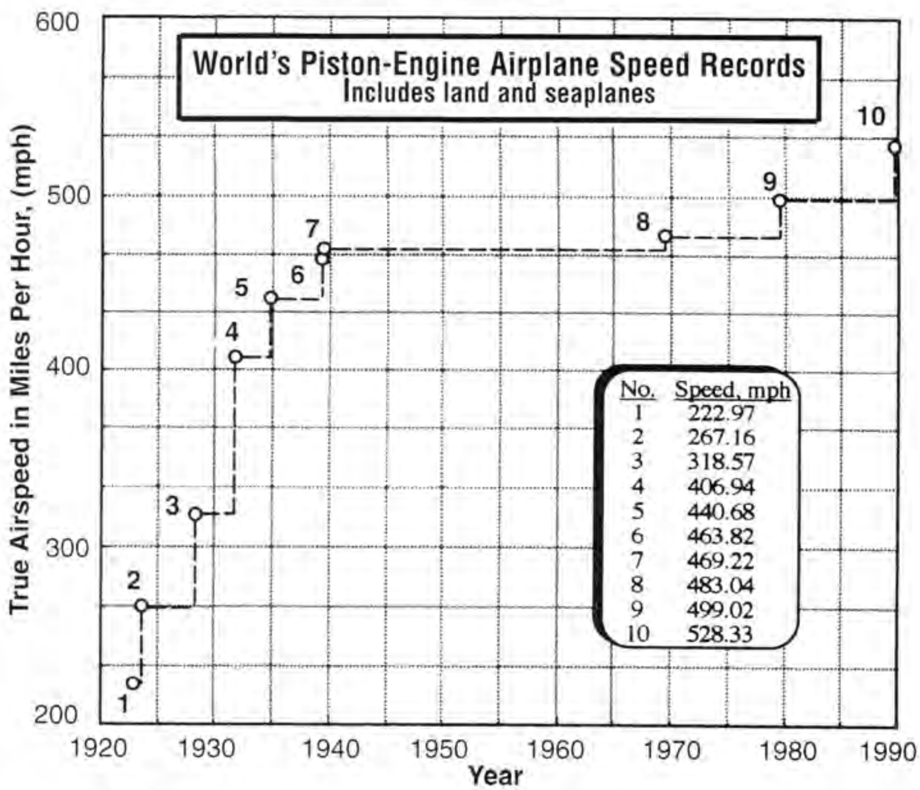
The chart (at the right) depicts ten of the official piston-engine propeller-driven airplane World's speed records. The chart shows the record speed measured in a three kilometer course and the year it was established. This chart covers a 70-year interval from 1920 to 1990. The World recognized Fédération Aéronautique Internationale (FAI)[1] was the flight observer and grantor of all speed records. Each record holder is chronologically numbered and identified in the table at the end of this section.

The trend shows significant increases with time until speed exceeds 400 miles per hour (mph) (644 kilometers per hour (kph)). The speed increases then begin a noticeable flattening until there was very little increase with time. The 500-mph mark was an elusive barrier and thought to be unbreakable. The record in 1939 was 469.22 mph (755.14 kph) and was broken 30 years later with a speed of 483.04 mph (777.38 kph). It took 20 more years to set the current World's record of 528.33 mph (850.26 kph) that was officially established on August 21, 1989, by the highly modified F8F-2 *Rare Bear®* airplane.

Absolute Maximum Speed was the Goal

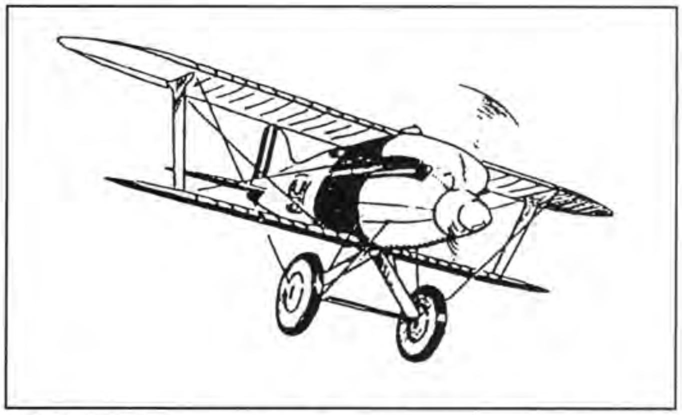
As might be imagined, the early 1920s airplanes, designed for speed, were externally braced biplanes with fixed landing gear – very high drag configurations. These were replaced, in the late '20s and early 1930s, by externally braced monoplanes with fixed pontoons (seaplanes). Gone was the upper wing, but added were the high drag pontoons. Primary structural material of these airplanes was wood and wire. To overcome the high drag, engine horsepower had to be significantly increased if there was to be any hope of a speed record.

Propellers were fixed-pitch and made of wood until about 1923 when aluminum alloy propellers began to appear on the Curtiss machines, unannounced and somewhat secretly.



Absolute World Record speed over a straight course for piston-engine airplanes as recognized by the FAI from 1922 through 1989, excluding the war years of 1940 to 1945, (by the author, R.W. Kempel)

In some situations, just getting off the water proved impossible. With full loads of fuel and pontoons low in the water some propellers were unable to produce sufficient low speed thrust to become airborne. The water drag was just too high to get 'on-the-step' so they could accelerate to takeoff speed. The high fixed-pitch propellers were designed to provide high



The Curtiss R2C-1, that broke the speed record in 1923 at 267.16 mph (429.95 kph). (No. 2 on the chart.) This airplane is similar in appearance to the 1922 R-6 record holder. (Douglas Rolfe, Airplanes of the World - From Pusher to Jet, 1490 to 1954*)*

thrust at high speed not at low speed. The high pitch angles of the fixed-pitch propellers can be seen in photographs of some of these airplanes.[2] In some instances the high torque generated by these propellers also caused low speed piloting problems.

