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COMPARISON OF AILERON CONTROL CHARACTERISTICS AS DETERMINED IN FLIGHT TESTS OF P-36, P-40, SPITFIRE, AND HURRICANE PURSUIT AIRPLANES

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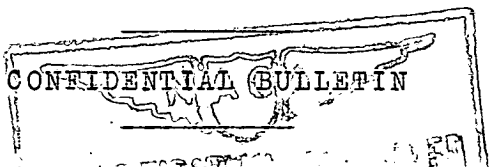

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The Army Air Force has made available several pursuit-type airplanes for quantitative investigation of their flying and handling qualities. One item of special interest obtained from the results of the investigation is a comparison of the aileron control characteristics of the P-36, P-40, Hawker Hurricane, and Supermarine Spitfire airplanes. Figure 1 shows the design characteristics of the ailerons and the control sticks of the four airplanes.

Aileron effectiveness may be expressed in terms of the helix angle generated by the wing tip in a steady roll. This angle is given by the expression $pb/2V$, where p is the rolling velocity, b the wing span, and V the true airspeed, expressed in consistent units. This quantity is convenient to use because, although it does not represent directly the rolling velocity of airplanes of different spans or airplanes operating at different speeds, it provides a satisfactory basis for computing the rate of roll and the time required to bank a given amount under any given set of conditions. The ratio of $pb/2V$ obtained in any roll to the maximum value reached with full aileron deflection indicates the fraction of the maximum aileron travel that was reached. A complete discussion of this criterion for aileron effectiveness is given in reference 1.

The aileron effectiveness of the various airplanes is compared in the following table on the basis of the response obtained with stick forces of 30 and 5 pounds. A force of 30 pounds is somewhat less than the greatest stick force exerted by the pilot. Repeated flight measurements have shown, however, that this force is a reasonable upper limit for maneuvering at high speeds. The comparisons at a stick force of 5 pounds are also included to bring out a rather interesting fact regarding the order of merit of aileron effectiveness for the various airplanes when very light forces are used:

Airplane	pb/2V corresponding to full aileron deflection	pb/2V obtained with 30-lb stick force at 230 mph indicated airspeed (radians)	Rolling velocity obtained with 30-lb stick force at 230 mph indicated airspeed at 10,000 ft (deg/sec)	pb/2V obtained with 5-lb stick force at 230 mph indicated airspeed (radians)	Rolling velocity obtained with 5-lb stick force at 230 mph indicated airspeed at 10,000 ft (deg/sec)
P-36	0.110	.0.035	43	0.007	9
P-40	.080	[a].075	90	.006	8
Hurricane	.082	.057	64	.017	19
Spitfire	.085	.050	63	.012	15

[a]Full stick deflection obtained with 19.5-lb force.

A further comparison of the aileron performance of the four airplanes is given in figure 2, which shows how the control-force characteristics influence the rolling velocities obtained throughout the speed range. The P-40 ailerons are seen to give considerably higher rolling velocities at high speeds than those of the other airplanes. It is apparent from these data that the P-40 ailerons are better adapted than the ailerons of the other airplanes for combat flying.

The ailerons of the P-40 and the P-36 airplanes were identical in shape. On these ailerons the stick force increased linearly with deflection for small deflections, but only a slight increase in stick force was required to move the stick from one-half to full deflection. The aileron systems on the two airplanes differed only in that the maximum deflection of the ailerons of the P-40 airplane was reduced, while the stick travel was increased over that of the P-36 airplane. Thus, for a given speed, the rolling velocity of the P-36 airplane for maximum aileron deflection was greater but, for a given aileron deflection, the P-40 airplane required a smaller stick force than the P-36 airplane because of the increased mechanical advantage of the control stick.

The aileron systems of the Spitfire and the Hurricane airplanes had very similar performance, though the geometric shape of the ailerons was different in the two airplanes. Their stick forces increased linearly with aileron deflection for small deflections but increased much more rapidly near maximum deflection. The mechanical advantage of the control sticks of the British airplanes was less than that of the P-36 airplane.

The ailerons of the Spitfire and the Hurricane airplanes were less effective than the ailerons of the P-40 airplane at high speeds because the large control forces limited the obtainable aileron deflections. For small deflections, however, the ailerons of the British fighter airplanes were very light and responsive. Many pilots were very favorably impressed with the aileron characteristics because of this fact. A true picture of aileron characteristics was obtained only after tests were conducted under simulated combat conditions where large aileron deflections are required.

