Curiosity Number 20. Subsonic parasite drag of airfoils with differing leading edge radii

W.H. Mason, July 16, 2017

This contribution to the list is from an informal memo written in 1984. I had forgotten about it, but found it in my papers recently. It had been suggested to me (from an aerodynamicist at Wright Field that I still interact with!) that increasing an airfoil's leading edge radius would increase its subsonic basic parasite drag. It appears I did a study using both Grumfoil and the Korn code to check out this assertion. The results are interesting. Parasite drag decreased (very) slightly with significantly increased leading edge radius.

That same folder contains a suggestion from Warren Davis that I should repeat the study. Instead of fixing the transition at 10% chord I should specify the transition location for each airfoil at its minimum pressure location. Apparently I never did it. It would be a good homework problem.

I've included the plots that were attached to the memo. I include them to illustrate what came out automatically when we ran codes in those days. There was no post processing software. We wrote our own plotting packages and it was easy to tailor the plotting to our needs. Today the flow visualization developers think they know what we want, but they aren't configuration aerodynamicists.

March 29, 1984

To: M. Siegel, R. Meyer

From: W. Mason

Subject: Leading Edge Radius Effects on Profile Drag

Objective: Use the Grumfoil and Korn Programs to assess the effect of varying leading edge radius on the profile drag of a symmetric airfoil at zero angle of attack. There have been some assertions that increasing the leading radius of an airfoil would increase the profile drag at subsonic speeds.

Assumption: L.E. Radius should have no effect on profile drag.

Model Calculation:

Use three airfoils with the same thickness, and an analytic procedure for smoothly varying the leading edge radius. The particular airfoil was picked because it was tested (NACA R-492, but results were reported without describing transition location).

		Relative L.E. Radius
1.	NACA 0009-33	1/4th Basic Value
2.	-63	Basic Value
3.	-93	3x Basic Value

This is a 12 fold variation in L.E. Radius

Test Conditidtions: $M=.15$, $Re=6\times10^{6}$, Transistion at $x/c=0.10$. Zero angle of attack.

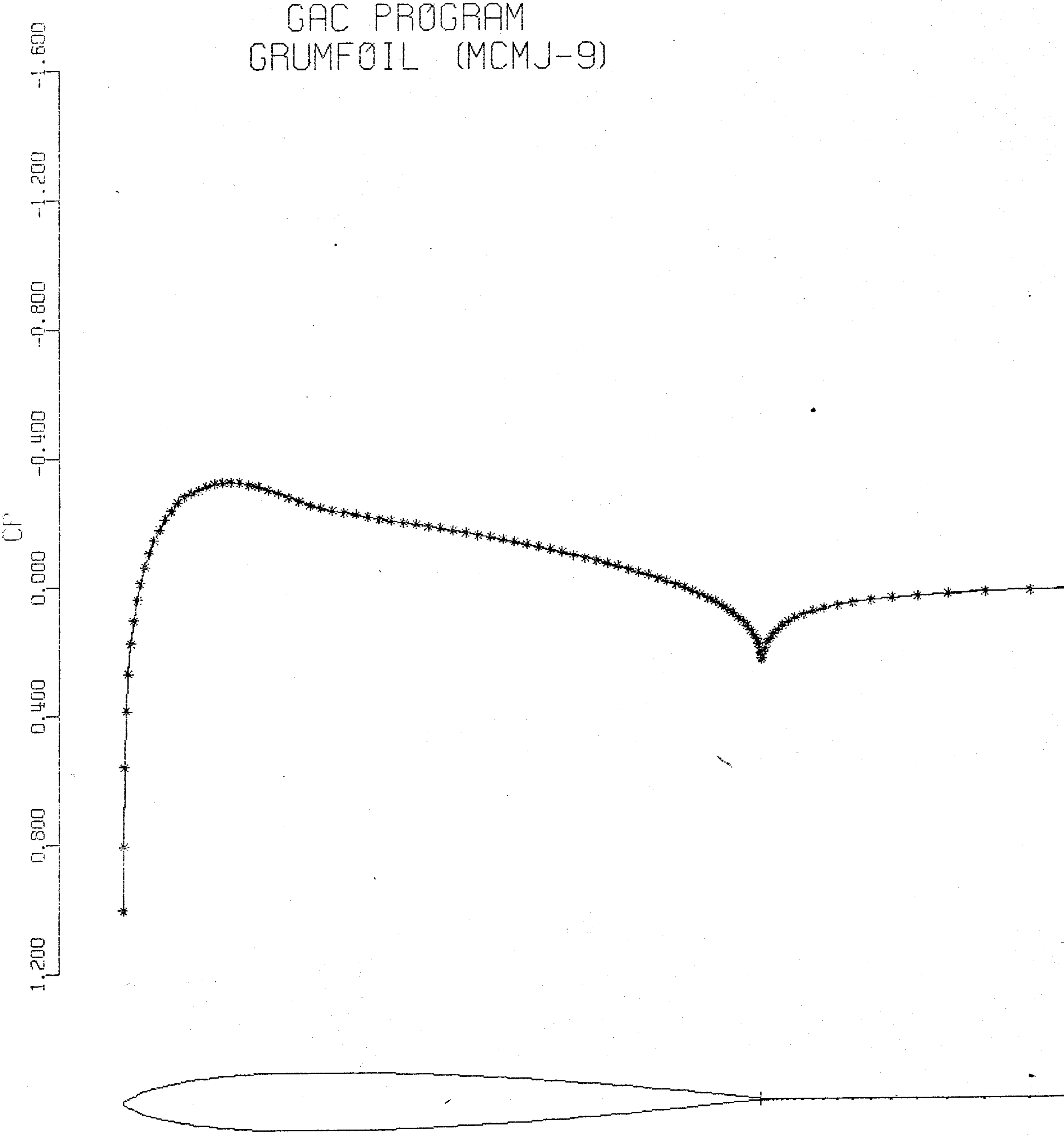
Results:

