TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 801

TESTS OF ROUND AND FLAT SPOILERS ON A TAPERED WING IN THE NACA 19-FOOT PRESSURE WIND TUNNEL

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SUMMARY

Several arrangements of round and flat spanwise spoilers attached to the upper surface of a tapered wing were tested in the NACA 19-foot pressure wind tunnel to determine the most effective type, location, and size of spoiler necessary to reduce greatly the lift on the wings of large flying boats when moored. The effect of the various spoilers on the lift, the drag, and the pitching-moment characteristics of the tapered wing was measured over a range of angles of attack from zero to maximum lift. The most effective type of spoiler was found to be the flat type with no space between it and the wing surface. The chordwise location of such a spoiler was not critical within the range investigated, from 5 to 20 percent of the wing chord from the leading edge.

INTRODUCTION

The practice of mooring large flying boats necessitates the use of some form of "spoiler" to destroy the lift that might be experienced by the wings of such aircraft in high winds and thus prevent them from lifting off the water. In the past, spoiling action has been obtained through the use of "spoiler boards," which are simply flat planks attached normal to the upper surface of the wing. The attachment and the transportation of such spoiler boards is impracticable on present-day airplanes, and a simpler method of obtaining the desired spoiling action is being sought.

Data presented in reference 1 indicate that considerable spoiling action might be obtained from a protuberance on the wing surface near the leading edge and, on the basis of those results, it has been suggested that the wing lift could be partly destroyed by securing a hawser along the upper surface of the wing about 5 percent of the wing chord back from the leading edge. A thin flat metal strip temporarily fastened to the wing upper surface and rolled up and stowed when not in use was also considered.

The Bureau of Aeronautics, Navy Department, has requested the NACA to make an investigation to determine the size necessary, the most effective type, and the chordwise location of spanwise spoilers that may be used to destroy the lift on the wings of large aircraft when moored. The present investigation includes tests of various arrangements of round and flat spoilers attached to the upper surface of a tapered wing at three chord locations: 5, 10, and 20 percent of the chord from the leading edge of the wing. The lift, the drag, and the pitching moments of the wing were measured for the various spoiler arrangements and for the wing alone.

APPARATUS AND TESTS

Plan and elevation views of the wing model used in the present tests are shown in figure 1, and a typical section of the wing is included in figure 2. This wing had been previously used in connection with another investigation and was available for the spoiler tests. The model was built of laminated mahogany with a smooth finish but was not highly polished. It has an area of 35.8 square feet, a span of 14.4 feet, and a mean aerodynamic chord of 2.485 feet.

The various spoiler arrangements, locations, and sizes are shown in figure 2. The $\frac{3}{4}$-, the $1\frac{1}{8}$-, and the $1\frac{1}{2}$-inch spoilers represent 2.5, 3.75, and 5 percent of the mean aerodynamic chord of the wing, respectively. The spoilers were mounted on the upper surface of the wing, perpendicular to the wing surface at the point of location, and they extended along 90 percent of the span. The spoilers were rigidly attached to the wing by metal brackets that were too small in size and too few in number to have any appreciable spoiling effect.

The wing was mounted on the standard force-test supports in the test section of the NACA 19-foot pressure tunnel as shown in figure 3. The angle of attack can be changed from outside the tunnel by a calibrated electric drive. All forces acting on the wing are transmitted to a six-component automatic recording balance.

The investigation was conducted in the NACA 19-foot pressure tunnel, with the tunnel in the closed-throat condition and operating at atmospheric pressure. Tests were made of the wing alone, and also with spoilers attached, through a range of angles of attack from -2° to 18°. Each arrangement was tested at a dynamic pressure of about 50 pounds per square foot, which gives a test Reynolds number of approximately 3,000,000. The round spoiler $1\frac{1}{2}$ inches in diameter was tested only at the 20-percent-chord location, but all of the other spoilers were tested at all three chord locations.

RESULTS AND DISCUSSION

All the results are presented in standard nondimensional coefficient form and are corrected for tares and jet-boundary interference effects. The symbols and coefficients are defined as follows:

C_L lift coefficient $\left(\frac{\text{lift}}{qS}\right)$

C_D drag coefficient $\left(\frac{\text{drag}}{qS}\right)$

$C_{m_{c/4}}$ pitching moment coefficient

$$\frac{\text{pitching moment about } c/4}{qcS}$$

where

q dynamic pressure of air $\left(\frac{1}{2}\rho V^2\right)$

ρ mass density of air

V velocity of air stream

S total wing area (35.8 sq ft)

c mean aerodynamic chord of wing (2.485 ft)

The aerodynamic characteristics of the wing with the various spoiler arrangements and of the wing alone are shown in figures 4 to 9. The most effective type of spoiler and the best location may be obtained from the results given in figures 10 and 11, where the amount that the spoiler decreased the lift (ΔC_L) is plotted against the chord location for angles of attack of 8° and 12°. The two angles of attack are representative of the range of angles of attack in which most flying boats ride when moored. This range of angles was made higher than the sum of the angles of trim and wing setting to allow for the amount the boat might pitch.

