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5.4 An Application of the Ogee Tip

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Introduction

Wind tunnel tests by NASA indicate that the aerodynamic performance of a rectangular 3-D wing can be increased by changing the tip to an ogee shape. Test data obtained during the tests show substantial gains in L/D throughout the angle of attack range of interest.

In order to investigate the potential gains in both cruise and climb performance, a Beech Baron was modified to include a pair of ogee tips on the configuration. Estimated gains in performance based on rectangular wing test data were somewhat optimistic. Increases in cruise speed and climb rate were predicted to be as much as 5 mph and 100 fpm, respectively. A series of quick tests were scheduled to see if the predicted gains could be realized in practice.

Ogee Tip Review

Ogee tip research during the past few years has been in conjunction with rotor blade study. One of the basic problems associated with rotor blade flows is the concentrated tip separation vortex generated with rectangular tips which degenerate the quality of the flow field encountered by the following blade. The ogee tip is designed to eliminate or diffuse the separation vortex. This is accomplished by cutting back the tip streamwise edge, starting at the leading edge as shown in Figure 1. Wind tunnel tests by NASA to indicate that the separation vortex can be diffused with the ogee tip. Figures 2, 3, and 4 show upper surface isobars for a rectangular wing and an ogee tip section with the same wing are. (Plots taken from reference 1.) As noted, the separation vortex is eliminated.

Balance data indicate that the decreased primary vortex activity leads to a substantial increase in wing L/D. Figure 5 shows the comparison between the rectangular wing and the equivalent ogee tip configuration.

The Modified Beech Baron

The Beech Baron was chosen as the test bed for two reasons. First, it has a detachable tip to easily accommodate the ogee tip; and second, the higher performance allows a chance for greater absolute changes in incremental performance, thus improving the flight-test accuracy.

Figures 6 and 7 show the baseline and modified Baron wing. As noted, the baseline tip is simply removed and the ogee tip is installed. The wing areas are the same. The ogee tip is a constant 23012 section along the tip span.

Flight Test Results

Flight tests included both speed-power and sawtooth climbs. Results, as noted in Figures 8, 9, and 10, indicate that incremental changes in performance due to the addition of the ogee tips are on the order of the data scatter associated with flight test techniques used. Climb data at density altitudes of 5500 feet and 9500 feet show a possible increase in climb at high C_L values and a decrease at low C_L values. The speed-power data indicate no substantial change in level-flight speeds.

References

1. "Effect of Sweep Angle on the Pressure Distributions and Effectiveness of the Ogee Tip in Diffusing A Line Vortex," J.C. Balcelak and R.F. Feller, NASA CR 32355

2. Rorke, J.B., Moffitt, R.C., and Ward, F.J., "Wind Tunnel Simulation of Full-Scale Vortices," Preprint #623, 28th Annual National Forum of the American Helicopter Society, Washington, D.C., May 1972.

3. Landgrebe, A.T., and Bellinger, E.D., "Experimental Investigation of Model Variable - Geometry and Ogee Tip Rotors," United Aircraft Research Laboratories, NASA Contract No. NAS - 10906, to be published, 1973.