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REFERENCE

1. Gilruth, R. R., and Turner, W. N.: Lateral Control Required for Satisfactory Flying Qualities Based on Flight Tests of Numerous Airplanes. Rep. No. 715, NACA, 1941.

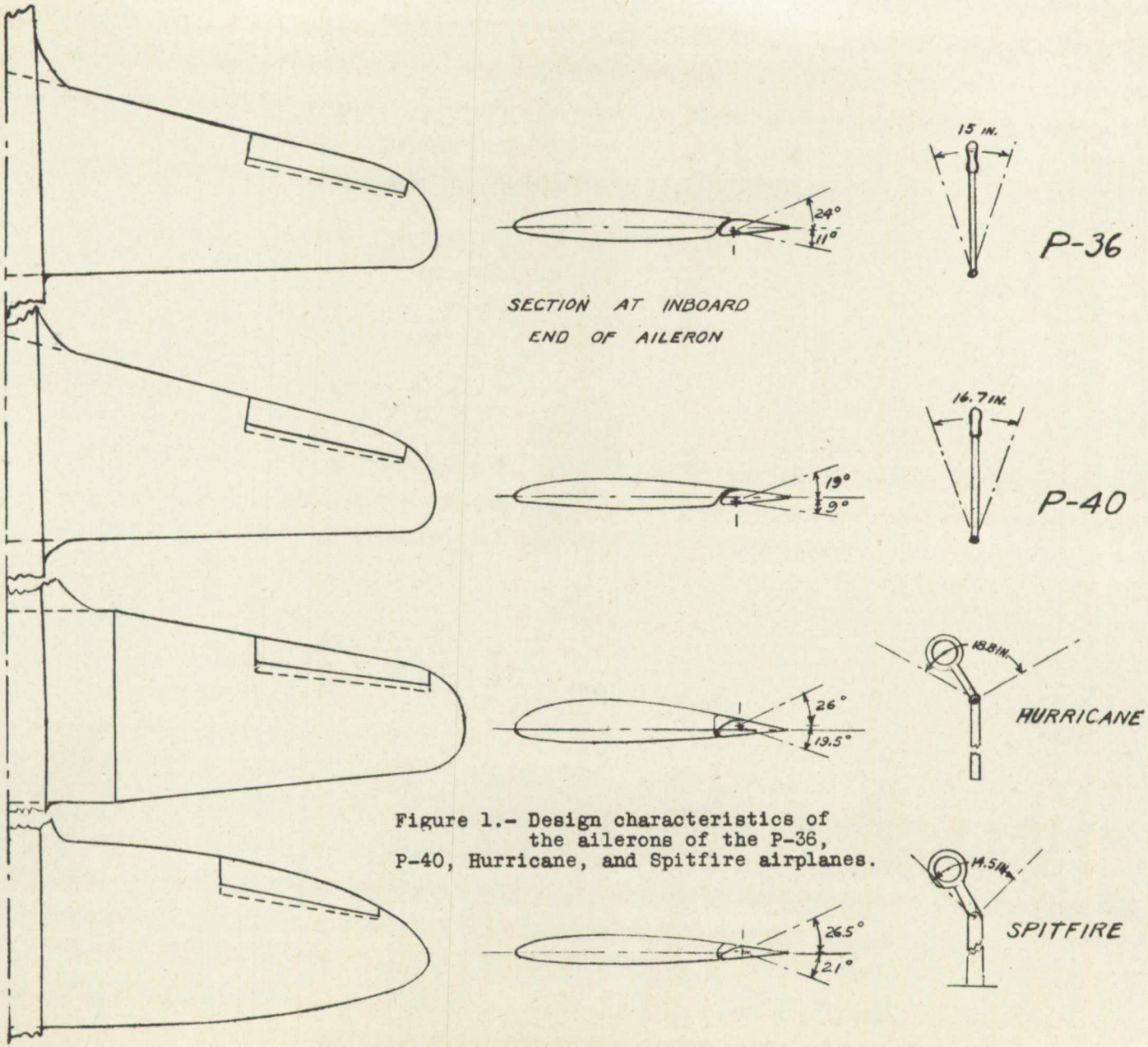

Figure 1.- Design characteristics of the ailerons of the P-36, P-40, Hurricane, and Spitfire airplanes.

