R.A.E. Technical Note No.Aero 1106 (Misc.) (Revised)

Comments on N.A.C.A. Advance Confidential Reports Nos.A.R.C. 6423 and 6422 - "Stalling characteristics of a Supermarine Spitfire VA airplane" by Vensel and Phillips and "Measurements of the flying qualities of a Supermarine Spitfire VA airplane" by Phillips and Vensel. September, 1942.

by

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1. The recording instruments fitted to the aircraft for the purpose of a programme of handling tests were:-

1. Time recorder.
2. A.S.I. recorder.
3. Aileron angle recorder.
4. Elevator angle recorder.
5. Rudder angle recorder.
6. Rolling velocity recorder.
7. 3-axis accelerometer.
8. Sideslip vane.
9. Recording inclinometer (bank).
10. Recording inclinometer (pitch).
11. Elevator force recorder.
12. Rudder force recorder.
13. Aileron force indicator (visual).

Synchronised records of these instruments were obtained during various manoeuvres, including take-off, landing and stalling. As a result a considerable body of valuable data was amassed in 18 hours flying, and the results are worthy of careful study by all those interested in the flying qualities of modern fighters. Nevertheless, the final conclusions could mostly have been reached with less elaborate apparatus; while the information obtained could have been very usefully extended - in view of the apparatus available - if the aircraft had been treated primarily as a fighting machine.

2. Important handling qualities which must be investigated on a fighter may be grouped under the following heads:-

(i) Stability and control in a high speed dive.
(ii) Stability and control at medium and low speeds.
(iii) Turning circles at medium speeds.
(iv) Ease of take-off and landing.
(v) Stalling behaviour.

The adequacy with which these points have been covered during the American tests is discussed briefly below.

2.1. Stability and control in a high speed dive. This was not touched, since the highest speed attained during the tests was 295 m.p.h. V_i. Neglect of the vital speed region round 400 m.p.h. V_i resulted in erroneous conclusions being drawn from the measurements at lower speeds. For example it is stated that "there was very little reduction in aileron effectiveness either by separation of flow near minimum speed or by wing twist at high speeds". Actually, of course, loss of aileron power due to wing twist at high speeds is one of our biggest problems on the Spitfire - at 400 m.p.h. V_i about 65% of the aileron power is lost thereby.

2.2. Stability and control at medium and low speeds. This was covered admirably, with the exception of static longitudinal stability. Trim curves at two C.G. positions were not done, so that the neutral points remained undetermined. Qualitatively and quantitatively (stick force per g, aileron heaviness and response, etc.) the conclusions agree closely with results obtained at the Royal Aircraft Establishment.

2.3. Turning circles at medium speeds. From a handling viewpoint the important measurement required here is C_L max. on the glide and at full throttle; knowing this, the turning performance may be estimated from a knowledge of the straight flight performance. The only reliable method of obtaining C_L max. in flight is by use of swivelling pitot and a trailing static head. Operation of a trailing static head from a single seater is admittedly awkward, but has been done successfully on the Spitfire, Me 109, Whirlwind and Buffalo.

Values for flaps up C_L max. on the Spitfire, measured in this way at the Royal Aircraft Establishment, are 1.36 on the glide and 1.89 at full throttle. During the American tests reliance was placed on a swivelling pitot-static head mounted on a pole ahead of the wing tip, the readings being corrected by applying a position error correction (obtained by flying in formation with an aircraft of known position error). As a method of measuring stalling speeds this is thought to be unreliable, and the values of C_L max. quoted (between 1.1 and 1.2 flaps up) appear to be unduly low; C_L max. at full throttle was not obtained. The conclusion that "the excellent stall warning is obtained at the expense of a high maximum lift coefficient" is not borne out by the Royal Aircraft Establishment measurements quoted above.

2.4. Ease of take-off and landing.

Complete time histories of all three control movements during take-off and landing are given, and are of considerable interest, since records of this type are scarce. Angle of sideslip was also measured, by taking the mean of the readings of two vanes mounted on poles ahead of each wing tip. The take-off sideslip records exhibit extraordinary features. They suggest that with wings level the aircraft starts the take-off run with a sideslip angle of nearly 20°, has a sideslip angle of about 11° at take-off, and when climbing at 120 m.p.h. V_i, 14 seconds after take-off, still has a sideslip angle of 8°. The Americans have obtained similar records on other single seater fighters, and told us that during the take-off the pilot has no sensation of skidding - his pendulum needle is central. Our present view is that the apparent sideslip probably arises from vane calibration errors, but this is a matter which might profitably be explored further.

2.5. Stalling behaviour. Our own information on the character of the stall of the Spitfire is in general agreement with the N.A.C.A. report on the Spitfire VA, but measurements of stalling speed at the Royal Aircraft Establishment gave a higher C_L max. for the Spitfire I as mentioned and discussed in §2.3. The characteristic root stall followed by a separation of flow at the tip of the wing had been noticed in some flight tests in 1940, as also the suppression of root turbulence with engine on.