RESEARCH MEMORANDUM

TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF TWO
NACA 7-SERIES TYPE AIRFOILS EQUIPPED WITH
A SLOT-LIP AILERON, TRAILING-EDGE FRISE
AILERON, AND A DOUBLE SLOTTED FLAP

By

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
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TWO-DIMENSIONAL WIND-TUNNEL INVESTIGATION OF TWO
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SUMMARY

A two-dimensional wind-tunnel investigation was made of two
NACA 7-series type airfoils of approximate 17.7-percent chord and
15.4-percent chord thickness, each equipped with a 30-percent-airfoil-
chord double slotted flap, a slot-lip aileron, and a trailing-edge Frise
aileron with two amounts of aerodynamic overhang balance. Airfoil lift
and drag, Frise aileron hinge moment, and slot-lip aileron hinge moment
were measured for both airfoils through a large range of deflection of
flap, Frise aileron, and slot-lip aileron and section angle of attack.
The data presented indicate that for a wing having a profile of the
NACA 7-series type, a slot-lip aileron can be combined with a trailing-
edge Frise aileron on a full-span double slotted flap so as to provide
satisfactory lateral control characteristics at large flap deflections.

INTRODUCTION

The use of full-span flaps on large airplanes with high wing loadings
to obtain the required high values of maximum lift coefficient for landing
and take-off has complicated the problem of obtaining satisfactory lateral
control during both the high-lift and high-speed flight conditions. A
collection of available test data on lateral-control devices used in con-
junction with full-span flaps is presented in reference 1. A system con-
sisting of plain trailing-edge ailerons for the flaps-up condition and
slot-lip ailerons for the flaps-down condition has proven satisfactory.
Only a limited amount of data is available, however, on this type of
lateral-control system on low-drag-type airfoils equipped with double
sloTTed flaps.
A two-dimensional investigation was made in the Langley two-dimensional low-turbulence pressure tunnel of two NACA 7-series-type airfoils of approximate 15.4-percent chord and 17.7-percent chord thickness, each equipped with a double slotted flap, slot-lip aileron, and straight-sided trailing-edge Frise aileron. The Frise ailerons were tested with overhang balances of 35.1 percent and 40.8 percent of the aileron chord. Tests were made at a Reynolds number of $6 \times 10^6$ and included measurements of airfoil lift, drag, and aileron hinge moments through a wide range of deflection of flap and ailerons.

**SYMBOLS**

The symbols used in the presentation of results are defined as follows:

- $c_l$: airfoil section lift coefficient
- $c_d$: airfoil section drag coefficient
- $\Delta c_l$: increment of airfoil section lift coefficient
- $c_{ha}$: Frise aileron section hinge-moment coefficient ($\frac{h_a}{\eta c_a^2}$)
- $c_{h2}$: slot-lip aileron section hinge-moment coefficient ($\frac{h_2}{\eta c_l^2}$)
- $\alpha$: airfoil section angle of attack measured with respect to wing reference line, degrees (fig. 2)
- $\Delta \alpha$: increment of airfoil section angle of attack, degrees
- $c$: chord of airfoil with movable surfaces neutral; measured parallel to wing reference line
- $c_a$: chord of Frise aileron measured parallel to wing reference line from hinge axis to airfoil trailing edge
- $c_l$: chord of slot-lip aileron measured parallel to wing reference line from hinge axis to aileron trailing edge
- $c_b$: chord of Frise aileron overhang measured parallel to wing reference line from aileron hinge axis to aileron leading edge
$\delta_f$  flap deflection with respect to wing reference line; positive when trailing edge is deflected downward, degrees

$\delta_a$  Frise aileron deflection with respect to flap; positive when trailing edge is deflected downward, degrees

$\delta_i$  slot-lip aileron deflection with respect to wing reference line; positive when trailing edge is deflected downward, degrees

$R$  Reynolds number based on airfoil chord

$q$  free-stream dynamic pressure

$h_a$  Frise aileron hinge moment per unit span; positive when trailing edge tends to deflect downward

$h_i$  slot-lip aileron hinge moment per unit span; positive when trailing edge tends to deflect downward

$$c_{h_a\alpha_0} = \left( \frac{\partial c_{h_a}}{\partial \alpha_0} \right) \delta_a, \delta_i, \delta_f$$

$$c_{h_a\alpha_a} = \left( \frac{\partial c_{h_a}}{\partial \alpha_a} \right) \alpha_0, \delta_i, \delta_f$$

The subscripts to the partial derivatives denote the variables held constant when the partial derivatives were taken. The derivatives were measured at zero angle of attack and at zero aileron deflection.