The results plotted in figures 10 and 11 indicate that the best type of spoiler tested was a flat spoiler with no space between it and the wing. The location of the flat spoiler is not very critical with regard to the spoiling action, provided that it is located within the range of chordwise locations tested; the best average location is approximately 12 percent of the chord back from the leading edge. This effect is also illustrated in figure 3(b) of reference 2 for the angle of attack that is applicable to the present investigation.

The sign of the pitching moment is changed from positive (stalling moment) with the wing alone to negative (diving moment) in most cases with the flat spoiler. (See figs. 4, 5, and 6.) This effect tends to decrease the angle of attack of the flying boat and thereby assists in decreasing the lift.

That the round spoilers were not so effective as the flat spoilers is indicated by the data. The most effective type of round spoiler is also one with no space between it and the wing. The best location for a round spoiler is approximately 5 percent of the chord back from the leading edge, as shown in figure 11.

The size of round spoiler necessary to obtain the amount of spoiling needed would probably prevent the use on a full-scale airplane of a large hawser for this purpose. It might be feasible to use a round, airtight, balloon-fabric tube and inflate it with air or carbon dioxide after it had been attached to the wing. This arrangement would probably require more equipment and stowage space than an arrangement of a flat spoiler.

If a full-scale wing having an average chord of 10 feet is assumed, the flat spoiler, 2.5 percent of the chord in width, would be only 3 inches wide. Flat spoilers for full-scale airplanes could be made of a fabric webbing or a metal strip supported by short removable posts along the wing span and perpendicular to the wing surface. This type of spoiler would weigh very little, be easy to install, and be quite effective for the purpose intended.

CONCLUDING REMARKS

The most effective type of spoiler tested was the flat spoiler with no space between it and the wing surface. The chordwise location of this type was not critical within the range investigated, between the 5- and the 20-percent-chord locations from the leading edge. A flat spoiler 2.5 percent of the mean aerodynamic chord in height would probably be sufficient to prevent a moored flying boat from lifting off the water.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., January 2, 1941.

REFERENCES

1. Jacobs, Eastman N.: Airfoil Section Chsracteristics as Affected by Protuberances. Rep. No. 446, NACA, 1932.

2. Shortal, J. A.: Effect of Retractable-Spoiler Location on Rolling- and Yawing-Moment Coefficients. T.N. No. 499, NACA, 1934.

