MR Nov. 1941

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED
November 1941 as
Memorandum Report

TESTS OF A 0.1475c AILERON WITH A TAB ON LOW-DRAG SECTION FOR CURTISS XP-60 AIRPLANE IN THE LOW-TURBULENCE TUNNEL

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WASHINGTON

L-117

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for

Materiel Division, Army Air Corps

TESTS OF A 0.1475c AILERON WITH A TAB ON LOW-DRAG SECTION FOR CURTISS XP-60 AIRPLANE IN THE LOW-TURBULENCE TUNNEL

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INTRODUCTION

Preliminary two-dimensional tests of the hinge-moment characteristics of a 0.1725c internally balanced aileron on the subject XP-60 wing section indicated that more internal balance would be required if light stick forces were to be obtained at high speeds. The present series of tests were therefore undertaken in order to investigate methods of reducing the slope of the hinge-moment curve while still maintaining the required aileron effectiveness.

TESTS AND RESULTS

Measurements of the hinge moment and lift coefficient were made in the low-turbulence tunnel on an aileron having the following characteristics:

aileron chord, c_a = 0.1475c

aileron overhang = $0.60c_a$

aileron tab = $0.26c_a$

where c = wing chord

The ends and gap between the leading edge of the aileron and the model were sealed as shown in figures 1 and 2. The effective balance, that is, the distance from the hinge point to the middle of the gap, is $0.689c_a$. Because this aileron was of shorter chord than those previously tested on this model, the skirts overhanging the aileron were extended. One-eighth-inch clearance was maintained between the skirt ends and the aileron.

Tests were made with the following tab motions:

motion no. 1, tab locked . . . $\delta_t = 0$ degrees

motion no. 2, tab leading . . $\delta_t = \frac{\delta_a}{4}$ degrees

motion no. 3, tab leading . . $\delta_t = \frac{\delta_a}{2}$ degrees

motion no. 4, tab leading . . $\delta_t = 4.77 \sin 8\delta_a$ degrees

where

δ_t is the tab deflection relative to the aileron deflection, and

δ_a is the aileron deflection

The relations, motions no. 2 and no. 3, were obtained with a simple bar linkage. The relation, motion no. 4, was obtained with the geared mechanism shown in figures 3 and 4.

The results of these tests are given in figures 5 and 6.

DISCUSSION

In figure 5, the aileron with motion no. 1 (tab locked) was overbalanced except at the outer limits of the aileron motion. Because of this overbalance, a leading tab was added which would increase the effectiveness of the 0.1475c aileron as well as reduce the overbalance. As shown, the aileron with motion no. 2 $\left(\frac{\delta_t}{\delta_a} = 0.25\right)$ was still slightly overbalanced for small deflections although the effectiveness was increased slightly over that for the aileron with the tab locked. With motion no. 3 $\left(\frac{\delta_t}{\delta_a} = 0.50\right)$, the aileron was slightly underbalanced, giving a negative slope of the hinge-moment curve throughout the range of aileron deflections. The effectiveness was again increased due to the faster tab motion.

Data for motion no. 4 ($\delta_t = 4.77 \sin 8\delta_a$) given in figure 6 show that the sinusoidal tab motion results in a nearly linear relation between hinge moment and aileron deflection. Although the geared tab gave slightly higher hinge moments than motion no. 3 in the range of low aileron deflections, the hinge moments using motion no. 4 can be varied by a simple adjustment of the amplitude of the tab motion (see fig. 3).

The aileron effectiveness of the 0.1475c aileron with tab motions no. 3 and no. 4 was practically the same as the effectiveness of the 0.1725c aileron obtained in the preliminary tests.

