NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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TESTS OF A HIGHLY CAMBERED LOW-DRAG-AIRFOIL SECTION WITH A LIFT-CONTROL FLAP

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SUMMARY

Tests were made in the NACA two-dimensional low-turbulence pressure tunnel of a highly cambered low-drag airfoil (NACA 65,3-618) with a plain flap designed for lift control. The results indicate that such a combination offers attractive possibilities for obtaining low profile-drag coefficients over a wide range of lift coefficients without large reductions of critical speed.

INTRODUCTION

The ability of certain flaps to shift the low-drag range of the NACA low-drag airfoils should have important applications in improving airplane performance. Such flaps seem to offer advantages for take-off, climb, maneuvering, and perhaps, cruising at high altitudes. They also facilitate the design of nose air-intake slots to be efficient for both high speed and climb.

Such advantages, however, appear to be at least partly dependent upon the use of full-span flaps or drooped ailerons with partial-span flaps to avoid drag increments associated with the flap ends and the distortion of the span-load distribution. It was suggested in reference 1 that such difficulties might be partly overcome by designing the wing initially for the high lift-coefficient range. The high camber of the resulting wing could then be reduced through the use of upward flap deflections and negative aileron droop for the low-lift or high-speed flight conditions. The upward flap deflection would also reduce the rather large moment coefficients of the highly cambered airfoil for the high-speed range of lift coefficients.

The present tests were therefore made to obtain section characteristics of a highly cambered low-drag airfoil (NACA 65,3-618) with such a flap. Plain flaps suitable for this application have been shown to be effective in shifting the low-drag range, have reasonably good maximum lifts for many applications, and require a minimum of mechanical complexity. Such flaps also eliminate the necessity for discontinuities at the flap end for small deflections when used with drooped ailerons.

METHODS AND APPARATUS

The tests were made in the NACA two-dimensional low-turbulence pressure tunnel by the methods described in reference 1. Drag coefficients were obtained by the wake-survey method and lift coefficients were obtained by measurement of the lift reaction on the floor and ceiling of the tunnel. Moment coefficients were measured by means of a simple balance. All results are fully corrected.

The model was built of wood with a 24-inch chord. It was painted and sanded to produce aerodynamically smooth surfaces. The model was equipped with pressure orifices for tests made to obtain pressure distributions, but these orifices were filled and smoothed for all other tests. The flap arrangement is shown in figure 1. Unpublished tests indicated that the skirt shape used for these tests (fig. 1) was advantageous in extending the low-drag range and in obtaining suitable hinge-moment characteristics for internally balanced ailerons. The gap around the flap leading edge was filled with modeling clay without changing the external contour. Airfoil ordinates may be obtained from the data in reference 1.

RESULTS AND DISCUSSION

Lift characteristics for the combination are presented in figure 2 for a Reynolds number of approximately 6×10^6. The increment in maximum lift coefficient is about 0.8 for a flap deflection of 40°. Higher maximum lift coefficients probably could be obtained by slight modification of the skirt on the lower surface to permit larger flap deflections. Characteristic jogs in the lift curves appear at lift coefficients of about 1.1 to 1.3

for small positive flap deflections. These jogs are commonly found in the characteristics of ailerons and plain flaps and are attributed to rather sudden flow breakdowns over the flap. Such jogs do not occur at large positive, neutral, or small negative flap deflections.

Drag and moment characteristics for the combination are presented in figure 3. The flap is very effective in shifting the low-drag range to lower lift coefficients with practically no increase in drag and to higher lift coefficients with only moderate drag increases. Thus, with proper selection of flap deflections, comparatively low section drag coefficients are obtainable over a range of lift coefficients from below 0 to about 1.2. This range of lift coefficients is thought to be sufficiently broad to cover the most important flight conditions, except conditions for take-off and landing, for most airplanes. A comparison with the data of reference 1 indicates that the drag coefficients of the flapped airfoil in the low-drag range are probably slightly higher than those for the plain airfoil.

The rather large pitching-moment coefficients of the airfoil with flap neutral are reduced to values of only about -0.02 (fig. 3) by a flap deflection of -10°. Small pitching-moment coefficients together with low drag coefficients are thus available for the high-speed flight condition.

