A Speed Greater Than That of Sound

by Robert W. Kempel

Test Pilots Pierce Dread Barrier—The world's first officially recorded and documented supersonic flight, October 14, 1947, by the XS-1 (later as the X-1) was a poorly kept secret on and around Muroc Air Force Base (AFB). The XS-1 had achieved a Mach number of 1.06 (700 miles per hour (mph) or 1,126.5 kilometers per hour (kph)) at 43,000 feet (13,106 meters (m)) altitude on this date. Less than three months later the secret flight was unofficially made public by the press. On December 22, 1947, the prominent trade magazine *Aviation Week* broke the story of the world's first officially recorded supersonic flight. Concurrent with this story, the morning edition of the *Los Angeles Times* of December 22, 1947, published an "extra" edition with a large bold headline, with photographs (below), announcing the event.

The caption, by noted aviation editor Marvin Miles, in the upper right-hand corner read: **Test Pilots Pierce Dread Barrier at 70,000 Feet Altitude Above Desert**

Three Americans have pierced the wall of sound!

The dread barrier to supersonic flight was first conquered at Muroc Air Base early last month when Capt. Charles Yeager, Air Force pilot, hurtled the XS-1 rocket plane through the wall at approximately 70,000 feet. The Times *learned from reliable sources.*

EXTRA

Los Angeles Times

U.S. MYSTERY PLANE TOPS SPEED OF SOUND

Test Pilots Pierce Dread Barrier at 70,000 Feet Altitude Above Desert

The "reliable sources" are assumed to have been the *Aviation Week* article. Bob Holtz, the editor of *Aviation Week* was threatened with prosecution for the publication of official United States Air Force (USAF) Secrets. This threat, however, was never carried out.

The caption was in the plural mentioning 'pilots' which presents somewhat of a mystery. The three Americans the *Times* referred to were Capt. Chuck Yeager and the National Advisory Committee for Aeronautics (NACA) civilian test pilots Howard Lilly and Herbert *(Bob?)* Hoover.[1] The NACA was flight testing the XS-1 number 2 airplane and flew four subsonic flights in 1947, but it would be early 1948 before they would go supersonic. A review of all USAF XS-1 number 1 airplane flights between October 14 and December 22 do not include any other pilots. Between these dates there was a total of eight powered XS-1 flights, number 9 through 16, flown by the USAF and these were all piloted by Capt. Yeager. Capt. Yeager made three glide flights before the powered flights bringing his year's total to 19. On November 6, the last flight of 1947, the XS-1 reached Mach 1.35 at 48,600 feet (14,813m) altitude. Newspapers have, at times, been known to make good stories even better by exaggeration or possibly their source was incorrect when they referred to three Americans and '70,000 feet altitude' in the *Times* article. If there was more than one pilot that achieved supersonic flight between October and December 1947; who was it?

The first supersonic flight remembered at the NACA High Speed Flight Station—At NACA's High Speed Flight Station (HSFS), the world's first supersonic flight was remembered 10 years later by program participants. Their recollections were printed in the HSFS *X-Press* employee newspaper, October 14, 1957, on the 10th anniversary of the first recorded supersonic flight. This story was written by XS-1 program participants and is, therefore, considered of historical significance. The following appeared in the *XPress* by an unknown anonymous writer:

"In 1944 contracts were let for construction of the first two research airplanes. Bell Aircraft Corp. began design of the X-1 (originally known as Project MX653 and later as XS-1) under Air Force sponsorship, and the Douglas Aircraft Co. about the same time undertook construction of the D-558, sponsored by the Navy. The first of these was to be powered by a rocket motor; the second, by a turbojet engine.

First to reach the flight-test stage was the X-1 of which two originally were constructed. The fuselage lines were adapted from the basic shape of a .50-calibre bullet. Straight wings, with thick, tapered aluminum skin, were provided to insure enough structural

strength to withstand the loads expected at the altitudes and speeds programmed. The strength factor was specified at 18g, instead of 12g, then required for fighters. One set of wings (on airplane 2, tail number 6063), had a thickness of 10 percent, much less than anything then flying; the second set (on airplane 1, tail number 6062), was only 8 percent thick.

The power plant of the X-1 was a four-barrel rocket engine developed by Reaction Motors, Inc., under Navy contract. Each rocket barrel produced 1,500 pounds of thrust, for a total engine thrust of 6,000 pounds.

In the fall of 1945, before the rocket engine was ready, the airframe of the X-1 was completed. To save time, Bell engineers proposed carrying the airplane aloft in a "mother ship," then releasing it to fly without power. In this way the general airworthiness of the X-1 could be determined before the rocket motor was completed. These tests were conducted early in 1946 at Pinecastle Air Force Base, Florida, and a group from the Langley Laboratory was sent to maintain and operate the 500 pounds of instrumentation carried by the X-1, and to provide technical guidance. The "mother ship" technique has been used since with others of the research-airplane series.

Following the successful glide tests, it was decided that, in the interest of maximum safety for the pilot, powered flights should be made in the vicinity of the largest available landing area. The choice was the Air Force installation on the edge of Rogers Dry Lake in the Mojave Desert of California, known then as Muroc and now as Edwards Air Force Base.

Opposite: *The front page of the December 22, 1947,* Los Angeles Times, *announcing the world's first supersonic flight in a mystery airplane. (NASA History Office)*

Above: *The XS-1 airplane in powered flight over the Mojave Desert's Muroc Air Force Base on October 14, 1947. The supersonic jet plume from the rocket engine can be seen in the diamond pattern. (Air Force Flight Test Center (AFFTC) History Office)*

After installation of the R. M. 1. (sic) engine at Bell Aircraft's Niagara Falls plant, the first of two X-1 research airplanes was taken to Edwards early in October 1946. The previous month, 13 engineers, instrument technicians, and technical observers, all from Langley, were designated the NACA Muroc Flight Test Unit. On September 30, they began work at the desert base. The first successful rocket-powered flight was made December 9 by Chalmers H. ("Slick") Goodlin, company test pilot. By June 1947 performance up to a Mach number of 0.8 was fully demonstrated by Bell Aircraft pilots in a series of 21 powered flights.

On June 30, at a meeting at Wright-Patterson Air Force Base, the Air Force and NACA agreed to divide responsibilities. Each agency was to use one of the X-1 airplanes in complementary flight programs. The Air Force objective was to exploit the airplane's maximum performance in as few flights as were reasonable, consistent with safety. The NACA program was necessarily

more extensive: to acquire the desired detailed information. The NACA group, now permanently assigned at Edwards, was to furnish engineering and instrumentation assistance to the Air Force group, while the air launching of the NACA airplane was to be handled by the Air Force.

The Air Force received its X-1 in August 1947; mechanical difficulties delayed flights of the other model by the NACA until after the first of the year. The historic first supersonic flight was made on October 14, 1947, by then Capt. Charles E. Yeager, USAF. On March 4, 1948, NACA pilot Herbert Hoover became the first civilian to fly faster than sound .”[2]

The Background by Walter C. Williams[3]—In order to describe the events leading up to the first supersonic flight in the X-1 by then Air Force Capt. Charles E. Yeager, perhaps it is most important to give the tempo, or mood, of the time.

In this day of Russian satellites, Intercontinental Ballistic Missiles, bombers and fighters that fly at Mach numbers of 2 or better, jet transports that will carry over 100 people at speeds higher than had been explored at the time of the X-1 flight, it is difficult even for those directly concerned to picture the state of the art as it was then. Up to the inception of the research airplane program, flying as far as we knew had been limited to Mach numbers of 0.8 on a reasonably consistent and safe basis, with a few excursions above 0.8 which in most cases led to serious difficulties of one sort or another- control, buffeting, even loss of the airplane. This, then, was the field we were setting out to explore.