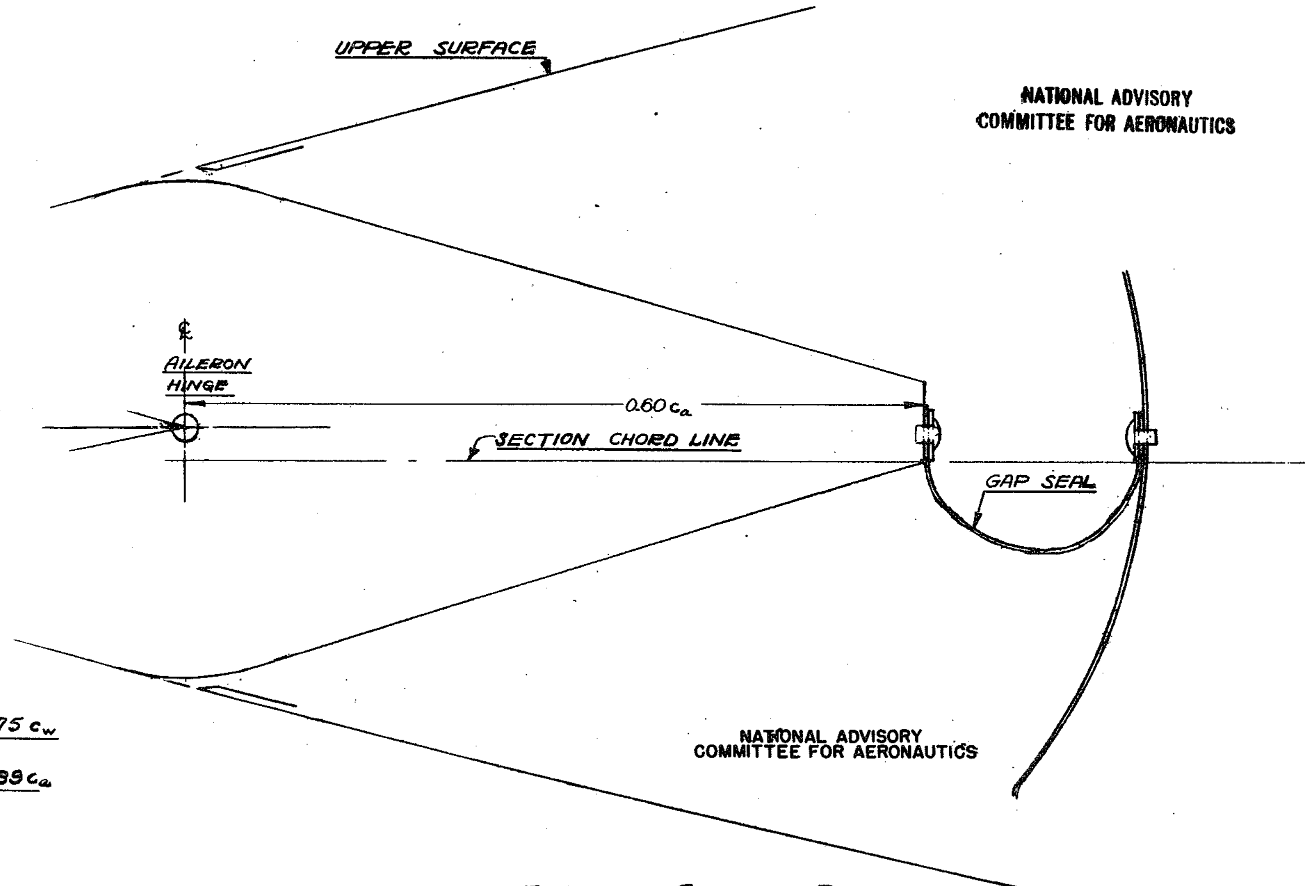
Other qualities of the aileron in addition to those given directly in figures 5 and 6 have a bearing on the choice of aileron design. It may be pointed out that the arrangement with a simple leading tab has certain advantages over the plain aileron. The tab rate can be easily adjusted during flight testing to give the desired range of stick forces. Furthermore, an analysis of the data indicates that the change in hinge moment due to rolling is considerably less for the aileron with a leading tab than for a plain aileron of larger chord having the same effectiveness. When equally balanced in the low-deflection range, the tabbed aileron has slightly lower hinge moments for large aileron deflections than the plain aileron, because of the tendency of the tab to lose its effectiveness at these large deflections, thus relieving the unbalanced hinge moment at a point where the tab is no longer required. The beneficial effect on hinge moments at large deflections is of course smaller than with the geared tab, for which it is possible to effect large reductions in the hinge moments at large aileron deflections.

