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Interim note on fighter aileron comparison F.W.190

by

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1. Introduction

Considerable interest in the ailerons of the F.W.190 was aroused during preliminary handling trials. The pilots considered the ailerons to be extremely effective, and on this score, thought that the F.W.190 had a definite advantage over our own fighters. In view of these opinions, and also for comparison with the aileron performance standards laid down in A.D.M.295, detailed aileron tests were deemed desirable.

2. Description of ailerons

The ailerons are Frise type with a fairly sharp nose, and are fitted with small metal trimming tabs which are only adjustable on the ground. The covering is fabric, but the rib spacing is close - about 4¼ in. between adjacent rib centres. Each aileron is supported by three hinges, and the gaps in the ailerons for accommodating these are well sealed. The operation is through push-pull rods, the friction on the ground being extremely small.

Relevant geometrical details of the wing and ailerons are given in Table 1 at the end of this note; drawings of the plan form and section are shown in Fig.1.

3. Results

Synchronised, automatically recorded readings of aileron angle and angle of bank were taken at speeds between 200 m.p.h. A.S.I. and 400 m.p.h. A.S.I., using a "rat" to record angles, and a free gyro for measuring angle of bank, the instruments being synchronised by a common electrical timer. Measurements were made both to port and starboard using roughly quarter, half, and three quarters full aileron movement, and in most cases the stick force to apply aileron was noted on a Henschel type stick force indicator. All the observations of the time to bank have been corrected to 10,000 ft.

The steady rate of roll was found to be the same to port and starboard, and proportional to the aileron angle applied. The variation of the steady rate of roll per unit aileron angle with speed is shown in Fig.3, the shape of the curve having been determined by plotting the rate of roll per unit aileron angle in the form shown in Fig.2. From these results the loss in rate of roll due to wing torsion has been calculated, and this loss is also plotted against speed in Fig.3. The calculation, assuming the Glauert correction for compressibility effects, is based on the formula

$$\frac{\text{rate of roll of actual aircraft}}{\text{rate of roll of aircraft with rigid wings}} = 1 - \frac{V_i^2}{V_r^2\sqrt{1 - M^2}}$$

where M is the Mach number, appropriate to V_i, V_i the E.A.S., and V_r the reversal speed (E.A.S.) in an equivalent incompressible fluid. The measured rates of roll on the F.W.190 give a reversal speed (V_r) of 760 m.p.h. E.A.S. (Fig.2).

Stick forces for various aileron angles and speeds are given in Fig.4 where it will be seen that the stick force is roughly proportional to the aileron angle applied, and also follows the 'speed squared' law; there is thus no increase of $-Kb_2$ with speed. This is probably due to the fact that an effort has been made to cut down distortion to a minimum, both by using a small rib spacing and by employing a push-pull rod control circuit. The latter is effective mainly by reducing the variation of the upfloat of the ailerons with speed; from 200 m.p.h. A.S.I. to 400 m.p.h. A.S.I. the upfloat (measured on the starboard aileron) was sensibly constant at 1^o.

Kb_2 has been calculated from the stick force measurements; its value is -0.11, approximately constant over the range of the tests (Fig.4).

It should be pointed out, however, that where Frise ailerons are used, there is liable to be a variation in the feel of the control from aircraft to aircraft. Our pilots, who have now flown three F.W.190s, have, in fact, noticed this variation; they report that the machine on which the measurements were made had rather heavier ailerons than the other two.

Some interesting pictures of F.W.190s banking into tight turns have been obtained by R.A.F. pilots during actual combat, and have been communicated to us by the Operational Research Section of Fighter Command. Fig.5 shows curves deduced from a typical selection which were taken from the attacking Spitfires with the G.45 camera gun. The films chosen were those in which the background showed that the Spitfires were not rolling, so that the curves in Fig.5 represent the actual times to bank of the enemy aircraft. The speed and height are unfortunately not known, but the maximum rate of roll in Fig.4 is about 120 degrees per second. In Fig.6 the steady rate of roll for a stick force of 50 lb. is plotted against speed. From this it can be seen that at 10,000 ft., assuming the pilot does not apply more than 50 lb. to the stick he can generate a rolling velocity of 120 degrees per second at any speed between 170 m.p.h. E.A.S. and 300 m.p.h. E.A.S.

4. Comparison with A.D.M.295 and allied fighter aircraft

The best method of comparison of the rolling performance of different aircraft is based on the steady rate of roll a pilot can generate using a definite stick force, say 50 lb., or full aileron if this requires less than 50 lb. on the stick. This course has been adopted in Fig.6 which shows the results obtained for the F.W.190, Mustang[1], Typhoon[2], and Spitfire V[3] (metal covered ailerons) with both standard and clipped wings. On all these aircraft instrumental records of rolling performance have been obtained at the R.A.E. similar to those under discussion for the F.W.190. In this connection it is worth noting that "instrumentation" is essential when obtaining the curves of Fig.6. Stop-watch measurements of time to bank on fighters are rarely of sufficient accuracy, since the times to be measured are so small.

There is little to chose between the F.W.190 and the clipped wing Spitfire over the whole speed range, although both show a considerable improvement on the standard Spitfire V. The Mustang comes out top at 400 m.p.h. E.A.S. but falls away appreciably below 350 m.p.h.; while the Typhoon has a comparatively poor rolling performance at all speeds.

The A.D.M.295 criterion for aileron performance is expressed in the form of a minimum time to 45° bank using 50 lb. stick force at 400 m.p.h. E.A.S. This minimum time is made proportional to the square root of the wing area. From the analysis of the synchronised aileron angle and angle of bank records on the above aircraft, it appears that on the average it takes a pilot about ½ second to put on an aileron angle corresponding to about 50 lb. when he is trying to apply control quickly. Also, the time to 45° bank is then fairly accurately estimated by assuming the aircraft commences to roll (at the steady rate) ¼ second after the pilot starts to move the stick. On this basis times to 45° bank have been calculated from the results shown in Fig.6, and are compared below with the times required in A.D.M.295. Reversals speeds are also shown in the same table.

Aircraft	Wing area	A.D.M. standard time to 45°	Time to 45° from measured results	Aileron reversal speed
F.W.190	205 $ft.^2$	0.78 sec.	0.85 sec.	760 m.p.h.E.A.S.
Mustang	236	0.83	0.77	850
Typhoon	279	0.90	1.86	740
Spitfire V Standard wings	242	0.84	1.35	580
Spitfire V Clipped wings	229	0.82	0.91	660

It will be seen that the Mustang alone beats the required time, but the F.W.190 and clipped wing Spitfire come quite close to the A.D.M.standard. Both the standard Spitfire V and Typhoon are down on this rolling criterion.

The above results indicate that A.D.M.295 lays down a satisfactory standard for aileron performance at high speeds. From the Mustang results, however, it is seen to be unsafe to assume "good at high speeds, then good at the lower speeds". It should be noted, however, that there have been few complaints in this country of the Mustang aileron performance at medium speeds, while control during the approach and landing is considered adequate; the excellent manoeuvrability at high speeds is greatly appreciated. The Mustang designer has achieved this mainly by cutting down the maximum aileron travel to ±10° from the more conventional ±20°. Any attempt to improve manoeuvrability at medium speeds at the expense of manoeuvrability in the dive would undoubtedly be fiercely resisted.

The above table shows that the aileron reversal speed of the F.W.190 is about average: about the same as the Typhoon, probably less than the Mustang, but greater than the Spitfire V.