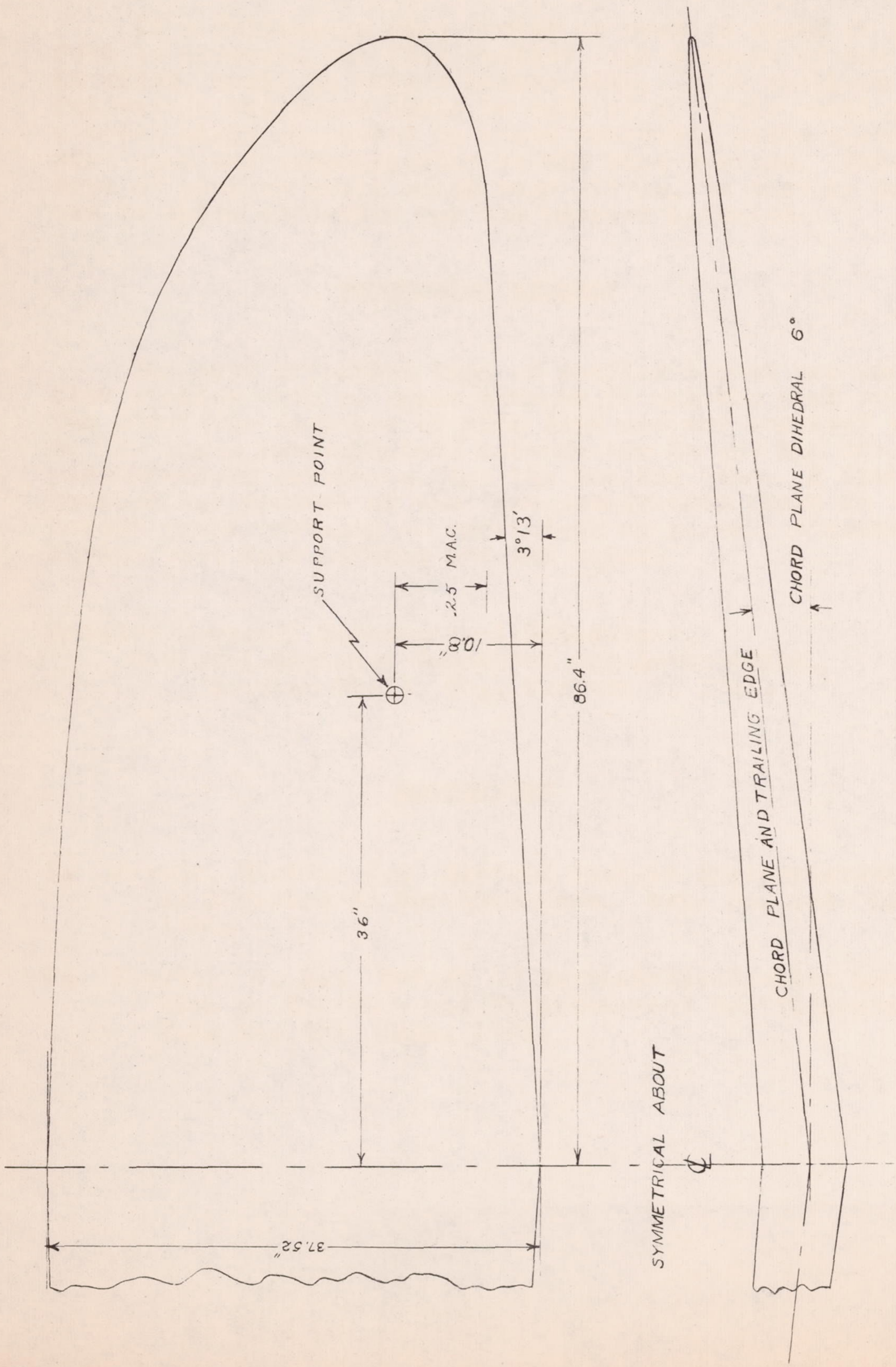

FIGURE 1. - PLAN AND ELEVATION OF WING.