Comparison of these two-dimensional results with similar tests on the left wing panel of the 0.36-scale model tested in the 7- by 10-foot tunnel shows a discrepancy in the percent balance needed to give zero slope to the hinge-moment curve. The two-dimensional results from the low-turbulence tunnel show that on an aileron without a tab an effective balance of $0.62c_a$ is required; whereas the necessary percent balance, as judged from the 7- by 10-foot tunnel data, is $0.56c_a$. About one-half of this discrepancy may be due to a decrease in the unbalanced portion of the hinge moment caused by three-dimensional flow at the ends of the aileron. The remainder of the discrepancy remains unexplained, although scale effects and the effects of model supports may account for some of the difference between the tests in the two tunnels.

CONCLUSIONS

The data presented in this report show several possible arrangements for obtaining low aileron hinge moments while maintaining aileron effectiveness. The simple leading tab has some important advantages over the plain aileron and is suitable for use when extreme aileron travel at high speed is not necessary. If low hinge moments are required with large aileron deflections, the geared arrangement appears to be satisfactory from the aerodynamic point of view.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Virginia, November 29, 1941.



WING CHORD = c_w
AILERON CHORD = c_a = 0.1475 c_w
BALANCE = 0.60 c_a
EFFECTIVE BALANCE = 0.689 c_a

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FIG. 1 AILERON BALANCE
STA. 122
SCALE - FULL