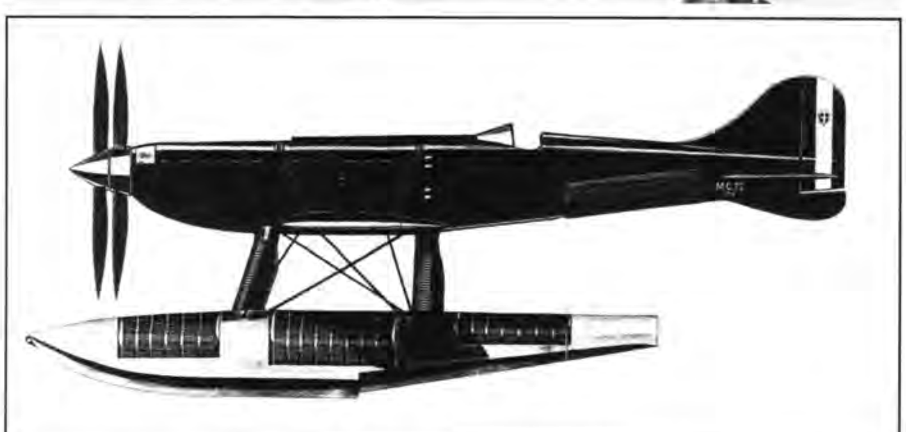
Supermarine—R. J. Mitchell (designer of the *Spitfire*) appreciated the drag reducing benefits cantilevered surfaces would provide, but the primary airframe building material was wood and when speed was increased, with engine power increases, these airplanes were susceptible to disastrous wing or tail flutter. High speed flutter was a new phenomenon and was little understood in the early 1920s. Wood lacked the stuffiness that was required to resist flutter at the ever increasing speeds. A good example of the disastrous consequences of wooden wing flutter was the loss of the beautiful Supermarine S.4 in late October 1925, during a test flight due to this phenomenon. This airplane had fully cantilevered wooden wings and tail-surfaces, but this was pushing wood design too far in a 239 mph airframe. When the SA encountered flutter the wing didn't break, but it was so violent that control was lost and the airplane broke at impact with the water. The injured pilot was rescued and survived. The 1927 Supermarine S.5 reverted to an externally braced wooden wing with cantilevered tail surfaces and with limited aluminum sheet-metal on the fuselage.

The S.6B (S 1595) seaplane broke the World's speed record *(number 4 on the chart)* on September 29, 1931, at 406.94 mph (654.91 kph). This airplane's primary structure was wood, but it incorporated a metal externally braced wing. The engine was a Rolls-Royce Type R, predecessor to the *Merlin*, rated at 2,300 hp at 3,200 rpm. Note the large propeller pitch angle, for speed, in the photo below.

Progress was certainly being made in aerodynamics, structures, and engine power. For a few more years the brute force of engine power would have to win the speed records as structural materials and science would evolve more slowly.

Macchi-Castoldi—On October 23, 1934, the Macchi-Castoldi MC-72 seaplane *(number 5 on the chart)* broke the record with a speed of 440.68- mph (709.20 kph). This was accomplished in an externally braced monoplane airframe with two tandem back-to-back Fiat AS-5 engines, the AS-6, and with fixed pontoons. The engines each turned a two-bladed coaxial fixed-pitch propeller rotating in opposite directions and developed a total of 3,100 hp at 3,200 rpm. Technically speaking, this airplane was not a contra-rotating machine although it had the appearance of one. A contra-rotating configuration is usually associated with a single engine turning two opposite rotating propellers through a gearbox. Counter rotating propellers canceled the large torque that caused some piloting problems in these airplanes. This airplane still retains the World's Speed Record in its class.

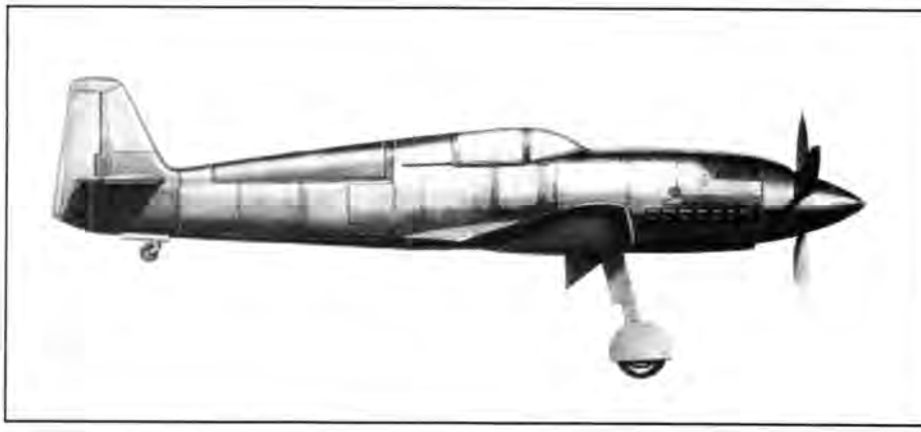
The next step. This was the last of the record setting externally braced pontoon airframes as progress was being made in all-metal airplane structures as well as more powerful engines.

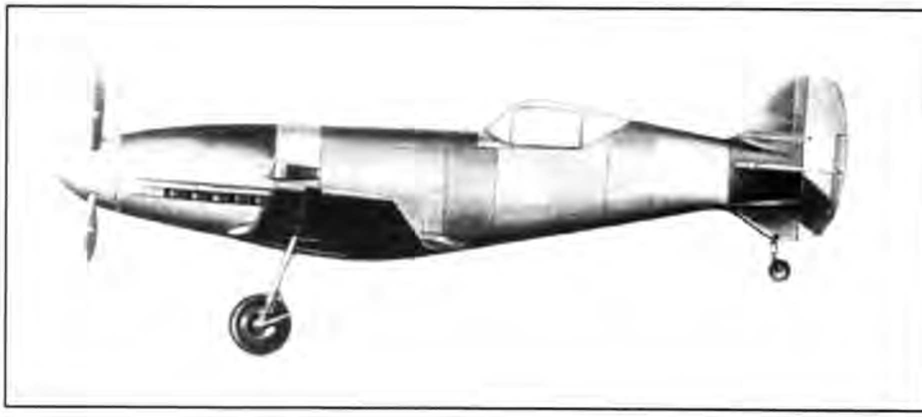


Top: *The Supermarine S.6B (S1596) record breaking seaplane. It was S1595 that flew at a record speed of 406.94 mph (654.91 kph) in 1931. (No. 4 on the chart.) (C. R. Roseberry,* The Challenging Skies*)* ***Above:*** *The 1934 record-breaking Macchi-Castoldi MC.72 at a speed of 440.68 mph (709.20 kph). This airplane had two separate engines, in tandem, turning two coaxial fixed-pitch propellers in opposite directions. This airplane has retained the Absolute World Record in its class for over 66 years. (Carlo Demand,* Conquers of the Air*)*

In addition, propeller technology progressed to metal and variable pitch mechanisms. Variable pitch propellers began to appear sometime between 1933 and 1935. Retractable landing gear, enclosed cockpits, and wing flaps became almost standard equipment on airplanes designed for speed.

Heinkel—The He 100V-8 airplane achieved a record speed of 463.82 mph (746.44 kph) on March 30, 1939. *(number 6 on the chart).* In 1937 Ernst Heinkel launched the design and then produced the He 100, a very sleek monoplane, that was meant to exceed 700 kph (435 mph) and to be a mass produced military fighter. This airplane was all-metal, had fully cantilevered surfaces, retractable landing gear including tail wheel and, very importantly, a variable pitch propeller. A variation of the Heinkel pre-production, He 100V-8, the production airplane, He 100V-8, was designated 463.82 mph record breaking airplane, to attack the World's speed record in 1939. To achieve this objective, the wing span was reduced by 1.8 m (5.9 feet) and a special Diamler-Benz DB 601R inverted-vee engine capable of producing over 1,800 hp was installed. This engine had an estimated life expectancy of about one hour due to the stress of running at maximum rpm. This record was, however, short lived.