MODELS

The airfoils tested were of approximate 15.4–percent chord and 17.7–percent chord thickness and were of the NACA 7–series type (reference 2). Ordinates of the basic airfoils are given in tables I and II. The cusps near the trailing edge were removed by drawing straight lines from the trailing edge tangent to the airfoil contour. A photograph and profile sketches of the models showing the double slotted flap, straight–sided Frise aileron, and slot–lip aileron, hereinafter referred to as "flip," are presented in figures 1 and 2.

The arrangement and pertinent dimensions of the flap and control surfaces are shown in figure 3. The vane of the double slotted flap was fixed with respect to the remainder of the flap and the total flap rotated
as a unit about the hinge axis shown in figure 3. The over all length of the aileron remained constant and the percentage of overhang balance with respect to the aileron chord behind its hinge axis was changed by changing the position of the hinge axis. Overhang balances of 35.1 percent and 40.8 percent of the aileron chord were tested with resulting aileron chords of 0.150c and 0.144c, respectively. The angle of attack of the models was measured with respect to the wing reference line as shown in figure 2. The angle of attack during previous lift tests of the 0.154c thick airfoil with a double slotted flap, contour Fraise aileron, and flip (reference 3) was measured with respect to a different reference line also indicated on figure 2.

The models had chords of 24 inches measured parallel to the wing reference lines and were tested in an aerodynamically smooth condition. All slots were unsealed except for a few tests in which the aileron slot was sealed with modeling clay.

APPARATUS AND TESTS

The models were tested in the Langley two-dimensional low-turbulence pressure tunnel. A description of this tunnel and of the methods by which the lift and drag data were measured and corrected to free-air conditions is given in reference 4. Hinge moments of the Fraise aileron and of the flip were measured with resistance-type electrical strain gages. The corrections to the hinge moments are very small (in the order of 0.003c₁) and, therefore, were not applied.

Drag measurements were made on both airfoils with all movable surfaces neutral and on the 0.177c thick airfoil with only the flap deflected. Lift, aileron hinge moment, and flip hinge moment were measured for both airfoils with the ailerons having overhang balances of either 0.351c₂ or 0.408c₂. The measurements were obtained for a large range of deflection of flap, Fraise aileron, and flip. The scope of the investigation is outlined in table III which may also be used as a figure index for the basic data. The basic lift and flip hinge-moment data obtained on the airfoils equipped with the aileron of larger balance are not presented inasmuch as these data are very similar to the data presented for the smaller aileron balance.

During each test run, the deflections of the movable surfaces were held constant while the angle of attack was varied in both an increasing and a decreasing direction. For some combinations of movable-surface deflection a difference in lift or hinge-moment values existed at the same angle of attack. For these conditions arrows are drawn along the curves to indicate the direction of the change in angle of attack.
The Reynolds number for all tests was approximately $6 \times 10^6$ and the Mach number was less than 0.13.

RESULTS AND DISCUSSION

The basic data are presented in figures 4 to 14 and analysis curves are presented in figures 15 to 23.

Lift Characteristics

The existence of sharp breaks in the lift curves of the 0.154c thick airfoil equipped with a true-contour aileron was indicated in reference 3 for flap deflections of 50° and greater. For this investigation, therefore, the flap deflection of the 0.154c thick airfoil was limited to 40°. A few tests of the 0.177c thick airfoil with a flap deflection of 50° indicated that sharp breaks in the lift curves and unsteady flow conditions also existed (fig. 4(i)). The remainder of the tests on the thicker airfoil, therefore, were limited also to a maximum flap deflection of 40°.

The variations of maximum lift coefficient with flap deflection for the neutral aileron condition are presented in figure 15 for both airfoils tested and for the 0.154c thick airfoil with the true-contour aileron (reference 3). The change in the aileron profile from true to straight-sided contour has no effect on the airfoil maximum lift coefficients at all the flap deflections tested.