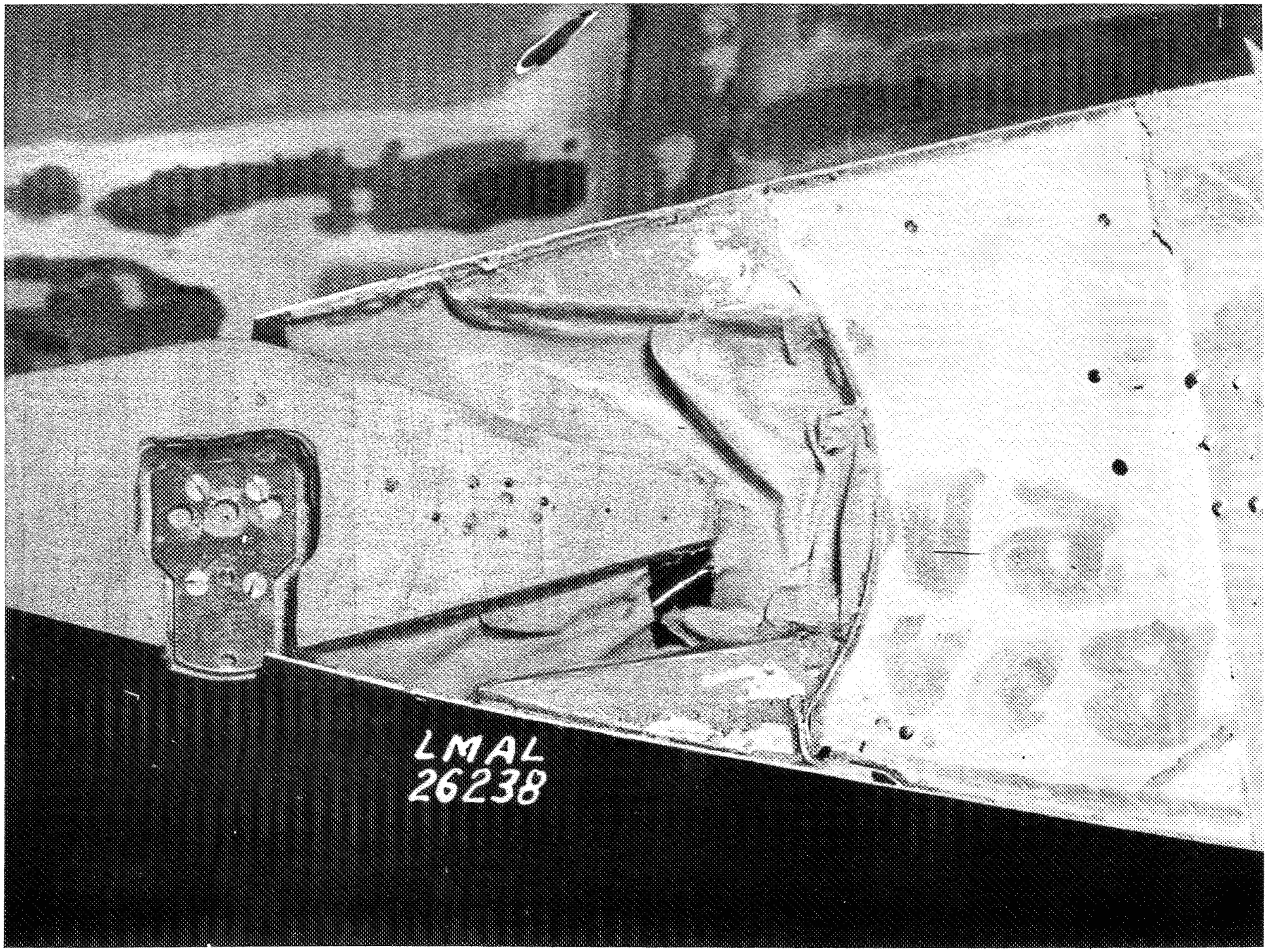
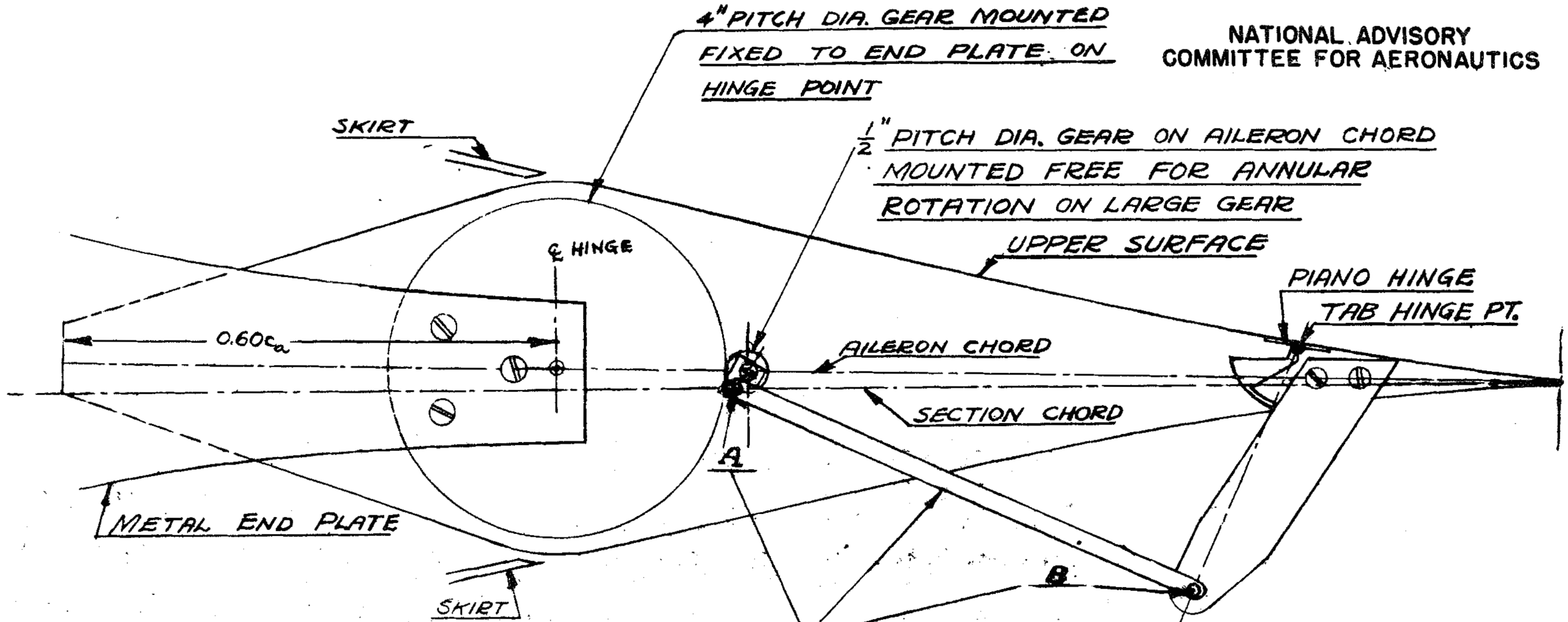


Figure 2.- The 0.1475c aileron showing rubber end seal.



NOTE: THE RATIO OF PITCH DIA'S. OF THE GEARS DETERMINES THE FREQUENCY OF THE SINUSOIDAL MOTION. THE BAR LINKAGE DETERMINES THE AMPLITUDE.