Top: *The clipped-wing Heinkel pre-production, He 100V-8 that achieved a record speed of 463.82 mph (746.44 kph) in early 1939. (No. 6 on the chart.) (Carlo Demand,* Conquers of the Air) ***Above:*** *The record-breaking one-of-a-kind record Me. 209V-1 (AKA Bf 109R) that achieved a speed of 469.22 mph (755.14 kph) one month after the previous record was set in 1939. (No. 7 on the chart.) (Carlo Demand, Conquers of the Air)*

Messerschmitt—On April 26, 1939, a one-of-a-kind Messerschmitt, Me 209V-1 *(number 7 on the chart),* broke the World's speed record at 469.22 mph (755.14 kph). This record does, however, carry somewhat of a blemish in that the airplane was registered, for the record, as a Bf 109R that gave the erroneous impression that it was a production version of Messerschmitt's interceptor airplane. As can be seen in the side-view of the Me 209 (right) this airplane bares no resemblance to the famous Bf 109. This record was established less than two months following the previous one and stood for 30 years until the middle of 1969.

Future Speed Records and the Laws of Physics

From 1939 on, all propeller-driven World speed record holding airplanes would be single-engine monoplane configurations, all-metal semi-monocoque construction, internally braced, cantilever (drag reducing) wings and tail surfaces, and with retractable landing gear. Gone was any sign of external bracing. Smooth skin, close fitting engine cowling, and retractable landing gear was the order of the day for speed.

Included in these important advancements was perhaps one of the most important and frequently ignored, the all-metal variable pitch propeller. Without an efficient propeller, operating at the correct rpm and pitch angle, to produce maximum thrust the more powerful engines would have been much less effective and record speeds would not have been achieved.

As the chart and table *(next page)* implies, with the increases in speed, from the early 1920s to the middle '30s, advances in aerodynamic streamlining, monoplane configuration, more powerful engines, improved structures, etc., would seem to indicate a future with unabated increases in record speeds. As these advances were made, the conventional laws of physics would seem to indicate that if an ever larger mass of air was accelerated through a propeller the speed should increase as it had in the past. This was, however, not to be. The chart clearly indicates that by the late 1930s the curve was beginning to bend in the direction of diminishing increase in speed for ever increasing horsepower. In 1939 this trend was not foreseen or immediately apparent to engine or airframe manufacturers or to governments who spent the money and enjoyed the propaganda and prestige of being a World's record speed holder.

In the 50-year interval between 1939 and 1989 the difference between record holding speed is only 59.11 mph (95.13 kph). To achieve this modest increase in speed, engine horsepower increased by 122 percent.

Nineteen thirty-nine was a time when conflict between nations was looming. The aeronautical technology developed in achieving speed would be directly applied to warplanes. The stimulus and unlimited funding in the continuation of the Great War, WW II, would demonstrate to airplane and engine manufacturers that there was an upper limit to the speed that could be attained with propeller-driven airplanes. The laws of physics still worked, but in a way none or most of them had foreseen.

We will now take a hiatus from speed records and turn to

Propeller Airplane Speed Record Holders

For the three Kilometer (3km) straight course (two passes)

Chart No.	Airplane	Record Speed, Mach No. and Date	Configuration	Engine, hp and Comments
1	Curtiss R-6	222.97 mph, (M = 0.29) 358.84 kph, 10-18-1922	Biplane, externally braced fixed landing gear, Class C-1	Water cooled Curtiss D-12, 460 hp V-12
2	Curtiss R2C-1	267.16 mph, (M = 0.35) 429.95 kph, 11-4-1923	Biplane, externally braced fixed landing gear, Class C-1	Water cooled Curtiss D-12A, 488 hp
3	Macchi M.52*bis*	318.57 mph, (M = 0.42) 512.69 kph, 3-30-1928	Monoplane pontoon seaplane externally braced, Class C-2	Water cooled Fiat AS-3 V-12 970 - 1,030 hp, Alumin. prop
4	Supermarine S.6B (S1595)	406.94 mph, (M = 0.54) 654.91 kph, 9-29-1931	Monoplane pontoon seaplane externally braced, Class C-2	Water cooled R-R R-29 V-12 2,300 hp @ 3,200 rpm
5	Macchi-Castoldi MC-72* Class C-2	440.68 mph, (M = 0.58) 709.20 kph, 10-23-1934	Monoplane seaplane, externally braced, 2 engines & 2 props	Water cooled Fiat AS-6 (2AS-5) 3,100 hp @ 3,200 rpm
6	Heinkel He 100V-8	463.82 mph, (M = 0.61) 746.44 kph, 3-30-1939	Monoplane retractable gear cantilever surfaces, Class C-1	Water cooled DB 601R inv. V-12, 1,800 hp @ 3,000 rpm
7	Messerschmitt Me 209V-1	469.22 mph, (M = 0.62) 755.14 kph, 4-26-1939	Monoplane retractable gear cantilever surfaces, Class C-1	Water cooled DB 601 ARJ, 2,300 hp @ 3,500 rpm
8	Grumman F8F-2 Conquest I	483.04 mph, (M = (0.64) 777.38 kph, 8-16-1969	Monoplane retractable gear cantilever surfaces (fighter) (modified for speed record)	Air cooled radial R-2800-34W, 2,100 hp (?) Class C-1
9	North American P-51D *Red Baron*	499.02 mph, (M = 0.66) 803.09 kph, 8-14-1979	Modified WWII fighter contra-rotating 3-blade props., Class C-1	Liquid cooled Rolls-Royce Griffon 87 over 2,145 hp
10	Grumman F8F-2 *Rare Bear®*	528.33 mph, (M = 0.71) 850.26 kph, 8-21-1989	Modified fighter, Class C-1 Mod. Ham.-std. 3-blade prop.	Air cooled radial R-3350 turbo-compound, 4,000 + hp

The FAI categorizes airplanes as follows: Group 1 Piston Engine
Class C-1 Landplanes Current record holder is Rare Bear®, 1989
Class C-2 Seaplanes * Current record holder is Machi-Castoldi MC-72, 1934

airplanes designed to go faster and higher. The next section will review the developments of aircraft technology as the quest for record speed is interrupted by the quest for survival during the war years of 1939 through 1945. The postwar speed records, from 1969 to 1989, will be discussed later.