The rate of change of maximum lift coefficient with flap deflection for the 0.177c thick airfoil decreases through a range of flap deflection from approximately 20° to 25°, and then increases when the flap is deflected more than 25°. A discontinuity also occurs near this range for the thinner airfoil. This discontinuity is probably caused by the lower-surface skirt of the airfoil which blocks the flow of air through the slot between the flap and the vane of the double slotted flap at low flap deflections. When the flap deflection is large enough to permit better air flow conditions through this slot over the vane, the maximum lift is increased. A similar variation of maximum lift coefficient with flap deflection was shown by tests of a double-slotted-flap model with lower-surface airfoil skirts of different lengths as reported in reference 5.

The maximum section lift coefficients of the 0.177c thick airfoil are lower than those of the thinner airfoil at flap deflections less than approximately 180°. At flap deflections greater than approximately 30°, however, higher values of maximum section lift coefficients were obtained on the thicker airfoil. Values of maximum section lift coefficient of 2.92 and 2.85 were obtained on the 17.7-percent and 15.1-percent thick airfoils, respectively, at a flap deflection of 40° with both ailerons neutral.
Aileron and Flip Lift Effectiveness

The variations of section lift coefficient with aileron deflection and with flip deflection are presented in figures 16 and 17, respectively, for the airfoil at zero angle of attack. In order to facilitate an analysis of the aileron and flip lift effectiveness, values of the increment of section angle of attack required to maintain a constant lift coefficient are plotted against aileron deflection in figure 18 for various flip deflections on both airfoils with the double slotted flap retracted and deflected 25° and 40°. The lift coefficient chosen at each flap deflection for this analysis corresponds to approximately the minimum value of maximum lift obtained throughout the range of deflection of the aileron and flip.

At the double-sloped-flap deflections of 25° and 40° the Frise aileron was generally more effective for negative aileron deflections than for positive aileron deflections on both airfoils with flip neutral. At a flap deflection of 40° on the 15.4-percent-chord thick airfoil, the airflow over the aileron became unsteady and erratically stalled and un stalled at aileron deflections of 5° and greater (figs. 5(g), 5(h), 6, and 18(e)). The effect of sealing the aileron slot was investigated at a flap deflection of 40°, and the results are presented in figures 5(h), 6, and 18(f). Sealing the aileron slot precipitated aileron stall at aileron deflections of 10° and 15° with the flip neutral but tended to prevent the aileron stall at an aileron deflection of 5° with the flip neutral and at an aileron deflection of 10° with the flip deflected -3°. The data for the true-contour Frise aileron (reference 3) indicated that sealing the aileron slot also precipitated aileron stall at aileron deflections of 10° and 15° with the flip neutral at flap deflections of 45° and 50°. Fairing the aileron slot to the aileron contour, however, in addition to sealing the slot eliminated the aileron stall at flap, aileron, and flip deflections of 40°, 10°, and 0°, respectively (figs. 6 and 18(f)).

The variation of flip effectiveness with flap deflection is shown by comparison of figures 18 and 19. With the flap retracted the flip is very ineffective in producing a change in angle of attack at a section lift coefficient of 0.4. A large increase in flip effectiveness occurs with increasing flap deflection with the result that at a flap deflection of 40° the flip is more effective than the aileron. The flip is more effective on the 0.154c thick airfoil than on the 0.177c thick airfoil through the complete range of flap deflection at a flap deflection of 25°. With a 40° deflection of the flap and with the aileron neutral the flip on the thinner airfoil is also more effective than the flip on the thicker airfoil only for flip deflections greater than -10°.

Inasmuch as the change in angle of attack required to maintain a constant lift coefficient is a measure of the rolling effectiveness of a control-surface installation, a study of figure 18 indicates that use of
the flip in combination with the aileron will most likely result in a
rolling effectiveness at a flap deflection of 40° equal to or greater than
the effectiveness of the aileron alone with the flap retracted.

**Hinge-Moment Characteristics**

A large quantity of basic hinge-moment data of the straight-sided
Frise aileron and of the flip is presented as an aid in the design of
similar complex control-surface installations. The discussion of these
data is restricted to the general trends of the hinge-moment parameters
and hinge-moment characteristics that are instrumental in determining the
design of control surfaces and the lateral-control linkage systems.