Some loss of critical speed must, of course, be accepted in the use of an airfoil not specifically designed for the high-speed condition. Examination of the pressure coefficients S (reference 1) presented in figures 4 to 7 shows, however, that this loss need not be very large. The maximum pressure coefficient shown in figure 5 for a flap deflection of -10° and a lift coefficient of 0.2 is slightly higher than that for the comparable airfoil cambered for use at the same lift coefficient (NACA 65,3-218) as estimated from mean-line theory (reference 1) and unpublished pressure distributions on the symmetrical (NACA 65,3-018) airfoil. The difference corresponds to a loss in critical speed of about 6 to 10 miles per hour to a value of about 447 miles per hour for the flapped airfoil at an altitude of 25,000 feet. While such a loss would not be tolerated for an airplane for which a high critical Mach number was of prime importance, such a reduction of critical speed is thought to be of little importance for many airplanes.

CONCLUSIONS

A plain flap on a highly cambered NACA low-drag-airfoil section appears to offer attractive possibilities for obtaining low profile-drag coefficients over a wide range of lift coefficients without large reductions of critical speed for the high-speed flight conditions.

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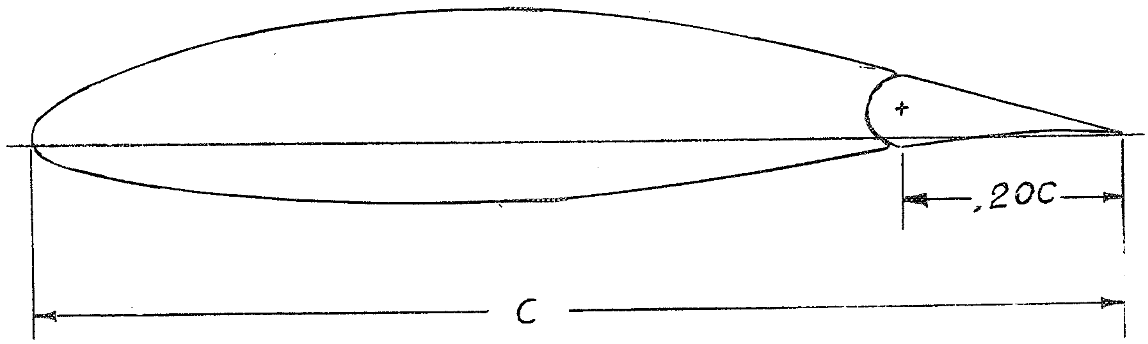
REFERENCE

1. Jacobs, Eastman N., Abbott, Ira H., and Davidson, Milton: Preliminary Low-Drag-Airfoil and Flap Data from Tests at Large Reynolds Numbers and Low Turbulence, and Supplement. NACA A.C.R., March 1942.



