Attacking the Sound Barrier 1935-45

Introduction

It is some 70 years since fighter pilots began to encounter the Sound Barrier, the breaking of which, in Britain, attracted intense public interest. There was even a film of the same name, giving the impression that we, in this country, were the first to breech it. In the USA, where the rocket propelled Bell X-1 reached the speed of sound in October 1947, the truth was only gradually released to the public. Slightly later, the swept wing prototype, XF-86 Sabre, did break the barrier, this being the first jet propelled aircraft to do so. With its swept wings, it was the shape of the future and of our present.

The interest in Britain was quite morbid. As a typical piston engine aircraft approached the speed of sound, any aircraft, with the exception of the Spitfire, would be subject to extremely serious buffeting, in some cases leading to structural damage. More significantly, and without exception, aircraft would encounter a strong nose down tendency, with speeds tending to become ever higher as the ground approached. Pilots reported that it seemed impossible to pull out until the altitudes became uncomfortably low. In the film, the son of the aircraft designer gets killed in making the attempt. It was a mirror of reality. The son of Sir Geoffrey de Havilland, the aircraft designer, was killed in testing the DH 108, Britain's first swept wing jet. It did reach the speed of sound, once, and then in an uncontrollable vertical dive.

The Sound Barrier as an Idea

The term sound barrier was coined by FW Hilton during a visit by newspapermen to the NPL in 1935, when he pointed out that increase in aircraft drag increased very rapidly as the peed of sound was approached. This is basically caused by the formation of a shock wave of a compression type over the wing. As air flows through the shock there is an increase in temperature, pressure and density. The Mach number behind the shock falls to less than supersonic, and there is also a decrease in velocity. It is probably best to think of the temperature increases, and fall in velocity, as the energy losses responsible for the increase in drag.

As the speed of sound is approached, the "drag coefficient", of an aircraft, increases by a factor of 5-10. The drag coefficient is a measure of how well aircraft (or any other body) is streamlined. Up to what is termed "the critical Mach number", the drag coefficient is constant, although obviously, as the velocity of the aircraft increases, so does drag and the power needed for propulsion. An early model of the Spitfire could do about 290 mph at sea level on a Merlin engine giving 880hp. Even without sonic barrier issues, 750 mph would have been extremely difficult with a piston engined aircraft. Needing at least 15000 hp. But if we bring in the increase in drag coefficient, because of sound barrier issues, the power required is in the plus 50 thousand horsepower bracket. No wonder the sound barrier seemed so real before the era of the jet engine and the swept wing.

American Investigations

Discounting early work on projectiles, a breakthrough in understanding came in America in the development of new aerodynamic profiles for propellers. Since the early twenties it had been known that when tip velocities approached the speed of sound, there was a drop in propeller efficiency and an appalling increase in noise. Propellers were creating a continuous sonic bang.

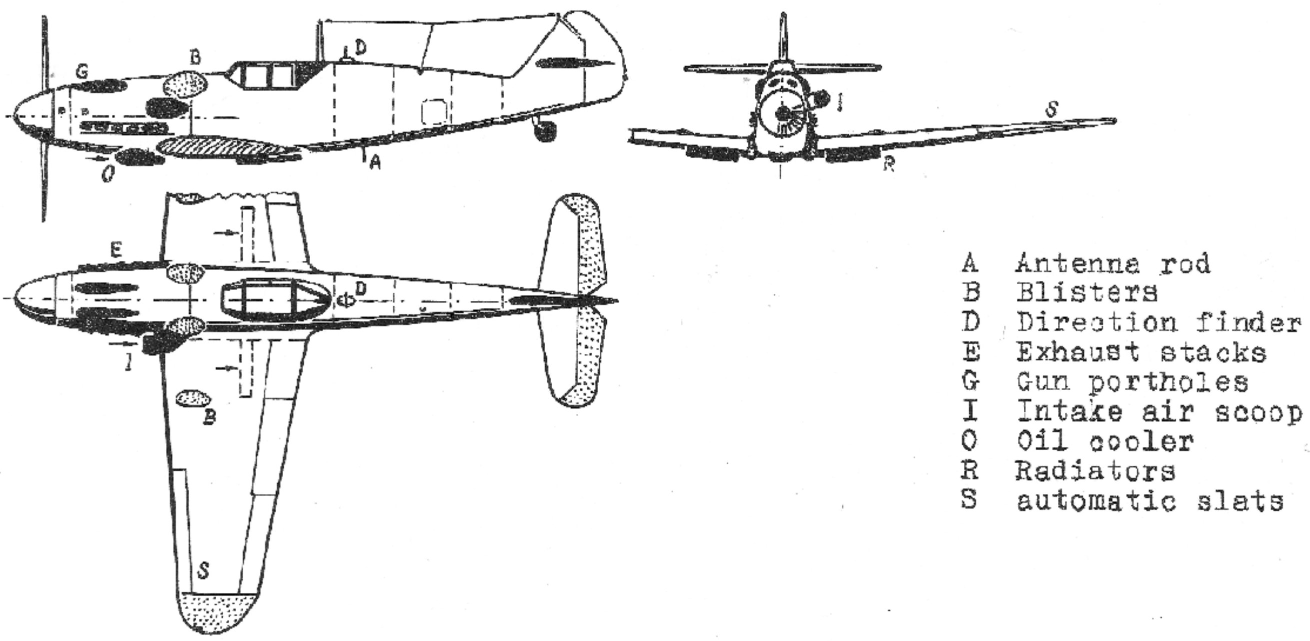
John Stack and his colleagues at the US Government research centre at Langley, Virginia, used Schlieren photography to reveal exactly how flows at transonic and supersonic speeds differed from low speed airflows. But it was well into the 1940s that their research began on aircraft. The R&D priority, up to the start of the World War II, was the improvement of commercial piston engine transports.