It has always been apparent that the designers of fighter aircraft, quite naturally, believed that the next generation of fighter should fly higher and faster than the preceding designs. The "next" being the one immediately following whatever it was they were working on at the time. This was the given assumption and approach taken by engine and airplane designers before the outbreak of WW II. The thinking was, I suspect, that higher kinetic energy (speed) and higher potential energy (altitude) would give their fighter or interceptor design an advantage over their potential opponent. This is also the kind of airplane fighter pilots wanted. Fighter pilots wanted to initiate any competition from an advantageous position that was higher and faster than their adversary. They wanted an airplane with superior speed and maneuverability, to see their adversary first, and have the sun at their backs. This was the formula for success and it had worked since the Great War.

Fighter Aircraft – 1939 to 1945

The advances made in achieving speed records was not wasted by the designers of military aircraft. Indeed many of the designers and manufacturers of war planes were the same as the ones participating in the racing arenas of the world. The goals were, however, now survival in a combat arena and superiority.

Mach Number – The Sonic Barrier

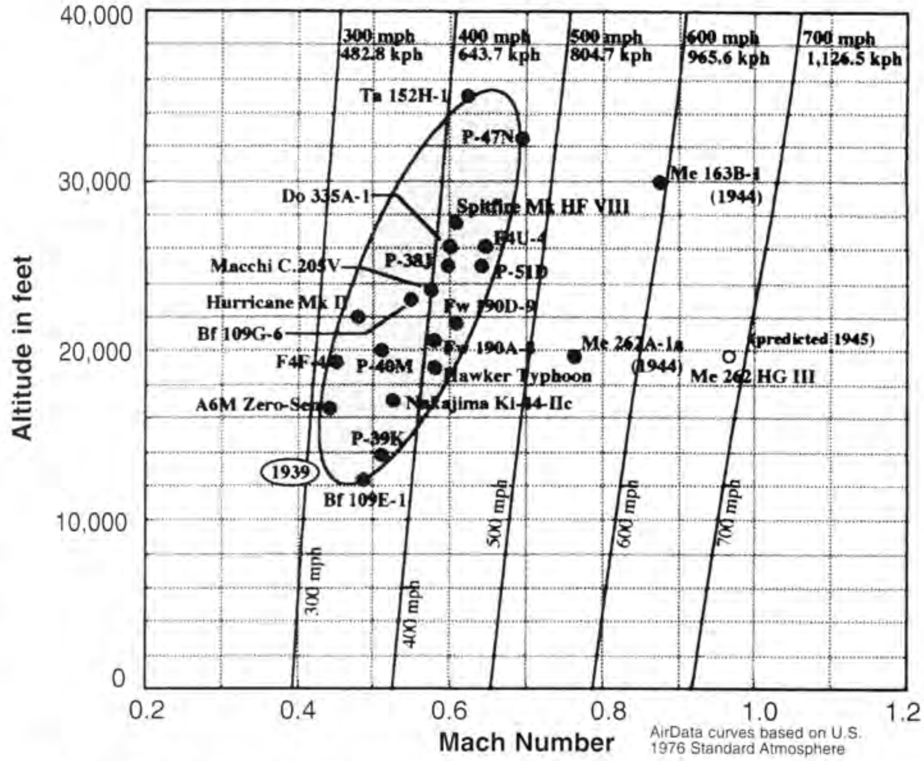
An unforeseen problem, however, was lurking in the wings. The problem came about due to the combination of the increasing power of piston engines turning big propellers, sleek airframes, high speed, and the nature of the air in which they were immersed. This unforeseen problem, which was also invisible, was just becoming painfully apparent to the operators of high performance airplanes as their airspeed and altitude capabilities increased. The problem was Mach number, the ratio of airplane speed to the speed of sound. The so-called "Sound Barrier." This problem was about to rear its head with a vengeance.

The diagram[3] shows where the most advanced operational fighter aircraft of World War II were with respect to maximum level flight performance capabilities[4] from 1939 through 1944 as a function of altitude and Mach number. Lines of constant true airspeed in miles per hour (mph) and kilometers per hour (kph) are used as relative indicators. Airplane speed in miles per hour is used throughout this article as this was typical practice during this era in England and the United States while Europeans used kilometers per hour.

All the airplanes within, or on, the shaded ellipse were the World's best propeller driven WWII fighters. To the right of the ellipse are the Me. 262 turbojet, Me. 163 rocket (dark symbols) and proposed Me. 262 HG III (open symbol). The data indicate that as WWII progressed, with time, operational altitude gains were significant, for the propeller driven airplanes, while increases in speed (Mach number) were not. For example, engine horsepower increased as much as 75% (from 1,000 to 1,750 hp) in the same airframe while the increase in level flight speed was only 17 mph. Obviously a limit of diminishing returns had been reached. The problem was the propeller. The propeller, at high rpm, was the first transonic aerodynamic problem to occur (the wing was next) due to the formation of shock or compression waves at the tips with their resulting steep drag rise. The engine's increased power was taken in overcoming this increased drag. Designers were forced to the conclusion that propeller-driven fighters had reached an upper limit and if an increase in performance was to be obtained alternate means of propulsion would be required. *The propeller had to go!* In 1944 Dr. Willy Messerschmitt indicated that, . . . *he would be involved in no more fighter projects powered by the piston engine.* As one German engineer stated, . . . *the era of the high performance piston-engine fighter was finally drawing to a close.*

All the airplanes, on this diagram, had the capability of achieving higher Mach numbers while in a powered dive. Some pilots, during WWII, reported that they reached airspeeds approaching *Mach one* in their propeller-driven airplanes, the so-called sonic or "Sound Barrier," but this is doubtful because cockpit airspeed indicators of this era were not capable of accurate readings, due to the compressibility of air, at high speeds. The airplanes did, however, suffer the adverse effects of transonic aerodynamics with airframes designed to operate at subsonic speeds. Some of these airplanes suffered catastrophic structural and/or control failure when the critical Mach number[5] was exceeded usually between a true Mach Number of 0.67 to 0.8. The Lockheed P-38 was one of the airplanes that suffered this fate on many occasions until it was fitted with a dive brake. Before dive brakes were retrofitted to operational P-38s some were lost and others suffered serious damage following high-speed dives. This problem caused some pilots to be wary and the P-38's reputation suffered until the means of recovery was demonstrated. The pilot's manual restricted the P-38 to 460-mph (740 kph), indicated air speed, from 30,000 feet with the dive brake extended. At this indicated speed Mach would be less than 0.85. The Messerschmitt Me. 262 suffered this problem too, usually with catastrophic results because there was no way to recover.