**Frise aileron.--** The variations of the straight-sided Frise aileron
section hinge-moment coefficient with aileron deflection are presented in
figure 20 for flap deflections of 0°, 25°, and 40°. A summary of the basic
aileron hinge-moment parameters $c_{h\alpha\alpha}$ and $c_{h\alpha} \beta$ is presented in
table IV for a range of double-slotted flap and flip deflections. All
values of $c_{h\alpha\alpha}$ and $c_{h\alpha} \beta$ were determined at zero aileron deflection
and zero angle of attack.

For the 17.7-percent-thick airfoil with the double-slotted flap and
flip neutral, an increase in aileron overhang balance chord from 0.351$c_a$
to 0.408$c_a$ increased positively the values of $c_{h\alpha\alpha}$ and $c_{h\alpha} \beta$
from 0.0003 to 0.0008 and from -0.0034 to -0.0013, respectively. On the
15.4-percent-thick airfoil, the values of $c_{h\alpha\alpha}$ and $c_{h\alpha} \beta$
increased positively from -0.0013 to -0.0002 and from -0.0060 to -0.0037, respectively,
with the increased aileron overhang balance. The increase in aileron over-
hang balance on both airfoils also increased the values of $c_{h\alpha\alpha}$ posi-
tively at double-slotted-flap deflection of 25° and 40° with the flip
neutral, but generally increased the values of $c_{h\alpha\alpha}$ negatively for the
same double-slotted flap and flip configurations.

Deflection of the double-slotted flap with flip neutral, generally
resulted in a negative increase in $c_{h\alpha\alpha}$ and $c_{h\alpha} \beta$ with maximum values
resulting at a flap deflection of 25°. At double-slotted-flap deflections
of 25° and 40°, however, the values of $c_{h\alpha\alpha}$ and $c_{h\alpha} \beta$ varied inco-
sistently with flip deflection for all configurations investigated.
The effects of flip deflection on the neutral aileron hinge-moment characteristics at double-slotted-flap deflections of 25° and 40° are presented in figure 21 for both airfoils investigated. In general, low flip deflections appear to have little effect on the neutral aileron hinge-moment coefficients; however, an increase in the magnitude of the aileron hinge moments occurs at the high flip deflections.

As mentioned in the discussion of the lift characteristics, the aileron stalled on the 15.4-percent-thick airfoil at a flap deflection of 40° and aileron deflections of 5° and greater. At these combinations of control-surface deflection, values of the lift coefficient measured when the angle of attack was increased differed from those measured when the angle of attack was decreased. This hysteresis effect is caused by a change in air flow conditions through the various control-surface slots when the airfoil is stalled. The irregular nature of the air flow is evidenced also in the aileron hinge moments which differ in value for increasing and decreasing angles of attack at the same control-surface deflections. (See figs. 9(g), 9(h), 9(i), 10(e), and 10(f).)

Flip. The values of the flip hinge-moment coefficients are not considered to be as quantitatively accurate as the values of the Frise aileron hinge moments because of considerable difficulty experienced in eliminating friction from the flip strain-gage system. The flip hinge-moment data, however, are believed to be sufficiently accurate quantitatively to obtain indications of the order of magnitude of the flip control forces.

The flip hinge-moment coefficients for several combinations of control-surface deflection exhibited a hysteresis effect for increasing and decreasing angles of attack (figs. 11 and 12). Hysteresis loops were measured at some configurations for which a similar spread in lift or aileron hinge moments was not measured. This result seems to indicate that the flip was very sensitive to small changes in air flow conditions over the airfoil that were not large enough to affect the airfoil lift or Frise aileron hinge moments. Data not presented indicate, however, that if the angle of attack is not increased to the airfoil stall the value of the flip hinge moment will be independent of the previous direction of change in angle of attack. The flip hinge-moment hysteresis loops that occurred during these tests without a similar lift effect may not be serious, therefore, under actual flight conditions.