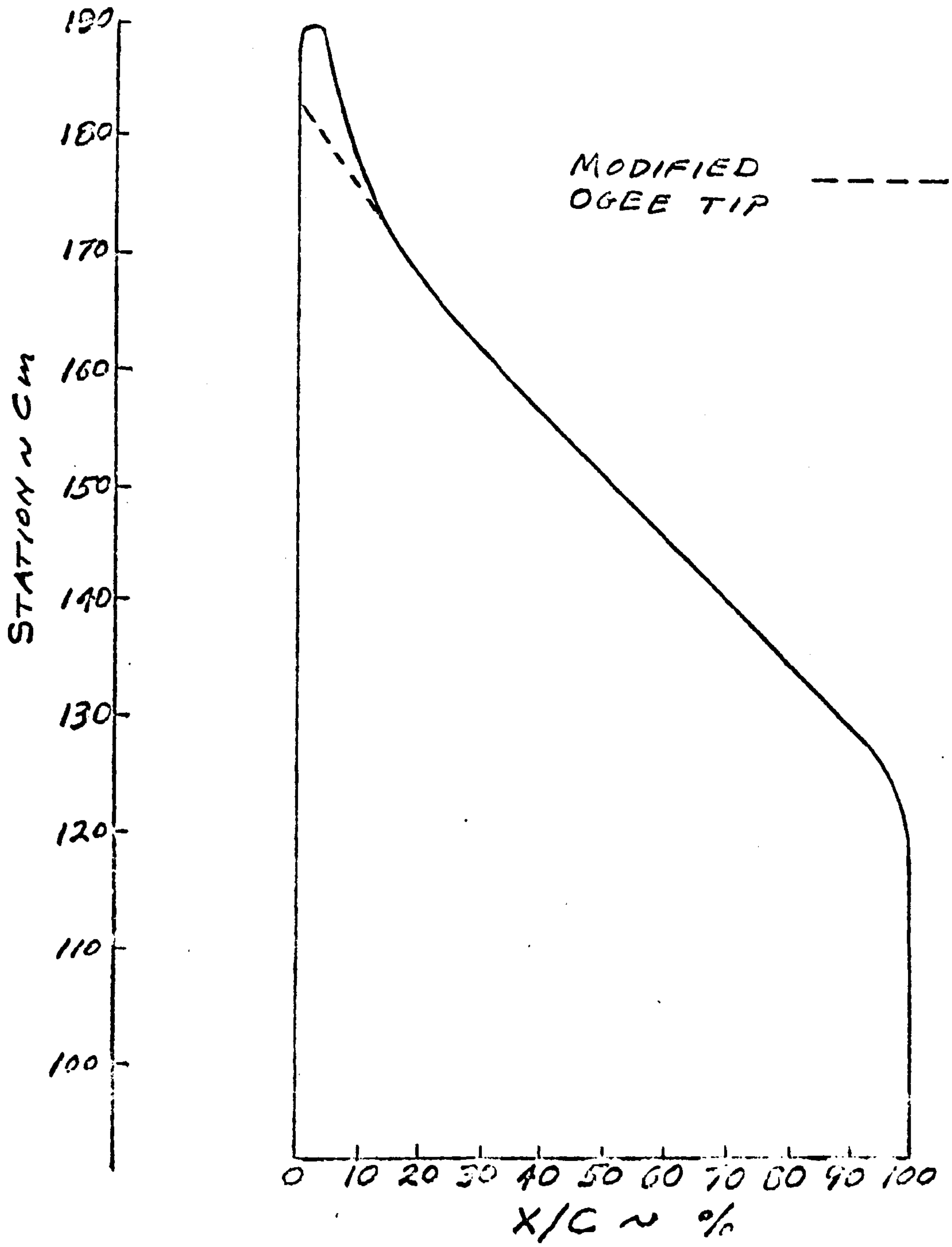

Figure 1. Ogee Tip Planform

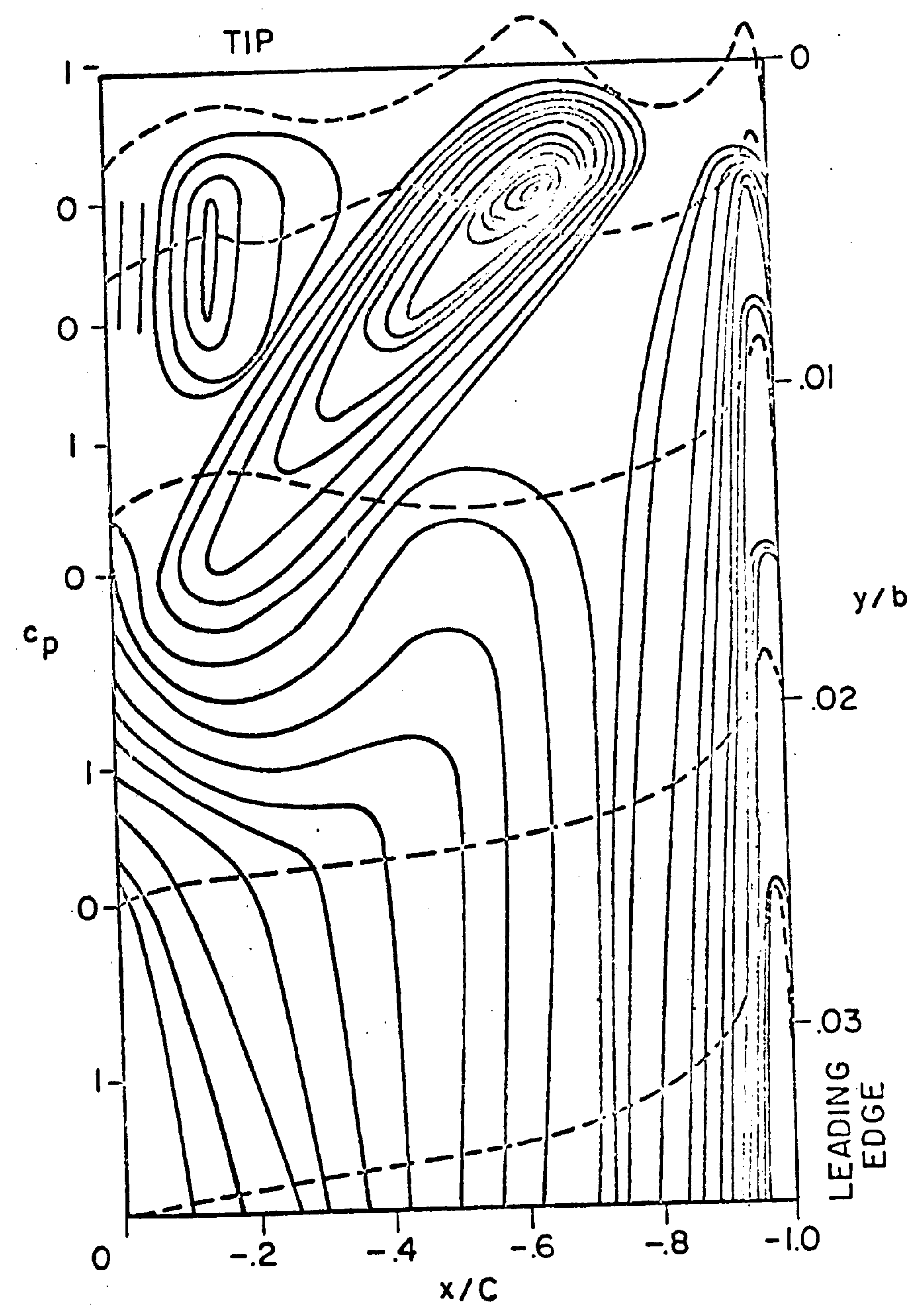

Figure 2. Isobars on top surface of wing (tip region)
$\lambda = 0$, $\alpha = 12°$