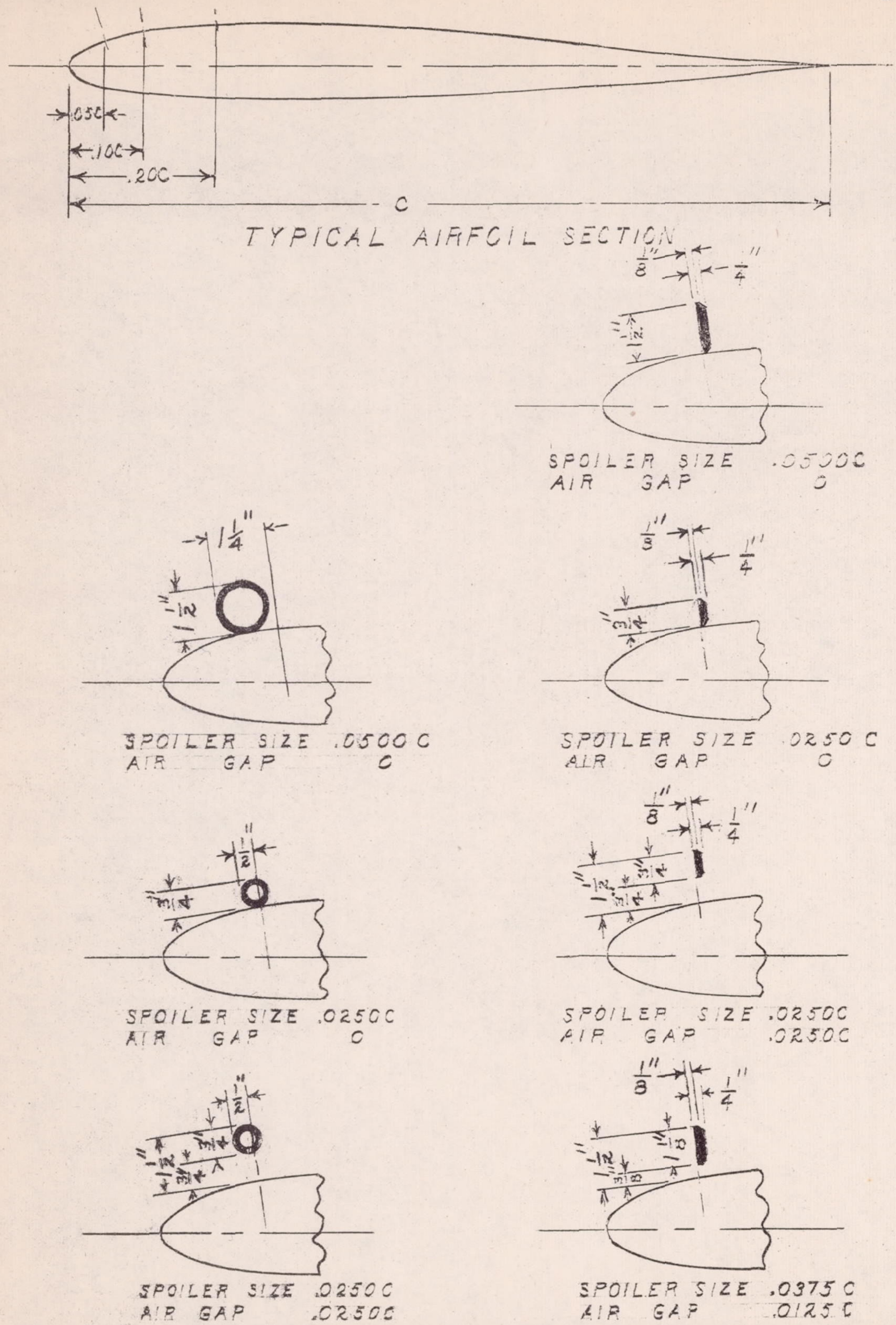

FIGURE 2 - SPOILER ARRANGEMENTS AND LOCATIONS.

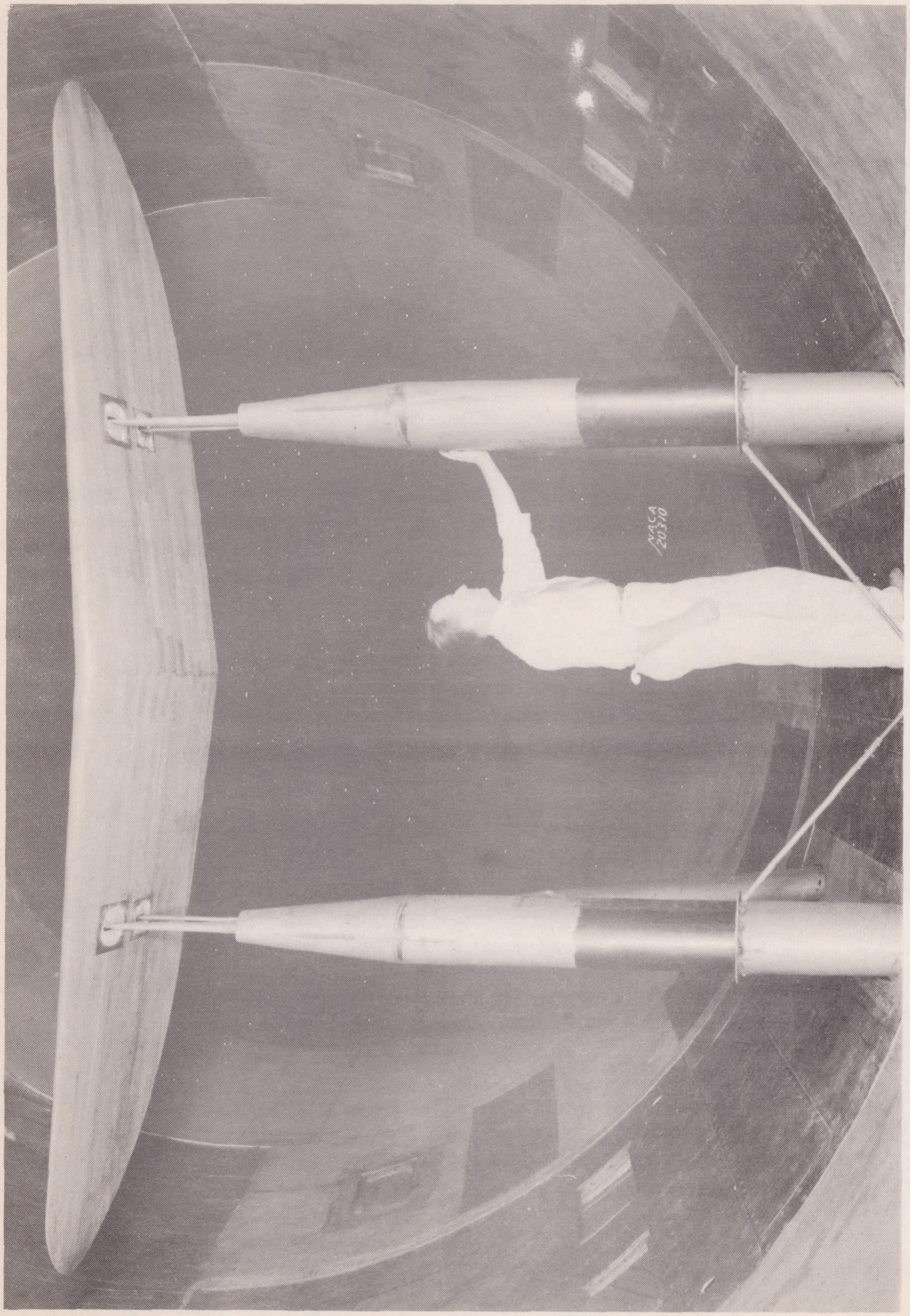

Figure 3.- Wing model mounted for test in the NACA 19-foot pressure wind tunnel.