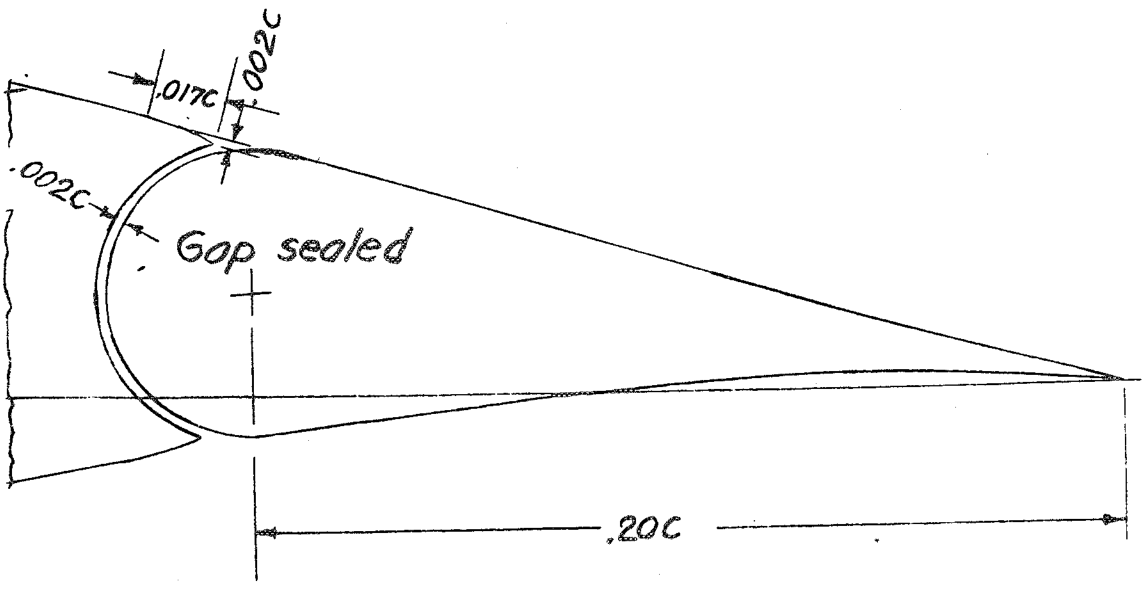


Figure 1.- NACA 65,3-618 airfoil with lift-control flap.

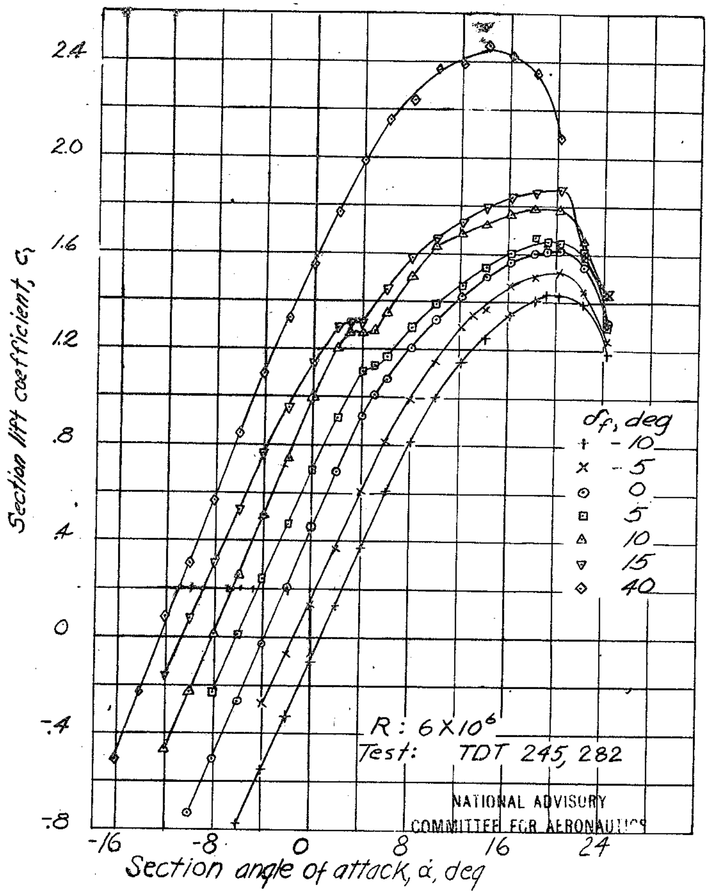


Figure 2.- Lift characteristics of NACA 65,3-618 airfoil with lift-control flap.