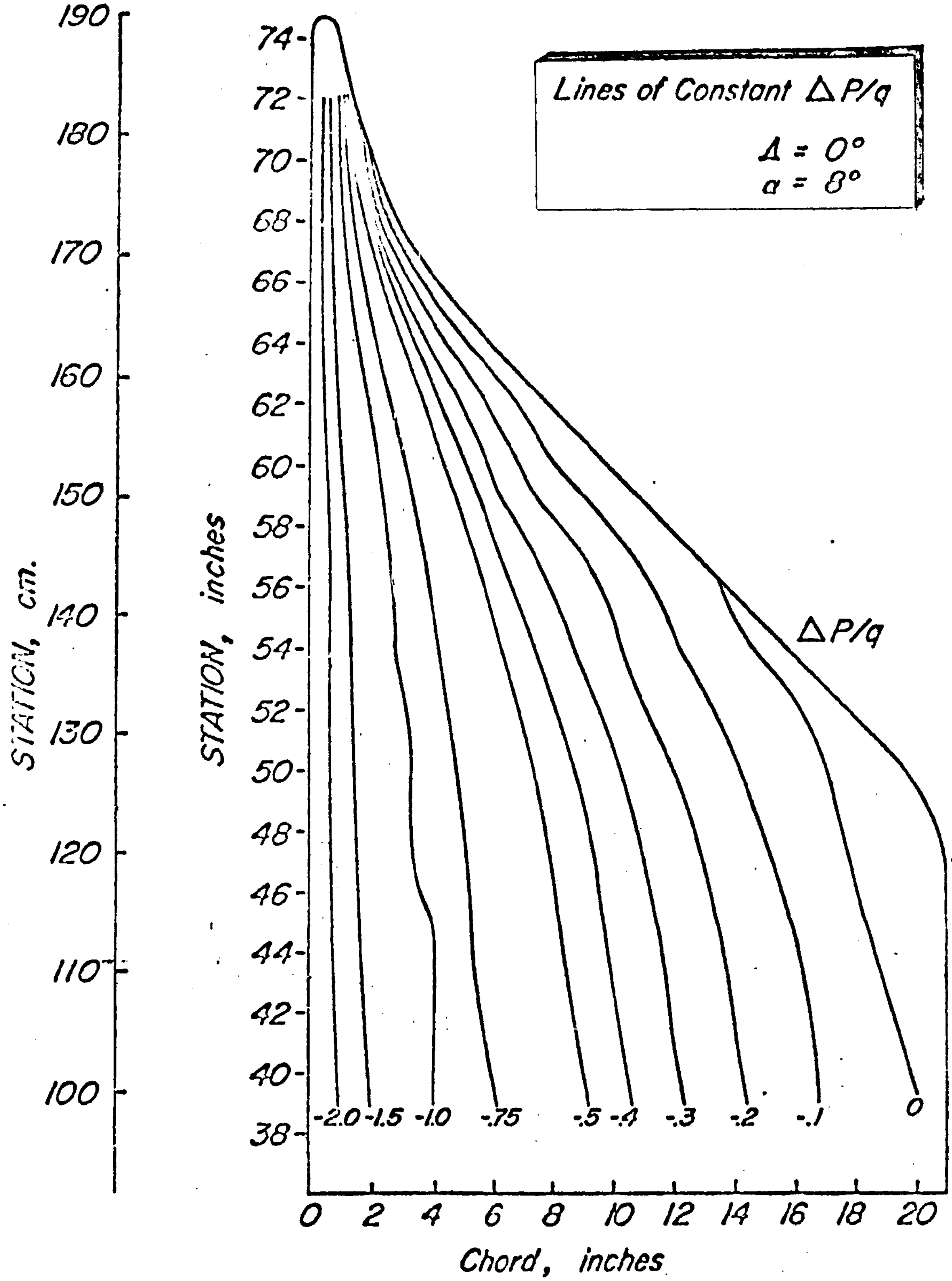

Figure 3. Contour pressure plot of the ogee-tip section at $\alpha = 8^{\circ}$ and $\Lambda = 0^{\circ}$