Cross plots of the basic data showing the effect of aileron deflection and flip deflection on the flip hinge-moment coefficients are presented in figures 22 and 23, respectively. With the double slotted flap retracted, intermediate and large positive deflections of the Frise aileron cause an opening tendency of the slot-lip aileron which would add to the stick force if the flip were connected in the linkage system. This opening
tendency at positive aileron deflections in addition to the poor lift effectiveness of the flip with the flaps up appear to warrant a control linkage system that would disengage the flip from the system when the flap is retracted. For both airfoils at a flap deflection of $25^\circ$ and at an angle of attack of $0^\circ$, the flip has a closing tendency. For the 0.177c thick airfoil, negative aileron deflections have no appreciable effect on the closing tendency of the flip, but reduce the closing tendency for the thinner airfoil. Positive aileron deflections increase the flip closing tendency on both airfoils. Variation of flip hinge moment with flip deflection was nonlinear (fig. 23).

Deflection of the double slotted flap from $25^\circ$ to $40^\circ$ decreases the closing tendency of the flip at all Frise aileron deflections at an angle of attack and flip deflection of $0^\circ$. Aileron deflection has very little effect on the flip hinge moments for both airfoils at a flap deflection of $40^\circ$. An opening tendency exists at intermediate flip deflections (fig. 23) from approximately $-10^\circ$ to $-15^\circ$ on the 17.7-percent-thick airfoil and from approximately $-10^\circ$ to $-21^\circ$ on the thinner airfoil. Elimination of the opening tendency of the flip may be accomplished by modifying the flip overhang balance. In a flight investigation of a slot-lip aileron on an airplane (reference 6), a spring was incorporated into the lateral-control system to counteract an opening tendency of the slot-lip aileron.

**Drag Characteristics**

Profile drag characteristics of the 17.7-percent chord and 15.4-percent chord thick airfoils are presented in figures 13 and 14, respectively. With all control surfaces neutral, the drag coefficients for the 17.7-percent thick airfoil were lower than the values for the 15.4-percent thick airfoil at positive lift coefficients and greater than the values for the thinner airfoil at negative lift coefficients. The increase in section drag coefficient with flap deflection is shown in figure 13 for the 17.7-percent thick airfoil.

**CONCLUDING REMARKS**

Results have been presented of a two-dimensional wind-tunnel investigation of two NACA 7-series type airfoils of 17.7-percent chord and 15.4-percent chord thickness, each equipped with a double slotted flap, slot-lip aileron (flip), and trailing-edge Frise aileron with two amounts of aerodynamic overhang balance. Sharp breaks in the lift curves and irregular flow conditions occurred at a flap deflection of $50^\circ$ which indicate the advisability of limiting deflection of the double slotted flap to $40^\circ$. At a flap deflection of $40^\circ$ with both ailerons neutral, values of maximum section lift coefficient of 2.92 and 2.85 were obtained on the 17.7-percent and 15.4-percent thick airfoils, respectively.
The lift effectiveness of the flip increased with flap deflection and was greater than the Frise aileron effectiveness at a flap deflection of 40°. With the flap retracted, the flip lift effectiveness was negligible and the flip hinge moments indicated an opening tendency at positive deflections of the Frise aileron. This combination of flip characteristics appears to warrant a lateral control linkage system that would disengage the flip from the system when the flap is retracted.

With the flip neutral and with the flap retracted or deflected 25° and 40°, the increase in Frise aileron overhang balance was effective in reducing the negative rate of change of aileron section hinge-moment coefficient with aileron deflection \( c_{h_{\alpha_{a}}} \). The increase in overhang balance, however, generally caused the rate of change of aileron section hinge-moment coefficient with angle of attack \( c_{h_{\alpha_{a}}} \) to increase negatively at flap deflections of 25° and 40°. The values of \( c_{h_{\alpha_{a}}} \) and \( c_{h_{\alpha_{a}}} \) were largest at a flap deflection of 25° and varied inconsistently with flip deflection for the deflected flap configurations.

The data presented indicate that a slot-lip aileron can be combined with a trailing-edge Frise aileron on a full-span double slotted flap so as to provide satisfactory lateral-control characteristics at large flap deflections on a wing having a profile of the NACA 7-series type.