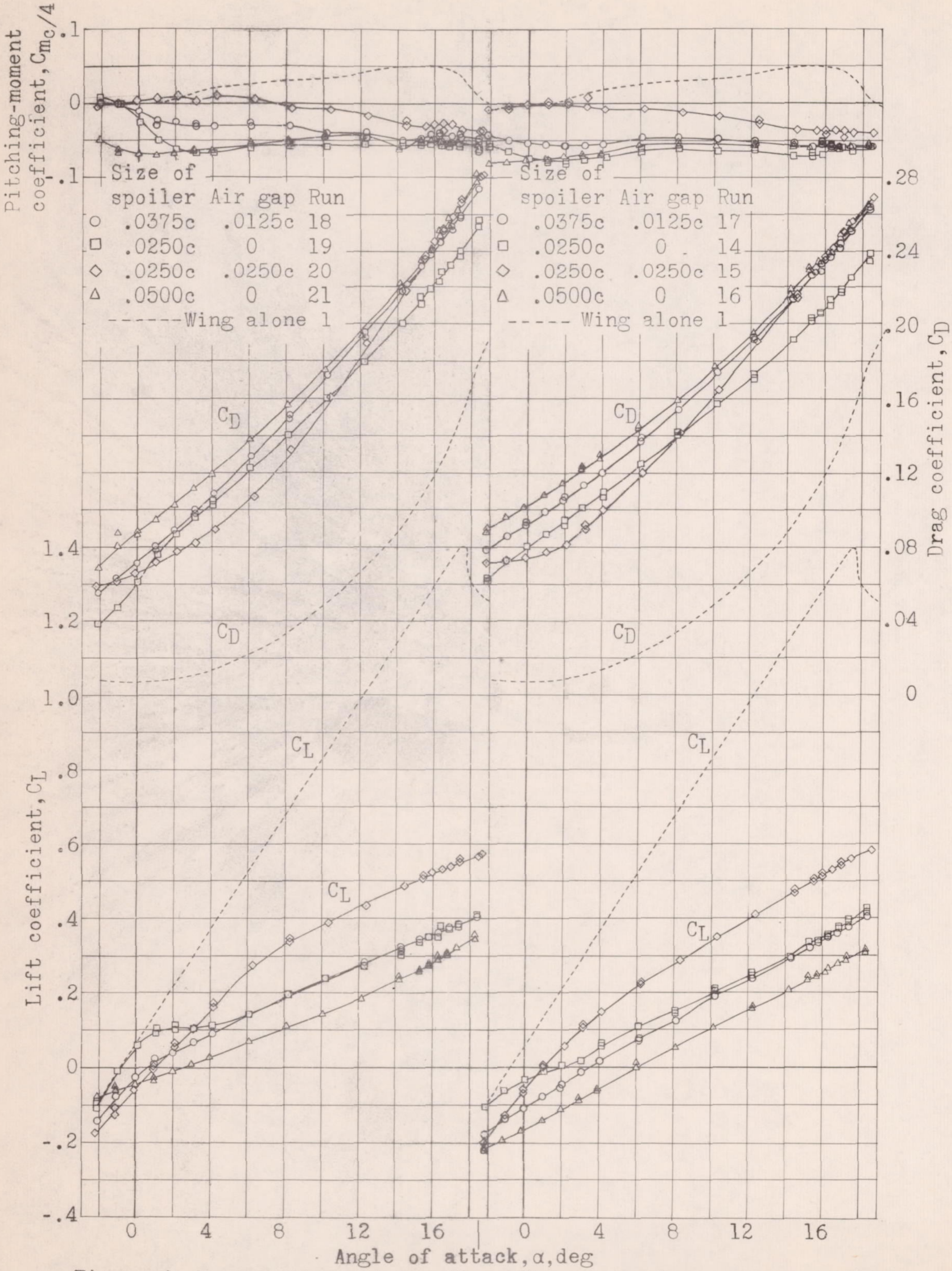

Figure 4.-5-percent-chord location. Figure 5.-10-percent-chord location.

Figures 4,5.- Effect of flat spoilers.