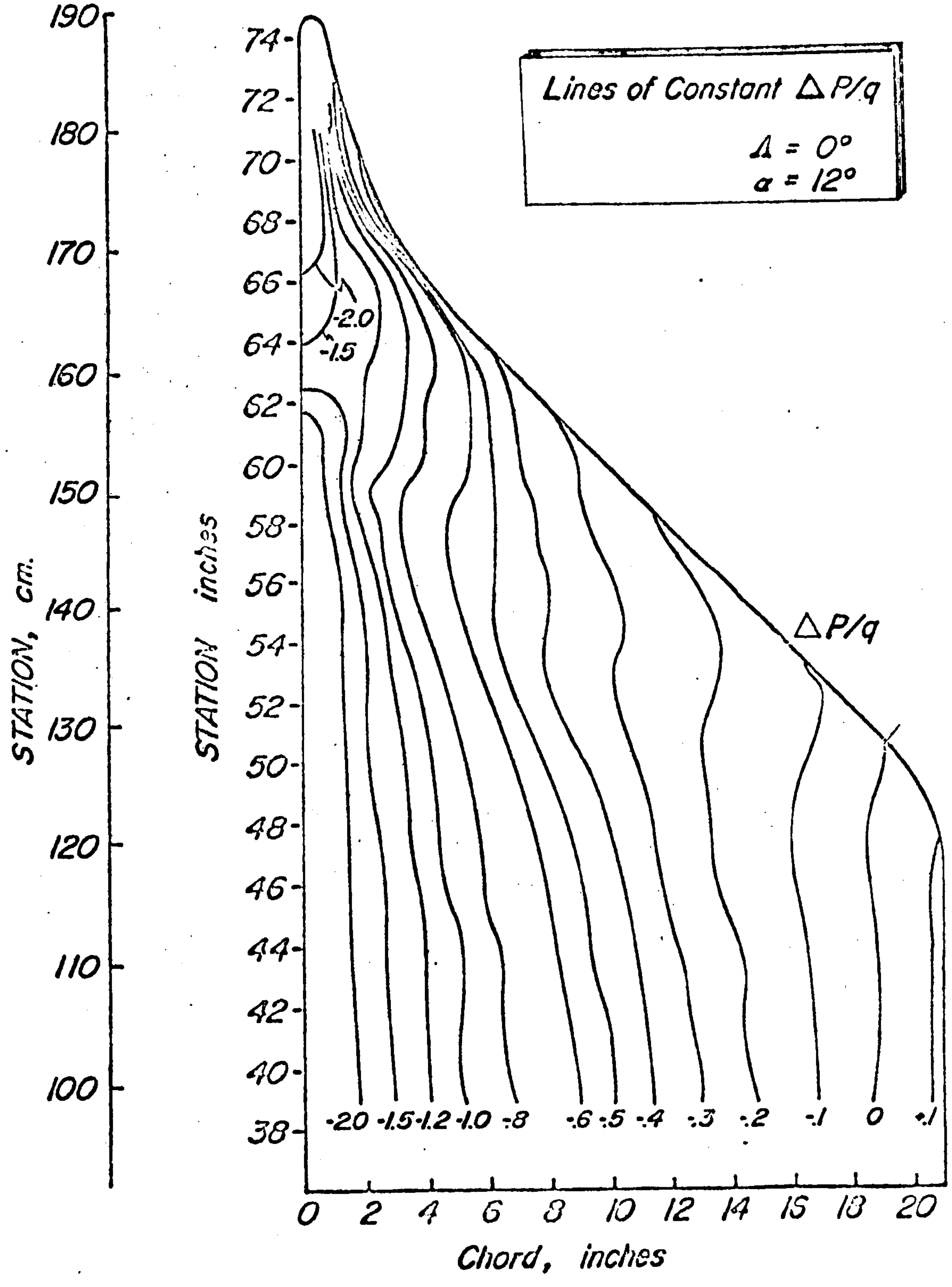

Figure 4. Contour pressure plot of the ogee-tip section at $\alpha = 12^{\circ}$ and $\Lambda = 0^{\circ}$