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Langley Air Force Base, Va.
REFERENCES


TABLE I.- ORDINATES FOR THE APPROXIMATELY 17.7-PERCENT-CHORD THICK NACA 7-SERIES-TYPE AIRFOIL

[Stations and ordinates given in percent of airfoil chord measured along wing reference line]

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## Table II: Ordinates for the Approximately 15.4-Percent-Chord Thick NACA 7-Series-Type Airfoil

[Stations and ordinates given in percent of airfoil chord measured along wing reference line]

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Table III.- Test program and figure index of data obtained for each NACA 7-series-type airfoil equipped with double slotted flap, straight sided Prise alleron, and flip.

(a) 0.177a-thick airfoil; \( c_b = 0.353c_a \)

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- \( \theta \) denotes airfoil lift data
- \( \alpha \) denotes alleron hinge-moment data
- \( \theta \) denotes flip hinge-moment data
Table III. - Test program and figure index - Continued

(b) 0.1546-thick airfoil; \( c_p = 0.3510 \alpha \)

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1 denotes airfoil lift data
2 denotes alleron hinge-moment data
3 denotes flip hinge-moment data
Table III.—Test program and figure index—continued

(a) 0.177-in-thick airfoil; \( \alpha_p = 0.30 \alpha \)

| \( \alpha \) | 0 | 5 | 10 | 15 | 20 | 0 | 5 | 10 | 15 | 20 | 0 | 5 | 10 | 15 | 20 | 0 | 5 | 10 | 15 | 20 | 0 | 5 | 10 | 15 | 20 |
| -25 | -20 | -15 | -10 | -5 | 0 | 5 | 10 | 15 | 20 | 0 | -20 | -15 | -10 | -5 | 0 | 5 | 10 | 15 | -15 | -10 | -5 | 0 | 5 | 10 | 15 | 20 |
| \( \alpha_p \) | 0 | 5 | 10 | 15 | 20 | 0 | 5 | 10 | 15 | 20 | 0 | 5 | 10 | 15 | 20 | 0 | 5 | 10 | 15 | 20 | 0 | 5 | 10 | 15 | 20 |

1 denotes airfoil lift data
2 denotes aileron hinge-moment data
3 denotes flap hinge-moment data
4 denotes data not presented

NACA RM No. 19523
### TABLE IV: AILeron Section Hinge-Moment Parameters Measured at $\delta_a = 0^\circ$, $\alpha_o = 0^\circ$

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Figure 1.— Photograph of the 24-inch chord approximately 15.4-percent-chord thick NACA 7-series-type airfoil equipped with double slotted flap, trailing-edge Prise aileron, and slot-lip aileron.
Figure 2.— Profile sketches of the NACA 7-series-type airfoils equipped with double slotted flap, trailing-edge aileron and flip.
Figure 3.—Arrangement of the movable surfaces on the NACA 7-series-type airfoils.
(b) \( \delta_r = 50^\circ \).

Figure 3.-- Concluded.
(b) $\alpha_x = 0^\circ$

Figure 4.- Continued.
(a) $\delta_a = 25^\circ$.

Figure 4a - Continued.
(a) $\alpha_t = 25^\circ$.

Figure 4. - Continued.
(c) \( \alpha = 45^\circ \).

Figure 4.—Continued.
Figure 5.— Lift characteristics of the approximately 15.4-percent-chord thick NACA 7-series-type airfoil with double slotted flap, straight-sided Frise aileron, and flip. Aileron balance, 0.35 lca; $R = 6 \times 10^6$ (approx.).
Figure 5—Continued.
Section angle of attack, \( \alpha_o \), deg

\( \delta_f = 25^\circ \)

*Figure 5.* Continued.
Figure 5.— Continued.
Figure 5—Concluded.
Figure 6.—The effect of sealing the aileron slot on the lift characteristics of the approximately 15% percent-chord thick NACA 7-series-type airfoil with double slotted flap, straight-sided Pruss aileron, and flap. Aileron balance, 0.4052\(\sqrt{c}\); \(\delta_2 = 40^\circ; R = 6 \times 10^6\) (approx.).
Figure 7.— Ring moment characteristics of a straight-sailed Prise aileron on the approximately 17.7-percent-chord thick NACA 7-series-type airfoil with double slotted flap and ripples. Aileron balance, 0.35$C_D$; $R = 5 \times 10^6$ (approx.).
(b) $\delta_f = 0^\circ$.

Figure 7—Continued.
(a) $\delta_x = 25^\circ$.