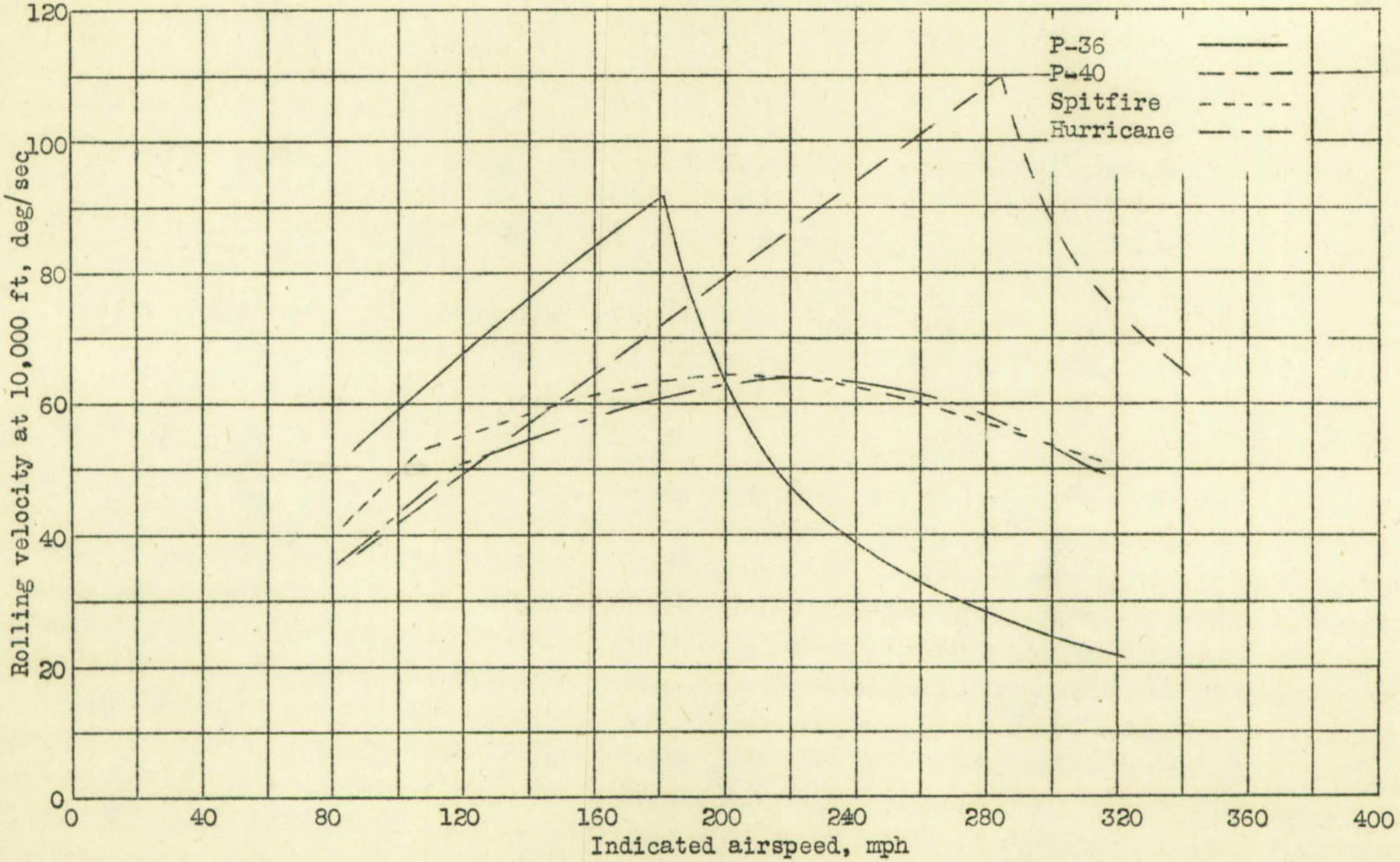

Figure 2.- Rolling velocities obtained with a stick force of 30 pounds at 10,000 feet altitude. On straight portions of curves full aileron deflection is reached with less than 30 pounds force.