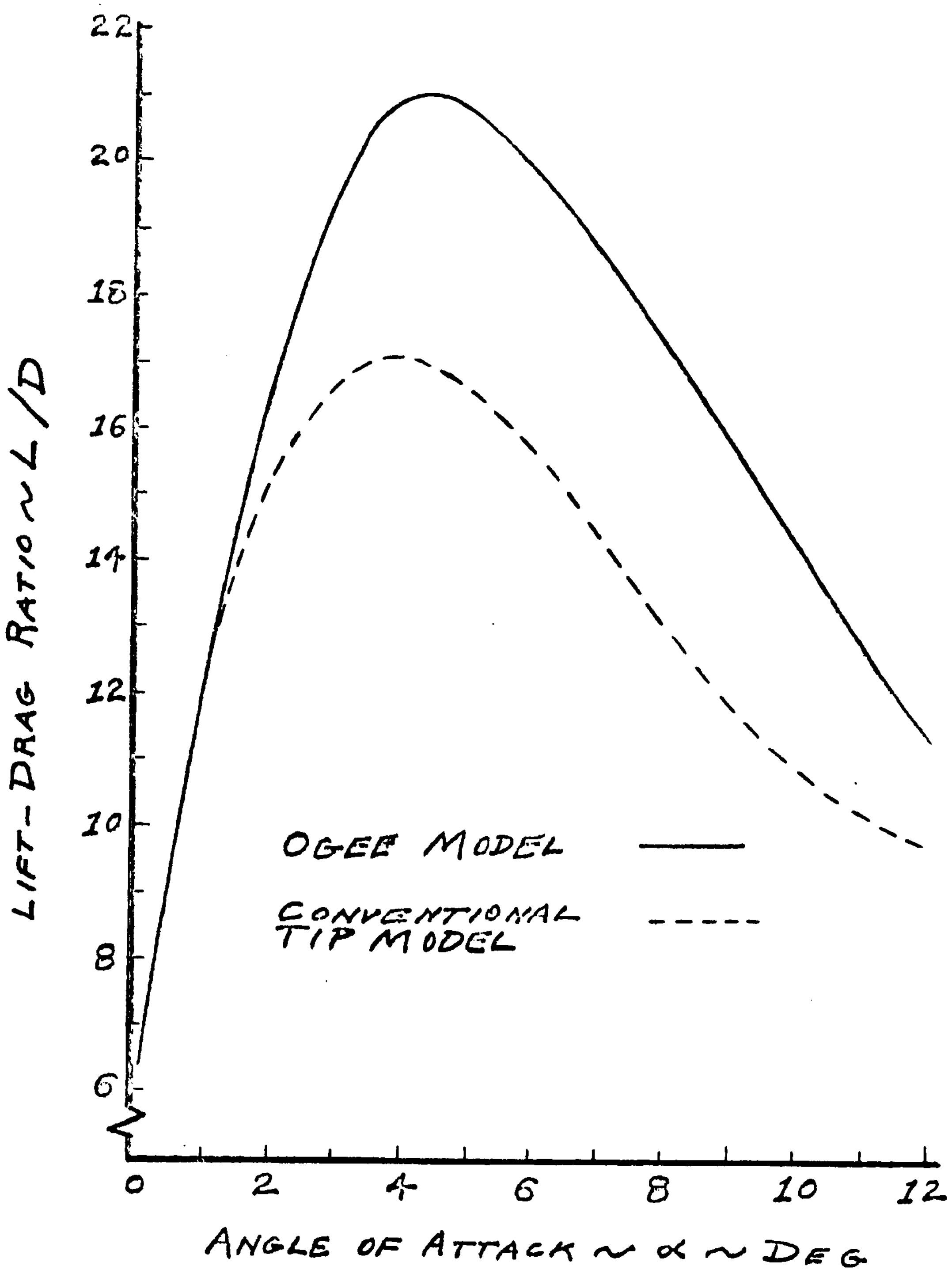

Figure 5. Lift-to-Drag Ratios vs. Angle of Attack

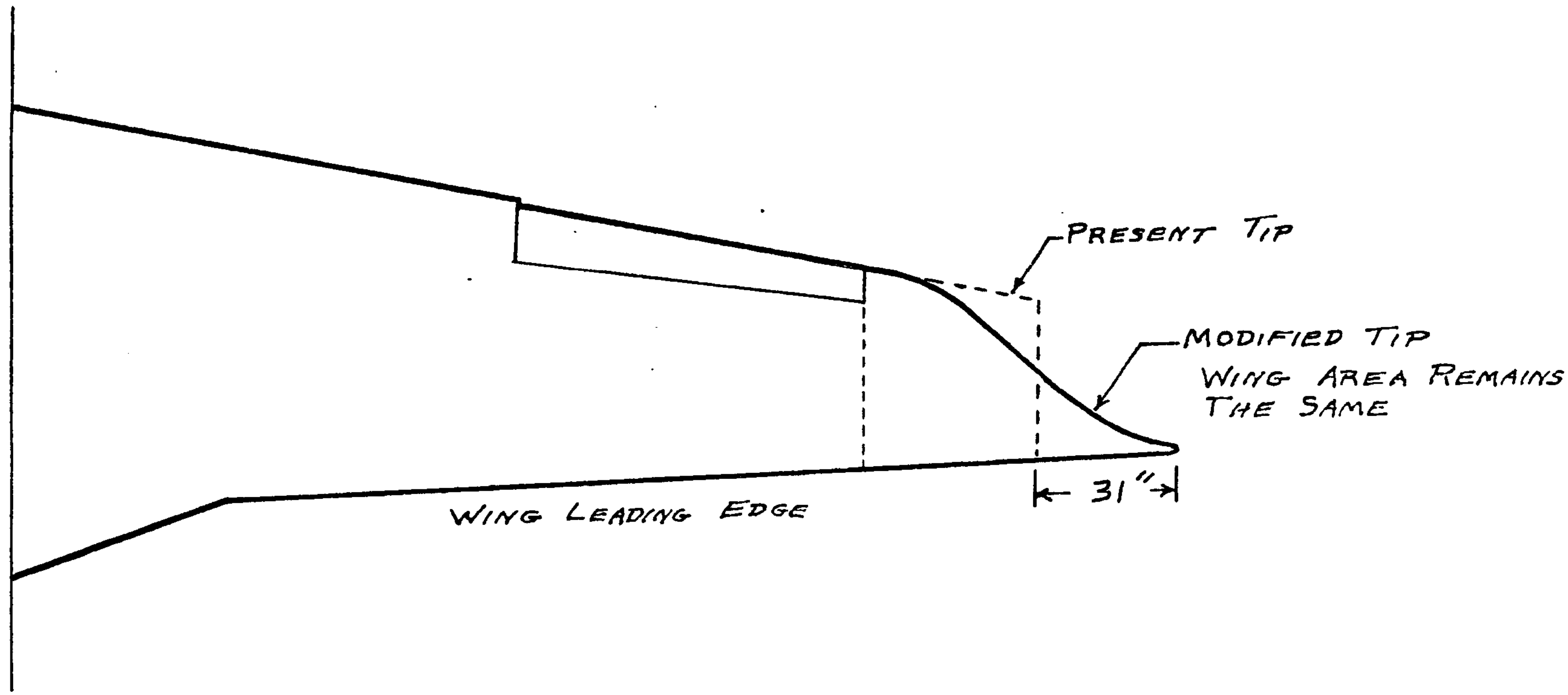

