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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 701

THE EFFECT OF A GAP BETWEEN ELEVATOR AND STABILIZER ON THE STATIC STABILITY AND MANEUVERABILITY ABOUT THE LATERAL AXIS IN FLIGHT

By Walter Hübner

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THE EFFECT OF A GAP BETWEEN ELEVATOR AND STABILIZER ON THE STATIC STABILITY AND MANEUVERABILITY ABOUT THE LATERAL AXIS IN FLIGHT*

By Walter Hübner

A number of German airplane types have a gap between elevator and stabilizer. The effect of this open space is not generally known, although English wind-tunnel experiments** have shown that even a very small gap exerts a profound influence on the elevator action. The purpose of the present free-flight measurements is to ascertain whether fairing over the gap would actually result in an appreciable improvement.

The airplane selected was a Heinkel HD-32 having the following general characteristics (fig. 1):

Engine:	Siemens SH 12, 112 hp	
Propeller:	Schwarz No. 27068	H = 2.3 m (7.55 ft.) D = 2.6 " (8.53 ")
Wing area		23.6 m^2 (254.03 sq.ft.)
Span, upper wing		10.45 m (34.28 ft.)
Span, lower wing		9.00 m (29.53 ft.)
Airfoil:	Göttingen 422	

*"Flugmessungen über den Einfluss eines Spaltes zwischen Höhenruder und -flosse auf die statische Stabilität und Steuerbarkeit um die Querachse." Z.F.M., June 14, 1932, pp. 318-320.

**Bryant, L. W., and Batson, A. S.: Pressure Distribution Over the Tailplane of B.E.2C. Part I. R.& M. No. 661, British A.C.A., 1919.

Angle of incidence to propeller axis:	
Upper wing	0°
Lower wing	0°
Stabilizer	-3.4°
Leading edge of lower wing behind that of upper wing	0.72 m (2.36 ft.)
Leading edge of mean wing chord behind that of upper wing	0.33 m (1.08 ft.)
Length of mean wing chord	1.35 m (4.43 ft.)
Area of stabilizer	1.38 m^2 (14.85 sq.ft.)
Area of elevator	2.02 m^2 (21.74 sq.ft.)
Span of stabilizer	2.61 m (8.56 ft.)
Span of elevator	3.62 m (11.88 ft.)
Chord of elevator	0.56 m (1.84 ft.)
Length of control lever	0.65 m (2.13 ft.)
Transmission ratio control lever to elevator	1:1.38
Friction in control measured on stand at control stick	1.45 to 1.85 kg (3.2 " 4.08 lb.)
Gross weight during measurement	791 to 814 kg (17.43 to 17.95 lb.)

The test program included open and faired-over gap (fig. 2), different c.g. positions with open and closed throttle in unaccelerated flight, dynamic pressure, elevator displacement, elevator force, and pitching. The force on the stick was determined on the stand with respect to pitching and displacement, this being necessary in order to keep the weights of the control in equilibrium.

The results of closing the gap were distinctly noticeable on the general behavior of the airplane by a lower stick force and enhanced elevator effect. Although no tail landings could be made with gap open, the elevator effect, with gap closed, was such as to make the tail skid touch the ground ahead of the wheels.

The size and the method of closing the gap is indicated in Figure 2. A strip of varnished linen is glued to stabilizer and elevator.

In Figure 3 the lift coefficients are plotted against the elevator displacement with open and closed gap for the same c.g. position. The change in elevator displacement with the lift factor $\partial\beta/\partial c_a$ is shown in Figure 4 versus the c.g. position, along with the magnitude of the static stability by fixed control $\partial c_m/\partial c_a$.* According to figure 4 the limit of the static stability with fixed control lies, for open gap and full throttle, at 26.7 c.g. position, at 28.6 per cent of the mean wing chord with closed gap and at 34.9 and 36.9 per cent of the mean wing chord in throttled flight.

The static elevator effect is $\frac{dc_m}{d\beta} = 0.024$ for open gap in flight with full throttle and $\frac{dc_m}{d\beta} = 0.012$ with throttle closed. With gap closed the static elevator effect is $\frac{dc_m}{d\beta} = 0.034$, with throttle open and $\frac{dc_m}{d\beta} = 0.015$ with throttle closed.

Figure 5 exhibits the results of stick force measurements with open and closed gap. The reduction in stick force by closing the gap amounts to about 1.5 kg (3.3 lb.) in flight with open throttle, or about 60 per cent by low dynamic pressures, and 30 per cent by high dynamic pressures. The improvement in throttled flight lies within measuring accuracy.