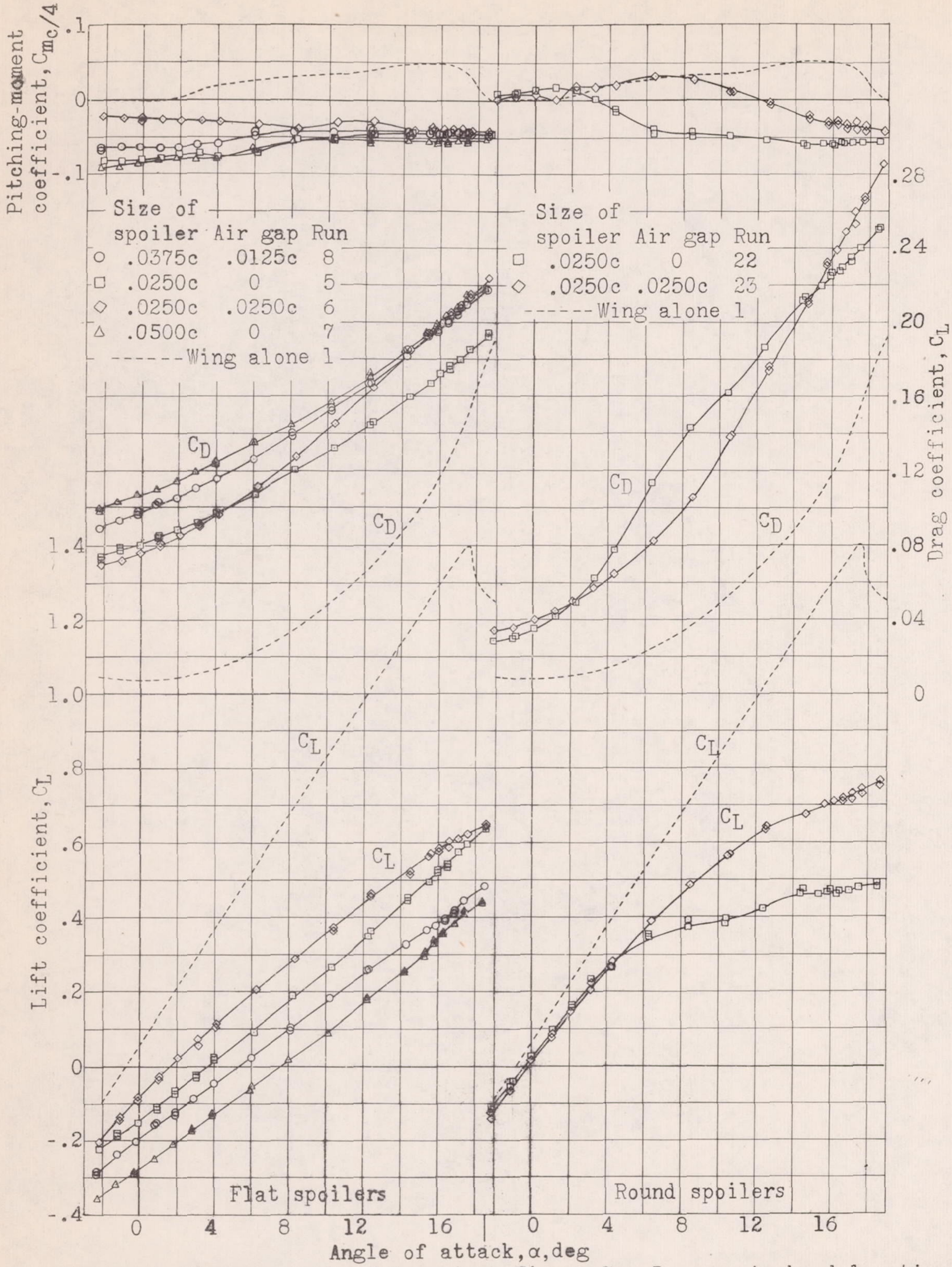

Figure 6.-20-percent-chord location. Figure 7.- 5-percent-chord location.

Figures 6,7.- Effects of flat and round spoilers.