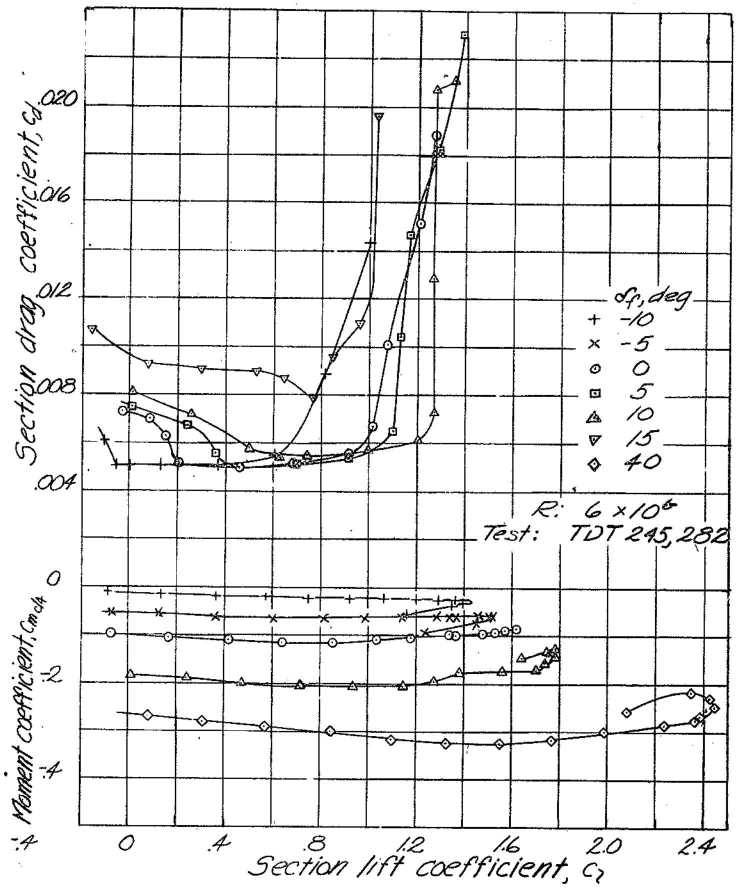


FIGURE 3.- Drag and moment characteristics of NACA 65,3-618 airfoil with lift-control flap.

