$$V_{MAX} = \sqrt{(35{\cdot}18\sqrt{(518{\cdot}7 - (3{\cdot}57A/1000)) \times (1 - (0{\cdot}568(T/H))2)] - (0{\cdot}0357P \times R \times D)^2}}$$

THE OTHER SOUND BARRIER

Supersonic shockwaves — the true limiting factor for propellers?

In the wake of his investigation into the Westland Whirlwind fighter's notorious propulsion problems in *TAH20*, **MATT BEARMAN** set about delving further into the complex, often counterintuitive, world of propellers and the forces at play on them. The results were surprising — and could potentially rewrite the history behind some enduring myths and mysteries

IN THE EVENING of September 2, 1940, Avro's chief test pilot, Harry "Sam" Brown, looked on disapprovingly as Mr Gillmore once again took a spanner to the propeller hub of the company's latest bomber prototype, Avro Manchester L7246, at Woodford. Brown then turned his attention back to writing his daily log: "The chap from de Havilland doesn't seem to know his job".[1] The following day he recorded making a decision; he would not fly the aircraft again until its propeller problems had been resolved. Brown took L7246 up again on September 27 — only to be disappointed once more: "Eighth attempt; 43min flight in fairly good weather. Propellers badly adjusted and hydraulic pumps failed".

The Manchester just hadn't been right from the start. Of course it was the Rolls-Royce Vulture engines that were the problem — or so it seemed — just as the same company's Peregrines had been for the Westland Whirlwind (see the author's *The Whirlwind Becalmed* in *TAH20*). The thing just would not go as fast or as high as the design calculations had said it should. That could surely only be the engines, and the apparent incompetence of the propeller people had compounded it. Sometimes the blades just wouldn't come out of fine pitch no matter how much power was put on, or however much the "coarse" switch was held down on the Exactor pitch control. The latter eventually lost pressure altogether, which didn't help — much as with the Whirlwind, in fact.

If a pilot did manage to come out of fine pitch, the Manchester would get up to altitude and just get noisier and noisier until the pitch mechanism did something alarming or the quill-shaft driving the hydraulic pump broke. There was also the vibration of the engine, aeration of the oil and overheating to contend with. Brown's log continued the litany of setbacks:

"April 25, 1941: L7246, 30min. Had trouble with the propeller-pitch mechanism. Won't fly it again until de Havilland sort[s] the problem.

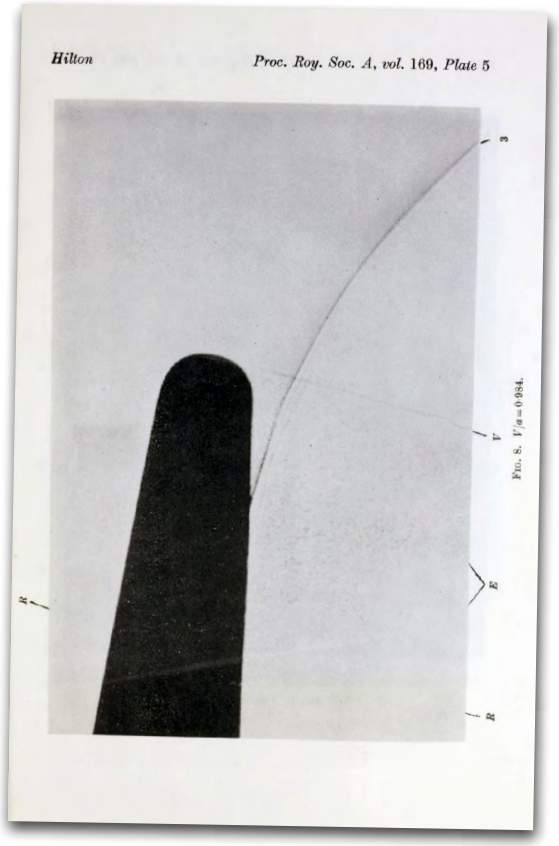
"April 26: L7246, airborne 25min. Propellers still very unsatisfactory.

"April 28: L7246, take-off 1130hr. Pitch mechanism better but still wanting adjustment."

Later that afternoon he wrote, "with Mr James of Rolls-Royce and Mr Gillmore of de Havilland. Take-off 1500hr; 5min after take-off the starboard Vulture packed up. Staggered back to Woodford and forced-landed with great difficulty".

One Avro engineer told Robert Kirby, author of the excellent *Avro Manchester — The Legend Behind the Lancaster* (Fonthill Media, 2015): "We used to listen to Manchesters taking off from Woodford. If the whine of the propellers continued after 1,000ft [300m] and hadn't changed into coarse [pitch], sure enough there'd be a 'bang' as the unit went and then the engine failed".

Rolls-Royce issued "Modification 44" in June 1941. As well as altering nut-tightening limits and relieving the strain on con-rods it also reduced permissible r.p.m. from 3,200 to 2,850. Now the engines began lasting as long as they were supposed to — 120hr between overhauls, rising to 180 with experience. The curious thing about this change was that performance also improved. The Aeroplane & Armament Experimental Establishment (A&AEE) at Boscombe Down had already noted this during acceptance trials. Counter-intuitively, reducing r.p.m gave shorter take-off runs and higher maximum true airspeeds (TAS).[2]



VIA AUTHOR

ABOVE ***The "smoking gun"? In 1938 Professor W.F. Hilton took this photograph of a supersonic shockwave produced by a propeller blade moving at Mach 0·984. The wave (the curved line coming off the prop about two-thirds of the way up its length) leaves the surface at the point where the flow becomes supersonic, and is essentially a "mini sonic boom".***

OPPOSITE PAGE ***The Avro Manchester prototype L7246 with its original twin-finned tail, before a third central fin was added. The Manchester made its first flight in the hands of "Sam" Brown at Ringway on July 25, 1939, but suffered from recurrent powerplant problems and in total only 202 were ultimately built.*** PHILIP JARRETT COLLECTION