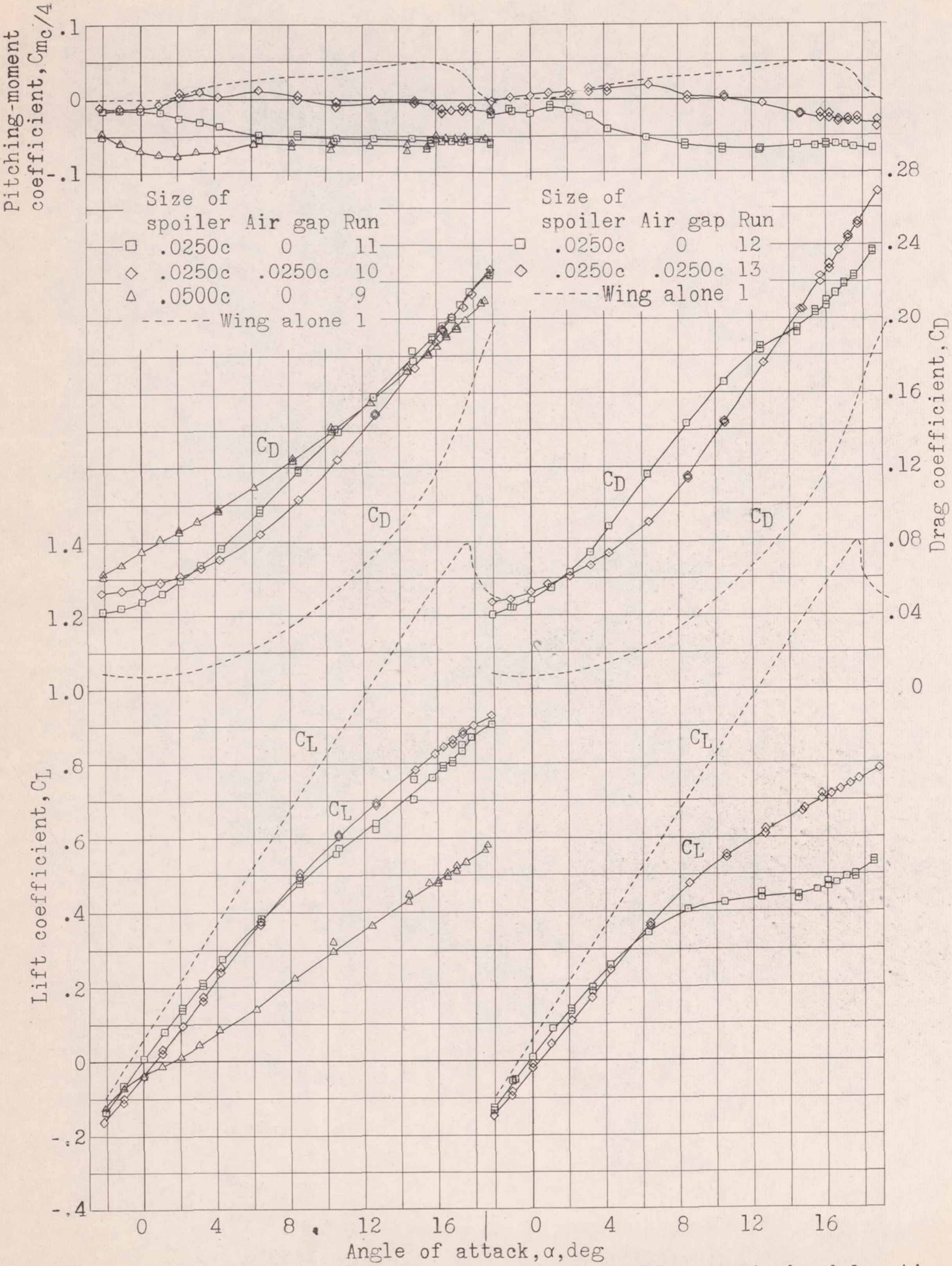

Figure 9.-20-percent-chord location. Figure 8.-10-percent-chord location.

Figures 8,9.- Effects of round spoilers.