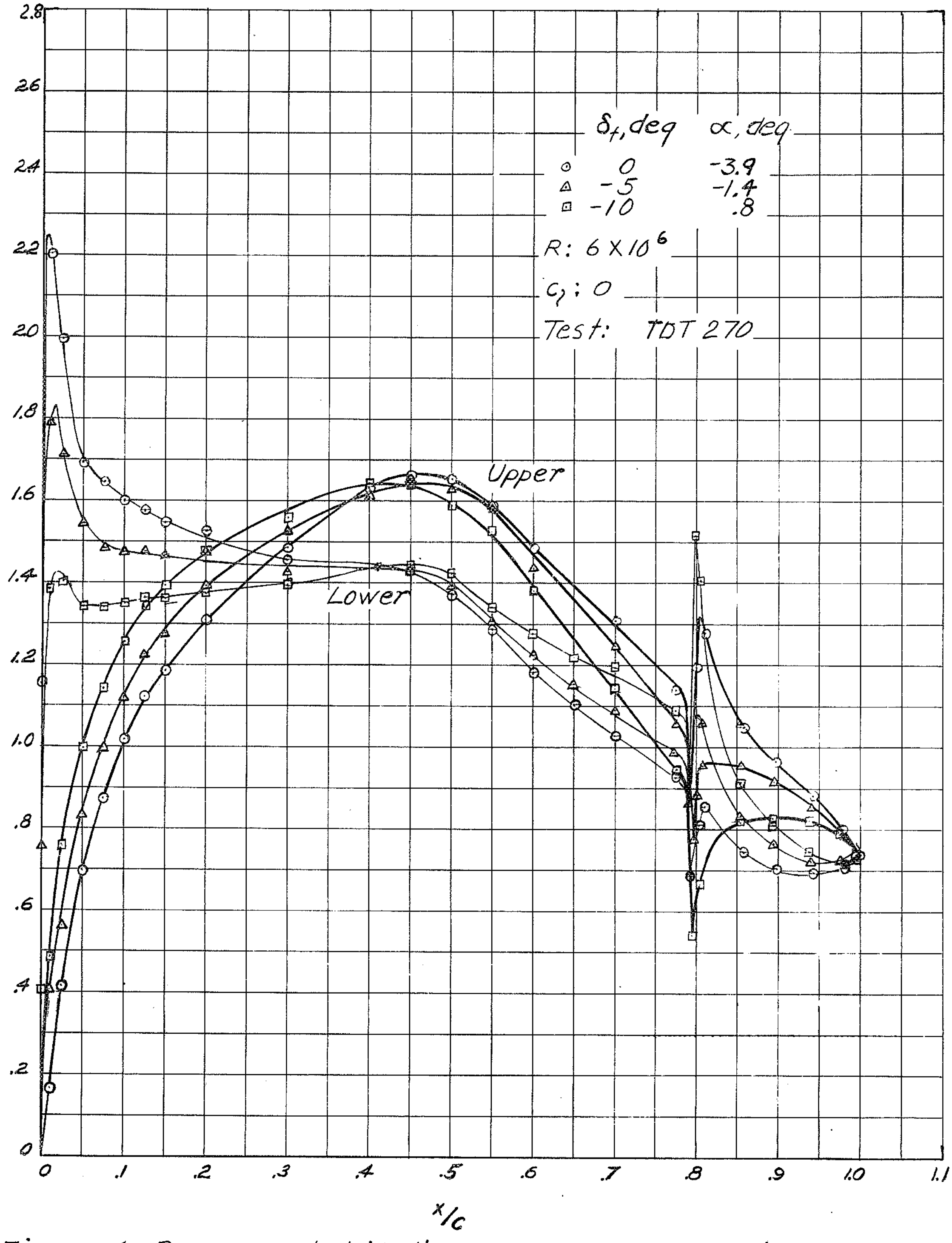


Figure 4.- Pressure distributions for NACA 65,3-618 airfoil with lift-control flap. $c_l = 0$.

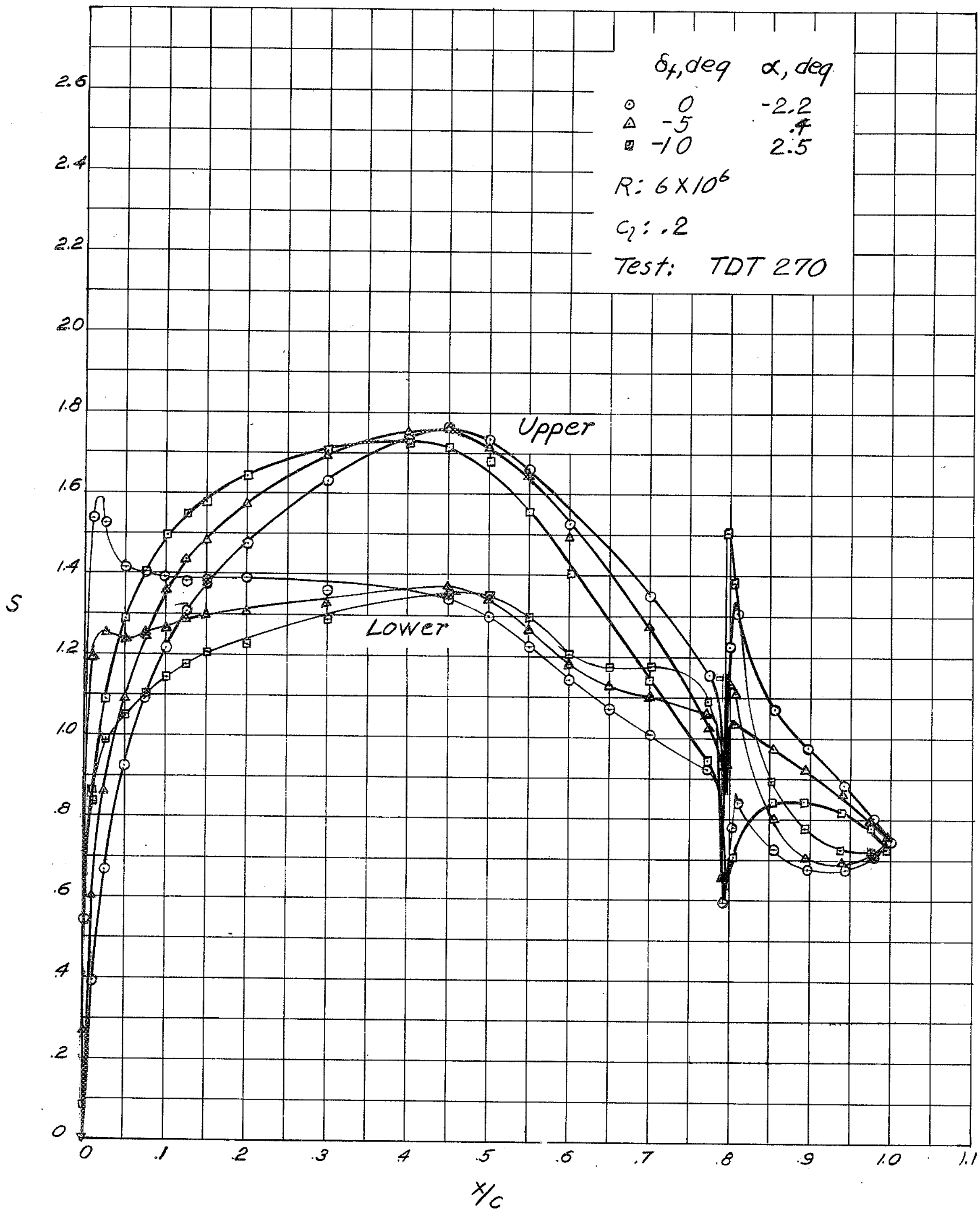


Figure 5.- Pressure distributions for NACA 65,3-618 airfoil with lift-control flap. $c_l = 0.2$