REDUCING LINKAGE FOR CONTROLLING THE AMOUNT OF TAB DEFLECTION. THE PIVOTS "A" & "B" ARE ON TANGENTS OF THEIR RESPECTIVE ARMS. RADIUS ARM AT "A" BEING 1/12 OF RADIUS ARM AT "B".

FIG. 3 CURTISS LOW DRAG SECTION – AILERON
NO SCALE
AILERON CHORD, $c_{a_s} = 0.1475 c_w$
TAB = $0.26 c_a$

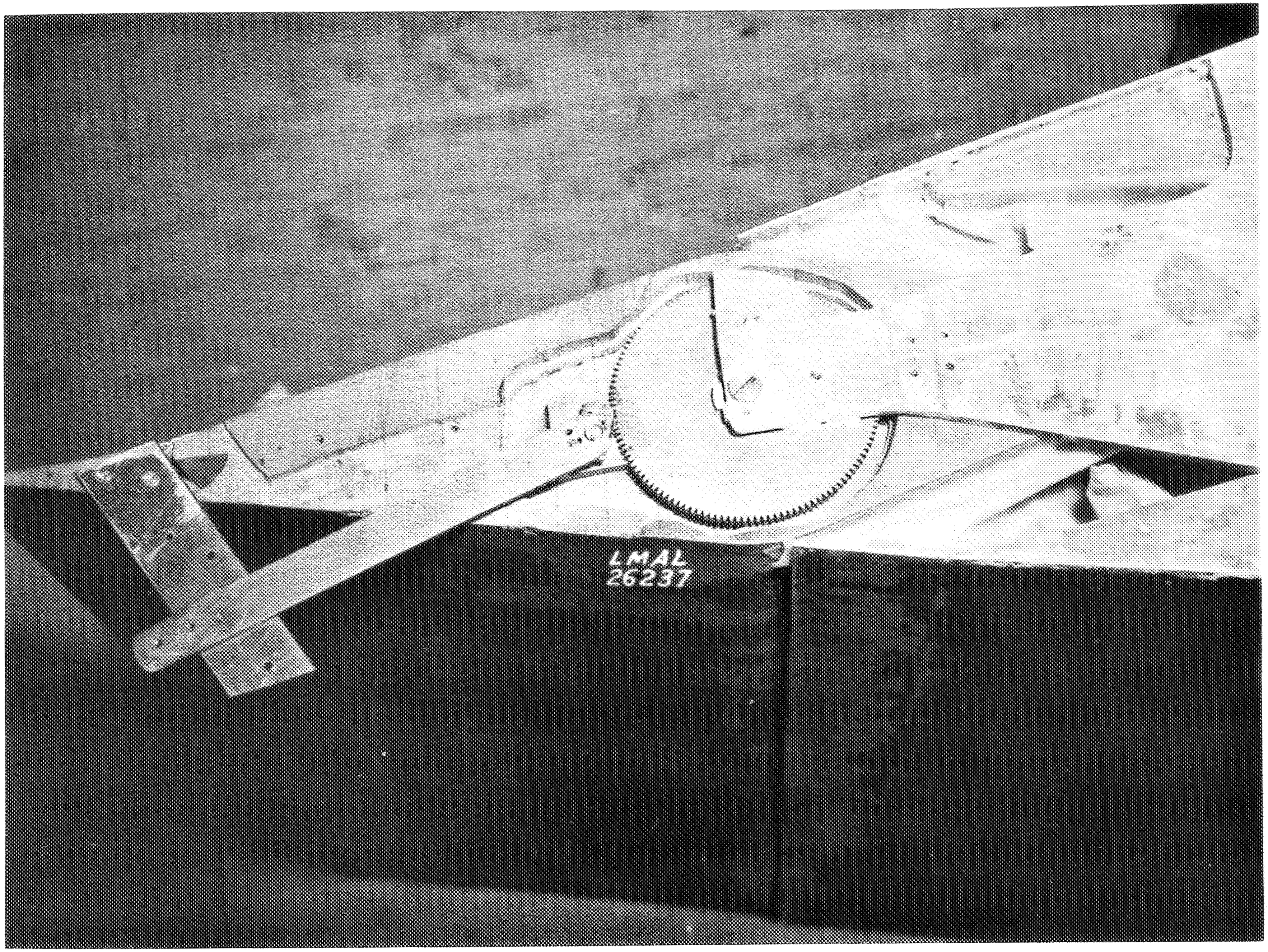


Figure 4.- The 0.1475c aileron showing geared tab mechanism.