Individual Airplane Level Flight Performance



Mach number was the critical limiting factor in just how fast WWII propeller-driven fighter airplanes could go in level flight. By Mach 0.7, no matter what was done to increase engine horsepower, neither friend nor foe could go significantly faster. (by the author, R.W. Kempel)

The famous Lockheed P-38 ran into transonic problems around 1940, which was early in its operational career. (National Air and Space Museum Archives)

The Me. 262A-1a[6] was the world's first operational (1944) turbojet fighter that, incidentally, also included a wing with an 18.5 degree sweep. This airplane's operational Mach number was 0.763 (540 mph or 869 kph) at 6,000 m (19,685 feet). Another innovative feature of this airplane, besides the turbojet engines, was a pilot controlled electrically adjustable all-movable horizontal stabilizer. The designers of the Me. 262 knew that significant airframe transonic aerodynamic variations would also require significant pitch trim adjustments at operational speeds. The cockpit tailplane adjustment control lever was located on the pilot's left console. Pilots made extensive use this feature. The biggest operational problem with this airplane was that it had no speed-brake.

The proposed Me. 262 HG III was in the wind-tunnel stages of development when the war ended in May 1945. This airplane had a wing and horizontal stabilizer sweep angle of 45 degrees and was predicted to be capable of achieving a speed of 684 mph (1,100 kph) or Mach number of 0.97 at 6,000 meters (19,685 feet) in level flight.

The Me. 163B-1 interceptor was a rocket-powered flying wing with a 27 degree leading edge sweep and was somewhat of a novelty on the WWII scene. This airplane's operational

The revolutionary Messerschmitt Me. 262A-1a twin turbojet fighter with an operational airspeed of 540 mph (869 kph). Pictured here is "White 10" of III./EJG2 that was operational in early 1945.(Steve Ferguson, Messerschmitt Me. 262*)*

Mach number was 0.879 (959 kph or 596 mph) at 9,144m (30,000 feet). Due to the toxicity and explosive nature of the propellants used, this airplane was more hazardous to pilots and ground crew than its intended victims.

Germany's Dr. Adolf Busemann had suggested the use of wing sweep as a means of increasing critical Mach number as early as 1935. Germany was the only country to have had swept-wing fighters in operation, in the prototype, and proposal stages during WWII. This chart indicates where advancements in propulsion and aerodynamics pushed fighter aircraft development under the stimulus and desperation of war. Following WWII the victorious powers made extensive use of advanced German aeronautical hardware, engineering technology, and, in some cases, scientists and engineers.

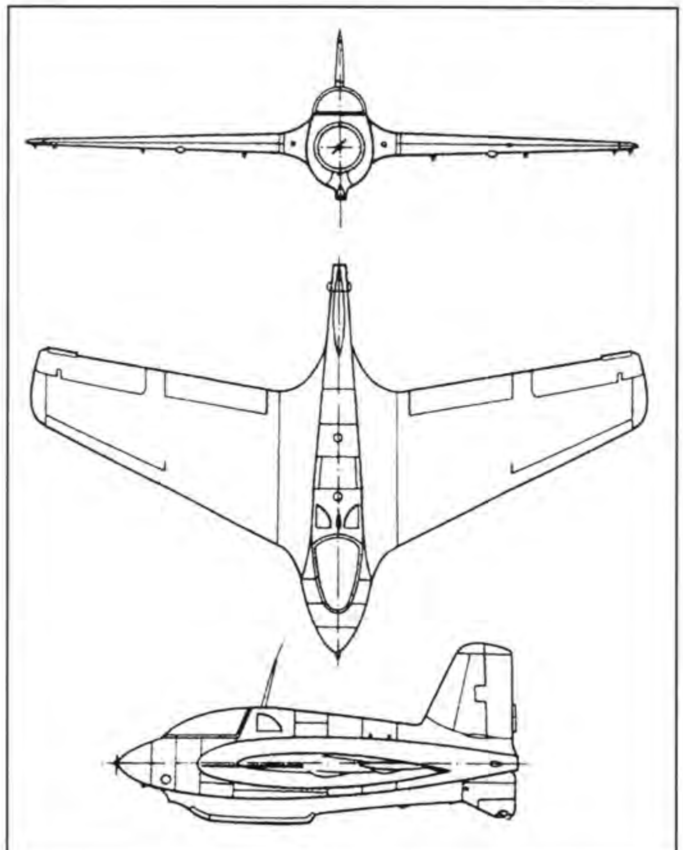
The Propeller and Transonic Speed, A Closer Look

Airplane piston-engines of 1939 ranged from about 1,100 to 1,500 hp and toward the end of WWII some were rated at over 2,200 hp. Engine manufacturers went to extraordinary efforts to achieve this result. To boost engine power multi-stage superchargers were added, compression ratios were increased, fuel octane was boosted to 100 and above, water/methanol injection was added, etc. This tremendous effort to increase engine power, however, did not bring the intended increase in speed. The question is why not? The answer to this question is because of the propeller and the speed at which it moves and rotates in air.

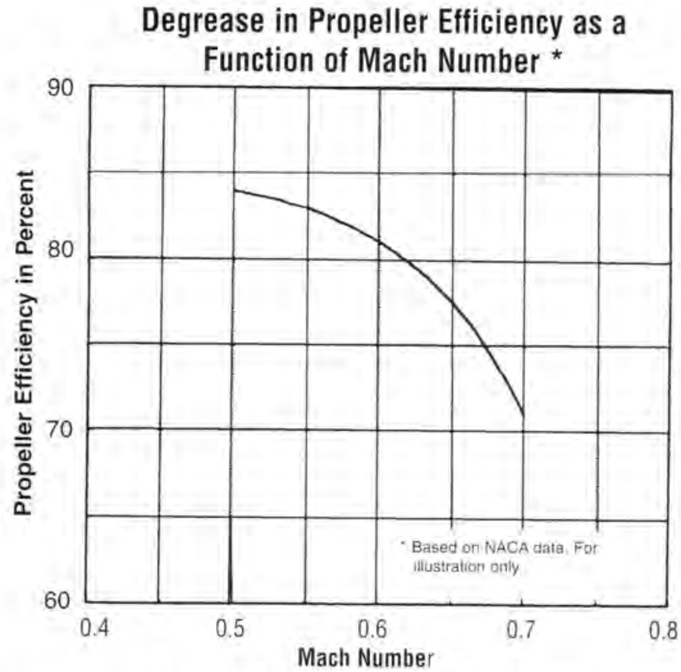
The propeller at relatively low speed can be a very efficient means of propulsion, however, at high speeds the situation changes drastically. Like a wing, the propeller is an airfoil and the speed of air flowing over it is a combination of the airplane speed and its rotational speed. Propeller shapes of this era were designed for efficient operation at subsonic speed and not transonic speed. The trouble began at the tips of large diameter propellers at high rpm and speed.