During the acceptance tests of the X-1, the speed was limited to 0.8 Mach number, a limitation set because it was felt that no manufacturer should be forced to guarantee satisfactory characteristics in the relatively unexplored area above 0.8. During the 20 acceptance test flights, a Mach number of 0.8, or perhaps a little better, was reached. The rocket engine system was proved to be a reasonable power plant. It would be well to point out here that our NACA group, along with the Air Force Flight Test group and the manufacturer was, in many ways, a very lonely group and was alone in its belief that this project would succeed. I do not wish to imply that we did not have the proper backing. Top management of all concerned gave their wholehearted support to the program; however, at the contemporary level and intermediate supervisory level there were many dismal predictions, such as:

“The program will fold right after the first powered flight as soon as the airplane blows up.”

“The drag is too high, you can’t even get the speeds.” “From what we know, the airplane will come completely apart a little above 0.9 Mach number.”

These and other similar comments were common. But, it might be said, like the bumble bee, we went ahead. In addition to these known fears and comments, England, who had been attempting such testing, had lost the DH-108 in transonic flight, killing the pilot. This led the British to adopt a policy of model testing and possibly remote guidance for the airplanes before they would ever attempt manned supersonic flight. This, without question, set their effort back unmeasured number of years. These things were all hanging heavy over our heads.

We were enthusiastic, there is little question. The Air Force group—Yeager, Ridley—were very, very enthusiastic. We were just beginning to know each other, just beginning to work together. There had to be a balance between complete enthusiasm and the hard, cold facts. We knew and felt, that if this program should fail, the whole research airplane program would fail. And the whole aeronautical effort would be set back. So, our problem became one of maintaining the necessary balance between enthusiasm and eagerness to get the job completed with a scientific approach that would assure success of the program. This was accomplished.

To say that we went ahead completely on our own would be foolish. We had some information-acceptance tests showing that low-speed wind-tunnel tests gave an accurate prediction of the behavior characteristics of the airplane. We had some transonic tunnel data up to about 0.85 Mach number that showed things would be reasonably satisfactory. We also had data from the then newly developed wingflow method, where models were placed in the high-speed flow over a subsonic airplane’s wing. These data, however, ended at 0.93 Mach number with various pertinent quantities showing abrupt changes for limits. With this information on hand, and knowing the results of acceptance tests, the Joint Air Force-NACA program was started.

As has been pointed out, there were two airplanes involved: the Air Force airplane (tail number 6062) to exploit the speed potential of the airplane in as short a time as consistent with safety, and the NACA program (airplane, tail number 6063) to provide the detailed information. Actually, an exploratory program, as we have learned, is the first phase in testing of any airplane. The Air Force airplane was ready for flight first, and so began the systematic step-by-step approach to the problem of flying at speeds faster than anyone had flown before, or, to be “corny,” thus began the conquest of the sound barrier. Small incremental increases in Mach number were made, making pullups at the maximum Mach number to aid in predicting what the characteristics might be at somewhat higher Mach numbers in level flight. The stabilizer effectiveness was checked in flying the airplane; runs were made at several stabilizer settings; actual pullups were made using the stabilizer. In the second flight a Mach number of 0.89 was successfully reached in powered flight, after which five or six maneuvering flights were conducted around a Mach number of 0.90 to evaluate trends in elevator and stabilizer effectiveness, wing and balancing horizontal-tail loads, and buffeting. On the eighth flight, October 10, 1947, an indicated Mach number of 0.94 was reached in flight; however, after the flight indicators were corrected for the influence of the airplane’s pressure field it was

***Opposite:** The men of Mach One Team. (1st row from the left to right:) Ed Swindell (B-29 pilot); Bob Cardenas (B-29 pilot); Chuck Yeager (XS-1 test pilot); Jack Ridley (flight test engineer). 2nd row: Bob Hoover (back-up XS-1 pilot and chase pilot); Dick Frost (Bell XS-1 test pilot and engineer); missing is Jack Russell (XS-1 crew chief). (AFFTC History Office)*

***Right:** Two-view drawing of the USAF's Bell XS-1, tail number 6062,* Glamorous Glennis*, flown by Capt. Charles E. Yeager. (AFFTC History Office)*

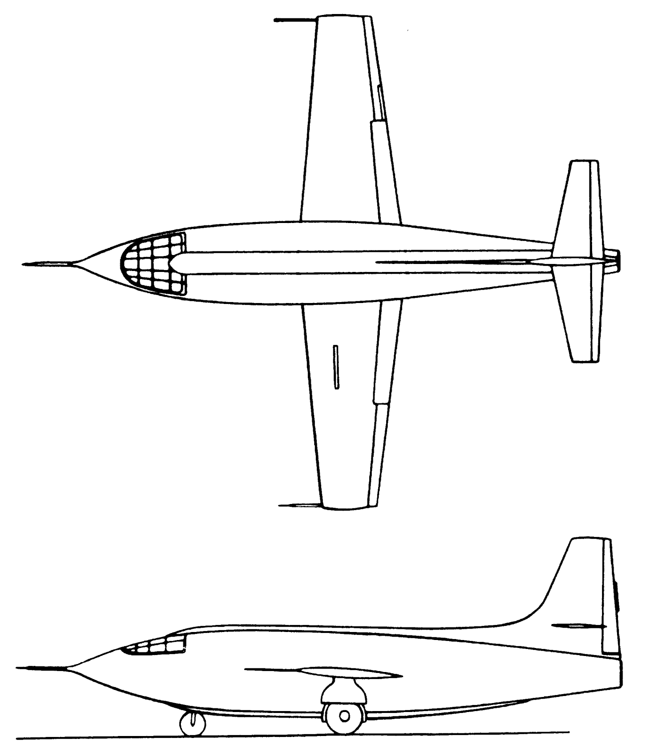
found that the true Mach number was approximately 1. The tabulated data showed (a Mach number of) 0.997. It wasn't felt that it was a clear-cut case of a sonic flight. It was only a matter of repeating the previous flight but to a slightly higher speed—this was done on October 14 in flight number nine, to a Mach number of 1.06. In this flight, the now typical jump in the airspeed and altitude readings occurred, caused by the bow (shock) wave passing over the static-pressure holes [in the nose boom]. There was then little doubt that highly publicized and feared "sonic barrier" had been breached.

XS-1 flight test method—While others have claimed to have gone supersonic before the XS-1, none have been able to offer unassailable proof or data substantiating the accomplishment and thus lack credibility. The XS-1 can and has presented documented proof of the world's first piloted supersonic flight even though no independent observers were present due to the highly classified nature of the program.

A recent challenge and seemingly more credible claim has been launched attributing the first supersonic flight to the XP-86 swept-wing turbojet fighter prototype, but the basis for this is pure conjecture and anecdotal and no proof has been presented or has been forthcoming. The author of this claim stated that, ". . Yeager was able to claim an official record because the NACA had set up a precision radar theodolite facility at Muroc, which pinpointed speed, altitude, and location of the subject aircraft." In addition, this author indicated that this radar "clocked" or "measured" a supersonic Mach number for the XP-86 in "mid to late November 1947." This reflects an incorrect understanding of the use and capability of the NACA radar and the historical record needs correction and clarification.

The NACA Muroc mobile radar, a SCR 584 with M-2 optical tracking unit, did play a key role in the determination of the XS-1 Mach number, but not to measure or clock Mach number. Mach number is the ratio of true airplane speed to the ambient speed of sound and, as a ratio, was not directly measurable by a 1947 radar. The NACA Muroc radar was never tasked with nor did it have the capability of determining Mach number. If the NACA radar had somehow been used to determine Mach number the result would have been totally unreliable, only a crude estimate, and not at all accurate for research or scientific purposes.