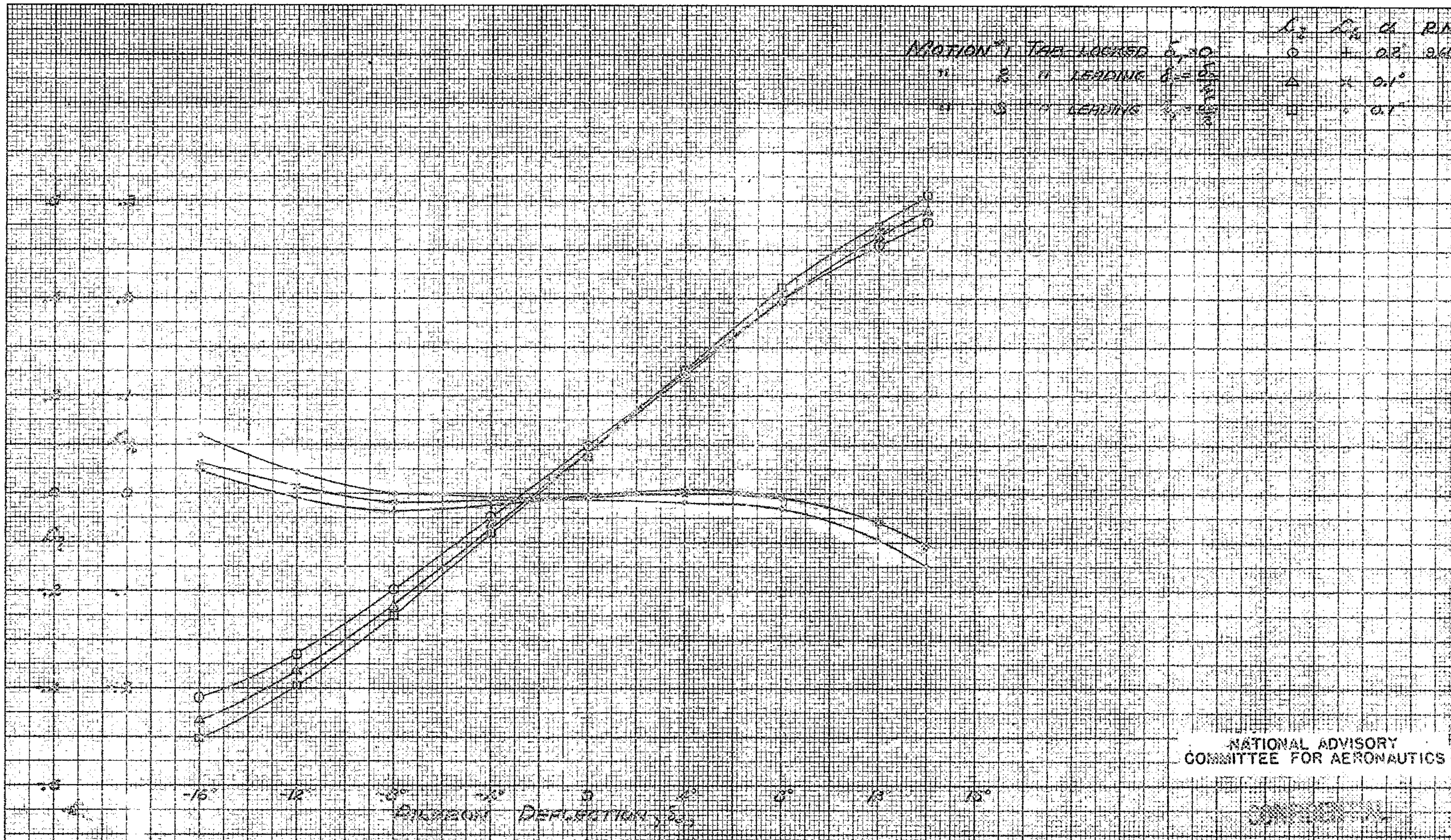


FIG. 5 CURTISS LOW DRAG SECTION – NACA 66, 2-116 (approx.)
XP-60 80.5 INCH CHORD
AILERON —— 0.1425 c_w CHORD, 0.583 c_a BALANCE, AND
0.25 c_a TAB
GAP AND ENDS SEALED