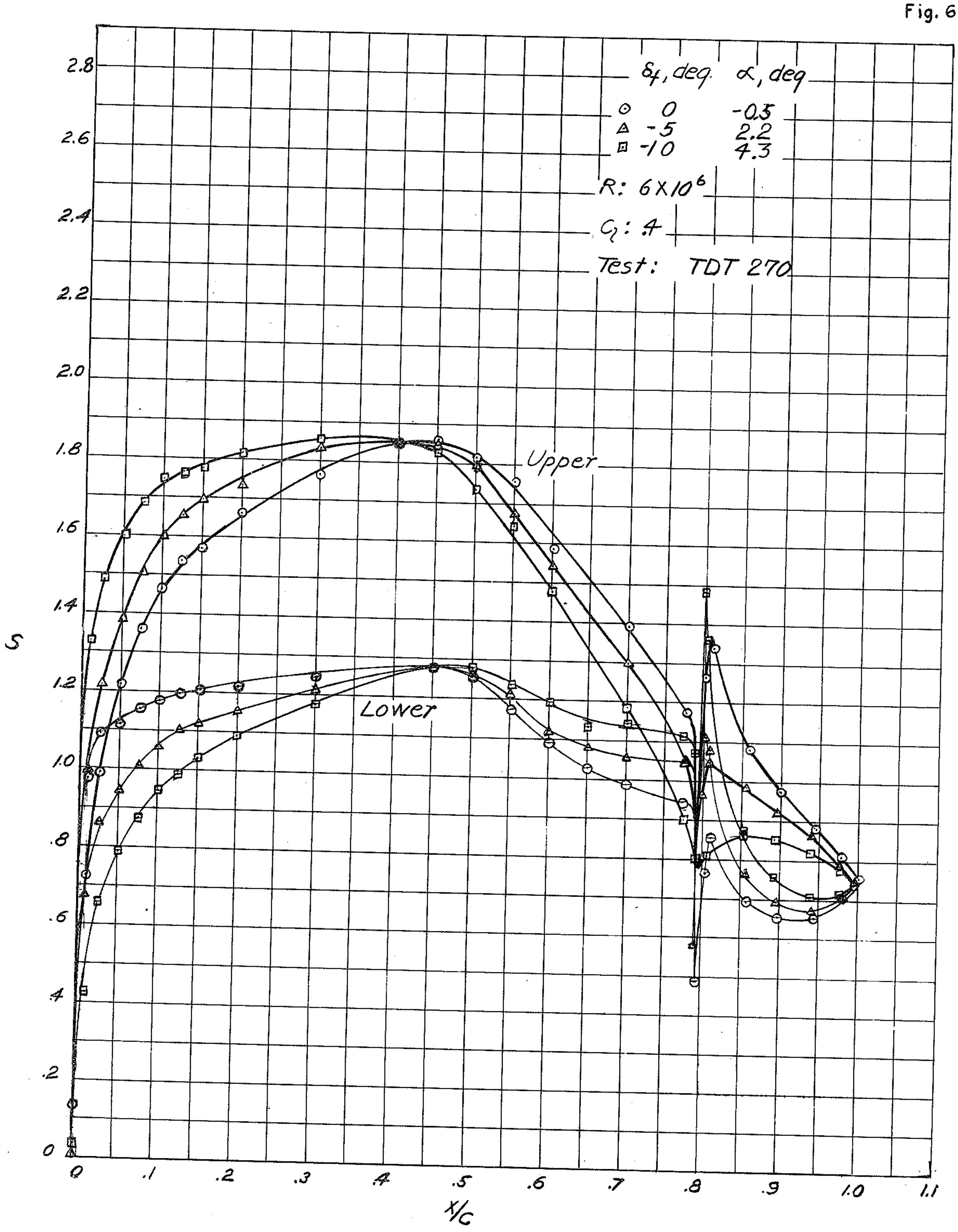


Figure 6.- Pressure distributions for NACA 65,3-618 airfoil with lift-control flap. $c_l = 0.4$.