The XS-1, tail number 6062, on its historic world's first piloted supersonic flight, did obtain significant historical data that was recorded both on the ground and aboard the airplane. The XS-1 was fully instrumented for aerodynamic flight research with a state-of-the-art data acquisition and recording system. Included in the XS-1 instrumentation were the air-data parameters, namely, impact and static pressure for determination of airspeed and altitude. The device for sensing these pressures was the NACA air-data-boom located on the nose of the XS-1 (see the XS-1 photograph and two-view drawing). This boom provided pressure orifices connected to sensors and transducers designed to read and record both impact and uncorrected static pressure in front of the airplane. This system also provided uncorrected inputs to the pilot's cockpit airspeed, altimeter, and Machmeter instruments. Those readers familiar with the measurement of airspeed and altitude of airplanes, at subsonic speeds, understand that both impact

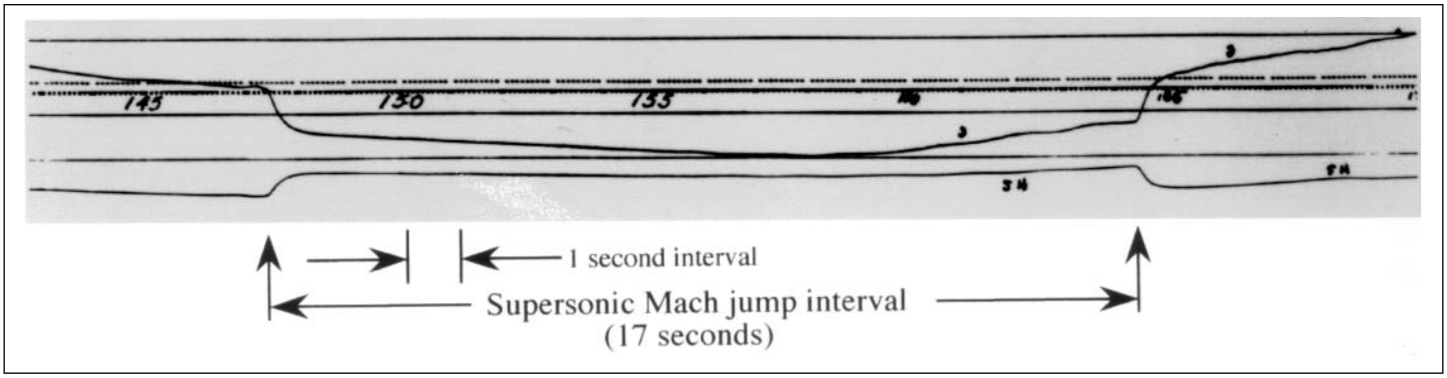


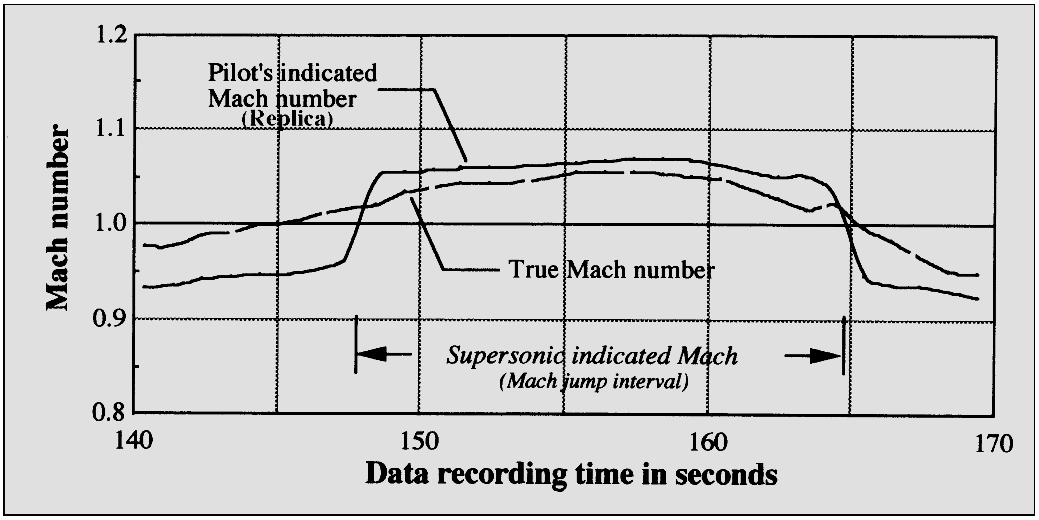
Bell XS-1, (6062)

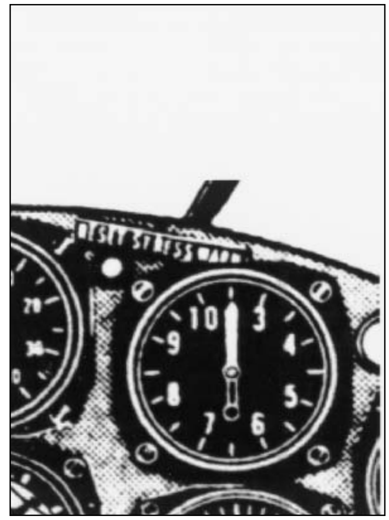
and static pressure are required measurements in the determination of these. The NACA boom air-data system provided very accurate, but uncorrected, measurements of this information that were recorded on moving photographic film as a function of time. After flight, when the XS-1 landed, the film data drums were offloaded and the film containing the recorded data processed. Before a scientifically accurate Mach number could be determined from the acquired XS-1 data the static pressure installation needed to be corrected for its position error. This is where the NACA Muroc precision radar theodolite facility entered the picture.

The NACA radar played a key role in the determination of the XS-1 static pressure position error by guiding and tracking a specially instrumented support aircraft that measured and recorded, with high precision, the existing atmospheric static pressure as it flew, at various altitudes, within the XS-1 flight corridor. The radar also recorded the support airplane's location and altitude within the corridor. This measured static pressure, when processed, was then designated the current true static pressure for a particular mission. Using this true static pressure and comparing it with the onboard mission recorded XS-1 static pressure and combining these with the radar location and altitude data an accurate position error for this airplane was determined. Continuing the process, with these data, provided the basis for the scientifically sound and accurate determination of XS-1 Mach numbers. To be sure the radar played a key role in XS-1 flight research, but not in the direct determination of Mach number.

Flight data recording—Following a particular mission the XS-1 film data drums were removed and the film containing the raw recorded data was processed and prepared for interpretation and analysis. Illustrated is a copy of the actual processed film with the raw air-data recorded aboard the XS-1 airplane during its historic flight of October 14, 1947. Shown is a 25-second interval between the data time of 145 seconds and 170 seconds with time progressing from left to right. Time is indicated in 1-second increments by the dashed line (second from the top). The air-data are the two traces that show movement between the left and right







Top: *Historic raw flight data—first onboard recording of an in-light shock-wave induced Mach jump as the XS-1 airplane exceeded the speed of sound on October 14, 1947. (NASA photo 9220259)*

Above left: *Illustrated are the official finalized flight data from the world's first recorded excursion beyond the sound barrier. The airplane was the USAF's Bell XS-1 and the time was shortly after 10:26 the morning of October 14, 1947. (© R.W. Kempel from 1947, NACA Muroc Height Test Unit data.)*

Above right: *The Bell XS-1 cockpit Machmeter, in one-tenth increments (scaled to a maximum of only Mach 1), as seen on October 14,1947. (AFFTC History Office)*

Opposite: *The massive Republic P-47, similar to this, was claimed to have been the first piloted airplane to have achieved a speed greater than that of sound. (AFFTC History Office)*

sides. The top trace is the recording of impact pressure and the lower trace is the static pressure. Values for these were determined by their distance from the reference center-line.

The raw data (above) clearly shows that at time 147 seconds there is a noticeable jump in both the impact (top) and static pressure (bottom) trace. This jump was caused by the airplane's compression or shock wave, sensed by the boom orifices, as supersonic speed was attained. At just after 164 seconds the airplane decelerates as it returns to subsonic speed and the compression or shock wave traverses the orifices in the other direction.

Once processed, the film, from the XS-1 flight, was analyzed by engineers who applied the appropriate calibrations and corrections in the final determination of a scientifically accurate Mach number, airspeed, and altitude. This process was scientifically rigorous with checks and balances to insure that the results were absolutely correct.