The German Programme and the Me 109

Diving to either meet or escape the enemy was a feature of aerial combat in WWII, and pilots soon encountered Mach No problems; loss of control, buffeting, and a nose down tendency. A case can be made for saying the Germany was the first to put in hand investigations. Well before war broke out there was a secret programme to investigate the swept wing. But, in 1941 on a more practical level, the Reichsluftfarhtministerium asked for tests on the Me 109 as pilots reported a loss of control when diving from altitude. This would have been a frequent occurrence. In contrast to British fighters, the Me 109 used fuel injection. Bunting over into a high speed dive was a proven method of escape or attack. There was no risk of a loss of engine power.

But even in 1939 the B model of the Me 109, with the low powered Jumo 210, had crashed in a dive   Flight tests showed that at a Mach number of 0.78-0.80, a nose down pitch began, with, sometimes, an uncontrollable roll developing. The maximum allowable Mach No was set 0.805. This is not surprising. The aerodynamics of the Me 109 dated from the early thirties. The wing was fairly thick by the standards of today, over 14% at the wing root, and around 11% near the tip. High wing thickness-chord ratios give high drag at transonic speeds and lower the critical speed. The Me 109 had other problems. The horizontal tail was positioned half way up the fin, hence there would have been shock wave interactions of the type encountered on the early Meteors.

Figure 1 : Me109 G and Drag Breakdown



Drag Breakdown of Me 109G

- **Basic wing drag, including surface roughness - 37.5%**
- **Fuselage, including surface roughness and poor canopy - 13.7%**
- **Tail surfaces- interference and roughness – 6.9%**
- **Engine and radiator installation – 23.3%**
- **Guns, tailwheel , antenna – 11.4%**
- **Induced drag from wing - 7.2%**

Willi Messerschmitt seemed be unconcerned about this issue, having no other priority than churning out as many Me 109s as feasible. Build quality was poor and there was no effort to improve the basic aerodynamics. SG Horner, who was in the Messerschmitt organisation, has concluded that the maximum speed could have been increased from 610 km to 800 km/ hour with the same power plant (375 to 500 mph) if the aircraft had been cleaned up. Horner refers to the Me 109G model, which was particularly bad. Figure 1 shows the configuration of the aircraft and details the “drag breakdown”.

In addition, I would add that in my view the Me109 might be regarded as souped up and much modified version of the Me 108 Taifun, which for its time was probably the most sophisticated light aeroplane in Europe. The prototype flew in 1934. It was a four seater with a top speed of 190 mph on 230 hp. One of the biggest changes, apart from the engine of course, was the reduction in wing thickness, which on the Taifun was 16% at the root and 13% at the wing tip, these being only good for medium speeds.

Fig 2 : A Me 108 Taifun rendered in Luftwaffe markings
http://www.luftwaffephotos.com/lme1083.htm

British Investigations and the Spitfire

The RAE (Royal Aircraft Establishment) was not as well provided as its German counterparts and so Britain did not get its first big transonic wind tunnel until 1942. It may be there was a degree of complacency in this country. The Hurricane was a fairly draggy aircraft, unlikely to reach really high speeds even in a dive. The Spitfire, although much more capable, having a wing section and thickness which allowed it to reach over 90% of the speed of sound would rarely be in trouble. But both fighters had Merlin engines using carburettors. If a Spitfire was pushed into a dive, the engine would cut out because of over-fuelling. One would assume that there was not that much experience of high speed diving until Miss Shilling came up with her orifice solution to the carburettor problem in early 1941.