As an airplane or propeller approaches the speed of sound, sonic speed, an interesting phenomenon takes place. The pressure disturbance of the air immediately in front of the moving airplane or propeller undergoes a drastic change. This change is characterized by an almost instantaneous increase in temperature, pressure, and density. A shock or compression wave is formed (this is what we hear today as a sonic boom or an explosion). As the airflow is undergoing the transition between speed lower than the speed of sound (subsonic) to a speed above the speed of sound (supersonic) it is subject to irregular and erratic flow instabilities. This is what is called transonic flow. As a consequence of this condition an additional force resisting the movement of the airplane or propeller also becomes apparent. This force is what is called wave drag. Wave drag does not occur at subsonic speed and this force is the source of what has been called the "Sound Barrier." Wave drag causes a significant airplane drag-rise that was once thought to be an impenetrable barrier. The propeller reaches a sonic speed condition long before the wing so this is where transonic problems were (will be) encountered first. When this situation was (is) encountered the propeller also experienced a significant drag-rise accompanied by a large drop in efficiency as illustrated in the chart.

Conventional WWII propeller efficiencies approaching 90



The impressive, but dangerous, rocket-powered Me. 163B-I designed by Dr. Alexander Lippisch and capable of a speed of 596 mph (959 kph) in level flight. (John W.R. Taylor, G.P. Combat Aircraft of the World*)*



At a free-stream Mach number of 0.7 a typical WWII fighter propeller had lost significant effectiveness as a propulsive device. (by the author, R.W. Kempel)

percent were not uncommon. However, as the Mach number approached 0.6, efficiency is seen to drop dramatically, as shown in the data curve at the left. At Mach 0.7 the efficiency of the WWII era propeller was seriously degraded. This result is clearly seen in the performance of propeller driven WWII airplanes in the previous chart. The propeller efficiency chart clearly illustrates the problem and corroborates the level flight performance data. To have the capability to achieve a level flight Mach number of 0.7 in a WWII fighter was the exception and barely possible.

At a Mach of 0.7, for example, the engine torque was required to overcome the drag due to the sonic drag-rise. Accompanying this, the air flow became irregular and erratic, the propeller could no longer provide adequate propulsive force. In essence the propeller began to stall and efficiency fell significantly. This is why fighter engine power increased so drastically, but speed didn't. The faster the fighter pilot tried to go the worse the situation became. This situation affected friend and foe alike and caused engines to blow-up and propellers to separate from the airplane.

In an attempt to overcome the loss of efficiency at high speed, propellers with large paddle-shaped blades began to appear toward the later part of WWII. This shape blade attempted to put the thrust producing portion of the propeller closer to hub to preserve efficiency. Examples of these type propellers can be seen, in photographs, on such aircraft as the Ju. 88G, Fw. 190D, and Ta. 152H.

Which WWII Propeller Fighter was the Fastest?

Perhaps the best example of the increase of propeller-driven airplane performance can be shown in the North American P-51. The P-51D had a 1,450 hp Packard-*Merlin* engine and a maximum level flight performance of 437 mph at 25,000 feet (Mach 0.640) compared to the P-51H with a water injected 2,218 hp engine and a performance of 487 mph at 25,000 feet (Mach 0.703). This is an increase in true airspeed of 50 mph, about 11 percent, and an increase in Mach number of 0.063 while the engine increase in horsepower was 53 percent.

The highest speed recorded by a piston-engine airplane was 0.91 Mach in a terminal velocity dive. Depending on altitude, the speed was 600 to 650 mph (966 to 1,046 kph). This record speed was attained by a fully instrumented *Spitfire* PR Mk XI in flight test by the Royal Aircraft Establishment (RAE), Farnborough and is, therefore very credible. This *Spitfire* was powered by a *Merlin* 63 engine rated at 1,650 hp at 3,000 rpm and driving a 4-blade Rotol propeller.

This speed was attained, in a dive, from an altitude of 40,000 feet (12,192 m). It was reported that when the Mach-meter reached 0.83 a gentle shaking started on the tail, and the machine started to nose down into a steeper dive without any pushing by the pilot. The dive angle would then steepen rapidly and the airplane started shaking badly and rolling from side to side. At Mach 0.86 the pilot had to pull the equivalent of 60 pounds stick force to stop the dive from steepening any further. When Mach 0.91 was reached, 80 pounds of stick force was required to recover resulting in the propeller, with parts of the engine and airplane, separating from the airframe. The *Spitfire* was, however, landed safely, minus the propeller, with the valuable camera records intact. The corrected and verified speed reached in this dive remains the highest Mach number ever registered by a piston-engine aircraft.

It was reported that Republic Aviation's experimental lightweight XP-47J, with a 2,800 hp R-2800-57 engine, achieved a speed of 504 mph (811 kph) in level flight. Altitude at which this speed was attained is unknown. The Mach number could have been anywhere from 0.65 to 0.75 depending on altitude. It was reported that this was the fastest propeller airplane of WWII. This was an impressive speed for a War's end experimental, non-production, propeller-driven airplane and should be noted.

The fastest piston-engine airplane, in level flight, is believed

The successor to the famous Spitfire, the Spiteful, first production model RB515, similar to the fastest WWII piston-engine fighter, RB518, at 494 mph (795 kph) in level flight. This was the last piston-engined fighter produced by Supermarine and was too late to see action in WWII. (Bruce Robertson, Spitfire — The Story of a Famous Fighter*)* to have been the last variant of the famous British *Spitfire*, the Spiteful F. 16 RB518. This airplane was equipped with a 2,375 hp *Griffon* 69 engine and a 5-blade propeller and was entering production at war's end. This airplane attained an impressive speed of 494 mph at 28,500 feet (Mach 0.724) in October 1947. Following this flight, it was said, the engine was ruined.

This is the highest speed and Mach number attained by a WWII era propeller-driven fighter airplane according to the data this author has been able to find. This speed was, of course, unofficial and some conjecture and speculation will always remain, but this is the stuff good hangar stories are made.

The absurd—In 1942, a press release stated that a P-47C achieved a diving speed of 725 mph (1,167 kph) at 26,000 feet. This would translate to a supersonic Mach number of about 1.1. For a subsonic wing with no sweep, the drag rise begins somewhere around Mach 0.70. The drag rise is, typically, gradual until Mach approaches 0.8. Between Mach 0.8 and 0.9, say between 600 and 650 mph, the drag rise (increase) is so high that this is what gave rise to the idea that this speed range or beyond was a barrier. This is a region of significant aerodynamic pressure change over any airframe and in particular a straight wing designed for subsonic speed. This pressure change will in turn adversely affect airplane trim, dynamic, and control characteristics. It is highly unlikely that a WWII propeller-driven fighter ever went supersonic despite high speed claims by hot pilots or the excitable press. After WWII, airframe designs were developed specifically to penetrate this transonic Mach range and beyond. It was then determined that this was not a barrier after all just an impediment on the way to supersonic speed.