This raw data recording with a single final corrected value for maximum Mach number, speed, and altitude have been widely distributed. However, the 30-second interval of the final data of the world's first recorded piloted supersonic flight has never been publicly shown!

Illustrated on the finalized data chart (above left) is a replica of the cockpit Machmeter indication showing the recorded jump-interval of 17 seconds. Postflight final analysis indicated that the airplane Mach number had been supersonic for 20.5 seconds. This determination was made when reduction of the recorded data accounted for compressibility and is illustrated in the true Mach number trace.

The maximum Mach on this first supersonic flight, was determined to have been 1.06 at 43,000 feet (13,106m) by meticulous analysis. The final data curve shows the pilot's Machmeter reading, indicated Mach, even though it went slightly off his scale at the time, and the true Mach number as scientifically determined by postflight analysis using all recorded and corrected ground and flight data.

The pilot's cockpit Machmeter is shown as it was seen on that historic flight of October 14, 1947. Captain Yeager stated, in his postflight report, that: "At 42,000' [feet indicated] in approximately level flight, a third (rocket) cylinder was turned on. Acceleration was rapid and speed increased to.98 (indicated) $Mach_i$. The needle of the Machmeter fluctuated at this reading momentarily, then passed off the scale. Assuming that the off-scale reading remained linear, it is estimated that 1.05 $Mach_i$ was attained at this time. Approximately 30% of fuel and lox (liquid oxygen) remained when this speed was reached and the motor was turned off." Later this Machmeter (right) was replaced with an instrument with an increased, 0.5 to 1.5 Mach number range.

Bell Aircraft Corp. XS-1 airplane—The XS-1, tail No. 6062, was a small rocket-powered airplane carried aloft and launched from a modified Boeing B-29. It was constructed from heavy gauge high-strength aluminum. Airplane length was 30.9 feet (9.42 m) with a span of 28 feet (8.53 m). Fully loaded launch weight was 12,250 pounds (5,557 kg) and the landing weight, with propellants expended, was 7,000 pounds (3,175 kg). Landings were unpowered, after rocket propellants were expended, on Muroc Dry Lake. A two-view diagram of the bullet shaped Bell XS-1 airplane is shown on page 289.

The wing, although not swept, was of a very thin airfoil section. The wing was 8 percent thick and the all-movable horizontal stabilizer, with elevator, was 6 percent thick. These were very thin airfoils for the day. These thin airfoils were designed to get the drag-divergent Mach number closer to 1. By comparison, the thinnest high-speed World War II fighter had an airfoil thickness of about 12 percent. The rocket engine was a man-rated four-chamber Reaction Motors, Inc. XLR-11 RM-3[4] producing 1,500 pounds of static sea level thrust per chamber for a total of 6,000 pounds thrust. Propellants consisted of liquid oxygen as the oxidizer and water-alcohol as the fuel.

The primary objective of the XS-1 rocket airplane program was to be the first to penetrate the so-called dread sound barrier. The flight of October 14, 1947, was very credible based on the participating organizations such as the USAF and NACA with their highly trained engineering personnel. The acquisition of precision data from onboard instrumentation and ground optical and radar tracking assured accurate recording of raw data. The reduction of the raw data from the different sources, by experienced personnel, assured that scientifically accurate airspeed and altitude numbers would result.

The maximum operational flight performance of the XS-1 was the achievement of a Mach number of 1.45 at 40,130 feet (12,232 m) at a speed of 957 mph (1,540 kph) on March 26, 1948. Chuck Yeager was the pilot on this the highest Mach attained by the XS-1 airplane. Chuck Yeager made the last flight in the XS-1 on May 12, 1950, to obtain air-to-air photographs for the motion picture Jet Pilot. Following this, the 59th flight, the airplane was retired and presented to the Smithsonian Institution for display as the X-1.

The Harbinger of Piloted Supersonic Flight

In 1935, 12 years before Capt. Yeager's famous flight, a historic international conference on High Speed Flight was convened in Rome. At this conference, the Fifth Volta Conference, distinguished scientists and aeronautical engineers formally presented their thoughts concerning the problems associated with the attainment of flight to very high speeds. If there was a specific time marking an epoch in aviation, besides the achievement of heavier-than-air flight itself, this conference was it. The age of piloted supersonic flight.

This conference was held one year after Italy had captured the official standing World's Absolute Speed Record, for seaplanes, at 440.68 mph (709.20 kph) in the Macchi-Castoldi MC.72. At this meeting ideas on subjects such as airplane speeds in excess of 1,000 mph (1,609 kph) and orbital flights were presented and discussed. This conference and this speed record marked singular historic events that foreshadowed the direction piloted flight would take. Among scientists and engineers, at least, the stage for supersonic flight was being set.

At that time supersonic flight was a realm unbeknownst to most of the world of practical aviation or even most practicing aeronautical engineers. This was a time when the fastest military airplanes about to become operational would be capable of maximum speeds of only 300 to 350 mph (483 to 563 kph) in level flight. This was a long way from a sea-level sonic speed of 761 mph (1,225 kph). The approach to sonic speed was still several steps in the future. Little did the designers of the world's highest performance airplanes realize that the competition and stimulus of World War II would push their designs into the realm of transonic flight. The word transonic would not be coined for another five years.

Entering the realm of the transonic[5]—In 1939, a new World's Absolute Speed Record was set by a Messerschmitt Me 209 at 469.22 mph (755.14 kph). This record would stand for 30 years and it took 20 more years to establish the current Absolute Speed Record for piston-engine airplanes. The current Speed Record, for piston-engine airplanes, is 528.33 mph (850.26 kph), set In 1989, which is just 59.11 mph (95.12 kph) faster than the 1939, Me 209 Record. This is the case even though the current Record holder had an engine with about twice the horsepower of the Me 209. So, it would seem, that in a span of over 50 years not a great deal of progress had been made in achieving greater speed with increasing power.

The question immediately asked is; what was the problem? If doubling engine power and using more advanced aerodynamic technology only brought an increase in Record Speed of less than 13 percent, there must have been a problem. Indeed there was a problem and it was, and still is, what has been called the "sound barrier" or a "wall of sound" as some have put it. A barrier or wall wasn't exactly what the problem was, but rather the pressure field generated by and surrounding airplanes or any object as it approaches the speed of sound. The sound or pressure waves bunch together as an airplane approaches sonic speed to form shock waves. Some have called the problem "compressibility" and it manifests itself as a tremendous increase or resistance in the movement of an airplane through the air. This resistance is what has been called the transonic drag rise. Airplane drag can be thought of as the force acting opposite engine thrust. Thrust is the force that propels an airplane through the air and drag is the force that resists its movement.

Unfortunately, on airframes designed in the 1930s and '40s, at transonic speed, in addition to the increase in drag, the air-flow is unsteady and not necessarily parallel to the body and what happened was called shockwave or pressure-wave induced separation. The result was that pulsating pressure-waves flowed back to the tail surfaces and the pilot felt a buffeting on the airplane and all the control surfaces. This buffeting was reminiscent of driving one's automobile over a rough dirt road at high speed. This situation also resulted in an airplane trim change, commonly referred to as Mach-tuck, that could and did result in loss of control or in an unrecoverable flight condition.

This then was what became popularly known as the "dread barrier" or a "wall of sound" that was lurking, in the skies, for unsuspecting pilots in their high performance fighter planes of 1940s vintage. Once it became vaguely known that there was a boundary or barrier of some kind to be overcome, young eager pilots, with the urging of airplane makers, rose to the challenge to be the first to penetrate this mysterious "wall" even though it would cost some dearly.

Piercing the dread barrier in piston-engine propeller airplanes—Among young bold pilots, in hangars, on flight-lines, and in clubs,

it became known that the first to penetrate the mysterious sound barrier would certainly win fame. In addition to the celebrity status a pilot might attain, the airplane and its manufacturer would receive recognition too.