Figure 6. Ogee Wing Tip on Beech Baron

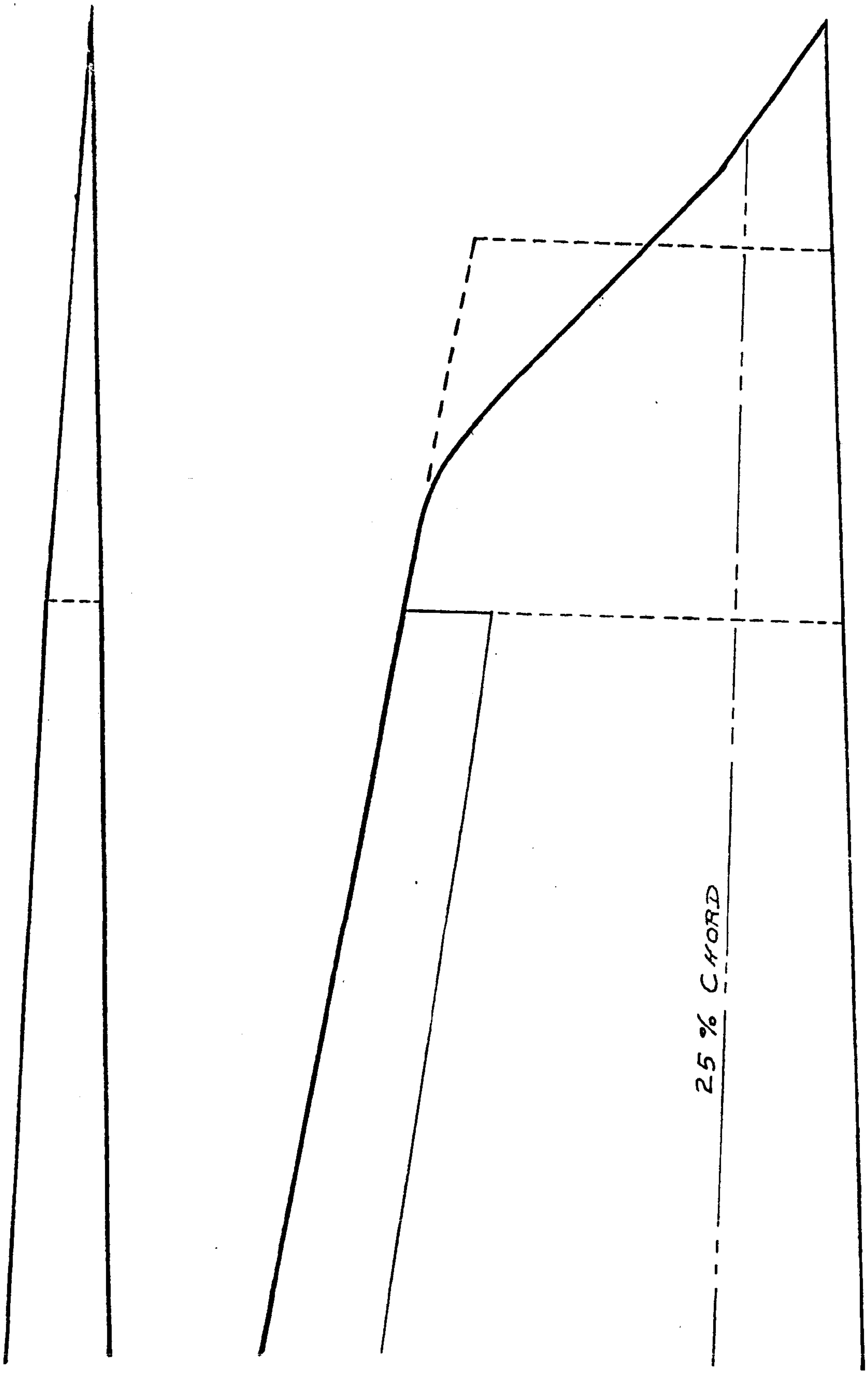

Figure 7. Wing Geometry