The Red Baron in-flight showing the enlarged vertical stabilizer and modified canopy. Note: The high pitch angle of the contra-rotating propellers. (Bruce Treadway, Air Classics*)*

Absurd claims have circulated and include stories that some WWII pilots, while sitting around a hangar someplace, claimed to have reached almost 800 mph in some high performing piston engine fighter too. These stories, like wine, probably get better with age. So all this author can say is, tell us again what speed you got to in your WWII propeller-driven airplane so we can all have a good laugh.

Conclusions about WWII Propeller-Driven Fighters

On the basis of the data, propeller-driven airplanes were limited to level flight speeds under 500 mph. Mach number was the limiting factor in determining how fast a WWII propeller-driven fighter could fly. To have achieved a free-strewn Mach number of 0.7, in level flight, was exceptional. This result was independent of the tremendous horsepower increases made to piston-engines from 1939 to 1944. The limiting element was not engine power but the loss of propeller efficiency at high speed (Mach number).

From the data presented it is concluded that WWII era propeller-driven fighters were able to significantly increase operational altitudes while only modest gains in airspeed were realized. Piston-engine power was increased by 50 to 75 percent with a degree of mechanical sophistication and complexity and in some cases requiring relatively exotic fuels hitherto unknown. Even so, increases in maximum airspeeds of only 100 to 150 mph were realized in a 5-year span of intense effort. Costs to achieve all this to the combatants is unknown, but the sums must have been enormous.

In 1944 a startling new concept in airplane propulsion was introduced in the combat arena. The turbojet. Here was an engine that was significantly simpler than a piston-engine, could operate on low grade fuel, and could typically increase level flight airspeed by 100 mph in one step. This was indeed a significant breakthrough. The turbojet was, however, not without its developmental difficulties, but that is another story.

1945 was about the time when the development of piston-engined fighters was abandoned in favor of the turbojet. The next problem to face the fighter airplane designer was how to increase the performance of the turbojet engine and get a wing through the "Sound Barrier," but that's another story too. Nature had lots of time. Only man was impatient because we are always looking to the unknown.

Post WWII Years and New Speed Records

During the war years, quite naturally, competitive air racing and attempts to establish new official speed records were suspended. Following WWII, for the victors, there were an abundance of demilitarized aircraft, of all types, available for purchase by civilians. One entrepreneurial individual purchased so many surplus airplanes, at a relatively modest price too, that he had the seventh largest air force in the world. Practically speaking there was nothing this individual could possibly do with all these airplanes so he selected a dozen of the best to keep, drained the fuel from the rest, sold it for as much as the fleet had cost him and disposed of the rest. Unfortunately many were scrapped. This was the way things were in the years shortly after WWII.

Fortunately, many fast airplanes, fighters and bombers, like the P-38, P-47, P-51, de Haviland *Mosquito*, *Spitfire*, B-25, B-26, etc., were converted for private use and some for racing. There was a brief resurgence, following WWII, of the famous air races such as the Bendix and Thompson Trophy Races, but these were relatively short lived. Many of the surplus airplanes were still around, but many were destroyed in crashes, sold to foreign governments, or used in movies, and many began finding their way to museums or bone-yards.

Speed records were being broken by turbojets and there was little thought or interest in breaking the 1939 piston-engine speed record. Then in 1964 pylon racing was reestablished at Mojave, California, that was later to become the famous Reno National Air Races. This interest in fast propeller-driven airplanes seems to have given new interest in breaking the World's absolute piston-engine speed record. The question, around the hangars, was; could the illusive 500 mph record be set and if it could what then?

1969 speed record—On August 16, 1969, a highly modified F8F-2 Grumman *Bearcat* fighter attacked and broke the existing FAI World's official speed record at an amazing 483.04 mph[7] (777.38 kph), number 8 on the chart. After more than 30 years the record was finally broken. It is suspected that the operators and promoters became aware of just how costly it was, without government help, to attack the World piston engine speed record because it was 10 more years before it was done again.

Red Baron—The *Red Baron* set a World's Speed Record at 499.02 mph (803.09 kph) on August 14, 1979, *(number 9 on the chart)*. Even though this airplane was a highly modified North American P-51D, the modification and speed attempt were private ventures. This airplane was reconstructed from the cockpit forward to accommodate a Rolls-Royce *Griffon* 87[8] 12 -cylinder 60 degree 'vee' type liquid-cooled engine that turned two three-blade contra-rotating propellers. Originally this stock engine, at 36.7 liters displacement and 2,140 pounds, was rated at 2,145 hp. Other airframe modifications included clipping approximately 6 feet from the wing span and 12 inches from the horizontal stabilizer. Enlargement of the vertical stabilizer, removal of the dorsal fillet, and major canopy reshaping were also accomplished. The span of the ailerons was significantly reduced which also reduced roll control effectiveness and was, no doubt, acceptable from a piloting standpoint because fighter roll rates around pylons were not required.

About one month following the establishment of the World's Speed Record the *Red Baron* blew its engine while racing at the Reno Nationals. Pilot, Steve Hinton, was unable to effect an emergency landing and the airplane came down in open uneven, rocky, brush-filled terrain. Fortunately the crash occurred in open country away from structures and spectators as Steve steered away from these. Miraculously, Steve's injuries were relatively minor considering the violence of the crash and he made a full recovery. The *Red Baron* was, however, totally destroyed.

Rare Bear®—The current reigning World's Absolute Speed Record holder is Mr. Lyle Shelton's highly modified F8F-2[9] *Rare Bear*® at an amazing, FAI recognized, 528.33 mph (850.26 kph), *(number 10 on the chart)*. This feat was set on August 21, 1989, at Las Vegas, New Mexico. This Record beat the *Red Baron*'s by 29.31 mph (47.17 kph). Why was Las Vegas, New Mexico chosen to attempt a new World's Speed Record? Las Vegas, NM, is situated on the southeastern slope of the Rocky Mountains at an elevation of 6,436 feet above mean sea level (MSL). The *Rare Bear*® could then fly the three kilometers straight course at the rules required, not to exceed, altitude of 75m (246-feet) above ground level (AGL) and be at approximately 6,682 feet (2,037m) MSL. The air density at this altitude is approximately 20 percent less than 75m above MSL. At this altitude, and record speed, the drag producing air pressure on *Rare Bear*® was approximately 124 pounds per square-foot (5,955 Newtons per square meter) less than at MSL. Very significant for a record attempt.

The *Rare Bear*® airframe has an interesting history. Mr. Lyle Shelton literally rescued it, as an abandoned wrecked skeleton, from the trash-heap in 1969. The hulk was trucked to California where it was refurbished back to flyable condition by Mr. Shelton's crew of dedicated volunteers. *Rare Bear*®, then known as *Able Cat*, took flight again on September 13, 1969. *Able Cat* appeared at the Reno National Air Races in 1971, and the same year was renamed *Phoenix I*. The name *Rare Bear*® was chosen in 1980 and has been prominately seen with this moniker ever since.