In 1940, in the USA with WWII looming, many young airmen were being trained to fly newly designed sleek very powerful fighter airplanes. Among these airplanes were two particular designs, piloted by daring young men, that would win wartime fame for their exploits: the Republic P-47 *Thunderbolt*, and Lockheed P-38, *Lightning*. The "P" designated these as pursuit airplanes.

The air-cooled single radial engine Republic Aviation, Inc. XP-47B flew for the first time in early 1941. Later production models of this airplane were quite heavy, being over 15,000 pounds (6,804 kg) maximum gross weight. It was, however, known for its ruggedness, high power (over 2,000 hp), and its ability to bring its pilots home even with severe battle damage.

The Lockheed Aircraft Corp. XP-38 flew for the first time in early 1939. This airplane used two liquid-cooled, 12-cylinder vee-engines; production versions were in the same weight and power class as the P-47.

The P-38 was known for its long range and endurance and by the enemy as the Forked-tail devil.

Both these airplanes had a level flight speed range greater than 400 mph (644 kph) at their operational altitude between 20,000 and 30,000 feet (6,096 and 9,144 m). In powered dives, however, speeds could be significantly faster. In this situation some pilots had reported that, as airspeed increased, their airplanes began to shake wildly, lose equilibrium, and the control forces became so high that control was nearly lost. Indeed in some high speed dives both airplane and pilot were lost. The mysterious barrier had been met.

The Thunderbolt and Lightning in high speed dives—During a wartime situation no government will willingly release negative propaganda nor will any involved support industries. Therefore, the following are very glowing press releases issued by the Republic and Lockheed companies relating to in-flight incidents that occurred in a P-47 and P-38. We will assume that the airspeeds reported, in the following reports, are true airspeed, but not necessarily accurate, as reported by the test authority.

The following is the unclassified Public Relations story issued in 1942 by Republic Aviation.

"Farmingdale, N. Y.—December 1, 1942—New aerodynamic and speed frontiers were established November 15 at an East Coast Air Base when two Army lieutenants, in Republic P-47 *Thunderbolt*s, dived these powerful fighter planes at 725 miles an hour and probably became the first human beings to hurtle through space at a speed greater than that of sound. More than twelve miles per minute!

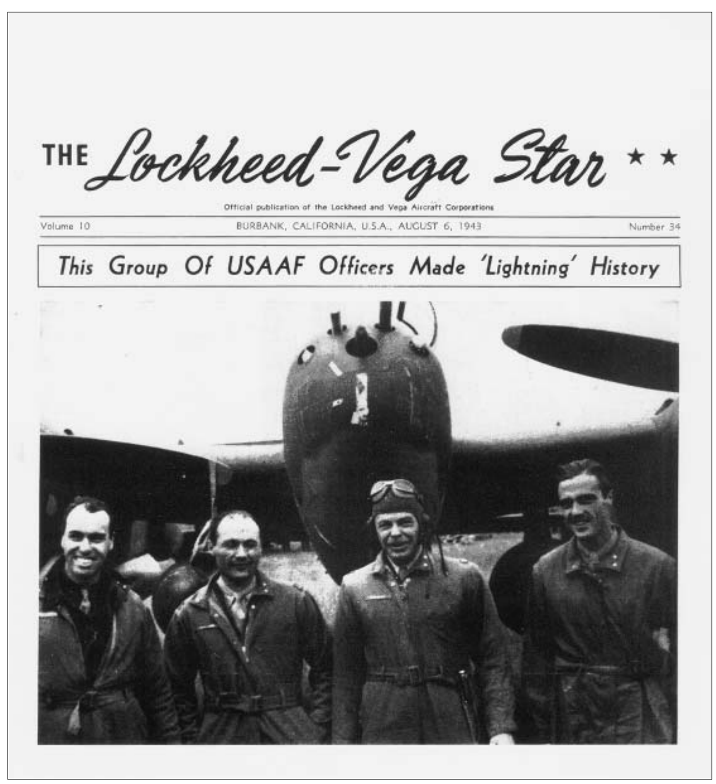
"Lieutenant Harold E. Comstock, 22, of Fresno, California, and Lieutenant Roger Dyar, of Lowell, Ohio, did not reach that unexplored aerodynamic horizon where the airflow theoretically breaks up, splashes against the plane's surfaces, and may cause the craft to lose its essential flying characteristics and flop around like a drunken pigeon. But they did attain a speed where the air pounded against the vertical or "straightened out" control surfaces with such tremendous force that their Joy sticks were frozen solid! When the stick won't respond to a young man's muscular tug while the young man is plummeting earthward at substantially more than 1,000 feet every second—well, as Lieutenant Dyar puts it, it results in "that old unsatisfactory condition."

Very impressive indeed for a P-47, in 1942, having achieved 725 mph (1,166.8 kph). At 25,000 feet (7,620 m) altitude this would have been a supersonic Mach number of 1.05. Below is the equally impressive P-38 story published in the Lockheed employees newspaper dated August 6, 1943.

World Record P-38 Dive Told For First rime

"HE TOLD ME HE WENT STRAIGHT DOWN – VERTICAL – IN A FULL POWER DIVE, EVERYTHING WIDE OPEN, AND THAT HE HOLLERED LIKE A BANSHEE ALL THE WAY DOWN FROM 43,000 TO 18,000. THEN HE LEVELED OFF IN A WIDE ARC AND WAS IN LEVEL FLIGHT AGAIN AT ABOUT 8,000 FEET."

In these dramatic words Hall L. Hibbard, vice-president and



THE *Lockheed-Vega Star* ★ ★

Official publication of the Lockheed and Vega Aircraft Corporations

Volume 10 BURBANK, CALIFORNIA, U.S.A., AUGUST 6, 1943 Number 34

This Group Of USAAF Officers Made 'Lightning' History

Opposite upper: *Example of the world famous Lockheed P-38, one similar to this, was claimed to have reached 780 mph (1,255.3 kph) in a terminal velocity dive in September 1942. (AFFTC History Office)*

Opposite lower: *U.S. Army Air Force Lieutenant Colonel Cass S. Hough (second from the left) had, it was claimed, "established what to date appears to be the highest speed ever attained by any human being on earth. (Lockheed Martin Aeronautics Company)*

Above: *The revolutionary 1944 Me 262 turbojet fighter with an operational level-flight airspeed of 540 mph (869 kph). (Mr. Steve Ferguson)*

chief engineer of Lockheed, this week described second-hand the longest vertical dive in history -nearly five miles- made at 780 miles an hour in a Lockheed *Lightning* P-38 by Lieut. Col. Cass Hough of Plymouth, Mich., last September.

Kept secret until now, first official report of Hough's feat was flashed out of London yesterday when United States Army Headquarters in England announced that Hough, who is Technical Director of the 6th Fighter Command, had been awarded the Distinguished Flying Cross for "flights which took him knowingly into unexplored fields."

"Col. Hough returned to the factory shortly after his dive, to give us a complete report on his findings," Hibbard revealed, "The dive was made in England in one of the first P-38s to fly across the Atlantic. Hough said one of the reasons why he did it was that he wanted to convince the British that the P-38 could do certain things they said it couldn't do.

"He made his dive on a very clear day in a standard P-38 that was in no way fitted out especially for a feat of this kind. Of course, he had plenty of oxygen, which he used throughout the high altitude phases of the flight and until he had pulled out of his dive.

"Hough told us that when he reached 43,000 feet he turned over on his back and slipped into the dive. He opened the throttle wide, gave the plane everything her two Allison engines had and kept her vertical until he hit 18,000 feet. Then he eased out. The noise, he said, was deafening as the wind struck the plane at such a high velocity. In fact, the two most definite impressions of the dive that he had afterwards were the noise of the wind and the crazy way in which the altimeter and rate of climb indicator dials kept spinning.