for Ogee Tip Baron

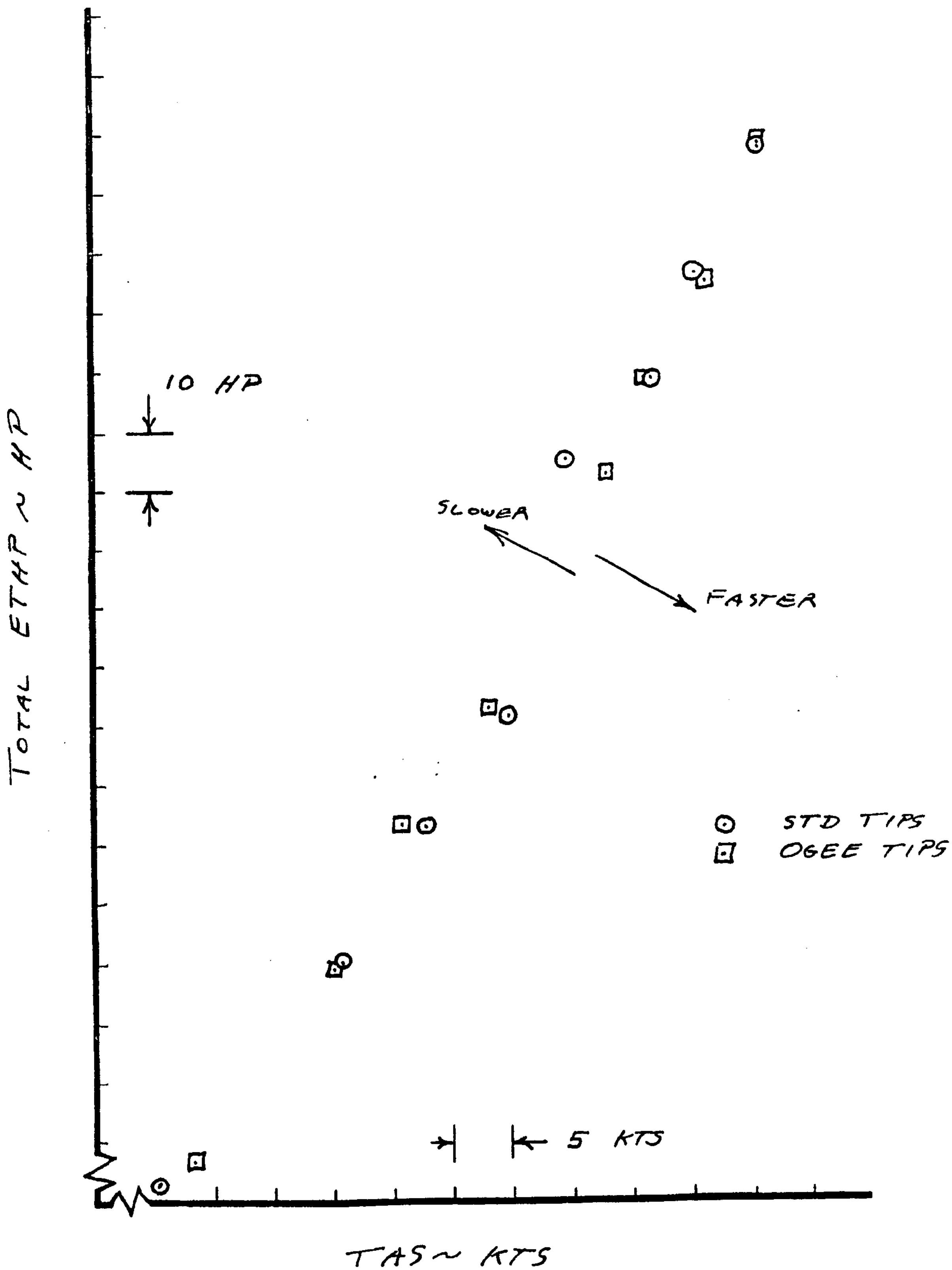

Figure 8. Speed-Power Std. Tips vs. Ogee Tips 16,000 Ft.