	Drag - in Counts - Grumfoil w Base Press	Grumfoil w/o Base Press	Korn
NACA 0009-33	68.0	71	74.8
-63	67.6	70.	72.8
-93	66.3	69.	72.8

Pressure Distributions: see Figures 1, 2, and 3

Conclusion: Both codes predicted <u>decreasing</u> drag with <u>increasing</u> leading edge radius. However the change is relatively minor: a 1200% increase in L.E. Radius led to a 2.5% decrease in profile drag.

GAC PRØGRAM
GRUMFØIL (MCMJ-9)



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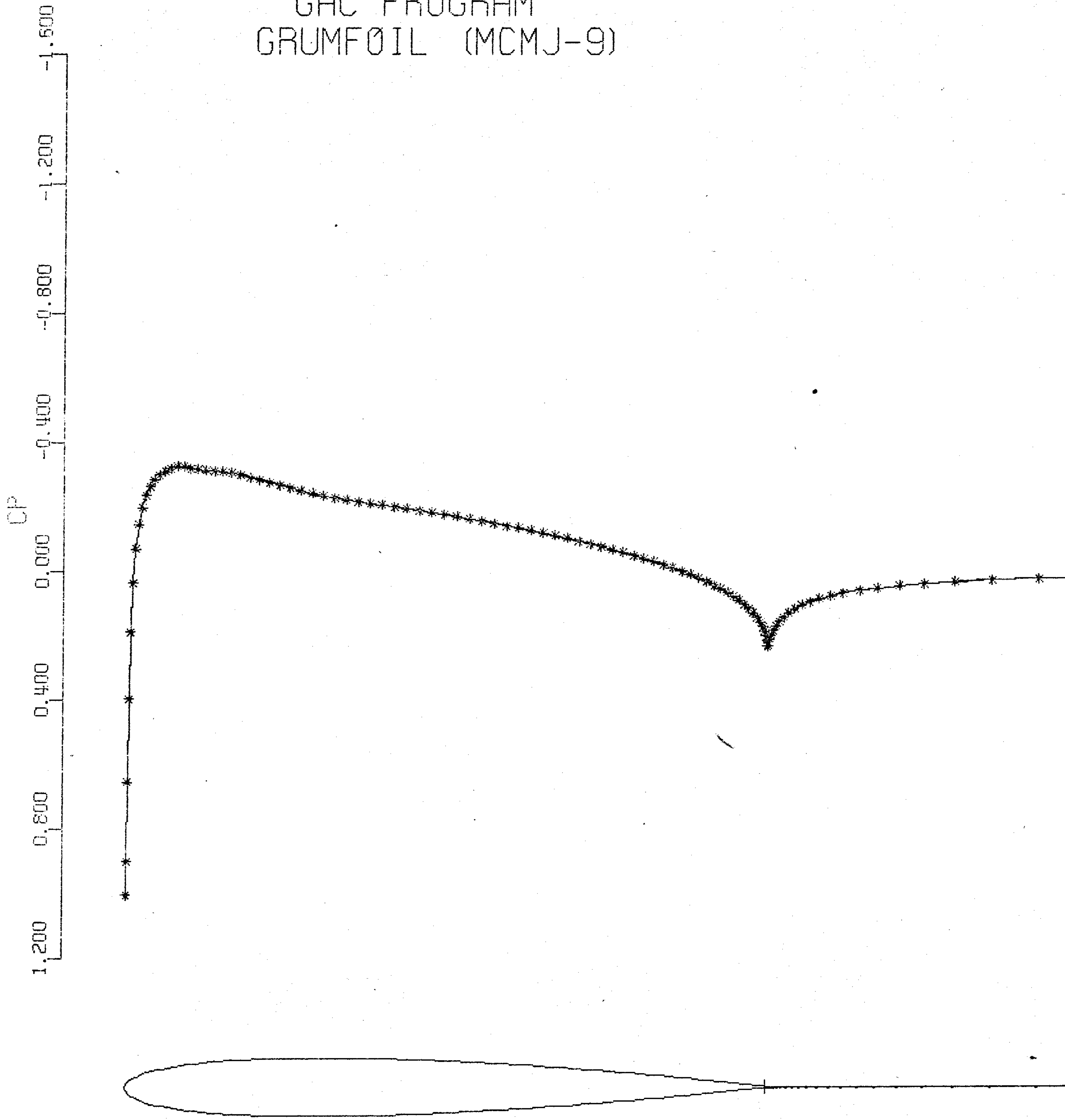
CLP= 0.0000 CDP=0.0006 CMP=0.0000 CL = 0.0000 CD =0.0071 CDB =0.006
CLT= 0.0000 CDT=0.0071 VARYING WAKE THICK WITH CURV