The moments impressed by the weight of the elevator control affect the forces which the pilot exerts on the

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*According to experience and in agreement with theoretical considerations the relationship of $\partial c_m/\partial c_a$ to c.g. position r is approximately

$$\frac{d}{dr}\left(\frac{\partial c_m}{\partial c_a}\right) = -1.$$

control stick. The amount of force exerted by these moments with respect to the dynamic pressure was determined by means of the pitching and the stand measurement shown in Figure 7, after which the stick force which the pilot would have to exert, if the control were weightless, was computed. (Fig. 6.) Its reduction, by covering the gap, averages about 20 per cent for open throttle flight.

The elevator moment coefficients with open and closed gap are not summarily comparable, since they depend upon elevator displacement as well as upon angle of attack. But by equal angle of attack, different elevator displacements are always present with closed and open gap, for which reason it was deemed superfluous to illustrate them

The improvement in static stability and controllability resulting from fairing over the gap between elevator and stabilizer is such as to almost make it mandatory, especially since it is a comparatively simple matter and inexpensive.

SUMMARY

The effect of closing the gap between elevator and stabilizer on the static stability and controllability is tested in free flight. Faired over, the stability range with fixed control is improved 2 per cent of the mean wing chord in flight with open and closed throttle. The static elevator effect rose by ~ 40 per cent in full throttle flight, and by ~ 25 per cent in closed throttle flight.

The effect of closing this gap was a noticeably lower elevator force and improved elevator effect, particularly when landing.

On the basis of these results the closing of the gap is recommended.

(The application of these data on a commercial airplane of 4,000 kg (8,818 lb.) likewise resulted in appreciably lower stick forces at full throttle and a decidedly greater elevator effect. The landing characteristics (tail landing) were also improved.)

Translation by J. Vanier,
National Advisory Committee
for Aeronautics.

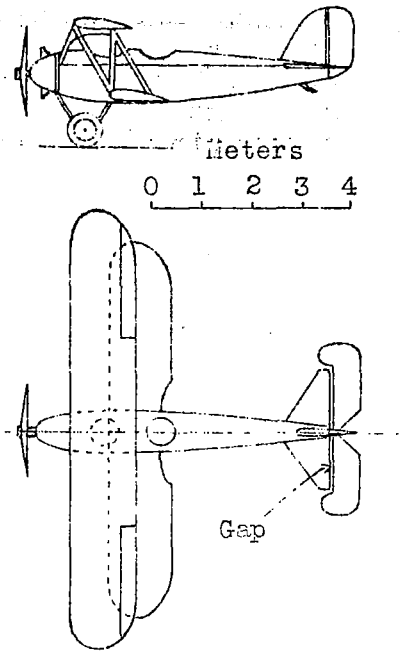

Figure 1.- Heinkel HD 32.

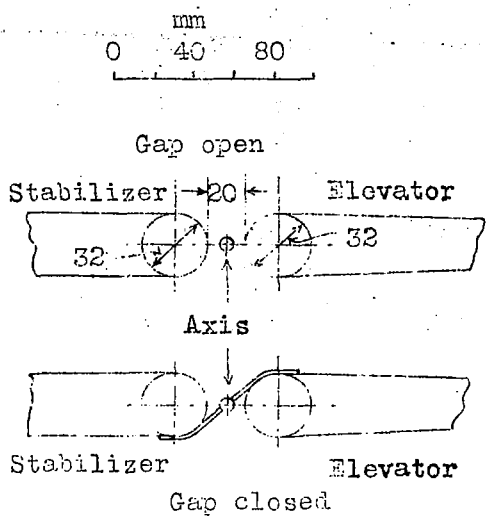

Figure 2.- Size of gap and method of closing.