Modifications to the *Rare Bear*® include clipping 5.5 feet (1.7 in) from the wing span, a streamlined canopy, installation of a Wright R-3350 turbo-compound engine, and a three-blade (reduced from four-blade) Hamilton-Standard propeller from a Lockheed P3 *Orion* patrol airplane.

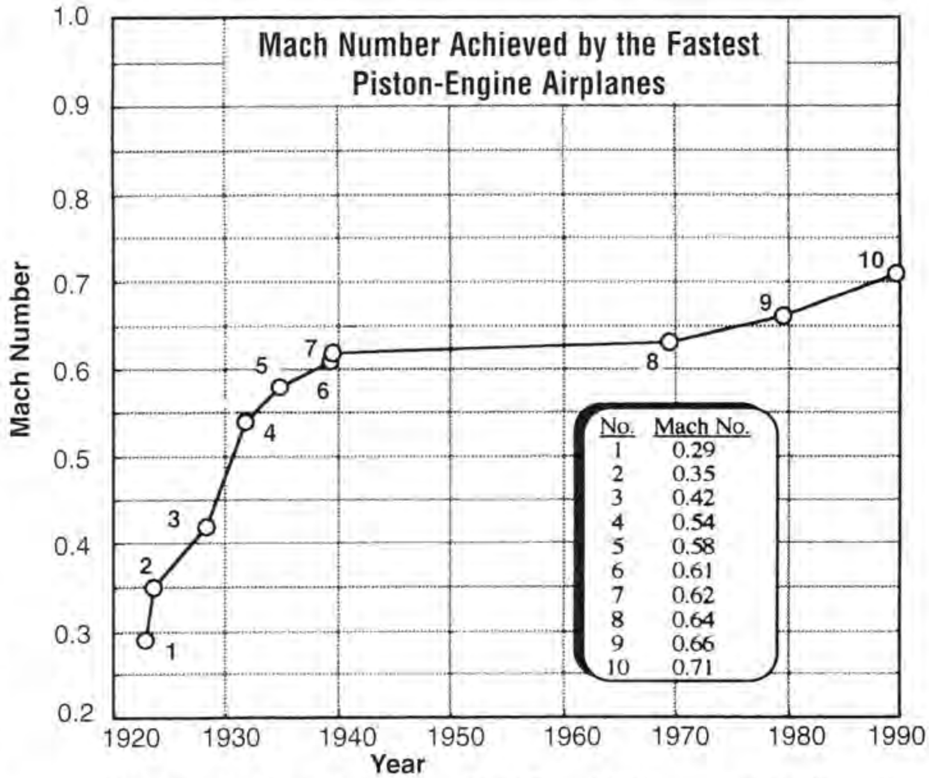
At the record true airspeed of 528.33 mph it took *Rare Bear*® only 12.7 seconds to cover the three kilometer course at a Mach number of 0.71. This Mach number certainly puts *Rare Bear*® in a class by itself. From all the foregoing we have seen that to have achieved Mach 0.7 in level flight by a piston-engine propeller-driven airplane is truly exceptional.

And so this record stands today as a tribute to Mr. Lyle Shelton's tenacity and leadership, the hard-working team, and dedicated sponsors that have made it all possible. It used to be that governments supported tremendous efforts such as this, but no more. Obviously there's a lot more than great deals of money to this story. It's really a story about people. The secrets of exactly how *Rare Bear*® achieved this goal will probably never be known by those of us outside the team, but one thing is for sure it involved a great deal of hard work.

Rare Bear® stands alone as the holder of the World's Absolute Speed Record for piston-engine airplanes recognized by the Fédération Aéronautique Internationale. The chart at the right summarizes the trend of Mach number of these record

Lyle Shelton's Rare Bear® as it appeared at the 1983 Reno National Air Race. Rare Bear® won the National Championship at Reno in 1988. (Michael OLeary, Air Classics) holders over the 70-year interval from 1920 to 1990. Increases that were established in the first twenty years have not and, no doubt, will not be seen again.

Will anyone rise to challenge *Rare Bear*'s record or can it be beaten? There has been hangar talk of 600 mph (966 kph). How about Mach 0.8? Could it happen? There are some new developments taking place in the world of propeller design in the form of prop-fans. These propellers, designed for turboprops, are made of advanced materials with swept tips, with smaller diameters, and six to ten blades. Could they work on a piston engine? Even if an advanced propeller would work, how about the Mach effects on an unswept wing? Only time will tell. ❑



Mach number achieved by Absolute World Record Holders over a straight course from 1922 to 1989. Mach numbers were determined using the U.S. 1976 Standard Atmosphere. (by the author, R. W. Kempel)

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NOTES:

1. The FAI is the official rule and sanctioning agency for the world's airplane speed records. The existing record was broken when 1) the new speed was at least 5 mph (8 kph) faster, and 2) when the airplane landed smoothly and undamaged after its flight. Records are average speed over 3 km, flown twice (once in each direction), not higher than 75 meters above ground level.

2. Propeller pitch is measured from the plane of rotation. Maximum propeller pitch would be in the feathered position as close as possible in the direction of air flow. Low (fine) pitch is for low speed, such as takeoff, and high (coarse) pitch is for high speed.

3. All data points and curves presented on this diagram were computed based on the 1976 U. S. Standard Atmosphere.

4. The capabilities of the various airplanes were not given in terms of Mach number. Speeds were given in mph or kph and altitudes were either feet or meters. Appropriate conversion factors were used where necessary before computations were made.

5. Critical Mach number is the free-stream Mach number at which a local Mach of one (M = 1) is attained anywhere over the surface of an airplane (usually the wing). A critical Mach number can occur at a speed significantly below a free-stream of one.

6. The Me 262 had a thin wing (less than 12% at the root) which was a NACA symmetric airfoil section. NACA being the National Advisory Committee for Aeronautics, the predecessor of NASA.

7. There is some confusion concerning this record as there are two listings for the speed. The first is for a speed of 483.041 mph and the second is for 769.23 kph (477.98 mph). It is unknown which number is the correct one. Whichever one it is, it is recognized by the FAI.

8. It is speculated that the engine was a *Griffon* 87 as only those numbered above 80 were designed as contra-rotating propeller configurations. The *Red Baron* has been listed as having a "*Griffon* 57" engine, but there was no *Griffon* engine with this designation.

9. The F8F-2 was designed by Grumman Aircraft Company for the U. S. Navy and was inspired by the famous Focke-Wulf Fw. 190. The F8F-2 was originally powered by a Pratt & Whitney R-2800-34W engine of 2,100-hp. Maximum speed was 447 mph (719 kph) at 16,000 feet. It entered service too late to see combat during WWII.