"He told us that he'd suffered no ill effects from the dive other than ears that were stopped up for a couple of days. The plane. he said, had taken it in stride and had felt very solid all the way down. There was no buffeting and the entire procedure including the pullout was as easy as the flow of oil."

Hough was one of four Air Force colonels who flew Lockheed *Lightning*s across the Atlantic a year ago in the first trans-oceanic flight by fighter aircraft. The officers were accompanied by scores of other P-38s and convoying bombers flying in mass formation.

Once more a very impressive 1942 airplane story, having achieved 780 mph (1,255.3 kph) in a P-38. At 25,000 feet (7,620 m) altitude this would have been a supersonic Mach number of 1.13.

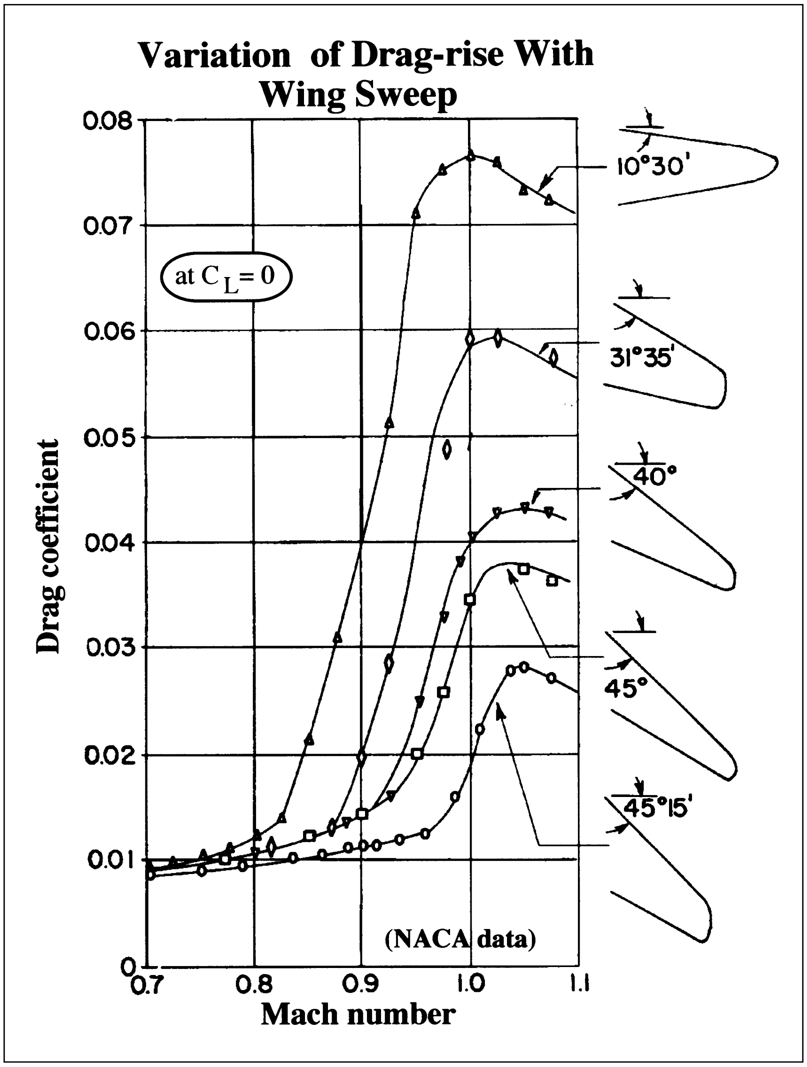
The Lockheed P-38 was one of the airplanes that suffered transonic controllability problems and many loses were recorded until it was fitted with what Lockheed called a dive brake, but was more like a spoiler. The under-wing spoilers were retrofitted to operational P-38s after some were lost and others 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 airspeed, from 30,000 feet (9,144 m) with the dive brake extended. At this indicated airspeed Mach would be less than 0.85.

Concerning the reported attainment of a speed greater than Mach 1 by a *Lightning*, Clarence L. "Kelly" Johnson, codesigner of the P-38, in his 1985 book *Kelly* stated that "… we knew that would have been impossible. The P-38 just could not have withstood that; it had to be an inaccurate airspeed reading because of instrument lag in the rapid change in altitude—(the) speed of sound, of course, being different at different altitudes."

Turbojets usher a new era of airplane propulsion—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 in the case of the Messerschmitt Me 262 increase level flight airspeed by 100 mph (161 kph), in one step, as compared with the best piston-engine fighters. This was indeed a significant breakthrough. The turbojet was, however, not without its developmental difficulties, but that's another story.

The Me 262A-la was the world's first operational 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 of this feature, but on occasion runaway trim proved disastrous.

The Me 262 had a reputation of becoming uncontrollable and unrecoverable in high speed dives. This airplane had no means of recovery such as a speed brake or spoiler like the P-38. Operationally, the pilots were to limit the maximum airspeed to no



Left: *Illustration of transonic drag rise for a typical 1940s era airfoil for five different sweep angles from NACA wind-tunnel tests. (NASA SP-367)*

Opposite: *The number one North American Aviation, Inc. 1947prototype XP-86 turbojet fighter, PU 597, over the Mojave Desert. (Air Materiel Command photo from R.E. Williams collection)*

more than 1,000 kph (621.4 mph) which would have been close to Mach 0.9.

Recently a published report stated that a WW II Luftwaffe Me 262 pilot claimed that "…he broke the sound barrier first – not Chuck Yeager." This event happened on April 9, 1945, just before the end of hostilities in Europe. Hans Guido Mutke, the pilot, reported that he had reached an indicated airspeed of 690 mph (1,110.5 kph). Hans reported that he entered heavy aerodynamic buffet, that both engines flamed-out, and that the wings sustained severe structural damage. How the landing was effected was not stated.

The article indicated that the claim to have been one of the world's first supersonic flights can not be verified. Hans, the elderly ex-pilot, has enlisted the aid of a Munich Technical University professor to assist him in verifying his claim by way of a computer simulation. The Professor claims that his results, so far, are inconclusive because the aerodynamic data for the Me 262 are not reliable. In addition, the head of the Decutsches Museum "rejects the pilot's claim" as does this author. Engine flameout, in his dive, and the end of hostilities, May 7, are probably what preserved Hans' life.

In documented flight test, the highest corrected speed recorded by a Me 262 was 1,005 kph (625 mph) or about Mach 0.9. A more advanced version (HG III) was predicted to be capable of 1,100 kph (684 mph).

The problem with the Me 262 was the subsonic NACA wing airfoil section even though it was only of 12 percent thickness ratio and swept at 18.5 degrees. These helped increase the critical Mach number, but the engines couldn't overcome the transonic drag rise. The Me 262's two axial-flow Jumo 109004B turbojet engines could only produce about 1,980 pounds (898 kg) of static thrust each. Clearly, without a more significant reduction in drag rise these engines, under the best conditions, could not have made the Me 262 a supersonic airplane.

Supersonic Speeds In Subsonic Airframes—Impressive, if true, having attained supersonic speeds in subsonic airframes. Were these stories really true or, propaganda, erroneous airspeed readings, just bad aeronautical science, a mistake by over zealous pilots, company spokesmen, and reporters?

In the light of history, the lack of any hard data, and more advanced aeronautical research these three claims simply can not be substantiated technically or scientifically. This was a period of transition from probing transonic flight in high speed dives, operationally, to the flight testing of experimental airplanes capable of supersonic speed and that didn't happen until several years later.

On the basis of more modern scientific information and flight test data it has been determined that propeller-driven airplanes were typically limited to level flight speeds under 500 mph (805 kph). Mach number was the limiting factor in determining how fast a WWII propeller-driven fighter could fly. To have achieved a free-stream Mach number of 0.7, in level flight, was exceptional. This result was not in proportion to 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 (thrust) at high local transonic Mach number. It has been experimentally determined that as propeller tip-speed approaches that of sound, the thrust dropped significantly and the drag, in the plane of the prop, increased dramatically. In essence the prop stalled and the engine torque required to maintain rpm rose abruptly.