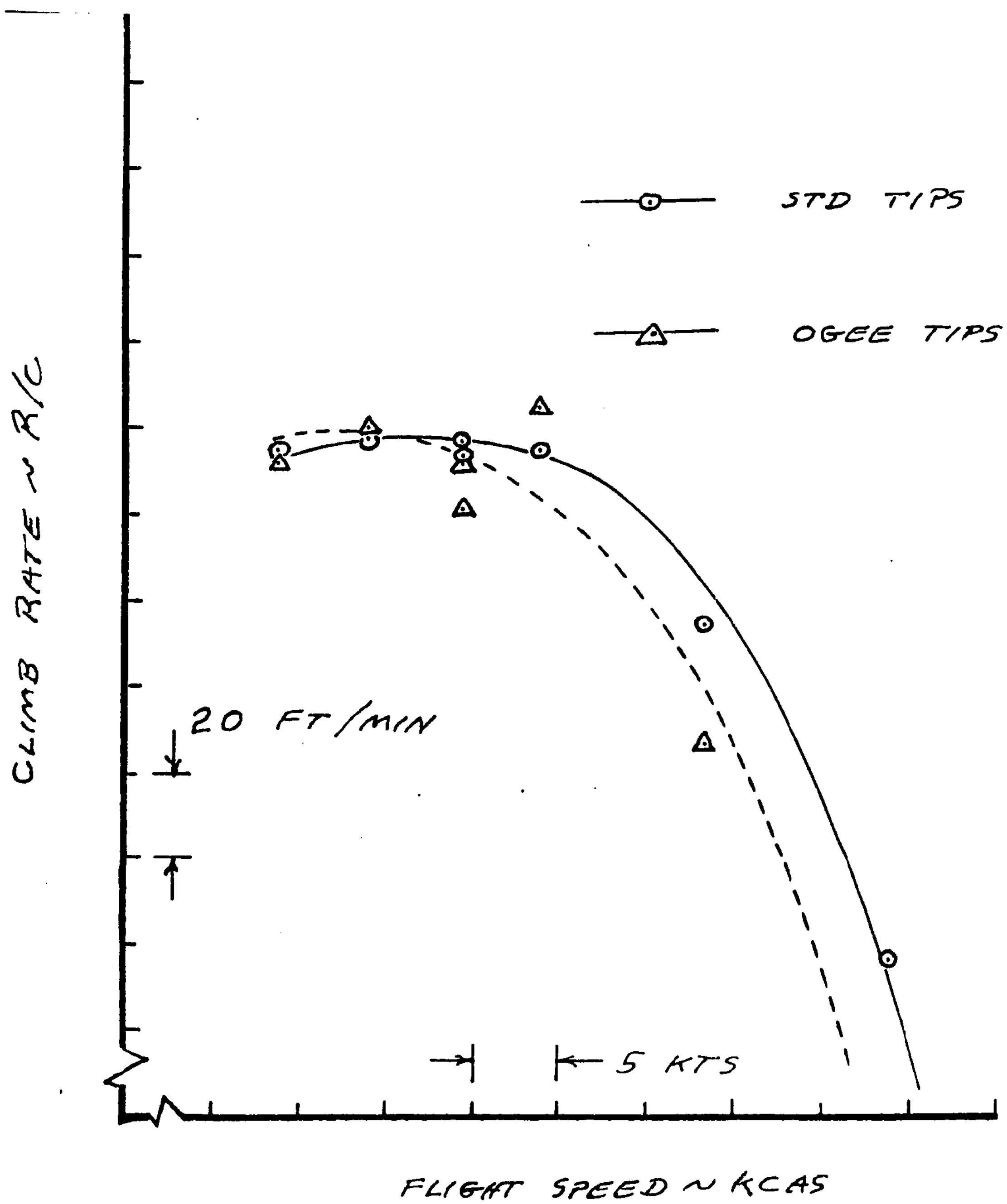

Figure 9. Ogee Tip Configuration R/C vs. KCAS
Density Alt. 5549 Ft.

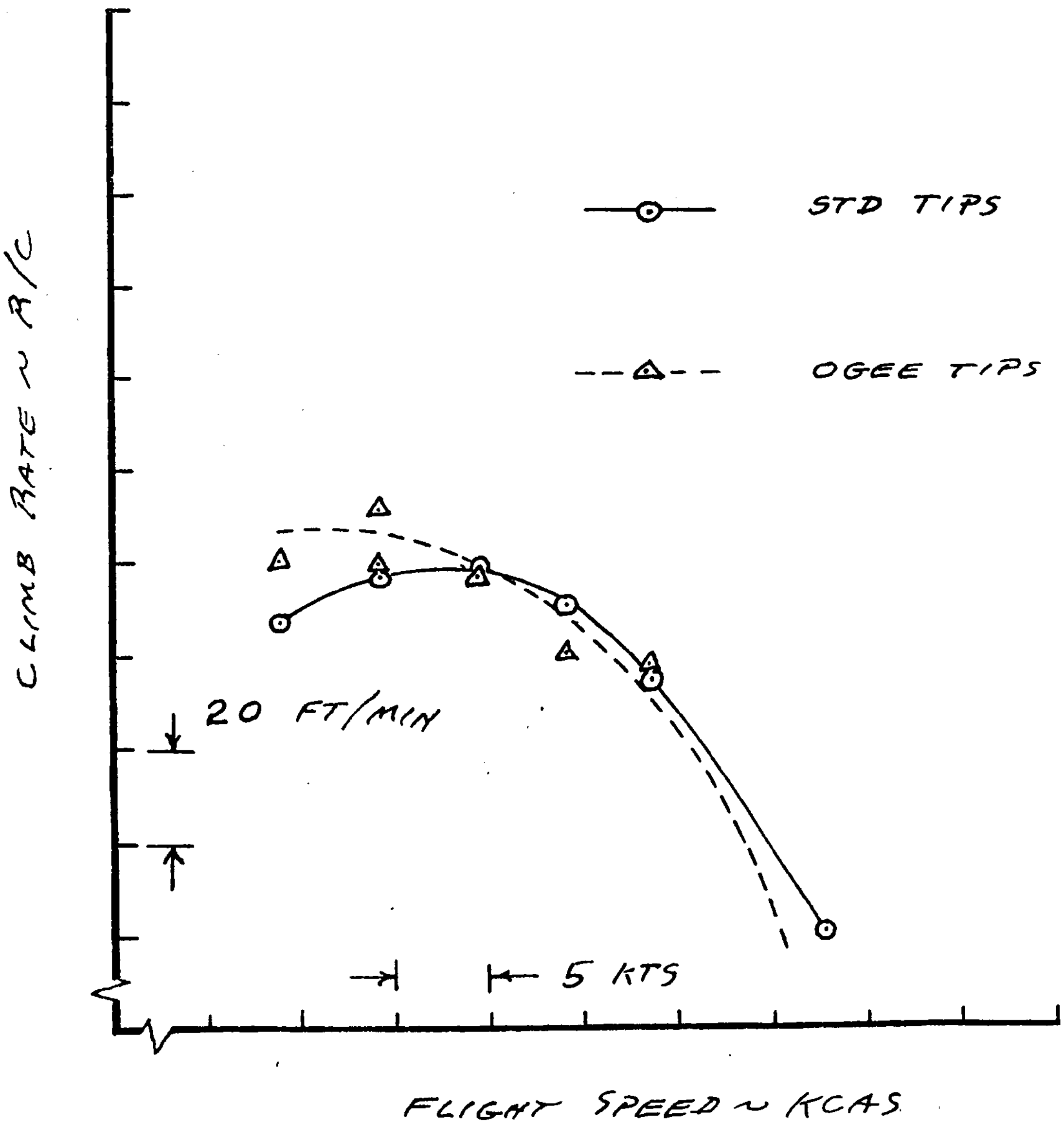

Figure 10. Ogee Tip Configuration R/C vs. KCAS
Density Alt. 9623 Ft.