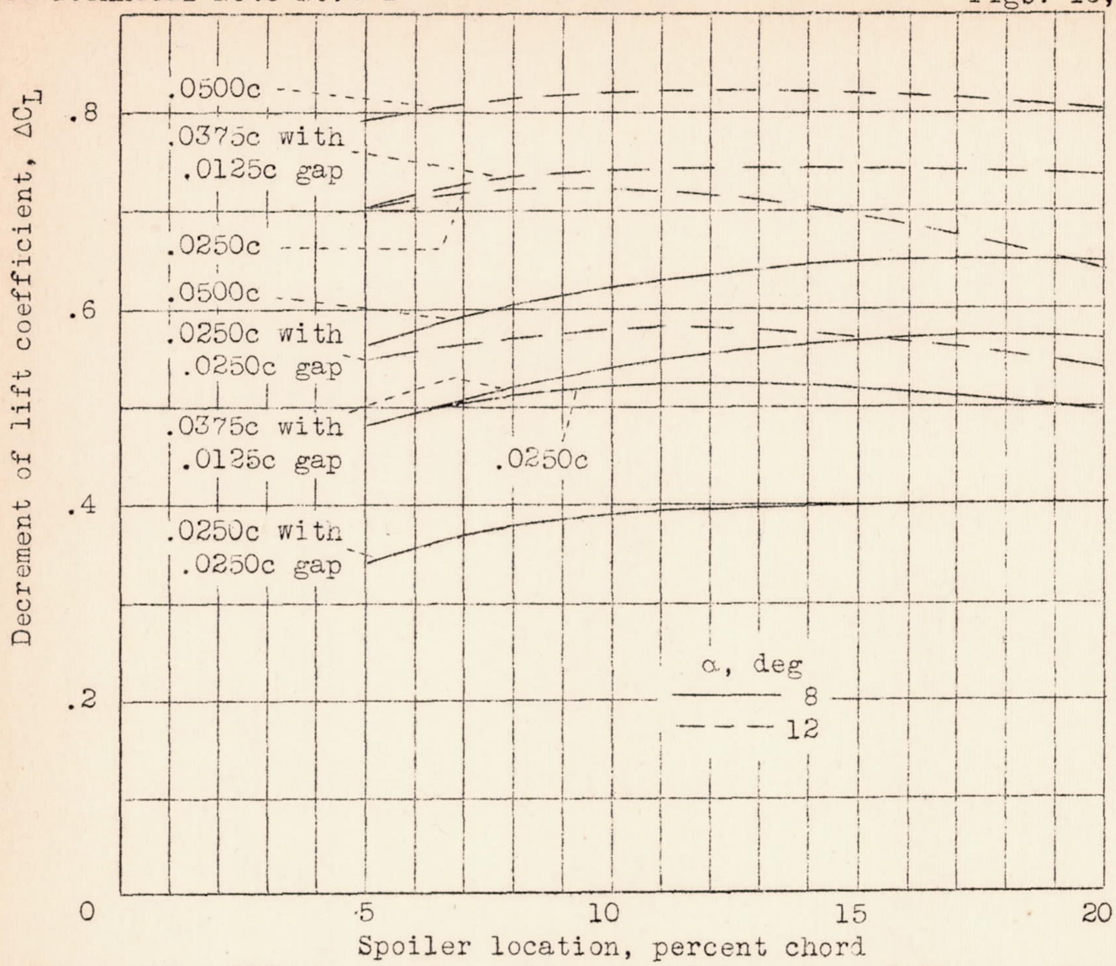

Figure 10.- Effect on lift coefficient of location of flat spoilers.

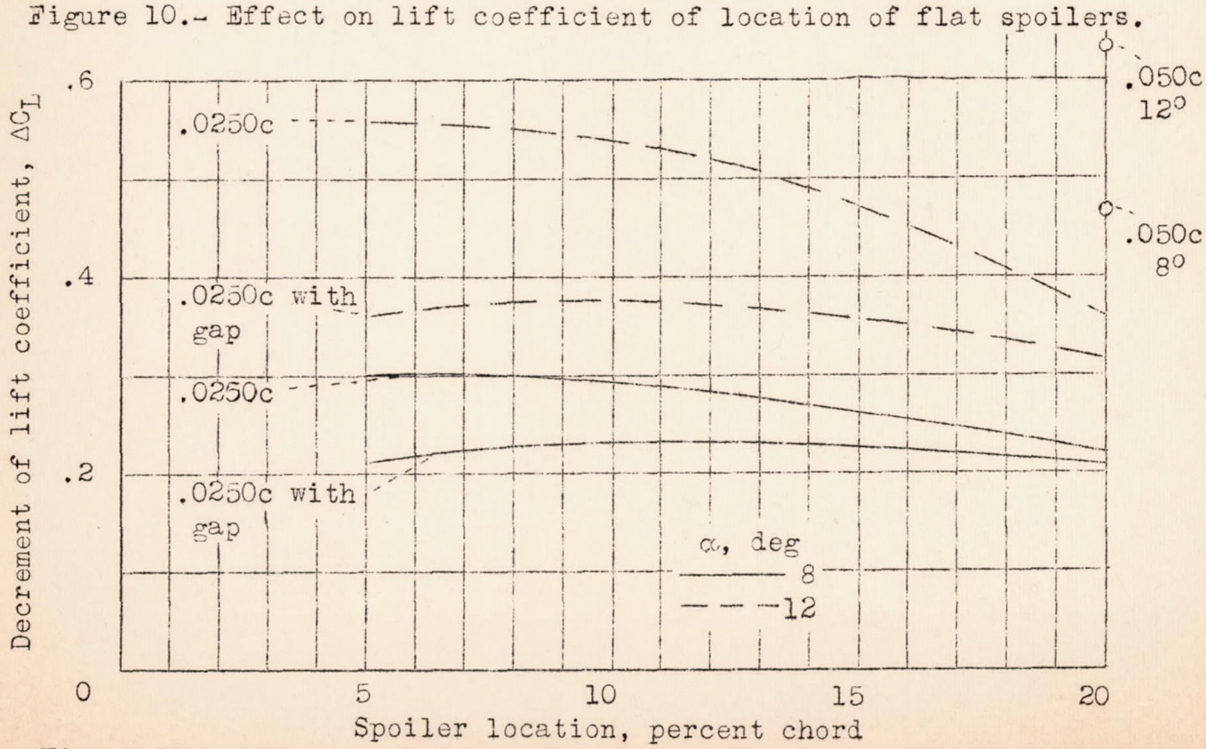

Figure 11.- Effect on lift coefficient of location of round spoilers.