The highest in-flight true Mach number ever documented by a piston-engine airplane was 0.91 in a Royal Aircraft Establishment flight test Supermarine *Spitfire P.R. XI* while in a terminal velocity dive. At this Mach number the true airspeed was between 600 and 650 mph (966 to 1,046 kph) and the airplane lost its propeller and parts of the engine cowling but landed safely with the flight records.

We in the aeronautical sciences have learned a great deal concerning transonic and supersonic aerodynamics since 1942. For example, the drag rise for a typical subsonic wing of the 1940s era with little or no sweep begins somewhere around Mach 0.70 as illustratcd in the data curve.[6] The drag rise is, typically, small and gradual until Mach approaches 0.8. Between Mach 0.8 and 0.9, say between 550 and 650 mph (885 and 1,046 kph), the drag rise is so high that this is what gave rise to the idea that this speed range or beyond was a barrier. If, on the other hand, the wing was swept the drag rise was found to be delayed, more gradual, and reduced in magnitude as Mach number increased as is illustrated. Besides wing sweep, thinner airfoils were found to help in producing this effect too. The Spitfire and Me 262 had wings of 12 percent thickness ratio while most WWII fighters were 15 percent or more. The Me 262 had the added benefit of a modest sweep angle as well.

This data curve is somewhat simplistic, but illustrates the point concerning the benefits of wing sweep on drag rise and should be used for instructive purposes only.

Germany's Dr. Adolf Busemann had suggested the use of wing sweep as a means of increasing critical Mach number and reducing wing drag rise in 1935 at the historic Fifth Volta Conference on High Speed Flight in Rome. Dr. Buseman's theory is verified by the NACA wind tunnel results shown in the data curve.

After WWII, airframe designs with higher thrust and thinner swept-wings 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.

On the basis of previous seemingly 'reliable sources,' exaggerated supersonic speed claims for World War II fighters, including the Me 262, have continued to circulate. Documented scientific proof or evidence to substantiate these claims simply does not exist. In addition, these claims have no validity in aeronautical science. Certainly, we in the aerospace community hesitate to say anything is impossible, but one thing this author can say categorically is that; no piston-engine propeller-driven or first generation turbojet airplane has proved to have reached or exceeded a speed of Mach 1. The truth was, is, and will remain, that if you can't produce the thrust you can't overcome the drag, transonic or otherwise.

The World's Second Supersonic Airplane—For comparison with the X-1 its contemporary the North American Aviation, Inc. first prototype XP-86 (PU 597) turbojet fighter is presented. This airplane was to begin flight tests at Muroc Army Air Force[7] (AAF) Base after its arrival on September 10, 1947.

The XP-86 had a maximum takeoff weight of about 16,000 pounds (7,257 kg) with a length of 37.5 feet (11.43 m) and a span of 37 feet 1 inch (11.3 m) which made it slightly larger than the X-1. Aerodynamically, the XP-86 had a wing with a leading edge sweep of 39 degrees (35 deg. at the quarter chord line) that was less than 11 percent thick. This wing was the key feature of the XP-86 that would later assist the production F-86 in gaining world renown success.

The XP-86 was powered by a General Electric designed, General Motors, Chevrolet Division produced, J35C-3 axial-flow turbojet engine. This engine was rated at between 3,750 and 4,000 pounds sea-level static thrust. With the swept wing the XP-86 airplane did have the potential of being capable of low supersonic speed, but with this early engine supersonic flight would have been difficult.

After successful taxi tests were completed, the first XP-86 (PU 597) airplane made its initial flight from Muroc on October 1, 1947, with North American's George S. "Wheaties" Welch (of Pearl Harbor P-40 fame) at the controls.

George Welch, officially, achieved supersonic flight, over Muroc AFB, in the third XP-86 prototype (PU 599) on April 26, 1948, thus becoming the third pilot in the world's second airplane and the first turbojet to do so. On this date the XP-86 achieved a Mach number of 1.0 17 (704.6 mph or 1,133.9 kph) at 25,000 feet (7,620 m).

The claim, by some, that on October 19, 1947, NACA's precision Muroc radar "tracked" or "clocked" the XP-86 at a supersonic Mach number is incorrect as this radar did not have this capability (see the earlier discussion of this subject). The report of this event continues to circulate and some insist that George Welch and the XP-86 were the first to exceed the sonic barrier. There are some that, to this day, claim that there is "very strong evidence" that the XP-86 did exceed the speed of sound on its maiden flight, but they are unanimous in failing to produce any substantial proof or scientific evidence to this fact. These reports must forever remain in the realm of speculation, conjecture, and anecdotal rumor. Those who continue to spread this rumor, without substantial proof, certainly do aviation history a disservice.

To add another voice to the XS-1 versus XP-86 supersonic controversy consider the following story, although not directly related. This is a first-hand account of the F-86 capabilities that relates to an inflight experience of test pilot Charles Tucker as he told it. The event occurred during a test flight, in the second half of 1949, as he piloted the number two Northrop X-4 Bantam twin-turbojet experimental semi-tailless airplane (vertical tail only configuration with tail number 6677). On this particular flight, Muroc Base Commander, Col. Albert Boyd, flew chase in an F-86. As Mr. Tucker relates the story "… We had finished the scheduled test flights and were on the way home at about 40,000 feet (12,192 m) over the western edge of the Mojave Desert. I could see the big hangars at the base in the distance. With nothing on my mind except getting home as quickly as possible, I pointed the nose of the X-4 at the hangars. This gave me about a 20-degree dive angle from my altitude, so I retarded the throttles somewhat, as I knew I would pick up quite a bit of speed. The airplane accelerated, and the anticipated Mach buffet began about 35,000 feet (10,668 m). As an experiment, I triggered the stick-mounted switch a bit to open the flaps/speed brakes at what I calculated to be about 1 to 2 inches. By the time I got to 30,000 feet (9,144 m), the buffet was gone and the airplane accelerated smoothly. When we got back on the ground, Al told me that he had given the F-86 all the power it had, and his airplane was shaking and complaining, but couldn't catch me. I figured I must have been going pretty fast, but the Mach meter in the X-4 only went to Mach 1.0, so I had no idea how fast I was actually going. A couple of weeks later, Walt Williams, head of the NACA group at Muroc, called me and told me that they had finished examining the telemetry data from that flight, and he wanted to congratulate me on going Mach 1.02 in the X-4. I felt pretty good about that, although breaking Mach 1.0 hadn't been on my mind at the time; I had just wanted to get home. No one else ever came close to that speed in the X-4."

This event took place in late 1949, almost two years after the first XP-86 flight of October 1, 1947, and the USAF chase F-86 couldn't stay with the X-4 at high subsonic to low supersonic speeds. The chase airplane was probably an F-86A, with the higher thrust GE J47 engine as compared with the prototype's J35, as this model began production deliveries in early 1949. In addition, the failure of Muroc's F-86s ability to achieve supersonic flight has been related to this author by at least one other contemporary Muroc test pilot who tried unsuccessfully, on more than one occasion, to achieve supersonic speed in an early F-86 during this era.

What is one, then, to conclude about the first XP-86 achieving a supersonic speed on its first flight or even shortly thereafter? One must, therefore, conclude that the probability is very low to nonexistent. No evidence exists that the XP-86 ever went supersonic before the USAF's officially advertised date of April 26, 1948.

Of all the previous claims to have been the first to have gone supersonic in their piston-engine or first generation turbojet airplanes, such as the Me 262, the XP-86, a second generation turbojet, may have come closest to actually succeeding.