Figure 7.— Continued.
(d) $\delta_2 = 25^\circ$.

Figure 7.-- Continued.
Figure 7. Continued.

(e) $\theta_x = 25^\circ$
Figure 7.— Continued.
All flow section lift moment coefficients, \( \alpha = \frac{c}{\rho} \) deg

\( \delta_r = 40^\circ \).

Figure 7.-- Continued.
Figure 7.-- Continued.
Figure 7—Continued.
Figure 7: Continued.
Section angle of attack, $\alpha_0$, deg

(m) $\delta_f = 50^\circ$

Figure 7.-- Concluded.
Figure 5—Hinge-moment characteristics of a straight-slotted Prise aileron on the approximately 17.7-percent-chord thick NACA 7-series-type airfoil with double slotted flap and flip. Aileron balance, $0.405w_{a}; R = 6 \times 10^6$ (approx.)
Aileron section hinge-moment coefficient, $C_{h_m}$.
Fig. 8.- Continued.
Figure 3.- Continued.
Figure 5.— Continued.

(f) $\delta_r = 40^\circ$. 
Figure 9.— Hinge-moment characteristics of a straight-sided Prise aileron on the 15.4-percent-chord thick NACA 7-series-type airfoil with double slotted flap and flap. Aileron balance, 0.35 Lena; N = 6 x 10^6 (approx.).
Figure 9-- Continued.
Figure 9.— Continued.
(d) $\alpha = 25^\circ$.

Figure 9—Continued.
Figure 9: Continued.
Figure 9. Continued.
Figure 9—Continued.
(n) $\theta_r = 90^\circ$.

Figure 9.— Continued.
Figure 9.— Continued.
Figure 9—Continued.
Section angle of attack, $\alpha_0$, deg

(k) $\delta_1 = 45^\circ$.

Figure 9—Continued.
Figure 9c—Concluded.

Section angle of attack, \( \alpha \), deg

1. \( \alpha = 10^\circ \)
Figure 10. - Hinge-moment characteristics of a straight-sided Prise aileron on the approximately 15.4-percent-chord thick NACA 7-series-type airfoil with double slotted flap and flip. Aileron balance, 0.40S_{0}; R = 6 \times 10^6 \text{ (approx.)}
Section angle of attack, $\alpha_0$, deg

(b) $\delta_f = 25^\circ$.

Figure 10.— Continued.
Figure 10.— Continued.
Figure 10.—Continued.

(a) $\delta_e = 25^\circ$. 
(e) $\alpha_f = 40^\circ$.

Figure 10.—Continued.
Section angle of attack, \( \alpha_0 \), deg

\( \delta_r = 40^\circ \).

Figure 10.— Continued.
Section angle of attack, $\alpha_0$, deg

(g) $\alpha_0 = 40^\circ$

Figure 10: Continued.
Section angle of attack, $\alpha_0$, deg

(b) $\delta_x = 40^\circ$.

Figure 10a--Concluded.
Figure 11. - Hinge-moment characteristics of a flap on the approximately 17.7-percent-chord thick NACA 7-series-type airfoil with double-slotted flap and straight-sided Prise aileron. Aileron balance, 0.35 \% \min ; 

\( R = 5.0 \times 10^6 \) (approx.)
Figure 11. Continued.
Figure II.- Continued.
Figure 11.— Continued.

\( \delta_a = 0^\circ \)

\( \delta_r = 40^\circ \)

Section angle of attack, \( \alpha_x \), deg

NACA
Figure 11. -- Continued.
Section angle of attack, \( \alpha_0 \), deg

(g) \( \delta_0 = 45^\circ \)

Figure II: Continued.
Figure 11—Continued.
Section angle of attack, \( \alpha \), deg.

(1) \( \alpha = 40^\circ \).

Figure II.- Concluded.
Figure 12.— Hinge-moment characteristics of a flap on the approximately 15.4-percent-
chord thick NACA 7-series-type airfoil with double slotted flap and straight-sided
Prise aileron. Aileron balance, 0.3516 \text{deg}; B = 6 \times 10^6 \text{ (approx.)}
Figure 12.- Continued.
Figure 12.-- Continued.
(d) $\delta_r = 25^\circ$.

Figure 12.— Continued.
(e) $\alpha_f = 40^\circ$.