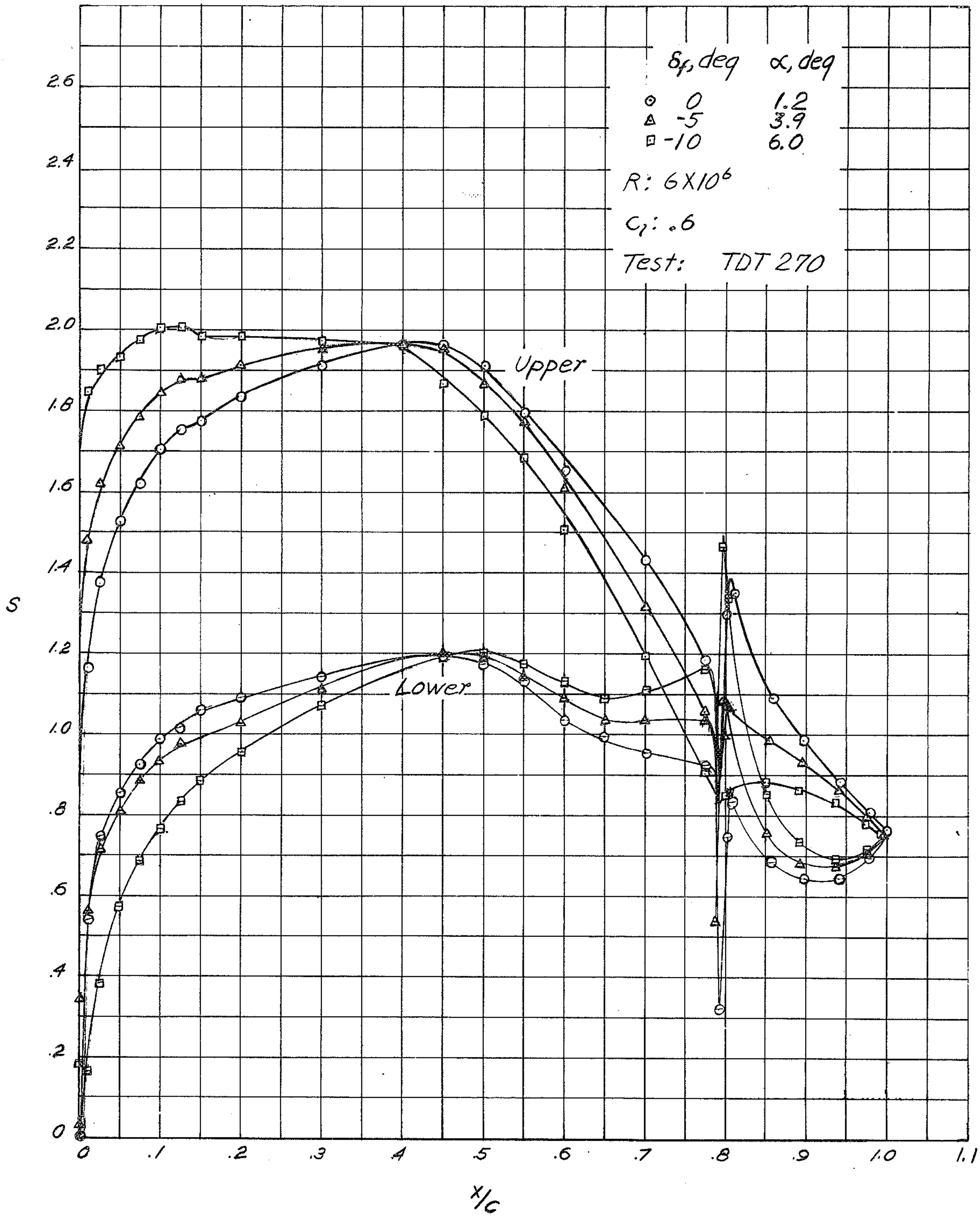


Figure 7.- Pressure distributions for NACA 65,3-618 airfoil with lift-control flap. $c_l = 0.6$.