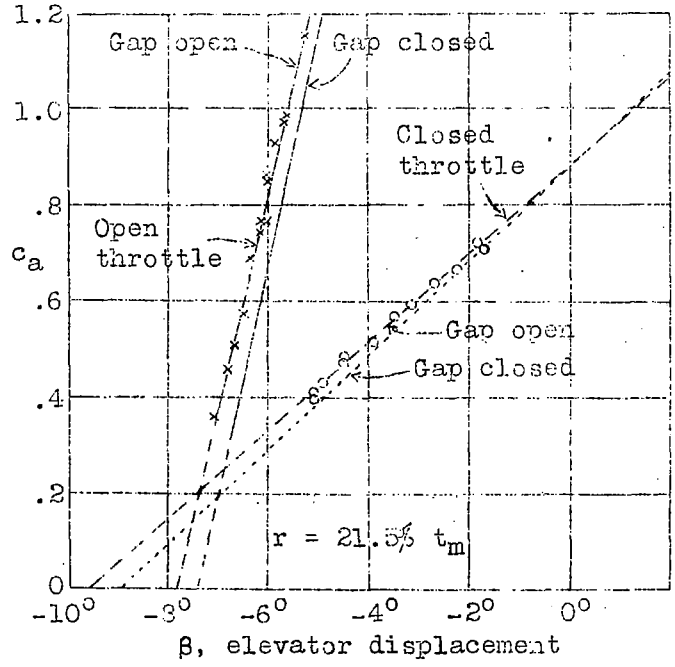

Figure 3.- Elevator displacement with gap open.

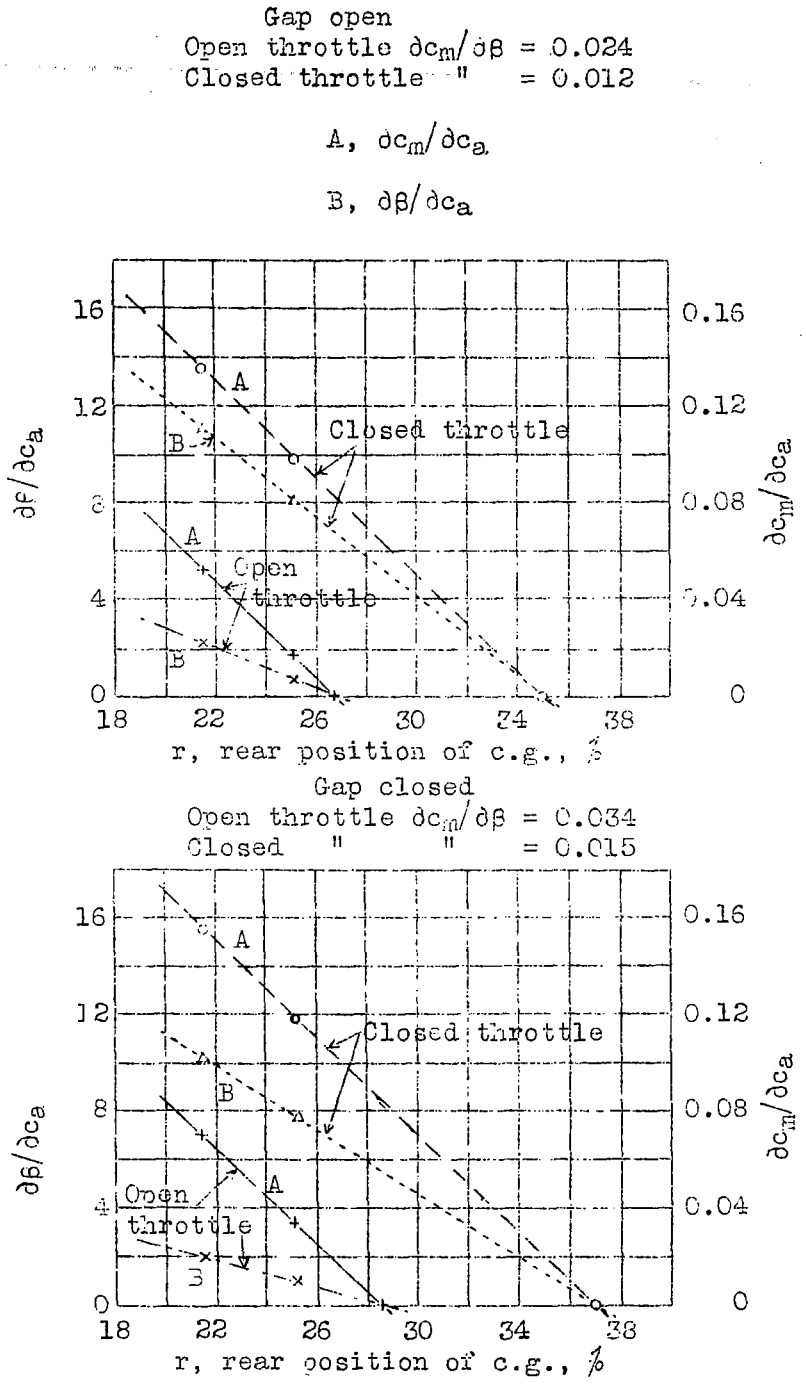

Figure 4.- Comparison of static longitudinal stability and controllability by open and closed gap.