Figure 12.—Continued.
Figure 12.- Continued.
Section angle of attack, $\alpha_0$, deg

$\theta_r = 40^\circ$

Figure 12—Continued.
Figure 12a—Continued.
Section angle of attack, $\alpha_0$, deg

(1) $\delta_x = 40^\circ$

Figure 12.- Continued.
\( \delta_x \) (deg) (deg)

\[ \delta_x = 0, 1 \]

Section angle of attack, \( \alpha_d \), deg

(1) \( \delta_x = 40^\circ \)

Figure 12 -- Concluded.
Figure 13.— Drag characteristics of the approximately 17.7 percent-chord thick NACA 7-series-type airfoil with double slotted flap, straight-sided Frise aileron, and flip. $R = 6 \times 10^6$ (approx.); $\alpha_a = 0^\circ$, $\delta_1 = 0^\circ$. 
Figure 14.— Drag characteristics of the approximately 15.4-
percent-chord thick NACA 7-series-type airfoil with double
slotted flap, straight-sided Frise aileron, and flip.
\[ R = 6 \times 10^6 \text{ (approx.)}. \]
Figure 15.– Maximum lift characteristics of the NACA 7-series-type airfoils with double slotted flap, straight-sided Frise aileron, and flip. $R = 6 \times 10^6$ (approx.); $\delta_a = 0^\circ$; $\delta_l = 0^\circ$; $c_b = 0.408c_a$. 

Flap deflection, $\delta_f$, deg

Maximum section lift coefficient, $c_{l,max}$

Airfoil

- 0.154$c$ thick
- 0.154$c$ thick (true-contour aileron, reference 3)
- .176$c$ thick
Figure 16.— Variation of section lift characteristics with deflection of straight-sided Prise aileron on two NACA 7-series-type airfoils with double slotted flap and flap.  $\alpha = 6^\circ; \beta = 0^\circ; R = 6.0 \times 10^6$ (approx.).
Figure 17.—Variation of section lift characteristics with flip deflection on two NACA 7-series-type airfoils with double slotted flap and straight-sided Wise aileron.

\( \alpha = 0^\circ; \delta_2 = 0^\circ; R = 6.0 \times 10^6 \) (approx.)
Figure 16.— Lift effectiveness of the straight-sided Prise ailerons and flaps on the NACA 7-series-type airfoils with double slotted flaps. \( R = 6 \times 10^6 \) (approx.).
Figure 18.—Continued.
Figure 18—Continued.
(f) 0.15c thick airfoil; \( \delta_f = 40^\circ; \quad c_t = 2.0. \)

Figure 18: Concluded.

Plain symbols, \( c_b = 0.35c_a \)
Flagged symbols, \( c_b = 0.40c_a \)

Figure 19: Lift effectiveness of the flip on the NACA 7-series-type airfoils with straight-sided Frise aileron and double slotted flap. \( R = 6 \times 10^6 \) (approx.); \( \delta_a = 0^\circ. \)
Figure 20. Aileron hinge-moment characteristics of a straight-sided Frise aileron on two NACA 7-series-type airfoils with double slotted flap and flip. $\alpha_0 = 0^\circ$; $\beta = 0^\circ$; $R = 6.0 \times 10^6$ (approx.).
Figure 20.— Concluded

(b) 0.15\text{\textsubscript{c}} thick airfoil.
Figure 21.— Variation of straight-sided Fries aileron hingemoment characteristics with flip deflection on two NACA 7-series-type airfoils with flap and double slotted flap. $\alpha_h = 0^\circ$, $\alpha = 0^\circ$; $R = 6.6 \times 10^5$ (approx.).
Figure 22. Effect of aileron deflection on flap hinge-moment characteristics on two NACA 7-series-type airfoils with double slotted flap and straight-sided Prise aileron. \( \alpha_0 = 0^\circ \); \( \alpha_f = 0^\circ \); \( R = 6.0 \times 10^6 \) (approx.).
Figure 27.— Hinge-moment characteristics of a flap on two NACA 7-series-type airfoils with double slotted flap and straight-sided Prise aileron. \( \alpha = 0^\circ; \delta_k = 0^\circ; \) 
\( R = 6.0 \times 10^6 \) (approx.).