The world's second supersonic pilot—History officially records the world's second pilot and the first civilian to achieve supersonic status as NACA's test pilot Herbert H. Hoover in the Bell X-1, number 2 (tail number 6063). This event occurred on March 10, 1948, when Mr. Hoover flew to Mach 1.065. This was more than a month before George Welch's supersonic flight of April 26. This then officially makes Herbert H. Hoover the second pilot to have officially achieve supersonic status and George Welch the third. If we count the Bell X-1 number 1 and 2 as basically a single airplane, then the XP-86 was the second airplane to fly supersonic.

Historical Significance

In the latter half of the 1940s test pilots had a keen interest in being the first to exceed the speed of sound. Their intense interest is exemplified and typified by the comment made by an ordinarily highly compensated company test pilot when he said "… I am so eager to make those (supersonic) flights that I'll do it for nothing if I have to." Surely he knew that fame and fortune awaited him if he had succeeded.

This just proves the adage, too, that few ever remember who came in second and it's always better to be the first in whatever you do.

The Bell XS-1. The Bell X-1, or XS1, stands alone, with Captain Charles E. "Chuck" Yeager, as the first airplane and pilot recorded and recognized in aviation history to have documented proof that they did indeed achieve a speed greater than that of sound. Having proven this, their position, as the first, in documented and recorded aviation history is assured.

The X-1, tail number 6062, now resides in a place of honor, on permanent display, at the Smithsonian National Air & Space Museum in Washington, D. C.

NACA's test pilot Herbert H. Hoover is historically recognized as the second pilot to have achieved supersonic status. The Bell X- I airplane, tail number 6063, is now on permanent display in front of the Dryden Flight Research Center,[8] in its modified configuration, as the X-1E.

The XP-86. The North American XP-86 and George Welch will always be remembered, by most, as the first turbojet, the second airplane, and the third pilot to have officially achieved supersonic status. There are some who contend that the XP-86 and George Welch were the very first to attain supersonic status. If this claim was or is true, the documented evidence simply does not exist nor can anyone produce it.

There is no doubt the XP-86 was the USAF's first fighter capable of supersonic flight. The early production P-86A was redesignated the F-86A in mid 1948, and began its operational career in early 1949. The F-86As were powered with the General Electric J47-GE-1, -7 and -13 engines. This engine provided about 4,850 to 5,200 pounds of static sea level thrust which was a significant improvement over the J35. This airplane won world fame as one of the best fighters ever produced and was used in the defense of many countries. Many young fighter pilots made their first excursion into the realm of the supersonic successfully in an F-86.

Edwards Air Force Base. In the future, Muroc AFB would go on to be renamed Edwards AFB on December 8, 1949, in honor of Capt. Glen W. Edwards who had been killed in the experimental Northrop YB-49 flying wing. With the passing of time, around 1952, Muroc Dry Lake would become known by its other locally familiar name, Rogers Dry Lake.

The 1950s would be the "Mach Busting" golden era of supersonic flight testing in experimental airplanes at Edwards. Mach 2 would be reached, over Edwards, in late 1953 by the Douglas D-558-2 *Skyrocket*. On September 27, 1956, Mach 3.2 would be achieved in Bell Aircraft's experimental sweptwing X-2. Then on October 4, 1957, the world's first artificial satellite, Sputnik 1, was put into orbit. The space age had been born and this changed everything. The National Advisory Committee for Aeronautics, NACA, would go on to become the National Aeronautics and Space Administration, NASA, (the so called space agency) on October 1, 1958. Before the decade was finished, the North American X-15 was preparing for an assault on Mach 6. And so it has gone at Edwards AFB until now. Is it any wonder that the motto at the Air Force Flight Test Center at Edwards is Ad Inexplorata—Toward the Unknown, very appropriate indeed. ☐

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The No.1 prototype XP-86, 559597, over the Mojave desert in formation with the No.2 XB-45 Tornado*, 559480, the first four-jet bomber. (Air Materiel Command photo from R.E. Williams collection)*

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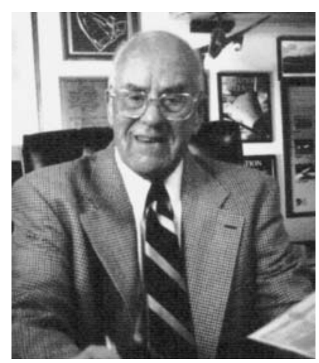
NOTES:

1. NACA was flight testing the number 2 XS-1 during this time, but no supersonic flights had been accomplished. NACA's Herbert Hoover has been officially credited with being the first civilian test pilot to achieve supersonic status. This event occurred in the number 2 XS-1 on March 10, 1948.
2. The record shows that NACA flew the number 2 airplane four times in 1947. Capt. Chuck Yeager flew the acceptance flight, for NACA, on September 23, 1947, and Herbert Hoover flew three subsonic flights later that year. In addition the record indicates that Herbert Hoover's supersonic flight was on March 10, 1948, and not on his flight of March 4.
3. Mr. Williams acted as NACA project engineer during preliminary glide flights of the XS-1 then being made at Pine Castle AFB (Muroc Dry Lake was flooded). When, as a result of these tests, it was determined that an air launch operation was feasible, and that all further testing should be performed at Muroc AAFB (Army Air Force Base), Mr. Williams was transferred to the Mojave Desert site in September 1946 to establish and direct a permanent NACA flight test operation.
4. More than 20 years after the XS-1's historic flight, NASA refurbished and upgraded several XLR-11 rocket engines for use in the Lifting Body experimental research programs at Edwards. The first of these to fly, under power, was the HL-10 on September 24, 1968. In some cases these rockets were retrieved from museums where they had been on loan.
5. The word transonic describes the speed of the air-flow about a body as it accelerates, locally, through the speed of sound and decelerates back to subsonic speed. The flow is neither all subsonic, slower than sound, nor all supersonic, faster than sound, but a mix between the two. The body itself is not necessarily at sonic speed, but can be considerably slower. The speed at which this condition exists is the body's critical Mach number.
6. The data curve is presented in coefficient form, a convenient engineering method to use dimensionless numbers, to indicate the change of the force of drag as a function of Mach number.
7. The U.S. Air Force (USAF) was established on September 18, 1947, between the time the airplane was delivered to Muroc and the time it made its first flight.
8. What had been the NACA High Speed Flight Station, at Edwards AFB, became the NASA Dryden Flight Research Center in 1976, so named in honor of Dr. Hugh L. Dryden, internationally recognized NACA/NASA aeronautical scientist.

ABOUT THE AUTHOR:



Mr. Robert W. Kempel, Senior Aerospace Engineering Consultant. Mr. Kempel has over 40 years of experience as an aerospace engineer and as a technical team leader in the conduct of Experimental Aerospace Vehicle Flight Research with NASA and the USAF at Edwards AFB, California. He has written over 26 formal NASA and USAF technical publications, some with prominent test pilots and test pilot/astronauts as co-authors. In addition, Mr. Kempel has written several historical documents and articles, of national and international interest.

Some highlights of Mr. Kempel's career include the responsibility as the principal stability and control, flight controls, handling qualities, and flight simulation engineer on the experimental rocket powered HL10 and M2-F3 lifting body vehicle flight research programs (1966-70s). (These vehicles were the precursors to the Space Shuttle, and future reusable launch vehicles.) He served as the remotely piloted vehicle systems manager/integrator on such programs as the Highly Maneuverable Advanced Technology (HiMAT) remotely piloted vehicle and the Boeing 720 Controlled Impact Demonstration program (remotely controlled crash). In these positions he was responsible for the development and flight qualification of all flight control systems, flight control laws, and remotely piloted systems. He was also responsible for the development of the flight control laws for the proposed NASA Oblique Wing Research Airplane.

Mr. Kempel is a native of Detroit, Michigan, and received his Bachelor of Science (BS) degree in Aeronautical Engineering from California State Polytechnic University (San Luis Obispo) in 1960 and has done advanced work at the University of Southern California (USC) and the University of California at Los Angeles (UCLA). Mr. Kempel is a lifetime member of the Society of Flight Test Engineers (SFTE).