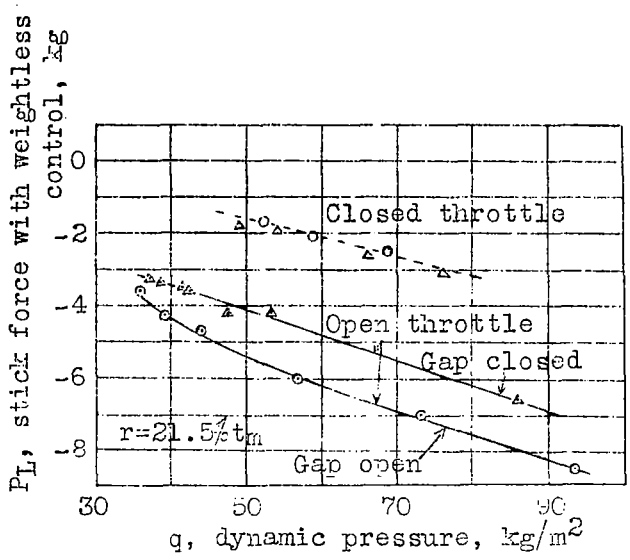

Figure 5.- Stick forces by open and closed gap.

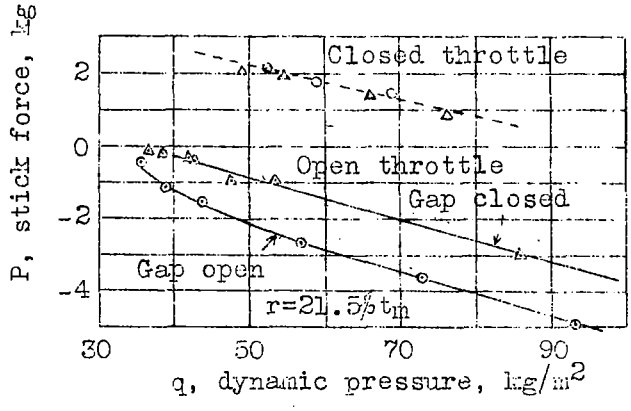

Figure 6.- Stick forces when assuming weightless control, showing those set up exclusively by the air loads on the tail.

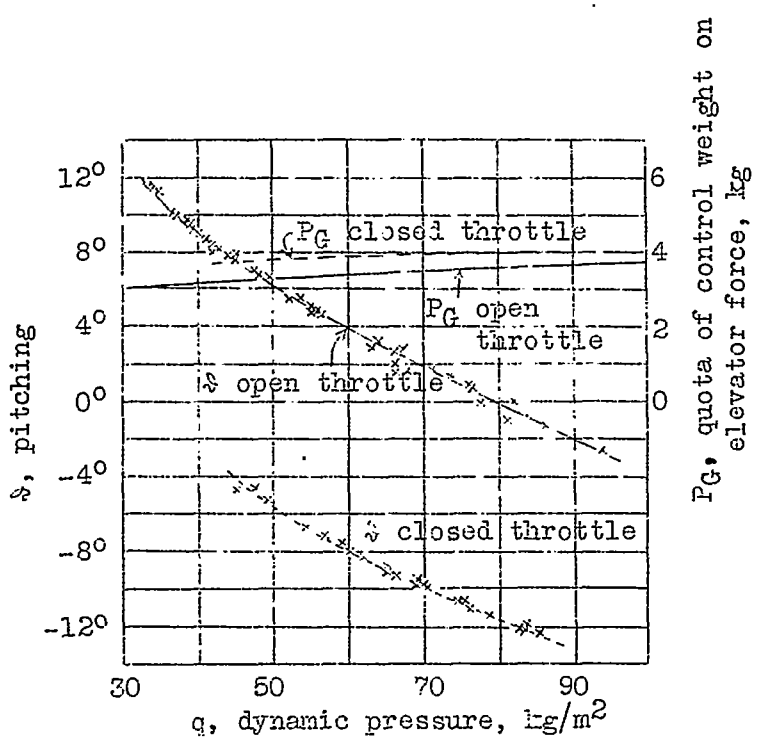

Figure 7.- Pitching versus dynamic pressure. The proportion of the control weights to the stick force at the stick: P_G.

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