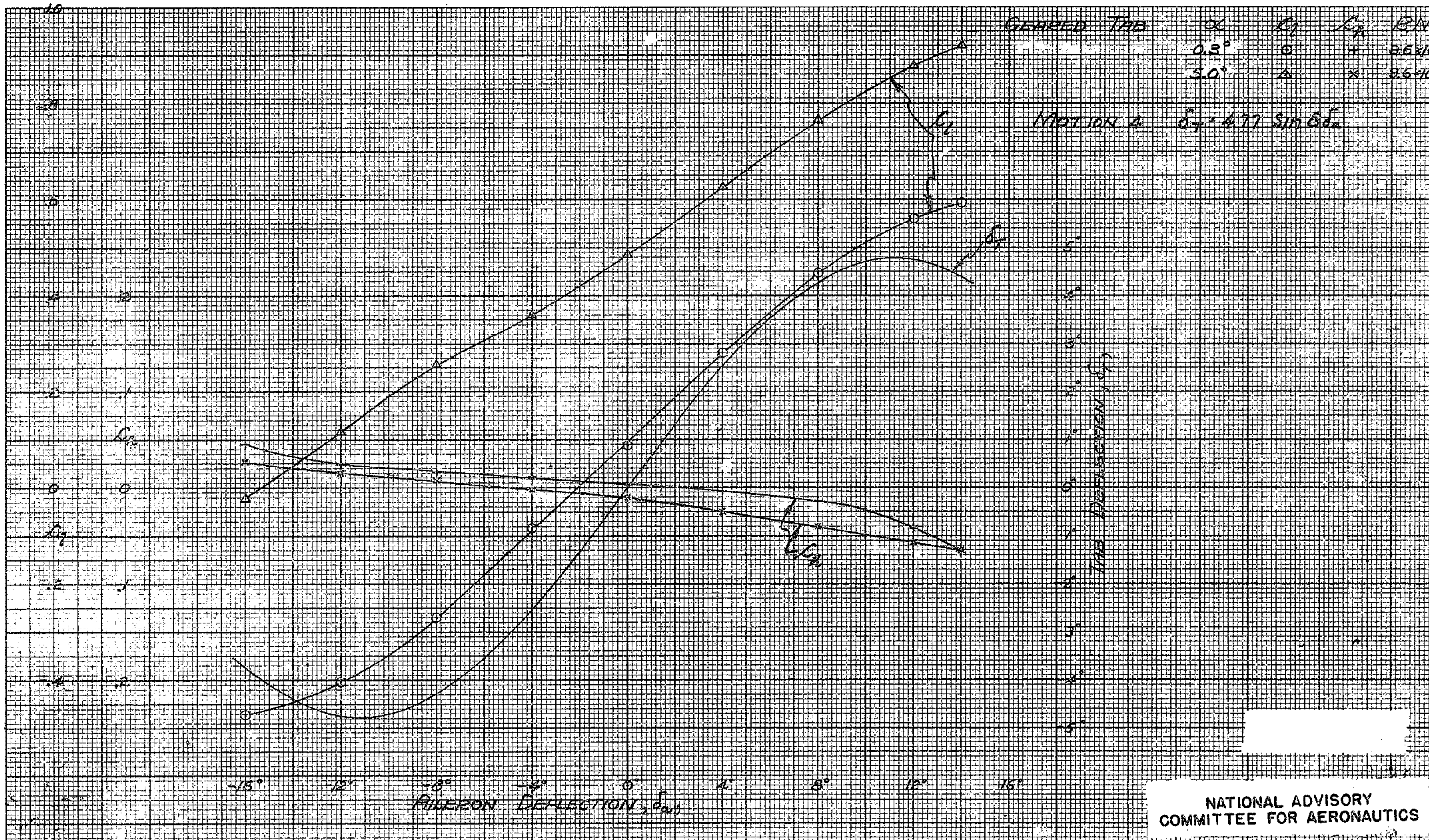


FIG. 6 CURTISS LOW DRAG SECTION – NACA 66,2-116 (APPROX.)
XP-60 80.5 INCH CHORD
AILERON 0.1475 C_w CHORD, 0.659 C_a BALANCE, AND 0.25 C_a TAB
GAP AND ENDS SEALED