Figure 3 : Westland Welkyn

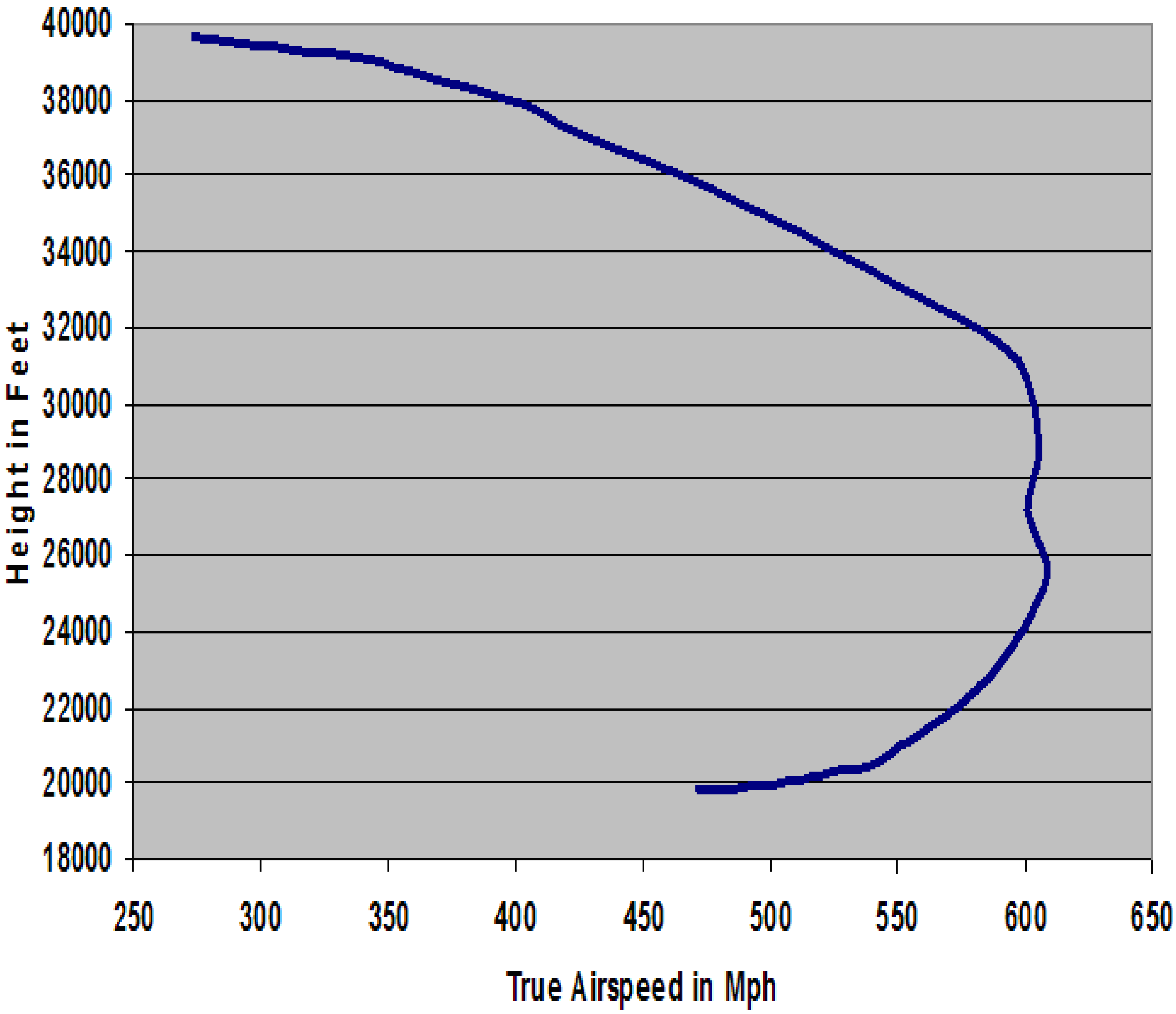
Then as one might say, the Mach No problems began to back up at the RAE. The high altitude, Westland Welkin, twin engined fighter was unusable at 40000 ft. Its highly loaded, very high aspect ratio wing called for a wing section in which the thickness-chord ratio was 21%. At only 60% of that of sound, the Welkin was pitching up and down and was useless for gun aiming.

Although other Allied fighter aircraft were not so compromised, all of them had much thicker wings than the Spitfire (13% at the wing root, 7% at the tip). Accordingly, permissible dive speeds, in terms of Mach number were quite low, P38 Lightning- 0.68, P47 Thunderbolt- 0.69, and the Hawker Typhoon – c.0.70. Even the Mustang and the Tempest were limited to just over 0.80.

What about the Spitfire? In test dives at the RAE, where the limitation was over-speeding of the propeller, a Mach number of 0.891 was achieved at around 28000 ft. Figure 3 shows that the actual speed was over 600 mph. And a writer in the magazine “Aeroplane” claimed that on a Met Flight, where he lost control at 51000 ft in a tropical thunderstorm, he reached Mach 0.96 in an uncontrolled dive

Was he shooting a line? Maybe! Many years back, I was in conversation with an elderly Spitfire pilot, and I asked how fast he got in dives. “Very fast” he said. “But one time I was on the ground, and I heard a very peculiar explosion. It was just like the sonic bangs at the airshows of the fifties. Then, just afterwards, I saw a Spitfire pulling out of a dive”. So perhaps the Americans were not the first, and the immortal Spitfire was on the point of creating another legend!

Fig 4: Spitfire IX Dive to Mach 0.89



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