GAC PRØGRAM
GRUMFØIL (MCMJ-9)



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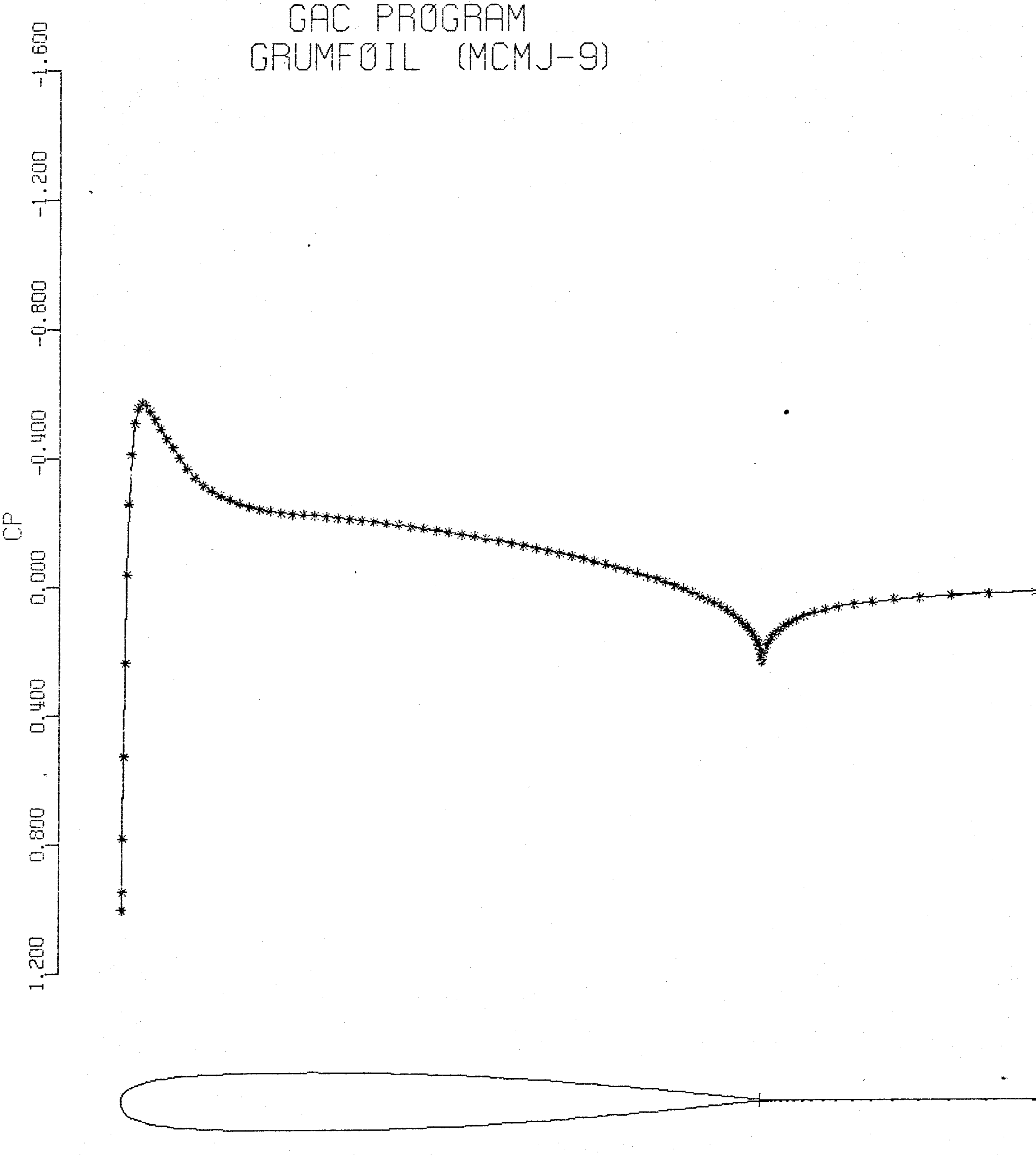
CLT= 0.0000 CDT=0.0070 VARYING WAKE THICK WITH CURV

GAC PRØGRAM
GRUMFØIL (MCMJ-9)



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CLT=-0.0000 CDT=0.0069 VARYING WAKE THICK WITH CURV